



China Classification Society

RULES FOR CONSTRUCTION OF OCEAN-GOING STEEL FISHING VESSELS

2018

Effective From 1 December 2018

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China Classification Society

RULES FOR CONSTRUCTION OF OCEAN-GOING STEEL FISHING VESSELS

2018

PART 1 GENERAL

Effective From 1 December 2018

PART 1 GENERAL

1 Application

1.1 Unless expressly provided otherwise, the Rules for Construction of Ocean-going Steel Fishing Vessels (hereinafter referred to as the Rules) apply to ocean-going steel fishing vessels of 24 m and over in length (hereinafter referred to as fishing vessels). Fishing vessels of more than 90 m in length are to comply with the requirements of China Classification Society (hereinafter referred to as “CCS”) *Rules for Classification of Sea-going Steel Ships*. Contents not covered in the Rules, such as fishing appliances and refrigeration apparatus are to comply with the relevant requirements of CCS.

1.2 Fishing vessels of less than 24 m in length are to be otherwise stipulated by CCS.

1.3 The strength, structures and arrangement of fishing vessels and the designing, manufacturing, installing and testing of out fittings, mechanical, electrical equipment, if ting appliances, materials and welding on board are to comply with the requirements of the Rules.

1.4 Any fishing vessel to be classed with CCS or maintain such class assigned shall also comply with the relevant provisions of CCS.

1.5 The surveys and certifications of marine products shall aslo comply with the relevant provisions of CCS.

1.6 Unless stated otherwise, the Rules apply to new vessels and marine products newly installed on all fishing vessels.

1.7 Vessels serving ocean-fishery such as refrigerated carrier, buy vessels, fishery law enforcement vessels and fishery research vessels are to be in accordance with the relevant provisions in the Rules for Classification of Sea-going Steel Ships of CCS.

2 Equivalent and Exemption

2.1 Any fishing vessel which embodies structure and features of a novel kind may be exempted from any requirement of the Rules if the application of which might seriously impede the incorporation of its features or its service, subject to agreement of CCS Headquarters. However equivalent measures should be provided to ensure the safety of the fishing vessels.

2.2 Any fitting, material, appliance or apparatus, other than that required in the Rules, may be allowed to be fitted in the vessel, if it is satisfied by trial thereof or otherwise that such fitting, material, appliance or apparatus is at least as effective as that required by the Rules.

2.3 Equivalence or substitution to those methods of calculation, criteria of evaluation, manufacturing procedures, materials, survey and test requirements specified by the Rules may be accepted subject to agreement of CCS Headquarters, when relevant tests, theoretical basis or experience in application is provided, or recognized effective standards are available.

3 Entry into Force of the Rules

3.1 Unless stated otherwise, after the Rules (including their amendments) are released, the effective date will be indicated on the title page of the publication.

3.2 In principle, all vessels constructed before the date of entry into force of the Rules are to continue to comply with the requirements previously applicable to them. For fishing vessels which have undergone modification of a major character, the modified and related portions are to comply with the new Rules.

3.3 With the consent of the shipyard, the owner and CCS, the requirements of the new rules may be adopted for the fishing vessel under construction; and where the requirements in the new rules are reasonable and practicable; CCS may agree that these requirements be adopted for the fishing vessel under construction. In any case, this is to be indicated in the corresponding technical documents.

3.4 The date of entry into force of the Rules is subject only to the date of approval for publishing the Rules, not to the date of entry into force of any other statutory requirements.

4 Interpretations of the Rules

4.1 The right of interpretations on the rules, guidelines and other relevant publications published by CCS is to be left solely to CCS Headquarters.

4.2 In case of any different understanding to the English version of the Rules, the currently effective Chinese version of the Rules is to be considered as solely authoritative.

4.3 Surveyors shall strictly abide by during their inspection the approved plans, calculations, specifications and other technical documents. Where there is any disagreement between the guidelines published by CCS and the Rules, the Rules are to be considered as solely authoritative..

5 Survey Methods

5.1 Among various surveys for fishing vessels, in addition to examination and check, UAVs, underwater robots and other technical equipment subject to agreement of CCS can be used for close-up examination on the arrangements, structures, systems, installations, appliances, components, etc. of fishing vessels.

6 Definitions

6.1 Unless expressly provided otherwise, for the purpose of the Rules:

(1) A *fishing vessel* means a vessel used for commercially catching fishes, seals, walrus or other living resources of the sea.

(2) An *ocean-going fishing vessel* means a fishing vessel engaged in marine fishing on the high seas and waters under the jurisdiction of other states.

(3) A *new vessel* means a fishing vessel contracted for construction on or after the date of entry into force of the Rules.

(4) An *existing vessel* means a fishing vessel which is not a new vessel.

(5) The *age of the vessel* means the years counted from the date on which the fishing vessel was built.

(6) *Vessel owner* means a generic term of the owner, operator or agent of a fishing vessel.

(7) *Approval* means the approval, agreement and ratification taking place in executing surveys for fishing vessels and marine products in accordance with the Rules carried out by CCS.

(8) *Length of vessel (L)* is 96% of the total waterline length measured at 85% of the minimum moulded depth on the upper edge of the keel plate, or the distance from the forward side of the stem to the center of the rudder stock, whichever is greater. The length of a vessel without a rudder stock is 96% of the total waterline length measured at 85% of the minimum moulded depth.

Provided that the stem above the waterline at 85% of the minimum moulded depth is concaved, the foremost end of the total length and the forward side of the stem are to be measured starting from the point perpendicularly projected on the waterline by the last point on the stem outline above the waterline (see Figure 6.1 (8)-1).

For a fishing vessel designed with a tilting keel, the waterline as datum line for measuring length is to be parallel to that at 85% of the minimum moulded depth D_{min} . This waterline is obtained by drawing a keel line parallel to the fishing vessel and a line tangent to the workdeck-type sheer curve as shown in the figure below. In this circumstance, the minimum moulded depth is the vertical distance measured at the point of tangency from the upper edge of keel plate to the upper beam on working deck side (see Figure 6.1 (8)-2).

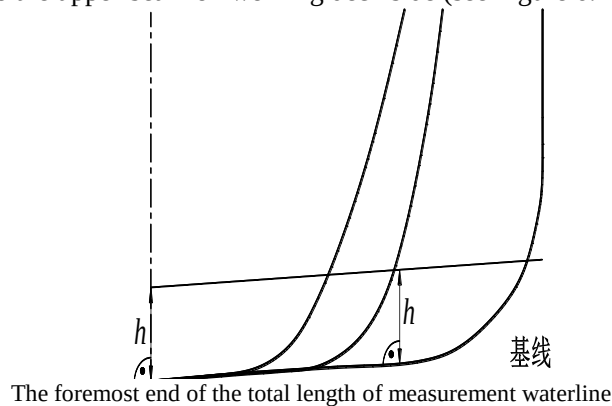


Fig. 6.1 (8)-1 The foremost end of the total length of measurement waterline of a fishing vessel with a concaved stem

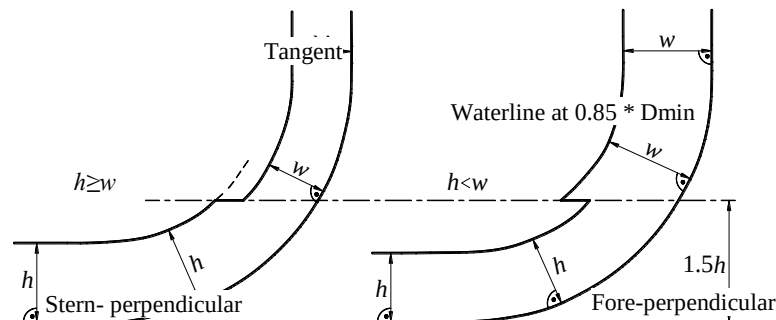


Fig. 6.1 (8)-2 Length of a fishing vessel designed with a tilting keel



China Classification Society

RULES FOR CONSTRUCTION OF OCEAN-GOING STEEL FISHING VESSELS

2018

PART 2 HULL

Effective From 1 December 2018

CHAPTER 1 GENERAL

Section 1 GENERAL PROVISIONS

1.1.1 Application

1.1.1.1 This PART applies to ocean-going steel fishing vessels of all welded construction.

1.1.1.2 This PART applies to fishing vessels with a principal dimension ratio ranging:

$$L/D \leq 14$$

$$B/D \leq 3.0$$

Where: L , B , D — See 1.1.2.1, 1.1.2.2 and 1.1.2.3 of this PART.

1.1.1.3 For fishing vessels in special types, dimensions and structural forms, the structural dimensions are to be otherwise considered, and approved by CCS.

1.1.2 Definitions

1.1.2.1 *Length of vessel L* (in m) means the distance on the summer load waterline from the fore side of the stem to the after side of the rudder post, or the center of the rudder stock if there is no rudder post; but L is not to be less than 96% and need not to be greater than 97% of the total length on the summer load waterline.

For vessels without a rudder stock (such as a fishing vessel designed with a full-revolving propulsor), L is to be 97% of the total length on the summer load waterline.

1.1.2.2 *Breadth of vessel B* (in m) means the molded breadth of a vessel Unless expressly provided otherwise, namely the maximum horizontal distance between the molded frame lines measured at the middle of the length L .

1.1.2.3 *Moulded depth D* (in m) means the vertical distance measured at the middle of the length L from the top of keel to the uppermost continuous deck beam along the vessel board. For a fishing vessel with a ladder-like uppermost continuous deck, if a raised deck is designed at the middle of the length L , the moulded depth of vessel is to be measured to the extension line of the lower deck parallel to the raised deck.

1.1.2.4 *Draught d* (in m) means the vertical distance measured at the middle of the length L from top of keel to the summer load waterline.

1.1.2.5 *Forward and after perpendiculars* are taken from the forward side and after side on the *length of vessel L* respectively. The forward perpendicular is to be coincided with the forward side of stem.

1.1.2.6 *Amidships* means the middle of the *length of vessel L* .

1.1.2.7 *A keel line* means the line of intersection between the upper edge of the keel or the inside of the shell plating at the Amidships. For bar keel, it means the line passing the point at which the bar keel intersects the inner extension line of the shell plating, and parallel to the keel grade.

1.1.2.8 *The uppermost continuous deck* means the uppermost deck which extends from the stem to the stern.

1.1.2.9 *Strength deck* means

.1 the uppermost continuous deck;

.2 the superstructure deck extending within $0.4 L$ amidships, and having a length not less than $0.15 L$, and the uppermost continuous deck extending outside the region of such a superstructure.

1.1.2.10 *Lower decks*: The continuous deck next below the uppermost continuous deck is to be named as 2nd deck, and so on. They are generally called lower decks.

1.1.2.11 *Bulkhead deck* means the highest continuous deck to which the transverse watertight bulkheads extend within the main hull.

1.1.2.12 *Platform decks* means the non-continuous decks below the strength deck, which are not considered to be effective decks for longitudinal strength.

1.1.2.13 *Superstructure and deckhouse*: Superstructure means an enclosed structure on the uppermost continuous deck, extending from side to side of the vessel or with the side plating not being inboard of the shell plating more than 4% of the breadth B . Forecastle, bridge and poop are regarded as superstructures. All other enclosed structures are to be termed as deckhouses.

1.1.2.14 *Long superstructure and short superstructure*: A superstructure having a length greater than $0.15 L$ and not less than 6 times its height is to be termed as a long superstructure, otherwise it is to be regarded as a short superstructure.

1.1.2.15 *Long deckhouse and short deckhouse*: A deckhouse having a length greater than $0.15 L$ and not less than 6 times its height is to be termed as a long deckhouse, otherwise it is to be regarded as a short deckhouse.

1.1.2.16 *Primary members*: The primary supporting members of hull are regarded as primary members,

such as side transverses, side stringers, transverses, deck girders, plate floors, bottom girders and bulkhead webs.

1.1.2.17 *Secondary members*: The stiffeners of the hull plate are generally regarded as secondary members, e.g. side transverses, beams, bulkhead stiffeners and members of bracket floors.

1.1.2.18 *Block coefficient* C_b is to be determined by the following formula:

$$C_b = \frac{\nabla}{(LBd)}$$

Where, ∇ ——— moulded displacement, in m^3 , corresponding to the summer load waterline;

L, B, d — see 1.1.2.1, 1.1.2.2 and 1.1.2.4 of this PART, in m.

1.1.2.19 The *main frame* means the side frame between the collision bulkhead and aft peak bulkhead, and below the lowest deck.

1.1.2.20 Frames in a tween deck space mean frames between two decks.

1.1.2.21 The *Fore peak* means the tank located in front of the collision bulkhead and below the bulkhead deck.

1.1.2.22 The *Aft peak* means the tank located behind the last watertight bulkhead at the aft of a fishing vessel and below the bulkhead deck or watertight platform deck.

1.1.3 Special Provisions

1.1.3.1 Unless expressly provided otherwise, L, B, D and d referenced in this PART refer to the definitions set out in 1.1.2.1, 1.1.2.2, 1.1.2.3 and 1.1.2.4 of this PART.

Section 2 HULL STRUCTURE MEMBERS

1.2.1 General Requirements

1.2.1.1 Except where otherwise stated, the section modulus or moment of inertia derived from the appropriate formulas in this PART is the minimum required value of the section in association with attached plating.

1.2.1.2 In formulae or tables where only midship and end scantlings are given, the reduction from the midship to the end scantlings is to be effected in as gradual a manner as practicable. At the break of structures, constructional arrangement is to be made to ensure a gradual transition.

1.2.1.3 Unless otherwise stated, any intermediate value between the values listed in the Tables may be obtained by linear interpolation.

1.2.1.4 When section steel is adopted, section elements with the combination of plates and section steel are listed in Appendix I of this PART. When the actual cross-sectional area of the ribband is smaller than that listed in the table, the area is to be calculated according to the actual ribband.

1.2.1.5 Where the decimal part of the calculated plate thickness in this PART is less than 0.25 mm, the part may be neglected; and where the decimal part is more than 0.25 mm but less than 0.5 mm, it is to be taken as 0.5 mm; where steel plate of 0.5 mm is unavailable, a round number of 1 mm is to be taken. However, where the calculated plate thickness exceeds 10 mm, if its decimal part is less than 0.5 mm, this part may be neglected; where the decimal part is not less than 0.5 mm, a round number of 1 mm is to be taken.

1.2.1.6 The scantlings of structural members specified in the Rules are minimum values.

1.2.1.7 When designing structural members, those subject to excessive corrosion or wear and tear in service may be adequately increased in thickness.

1.2.2 Attached plating of members

1.2.2.1 The effective sectional area A of attached plating of primary members is to be determined as follows, but is not to be less than the sectional area of the face plate:

.1 For a member attached to plane plating:

$$A = 10 f b t_p \text{ in cm}^2$$

.2 For a member attached to corrugated plating and parallel to the corrugations:

$$A = 10 a t \text{ in cm}^2$$

.3 For a member attached to corrugated plating and at right angles to the corrugations:

$$A = 10 b_f t_f \text{ in cm}^2$$

Where: f ——— factor, equal to $f = 0.3(l/b)^{2/3}$, but not exceed 1;

- b - the mean width, in m, of the load-bearing area of primary members;
 t_p —the mean thickness, in mm, of the attached plating;
 l —the overall length, in m, of the primary member;
 a —the width, in m, of corrugated plating flange;
 t —the thickness, in mm, of corrugated plating.
 b_f —the width, in m, of the face plate of primary members;
 t_f —the thickness, in mm, of the face plate of primary members;
 1.2.2.2 For secondary members, the width of attached plating is taken as one spacing of the corresponding members.

1.2.3 The span point of members

1.2.3.1 Except where otherwise stated, the span used for the calculating of the members in this PART is the effective span between the span points.

1.2.3.2 For primary members, the span point is to be taken at a point b_e distant from the end of the member (See Figure 1.2.3.2):

$$b_e = b_b \left(1 - \frac{d_w}{d_b}\right)$$

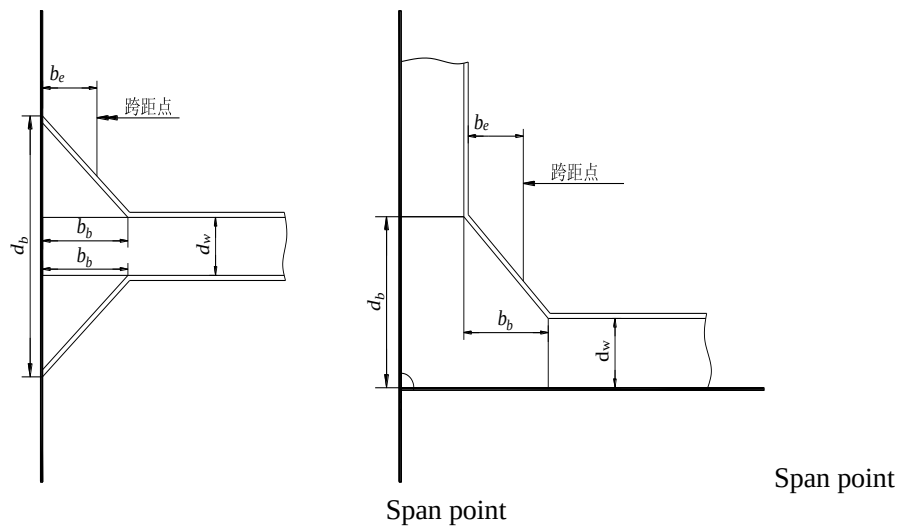


Fig. 1.2.3.2 Span points of primary members

1.2.3.3 For span points of secondary members where end brackets are fitted, see Figure 1.2.3.3-1. Where there is no end bracket, the span point is to be taken at the end of the member (as shown in Figure 1.2.3.3-2).

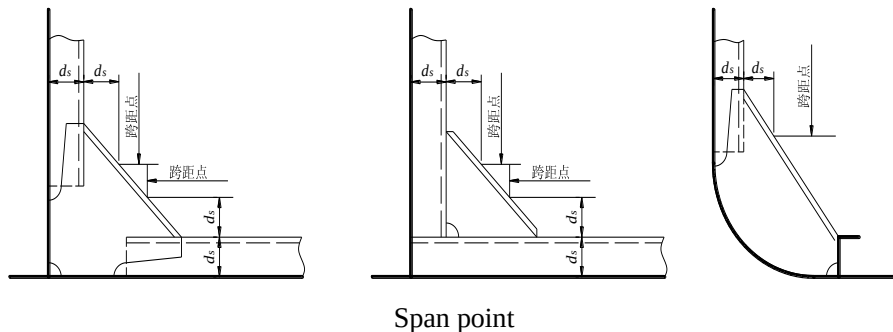


Fig. 1.2.3.3-1 Span points of primary members

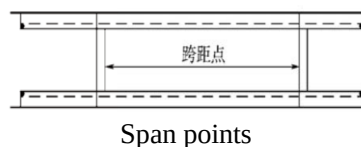


Fig. 1.2.3.3-2 Measuring points of secondary member span

1.2.3.4 Where the members are inclined to a vertical or horizontal axis and the inclination exceeds 10° , the span is to be measured along the member. The span of curved members is defined as the chord length between span points.

1.2.3.5 Where the ends of stiffening members are not substantially fixed against rotation and displacement, consideration will be given to the effective span to be used for the stiffener.

1.2.4 Structural details

1.2.4.1 Primary members are to be so arranged as to ensure effective continuity of structure, and abrupt changes of depth or section are to be avoided. Where members abut on both sides of a bulkhead, or on other members, arrangements are to be made to ensure that they are in alignment. Primary members in tanks are to form a continuous line of support and wherever possible, a complete ring framing. The connections of the ring framing are to be made of rounded corners having an adequate radius, and the radius of rounded corners is in general not to be less than the web depth of the adjacent members.

1.2.4.2 Unless expressly provided otherwise, the web thickness t_w of primary members is not to be less than $0.01 S_w$, in mm (where S_w = spacing of horizontal stiffeners on primary member web, or depth of unstiffened web, in mm); but not less than 7 mm in dry spaces and not less than 8 mm in tanks. For ships of less than 60 m in length, the web thickness may be reduced by 1 mm. For ships of less than 40 m in length, the web thickness may be reduced by 2 mm.

1.2.4.3 The sectional area A_f of face plate of primary members is not to exceed $d_w t_w / 150$ (cm²) (where d_w = depth of primary member web, in mm, t_w = thickness of primary member web, in mm).

1.2.4.4 Primary members are to be supported by tripping brackets. Where the primary members are of symmetrical section, the tripping brackets are to be fitted four secondary member spaces apart symmetrically or the tripping brackets are to be fitted alternately two secondary member spaces apart. Where the primary members are of asymmetrical section, tripping brackets are to be fitted on one side of the web at alternate secondary members. Tripping brackets are also to be fitted to the primary members in way of concentrated loads. If the ratio of depth to thickness of the web is greater than 55, tripping brackets or stiffeners are to be fitted close to the toes of end brackets.

1.2.4.5 The height of tripping brackets is to be extended to the face plate of primary members. The breadth is not to be less than 40% of the height; where the unsupported breadth of the face plate or flange of primary members exceeds $15 t$ (t being thickness of face plate of primary members), the tripping brackets are to be welded to the face plate or flange of primary members. The thickness of the tripping brackets is to be equal to that of the main member web. Where the free edge length l_b (m) is greater than $0.06 t_b$, the tripping brackets are to have face plate or flange, and the sectional area A (in cm²) of which is generally not to be less than $10 l_b$.

1.2.4.6 All openings on structural members are to be kept clear of areas of stress concentration and where this is impracticable, corresponding compensation is to be made. All corners of openings are to be well rounded. Where structural members are directly connected with plates, hard points are to be avoided.

1.2.4.7 Within $0.4 L$ amidships, where the web height of strength deck girders is greater than $65 t \sqrt{K}$ (t being web thickness, while K being material factor), horizontal stiffeners are to be provided parallel to face plate.

1.2.5 Secondary member end connections

1.2.5.1 Unless otherwise specified in this PART, the end connections of secondary members are to comply with the requirements of 1.2.5.

1.2.5.2 The ends of secondary members are generally to be bracketed, see Figure 1.2.6.2. Where secondary members pass through primary members, secondary members are to be connected to the webs of primary members by welding.

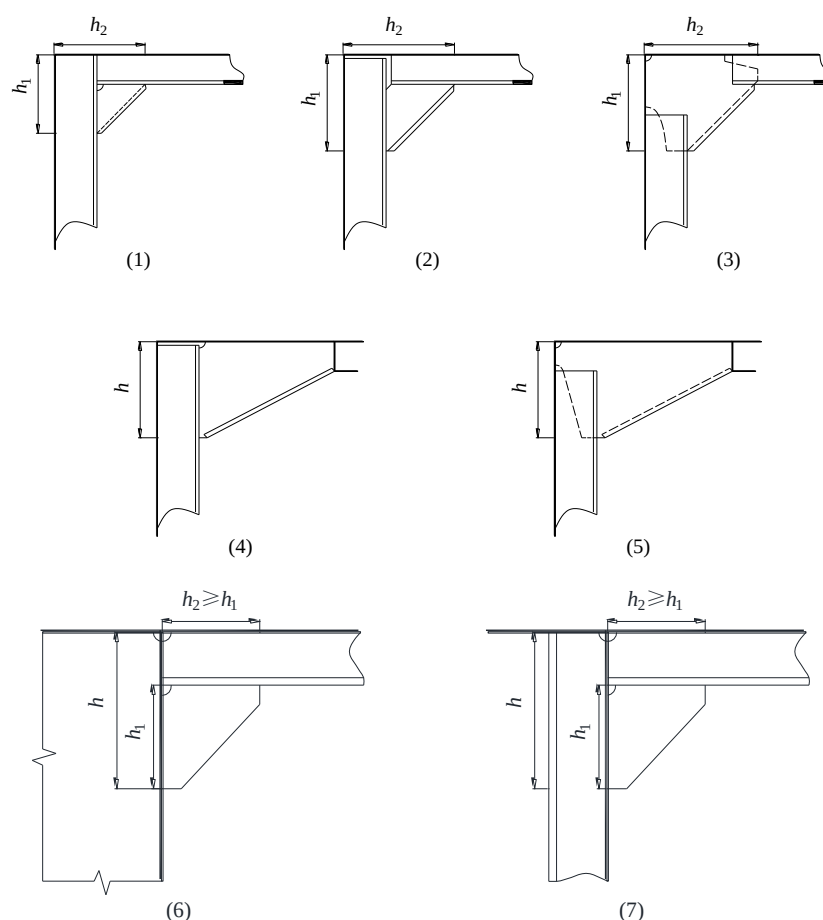


Fig. 1.2.5.2 Secondary member end connections

1.2.5.3 Where the secondary members contributing to longitudinal bending strength are cut in way of bulkheads or transverse primary members, connecting brackets are to be provided so as to ensure the longitudinal continuity. The brackets at both sides of the bulkheads or transverse primary members are to be in alignment.

1.2.5.4 The section modulus W of frames that is used for determining the scantlings of brackets is to be selected as follows:

.1 For the brackets connecting the secondary to the primary members, W is the section modulus of the secondary members.

.2 For the brackets at frame ends, W is the section modulus of the frames.

.3 For other brackets, W is the lesser of section moduli of two connecting members.

1.2.5.5 The thickness t of brackets is to be not less than that obtained from the following formulae:

$$t = 0.25\sqrt{W} + 3.5 + C \quad \text{mm}$$

Where: W —section modulus of frames, in cm^3

C —coefficient, determined according to the following requirements:

$C = 1.5$, flange-free bracket;

$C = 1.0$, bracket in the fluid tank;

$C = 2.5$, flange-free bracket in the fluid tank;

$C = 0$, others.

1.2.5.6 Where the height of frames $h > 100$ mm or the free edge is more than 40 times the thickness of brackets in length, the brackets are to be flanged or fitted with face plates. The breadth b of the flanges or face plates is not to be less than that obtained from the following formula:

$$b = W 0.04 + 40 \text{ mm, and not less than } 50 \text{ mm}$$

Where: W —Rule section modulus of frames, in cm^3 .

1.2.5.7 The arm length h of brackets is not to be less than 2.2 times the web depth of frames (where the ends of frames are welded, it may be reduced to not less than twice the web depth, see Figure 1.2.5.2 (1)), and is not to be less than that obtained from the following formula:

$$h = 75 \sqrt{\frac{W}{t - t_c}} \quad \text{mm}$$

Where: W —section modulus of frames, in cm^3 ;

t —thickness of brackets, in mm;

t_c —Corrosion allowance, see 1.6.3.2 of this PART.

1.2.5.8 The two arms of the brackets are to be as far as possible equal in length. Where the two arms are not the same in length, they are to comply with the following:

$$h_1 + h_2 \geq 2h$$

$$h_1 \geq 0.8h$$

$$h_2 \geq 0.8h$$

Where: h_1, h_2 - actual length of bracket arms, in mm, as shown in Figure 1.2.5.2;

h -arm length of brackets, in mm, see 1.2.5.7 of this Section.

1.2.5.9 Where the frame is lapped to the bracket, the length of overlap is not to be less than 1.25 times the web depth of the frame.

1.2.5.10 Where the frames are bracketed to primary members, such brackets are in general to be extended to the face plates of primary members.

1.2.6 Primary member end connections

1.2.6.1 Unless otherwise specified in this PART, the end connections of primary members are to be in compliance with the requirements of 1.2.6.

1.2.6.2 The ends of primary members are to be fitted with connecting brackets. Where two primary members are connected with a bracket, the scantlings of the bracket may be determined based upon the primary member having the lesser section modulus.

1.2.6.3 The arm length of the end bracket, which includes the web depth of the primary member, is not to be less than twice the web depth of the primary member, and the thickness of the bracket is not to be less than that of the web plate of the primary member. The brackets are to be flanged or fitted with face plates, the scantlings of which are generally to be the same as the face plates of primary members. The web plates of primary members are to be welded to connecting members. Where the side length of the non-stiffened triangle of the bracket is greater than $100t$ (t being the web thickness of the bracket), stiffeners parallel to the face plate of the bracket are to be fitted.

1.2.6.4 Where primary members, which are not in tanks, are connected by integral end brackets to bulkheads (i.e. the web plates of primary members gradually raised at ends), the arm length of brackets is not to be less than 1.5 times the web depth of primary members. The web plates of primary members are to be welded to bulkheads and the face plates are to be extended continuously to the bulkheads.

1.2.6.5 Where the deck girders or transverses are to be connected to bulkheads or vertical members of shell plating, the increase of scantlings of the vertical members may be required in order to ensure that connecting joints have adequate resistance to rotation.

1.2.6.6 In order to avoid the stress concentration at ends of primary strength members, the thickness of their web plates are to be adequately increased in way of toe ends of large brackets, and the face plates of brackets are to be beveled to ends. The height of toes is in general not to be greater than the thickness t_w of bracket toes, and is not to be less than 15 mm. For the recommended structural configuration of toe ends of large brackets, see Figure 1.2.6.6.

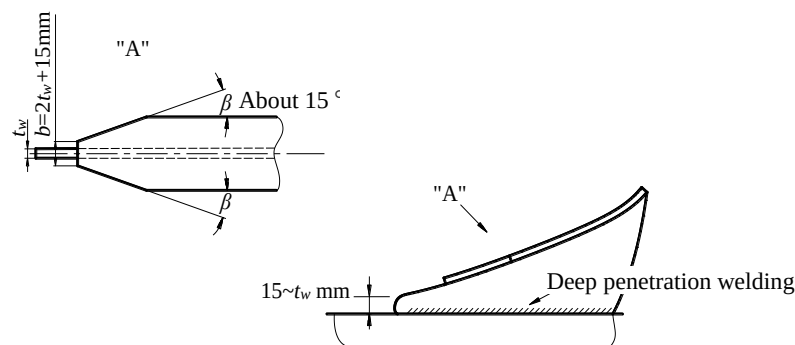


Fig. 1.2.6.6 Structure form at the bracket toe

1.2.7 Standard spacing of framing members

1.2.7.1 The standard spacing S_b of frames, beams or longitudinals (bottom, side and deck) is to be calculated by the following formula: and are not to be greater than 0.7 m.

$$S_b = 0.0016L + 0.5 \text{ m}, \text{ but not}$$

greater than 0.7 m

1.2.7.2 In fore and aft peak tanks, the standard spacing S_b of frames or side longitudinals is to be that obtained from 1.2.7.1 or 0.6 m, whichever is the lesser.

1.2.7.3 Within $0.05L$ at ends, the standard spacing S_b of deck longitudinals or deck transverses of superstructures and deckhouses is to be that obtained from 1.2.7.1 or 0.6 m, whichever is the lesser.

Section 3 HULL STRUCTURAL STEEL

1.3.1 General Requirements

1.3.1.1 The manufacturing and testing of marine steel are to comply with the relevant provisions of Chapter 1 and Chapter 2 of PART SEVEN.

1.3.1.2 The chemical compositions and mechanical properties of hull structural steel are to comply with the relevant requirements of Chapter 3 of PART SEVEN.

1.3.1.3 Steel castings or steel forgings used for the construction of stern posts, rudder posts, shaft brackets, rudder stocks and other hull structures are to comply with the relevant requirements of PART SEVEN.

1.3.1.4 Materials other than steel are to be specially considered in accordance with the principle of equivalence.

1.3.1.5 For fishing vessels less than 30 m in length, the secondary components, short superstructures and deckhouses can be made of rimmed steel.

1.3.1.6 Except where otherwise stated, the elastic modulus of steel is to be taken as $2.06 \times 10^5 \text{ N/mm}^2$.

1.3.2 Material grade

1.3.2.1 The grades, chemical compositions and mechanical properties of the hull structural steel are to comply with the requirements of Section 2, 3 and 4, CHAPTER 3, PART SEVEN.

1.3.2.2 Class A/AH steel can be used for hull structural steel at normal temperatures.

1.3.3 Requirements for steel used for refrigerated space structures

1.3.3.1 Where the minimum design temperature of the refrigerated space and room falls below 0°C , the steel grade for the deck plating, webs of deck girders, longitudinal bulkhead strakes attached to deck and beams for supporting hatchway covers and their face plates is to comply with the requirements of Table 1.3.3.1.

Steel Grade of Structural Members in Refrigerated Spaces

Table 1.3.3.1

Designed temperature Thickness of steel plate (mm)	$0^\circ\text{C} \sim 10^\circ\text{C}$		$-10^\circ\text{C} \sim -25^\circ\text{C}$		$-25^\circ\text{C} \sim -40^\circ\text{C}$		$-40^\circ\text{C} \sim -55^\circ\text{C}$	
	Mild steel	Higher tensile steel	Mild steel	Higher tensile steel	Mild steel	Higher tensile steel	Mild steel	Higher tensile steel
$t \leq 12.5$	B	AH	D	DH	E	EH	E	EH
$12.5 < t \leq 25.5$	D	DH	E	EH	Specially considered	Specially considered	Specially considered	Specially considered

1.3.3.2 The minimum design temperature of the refrigerated space deck may be assessed by a temperature gradient calculation or may be determined in accordance with Table 1.3.3.2.

Minimum Design Temperature of Refrigerated Space Deck

Table 1.3.3.2

Item	Arrangement	Deck temperature
1	Deck not covered with insulation in the refrigerated space	Temperature of the refrigerated space
2	Deck covered with insulation in the refrigerated space and not insulated on the other side	Temperature of the space on the uninsulated side
3	Deck covered with insulation on both sides: (1) Temperature difference not greater than 11°C (2) Temperature difference greater than 11°C but not greater than 33°C	Mean of the temperatures of the spaces above and below the deck Mean of the temperatures of the spaces above and below the deck less 3°C

Note: If one of the relevant internal tanks is a non-refrigerating tank or freezing tank, the temperature of that tank is taken as 5°C .

1.3.4 Requirements for structural steel of fishing vessels navigation in ice

1.3.4.1 For fishing vessels navigation in ice, the impacts of ambient temperature are to be considered. Generally, the hull plates of fishing vessels navigation in ice are to be made of higher grade of steel plates.

1.3.5 Requirements for hull structural steel exposed to low air temperatures

1.3.5.1 For ships intended to operate in areas with low air temperatures (below and including -20°C), e.g. regular service during winter seasons to Arctic or Antarctic waters, the materials in exposed structures are to be selected based on the design temperature t_D .

1.3.5.2 The grades required for hull members are to be selected according to the plate thickness and design temperature of hull structural members.

Steel grade required at low temperature

Table 1.3.5.2

Plate thickness, mm	-20~-25°C		-26~-35°C		-36~-45°C		-46~-55°C	
	Mild steel	Higher tensile steel	Mild steel	Higher tensile steel	Mild steel	Higher tensile steel	Mild steel	Higher tensile steel
$t \leq 10$	A	AH	B	AH	D	DH	D	DH
$10 < t \leq 15$	B	AH	D	DH	D	DH	D	DH
$15 < t \leq 20$	B	AH	D	DH	D	DH	E	EH

1.3.6 Use of aluminum alloy

1.3.6.1 The use of aluminum alloy is permitted for superstructures, deckhouses, hatch covers, or other similar structures, based on equivalent strength, instead of hull structural steel as required in the Rules. The chemical composition and mechanical properties of aluminum alloys used are to comply with the relevant requirements of Chapter 8, PART ONE of CCS Rules for Materials and Welding.

1.3.6.2 Unless stated otherwise, the modulus of elasticity of aluminium alloy may be taken as 70000N/mm²

1.3.6.3 The scantlings of aluminum alloy structure may be obtained from the following formula:

For plating thickness: $t_a = t_s \sqrt{K_a}$ in mm

For section modulus: $W_a = W_s K_a$ in cm³

Where: t_s —thickness of mild steel plating as required in the Rules, in mm;

W_s —section modulus of mild steel as required in the Rules, in cm³;

K_a —Material factor for aluminum alloy $K_a = 235/R_{p0.2}$;

$R_{p0.2}$ —the minimum yield stress of parent material which could be guaranteed under delivery condition, in N/mm².

Section 4 WELD DESIGN FOR HULL STRUCTURES

1.4.1 General requirements

1.4.1.1 This Section applies to the weld design for normal hull structures and components. Welding procedures for the construction of hull are to comply with the relevant requirements of CCS Rules for Materials and Welding.

1.4.1.2 The arrangement of welds in hull structures is to be such as to allow adequate access for completion of all welding operations. Welded joints are to be so arranged as to facilitate the use of flat (downhand) welding wherever possible.

1.4.1.3 Where welding is used for hull structures, care is to be taken to avoid the arrangement of welded joints in positions of stress concentration. Adequate transition is to be made in way of the abrupt changes of shape or section, and excessive concentration of welds over such positions is to be avoided.

1.4.1.4 Parallel welded seams in the main hull structures are to be spaced an adequate distance apart. The distance between two parallel butt welded seams is not to be less than 100 mm, and the butt welded seams are not to be intersected with an acute angle. Where a butt welded seam is in parallel with a fillet welded seam, the distance between them is not to be less than 50 mm. The distance between the above two welded seams is in general the distance between inner edges of two weld toes (as shown in Figure 1.4.1.4).

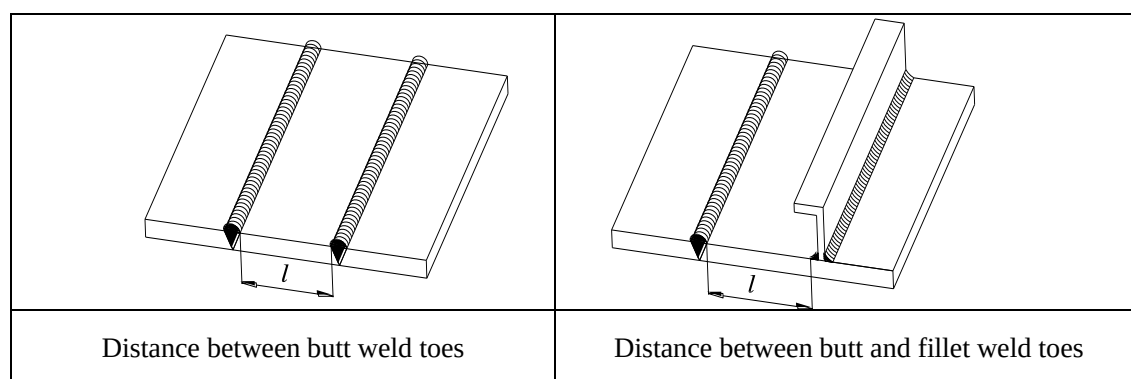


Fig. 1.4.1.4 Weld spacing measurement position

1.4.1.5 The shell plating, deck plating, inner bottom plating and bulkhead plating are all to be connected by butt welds.

1.4.1.6 The use of permanent backing bars in highly stressed welds in hull structures is to be avoided as far as possible.

1.4.1.7 Double continuous fillet welding is to be adopted in the following locations:

(1) boundaries of weathertight decks and erections, including hatch coamings, companionways and coamings of other openings;

(2) boundaries of tanks and watertight compartments;

(3) connections in foundations and supporting structures;

(4) all structure in the aft peak and the aft peak bulkhead stiffeners;

(5) all lap welds in tanks;

(6) primary and secondary members to bottom shell in the 0.25 L forward;

(7) centreline girder to keel plate;

(8) boundaries of galleys, pantries, laundry rooms, bathrooms, toilets and storage battery rooms, etc.;

(9) primary and secondary members to plating in way of end connections, and end brackets to plating in the case of lap connections;

(10) fillet welding of other structure will be specially considered.

1.4.1.8 Boundaries of pantries and storage battery rooms, etc. are continuously welded on one side;

1.4.1.9 Details of the welded connections of main structural members of the hull, including type and size of welds, are to be clearly indicated on the plans submitted for approval. The extent to which automatic welding is used is to be indicated on the plans. Details of the proposed welding method and its procedures, including preheating temperature and post-weld heat treatment methods, are also to be indicated on the drawings for review.

1.4.2 Welding consumables

1.4.2.1 Welding consumables used for hull structures are to comply with the requirements of Chapter 3 of PART EIGHT for Materials and Welding. The grade of welding consumables selected is to be suitable for the grade of hull structural steel, and is to comply with the requirements of Table 1.4.2.1.

Selection of welding consumables

Table 1.4.2.1

Welding material grade	1	2	3
Hull structural steel grade	A	A, B, D	A, B, D, E

1.4.2.2 For the joining of steels of different strength levels, the welding consumables of higher grade in general may be of a type suitable at structural discontinuities or areas of stress concentration, and those of lower grade can be used at other sites.

1.4.2.3 Low hydrogen electrodes are to be used for the welding of the following structural members and components:

.1 Circumferential butt welds in the joining of block sections and butt welds of girders;

.2 Masts, derricks, boat davits, bollards and other outfits subjected to heavy loads and all other highly stressed fittings;

.3 Components for which high rigidity is required, such as stems, stern frames, propeller shaft brackets, and joints between them and the shell plating and the hull framing;

.4 Main engine seatings and the associated structural members.

1.4.3 Butt, lap and slot welds

1.4.3.1 Where plates of different thicknesses are to be butt welded and the difference in thickness is equal to

or greater than 4 mm, the edge of the thicker plate is to be tapered so as to ensure a uniform transition. The width of taper is not to be less than 4 times the difference in thickness. Where the difference in thickness is less than 4 mm, the transition may be achieved within the width of the weld.

1.4.3.2 If overlap welding is necessary, the overlap width of the two plates is to be 3 to 4 times the thickness of the thinner plate, but it needs not be greater than 50 mm. The overlapping surfaces are to be fit tightly. Continuous fillet welding is to be applied at both ends of the overlap.

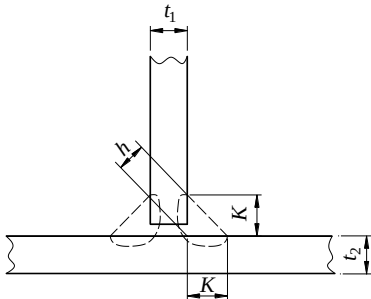
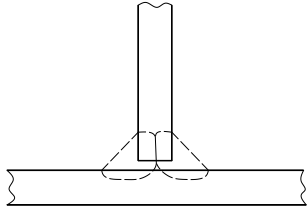
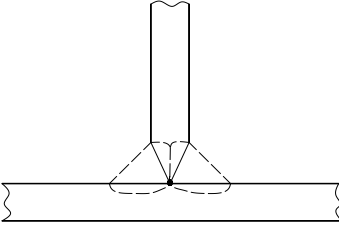
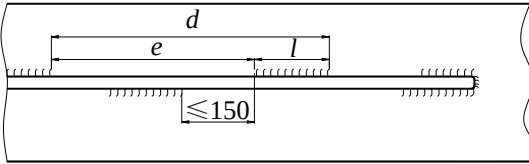
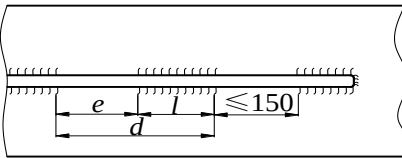
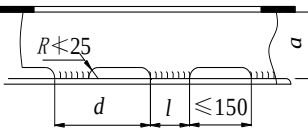
1.4.3.3 Connection of side plating to internal profile webs, where internal access for fillet welding is not practicable, is to be by means of slot welds on to flat bars on the webs. The slots are to have a minimum length of 75 mm and, in general, a minimum width of twice the side plating thickness. The ends of the slots are to be rounded. The space between the slots is not to exceed 150 mm, welding is to be based on a weld factor of 0.44, and the requirements for fillet leg length in paragraph 1.4.4 are to be complied with.

1.4.4 Fillet welds

1.4.4.1 T-connections of hull structures are generally to be made by fillet welds on both sides of the abutting plate. The types and application of fillet welds are to be as shown in Table 1.4.4.1.

Fillet weld type

Table 1.4.4.1

Item	Fillet weld	Type	Remark
1	Double continuous		One type of the double continuous fillet welding used for ordinary connection K – leg length h – throat thickness t 1 , t 2 – thickness of plates
2	Double deep penetration		One type of the double continuous fillet welding used for significantly stressed connection
3	Double full penetration		One type of the double continuous fillet welding used for highly stressed connection
4	Staggered intermittent		Welding to be carried round both ends of plating l – length of weld e – spacing of welds d – distance between weld fillets
5	Chain intermittent		Welding to be carried round both ends of plating l – length of weld e – spacing of welds d – distance between weld fillets
6	Scalloped construction	 hold height $\geq 0.25a$ or 75mm, whichever is the lesser	Welding to be carried round ends of all lugs

1.4.4.2 The size of fillet welds for hull structural connection is to be determined as follows:

.1 The throat thickness h of fillet welds is to be determined from the following formula:

$$h = w_{\tau} t_p \frac{d}{l} \quad \text{in mm}$$

Where: w_{τ} —weld factor. The weld factors used for hull structures are as specified in Table 1.4.4.2 of this Section. Where an approved automatic deep penetration procedure is used, w_{τ} may be 85% of the value given in the Table. Under certain special load conditions, or where corrosion is to be considered, the value w_{τ} is to be appropriately increased.

t_p —The minimum thickness of the member, in mm, thickness of the thinner plate of the abutting plates, in mm

d —distance between weld fillets, in mm, i.e. the distance between start positions of successive weld fillets for intermittent welding, as shown in items 4, 5 and 6 of Table 1.4.4.1 of this Section; where the fillet weld is continuous, d is to be equal to l ;

l —the length of weld fillet, in mm, clear of end craters, and is not to be less than 75 mm;

.2 The fillet leg length K is not to be less than the value obtained from the following formula:

$$K = \sqrt{2} w_{\tau} t_p \frac{d}{l} \quad \text{in mm}$$

Where: w_{τ} , t_p , d and l are the same as defined in .1 above;

The value K can also be checked by w_{τ} the welding coefficient from Appendix II of this PART.

.3 When the thicknesses of the two fillet joints differ greatly, the size of the fillet weld is to be specially considered.

Welding Factors

Table 1.4.4.2.1

Item	Welding coefficient	Remark
1 General application (except as required below): (1) Watertight or oiltight plate boundaries (2) Non-tight plate boundaries	0.34 0.13 0.10	
(3) Longitudinals, frames, beams, and other secondary members to shell, deck or bulkhead plating	0.13 0.21 0.1	In tanks In way of end connections
(4) Panel stiffeners (i.e. small stiffeners)	0.27	
(5) Overlap welds	0.21	Double continuous
(6) Longitudinals of the flat-bar type to plating		
2 Bottom structure of fishing tank area (1) Tight centre girder: to keel to inner bottom (2) Non-tight centre girder (or centre keelson): to keel to inner bottom (or face plate of centre keelson) (3) Tight boundaries of floors, girders (4) Non-tight boundaries of floors, girders (or side keelson) and brackets	0.44 0.44 0.27 0.21 0.39 0.21 0.27	Deep penetration welding No scallops In way of 0.2 × span at ends In way of brackets at lower end of main frame
3 Hull framing (1) Webs of web frames and stringers to shell (2) Webs of web frames and stringers to face plate (3) Tank side brackets to shell and inner bottom	0.16 0.13 0.34	Main webs to the shell plating Bracket at the rib end to the outer plate 0.34
4. Decks and supporting structure (1) Strength deck plating to shell (2) Other decks to shell and bulkheads (except where forming tank boundaries) (3) Webs of cantilevers to deck and to shell in way of root bracket (4) Webs of cantilevers to face plate (5) Pillars: end connections end connections (tubular) (6) Girder web connections and brackets in way of pillar heads and heels (7) Web plates of hatch girders and deck web beams to deck, their face plates	0.21 0.44 0.21 0.34 0.44 0.21 0.16	See single or double-sided groove of deck stringer in PART EIGHT 4.2.4. Root ≤ t/3 or 10 mm, whichever is lesser. Generally, continuous welding on both sides is adopted. Notes: Deep penetration welding t > 10mm groove
5 Bulkhead and liquid tank structure		

(1) Boundaries of watertight bulkheads at the bottom, inner bottom and bilge	0.39	
(2) Stiffeners and other pillars on watertight bulkheads	0.13	
(3) Boundaries of ribbed bulkhead	0.44	
(4) Non-watertight pillar bulkhead boundaries	0.13	
(5) Perforated flats and wash bulkhead boundaries	0.10	
6. Structure in machinery space		
(1) Non-tight centre girder (or centre keelson) to keel and inner bottom	0.27	Deep penetration, edge to be prepared with maximum root $\leq t/3$.
(or face plate of centre keelson)	0.27	
(2) Non-tight floors to centre girder (or centre keelson) in way of engine, thrust and boiler bearers	0.21	
(3) Non-tight floors and girders (or side keelsons) to shell and inner bottom	0.44	
(4) Main engine foundation girders to top plate	0.44	
Main engine foundation girders to hull structure	0.27	
Floors to main engine foundation girders	0.21	
Brackets to main engine foundation girders	0.13	
(5) Transverse and longitudinal framing to shell		
7. Construction in 0.25L forward		
(1) Floors and girders (or centre keelson, etc.) to shell and inner bottom	0.21	Unless a greater weld factor is required
(2) Bottom longitudinals to shell	0.13	
(3) Transverse and longitudinal side framing to shell	0.13	
(4) Tank side brackets to frame and inner bottom	0.34	
(5) Panting stringers to shell and frames	0.34	
(6) All internal structure in fore peak	0.13	
(8) Aft peak construction: All internal structure including stiffeners on aft peak bulkhead	0.21	Unless a greater weld factor is required
9 11. Superstructure and deckhouses		
(1) Connection of external bulkheads to deck	0.34	1st and 2nd tier erections Elsewhere
(2) Internal bulkheads to deck	0.21	
	0.13	
10 Hatchways and closing arrangements		
(1) Hatch coamings to deck	0.34	0.44 at corners
(2) Hatch coaming stays (stiffeners, brackets) to coaming to deck	0.13	
(3) Hatch cover rest bar	0.21	Increased welding may be required 0.13 for tank covers and where covers strengthened for loads over
(4) Cleats and fittings	0.16	
(5) Primary and secondary stiffening of hatch covers	0.44	
	0.10	
13. Steering control systems		
(1) Rudder		Increased welding may be required
① Fabricated mainpiece and mainpiece to side plates and webs	0.44	
② Slot welds inside plates	0.44	
③ Remaining construction	0.21	
(2) Fixed and steering nozzles: Main structure	0.44	
Elsewhere	0.21	
(3) Thruster units and stabilizers: Main structure	0.44	
Elsewhere	0.21	
12 Miscellaneous fittings and equipment		
(1) Rings for manhole type covers to deck, inner bottom or bulkhead	0.34	
(2) Frames of shell and weathertight bulkhead doors	0.34	See 4.2.5 of PART EIGHT Special equipment subject to design Increased or full penetration welding may be required
(3) Stiffening of watertight doors	0.21	
(4) Ventilator, air pipe, etc., coamings to deck	0.34	
Elsewhere	0.21	
(5) Ventilator, etc., fittings	0.21	
(6) Scuppers and discharges, to deck	0.44	
(7) Masts, derrick posts, crane pedestals, etc., to deck	0.44	
(8) Deck machinery seats to deck	0.21	
(9) Mooring equipment (bollards, etc.) seats to deck	0.21	
(10) Bulwark stays to deck	0.21	
(11) Bulwark attachment and guard rails, stanchions, etc., to deck	0.34	
(12) Bilge keel backing bars to shell	0.34	
(13) Bilge keels to backing bars	0.21	
(12) Bilge keel base to the outer plate		
(13) Bilge keel to seat plate		

Note: The tensile stress of the welds at the ends of pillars installed in deep tanks or under watertight platforms is not to be greater than 108N/mm^2 .

1.4.4.3 Where the thickness of the abutting member of the T connection (e.g. the web of a stiffener) is greater than that of the table member (e.g. bulkhead plating, shell plating or deck plating), the welding is to be double continuous and the throat thickness h of the weld is to be neither less than the value given in Table 1.4.4.4.2 of this Section, nor less than the greater of the following:

$$h = 0.5Ct_v \text{ in mm}$$

$$h = 0.21t_h \text{ in mm}$$

Where: t_v —thickness of the abutting member, in mm;

t_h —thickness of the table member, in mm;

C —Coefficient, 0.27 for liquid tanks and 0.21 for other parts.

1.4.4.4 Except as permitted by 1.4.4.3 of this Section, the throat thickness of all fillet welds is to comply with the following requirements:

- (1) The limits of throat thickness are to be as shown in Table 1.4.4.4.1;
- (2) The minimum value of throat thickness is also to comply with the requirements of Table 1.4.4.4.2.

Limits of Throat Thickness

Table 1.4.4.4.1

Item	Limits of welding throat thickness, in mm	
	Minimum	Maximum
Double continuous welding	$0.21 t_p$	$0.44 t_p$
Intermittent welding	$0.27 t_p$	$0.44 t_p$

Note 1: t_p See 1.4.4.2 of this Section.

Note 2: When the actual plate thickness t'_p exceeds 25 mm, $t_p = 0.5(t'_p + 25)$.

Minimum Throat Thickness

Table 1.4.4.4.2

Plate thickness t_p		≤ 7.5	> 7.5
Minimum throat thickness (mm)	Manual or automatic welding	3	3.25
	Automatic deep penetration welding	3	3

Note: See t_p 1.4.4.2.1 of this Section.

1.4.4.5 Where intermittent fillet welds are used for the connection of hull members, double continuous fillet welding is to be carried out for a specified length of round-the-end weld in the following locations:

.1 The length of the round-the-end weld at the ends of brackets is not to be less than the depth of the connecting members, nor less than 75 mm.

.2 Where the ends of sections, particularly of short sections, are snapped off, the length of the round-the-end weld is to be not less than the height of such sections or the length of snapping.

.3 Where fillet welding is used in way of brackets, lugs and scallops and at the orthogonal connections with other members, the length of the round-the-end weld is not to be less than 75 mm for plate thickness > 12 mm, and not less than 50 mm for plate thickness ≤ 12 mm.

1.4.4.6 Where scallops are cut in the structural members for intermittent welding, both ends of the scallop are to be rounded and smooth. But no scallops are permitted in the following positions:

- (1) in way of the ends of brackets where stress concentration occurs;
- (2) in the main frames, longitudinals and stiffeners for a region of at least 230 mm on each side of the intersection with a primary supporting member.

1.4.4.7 Where a structural member passes through a watertight or an oiltight bulkhead, in addition to the fitting of a welded collar on the bulkhead, a small semicircular notch is to be cut on one side of the passing member as shown in Figure 1.4.4.7(1). And double continuous fillet welding is to be carried out round the end of the semicircular notch to the bulkhead so as to ensure tightness of the bulkhead.

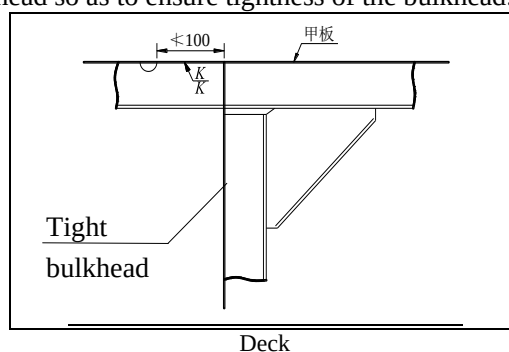


Fig. 1.4.4.7 Position of double-sided continuous round-the-end weld

1.4.4.8 The size of fillet welds in primary members is to comply with the following:

- .1 Weld factors may be obtained from Table 1.4.4.8.1

Weld Factors of Primary Members

Table 1.4.4.8.1

Cross-sectional area of face plate of T-type members A , in cm^2	Position ^{Note 1}	In tanks		In dry spaces	
		To face plate	To plating	To face plate	To plating
		w_τ	w_τ	w_τ	w_τ
$A \leq 30$	At ends	0.21	0.27	0.21	0.21
	Remainder	0.10	0.16	0.10	0.13
$30 < A \leq 65$	At ends	0.21	0.34	0.21	0.21
	Remainder	0.13	0.27	0.13	0.16
$65 < A \leq 95$	At ends	0.34	0.44 ^{Note 2}	0.21	0.27
	Remainder	0.27	0.34	0.16	0.21
$95 < A \leq 130$	End	0.34	0.44 ^{Note 2}	0.27	0.34
	Remainder	0.27	0.34	0.21	0.27
$130 < A$	At ends	0.44	0.44 ^{Note 2}	0.34	0.44 ^{Note 2}
	Remainder	0.34	0.34	0.27	0.34

Note 1: The weld factors "at ends" are to be applied for $0.2 \times$ the length of the member from each end, but at least beyond the toes of the member end brackets. On vertical webs the increased welding may be omitted at the top, but is to extend at least $0.3 \times$ length from the bottom. "Length of the member" means the overall length of the member (including the end brackets).

Note 2: Where the web plate thickness is increased locally, the throat thickness is to be determined by $0.44 t_P$ or $0.34 t_c$, whichever is the greater. For t_P , see 1.4.4.2(1) of this Section, and t_c is the increased thickness of plate.

Note 3: If fillet welding is adopted, the height of the fillet K can also be checked in the appendix II at the end of this PART according to the welding coefficient w_τ in the table.

.2 Where the webs of primary members are cut for the passage of secondary members and the width of the notch exceeds 15% of the stiffener spacing, the weld factor w_τ or the leg length K of fillet weld is to be multiplied by coefficient C obtained from the following formula:

$$C = \frac{0.85 \text{ stiffener spacing}}{\text{Length of web plating between notches}}$$

.3 In calculation of the throat thickness, the overall length of the weld at the ends of the member may be taken into account.

1.4.4.9 The area of welding of end connections of primary members is not to be less than the cross-sectional area of the member, and the weld factor is not to be less than 0.34 in tanks or 0.27 elsewhere.

1.4.4.10 Where a longitudinal strength member is cut at a primary support and the continuity of strength is provided by brackets, the area A_w of weld is not to be less than the cross-sectional area of the strength member.

1.4.4.11 Where the secondary member passes through, and is supported by, the web of a primary member, the weld connection is to be in accordance with the following:

(1) The area A_w of weld is to be not less than $0.5\sqrt{W}$ and the weld factor not less than 0.34 in tanks or 0.27 in dry spaces, where W is the section modulus of the secondary member, in cm^3 .

1.4.4.12 The fillet welding of secondary member end connections is to be in accordance with Table 1.4.4.12 and where two values are given, the greater is to be taken.

Weld Factors of End Connections of Secondary Members

Table 1.4.4.12

Connection	Weld area A_w , in cm^2	Welding factor w_τ
1 Stiffener welded direct to deck, shell, bulkhead plating etc.	$0.25 A_s$ or 6.5	0.34
2 Stiffener to bracket or bracket lapped to stiffener		0.27
(1) in dry space		0.34
(2) in tank		0.34
(3) main frame to tank side bracket in $0.15L$ forward	—	0.34
3 Bracket welded to face of stiffener and bracket connection to shell, deck, bulkhead plating, etc.		0.34
4 Stiffener to plating for $0.1 \times$ span at ends where not fixed by welding	—	0.34

Note 1: In the table, A_s refers to the cross-sectional area of the stiffener, in cm^2 ; A_w refers to weld area (cm^2)=total weld length (cm) * weld throat thickness.

Note 2: If fillet welding is adopted, the height of the fillet K can also be checked in the appendix II at the end of this PART according to the welding coefficient W_t in the table.

Section 5 USE OF HIGHER TENSILE STEEL

1.5.1 General Requirements

1.5.1.1 The chemical compositions and mechanical properties of higher tensile steel are to comply with the relevant requirements of PART SEVEN.

1.5.1.2 When higher tensile steel is used on the hull, its type, grade and distribution are to be indicated on the structural drawing for maintenance.

1.5.1.3 The Material factor K is shown in Table 1.5.1.3.

Material factor K		Table 1.5.1.3.	
Yield Strength R_{eH} , MPa	K	Yield Strength R_{eH} , MPa	K
235	1	355	0.72
315	0.78	390	0.68

1.5.2 Overall longitudinal strength

1.5.2.1 When the hull structure in the middle area of the hull is made of higher tensile steel, the minimum section modulus W_{h0} and moment of inertia I_h in the amidships are not to be less than the values calculated by the following formulas:

$$W_{h0} = KW_0 \text{ in cm}^3$$

$$I_h = 3W_0L \text{ in cm}^4$$

Where: W_0 —the minimum section modulus in the amidships, in cm^3 ; calculate according to 2.1.5.1 of CHAPTER 2 of this PART;

K —material factor, selected in accordance with 1.5.1.3 of this PART.

1.5.2.2 When the hull is partially made of higher tensile steel, the vertical range of Higher tensile steel is not to be less than:

When the higher tensile steel is used for the strength deck structure, the area from the side of the deck to downward $y_1(1-K)$; when the bottom structure is made of Higher tensile steel, the area above $y_2(1-K)$ the flat keel. y_1 And y_2 are the vertical distances (in m) from the neutral axis to the deck side and the plate keel respectively, as shown in Figure 1.5.2.2. Where, K is the Material factor.

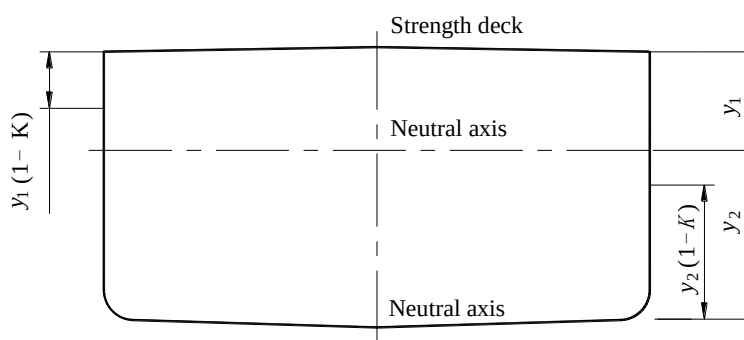


Fig. 1.5.2.2 Vertical arrangement range of higher tensile steel

1.5.2.3 When the amidships area is made of higher tensile steel and the ends are made of mild steel, the area using Higher tensile steel is to extend to the end and the point where the Mild steel plate thickness is equal to the Higher tensile steel thickness at amidships (See Figure 1.5.2.3).

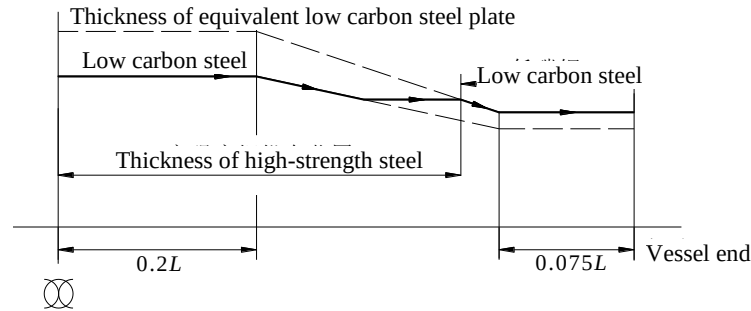


Fig. 1.5.2.3 Longitudinal arrangement range of Higher tensile steel

1.5.2.4 When the strong deck is made of higher tensile steel, generally the longitudinal continuous members (hatch coaming, deck opening stiffener, etc.) welded to the strong deck adopt corresponding Higher tensile steel.

1.5.3 Local strength

1.5.3.1 When the high-strength steel is used for the hull plating or strength deck, the thickness of the outer plate or strength deck t_h in the $0.4L$ area of the vessel is not to be less than the value calculated by the following formula:

$$t_h = \frac{S_h}{s} t \sqrt{K} \quad \text{in mm}$$

Where: t —Plate thickness of hull outer plate or strong deck made of Mild steel, in mm;

K —Material factor, see 1.5.1.3 of this PART;

s —Length of the short side of the grid made of low carbon steel, in m;

S_h —Length of the short side of the grid made of Higher tensile steel, in m;

1.5.3.2 When the members other than those in 1.5.3.1 of this PART, Section 9 of CHAPTER 2 in this PART are made of higher tensile steel, the thicknesses of the plates t_h , section modulus of member W_h , sectional area of member A_h and moment of inertia I_h are not to be less than the values calculated by the following formula:

$$t_h = t \sqrt{K} \quad \text{in mm}$$

$$W_h = WK \quad \text{in cm}^3$$

$$A_h = AK \quad \text{in cm}^2$$

$$I_h = I \quad \text{in cm}^4$$

Where: t —thicknesses of hull members made of low carbon steel as stipulated in the Rules, in mm;

W —Section modulus of hull members made of low carbon steel as stipulated in the Rules, in cm^3 ;

A —Sectional areas of hull members made of low carbon steel as stipulated in the Rules, in cm^2 ;

I —moment of inertia of hull members made of low carbon steel as stipulated in the Rules, in cm^4 ;

K —Material factor, see 1.5.1.3 of this PART;

1.5.3.3 The provisions of 1.5.3.2 of this PART do not apply to the minimum thicknesses specified in this PART.

Section 6 CORROSION CONTROL FOR HULL STRUCTURES

1.6.1 General Requirements

1.6.1.1 Effective means are to be taken for all fishing vessels to prevent excessive corrosion of hull members.

1.6.1.2 All seawater ballast tanks having boundaries formed by the hull envelope plating are to have epoxy or other equivalent anticorrosive coating.

Except for those as specified in 1.6.1.2, the other spaces such as bilges in double bottom vessels, spaces below solid floors of single bottom vessels, cofferdams, fresh water tanks, fish tanks, fishing tackle cabins, forepeak, afterpeak, etc. are to be applied with suitable protective coating, according to the service of the spaces.

Effective anticorrosive measures are to be taken for the seriously corroded spaces which are prone to being polluted but not easy to clean (such as the lower part of the clutch, the lower part of the steering gear, and chain locker), such as enclosing dead ends and adding anticorrosive paint.

1.6.1.3 All the vessel side plates, transverse bulkheads, their stiffeners and end brackets exposed to the cargo at loading spaces are to be provided with adequate non-toxic protective coatings.

1.6.1.4 Right before application of coatings to any structure, surface preparation is to be made in accordance with coating manufacturer's workman vessel requirements and the surfaces are to be thoroughly cleaned to a corresponding degree. The number of coatings and total dry film thickness are to comply with the design requirements.

1.6.1.5 Where bimetallic connections are made, measures are to be incorporated to preclude galvanic corrosion.

1.6.1.6 An appropriate number of anodes are to be provided on the hull plating, rudder blades and subsea valve box. The material, type, quantity, and distribution of the anodes are to comply with industry standards currently in effect.

1.6.2 External hull protection

1.6.2.1 Shell plating, particularly the portion between light and loaded load lines, weather decks and hatch covers are to be provided with suitable corrosion protection.

1.6.2.2 Where an impressed current cathodic protection system is fitted, plans or information showing the proposed layout of anodes, reference electrodes, wiring and methods of attaching to the rudder and propeller, are to be submitted.

1.6.2.3 A small cofferdam is to be included in the arrangements for glands, where cables pass through the shell. Cables to anodes are not to be led through tanks intended for the carriage of low flash point oils.

1.6.3 Corrosion allowance

1.6.3.1 The scantlings of hull structural members calculated in accordance with this PART are to include the values of corrosion allowance t_c as specified in 1.6.3.2~1.6.3.4. If the members are determined by direct calculation of finite elements, the scantlings conforming to the allowable stress standard are to be added with the corrosion allowance as specified in 1.6.3.2~1.6.3.4.

1.6.3.2 Corrosion allowances t_c of hull structural members (including plating and framing) are to be obtained as in Table 1.6.3.2.

Value of Corrosion Allowance t_c

Table 1.6.3.2

Thickness t , in mm	Corrosion allowance t_c , in mm
≤ 10	1.5
> 10	$0.1t + 0.5$, Max. 3.2

1.6.3.3 For boundaries of a liquid tank, the corrosion allowance is not to be less than 2.5 mm.

1.6.3.4 For dry spaces (cargo spaces in bulk carriers excluded), the corrosion allowances is to be $0.5t_c$ (see t_c in Table 1.6.3.2), but not less than 1.0 mm.

Section 7 COMPARTMENT TIGHTNESS TEST

1.7.1 General Requirements

1.7.1.1 The provisions of this Section apply to the following compartments and structures:

- .1 Gravity tank ^①;
- .2 Watertight or weathertight structure.

1.7.1.2 The purpose of the various tests specified in this Section is to verify the watertight integrity of tanks

^①Gravity tank means a tank that is subject to vapour pressure not greater than 70 kPa.

and watertight boundaries of fishing vessels under construction and major conversions or repairs^①, the suitability of tank structures, and the weathertight integrity of fishing vessel structure/outfitting members.

1.7.1.3 The testing of structures not listed in Table 1.7.4.1.1 is to be specially considered.

1.7.2 Definitions

1.7.2.1 The relevant definitions in this Section are as follows:

.1 Structural test:

A test to verify the structural adequacy of tank construction. This may be a hydrostatic test or, where the situation warrants, a hydropneumatic test.

.2 Leak test:

A test to verify the tightness of a boundary. Unless a specific test is indicated, this may be hydrostatic/hydropneumatic test or an air test. A hose test may be considered an acceptable form of leak test for certain boundaries.

.3 Hydrostatic test (leak and structural):

A test wherein a space is filled with a liquid to a specified head.

.4 Hydropneumatic test (leak and structural):

A test combining a hydrostatic test and an air test, wherein a space is partially filled with a liquid and pressurized with air.

.5 Hose test (leak):

A test to verify the tightness of a joint by a jet of water with the joint visible from the opposite side.

.6 Air test (leak):

A test to verify tightness by means of air pressure differential and leak indicating solution. It includes tank air test and joint air tests, such as compressed air fillet weld tests and vacuum box test.

.7 Compressed air fillet welding test (leak):

An air test of fillet welded tee joints wherein leak indicating solution is applied on fillet welds.

.8 Vacuum box test (leak):

A box over a joint with leak indicating solution applied on the welds. A vacuum is created inside the box to detect any leaks.

.9 Ultrasonic test (leak):

A test to verify the tightness of the sealing of closing devices such as hatch covers by means of ultrasonic detection techniques.

.10 Leak test (leak):

A test to verify that no visual dye penetrant indications of potential continuous leakages exist in the boundaries of a compartment by means of low surface.

1.7.3 Test Procedures

1.7.3.1 General requirements

Compartment tightness test is to be carried out close to the completion of work with all hatches, doors, windows, etc. installed and all penetrations including pipe connections fitted, and before any ceiling and cement work is applied over the joints. Specific test requirements are given in 1.7.4 and Table 1.7.4.1.1 in this Section. For the timing of the application of coating and the provision of safe access to joints, see 1.7.5, 1.7.6 and Table 1.7.6.1 of this Section.

1.7.3.2 Structural test procedures

.1 Type and time of test:

(1) Where a structural test is specified in Table 1.7.4.1.1, a hydrostatic test in accordance with 1.7.4.1 will be acceptable. Where practical limitations (strength of building berth, light density of liquid, etc.) prevent the performance of a hydrostatic test, a hydropneumatic test in accordance with 1.7.4.1 may be accepted instead.

(2) A hydrostatic test or hydropneumatic test for the confirmation of structural adequacy may be carried out while the vessel is afloat, provided the results of a leak test are confirmed to be satisfactory before the vessel is afloat.

.2 Number of structural tests:

(1) At least one tank of the same structure (i.e., tanks with the same structural design and construction

^①Major repair means a repair affecting structural integrity

and the same construction process approved by the CCS) is to be subjected to structural tests. All remaining tanks are to be subjected to air test. However, if the structural suitability of the tank has been verified by the structural tests required in Table 1.7.4.1.1 of this Section, other vessels of the same series (i.e. sister vessels built at the same vessel yard) have the same structure as the test tanks may be exempted from such structural tests, but the watertightness of all boundaries of all exempted tanks is to be verified by leak test and thorough surveys. For sister vessels years after the construction of the last vessel in the series, the above exemptions need to be reconsidered. In any case, at least one tank of each vessel is to be subjected to structural tests to verify the suitability of structural construction.

(2) Watertight boundaries of non-tank spaces (anchor chain tank excluded) may be exempted from structural tests, but the watertightness of all boundaries of exempted spaces are to be verified by leak tests and thorough surveys.

(3) After completion of the structural tests of the first tank, the remaining tanks may also need to undergo structural tests if necessary.

(4) The tanks to be subjected to structural tests are to be selected so that all representative structural members can perform the expected tensile and compression tests.

1.7.3.3 Leak test procedures:

.1 For the leak tests specified in Table 1.7.4.1.1, hose test, tank air tests, compressed air fillet weld tests, vacuum box tests in accordance with 1.7.4.3 through 1.7.4.6, or their combination, will be acceptable. Hydrostatic or hydropneumatic tests may also be accepted as leak tests provided that 1.7.5 and 1.7.6 are complied with.

.2 Air tests of joints may be carried out in the block stage provided that all work on the block that may affect the tightness of a joint is completed before the test. See also 1.7.5.1, 1.7.6 and Table 1.7.6.1 of this Section.

1.7.4 Test methods

1.7.4.1 Hydrostatic test

.1 Unless another liquid is approved, hydrostatic tests are to consist of filling the space with fresh water or sea water, whichever is appropriate for testing, to the level specified in 1.7.41.1.

.2 Special considerations are to be given to the test heads of high-density tanks tested using fresh or seawater.

1.7.4.2 Hydropneumatic test

.1 Hydropneumatic tests, where approved, are to be such that the test condition, in conjunction with the approved liquid level and supplemental air pressure, will simulate the actual loading as far as practicable.

The requirements and recommendations for tank air tests in 1.7.4.4 will also apply to hydropneumatic tests.

1.7.4.3 Hose test

.1 Hose tests are to be carried out with the pressure in the hose nozzle maintained at least at 0.2 MPa during the test. The nozzle is to have a minimum inside diameter of 12 mm and be at a perpendicular distance from the joint not exceeding 1.5 m.

.2 Where a hose test is not practical because of possible damage to machinery, electrical equipment insulation or outfitting items, it may be replaced by a careful visual examination of welded connections, supported where necessary by means such as a dye penetrant test or ultrasonic leak test or the equivalent.

1.7.4.4 Tank air test

.1 All boundary welds, erection joints and penetrations, including pipe connections, are to be examined in accordance with approved procedure and under a stabilized pressure differential not less than 0.015 MPa, with a leak indicating solution applied.

.2 It is recommended to increase the air pressure in the tank to 0.02 MPa and hold for 1 h on this level to reach a stable state. In addition, before the air pressure drops to the test pressure, the number of personnel near the tank is to be minimized, leaving at least one person.

.3 A U-tube with a height sufficient to hold a head of water corresponding to the required test pressure is to be arranged. The cross sectional area of the U-tube is to be greater than that of the pipe supplying air to the tank. A main pressure gauge or other approved methods are allowed to verify the pressure.

1.7.4.5 Compressed air fillet weld test

.1 In this air test, compressed air is injected from one end of a fillet welded joint and the pressure verified at the other end of the joint by a pressure gauge. Pressure gauges are to be arranged so that an air pressure of at least 0.015 MPa can be verified at each end of all passages within the portion being tested.

Remarks: Where a leak test is required for fabrication involving partial penetration welds, a compressed air test is also to be applied in the same manner as to fillet weld where the root face is large, i.e., 6-8 mm.

1.7.4.6 Vacuum box test

.1 A box (vacuum testing box) with air connections, gauges and an inspection window is placed over the joint with a leak indicating solution applied to the weld cap vicinity. The air within the box is removed by an ejector to create a vacuum of 0.02 MPa ~ 0.026 MPa.

1.7.4.7 Ultrasonic test

.1 An ultrasonic echo transmitter is to be arranged inside of a compartment and a receiver is to be arranged on the outside. The watertight/weathertight boundaries of the compartment are scanned with the receiver in order to detect an ultrasonic leak indication.

1.7.4.8 Penetration test

.1 A test of butt welds or other weld joints uses the application of a low surface tension liquid at one side of a compartment boundary or structural arrangement. If no liquid is detected on the opposite sides of the boundaries after the expiration of a defined period of time, this indicates tightness of the boundaries.

1.7.4.9 Other test

.1 Other methods of testing may be considered by CCS upon submission of full particulars prior to the commencement of testing.

1.7.5 Application of coating

1.7.5.1 Final coating

.1 For butt joints welded by an automatic process, the final coating may be applied any time before the completion of a leak test of spaces bounded by the joints.

.2 For all other joints, the final coating is to be applied after the completion of the leak test of the joint. See also Table 1.7.6.1.

.3 CCS may require a leak test before the final coating is applied to the automatic butt weld.

1.7.5.2 Temporary coating

(1) Any temporary coating which may conceal defects or leaks is to be applied at the time as specified for the final coating. This requirement does not apply to shop primer.

1.7.6 Safe access to joints

1.7.6.1 For leak tests, safe access to all joints under examination is to be provided. See also Table 3.

Test requirements for tanks and boundaries

Table 1.7.4.1.1

No.	Tank or boundary to be tested	Test type	Test head or pressure	Remark
1	Double bottom tanks	Leak and structural	The greater of: • Top of the overflow • to 2.4 m above top of tank Note 1, or • to bulkhead deck	
2	Double bottom (including box keel), inner plating	Leak and structural	The greater of: • Top of the overflow • to 2.4 m above top of tank	
3	Double side tanks	Leak and structural	The greater of: • Top of the overflow • to 2.4 m above top of tank	
4	Double side voids	Leak	See 1.7.4.4 through 1.7.4.6, as applicable	
5	Deep tanks other than those listed elsewhere in this table	Leak and structural	The greater of: • Top of the overflow • to 2.4 m above top of tank Note 1	
6	Fore peak tanks	Leak and structural	The greater of: • Top of the overflow • to 2.4 m above top of tank Note 1	After peak to be tested after installation of stern tube
7	(a) Fore peak space with equipment	Leak	See 1.7.4.4 through 1.7.4.6, as applicable	After peak to be tested after installation of stern tube

	(b) Aft peak with equipment	Leak	See 1.7.4.4 through 1.7.4.6, as applicable	
8	Cofferdams	Leak	See 1.7.4.4 through 1.7.4.6, as applicable	
9	(a) Watertight bulkheads	Leak	See 1.7.4.4 through 1.7.4.6, as applicable	
	(b) Superstructure end bulkheads	Leak	See 1.7.4.4 through 1.7.4.6, as applicable	
10	Watertight doors below freeboard or bulkhead deck	Leak Note 3 and 5	See 1.7.4.4 through 1.7.4.6, as applicable	
11	Double plate rudder blades	Leak	See 1.7.4.4 through 1.7.4.6, as applicable	
12	Shaft tunnels clear of deep tanks	Leak Note 2	See 1.7.4.4 through 1.7.4.6, as applicable	
13	Shell doors	Leak Note 2	See 1.7.4.4 through 1.7.4.6, as applicable	
14	Weathertight hatch covers and closing appliances	Leak Note 2 and 5	See 1.7.4.4 through 1.7.4.6, as applicable	Hatch covers closed by tarpaulins and battens excluded
15	Dual purpose tanks/dry cargo hatch covers	Leak Note 2 and 5	See 1.7.4.4 through 1.7.4.6, as applicable	
16	Chain lockers	Leak and structural	Top of chain pipe	
17	Ballast ducts	Leak	Whichever is greater: • ballast pump maximum pressure, or • setting of any pressure relief valve	
18	L.O. sump tanks and other similar tanks/spaces under main engines	Leak and structural Note 7	See 1.7.4.4 through 1.7.4.6, as applicable	
19	Fuel oil tank	Leak and structural Note 1	Whichever is greater: • Top of the overflow, or • to 2.4 m above top of tank Note 1, or • to top of tank Note 1 plus setting of any pressure relief valves, or, or • to bulkhead deck	

Note 1 The top of a tank is the deck forming the top of the tank, excluding any hatchways.

Note 2: Hose Test may also be considered as a medium of the test. Hose test See 1.7.2.1.

Note 3: Where water tightness of a watertight door has not been confirmed by prototype test, testing by filling watertight spaces with water is to be carried out. See SOLAS regulation II-1/16.2 and MSC/Circ.1176.

Note 4: As an alternative to the hose testing, other testing methods listed in 1.7.4.7 through 1.7.4.9 may be applicable subject to adequacy of such testing methods being verified where a hose test is not practicable.

Note 5: As an alternative to the hose testing, other testing methods listed in 1.7.4.7 through 1.7.4.9 may be applicable subject to adequacy of such testing methods being verified where a hose test is not practicable.

Note 6: Hydraulic test is not required where the water tightness of compartments and tanks on all the boundaries has been verified appropriately, and the structural strength of boundaries are ensured.

Note 7: Where L.O. sump tanks and other similar spaces under main engines intended to hold liquid form part of the watertight subdivision of the ship, they are to be tested as per the requirements of Item 5, Deep tanks other than those listed elsewhere in this table.

Application of Leak Test, Coating and Provision of Safe Access for Type of Welded Joints leak test Table 1.7.6.1

Type of welded joints		Leak test	Coating ^{Note 1}		Safe Access ^{Note 2}	
			Before leak test	After leak test but before structural tests	Leak test	Structural test
Butt	Automatic	Not required	Allowed ^{Note 3}	N/A	Not required	Not required
	Manual or semi-automatic ^{Note 4}	Required	Not allowed	Allowed	Required	Not required
Fillet	Boundary including	Required	Not allowed	Allowed	Required	Not required

	penetrations					

- Note 1: Coating refers to internal (tank/hold coating), where applied, and external (shell/deck) painting. It does not refer to shop primer.
- Note 2: Temporary means of access for verification of the leak test.

CHAPTER 2 HULL STRUCTURE

Section 1 LONGITUDINAL STRENGTH

2.1.1 Longitudinal strength requirements

2.1.1.1 For vessels not less than 65 m in length, their longitudinal strength is to be checked in accordance with the requirements of this Section. For vessels of unusual type or special loading and less than 65 m in length, their longitudinal strength may also be checked in accordance with the requirements of this Section.

2.1.1.2 The proportions of principal dimensions of dredgers that this Section apply to are as follows:

$$L/B > 5$$

$$B/D < 2.5$$

2.1.1.3 Fishing vessels that do not comply with the conditions specified in 2.1.1.2 of this PART are to be determined by direct calculation with reference to the methods specified in the CCS Rules for Classification of Sea-going Steel Vessels.

2.1.2 Design still water bending moment and shear force

2.1.2.1 The still water bending moment and shear force at each transverse section along the vessel's length are to be calculated from the following conditions:

- .1 Sail to the fishing ground with a full load of fuel, supplies, ice, fishing gear, etc.;
- .2 Depart the fishing ground with a full load of catches;
- .3 Arrive at the base port with a full load of catches, 10% of supplies, fuel, etc.;
- .4 10% of the supplies, fuel, etc. and the minimum amount of catches, usually 20% of the fully loaded catches when arriving at the base port;
- .5 More dangerous loading conditions than those described above.

2.1.2.2 In calculation of still water bending moments and shear forces, the downward loads are to be taken as positive values, the upward loads as negative values, and are to be integrated in the forward direction from the aft end of the length of the vessel. The sign conventions of the still water bending moments M_s and shear forces F_s (+, -) are as shown in Figure 2.2.2.2.

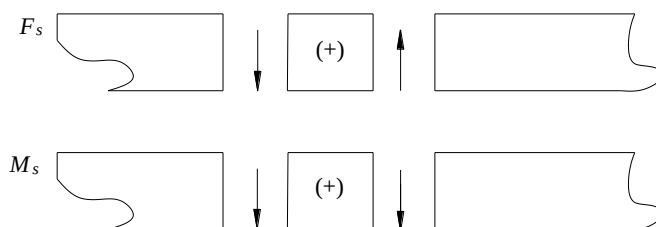


Fig. 2.1.2.2 Still water bending moments and shear forces (+, -)

2.1.3 Wave bending moment and wave shear force

The hogging and sagging wave bending moments $M_w(+)$ and $M_w(-)$ at each transverse section along the vessel's length are to be obtained from the following formulae:

$$M_w(+) = +190MCL^2BC_b \times 10^{-3} \quad \text{kN m}$$

$$M_w(-) = -110MCL^2B(C_b + 0.7) \times 10^{-3} \quad \text{kN m}$$

Where: M — distribution coefficient of bending moment, see Figure 2.1.3.1;

C_b — block coefficient, taken not less than 0.60;

C — coefficient, $C = 0.0412L + 4$.

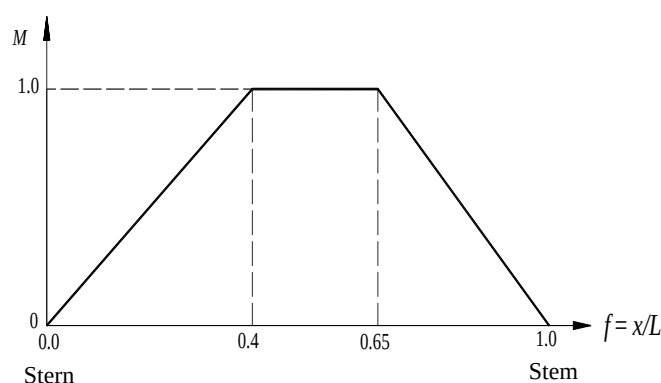


Fig. 2.1.3.1 Moment distribution coefficient

2.1.3.2 The hogging and sagging wave shear forces $F_w(+)$ and $F_w(-)$ at each transverse section along the vessel's length are to be obtained from the following formulae:

$$F_w(+) = +30F_1CLB(C_b + 0.7) \times 10^{-2} \quad \text{kN}$$

$$F_w(-) = -30F_2CLB(C_b + 0.7) \times 10^{-2} \quad \text{kN}$$

Where: F_1, F_2 — shear force distribution coefficient given in 2.1.3.2-1 and 2.1.3.2-2;

C — coefficient, see 2.1.3.1 of this Section;

C_b — see 2.1.3.1 of this Section.

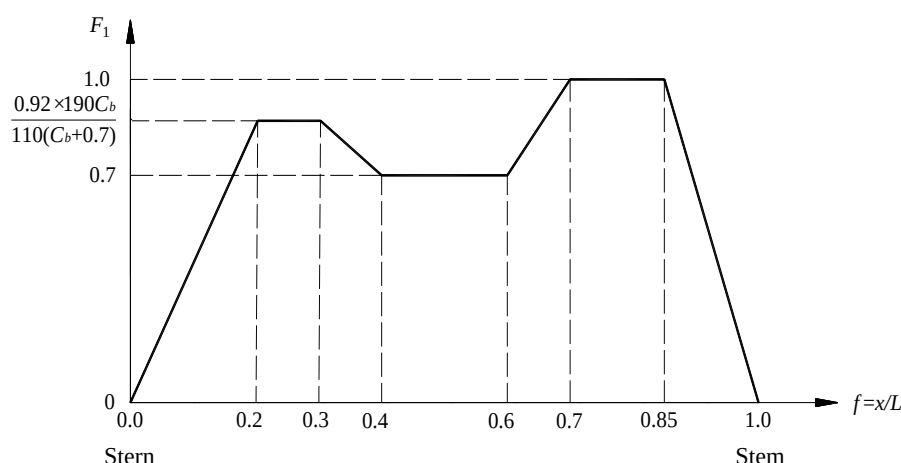


Figure 2.1.3.2-1 Shear force distribution coefficient F_1

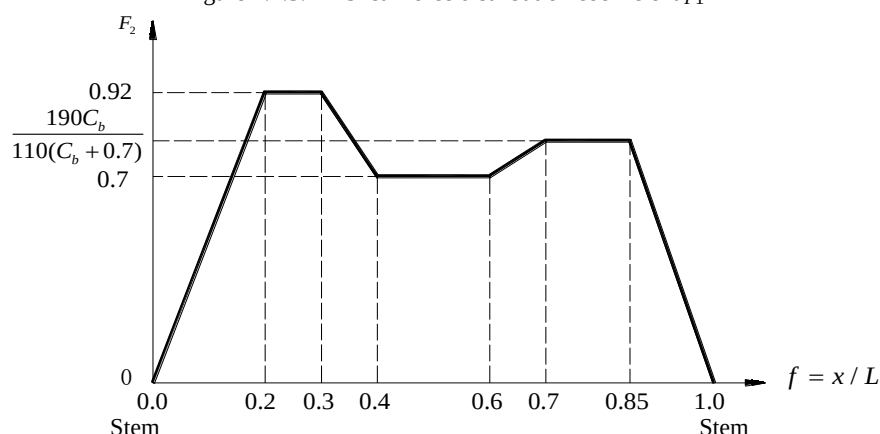


Figure 2.1.3.2-2 Shear force distribution coefficient F_2

2.1.4 Calculation of hull girder section properties

2.1.4.1 The moment of inertia of the hull girder section about its horizontal neutral axis divided by the vertical distance from the neutral axis to the top of strength deck at side gives the hull girder section modulus W_d at the strength deck; and that divided by the vertical distance from the neutral axis to the top of keel gives the hull girder section modulus W_b at bottom.

2.1.4.2 The strength deck and all continuous longitudinal members below the strength deck within $0.4L$

amidships may be included in the calculation of hull girder section modulus. The extension of the sheer strake above the strength deck and the continuous stringer angles may be included in the calculation. Where trunk decks or continuous hatch coamings (except inboard coamings of multi-hatch arrangements) above the strength deck are effectively supported by longitudinal bulkheads or deep girders, their sectional area may also be included in the calculation of the hull girder section modulus.

2.1.4.3 For multi-hatch arrangements, the effective sectional area for the inboard continuous hatch coaming and supporting members below is to be determined by direct calculation in accordance with support conditions. The following provision is applicable to cases without detailed calculation:

- .1 Where a continuous longitudinal underdeck girder, or girders, are arranged to support the inboard hatch coamings, 50% of their sectional area are to be included in the calculation of the hull girder section modulus. If the girder is fitted in conjunction with a longitudinal bulkhead, 100% of the sectional area may be included. In cases where the girders are enclosed box sections, or where the girders are not enclosed box sections and are adequately supported and effectively tied to the bottom structure, 80% of their sectional area may be included. The slender ratio of the above-mentioned girders is not to be greater than 60.
- .2 The percentage of the sectional area to be included for inboard continuous hatch coamings is to be the same percentage as that of the longitudinal girder under.

2.1.4.4 For the cases in 2.2.4.2 and 2.2.4.3 of this Section, when calculating the hull girder section modulus, the lever Z_t , vertical distance from the point considered to the neutral axis, is to be taken as follows, with Z_c being greater than the vertical distance from the neutral axis to the moulded deck line at side:

$$Z_t = Z_c \left(0.9 + 0.2 \frac{y}{B_1} \right)$$

Where: Z_c — vertical distance from the neutral axis to the top of the continuous strength member, in m;

y — horizontal distance from the top of the continuous strength member to the centerline of the vessel, in m;

B_1 — breadth of vessel at section considered, in m.

In calculation, Z_c and y are to be measured to the point giving the maximum value of Z_t .

2.1.4.5 Where deck longitudinals or deck girders are arranged above the strength deck, the sectional area may be included in the calculation of the hull girder section modulus. The lever Z_t is to be taken as the vertical distance from the neutral axis to the moulded deck line at side amidships plus the depth of the longitudinal member.

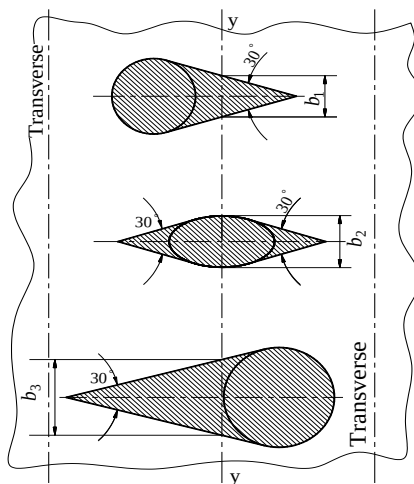
2.1.4.6 Deck openings having a length in the fore-and-aft direction exceeding 2.5 m or a breadth exceeding 1.2 m or $0.04B$ (whichever is the lesser) are to be deducted from the sectional areas used in the calculation of the hull girder section modulus.

2.1.4.7 Smaller openings (including manholes) smaller than those stated in 2.1.4.6 of this PART need not be deducted from the sectional areas used in the calculation of the hull girder section modulus, provided that the sum b_c of their breadths or shadow area breadths (as shown in Figure 2.1.4.7) in one transverse section complies with the following:

$$b_c \leq 0.06(B_1 - \sum b)$$

Where: B_1 — breadth of vessel at section considered, in m;

$\sum b$ — sum of breadths of deductible openings at section considered in accordance with 2.2.4.6 of this Section, in m.



Sum of breadths of small openings at y-y section is to be $b_c = b_1 + b_2 + b_3$

Figure 2.1.4.7 Opening breadths or shadow area breadths

2.1.4.8 Openings in longitudinals or longitudinal girders (such as lightening holes, freeing ports, single scallops in way of welds) need not be deducted from the sectional areas used in the calculation of the hull girder section modulus, if their depth does not exceed 25% of the web depth (with a maximum depth of 75 mm for scallops).

2.1.5 Hull girder bending strength

2.1.5.1 The minimum amidships section modulus W_0 is not to be less than that obtained from the following formulae:

$$W_0 = CL^2 B(C_b + 0.7) \text{ in cm}^3$$

Where: C —coefficient, the same as that in 2.1.3.1 of this PART;

C_b —the same as that in 2.1.3.1 of this PART.

2.1.5.2 Scantlings of all continuous longitudinal members of the hull girder based on the minimum amidships section modulus W_0 are to be maintained within $0.4L$ amidships. However, in special cases, based on consideration of type of vessel, hull form and loading conditions, the scantlings may be gradually reduced towards the ends of the $0.4L$ amidships, bearing in mind the desire not to inhibit the vessel's loading flexibility.

2.1.5.3 The moment of inertia of amidships section about the horizontal neutral axis I is not to be less than that obtained from the following formulae:

$$I = 3W_0 L \text{ in cm}^4$$

Where: W_0 —the minimum amidships section modulus, in cm^3 , calculated in accordance with 2.1.5.1 of this PART;

2.1.5.4 The hull girder bending strength outside $0.4L$ amidships is to comply with the requirements of 2.1.5.5 of this Section and also the following requirements:

.1 As a minimum, hull girder bending strength checks are to be carried out at the following locations:

- (1) in way of the forward end of the engine room.
- (2) in way of the forward end of the foremost cargo hold.
- (3) at any locations where there are significant changes in hull cross-section
- (4) at any locations where there are changes in the framing system.

.2 Continuity of structure is to be maintained throughout the length of the vessel. Where significant changes in structural arrangement occur, adequate transitional structure is to be provided.

The designer is to provide permissible hogging and sagging still water bending moment $\overline{M}_s(+)$ and $\overline{M}_s(-)$ of hull girders at each transverse section along the vessel's length, provided that the following conditions are satisfied:

(1) The permissible hogging and sagging still water bending moments $\overline{M}_s$ of hull girders are to cover the most severe hogging and sagging design still water bending moments calculated for any navigation condition given in the loading manual, see 2.1.2 of this Section.

(2) The permissible hogging and sagging still water bending moments $\overline{M}_s$ of hull girders are not to be greater than the values obtained from the following formulae:

$$\begin{aligned}\overline{M}_s(+)_\text{max} &= \overline{M} - M_w(+)_\text{kN m} \\ \overline{M}_s(-)_\text{min} &= -\overline{M} - M_w(-)_\text{kN m}\end{aligned}$$

Where: M_w — wave bending moment, see 2.1.3.1 of this Section;

$\overline{M}$ — combined permissible bending moment, in $\text{kN} \cdot \text{m}$, to be taken as one of the values obtained from the following formulae, whichever is the lesser:

$$\begin{aligned}\overline{M} &= W_d [\sigma] \times 10^{-3} \text{ kN m} \\ \overline{M} &= W_b [\sigma] \times 10^{-3} \text{ kN m}\end{aligned}$$

Where: W_d —section modulus at deck, in cm^3 ;

W_b —section modulus at keel, in cm^3 .

Permissible bending stress of hull girder $[\sigma]$ is determined in accordance with the following requirements:

$$[\sigma] = 175 / K \text{ in N/mm}^2, \text{ for } 0.4 L \text{ amidships}$$

$$[\sigma] = 125 / K \text{ in N/mm}^2, \text{ for } 0.1 L \text{ from the vessel's ends}$$

for other areas, to be obtained by linear interpolation, where K is Material factor, see 1.5.1.3 of this PART.

2.1.5.6 Longitudinal bending stress is to be calculated in accordance with the following formula:

$$\sigma = \frac{|\overline{M}_s + M_w|}{W_c} \times 10^{-3} \text{ N/mm}^2$$

In the formula: $\overline{M}_s$ —permissible still water bending moment, in kN m, see 2.2.5.5 of this Section;

M_w —wave bending moment, in kN m, calculated in accordance with 2.2.3.1 of this PART;

W_c —hull girder section modulus at the point considered, in cm³.

2.1.6 Hull girder shearing strength

2.1.6.1 Design still water shear force

.1 Under different loading conditions, the design still water shear force at each transverse section along the vessel's length is to meet the following conditions:

$$F_s(+) \leq \overline{F}_s(+)$$

$$|F_s(-)| \leq |\overline{F}_s(-)|$$

Where: F_s — design still water shear force under the conditions considered, in kN;

$\overline{F}_s$ — permissible still water shear force, in kN, calculated in accordance with 2.1.6.2.

.2 For type 1 and type 2 hull sections as shown in Table 2.2.6.2, the still water shear force F_s at transverse bulkhead is to be corrected in respect to alternate or significantly non-homogeneous hold loading conditions. The correction of shear force is as shown in Figure 2.2.6.1. The values N_k and N_m of shear force correction are to be calculated in accordance with the following formulae respectively:

$$N_k = F |F_{sA} - F_{sB}| \text{ kN}$$

$$N_m = F |F_{sA} - F_{sC}| \text{ kN}$$

Where: F_{sA} , F_{sB} , F_{sC} — shear force in kN, obtained by calculation based on hull girder at transverse bulkheads A, B and C respectively;

F — correction coefficient of still water shear force, calculated in accordance with the following formula:

$$F = \frac{B_0}{2.2(B + l_H)}$$

Where: B_0 — average breadth of the flat part of inner bottom of the hold considered, in m;

l_H — breadth of vessel, in m;

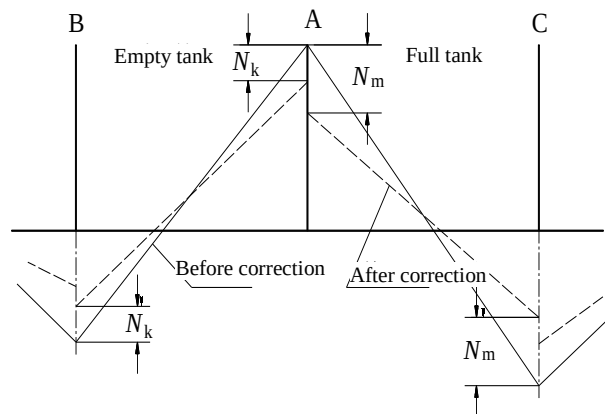


Figure 2.1.6.1 Shear force correction diagram

2.1.6.2 The designer is to provide permissible still water shear forces $\overline{F}_s(+)$ and $\overline{F}_s(-)$ of hull girders at each transverse section along the vessel's length, and are to cover the most severe positive and negative design still water shear forces calculated for any navigation condition given in the loading manual.

The positive and negative permissible still water shear forces $\bar{F}_s$ of hull girders are not to be greater than the values obtained from the following formulae:

$$\bar{F}_s(+)_\text{max} = [\tau] \frac{I\delta}{S} \times 10^{-2} - F_w(+)$$

kN

$$\bar{F}_s(-)_\text{min} = -[\tau] \frac{I\delta}{S} \times 10^{-2} - F_w(-)$$

kN

Where: F_w — wave shear force, in kN, calculated in accordance with 2.1.3.2;

I — moment of inertia about the horizontal neutral axis at the transverse section under consideration, in cm^4 ;

S — static moment, in cm^3 , about the horizontal neutral axis, of the area of the effective longitudinal members above the horizontal neutral axis, taken at the transverse section under consideration;

$[\tau]$ — Permissible shearing stress, $[\tau] = 110 / K$, N/mm^2 , where K is the *Material factor*, see 1.5.1.3 in this PART;

δ — the lesser of δ_1 and δ_2 . δ_1 and δ_2 are calculated in accordance with the following formulae:

$$\delta_1 = \frac{t_1}{f_1 + m_1}$$

$$\delta_2 = \frac{t_2}{f_2 + m_2}$$

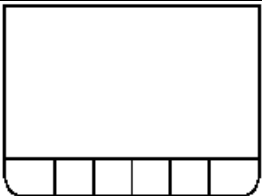
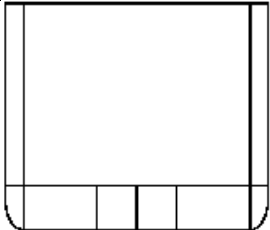
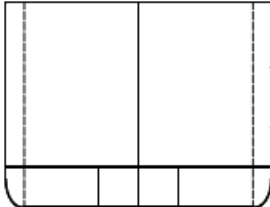
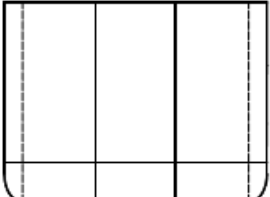
t_1 — thickness (the total thickness of inner and outer plating for double hull-skin vessel) of side shell at the horizontal neutral axis of the section under consideration, in mm;

t_2 — thickness of longitudinal bulkhead plating at the horizontal neutral axis of the section under consideration, in mm;

f_1, f_2, m_1 , and m_2 — coefficients, see Table 2.1.6.2.

Factors f_1, f_2, m_1 , and m_2

Table 2.1.6.2

No.	Hull configuration	Factor f_i	Factor m_i
1		$f_1 = 0.5$	$m_1 = 0$
2		$f_1 = 0.5$	$m_1 = 0$
3		$f_1 = 0.261 + 0.058A_1 / A_2$ $f_2 = 0.478 - 0.116A_1 / A_2$	$m_1 = 0.5m_2$ $m_2 = 0.5(0.1 + \gamma)$
4		$f_1 = 0.154 + 0.08A_1 / A_2$ $f_2 = 0.346 - 0.08A_1 / A_2$	$m_1 = m_2$ $m_2 = (0.1 + \gamma) \frac{b}{B}$

Notes: A_1, A_2 — shear areas of side shell and longitudinal bulkhead plating respectively, in cm^2 , at one side of the section under consideration. The area for the centerline bulkhead is actual area and not to be reduced for symmetry around the centerline;

b — horizontal distance from longitudinal bulkhead to side shell plating, in m;

γ — for transversely non-homogeneous loading condition, $\gamma = 0.15$; for transversely homogeneous loading condition, $\gamma = 0$.

2.1.6.3 For hull configurations not included in Table 2.2.6.2, e.g. vessels with three or four longitudinal bulkheads, the shearing stresses at side shell and longitudinal bulkhead plating may be determined by direct calculation.

2.1.6.4 Shear stress:

(1) The shearing stress τ at side shell is to be calculated in accordance with the following formula:

$$\tau = \frac{|\bar{F}_s + F_w| S}{I \delta_1} \times 10^2 \quad \text{N/mm}^2$$

Where: $\bar{F}_s$ — permissible still water shear force, in kN, see 2.1.6.2 in this PART;

S — static moment, in cm^3 . Where the point considered is above the horizontal neutral axis, S is to be taken as the static moment, about the horizontal neutral axis, of the area of all longitudinal members passing through the point above the neutral axis. Where the point considered is below the horizontal neutral axis, S is to be taken as the static moment, about the horizontal neutral axis, of the area of all longitudinal members passing through the point below the neutral axis;

F_w , I and δ_1 — see 2.1.6.2 of this PART.

.2 Shearing force τ at longitudinal bulkhead plating is to be calculated in accordance with the following formula:

$$\tau = \frac{|\bar{F}_s + F_w| S}{I \delta_2} \times 10^2 \quad \text{N/mm}^2$$

Where: $\bar{F}_s$ and S — see 2.1.6.4.1;

F_w , I and δ_2 — see 2.1.6.2 of this PART.

Section 2 SHELL PLATING

2.2.1 Bottom shell

2.2.1.1 Bottom shell means the shell plating between the plate keel and the bilge strake.

2.3.1.2 In a vessel with transverse bottom framing, the thickness t of bottom shell plating within $0.4L$ amidships is not to be less than the following:

$$t = 10s\sqrt{0.22+0.028L} + 1.5 \quad \text{in mm}$$

Where: s — spacing of frames, in m

2.3.1.3 In a vessel with longitudinal bottom framing, the thickness t of bottom shell plating within $0.4L$ amidships is not to be less than the following:

$$t_1 = 0.043s(L + 230) + 0.5 \quad \text{mm}$$

$$t_2 = 5.6s\sqrt{(d + h_1)} + 0.5 \quad \text{mm}$$

Where: s — spacing of longitudinals, in m, to be taken as not less than the standard spacing of longitudinals;

$h_1 = 0.26C$, to be taken as not greater than $0.2d$;

C — coefficient, see 2.1.3.1 of this CHAPTER.

2.2.1.4 The thickness t of bottom shell plating within the regions of $0.1L$ from the vessel's ends is not to be less than that obtained from the following formula:

$$t = 0.05L + 5.0 \quad \text{in mm}$$

2.2.1.5 Within the area $0.25L$ away from the fore perpendicular, the plating thickness adjacent to the flat keel and transverse bottom framing are not to be less than the values calculated according to 2.2.1.2 of this Section, and the longitudinal bottom framing is not to be less than the values calculated according to 2.2.1.3 of this Section.

2.2.1.6 The thickness of bottom shell plating beyond $0.4L$ amidships is to be tapered gradually to the end thickness of bottom shell plating.

2.2.1.7 When $24\text{m} \leq L < 30\text{m}$, the thickness of the bottom plate is to be the same as that in the middle.

2.2.1.8 The thickness of the bottom plating of the bow is to comply with the relevant requirements of

Section 13 of this CHAPTER.

2.2.2 Plate keel

2.2.2.1 In a vessel with transverse bottom framing, the breadth b of plate keel is not to be less than the following:

$$b = 900 + 2L \quad \text{in mm}$$

2.2.2.2 In a vessel with longitudinal bottom framing, the breadth b of plate keel is not to be less than the following:

$$b = 900 + 3.5L \quad \text{in mm}$$

2.2.2.3 The breadth of the plate keel is to be maintained over the whole length of the vessel. For fishing vessels $24\text{m} \leq L < 30\text{m}$, the breadth of the plate keel can be reduced by 100 mm compared to the above formula.

2.2.2.4 The thickness of the plate keel is not to be less than that of the bottom shell plating calculated according to 2.2.1 of this PART in accordance with its structural configuration plus 2 mm nor less than that of the adjacent bottom shell plating.

2.2.3 Bilge strake

2.2.3.1 Where the bilge is framed transversely, the thickness of the bilge plating is not to be less than the value obtained from 2.2.1.2 of this PART, and where the bilge is framed longitudinally, the thickness of the bilge plating is not to be less than the value obtained from 2.2.1.3 of this PART.

2.2.3.2 Where both the bottom and side shells are framed longitudinally and the bilge longitudinals are omitted, and where transverse strength members or corresponding bilge brackets are fitted in accordance with the

requirements of 2.6.14.5 of this PART, the thickness of the bilge strake is neither to be less than $\frac{r}{165K}$ (r being the radius of bilge, in mm, K being Material factor), nor to be less than that of the adjacent bottom plating.

2.2.4 Side shell plating

2.2.4.1 Side shell plating means the shell plating between the bilge strake and the sheer strake.

2.2.4.2 Where the side shell is framed transversely, the thickness of side shell plating is to comply with the requirements of 2.2.1.2 of this PART.

2.2.4.3 Where the side shell is framed longitudinally, the thickness t of side shell plating within $0.4L$ amidships is to be as follows:

.1 When $L < 60$ m, the thicknesses of side shell plating and top strake are to comply with the requirements of 2.2.1.3 of this PART.

.2 When $L \geq 60$ m, the thicknesses of side shell plating and top strake are to calculate according to the formula below:

(1) The thickness t of the side shell plating $\frac{1}{2}D$ away from the baseline is not to be less than the following:

$$t_1 = 0.06s(L + 110) + 0.5 \quad \text{in mm}$$

$$t_2 = 4.2s\sqrt{(d + h_2)} + 0.5 \quad \text{in mm}$$

(2) The thickness t of the side shell plating less than $\frac{1}{4}D$ away from the baseline is not to be less than the following:

$$t_1 = 0.06s(L + 110) + 0.5 \quad \text{in mm}$$

$$t_2 = 5.4s\sqrt{(d + h_1)} + 0.5 \quad \text{in mm}$$

Where: s —spacing of longitudinals, in m, to be taken as not less than the standard spacing of

longitudinals;

$$h_2 = 0.5C, \text{ to be taken as not greater than } 0.36d;$$

h_1 , and C —see 2.2.1.3 of this PART;

(3) The thickness t of side shell plating between $\frac{1}{4}D$ and $\frac{1}{2}D$ from base is to be obtained by

interpolation

between the values of t in (1), (2) above, but not less than t_1 in (2) above.

2.2.4.4 The thickness of side shell plating within $0.1L$ from the vessel's ends is to comply with the requirements of 2.2.1.4 or 2.2.1.7 of this PART.

2.2.5 Sheer strake

2.2.5.1 The width of the sheer strake is not to be less than: $800+5L$ (in mm), but need not be greater than 1,800 mm. But it is not to be less than 700 mm for fishing vessels below 45 m.

2.2.5.2 The upper edge of the sheer strake is to be dressed smooth. Any fittings welded to the top of the sheer strake within $0.5L$ amidships are to be avoided; scupper openings are not to be cut in the sheer strake which is protruded above the deck within $0.4L$ amidships or in way of breaks of superstructures. Scupper openings are to be strengthened according to 2.2.7.2 of this PART.

2.2.5.3 The thickness of the sheer strake is to be the same as that of the side shell plating, but in the area within $0.4L$ amidships, it is not to be less than 0.8 times the thickness of the strength deck side plating.

2.2.6 Local strengthening

2.2.6.1 Trawler fishing vessel

Oblique half-round bar rubbing strakes are to be provided from the top edge of the bulwark wall to the outer side of the vessel within 0.3 m below the maximum waterline, at least 1 m to the stern and 2 m to the tail of the screen frame, with a spacing not over 400 mm. If the profile indentation below the work deck is great, the rubbing strake can only be provided to sites with an indentation of 400 mm compared to working deck.

2.2.6.2 The thickness of the shell plating where the purse seine is installed is to be increased by 1 mm or doubled within the appropriate range.

2.2.6.3 The thicknesses of the wrapper sheet at the hub and that of the shell plating of multiple propeller stern frame arm at the fixing position are not to be less than 1.5 times of the thickness of the shell plating at the end. But the thickening is not necessary to be greater than 4 mm.

2.2.6.4 The shell plating in way of hawse pipe and one plate below or the shell plating from the head to below the anchor are to be increased in thickness or to be fitted with doubler plates.

2.2.7 Openings in shell plating

2.2.7.1 Openings cut in the turn of the bilge strake within $0.4L$ amidships are to be avoided as far as possible. But if necessary, the openings are to be elliptical with the major axis arranged in the fore and aft direction.

2.2.7.2 The circular openings on the sheer strake are to fully avoid the deck openings beyond the end points of the superstructure and the side of the deck hatch. In general, compensation will not be required if the opening depth does not exceed 20% of that of the sheer strake or 380 mm (whichever is the lesser).

2.2.7.3 Sea inlets and other openings are to have well rounded corners. It is to be compensated by thicker plate or web. The thickness of sea inlet box plating is to be the same as that of the adjacent shell.

2.2.7.4 Cargo door openings are to have well rounded corners, and are to be kept clear of the ends of superstructures and the deck openings outside the line of hatchways. Such openings within $0.4L$ amidships are to be fully compensated by insert plates or doubler plates with a sufficient length in the fore and aft direction.

2.2.7.5 The above requirements for the opening of the shell plating generally also apply to the head and tail end areas.

2.2.8 Bilge keel

2.2.8.1 Where bilge keels are fitted, they are to be welded to a continuous flat bar which may be continuously welded to the shell.

2.2.8.2 Bilge keels and flat bars are not to be interrupted abruptly, but to be gradually tapered at their ends and terminated on a suitably stiffened panel.

2.2.8.3 All butts of bilge keels, flat bars and shell plating are to be properly shifted from one another. The keel keel is properly supported to strengthen.

2.2.9 Square keel

2.2.9.1 The plate thickness of square keel is not to be less than the thickness of the plate keel. The internal frames are to be supported by transverse partitions at every other position. The transverse partitions are to be aligned with the ribbed plates. When the width of the square keel exceeds 300 mm, vertical partitions are to be added.

2.2.9.2 When it is designed to replace square keel with flat steel, the ratio of height to thickness is not to be

greater than 10. The thickness t is not to be less than the value calculated by the following formulae:

$$t = 10 + 0.6L \quad \text{in mm}$$

Section 3 DECKS

2.3.1 General Requirements

2.3.1.1 Where the platform decks terminate within $0.4L$ amidships, horizontal brackets are to be provided at their ends and are to extend over a suitable length.

2.3.2 Strength deck

2.3.2.1 For decks with transverse bottom framing, the thickness of strength deck t is not to be less than the value calculated by the following formula:

$$t = 0.05L + 4.5 \quad \text{in mm}$$

When the spacing of frames is greater than the standard spacing of frames, the plate thickness will increase by 0.5 mm per 150 mm of increasing.

2.3.2.2 For decks with longitudinal bottom framing, the thickness t of strength deck within $0.4L$ amidships is not to be less than the value calculated by the following formula:

.1 Beyond the line of openings:

$$t_1 = 0.06s(L + 110) + 0.5 \quad \text{in mm}$$

$$t_2 = 0.9s\sqrt{L + 75} + 0.5 \quad \text{in mm}$$

Where: s — spacing of longitudinals, in m, to be taken as not less than the standard spacing of longitudinals.

.2 Within the line of openings:

$$t = 0.9s\sqrt{L + 75} + 0.5 \quad \text{in mm}$$

Where: s — spacing of frames, in m, to be taken as not less than the standard spacing of frames.

2.3.2.3 Where the long bridge deck within $0.4L$ amidships is regarded as the strength deck, the amidships section modulus and the minimum thickness are to comply with the requirements of 2.1.5.1 and 2.3.2.2 of this PART.

2.3.2.4 When the length of vessel is greater than 60 m, the thickness of the strength deck $0.1L$ away from the vessel end can reduce by 1 mm compared with that at amidships.

2.3.2.5 The thickness of decks in heavy-load base areas such as net rolling machines, winches and windlass is to be at least 2 mm thicker, and can be replaced with double decks not less than the thickness of the deck. Beams and supporting structures of sufficient strength are to be provided below.

2.3.2.6 The tail slide of trawler fishing vessel is to be longitudinally strengthened with sufficient strength. The thickness of the slide plate is not to be less than the interpolation according to the following regulations: when $L = 30$ m, it is not to be less than 10 mm; when $L = 45$ m, it is not to be less than 12 mm; when $L \geq 75$ m, it is not to be less than 15 mm. The thickness of the side wall plate of the slideway is to be at least 1 mm larger than that calculated in 2.2.1.4 of this PART. The bottom of the slideway and its side wall are susceptible to the abrasion of the netting. Rubbing strakes are to be provided.

2.3.3 Deck side plating

2.3.3.1 The breadth of deck side plate within $0.4L$ amidships is not to be less than $(6.8L + 400)$ mm. The breadth of strength deck stringer plates at ends of the vessel is not to be less than 65% of that amidships. The thickness of strength deck stringer plates is not to be less than the thickness of strength deck plating.

2.3.4 Deck opening

2.3.4.1 Where the corners of engine/boiler room or hatch openings in the strength deck are parabolic or elliptical, insert plates are not required, but the requirements as shown by Figure 2.3.4.1 are to be complied with. The length-breadth ratio of the corner line portion is not to be less than 2.

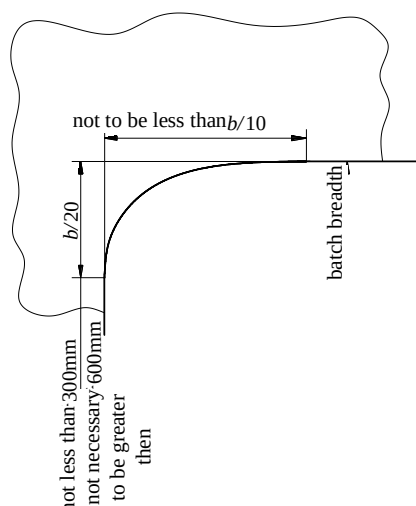


Figure 2.3.4.1 Schematic diagram of corner line

2.3.4.2 When the corners of the engine room or fishing tank openings on the power deck are circular, the ratio of the hatch corner radius to the hatch breadth is not to be less than 1/10. The sizes of the corner thickened plate or double plate are to comply with the requirements of Figure 2.3.4.2-1 or Figure 2.3.4.2-2.

The end seams of corner thickened plate are to avoid the end seams of hatch coamings. The thickness of thickening plate is to be 4 mm greater than that of the strength deck. The thickness of the doubled plate is to be equal to that of the deck plate.

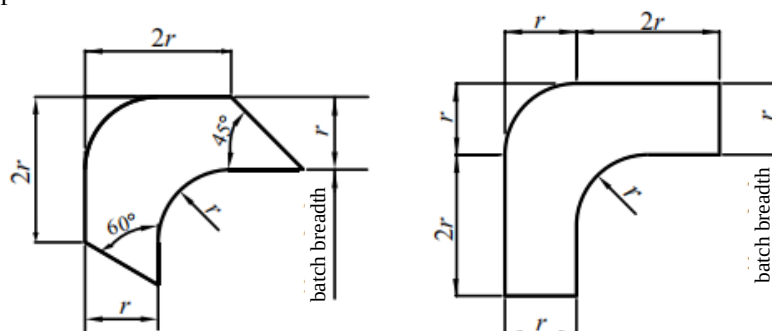


Fig. 2.3.4.2 (1) Schematic diagram of the thickened area of the corner Fig. 2.3.4.2 (2) Schematic diagram of the thickened area of the corner

2.3.4.3 Openings in the strength deck outside the line of hatchways are to be kept to a minimum and are to be arranged clear of hatch corners. Openings in the strength deck between amidships bridge or deckhouse end bulkheads and hatches are to be avoided so far as possible. When openings are required, special consideration should be given to their designs.

2.3.4.4 In the area within $0.4L$ amidships, for circular, oblong, or oval openings outside the strength deck hatch, if the total breadth in a cross section does not exceed 6% of the calculated breadth calculated by the section modulus of strength deck, no compensation is required. Otherwise, the following requirements are to be complied with:

- .1 The axis of the oval opening is to be arranged along the length of the vessel and the length-breadth ratio of openings is not to be less than 2;
- .2 The edges of round or oblong openings are to be strengthened as shown in Figure 2.3.4.4.2.

The sectional area of the open stiffened ring plate A is not to be less than the value calculated by the following formula:

$$A = rt \cdot 0.5 \text{ mm}^2$$

Where: r — radius of opening, in mm, and to be taken as the half breadth of the openings for elliptical openings;
 t — thickness of deck plating, in mm.

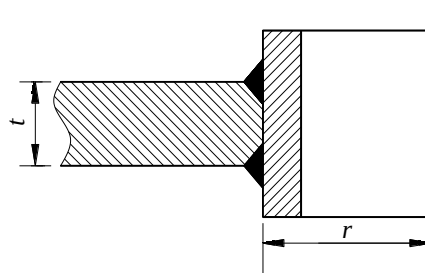


Figure 2.3.4.4.2 Ring form stiffening

2.3.4.5 In the area within $0.4 L$ amidships, other shaped openings outside the edge of the strong deck hatch are to be fully compensated, and the ratio of corner radius to opening breadth is not to be less than 1/10. Outside of this area, compensation is generally not required except for the places adjacent to the interruption of the forecastle and poop.

2.3.4.6 The above provisions also apply to the lower deck, but compensation shall be made only if the total breadth of the opening exceeds 15% of the calculated breadth of the mid-plane modulus used by the deck.

2.3.4.7 The above requirements for the opening of the deck generally also apply to the area within $0.4 L$ amidships.

2.3.5 Lower deck and platform deck

2.3.5.1 The thickness t of the lower deck within $0.4 L$ amidships is not to be less than the value calculated by the following formula:

$$t = 0.02 L + 5.5 \quad \text{mm}$$

2.3.5.2 The thickness t of the deck within $0.1 L$ amidships is not to be less than the value calculated by the following formula:

$$t = 0.02 L + 5 \quad \text{mm}$$

2.3.6 Raised quarter decks

2.3.6.1 The raised quarter decks are to comply with the relevant requirements of Section 15 of this CHAPTER.

2.3.7 Superstructure ends

2.3.7.1 The deck strengthening at ends of superstructures is to comply with the requirements of 2.15.5 of this PART.

2.3.8 Deck coverings

2.3.8.1 The deck coverings are not to corrode the steel plate. Before laying the coverings, the surface of the deck is to be completely derusted and painted.

2.3.8.2 The thickness of steel deck plating sheathed with wood planks is not to be less than 40 mm. The thickness of steel deck plating sheathed with wood planks may be reduced by 1 mm, but each plank is to be well secured to the deck plating at every beam by studs. The fasteners are to be buried under the surface of the wooden planks, filled and sealed. The planks are to be tightly crimped.

2.3.8.3 Where chemical covering is used as a substitute for wood sheathing, the thickness of the steel deck plating is not to be reduced.

Section 4 TRANSVERSELY FRAMED SINGLE BOTTOMS

2.4.1 General provisions

2.4.1.1 This Section applies to transversely framed single bottom structure.

2.4.2 Centre keelson

2.4.2.1 The center keelsons are to be provided in way of the central longitudinal section of the vessel. The depth of the center keelson is to be the same as that of floors, and the web thickness t and the sectional area A of the face plate of the center keelson are not to be less than the following within $0.4 L$ amidships:

$$t = 0.06 L + 6 \quad \text{mm}$$

$$A = 0.65 L + 2 \quad \text{cm}^2$$

In the forepeak tank, the centerline keelson may have the same depth and thickness and the same sectional area of face plate as the floor. The web thickness can be reduced by 12% outside the area within $0.4 L$ amidships.

For fishing vessels $L < 30$ m, the thickness of the above slab t and panel cross-sectional area A can be reduced by 10%.

2.4.2.2 The center keelson is normally to extend as far forward and aft as practicable. Where the center keelson is cut in way of a bulkhead, it is to be connected to the bulkhead by one of the following means:

- .1 The web plate of the center keelson is to be gradually raised, within one frame spacing to 1.5 times the original web depth at the bulkhead, and the face plate of the center keelson is to extend and to be welded to the bulkhead, as shown in Figure 2.4.2.2.1.
- .2 The center keelson is to be attached to the bulkhead by brackets having a face plate or flange, and the depth and length of the brackets are to be equal to the depth of the keelson. In this case, the face plate of the center keelson may not be welded to the bulkhead. The thickness of the brackets is to be the same as that of the web of the center keelson, as shown in Figure 2.4.2.2.2.
- .3 The face plate of the center keelson is, within one frame spacing, to be gradually widened to twice its original width at the bulkhead, and to be welded to the bulkhead, as shown in Figure 2.4.2.2.3.

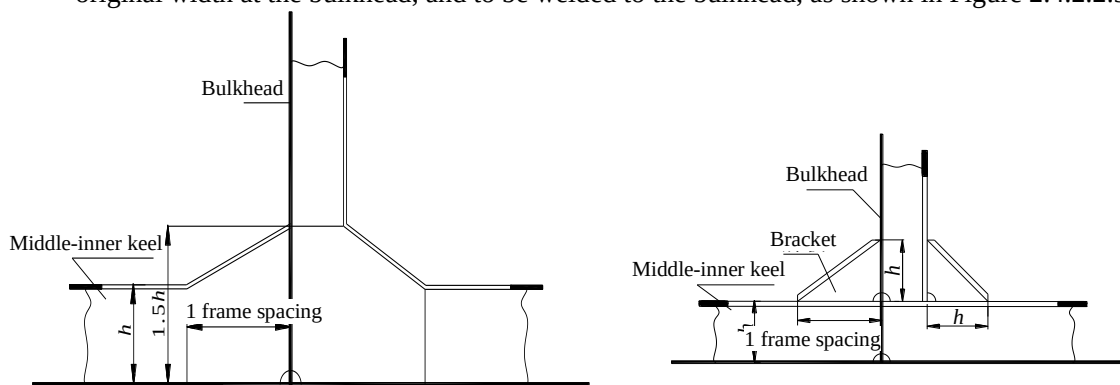


Figure 2.4.2.2.1 Type of web rise connection Figure 2.4.2.2.2 Type of bracket connection

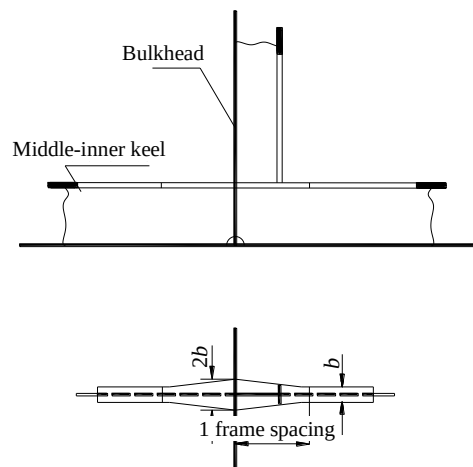


Figure 2.4.2.2.3 Panel widening connection type

2.4.2.3 Where a single main engine is fitted, the center keelson may be omitted in the machinery space provided that the longitudinal girders under the engine seating extend over the whole length of the engine room and brackets are fitted at the outside of both end bulkheads of the engine room for transition. Within the engine room where the center keelson is cut, however, gradually tapered brackets having a length not less than two frame spaces are to be fitted for transition, as shown in Figure 2.4.2.3.

In machinery spaces situated at the aft end, such engine seating girders are to be carried as far aft as practicable and the ends effectively supported by web frames or transverses. Where it is impracticable to provide transition brackets abaft the aft peak bulkhead because the aft body of the vessel is too fine, it can be otherwise considered.

2.4.2.4 In the area of $0.75L$ amidships, no relief holes are to be made on the web of the inner keel.

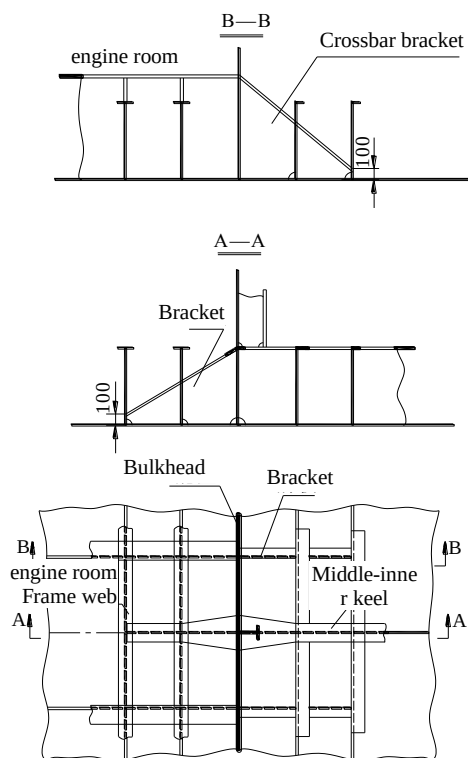


Figure 2.4.2.3 Transition bracket connection type

2.4.3 Side keelsons

2.4.3.1 The depth of side keelsons is to be the same as that of floors, and the web thickness t and the face plate sectional area A of side keelsons are not to be less than the following:

$$t = 0.063 L + 4 \quad \text{mm}$$

$$A = 0.25 L + 5 \quad \text{cm}^2$$

In the machinery space, the web thickness of side keelsons is not to be less than that of the center keelson as required in 2.5.2.1 of this PART.

2.4.3.2 One side keelson at least is to be fitted on each side of the center keelson where the breadth of vessel is not less than 4 m and not more than 9 m, and two at least where the breadth exceeds 9 m. Side keelsons are to be uniformly fitted and are to extend as far forward and aft as practicable. Outboard of the main engine seating girders, side keelsons as required in 2.4.3.1 of this Section are to be fitted, and attention is to be given to structural continuity.

2.4.3.3 The attachment of side keelsons to the bulkheads is to be the same as required for the center keelson (see 2.5.2.2 of this PART).

2.4.4 Floors

2.4.4.1 Plate floors are to be fitted at every frame and are, at the centerline, to have a web depth h , a web thickness t and a sectional area A of face plate not less than:

$$h = 42(B + d) - 70 \quad \text{in mm}$$

$$t = 0.5B + 3 \quad \text{in mm}$$

$$A = 3.5d - 0.5 \quad \text{in cm}^2$$

2.4.4.2 The thickness of the face plate of the floor is not to be less than that of its web plate. The breadth of the face plate is not to be less than 10 times its thickness, but need not exceed 15 times.

For fishing vessels $L \leq 30$ m, the face plate of floor can be replaced by folds.

2.4.4.3 In fishing vessels having considerable rise of floor, the depth of floor plates is to be increased. The floor plates forming part of a watertight, deep tank or tank bulkhead are not to be less than 900 mm in depth measured at the centerline, and have a thickness not less than that required for the bottom strake of a bulkhead.

For fishing vessels $L \leq 30$ m, the height of the floor in the middle and longitudinal sections can be appropriately reduced.

2.4.4.4 In machinery spaces the web thickness of floors is not to be less than that of the center keelson as required in 2.4.2.1 of this Section. The face plate of floor is not to be replaced by a folded edge, and the cross-sectional area of the face plate of floor is to be A increased by 20% according to the calculated value of

2.4.4.1 of this PART.

In way of machinery spaces situated aft or where there is considerable rise of floor, the depth of floors is to be appropriately increased in accordance with the vessel's lines and strength.

2.4.5 Bilge brackets

2.4.5.1 Floors are to be connected to the frames by bilge brackets. The depth of the bilge brackets measured from the base line is to be twice that of the floors in way of the centerline, and the length of the brackets, measured from the inner edge of frames, is to be equal to the floor depth on the centerline. The thickness of the brackets is to be equal to that of floors. The brackets are to have a flange or face plate. When flanged, the width of the flange is neither to exceed 10 times the thickness of the bracket nor to be less than 50 mm. The thickness of the bilge bracket is equal to the thickness of the floor.

2.4.5.2 Where it is impracticable to arrange the bilge brackets due to the vessel's lines or other reasons, the floors are to extend to the vessel's side and to be raised to the required depth for bilge brackets.

2.4.5.3 Where bilge brackets or floors are connected to the frames by means of a welded lap joint, the length of overlap is to be as follows:

- .1 when the depth of frames is 100 mm or less, the length of overlap is not to be less than twice the depth of frames;
- .2 when the depth of frames exceeds 100 mm, the length of overlap is neither to be less than 1.5 times the depth of the frame nor less than 200 mm.

2.4.6 Drain holes

Drain holes are to be cut in the floors and side keelsons in way of the bottom. Provision is to be made for the free passage of water from all parts of the bottom to the suctions, taking into account the pumping rates required.

Section 5 LONGITUDINALLY FRAMED SINGLE BOTTOM

2.5.1 General provisions

2.5.1.1 This Section applies to longitudinally framed single bottom structure.

2.5.2 Bottom longitudinals

2.5.2.1 The section modulus W of bottom longitudinals is not to be less than that obtained from the following formula:

$$W = 10sDl^2 \text{ in cm}^3$$

Where: s — spacing of longitudinals, in m;

l — span of longitudinal, in m.

2.5.2.2 The connections of bottom longitudinals to bulkheads are to provide adequate fixity and continuity of longitudinal strength. Where higher tensile steels are adopted, longitudinals are to be continuous through the transverse bulkheads.

2.5.2.3 Where the bottom longitudinals are cut in way of the bulkheads, the longitudinals are to be bracketed to the bulkheads. The scantlings of the bracket are to comply with the requirements of 1.2.5 of this PART.

Bottom longitudinals are to be welded to the web and vertical stiffeners of bottom transverses.

2.5.3 Plate floors

2.5.3.1 The spacing of plate floors is not to be greater than 3.6 m.

2.5.3.2 Where no longitudinal bulkhead is fitted in fish tank area, the plate floors are to comply with the requirements for plate floors specified in 2.5.3.4 of this PART.

2.5.3.3 Where one longitudinal bulkhead is fitted in the cargo tank region at the centerline of the vessel, the section modulus W and the section moment of inertia I of the plate floors are not to be less than those obtained from the following formulae:

$$W = 11SDl^2 \text{ in cm}^3$$

$$I = 10.5Wl \text{ in cm}^4$$

Where: S — spacing of plate floors, in m;

l — span of bottom transverse, in m.

2.5.3.4 Where the continuous centerline girder complying with 2.5.4.2 of this Section are fitted in way of center tanks of vessels having two longitudinal bulkheads within the cargo tank region, the section modulus W of

the plate floors of the center tanks and the net sectional area A of the associated webs at span points of the longitudinal bulkheads are not to be less than those obtained by the following formulae:

$$W = C_1 S D l^2 \quad \text{in cm}^3$$

$$A = C_2 S D l \quad \text{in cm}^2$$

Where: S — spacing of plate floors, in m;

l — span of bottom transverse, in m.

The bending moment coefficient C_1 and shear coefficient C_2 for centerline girders and plate floors are based on the number of plate floors in the tank and coefficient C , as given in Table 2.5.4.3 (intermediate values are to be obtained by interpolation). The coefficient K is to be calculated as follows:

$$K = \frac{l_G^3 I_F}{l_F^3 I_G}$$

where: l_G — span of centerline girder, in m;

l_F — span of plate floor, in m;

I_G — section moment of inertia of centerline girder, in cm^4 ;

I_F — section moment of inertia of plate floor, in cm^4 .

Bending moment coefficient C_1 and shear coefficient C_2

Table 2.5.3.4

K			0.02	0.06	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
3 plate floors	Girder	C_1	8.99	8.99	8.53	7.60	6.91	6.20	5.74	5.27	4.96	4.65	4.43	4.19
		C_2	0.84	0.84	0.81	0.73	0.68	0.62	0.59	0.54	0.51	0.48	0.46	0.45
	Ribbed plate	C_1	1.55	1.74	1.98	2.48	2.85	3.22	3.47	3.66	3.84	4.03	4.15	4.28
		C_2	0.31	0.33	0.35	0.39	0.42	0.45	0.47	0.49	0.50	0.51	0.52	0.53
5 plate floors	Girder	C_1	12.71	12.25	11.63	10.23	9.24	8.22	7.53	6.82	6.29	5.74	5.43	5.12
		C_2	1.43	1.39	1.33	1.21	1.12	1.03	0.97	0.91	0.87	0.83	0.80	0.77
	Plate floors	C_1	1.55	1.86	2.23	2.79	3.16	3.53	3.78	4.03	4.22	4.40	4.53	4.59
		C_2	0.32	0.34	0.37	0.41	0.44	0.47	0.49	0.51	0.53	0.54	0.55	0.56

Note 1: In the case of 2 plate floors, calculation may be performed as that for 3 plate floors, with C_1 being reduced by 20% and C_2 by 25% for centerline girders.

Note 2: In the case of 4 plate floors, the coefficient may be obtained by interpolation.

The net sectional area A of the web at mid-span of the bottom transverse is not to be less than $\left(\frac{1}{1.6C_2} - 1\right)A$.

The above W and A may also be determined by direct calculation.

2.5.3.5 For fishing vessels having two longitudinal bulkheads within the fishing tank region, the scantlings (including the section modulus and the net sectional area of webs at span points) of plate floors of wing tanks are generally to be the same as those of plate floors of center tanks.

2.5.3.6 The web depth of the plate floors is not to be less than 2.5 times the depth of the slot for the bottom longitudinals.

2.5.3.7 The ends of bottom transverse are to be bracketed to longitudinal bulkheads or vessel side. The brackets are to comply with the requirements of 1.2.6 of this PART. Where connected to vessel side, the brackets are as far as possible to form a ring system.

Where the side shell and longitudinal bulkheads are framed transversely in wing cargo tanks, the raised ends of bottom transverse in the tank are to extend to the lowest side stringer and to the lowest horizontal girder of the longitudinal bulkhead. Where the side shell and longitudinal bulkheads are framed longitudinally in wing cargo tanks, the plate floors in the tank together with web frames, longitudinal bulkhead vertical webs and deck transverses are to form a transverse framing structure. The radius of rounded corners of the connection of the transverse framing structure to plate floors in the tank is generally not to be less than the web depth of adjacent members. The face plate at the connection is to be continuous and have a sectional area not less than that of the

face plate of plate floors.

2.5.3.8 Where the web thickness in the fishing tank area meets the conditions of 2.5.3.2, 2.5.3.3, 2.5.3.4, and 2.5.3.5 in this Section, the thickness is increased by 1 mm and is not to be less than $s/80$ (s being the spacing of stiffeners). Vertical stiffeners are generally to be fitted on one side of the web plate of plate floors in line with the longitudinals. Where the web depth of plate floors exceeds $165t$ (t being the web thickness), an additional stiffener is to be fitted parallel to and at a distance of $1/4$ web depth from the face plate.

2.5.3.9 Plate floors are generally to be fitted with tripping brackets close to the toes of end brackets and elsewhere according to the relevant requirements in 1.2.4 of this PART.

2.5.4 Bottom centerline girder and bottom side girders

2.5.4.1 Where the length of the vessel exceeds 70 m and one centerline longitudinal bulkhead is fitted, one intercostal bottom side girder is generally to be fitted at about $1/4B$ from the centerline on each side.

2.5.4.2 For oil tankers without the centerline longitudinal bulkhead, a continuous bottom centerline girder is to be fitted. The section modulus W of the continuous centerline girder and the net sectional area A of the web at any section are not to be less than those obtained from the following formulae:

$$W = 10SDbl \quad \text{in cm}^3$$

$$A = 1.45bDS \quad \text{in cm}^2$$

where: b —supporting breadth, in m, taken as half the distance between span points of the bottom transverse at both sides;

S —spacing of plate floors, in m;

l —span of the centerline girder, in m.

2.5.4.3 The web depth of the bottom centerline girder is not to be greater than that of the plate floors. The web thickness of the bottom centerline girder is not to be less than that of the plate floors plus 2 mm.

2.5.4.4 The web thickness and face plate scantlings of the intercostal bottom side girders are to be the same as those of the plate floors in way, while the depth may be half of that of the plate floors.

2.5.5 Strengthening and end connections of bottom centerline girder

2.5.5.1 Docking brackets are to be fitted on both sides of the bottom centerline girder, midway between the plate floors or between the bottom transverse and the transverse bulkhead, and are to be connected to a suitable bottom longitudinal. These brackets are to have a face plate or a flange. The thickness of the brackets is to be the same as that of the web plate of the bottom centerline girder. The bracket on one side of the centerline girder is to be extended and welded to the face plate of the centerline girder but on the other side may be terminated at a suitable horizontal stiffener.

Tripping brackets are also to be fitted close to the toes of end brackets of the continuous bottom centerline girder.

2.5.5.2 Horizontal stiffeners are to be fitted on one side of the web of the continuous centerline girder. Additional vertical stiffeners are to be suitably fitted in way of vertical webs and end brackets.

The horizontal stiffeners are to be spaced not more than $50t$ apart (t being the web thickness of the centerline girder, K being Material factor).

Section 6 DOUBLE BOTTOMS

2.6.1 General Requirements

2.6.1.1 When $L \geq 75\text{m}$, a watertight double bottom is to be provided between the collision bulkhead and the stern tip bulkhead as much as possible.

2.6.1.2 An empty compartment is to be provided between the oil tank in the double bottom and the boiler feed water tank and the edible water tank, and between the fuel tank and the oil tank.

2.6.1.3 For fishing vessels with a double bottomed inner bottom raised at the side, only an empty compartment is required between the double bottom fuel tank and the tanks directly above those fuel tanks filled with fuel to the inner bottom. However, when the relative positions of the fuel tank and the tank are diagonal, the tanks are not considered to be adjacent.

2.6.1.4 Where the double bottom is interrupted, the continuity of bottom longitudinal members is to be maintained. The center and side keelsons within the single bottom in way of the break are to be the continuation of the center and side girders of the double bottom. The inner bottom plating is to extend beyond the break of the double bottom and to be gradually tapered for a length of not less than three frame spaces to form the face plate of the keelsons, and the breadth of the face plate at the break of the double bottom is not to be less than half the spacing of side keelsons. The margin plate is also to extend not less than three frame spaces beyond the break of

the double bottom. Where the margin plate is inclined, the extension portion is to have a face plate or flange, and the width of the margin plate may be reduced gradually.

Within the single bottom, side keelsons, which are not the direct continuation of the girders in the double bottom, are to be extended into the double bottom and to be gradually tapered off over a length of not less than three frame spaces with their free edges flanged.

2.6.1.5 Sufficient girders are to be arranged in way of the main machinery and structural continuity is to be maintained. In amidships machinery spaces, these girders are to extend for the full length of the space and are to be carried for at least three frame spaces beyond the fore and after bulkheads of the engine room. However, the extension beyond the after bulkhead is also to support the foremost shaft tunnel bearing; in machinery spaces situated at the aft end such girders are to be carried as far aft as practicable and the ends effectively supported by web frames or transverses.

Outboard of the main engine seating girders, side girders are to be arranged and attention is to be given to the structural continuity.

2.6.1.6 Manholes are to be cut in the floors and side girders. Except for lightened floors, the depth of manholes is not to exceed 50% of that of the double bottom, unless edge reinforcement is provided. Manholes cut in floors are to be arranged along a straight line in the fore and aft direction for easy access. Manholes or lightening holes are not permitted in way of the floor ends and in the side girders for one frame space from transverse bulkheads, unless the edges of holes are strengthened. The edges of all holes are to be smoothed.

2.6.1.7 Air and drain holes are to be cut in floors, side girders and bottom and inner bottom longitudinals to ensure the free passage of air and water from all parts of the tanks to the air pipes and suctions, account being taken of the pumping rates required.

2.6.2 Centre girders

2.6.2.1 Centre girders are to be provided in way of the central longitudinal section of the vessel. The depth h of center girders is not to be less than 760 mm in any case and not to be less than that calculated by the following formula:

$$h = L + 42d + 530 \quad \text{in mm}$$

2.6.2.2 The thickness t of center girders is not to be less than:

.1 For $0.4L$ amidships:

$$t = 0.065L + 5.5 \quad \text{in mm}$$

.2 For $0.075L$ from the vessel's ends, the thickness t of center girders may be decreased by 2 mm from that required in 2.6.2.2.1 above.

2.6.2.3 The center girders within $0.75L$ amidships are to be continuous and to extend as far as practicable to the stem and stern frame.

2.6.2.4 Manholes or lightening holes are not to be cut in the center girders within $0.75L$ amidships, but if such holes are essential in exceptional cases, suitable compensation is to be provided.

Outside $0.75L$ amidships, holes may be cut in center girders (excluding one frame space forward and aft of a transverse bulkhead) with a depth not exceeding 40% of that of the center girders at that place.

2.6.3 Duct keels

2.6.3.1 Duct keels (pipe tunnels) may be substituted for center girders. The thickness of side plates of the duct keel is not to be less than that of the watertight floors. The side plates are in general not to be spaced more than 2 m apart;

The bottom shell and inner bottom within the region of duct keels are to be suitably increased in thickness.

2.6.3.2 The framing members of the duct keel are to be as follows:

.1 Bottom and inner bottom stiffening members are to be fitted to the duct keel at every frame, and the section modulus W of these framing members is not to be less than that obtained from the following formula:

$$W = 22sdl^2 \quad \text{in cm}^3$$

Where: s — spacing of frames, in m;

l — span, in m, to be taken as the distance between side plates.

.2 Bottom and inner bottom stiffening members are to be gradually increased in scantlings at both ends and are to be connected to the side plates of the duct keel. The enlarged portions are to have a length and depth not less than 1.5 times the depth of the members. In such a case, brackets having the same thickness as the plate floors are to be fitted outside the side plates at each frame where no floor is fitted, and are to be attached to the longitudinals.

.3 Discontinuous bottom longitudinals are to be fitted on the centerline of the vessel in the box middle girder.

2.6.3.3 At the connection between the duct keel and the ordinary center girder, they are to be overlapped over a length not less than 3 frame spaces for transition.

2.6.4 Transverse framing — side girders

2.6.4.1 The thicknesses of side girders are the same as the thicknesses of plate floors in this area. The thicknesses of watertight side girders are to be the same as that of watertight plate floors in this area.

2.6.4.2 The setting of side girders is to be based on the principle that the distance between the girders or the distance between the girders and the side is not more than 4 m. At least one side girder is to be fitted on each side of the centerline when the breadth of the vessel exceeds 10 m. But forward of $0.2L$ from the F.P., the spacing of side girders is not to be greater than 3 frame spaces. Side girders are to be equally spaced as far as practicable.

2.6.5 Transverse framing — plate floors

2.6.5.1 The thickness t of solid floor is not to be less than that obtained from the following formula.

$$t = 0.03L + 5s + 2.6 \quad \text{in mm}$$

Where: s — spacing of frames, in m

The thickness of plate floors in bilge well is to be 2.5 mm greater than that given by the above formula.

2.6.5.2 Plate floors are to be fitted at least 4 frame spaces apart at a spacing not exceeding 3.2 m. Where the depth of floors exceeds 0.9 m, vertical stiffeners spaced not more than 1.5 m apart are to be fitted on the plate floors, generally having the same thickness as that of floors and a depth equal to 1/10 of the depth of floors. Plate floors are to be fitted at every frame in the engine room and under the boiler bearers, thrust seatings, transverse bulkheads and heels of pillars.

Plate floors are to be fitted at every frame forward of $0.2L$ from the F.P.

2.6.6 Transverse framing — watertight floors

2.6.6.1 The thickness of watertight floors is to be as follows:

- .1 The thickness of watertight floors is to be 2 mm greater than that of the plate floors in cargo holds. Watertight floors are to be fitted below transverse watertight bulkheads wherever practicable;
- .2 The thickness of oiltight floors in oil tanks is to be the same as required for the above watertight floors.

2.6.6.2 Where the depth of watertight floors is greater than 0.9 m, they are to be fitted with vertical stiffeners spaced not more than 0.9 m apart. Both ends of stiffeners are to be snapped, and the section modulus W of which is not to be less than that obtained from the following formula:

$$W = 5.5shl^2 \quad \text{in cm}^3$$

Where, s — spacing of stiffeners, in m;

h — vertical distance, in m, from the inner bottom to the top of overflow;

l — span of stiffener, in m, i.e. the considered height of double bottom;

The requirements of the stiffeners on the oiltight floors in oil tanks is to be the same as required in the above formula.

2.6.6.3 Where the double bottom tanks are interconnected with side tanks or cofferdams, the scantlings of the watertight floors are not to be less than those required for deep tanks, furthermore, vertical stiffeners are to be bracketed at both ends.

2.6.7 Bracket floors

2.6.7.1 Where transverse framing is adopted in the double bottom, bracket floors are to be fitted at every frame where no plate floor is fitted. The breadth of the brackets attaching the frames and the reversed frames to the center girder and margin plate is not to be less than 75% of the depth of the center girder, and the thickness of the brackets is to be the same as that of plate floors in that region. Where the depth of the double bottom is equal to 800 mm or more, the brackets are to have a flange or face plate on the unsupported edge and the breadth of the flange or face plate is to be 10 times the thickness but need not exceed 90 mm. Stiffeners having the same scantlings as the reversed frames are to be fitted on one side of the side girders (see Figure 2.6.7.1). Where l as shown in the Figure is greater than 2.5 m, struts as required in 2.6.7.2 of this Section are to be fitted.

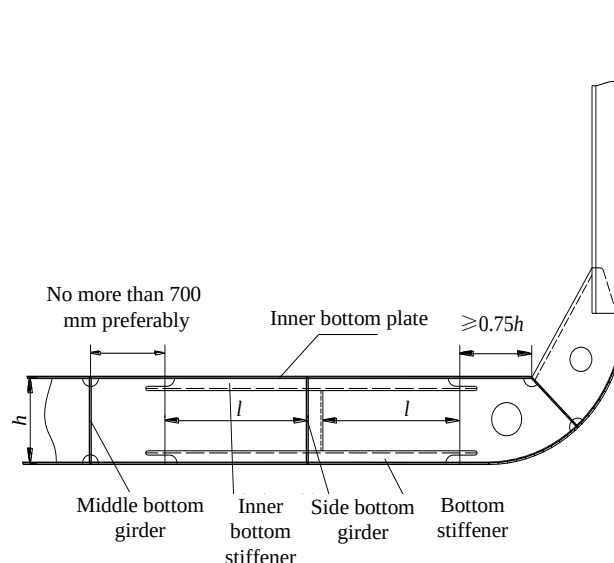


Figure 2.6.7.1 Structural type of double bottom bracket floors

2.6.7.2 The bottom frames of bracket floors are to have a section modulus W not less than that obtained from the following formula:

$$W = (15 - 2.5l_1)sd l^2 \quad \text{in cm}^3$$

Where: s — spacing of frames, in m;

l — span of bottom frames, in m, measured from the edge of the bracket to the side girder (see Figure 2.6.7.1);

l_1 — the same as l , but l_1 is to be taken as 2.5 m for $l > 2.5$ m.

Where struts are fitted at the mid-point of the span l , the section modulus W of the bottom frames is not to be less than half of that given by the above formula.

The cross sectional area A of the struts is not to be less than the following:

$$A = 23.8 + 0.04W \quad \text{cm}^2, \text{ when } W > 85 \text{ cm}^3;$$

$$A = 0.32W \quad \text{cm}^2, \text{ when } W \leq 85 \text{ cm}^3.$$

Where: W — section modulus of bottom frames, in cm^3

The reversed frames are to have a section modulus not less than 85% of that given above for the bottom frames.

When the inner bottom plate is subjected to large pressure, the above-mentioned stiffeners and the like are to be considered separately.

2.6.7.3 The attachment of bottom frames and reversed frames to brackets is to be the same as required in 2.4.5.3 of this CHAPTER for the attachment of frames to bilge brackets.

2.6.8 Lightened floors

2.6.8.1 Where transverse framing is adopted in the double bottom, lightened floors may be fitted at every frame where no plate floor is fitted, as substitutes for bracket floors. The thickness of the web plate of lightened floors is not to be less than that of the plate floor in the same region. The distance from the edge of the lightening hole to bottom and inner bottom is not to be less than 0.2 times the depth of the center girder; the distance from the edge of the lightening hole to the center girder and margin plate is not to be less than 0.5 times the depth of the center girder; the distance from the edge of the lightening hole to the side girder is not to be less than 0.25 times the depth of the center girder; and the length of the lightening hole is not to exceed 1.2 times the depth of the center girder, as shown in Figure 2.6.8.1. The dimensions of the vertical stiffeners on the floors are to comply with the requirements of 2.6.5.2 of this Section, and the spacing of the stiffeners is not to be more than 2.2 m.

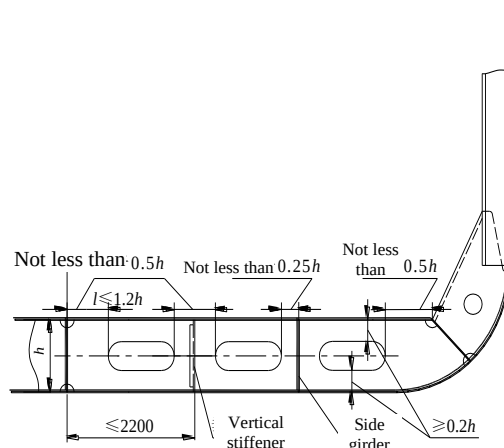


Figure 2.6.8.1 Structural type of double bottom lightened floors

2.6.9 Transverse framing — inner bottom plating and margin plate

2.6.9.1 The thickness t of the inner bottom plating is not to be less than the following:

$$t = 0.04L + 5s + 2.1 \text{ mm, and not less than 6 mm, in the area with } 0.4 L \text{ amidships;}$$

$$t = 0.055L + 4.8 \text{ in mm, in the compartment area.}$$

Where: s — spacing of frames, in m

For $0.075 L$ from the vessel's ends, the thickness is to be 0.9 times that required for $0.4 L$ amidships. The thickness of the inner bottom plating in other regions is to be tapered gradually to the end thickness from the thickness within $0.4L$ amidships.

2.6.9.2 Where the double bottom tanks are used to carry oil fuel, the thickness of the inner bottom plating is not to be less than 8 mm.

2.6.9.3 Where the margin plate is inclined downwards, the breadth of the margin plate is not to be less than 80% of the depth of the center girder. Where the margin plate is horizontal, the breadth is not to be less than that of bilge brackets plus 50 mm.

The thickness of the inner bottom side plating is to be 1.5 mm thicker than that in the fishing tank region; the inner bottom plating in the fishing tank region is not to be less than that required for the inner bottom plating within such spaces.

2.6.10 Longitudinal framing — bottom girders

2.6.10.1 The depth and thickness of the center girder are to be the same as required in 2.6.2.1 and 2.6.2.2 of this Section. Between plate floors, brackets having the same thickness as the plate floors are to be fitted on each side of the center girder, extending to the adjacent longitudinals. Such brackets are in general to be spaced not more than 1.20 m apart. Where the center girder is watertight, vertical stiffeners spaced not more than 0.9 m apart are to be fitted between the plate floors and brackets (when the distance between them is greater than one frame space). For these stiffeners, the section modulus is to comply with the requirements of 2.6.6.2.

2.6.10.2 At least one side girder is to be fitted on each side of the centerline when the breadth of the vessel exceeds 12 m but not greater than 20 m, and at least two side girders spaced apart generally not more than 5 m are to be fitted on each side of the centerline when the breadth of the vessels exceeds 20 m. Forward of $0.2L$ from the F.P. the spacing of side girders is not to be greater than four longitudinal spaces. Side girders are to be equally spaced as far as practicable.

The thickness of side girders and watertight side girders are to comply with the requirements of 2.6.4.1 of this Section. Where the double bottom tanks are interconnected with side tanks or cofferdams, the thickness of side girders is to be as required for deep tanks.

Side girders and watertight side girders are in general to be fitted with vertical stiffeners. Vertical stiffeners of side girders are to be spaced according to the provisions of 2.6.5.2 of this PART. Vertical stiffeners of watertight side girders are to comply with the requirements of 2.6.6.2.

2.6.11 Longitudinal framing — plate floors

2.6.11.1 In machinery spaces, plate floors are to be fitted at least at alternate frames, and are to be fitted at every frame under the main engine seating, boiler bearers, thrust seatings, transverse bulkheads and heels of pillars.

Plate floors are to be fitted at alternate frames within the region forward of $0.2L$ from the F.P. Elsewhere, the spacing of the plate floors is not to exceed 3.6 m.

2.6.11.2 The thickness of plate floors for longitudinally framing is to be 10% greater than that required in

2.6.5.1 of this Section, but need not exceed 15 mm, and the thickness of watertight and oiltight floors is to be the same as required in 2.6.6.1 of this Section.

Vertical stiffeners are to be fitted at each longitudinal. The thickness of the vertical stiffener of the non-watertight plate floors is equal to the thickness of the plate floors. The width of such stiffeners is not to be less than $1.65L$ (mm), with a minimum of 50 mm. In addition, the scantlings of vertical stiffeners for watertight floors are to comply with the requirements of 2.6.6.2 of this PART. Vertical stiffeners are to be attached to the inner bottom and shell longitudinals by welding.

The ratio of thickness to depth of the floors is not to be less than $1/130$. Where the double bottom tanks are interconnected with side tanks or cofferdams, the thickness of watertight floors and the stiffeners are to be as required for deep tanks.

2.6.12 Longitudinal framing — bottom longitudinals

2.6.12.1 The spacing of bottom longitudinals is not to be greater than 0.75 m.

2.6.12.2 The section modulus W of bottom longitudinals is not to be less than that obtained from the following formula:

$$W = \frac{8.5f}{0.73} (d + h_1) s l^2 \quad \text{in cm}^3$$

Where: s — spacing of longitudinals, in m;

l — span of longitudinal, in m, but not less than 1.5 m;

f — coefficient, taken as 0.52 when intermediate vertical struts are fitted, or 1.0 when no intermediate vertical strut is fitted;

h_1 — see 2.2.1.3 of this PART.

Where the spacing of plate floors is greater than 2.5 m, vertical struts connecting the bottom longitudinals and inner bottom longitudinals may be fitted at the midpoint of the spacing, and the cross sectional area A of the vertical struts is not to be less than the following:

$$A = 23.8 + 0.04W \quad \text{cm}^2, \text{ when } W > 85 \text{ cm}^3;$$

$$A = 0.32W \quad \text{cm}^2, \text{ when } W \leq 85 \text{ cm}^3;$$

Where: W — section modulus of longitudinals, in cm^3

2.6.12.3 The section modulus of inner bottom longitudinals is to be equal to 85% of that of the bottom longitudinals. In boiler rooms, the thickness of the longitudinals, struts and brackets is to be increased by 2 mm.

2.6.12.4 Where longitudinals pass through non-watertight floors, they are to be welded to the floors and the vertical stiffeners on the floors in way. Where longitudinals are cut in way of watertight floors, they are to be bracketed to the watertight floors. The scantlings of the brackets are to comply with the requirements of 1.2.5 of this PART.

2.6.13 Longitudinal framing — inner bottom plating and margin plate

2.6.13.1 The thickness of the inner bottom plating is to comply with the requirements of 2.6.9 of this PART. But for the calculation of the thickness of the inner bottom plating within $0.4L$ amidships, the s in the formula is to be taken as the spacing of longitudinals, and the value considered may be reduced by 1 mm.

2.6.13.2 The thickness of the margin plate is to comply with the requirements in 2.6.13.1 of this Section and in addition, is to be increased in accordance with the requirements of 2.6.9.3 of this PART.

2.6.13.3 The margin plate is to be provided with brackets at every frame, extending to the adjacent longitudinal (as shown in Figure 2.6.13.3). The edges of the brackets are to be strengthened, and the thickness of the brackets is to be the same as that of floors.

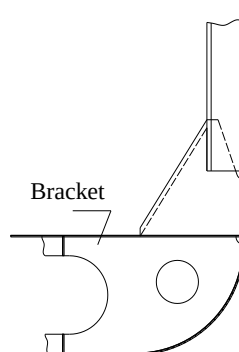


Figure 2.6.13.3 Type of brackets at every frame

2.6.14 Bilge brackets

2.6.14.1 Tank side brackets are to be fitted at every frame and their thickness is to be the same as that of plate floors. Circular lightening holes may be cut in the tank side brackets and the distance from any point of hole edges to the side of brackets is not to be less than 1/3 breadth of the bracket.

2.6.14.2 Tank side brackets are to be flanged or provided with a face plate on the free edge, and the breadth of the flange or face plate is generally to be 10 times the thickness of the bracket.

2.6.14.3 The standard depth and breadth of tank side brackets are to be as follows:

The depth of tank side brackets connecting secondary members is to be equal to 1/10 of the distance between the inner bottom and nearest deck or 2.5 times the depth of the web of frames, whichever is the greater. The depth of tank side brackets connecting primary members is to be equal to 1.8 times the depth of the web of web frames. The breadth of tank side brackets is to be equal to their depth. Where the inner bottom margin plate of the double bottom is horizontal, vertical stiffeners are to be fitted to the floors under the toes of the brackets (as shown in Figure 2.6.14.3). The requirements for the stiffeners are to be the same as required in 2.6.5.2 of this Section.

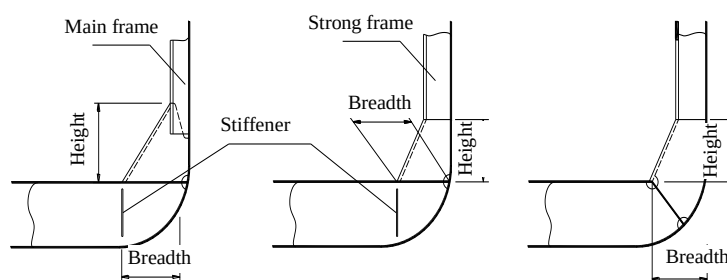


Figure 2.6.14.3 Double plate floors

2.6.14.4 Where lap joint is adopted for the connection of tank side brackets to frames, the length of overlap is to comply with the requirements of 2.4.5.3 of this PART.

2.6.14.5 Where bottom and sides of the vessel are framed longitudinally and no bilge longitudinals are fitted, the transverse strength members or corresponding bilge brackets in way are to have a spacing S not exceeding:

$$S = 8 \times 10^6 \frac{t^2}{Dr} \sqrt{\frac{t}{r}} \text{ in mm}$$

Where: t — Thickness of bilge plate, in mm;
 r — Bilge radius, in mm.

Furthermore, a suitable number of intermediate bilge brackets connected to the longitudinals situated at the upper and lower turns of the bilge are to be fitted between the plate floors.

Section 7 SIDE FRAMING

2.7.1 General Requirements

2.7.1.1 The spacing of frames of the forepeak and aft peak tanks and tail oblique frame spacing are not to be greater than 0.6 m. The maximum spacing of frames or side longitudinals of other sites are not to be greater than 0.7 m.

2.7.2 Frames

2.7.2.1 When calculating the section modulus of the main frame, the span of frames l shall be selected according to the following different areas:

.1 For frames between collision bulkhead and $0.2L$ from F.P., it is to be the greatest frame span l in that region;

.2 The maximum l of this region is to be taken as between $0.2L$ to fore perpendicular to collision bulkhead.

Spacing of frames l refers to the vertical distance from the upper edge of the face plate of plate floors or inner bottom plate on vessel side to the lowest deck line, but are not to be less than $\sqrt{D}$.

2.7.2.2 Except for the forepeak and aft peak tanks, the section modulus W of the main frame is not to be less than that obtained from the following formula:

$$W = csdl^2 \text{ in cm}^3$$

$$c = \frac{(2 + \frac{0.65d}{D})}{(1.45 - \frac{\sqrt{D}}{l})}$$

Where: c —coefficient,

s —spacing of frames, in m;

l —span of frames, in m. See the provisions of 2.7.2.1 of this PART.

If side girders complying with the requirements of 2.7.5 of this PART are provided and arranged equally, the section modulus of the main frame may be reduced as follows:

.1 Where one stringer is fitted, the section modulus of main frames may be 1/2 of the value required in 2.7.2.2 of this Section;

.2 Where two stringers are fitted, the section modulus of main frames may be 2/7 of the value required in 2.7.2.2 of this Section.

2.7.2.3 In any case, the section modulus of the main frame is not to be less than the section modulus of the deck frames calculated in accordance with 2.7.4 of this PART.

2.7.2.4 The moment of inertia I of main frames is not to be less than that obtained from the following formula:

$$I = 3.2Wl \text{ in cm}^4$$

Where: W —see 2.7.2.2 of this PART;

l —The actual span of frames, in m, where the side stringers are to be taken as the support points for the span.

2.7.3 Forepeak tank frame

2.7.3.1 The section modulus W and moment of inertia I of the frames in the forepeak and aft peak tanks are not to be less than the values calculated according to the following formulae respectively:

$$W = 2.3sdDl \text{ in cm}^3$$

$$I = 3.5Wl \text{ in cm}^4$$

Where: s —spacing of frames, in m;

l —span of frames, in m, being the vertical distance measured from the upper edge of floor to the side stringer (perforated flat), or distance between side stringers (perforated flats) or from the side stringer (perforated flat) to the lowest deck, in m, when $l < 2\text{ m}$, take 2 m.

2.7.4 Frames in 'tween decks and superstructures

2.7.4.1 The section modulus W of the frames in 'tween decks and superstructures is not to be less than that obtained from the following formula (and not to be less than 10cm^3):

$$W = cc_1sdl\sqrt{D} \text{ in cm}^3$$

Where: s —spacing of frames, in m;

l —span of frame, in m. For frames in 'tween deck space where the actual span is less than 2.6 m, $l = 2.6$ m is to be taken and for those in superstructures where the actual span is less than 2.3 m, $l = 2.3$ m is to be taken;

c —coefficient, to be taken as $0.7 + 4d / D$;

c_1 —coefficient, to be determined by the position of frame: $c_1 = 1.0$ for those in the first 'tween deck below the upper deck; $c_1 = 1.1$ for those in the second 'tween deck; $c_1 = 1.45$ for those in the third and lower 'tween decks; $c_1 = 0.90$ for those in forecastle; $c_1 = 0.80$ for those in bridge and poop;

2.7.5 Side stringers

2.7.5.1 Where side stringers are fitted to support the main frames and 'tween deck frames, the section modulus W and the moment of inertia I of the side stringers are not to be less than those obtained from the following formulae respectively:

$$W = 7.8hbl^2 \text{ in cm}^3$$

$$I = 2.5Wl \text{ in cm}^4$$

Where: b —width of areas supported by the side stringers, in m;

h —vertical distance, in m, measured from the mid-span of side stringer to upper deck at side, in m;

l —span of side stringers, in m;

2.7.5.2 Brackets are to be fitted and other equivalent measures are to be taken at the connection between side stringers and transverse bulkheads. Side stringers and web frames are to be so connected that an adequate continuity of the face plate or flange of side stringers is kept.

2.7.5.3 In transversely framed machinery spaces, side stringers are to be fitted to support main frames where the main frame span exceeds 3 m and their section modulus and moment of inertia are to comply with 2.7.5.1 of this Part. Their web depth is not to be less than 2.5 times that of main frames.

2.7.5.4 In transversely framed machinery spaces, an arrangement of intercostal side stringers may be accepted as an alternative to the side stringers specified in 2.7.5.3 of this PART and their web depth is to be the same as that of main frames, their web thickness t and sectional area A are to be respectively not less than those obtained from the following formulae:

$$t = 0.023L + 6 \quad \text{in mm}$$

$$A = 0.14L + 1 \quad \text{in cm}^2$$

2.7.5.5 The main frame in the machinery space is to be connected to the side stringers with brackets at every other frame position. The other main frames are to be connected to the side stringers with stiffeners, or directly connected to the girder web by welding.

2.7.6 Transverse framing - web frames

2.7.6.1 In way of machinery spaces situated astern, web frames are to be provided. The web frames are to extend from the bottom transverse or inner bottom plating to the upper deck. The spacing of web frames is not to be greater than five spacing of frames. The section modulus W' of web frames is not to be less than that obtained from the following formula:

$$W' = 0.2ncW \quad \text{in cm}^3$$

Where: n —Number of frame spacing between web frames;

W —Sectional modulus of main frames in the machinery space, calculated in accordance with 2.7.2.2 of this PART;

c —coefficient, selected according to the section modulus of main frame. See Table 2.7.6.1.

Coefficient Table 2.7.6.1

w , in cm^3	≤ 20	50	100	150	200	300	400	500	600
c	8.4	7.7	6.6	5.5	4.4	4.3	4.2	4.1	4.0

2.7.6.2 The web height of the web frame in machinery space is not to be less than 2.5 times the height of the adjacent main frame. When the main frame is not supported by side stringers, the web height of the web frame is not to be less than 2 times the height of the adjacent main frame.

2.7.6.3 For machinery amidships fishing vessels, if web frames are not provided in accordance with the provisions stipulated in 2.7.6.1 of this PART, the section modulus of main frames below the bulkhead deck in the machinery space is to increase by 50%.

2.7.6.4 The scantlings of web frames supporting side stringers are to be determined by direct calculation based on the assumptions that both ends are rigidly fixed and that they are subject to concentrated loadings transmitted by side stringers (the considered pressure head being the distance from the mid-span of side stringers to upper deck at side, in m), with the permissible bending stress being taken as 93.2 N/mm^2 , in N/mm^2 and the allowable shear stress as 83.4 N/mm^2 , in N/mm^2 .

2.7.7 Side longitudinals

2.7.7.1 The section modulus W of side longitudinals below the upper deck (including bilge longitudinals) is not to be less than that obtained from the following formula:

$$W = \frac{8.5}{f} hsl^2 \quad \text{in cm}^3$$

Where: s —spacing of longitudinals, in m;

l —span of longitudinal, in m;

f —The coefficient, to be taken in accordance with following two formulae, and to be taken as not greater than 1.077:

$$f = 1.73 - \frac{Z - Z_n}{D - Z_n}, \text{ when } Z \geq Z_n;$$

$$f = 1.73 - \frac{Z_n - Z}{Z_n}, \text{ when } Z < Z_n.$$

h — design pressure head, to be taken from the following formula:

$$h = 0.26C + d - \frac{Z}{D}(0.06C + d)$$

Z_n — the height of horizontal neutral axis, from base line, of hull cross section, in m;

C — coefficient, see 2.1.3.1 of this PART;

Z — height of longitudinals from base line, in m;

2.7.7.2 Within the region between 0.2L from the F.P. and the forepeak bulkhead, the section modulus of side longitudinals below the upper deck is to be in accordance with 2.7.7.1 of this PART and also in accordance with 2.7.7.4 of this PART.

2.7.7.3 For machinery spaces situated aft, the section modulus of side longitudinals in the areas of the machinery spaces is to be in accordance with 2.7.7.1 of this PART and in addition, not less than 0.8 times that obtained from the formula in 2.7.7.5 of this PART.

2.7.7.4 In the forepeak, the section modulus W of side longitudinals is to be taken as not less than that obtained from the following formula:

$$W = 7.5shl^2 \text{ in cm}^3$$

Where: s — spacing of longitudinals, in m;

h — vertical distance, in m, measured from the longitudinal to 3 m above the minimum bow height required by the load line;

l — span of longitudinals, in m, but taken as not less than 1.5 m.

2.7.7.5 In the aft peak, the section modulus W of side longitudinals is to be taken as not less than that obtained from the following formula:

$$W = 8.5sl^2(h + 0.167D) \text{ in cm}^3$$

Where: s — spacing of longitudinals, in m;

l — span of longitudinals, in m, but taken as not less than 1.5 m;

h — vertical distance from the longitudinal to upper deck at side, in m, but not to be less than 3 m;

2.7.7.6 The section modulus of side longitudinals (including bilge longitudinals) need not be greater than that of bottom longitudinals with the same spacing.

2.7.7.7 The side longitudinals are to penetrate web frames and the intersections of longitudinal webs and frame webs are to be welded. Where a side longitudinal is cut in way of a transverse bulkhead, brackets are to be fitted at the connection between the longitudinal and the bulkhead, and the brackets are to comply with the relevant provisions in 1.2.6 of this PART.

2.7.8 Longitudinal framing — web frames

2.7.8.1 Where the side is framed longitudinally, web frames supporting side stringers are to be fitted in line with plate floors. Web frames are to be provided in the solid floor plan. In general, the spacing of web frames is not to be greater than 3.6 m. The spacing of longitudinal web frames is not to be greater than 2.5 m in the forepeak and afterpeak tanks.

2.7.8.2 Other than in machinery spaces and forepeak and aft peak, the section modulus W of web frames is not to be less than that obtained from the following formula:

$$W = 10Shl^2 \text{ in cm}^3$$

Where: S — spacing of web frames, in m;

h — vertical distance, in m, measured from the mid-span of the web frame to upper deck at side;

l — span of web frames, in m.

2.7.8.3 In longitudinally framed machinery spaces, the section modulus W of web frames is not to be less than that obtained from the following formula:

below the lowest deck: $W = 10Shl^2$ in cm^3

In 'tween decks: $W = 4.4Sdl\sqrt{D}$ in cm^3

Where: S — spacing of web frames, in m;

h — vertical distance, in m, measured from the mid-span of the web frame to upper deck at side;

l — span of web frames, in m.

The web depth of web frames is not to be less than 2.5 times that of the side longitudinal supported by it.

2.7.8.4 In the longitudinally framed forepeak, the section modulus W and the moment of inertia I of web frames are respectively not to be less than those obtained from the following formulae:

$$W = 14Shl^2 \text{ in } \text{cm}^3$$

$$I = 2.5Wl \text{ in } \text{cm}^4$$

Where: S — spacing of web frames, in m;

h — vertical distance, in m, measured from the mid-span of the web frame to tank top or half of the vertical distance from the mid-span of the web frame to the top of overflow, whichever is the greater;

l — span of web frames, in m.

2.7.8.5 In longitudinally framed afterpeak, the section modulus W of web frames is not to be less than that obtained from the following formula:

$$W = 10Shl^2 \text{ in } \text{cm}^3$$

Where: S — spacing of web frames, in m;

h — vertical distance, in m, measured from the mid-span of the web frame to upper deck at side,

l — span of web frames, in m.

2.7.8.6 The end connections of web frames for longitudinal framing are to comply with the relevant provisions in Sections 6 and 8 of this CHAPTER.

2.7.9 Local strengthening

2.7.9.1 The scantlings of four frames fitted at each end of the bridge are to be calculated by the formula used for 'tween deck frames located below the upper deck in way of the bridge.

2.7.9.2 When the length of the forecastle and poop is greater than $0.25L$, the scantlings of two frames fitted at the rear end of the forecastle and front end of the poop are to be calculated by the formula used for 'tween deck frames located below the upper deck.

2.7.9.3 The section modulus of the web frame under the hatch end beam is not to be less than 1.67 times the section modulus of the ordinary web frame. Fishing vessels less than 30m in length are exempt from this restriction.

2.7.10 Connection at frame ends

2.7.10.1 Frames are connected to the beams by brackets. The sizes of brackets are to comply with the requirements specified in 1.2.5 of this PART.

2.7.10.2 Where 'tween deck frames terminate at lower decks, their lower ends are to be bracketed. The scantlings of the brackets are to be the same as those at the upper end of 'tween deck frames. If no brackets are provided at the discontinuity and the 'tween deck frames are welded directly to the lower deck, the 'tween deck frames are to be aligned with the lower 'tween deck frames or the main frames.

Section 8 DECK FRAMING

2.8.1 Deck load

2.8.1.1 The design head h of decks is to be selected according to the following requirements:

1 The design head h_0 of strong weather decks is not to be less than the value calculated by the following formula:

$$h_0 = 0.01L + d / D + 0.1 \text{ in m}$$

Where: d/D — ratio of the draught and moulded depth of vessel, d/D take 0.7 when < 0.7 .

h_0 it is neither to be less than 1.2 m, nor greater than 1.5 m.

.2 The design heads of other decks are to be selected according to Table 2.8.1.1.2.

.3 When $L \leq 30\text{m}$, the design head of the deck h is to be taken as: 1.0 m for strong deck; 0.6m for other decks.

Design heads h of decks Table 2.8.1.1.2

Deck name and location	Design head, in m
Weather/strength deck or exposed forecastle deck forward of $0.075 L$ from F.P.	$1.2 h_0$
Weather/strength deck or exposed forecastle deck between $0.075 L$ and $0.15 L$ from F.P.	$1.1 h_0$
When the lower deck, platform deck and superstructure deck are used for living and stowage	Take h_0 but not greater than 1.39
Short bridge deck, poop deck and deckhouse deck	When $d/D_s = 0.7$, 80% of h_0
Decks above the superstructure deck or above the first deck of deckhouse	Take 60%, 40% d/D_s of the value h_0 when $= 0.7$ in order ... but not less than 0.56

Note: Select according to actual load in deck machinery space, mast base, boom base, machinery space spare room and fishing tank. When the loading rate (the ratio of the mass of cargo in the cabin to the capacity) when $r > 0.72 \text{ t/m}^3$, the design head of corresponding deck is to be multiplied by $r/0.72$.

2.8.2 Deck beam

2.8.2.1 The section modulus W of deck beam is not to be less than that obtained from the following formula:

$$W = 4.6cshl^2 \text{ in cm}^3$$

Where: c —coefficient, $c=1.2$; for fishing vessels with multi-deck and $L < 30 \text{ m}$, $c=1$;

s —Beam spacing, in m;

h —Design head, in m, which can be selected according to the provisions of 2.8.1 in this PART;

l —Beam span, in m, i.e. between deck stringers, between hatch coamings and deck stringers, hatch coamings or deck stringers and beam brackets

The distance between the midpoints of the horizontal edges. This value is not be less than $B/3$.

2.8.2.2 Beam arch of weather deck beams: when $B \leq 10\text{m}$, generally it is not to be less than $2\%B$; when $B > 10\text{m}$, generally it is not to be less than $1\%B$.

2.8.2.3 The deck beam of the watertight bulkhead step is to meet the requirements of 2.10.6 of this PART.

2.8.2.4 The connection between the beam and frame is to comply with the requirements of 1.2.5 of this PART.

2.8.2.5 Beams are to pass through deck girders, and they are welded to the girder web by welding. Where beams are to be cut in way of the longitudinal stringer the beams are to be connected to longitudinal stringer by brackets. The scantlings of brackets are to comply with the requirements of 1.2.5 of this PART. The height of brackets is to extend to the longitudinal stringer face plate and weld firmly.

2.8.2.6 Strong beams are to be provided under concentrated loads such as cable lifter, hauling machine and mast, and at the top of the strong frames in machinery space. The section modulus of transverse is not to be less than the section modulus of the deck stringer. Web frames are to be provided under transverses. If no transverses are provided, they can be strengthened by other methods.

2.8.2.7 Transverses are to be connected to frames by one of the following methods:

- .1 When transverses are connected to the frames or longitudinal bulkheads by brackets with flanges or face plates, the arm length of the bracket is to be identical with the transverse web height. The thickness is to be identical with that of the transverse web. The dimensions of the flanges or panels of the brackets are to be the same as those of transverses with flange or face plates. In addition, the transverse webs are to be directly welded to frames or longitudinal bulkheads. If the arm length of the bracket is increased to 1.5 times the beam height, it is not necessary to weld the transverse web to longitudinal bulkhead.
- .2 When the web height of transverse is gradually increased at the connecting end to replace the bracket, its height and width are not to be less than 1.5 times the height of the transverse web. The panel is to be a continuation of the transverse face plate.

2.8.3 Transverse framing — deck girders

2.8.3.1 The spacing of deck girders supporting beams is not to be greater than 4 m; for weather strength

deck forward of 0.075L from F.P., the spacing of deck girders is not to be greater than 3.6 m; the spacing of deck girders after the afterpeak is not to be greater than 3 m; the modulus of section area W is not to be less than the value calculated by the following formula:

$$W = 4.75bhl^2 \text{ in cm}^3$$

Where: b — mean width, in m, of deck area supported by deck girders;

h — design head of deck, in m, see 2.8.1.1 of this PART;

l — span of deck girder, in m;

2.8.3.2 Where deck girders arranged to support beams are subject to a concentrated load, their section modulus W is to be not less than that obtained from the following formula:

$$W = 0.102cPl \text{ in cm}^3$$

Where: c — coefficient, to be selected according to the interpolation in Table 2.8.3.2. In the table, a is the distance, in m, between the application point of concentrated load P and the farther one of two supports of the girder;

P — concentrated load, kN;

l — span of deck girder, in m.

Coefficient c

Table 2.8.3.2

a/l	0.94	0.90	0.85	0.80	0.75	0.70	0.60	0.50
c	1.44	3.36	5.68	7.36	8.64	9.20	9.60	10

2.8.3.3 Where deck girders arranged to support beams are subject to two or three point loads, their section modulus W is to be determined by direct calculations assuming fixed ends and using an allowable bending stress of 124N/mm².

2.8.3.4 The moment of inertial I of deck girder is not to be less than that obtained from the following formula:

$$I = 2Wl \text{ in cm}^4$$

Where: W — section modulus of deck girders required in this Section, in cm³;

l — span of deck girder, in m.

2.8.3.5 The web depth of deck girders is not to be less than 1.6 times the depth of cut-outs for the passage of beams. The cut-outs in deck girders are to be designed to minimize the creation of stress concentration on the web. The web thickness of deck girders is not to be less than 1% of the web depth plus 4 mm. The web thickness of deck girders at the deckhouse is not to be less than 1% of the web depth plus 2 mm.

2.8.3.6 Holes cut for the passage of pipes or cables in the web of deck girders are to have a depth not greater than 25% of that of the web and a width not exceeding 60% of the spacing of beams or the web depth, otherwise compensation is required. The edges of holes are not to be less than 40% of the web depth from the face plate of girders. The edges of the holes are to be smooth and well rounded. The holes are not to be concentrated in the adjacent frame spaces. No holes are to be cut on the girder web within 200 mm from the toe of girder brackets.

2.8.3.7 The deck stringers and transverse bulkheads are to be connected in any of the following ways:

- .1 In addition to welding the girder webs to the bulkheads, brackets with face plates or flanges are to be provided at the junction of girder and bulkheads. The arm length of the brackets is to be equal to the height of the deck girder web. The thickness of the bracket is to be the same as that of the girder web, and the sizes of the face plate or flange of the bracket are to be the same as the size of face plate or flange of the girder;
- .2 Gradually raise the deck stringer web towards the bulkhead. The height at the bulkhead is to be 1.5 times the original height (1.2 times in the superstructure). Weld the raised web to the bulkhead. The length of web lifting range is not to be less than 1.5 times the original height of deck stringer web. Extend the face plate of deck girder to the bulkhead;
- .3 Deck girder counted in longitudinal strength is to pass through watertight bulkheads, or their connecting brackets may be passed through bulkheads. The girders are to be smoothly transited to brackets.

2.8.3.8 Deck stringers are to be provided with tripping brackets in accordance with 1.2.4.4 of this PART.

2.8.4 Transverse framing — deck transverses

2.8.4.1 For deck transverses supporting deck girders, the scantlings are to be determined by direct calculations assuming fixed ends and the function for sustaining concentrated loads transmitted by deck girders and using an allowable bending stress of 124N/mm².

2.8.4.2 The section moment of inertia I of deck transverses supporting deck girders is not to be less than that obtained from the following formula:

$$I = 2Wl \quad \text{cm}^4$$

Where: W —section modulus of deck transverses, in cm^3 , obtained according to 2.8.4.1 of this Section;

l —span of deck transverse, in m ;

2.8.4.3 The thickness and cutouts of the web of deck transverses supporting deck girders are to comply with the provisions in 2.8.7.7 and 2.8.7.8 of this Section.

2.8.4.4 The connections between deck transverses supporting deck girders and frames or web frames or longitudinal bulkheads are to comply with the provisions of 2.8.7.9 of this Section.

2.8.5 Deck longitudinals

2.8.5.1 The section modulus W of weather/strength deck is not to be less than that obtained from the following formula:

$$W = 1.1c_1shl^2 \quad \text{in cm}^3$$

$$W = 1.1(c_2sh + c_3sl^2L^2 \times 10^{-4}) \quad \text{in cm}^3$$

Where: s —spacing of longitudinals, in m ;

h —design head of deck, in m , see 2.8.1.1 of this PART, but outside the line of deck openings within 0.4L amidships:

$$h \geq \frac{22.6L}{1780 - L}$$

l —span of longitudinals, in m , to be taken as not less than 2 m ;

c_1 , c_2 and c_3 —coefficients, to be determined according to Table 2.8.5.1;

Coefficients c_1 , c_2 and c_3

Table 2.8.5.1

Item No.	Location of deck longitudinal	Region	c_1	c_2	c_3
1	Forward of 0.075L from F.P.		12.5	63.5	7.8
2	Between 0.075L ~ 0.15L from F.P.		12.5	57	7.2
3	At 0.15L from F.P.	Outside the line of openings	9	48.5	6.2
		Inside the line of openings	7.5	40	5.5
4	Between 0.15L ~ 0.3L from F.P.	Outside the line of openings	See note		
		Inside the line of openings	7.5	40	5.5
5	0.4L amidships	Outside the line of openings	10.5	—	—
		Inside the line of openings	7.5	40	5.5
6	Between 0.075L ~ 0.3L from A.P.	Outside the line of openings	See note		
		Inside the line of openings	7.5	40	5.5
7	Aft of 0.07L from A.P.		7.5	40	5.5

Note: The section modulus W of deck longitudinals in way of the region may be determined after tapering the section module of amidships and end deck longitudinals.

2.8.5.2 The section modulus W of cargo deck longitudinals is not to be less than the following:

$$W = 5.5shl^2 \quad \text{in cm}^3$$

Where: s , h and l —see 2.8.5.1 of this PART.

2.8.5.3 The section modulus W of accommodation and superstructure deck longitudinals is not to be less than the following:

$$W = 4.4shl^2 \quad \text{in cm}^3$$

Where: s , h and l —see 2.8.5.1 of this PART.

2.8.5.4 The web depth of deck longitudinals is in no case to be less than 60 mm .

2.8.5.5 The deck longitudinals outside the line of deck openings are to pass through deck transverses and to be connected to the deck transverse webs by welding. Where the deck longitudinals are cut in way of the web plates of hatch end beams or deck transverses (only for those inside the line of deck openings or at the vessel's ends), brackets are to be fitted at the connection between deck longitudinals and hatch end beams or deck transverses and the scantlings of the brackets are to comply with the relevant provisions in 1.2.5 of this PART. The brackets are to be extended to the face plate of hatch end beams or deck transverses along the web plates of hatch end beams or deck transverses.

2.8.5.6 Where deck longitudinals are cut in way of transverse bulkheads, brackets are to be fitted at the connection between deck longitudinals and transverse bulkheads and the scantlings of the brackets are to comply with the relevant provisions in 1.2.5 of this PART. Where higher tensile steel is adopted, the deck longitudinals outside the line of deck openings are to be continuous through the transverse bulkheads, but alternative arrangements may be considered.

2.8.5.7 The deck longitudinals outside the line of deck openings are not to be terminated at the same transverse section and their ends are to be suitably shifted from one another. These ends are to extend to the adjacent transverse members.

2.8.6 Longitudinal framing — deck girders

2.8.6.1 For deck girders supporting deck transverses, the scantlings are to be determined by direct calculations assuming fixed ends and the function for sustaining concentrated loads transmitted by deck transverses and using an allowable bending stress of 124N/mm^2 .

2.8.6.2 The section moment of inertia I of deck girders supporting deck transverses is not to be less than that obtained from the following formula:

$$I = 2Wl \text{ in cm}^4$$

Where: W — section modulus of deck girders, in cm^3 ; obtained according to 2.8.6.1 of this Section;

l — span of deck girder, in m.

2.8.6.3 The thickness and cutouts of the web of deck girders supporting deck transverses are to comply with the relevant provisions in 2.8.3.5 and 2.8.3.6 of this Section respectively.

2.8.6.4 The connections between deck girders supporting deck transverses and transverse bulkheads are to comply with the relevant provisions of 2.8.3.7 of this Section.

2.8.7 Longitudinal framing — deck transverses

2.8.7.1 Where the deck is framed longitudinally, deck transverses supporting the deck longitudinals are to be fitted in line with plate floors. Deck transverses are to be provided in the solid floor plan. In general, the spacing of deck transverses is not to be greater than 3.6 m; in the forepeak and aft peak, the spacing of deck transverses framed longitudinally, it is not to be greater than 2.5 m.

2.8.7.2 In the machinery spaces and aft peak tank, deck transverses supporting deck longitudinals are to be fitted in frames spaces of web frames.

2.8.7.3 The section modulus W of deck transverses supporting deck longitudinals is not to be less than that obtained from the following formula:

$$W = 5Shl^2 \text{ in cm}^3$$

Where: S — spacing of deck transverses, in m;

h — design head of deck, in m, see 2.8.1.1 of this PART;

l — spacing of transverses, in m.

2.8.7.4 The section modulus of deck transverses in single deck vessels is to be 15% greater than that obtained from the formula in 2.8.7.3 of this Part.

2.8.7.5 Where the deck transverses supporting deck longitudinals are subject to concentrated loads, their increased section modulus may be determined by calculations in accordance with the requirements for deck girders in 2.8.3.2 or 2.8.3.3 of this Section.

2.8.7.6 The section moment of inertia I of deck transverses supporting deck girders is not to be less than that obtained from the following formula:

$$I = 2Wl \text{ in cm}^4$$

Where: W — section modulus of deck transverses, in cm^3 ; as required in this Section;

l — spacing of transverses, in m.

2.8.7.7 The web depth of deck girders is not to be less than 1.6 times the depth of cut-outs for the passage of beams. The cut-outs in deck girders are to be designed to minimize the creation of stress concentration on the web.

The web thickness of deck girders is not to be less than 1% of the web depth plus 4 mm.

2.8.7.8 Holes cut for the passage of pipes or cables in the web of deck transverses are to have a depth not greater than 25% of that of the web and a width not exceeding 60% of the spacing of deck longitudinals or the web depth, whichever is the greater, otherwise compensation is required. The strength level of the material of strengthening pieces is not to be lower than that of the web material. The edges of holes are not to be less than 40% of the web depth from the face plate of deck transverses. The edges of the holes are to be smooth and well rounded. The holes are not to be concentrated in the spacing of adjacent longitudinals. No holes are to be cut on the web of deck transverses within 200 mm from the bracket toe of deck transverses.

2.8.7.9 The ends of deck transverses are to be bracketed to frames or web frames or longitudinal bulkheads, and the scantlings of brackets are to comply with the relevant provisions in 1.2.6 of this PART. Where the connection between deck transverses and web frames or longitudinal bulkhead vertical webs is designed as an integral structure, a ring system is generally to be formed and connecting brackets are to have the form of an circular arc with a radius generally not less than the web depth of deck transverses or web frames or longitudinal bulkhead vertical webs, whichever is the smallest. The brackets are to be provided with a face plate to connect the face plate of deck transverses and that of web frames or longitudinal bulkhead vertical webs, and the scantlings of the face plate are to be the same as those of the face plate of deck transverses. When the sizes of brackets are large, reinforcement frames are to provide on the brackets.

2.8.8 Deck hatch side girders

2.8.8.1 Where weather deck hatch side girders (including weather deck hatch side coamings) act as deck girders and are supported at both ends of the hatchway, their section modulus W and section moment of inertia I are not to be less than those obtained from the following formulae respectively:

$$W = 7hbl^2 \quad \text{in cm}^3$$
$$I = 2.6Wl \quad \text{in cm}^4$$

Where: h — design head of deck, in m, see 2.8.1.1 of this PART;

b — mean width, in m, of deck area supported by deck hatch side girders;

l — span of deck hatch side girder, in m;

2.8.8.2 The section modulus W and moment of inertia I of deck girder at the lower deck hatch are not to be less than that obtained from the following formula:

$$W = 5.2hbl^2 \quad \text{in cm}^3$$
$$I = 2Wl \quad \text{in cm}^4$$

Where: h — design head of deck, in m, see 2.8.1.1 of this PART;

b — mean width, in m, of deck area supported by 'tween deck hatch side girders;

l — span of 'tween deck hatch side girder, in m;

2.8.8.3 Where 'tween deck hatch side girders are subject to concentrated loads, the section modulus is to be increased to 1.1 times that obtained according to 2.8.3.2 or 2.8.3.3 of this Section.

2.8.8.4 The depth of the web of deck hatch side girders below deck is not to be less than that of the beam web to which it is connected.

2.8.8.5 In the calculation of the section modulus and section moment of inertia of deck hatch side girders (including hatch coamings), the upper edge of the horizontal face plate (excluding holes in the face plate) of hatch coamings may be included; or only the upper edge of the horizontal stiffener is to be included if no horizontal face plate is fitted.

2.8.8.6 The thickness of the web of deck hatch side girders is not to be less than 1% of its depth plus 4 mm. The thickness and structure of hatch coamings are to comply with the requirements of 2.18.1 of this PART.

2.8.8.7 A gradual transition in depth is to be made for the extension of deck hatch side girders.

2.8.8.8 Where the deck is framed transversely, a bracket is to be fitted at the connection between each beam and deck hatch side girders. These brackets are to extend to the face plate of deck hatch side girders, and the scantlings of the brackets are to comply with the provisions in 1.2.5 of this PART. However, the thickness of the bracket is not to be less than that of beam web.

2.8.9 Hatch end beams

2.8.9.1 Hatch end beams are to be fitted in accordance with the following requirements:

- 1 Where a pillar complying with the requirements of Section 10 of this CHAPTER is fitted at each corner of the hatchway (i.e. hatch end beams do not support hatch side girders), the section modulus of hatch end beams is to meet the requirements of 2.8.2.1 of this Section, but in this case, s in the

formula is to be the actual width of deck area supported by hatch end beams.

.2 Where hatch end beams support the full load of hatch side girders, pillars are fitted below the beams at the longitudinal centerline of deck and deck longitudinal girders or longitudinal bulkheads are also fitted at the longitudinal centerline, hatch end beams are to be continuous within the breadth of vessel and their section modulus W and section moment of inertia I are not to be less than those obtained from the following formulae respectively:

$$W = 4.6chAl \text{ in cm}^3$$

$$I = 3Wl \text{ in cm}^4$$

Where: c —Coefficient, to be taken according to the distance a between the hatch side girder and the longitudinal centerline: when $a \geq l/2$, $c=1.6$; when $a \leq l/3$, $c=1.5$; when $l/3 < a < l/2$ and c is to be obtained by interpolation method;

l —span of hatch end beams, in m;

h —design head of deck, in m, see 2.8.1.1 of this PART;

A —load area, in m^2 , $A = F_1 + F_2$, selected according to Fig. 2.8.9.1.2. Where no additional girders are provided, see Figure 2.8.9.1.2 (1),
where additional girders are provided, see Figure 2.8.9.1.2 (2).

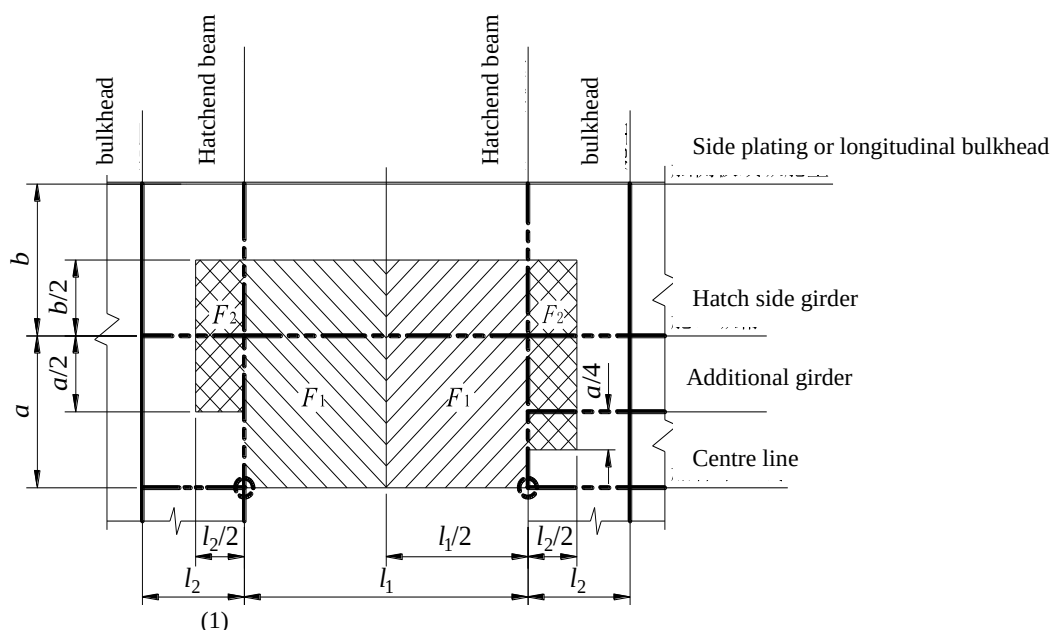


Figure 2.8.9.1.2 Area supported by the hatch end beam

2.8.9.2 The connections between hatch end beams and frames or web frames or longitudinal bulkheads are to comply with the requirements of 2.8.7.9 of this PART.

Section 10 PILLARS

2.9.1 Load supported by pillars

2.9.1.1 The load P supported by the pillar is to be calculated according to the following formula:

$$P = 7.06abh + P_0 \text{ kN}$$

Where: a —length of deck area supported by the pillar, in m, as shown in Figure 2.9.1.1;

b —mean width of deck area supported by the pillar, in m, as shown in Figure 2.9.1.1;

h —design head of the deck supported by the pillar, in m, see 2.8.1.1 of this PART;

P_0 —load transmitted from the pillar above, in kN.

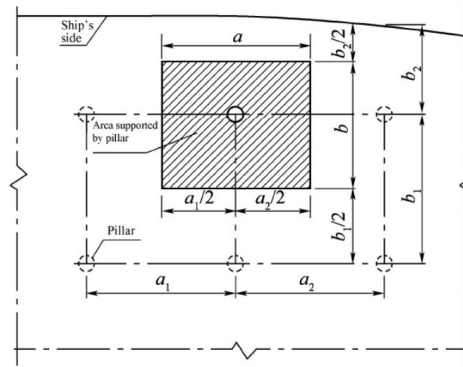


Figure 2.9.1.1 Schematic diagram of support area of pillar

2.9.1.2 When the upper and lower pillars are not on the same vertical line, the load of the lower pillar P shall be calculated as follows:

$$P = 7.06abh + cP_0 \quad \text{in kN}$$

Where: a , b and h —the same as 2.9.1.1 of this PART;

P_0 —the load of the upper pillar, in kN;

c —Coefficient, calculated by $2(l_1/l)^3 - 3(l_1/l)^2 + 1$, where l is the distance between the centerline of the lower pillar or the centerline of the pillar and bulkhead, in m; l_1 is the distance between the centerline of the upper pillar and the centerline of the lower pillar, in m.

2.9.2 Cross-sectional area of pillars

2.9.2.1 The cross-section area A of pillars is not to be less than that obtained from the following formula:

$$A = \frac{P}{12.26 - 5.1l/r} \quad \text{in cm}^2$$

Where: P —load applied on the pillars, in KN, to be calculated according to 2.9.1 of this PART;

l —the effective length of pillars, in m, to be taken as 0.8 times the whole length of pillars;

r —minimum radius of gyration of the cross section of pillars, in cm;

$r = \sqrt{I/A}$, Where I is the minimum moment of inertia of the pillar sectional area, in cm^4 ,

A —cross-sectional area of the pillar, in cm^2 ;

For solid round pillars, $r = 0.25D$; for hollow round pillars, $r = 0.25\sqrt{D^2 + d^2}$, where D is the outer diameter of the pillar and d is the inner diameter of the pillar, both in cm.

2.9.3 Wall thickness of pillars

2.9.3.1 The minimum wall thickness t of tubular pillars: when $L < 60\text{m}$, it is 5 mm; 6 mm in other conditions. The minimum wall thickness of hollow rectangular pillars or the minimum web thickness of I-shaped or channel-section pillars is to be the same as that of the wall thickness of tubular pillars.

2.9.3.2 Thick wall pillars are preferred in fishing tanks.

2.9.4 Strengthening of structures at the heads and heels of pillars

2.9.4.1 The structures at the heads and heels of pillars are to be so arranged that loads are reasonably supported and transmitted. Tubular and hollow rectangular pillars are to be attached at their heads to plates supported by efficient brackets. Longitudinal and transverse brackets are to be fitted at the heads and heels of the built or rolled-section pillars. The width of the brackets is not to be less than the pipe diameter or profile width, and the height of the brackets is not to be less than 1.5 times the pipe diameter or profile width. Doubler or insert plates are to be fitted below pillars.

2.9.4.2 Pillars are to be fitted on plate floors or girders, and these plate floors or girders are to be fitted with vertical stiffeners. Manholes are not to be cut in the floors and girders below pillars.

2.9.4.3 Where pillars are fitted on a shaft tunnel or any weak framing, structural strengthening is required in way of the pillars.

2.9.4.4 For pillars fitted inside ballast tanks or other tanks, attention is to be given to the effects of possible tensions.

2.9.4.5 Hollow pillars are not to be used inside oil tanks.

Section 10 WATERTIGHT BULKHEADS

2.10.1 General Requirements

2.10.1.1 Fishing vessels are to be provided with watertight collision bulkheads, watertight afterpeak bulkheads, watertight transverse bulkheads and watertight longitudinal bulkheads complying with the requirements of this Section.

2.10.1.2 The total number of transverse watertight bulkheads is, in general, not to be less than that given in Table 2.10.1.2.

Total number of watertight transverse bulkheads Table 2.10.1.2

L , in m	$L \leq 60$	$60 < L \leq 85$	$85 < L \leq 90$
Machinery amidships	4	4	5
Machinery aft	3	4	5

2.10.1.3 The arrangement of watertight bulkheads is to be reasonably uniform. When the tank length is not less than 30 m, measures shall be taken to ensure the transverse strength of the hull;

2.10.1.4 Where the bulkheads form the boundaries of deep tanks, the bulkhead structures are also to satisfy the requirements of Section 13 of this CHAPTER for the deep tank bulkheads.

2.10.1.5 The bulkheads may be of the plane, symmetrically corrugated or double-plated type.

2.10.2 Collision bulkhead

2.10.2.1 For the calculation of structural members of collision bulkheads, the calculated value of pressure head h is to be 1.25 times the height required accordingly.

2.10.3 Plane bulkhead plating

2.10.3.1 The thickness t of the watertight bulkhead plating t is not to be less than that obtained from the following formula, nor less than 5.5 mm:

$$t = 3.2s\sqrt{h} + 2.3 \quad \text{in mm}$$

Where: S — spacing of stiffeners, in m;

h — vertical distance, in m, measured from the lower edge of the plate in a strake to the bulkhead deck at side, to be taken as not less than 2.5 m;

2.10.3.2 The thickness of the lower strake of the bulkhead is to be 1mm thicker than the calculated value; the thickness of bulkhead plating in way of bilges or bilge wells is to be increased by 2.5 mm, and the thickness of bulkhead plating in way of the passage of the stern tube is to be doubled.

2.10.3.3 The lowest strake of bulkheads is not to be less than 900 mm in height measured from the inner bottom, or from the bottom in the case of single bottom. Where a double bottom is provided on one side and a single bottom on the other side of the bulkhead, the lowest strake is to extend at least 300 mm above the flat portion of the double bottom.

2.10.3.4 Where the difference in thickness between the bulkhead and the web of longitudinal girders attached to the bulkhead is greater than 4 mm, the thickness of bulkhead plating in way is to be increased.

2.10.3.5 The section modulus W of bulkhead stiffeners is not to be less than that obtained from the following formula:

$$W = cshl^2 \quad \text{in cm}^3$$

Where: C -Coefficient, to be selected according to the form of the two ends of the stiffener: when the two ends are connected with brackets, $C = 2.5$; when welding at the upper end and the lower ends are connected with brackets, $C = 3.3$; when welding on both ends, $C = 4.2$; when both ends are not connected, $C = 6$;

Where: S — spacing of stiffeners, in m;

h — vertical distance, in m, measured from the middle point of stiffener span to the bulkhead deck at side, to be taken as not less than 2 m;

For fishing vessels with a $L < 30$ m, the h value is taken from to be the actually measured value;

l — Span of stiffeners, in m, length of stiffeners including brackets. When girders are provided, distance between the end of the stiffener and the girder or between girders where girders are fitted.

2.10.3.6 The scantlings of end brackets of bulkhead stiffeners are to comply with the provisions in 1.2.5 of

this PART. Stiffeners unattached at ends are applicable only in the upper 'tween deck spaces.

2.10.3.7 The brackets at the ends of stiffeners are to be extended and efficiently welded to the beams or floors adjacent to the bulkhead respectively. However, when the span of the stiffeners is less than 3 m, it may not be extended according to this requirement.

2.10.3.8 Where a transverse bulkhead supports deck girders, bulkhead stiffeners are to be fitted in way of the deck girders. The sectional area of these stiffeners together with attached plating is also to comply with the requirements of Section 9 of this CHAPTER for pillars.

2.10.4 Bulkheads with symmetrical corrugations

2.10.4.1 Symbols for the dimensions of corrugations are as shown in Figure 2.10.4.1.

- S —full width of corrugation, in mm;
- a -width of the corrugation plane, in mm;
- b -width of the flange of corrugation, in mm;
- d_w —corrugation depth, in mm;
- α —The angle between the corrugation inclined plane part and the extension line of the plane part , °;
- t —Thickness of bulkhead, in mm.

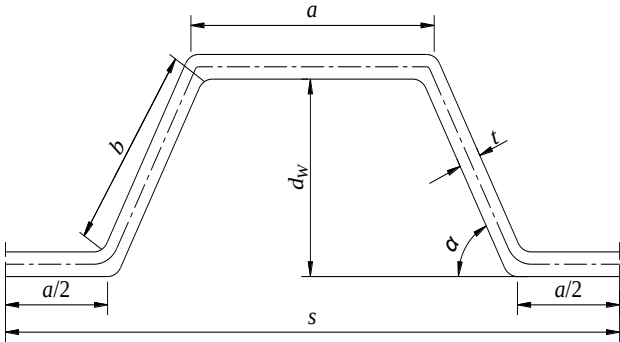


Figure 2.10.4.1 Dimensional diagram of corrugation bulkhead

2.10.4.2 Sizes of the corrugation bulkhead are to comply to the following requirements as well:

.1 The section modulus W of a corrugation over a spacing is not to be less than that obtained from the following formula:

$$W = cshl^2 \text{ in cm}^3$$

- Where: l —span of corrugations, namely the distance between support points, in m;
- h — vertical distance, in m, measured from the middle point of corrugation span to the bulkhead deck at side, to be taken as not less than 2 m;
- S —full width of corrugation, in m. See Figure 2.10.4.1 in this Section;
- C —coefficient, to be taken according to the end fixity as specified in Table 2.10.4.2.1.
- .2. The angle α between web and flange of corrugations is not to be less than 40 °.

C Value		Table 2.10.4.2.1
End fixity	See Figure 2.10.4.2.2(1)	See Figure 2.10.4.2.2(2)
C value	5.04	3.84

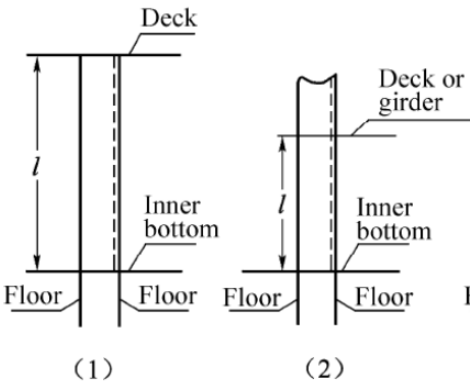


Figure 2.10.4.2.2 Schematic diagram of end fixity of corrugation bulkhead

2.10.4.3 The thickness of symmetrical corrugation bulkhead t is to comply with the requirements of 2.10.3.1 of this PART. When calculating, S is replaced by a or b , whichever is greater, and is to comply with the provisions of the following formula:

$$t \geq \frac{a}{70} \quad \text{in mm}$$

Where: a —see Figure 2.10.4.1 of this PART.

2.10.5 Bulkhead girders

2.10.5.1 The section modulus W of bulkhead girders is not to be less than that obtained from the following formula:

$$W = 6.6bhl^2 \quad \text{in cm}^3$$

Where: b —width of area supported by girders, in m;

h —vertical distance, in m, measured from the middle point of girder span to the bulkhead deck at side, to be taken as not less than 2 m;

l —Girder span, in m.

2.10.5.2 The web depth of girders is not to be less than 2.5 times that of the supported bulkhead stiffeners. The thickness of web is not to be less than the thickness of bulkheads at the girders. The breadth of the face plate of girders is not to be more than the web depth or 35 times the thickness of the face plate, whichever is smaller.

2.10.5.3 Tripping brackets are to be provided for girders in accordance with 1.2.4.4 of this PART.

2.10.5.4 The girder ends are to be connected by brackets. The brackets are to extend to the adjacent frames or bulkhead stiffeners. The breadth of the bracket along the girder is not to be less than the height of the girder web, and the thickness is not to be less than the thickness of the girder web. The brackets are to be provided with flanges or face plates.

2.10.6 Watertight bulkhead steps

2.10.6.1 The section modulus W of beams of decks or flats forming the steps in bulkheads is not to be less than that obtained from the following formula:

$$W = 4.2shl^2 \quad \text{in cm}^3$$

Where: S —spacing of beams, in m;

h —vertical distance, in m, measured from the deck or flat forming bulkhead steps to the bulkhead deck at side, but to be taken not less than 2 m;

l —span of beams, in m, but to be taken not less than 2 m;

2.10.6.2 The thickness of plating of the deck or flat forming the steps in bulkheads is to be 1 mm thicker than that required in 2.10.3.1 of this Section, and in this case S in the formula is to be taken as the spacing of beams.

2.10.6.3 The thickness of plating of the deck or flat forming the steps in bulkheads and the scantlings of beams are in no case to be less than those required, as appropriate, in Sections 3 and 8 of this CHAPTER for deck plating and beams.

Section 11 DEEP TANKS

2.11.1 General Requirements

2.11.1.1 The deep tanks referred to in this Section are ballast tanks other than double bottoms, water tanks for vessel, oil tanks with a flash point of not less than 60°C determined by closed cup test, etc.

2.11.1.2 Cofferdams are to be provided between non-edible oil tanks, fish tanks and fresh water tanks; if the spaces between the fish tanks and non-edible oil tanks meet the requirements specified in 3.3.1.2, 3.3.1.3 or 3.3.1.4, cofferdams are not needed.

2.11.1.3 The provisions of this Section regarding bulkheads also apply to horizontal and longitudinal bulkheads.

2.11.2 Plane bulkheads

2.11.2.1 The thickness of deep tank bulkhead t is not to be less than that obtained from the following formula:

$$t = 4s\sqrt{h} + 2.5 \quad \text{in mm}$$

Where: S — spacing of stiffeners, in m;

h — vertical distance, in m, measured from the lower edge of the plate in a strake to the top of the deep tank, or half the distance to the top of overflow, whichever is the greater.

According to the length of vessel, the thickness of bulkhead plate is not to be less than: 5 mm when $24\text{m} \leq L \leq 30\text{m}$; 6 mm when $30\text{m} < L < 60\text{m}$; and 7 mm when $L \geq 60\text{m}$.

2.11.2.2 The thickness of the lower strake of the bulkhead is to be increased by 1 mm compared with the value calculated in 2.11.2.1 of this PART; the thickness of bulkhead plating in way of bilges or bilge wells is to be increased by 2.5 mm.

2.11.2.3 The section modulus W of bulkhead stiffeners is not to be less than that obtained from the following formula:

$$W = 8.2shl^2 \text{ in cm}^3$$

Where: S — spacing of stiffeners, in m;

h — vertical distance, in m, measured from the mid-span of the stiffener to the top of the deep tank, or half the distance to the top of overflow, whichever is the greater.

l — Span of stiffeners, in m, length of stiffeners including brackets. When girders are provided, distance between the end of the stiffener and the girder or between girders where girders are fitted.

The ends of the stiffeners are to be connected by brackets. Bracket dimensions can be as specified in Section 10 of this CHAPTER. The ends of stiffeners are to be welded by brackets, and the scantlings of these brackets are to be in accordance with the relevant requirements in 1.2.6 of this PART. The ends of the stiffeners may also be connected directly to the deck plating or girders provided that the other side of the deck plating or girder is connected to an adjacent member having at least the same cross section as and in line with the said stiffener.

2.11.2.4 When the span of stiffeners is large, horizontal girders are to be provided for reinforcement. The spacing is generally not to be greater than 3 m and is to comply with the following requirements:

.1 The section modulus W of girders is not to be less than that obtained from the following formula:

$$W = 12bhl^2 \text{ in cm}^3$$

Where: b — breadth of areas supported by the girders, in m;

h — vertical distance, in m, measured from the mid-span of the girder to the top of the deep tank, or half the distance to the top of overflow, whichever is the greater.

l — Girder span, in m.

.2 The moment of inertia I of girders is not to be less than that obtained from the following formula:

$$I = 2.5Wl \text{ in cm}^4$$

Where: W and l are the same as 2.11.2.4.1 of this PART;

2.11.2.5 The height of girder web is to comply with the requirements of 2.10.5.2 of this PART.

2.11.2.6 Tripping brackets are to be provided for girders in accordance with 1.2.4.4 of this PART.

2.11.2.7 The connection at the ends of girders is to comply with the requirements of 2.10.5.4 of this PART.

2.11.2.8 Where the bulkheads of deep tank form a constituent part of watertight bulkhead, the bulkhead structures are also to satisfy the requirements of Section 10 of this CHAPTER for watertight bulkhead.

2.11.3 Bulkheads with symmetrical corrugations

2.11.3.1 Sizes of the corrugation bulkhead are to comply to the following requirements as well:

.1 The section modulus W of a corrugation over a spacing is not to be less than that obtained from the following formula:

$$W = cshl^2 \text{ in cm}^3$$

Where: l — span of corrugation, in m;

h — vertical distance, in m, measured from the mid-span of the corrugation to the top of the deep tank, or half the distance to the top of overflow, whichever is the greater.

s — full width of corrugation, in m. See Figure 2.10.4.1 in this PART;

c — coefficient, to be taken according to the end fixity as specified in Table 2.11.3.1.

.2 The angle α between web and flange of corrugations is not to be less than 40° .

c Value Table 2.11.3.1

End fixity	See Figure 2.10.4.2.2(1) in this PART	See Figure 2.10.4.2.2(2) in this PART
c value	13.6	10.6

2.11.3.2 The thickness of corrugation bulkhead t is to comply with the requirements of 2.11.2.1 of this

PART. When calculating, s is replaced by a or b , whichever is greater, and is to comply with the provisions of the following formula:

$$t \geq \frac{a}{70} \quad \text{mm}$$

Where: a —see Figure 2.10.4.1 of this PART.

2.11.4 Transverse side framing

2.11.4.1 The section modulus of side frames is to comply with the following requirements:

.1 The section modulus of frames other than those of forepeak and aft peak tanks is to be increased by 15% above that required in 2.7.2.2 of this PART, and is not to be less than the value W calculated in 2.7.4 of this PART;

.2 The section modulus W of the section modulus of frames to be not less than those obtained from the following formulae in addition to the requirement mentioned above:

$$W = 7shl^2 \quad \text{in cm}^3$$

Where: s —spacing of frames, in m;

h —vertical distance, in m, measured from the mid-span of frames to the top of the deep tank, or half the distance to the top of overflow, whichever is the greater;

l —span of frame, in m, the vertical distance measured from the upper edge of floor or inner bottom to the side stringer, or between side stringers or from the side stringer to the 'tween deck;
Whichever is greater, in m.

.3 The moment of inertial I of frames is not to be less than that obtained from the following formula:

$$I = 3.5Wl \quad \text{in cm}^4$$

Where: See W and l in 2.11.4.1.2 of this PART;

2.11.4.2 The height and breadth of end brackets of frames are to be increased by 20% above that required in 1.2.5 of this PART.

2.11.4.3 Side stringers supporting the frames are to comply with the requirements of 2.11.2.4 of this PART. The frames are to be welded to the side stringers. Side stringers are to extend to the bulkhead in deep tanks, and they are to form an annular frame with the bulkhead horizontal girders.

2.11.5 Longitudinal side framing

2.11.5.1 In addition to complying with the requirements of Section 7 of this CHAPTER, the section modulus W of side longitudinals is not to be less than that obtained from the following formula:

$$W = 9shl^2 \quad \text{in cm}^3$$

Where: s —spacing of longitudinals, in m;

h —vertical distance, in m, measured from the longitudinal to the top of the deep tank or half the distance to the top of overflow, whichever is the greater;

l —span of longitudinal, in m.

The end connections of side longitudinals are to comply with the relevant requirements of 2.7.5.7. The arm length of the end brackets is to be increased by 20% above that required in 1.2.5 of this PART.

2.11.5.2 The section modulus W of the web frames supporting the side longitudinals is not to be less than that obtained from the following formula:

$$W = 12shl^2 \quad \text{in cm}^3$$

Where: s —spacing of web frames, in m;

h —vertical distance, in m, measured from the mid-span of web frame to the top of the deep tank, or half the distance to the top of overflow, whichever is the greater;

l —Spacing of web frames, in m, a vertical distance measured from the upper edge of the plate floors or inner bottom to the deck.

2.11.5.3 The moment of inertial I of web frames section is not to be less than that obtained from the following formula:

$$I = 2.5Wl \quad \text{in cm}^4$$

Where: W and l are the same as 2.11.5.2 of this PART.

2.11.5.4 In deep tanks forward of 0.2L from F.P., the section modulus of web frames supporting the side longitudinals is to be increased by 20% above that obtained from 2.11.5.2 of this Section. In general, the spacing of web frames is not to be greater than 3.0 m.

2.11.6 Deck plating and framing

2.11.6.1 In addition to complying with the requirements of Section 4 of this CHAPTER, the plating thickness t of the deck (or flat) of deep tanks is not to be less than that obtained from the following formula:

$$t = 4s\sqrt{h} + 3.5 \quad \text{in mm}$$

Where: s — spacing of frames, in m;

h — vertical distance, in m, measured from deck (or flat) to the top of the deep tank, or half the distance to the top of overflow, whichever is the greater;

The plating thickness t of the deck (or flat) is not to be less than 6 mm for fishing vessel's length $L < 60\text{m}$; and is not be less than 7 mm for fishing vessel's length $L \geq 60\text{ m}$.

2.11.6.2 In addition to complying with the requirements of Section 8 of this CHAPTER, the section modulus W of longitudinals or beams of the decks (or flats) in deep tanks is not to be less than that obtained from the following formula:

$$W = 9shl^2 \quad \text{in cm}^3$$

Where: s — spacing of beams, in m;

h — vertical distance, in m, measured from deck (or flat) to the top of the deep tank, or half the distance to the top of overflow, whichever is the greater;

l — spacing of beams, in m.

2.11.6.3 In addition to complying with the requirements of Section 8 of this CHAPTER, the section modulus W of girders or transverses of decks (or flats) in deep tanks is not to be less than that obtained from the following formula:

$$W = 12shl^2 \quad \text{in cm}^3$$

Where: s — spacing of girders or transverses, in m;

h — vertical distance, in m, measured from deck (or flat) to the top of the deep tank, or half the distance to the top of overflow, whichever is the greater;

l — spacing of girders or transverses, in m.

The section moment of inertia I are not to be less than those obtained from the following formulae respectively:

$$I = 2.5Wl \quad \text{in cm}^4$$

Where: W and l are the same as 2.11.2.4.1 of this PART;

2.11.7 Longitudinal or wash bulkheads

2.11.7.1 Where a deep tank extends from side to side of the vessel, a longitudinal or wash bulkhead is to be fitted on the centerline.

2.11.7.2 Where the widest breadth of the tank exceeds 0.5B within the region forward of 0.3L from F.P., a wash bulkhead is to be fitted on the centerline of the tank. Where the widest breadth of the tank exceeds 0.7B, it is recommended that a longitudinal bulkhead be fitted on the centerline of the tank.

2.11.7.3 The thickness of the wash bulkhead is to be the same as that required for the bulkheads mentioned in this Section. The section modulus of the stiffeners of the wash bulkhead is to be equal to 50% of that of those bulkheads, but h is to be measured to the top of the deep tank. The stiffeners are to be connected by brackets at both ends. The area of perforations is not to be less than 5% nor more than 10% of the total area of the bulkhead.

Section 12 STEMS, STERN FRAMES, RUDDER POST, BULBOUS BOWS, PROPELLER SHAFT BRACKETS, PROPELLER DUCT AND RUDDER HORN

2.12.1 Stems

2.12.1.1 The cross-sectional area A of bar stems up to 0.5 m above the designed waterline is not to be less than the value obtained from the following formula:

$$A = 1.2L \text{ in cm}^2$$

From a position above 0.5 m from the designed waterline, the cross-sectional area may be gradually tapered to the stem head where the area may be reduced by 25%.

2.12.1.2 The thickness t of plate stems up to 0.5 m above the designed waterline is not to be less than that obtained from the following formula:

$$t = 0.1L + 5 \text{ in mm}$$

From a position above 0.5 m from the designed waterline, the thickness of stems may be gradually tapered, but it is not to be less than that of adjacent shell plating.

Plate stems are to be supported by horizontal webs spaced not more than 1 m apart. The web thickness is not to be less than the thickness of the adjacent shell plating. The webs are to be extended aft to be connected to frames or side stringers, but at least beyond the butts of stem plates and shell plating.

Where the radius of curvature of the stem is large, a centerline vertical web is to be fitted, having the same thickness as the horizontal webs.

2.12.1.3 Cast steel stems are to be easy for manufacture, and all fillets are to have adequate radii. The sectional area of cast steel stems is not to be less than that of bar stems required in 2.12.1.1 of this Section. Cast steel stems are to be provided with rib reinforcement.

2.12.2 Stern frames without rudder post

2.12.2.1 The stern frame without rudder post is composed of sole piece, propeller post and propeller boss.

2.12.2.2 The dimensions of the propeller post welded by steel plates (as shown in Figure 2.12.2.2) are not to be less than the values obtained from the following formulae:

$$\text{Length of stern frame } a = 46\sqrt{L} \text{ in mm}$$

$$\text{Thickness of stern frame } t = 2.3\sqrt{L} + 3, \text{ in mm}$$

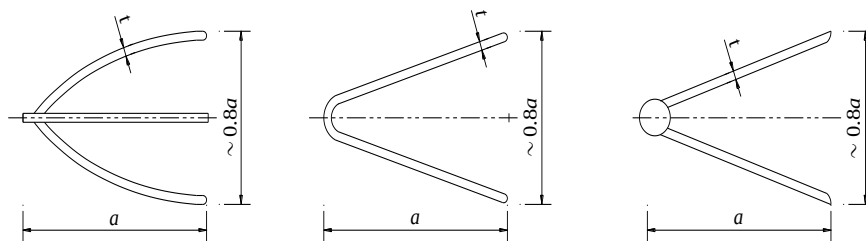
2.12.2.3 The dimensions of the cast steel propeller post welded by steel plates (as shown in Figure 2.12.2.3) are not to be less than the values obtained from the following formulae:

$$\text{Length of stern frame } a = 41\sqrt{L} \text{ in mm}$$

$$\text{Thickness of stern frame } t_1 = 3\sqrt{L}, \text{ in mm}$$

$$t_2 = 4\sqrt{L} \text{ in mm}$$

$$\text{Radius of fillet } R = 0.4L + 16 \text{ in mm}$$



(1) (2) (3)

Figure 2.12.2.2 Propeller post welded with steel plates

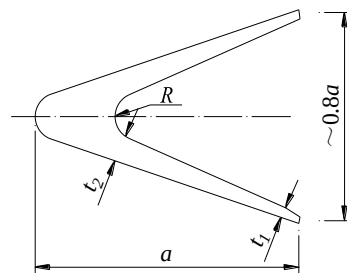


Figure 2.12.2.3 Cast steel propeller post

2.12.2.4 The breadth of stern frame as shown in Figures 2.12.2.2 and Figure 2.12.2.3 are for reference only. The actual situation is to be coordinated with the tail molded lines.

2.12.2.5 Fabricated or cast propeller posts are to be strengthened by horizontal brackets at positions depending upon the hull framing and the structural arrangements of propeller posts, but the spacing of the webs is not to exceed 650 mm. Cast steel stern frames are to be easy for manufacture, and all fillets are to have adequate radius; where the radius of curvature is large, a vertical web is to be fitted.

2.12.2.6 The section modulus W_z of sole pieces (see Figure 2.14.2.5) about the vertical neutral axis (z-axis) at any considered section, is not to be less than that obtained from the following formula:

$$W_z = 1.2AxV^2 \quad \text{in cm}^3$$

Where: A —total area of rudder, in m^2 ;

x —distance between the axis of rudder stock and the section under consideration, in m, x to be taken not less than $0.5l_s$; l_s is the maximum distance from the section to be calculated to the centerline of the rudder stock.

V —Maximum designed navigational speed, in kn.

The section modulus W_y of the above section to horizontal neutral axis (axis Y) is not to be less than 50% of the above formula.

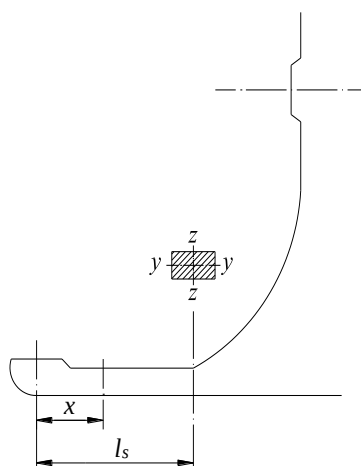


Figure 2.12.2.6 Sole piece type

2.12.2.7 The sole piece is to extend forward from the fore end of the propeller boss for at least 3 frame spaces and to be efficiently connected to the plate keel. The sectional area of the extended portion may be reduced gradually to the area required for effective connection with the plate keel.

2.12.2.8 The stern tube shaft is to be efficiently connected to the floor or bulkhead, and the thickness of the floor is to be increased by 3 mm.

2.12.2.9 The finished thickness t of the propeller boss in way of the passage of the stern tube shaft or propeller shaft is not to be less than that obtained from the following formula:

$$t = 0.1d + 40 \quad \text{mm}$$

Where: d —diameter of stern tube shaft or propeller shaft, in mm.

2.12.3 Propeller posts of twin screw vessels

2.12.3.1 The dimensions of rudder posts which are built integral with the hull of twin screw vessels (see Figures 2.12.3.1) are not to be less than as given below:

Breadth of section: $b = 33\sqrt{L}$ in mm

Thickness of section: $t_1 = 3.3\sqrt{L}$ in mm

$t_2 = 3.7\sqrt{L}$ in mm

$t_3 = 4.5\sqrt{L}$ in mm

Radius of fillet: $R = 4.4\sqrt{L}$ in mm

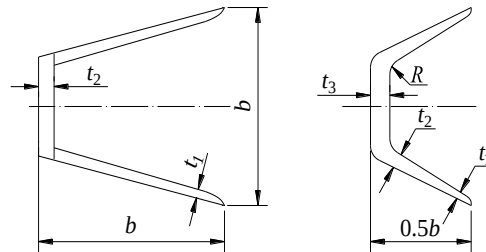


Figure 2.12.3.1 Rudder post of twin screw vessels

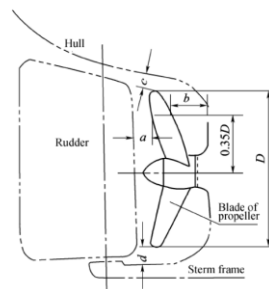


Figure 2.12.4.1 Clearance between the propeller and the stern frame or between the propeller and the rudder

2.12.4 Propeller clearances

2.12.4.1 It is recommended that the minimum clearances (see Figure 2.14.4.1) between the propeller and the stern frame or between the propeller and the rudder be not less than the following:

$$\begin{aligned} a &= 0.12D && \text{in mm} \\ b &= 0.20D && \text{in mm} \\ c &= 0.14D && \text{in mm} \\ d &= 0.04D && \text{in mm} \end{aligned}$$

Where: D — diameter of propeller, in m.

2.12.5 Bulbous bows

2.12.5.1 Where a bulbous bow is fitted, the structural arrangements are to be such that the bulb is adequately supported and integrated into the fore peak structure. The bulb is in general to be strengthened as follows:

- .1 At the fore end of the bulb, the structure is to be supported by horizontal diaphragm plates and in conjunction with the center girder;
- .2 Vertical transverse diaphragm plates are to be arranged in way of the transition from the peak framing to the bulb framing;
- .3 The shell plating is to be increased in thickness at the fore end of the bulb and in other areas likely to be damaged by the anchors and chain cables. The increased plate thickness may be the same as that required for plate stems.

2.12.6 Propeller shaft brackets

2.12.6.1 Propeller shaft brackets may be made of steel castings or fabricated from plates, or made of cast or forged pieces connected by welding. The connection of the arms to the bearing boss is to be made by full penetration welding.

2.12.6.2 The angle between the two arms of the herringbone shaft bracket is to be 90° as far as possible.

2.12.6.3 The scantlings of each arm and shaft bossing are not to be less than as given below:

$$\begin{aligned} \text{Thickness of arm: } t &= 0.45d && \text{in mm} \\ \text{Cross sectional area of arm: } A &= 0.45d^2 && \text{in mm}^2 \\ \text{Thickness of shaft bossing: } t &= 0.33d && \text{in mm} \\ \text{Length of shaft bossing: } l &= 3d && \text{in mm} \end{aligned}$$

Where: d — diameter of stern tube shaft or propeller shaft, in mm.

2.12.6.4 The hull framing in way of the bracket palm is to be strengthened and the shell plating in way is to be increased in thickness as required in 2.2.6.3 of this CHAPTER. Bracket arms are to be carried through the shell

plating and efficiently attached to floors, girders and shell plating.

2.12.7 Propeller duct

2.12.7.1 General requirements

- .1 The requirements of this Section apply to propeller ducts with an inner diameter of less than 5 m;
- .2 Longitudinal and transverse (ring-shaped) reinforced bulkheads are to be provided inside the duct shell plate;
- .3 The support of fixed ducts on the hull is to be particularly strengthened.

2.12.7.2 The design pressure of the propeller duct is to be determined as follows:

$$P_d = cP_{do} \text{ in kPa}$$

$$P_{do} = \varepsilon \frac{N}{A_p} \text{ kPa;}$$

N —Maximum shaft power, in kW;

A_p —Propeller disk area, in m^2 ;

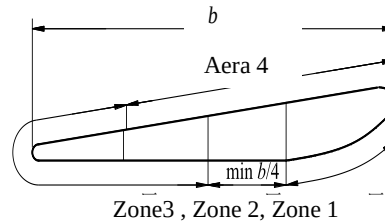
$$A_p = \frac{\pi D^2}{4}$$

Where: D — diameter of propeller, in m;

$$\varepsilon = 0.21 - 2 \times 10^{-4} \frac{N}{A_p}, \text{ but not less than } 0.10;$$

ε —Coefficient,

C —Coefficient, in zone 2 (propeller zone), $C = 1.0$; in zones 1 and 3, $C = 0.5$; in zone 4, $C = 0.35$ (as shown in Figure 2.12.7.2).



2.12.7.2 Design pressure zone division of propeller duct

2.12.7.3 The thickness of duct shell plate is not to be less than that obtained from the following formula.

$$t = 5a\sqrt{P_d} + 2 \text{ in mm}$$

Where: a —spacing of duct stiffening ring, in m;

P_d —Calculated value according to 2.12.7.2 of this PART.

The thickness of duct shell plate is not to be less than 8 mm. The thickness of zone 2 is to be added by 2 mm compared with the calculated thickness, but not necessary to be greater than 20 mm.

2.12.7.4 The thickness of the internal reinforced bulkhead is not to be less than that of the shell plate in zone 3 of the duct. It is recommended that the ring diaphragms are not to be less than two, but at least one is arranged in zone 2; the longitudinal diaphragms are not to be less than eight, and are necessary to be provided at the duct fixing position.

2.12.7.5 The section modulus W of section (see Figure 2.12.7.2 in this Section) about the vertical neutral axis, is not to be less than that obtained from the following formula:

$$W = nd^2bV_0^2 \text{ in cm}^3$$

Where: n —coefficient, for rotating tube rudder, $n = 1.0$; for fixed duct, $n = 0.7$;

d —inner diameter of the duct, in m;

b —duct length, in m;

V_0 —vessel speed, in kn, when $V > 10\text{kn}$, $V_0 = V$; when $V < 10\text{kn}$, $V_0 = (V + 20)/3$;

Where: V —the same as 2.12.2.6 in this Section.

2.12.7.6 The inner shell plates of the duct are to be welded to the internal reinforcement ring by double-sided continuous welding. Plug welding is only applicable to duct shell plates.

2.12.7.7 The breadth of the shell plates in zone 2 is not to be less than 200 mm. If machining is adopted to ensure roundness after cast steel or steel plate forming, the final plate thickness is not to be less than the specified

value.

2.12.8 Rudder horn

2.12.8.1 The rudder horn supporting the semi-suspended rudder may be welded with steel plate or cast steel, and its horizontal cross-sectional shape may refer to the cross section of the propeller pillar. The rudder horn is to extend into the hull and be firmly connected to the reinforced main structure. Transition plates with appropriate arc are to be fitted at the intersection of rudder horn and hull plating. The arc radius is not to be less than $0.8 + \sqrt{L}$ 150 (mm).

2.12.8.2 The bending moment M_b , shear force Q and torque M_T of any horizontal section on the rudder horn (as shown in Figure 2.12.8.2) are to be calculated according to the following formulae:

$$M_b = PZ \quad \text{in N} \cdot \text{m}$$

$$Q = P \quad \text{in N}$$

$$M_T = Pe \quad \text{in N} \cdot \text{m}$$

Where: Z and e are shown in Figure 2.12.8.2, in m;

P —support force of rudder horn, in N, calculated according to 3.1.4.6 of this Section.

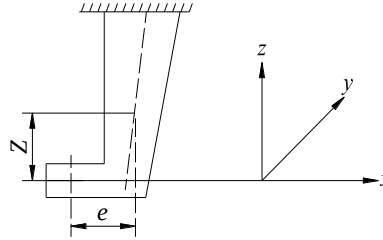


Figure 2.12.8.2 Schematic diagram of rudder horn

2.12.8.3 The section modulus W of any horizontal plane of rudder horn on the axis x is not to be less than the value obtained from the following formula:

$$W = \frac{C}{67} M_b \quad \text{in cm}^3$$

Where: C —conversion coefficient of material yield stress R_{eH} , when $R_{eH} > 235 \text{ N/mm}^2$, $C = (235/R_{eH})^{0.75}$, otherwise, $C = 235/R_{eH}$;

M_b —calculate the bending moment at the section, in $\text{N} \cdot \text{m}$, according to 2.12.8.2 of this PART.

2.12.8.4 The shearing stress τ on any horizontal plane of rudder horn caused by shearing force is not to be less than the value obtained from the following formula:

$$\tau = \frac{48}{C} \quad \text{in N/mm}^2$$

Where: C —see 2.12.8.3 of this PART.

2.12.8.5 The equivalent stress on any horizontal plane of the rudder horn σ_e is not to be greater than $120/C$ (N/mm^2) (See the coefficient C in 2.1.8.2.3 of this CHAPTER). The equivalent stress σ_e is to be calculated by the following formula:

$$\sigma_e = \sqrt{\sigma^2 + 3(\tau^2 + \tau_t^2)} \quad \text{N/mm}^2$$

Where: $\sigma = \frac{M_b}{W}$, in N/mm^2 ; M_b is shown in 2.12.8.2 of this PART; W is the section modulus of reference section to axis x , in cm^3 ;

$\tau = \frac{P}{A_y}$, in N/mm^2 ; P is shown in 2.12.8.2 of this PART; A_y is the effective shear area of reference section in the direction of axis Y , in mm^2 ;

$\tau_t = \frac{10^3 M_T}{2A_T t}$, in N/mm^2 ; M_T is shown in 2.12.8.2 of this PART; A_T is the area enclosed by rudder horn profile at the reference section, in mm^2 ;

t is the thickness of the plate of rudder horn, in mm.

Section 13 STRENGTHENING AT ENDS OF VESSEL

2.13.1 Fore peak strengthening

2.13.1.1 Solid floors are to be fitted at every frame. The web depth h and thickness t and the face plate sectional area A of the floors are not to be less than those obtained from the following formulae:

$$h = 85D + 140 \quad \text{in mm}$$

$$t = 0.03L + 6 \quad \text{in mm}$$

$$A = 0.85B \quad \text{in cm}^2$$

The height of floor is to ensure effective connection between frames and floors.

2.13.1.2 Centerline keelson is to be fitted at the longitudinal centerline section. The web depth and thickness and the face plate sectional area are to be as those required in 2.15.1.1 of this Section for solid floors.

2.13.1.3 For the extremely narrow bottom, the centerline keelson not extended to the bottom may be accepted, but the depth of the keelson is to be approximately equal to 1/3 of the floor depth. Or alternatively, the centerline keelson may be entirely omitted provided that the web of floors is fitted with horizontal stiffeners and that a perforated flat, instead of a face plate, is fitted at the top edge of the web.

2.13.1.4 In the case as mentioned in 2.13.1.3 of this Section, a centerline keelson gradually tapered off over several frame spaces is to be fitted forward of the collision bulkhead as the continuation of the centerline girder or centerline keelson abaft the collision bulkhead.

2.13.1.5 Where the side shell is framed transversely, panting beams spaced not more than 2 m apart vertically are to be fitted at alternate frames, from the top of floors up to the lowest deck, and at least to 1 m above the full-load waterline.

The cross-sectional area A and minimum section moment of inertia I of the panting beams are not to be less than:

$$A = 0.27L + 8 \quad \text{in cm}^2$$

$$I = ce h_i l^2 \quad \text{in cm}^4$$

Where: c — horizontal spacing of panting beams, in m;

e — vertical spacing of panting beams, in m;

h_i — calculation pressure head of panting beams, in m, $h_i = 0.04L + 3.30$;

l — span of panting beam, in m, namely distance between support points.

2.13.1.6 Where a fore peak space is used as a tank and the breadth of the tank at its widest point exceeds 0.5 B , efficient supporting members or wash bulkheads are to be fitted to support the panting beams. The wash bulkheads are to comply with the requirements of 2.11.7 of this PART.

2.13.1.7 Side stringers with flange or face plate are to be fitted at each panting beam, and are to have a web depth h and thickness t not less than:

$$h = 5.6L + 166 \quad \text{in mm}$$

$$t = 0.023L + 6 \quad \text{in mm}$$

2.13.1.8 Brackets are to be fitted at the lower edge of connections between side stringers and frames, the thickness of brackets is not to be less than that of the side stringer web and the brackets are to be extended to the flange or face plate of side stringers. Where panting beams are fitted, the arm length of brackets along the frames is not to be less than 75% the web depth of side stringers, and where no panting beams are fitted, the arm length is not to be less than 50% the web depth of side stringers. The webs of side stringers are to be welded to the frames.

2.13.1.9 If perforated flats are fitted in lieu of the panting beams in association with stringers, the flats are to be spaced not more than 2.5 m apart. The members are to comply with the following requirements:

.1 The thickness t of perforation platform plate is not to be less than that obtained from the following formula.

$$t = 0.023L + 5 \quad \text{in mm}$$

.2 Beams are to be fitted at alternate frames below the perforated flat, and their sectional area A without attached plating is not to be less than that obtained from the following formula:

$$A = 0.13L + 4 \quad \text{in cm}^2$$

.3 Scantlings of the brackets connecting the beams of the perforated flat to the frames are to comply with the requirements in 1.2.5 of this PART;

.4 The perforated area of the platform is not to be less than 10% of the total area of the platform.

2.13.2 Strengthening outside the fore peak tank

2.13.2.1 Within the region from the collision bulkhead to $0.15 L$ F.P., the side framing is to be strengthened as follows:

- .1 Discontinuous side stringers are provided along the extension of the side stringer or perforated platform in the forepeak, the web thickness is the same as the side stringers web or perforated platform. Except for transition range, web height is to be the same as the frame height.
- .2 The webs of discontinuous side girders are to be within a distance of not less than two frame spaces to the collision bulkhead, and gradually transit to the height of the side girder webs in the foreside tank (if perforation platform is in the forepeak, the height of side longitudinal girder web is to be calculated according to 2.13.1.7 of this PART);
- .3 The discontinuous side longitudinal girder are to be provided with face plates. The sectional area of face plate A is not to be less than the value calculated by the following formula:

$$A = 0.14L + 1 \text{ in cm}^2, \text{ and not to be less than } 6 \text{ cm}^2;$$

- .4 Where discontinuous side stringers are not provided, the section modulus W of the main frames in that area is to be increased by 25% over the calculation in 2.7.2.2 of this PART.

2.13.2.2 Where the length L of the vessel is equal to 65 m or over and the draught forward in navigation is less than $0.04 L$, the flat portion of bottom from $0.15 L$ F.P. to collision bulkhead is to be strengthened. The transverse extent of strengthening is not to be less than $0.014B$ (B being the breadth of the vessel) above the base line, but need not be greater than 0.28 m.

- .1 For reinforcement of the transverse framing double bottom, side girders are in general to be fitted not more than three frame spaces apart, and half-depth flanged side girders are to be fitted midway between the side girders. The side girders and half-depth side girders are to be extended as far forward as practicable.
- .2 Double bottom framed longitudinally is to be strengthened
 - (1) Plate floors are to be fitted at alternate of one frame space.
 - (2) The section modulus of bottom longitudinals is to be increased by 10% above that obtained from the formula in 2.6.12.2 of this CHAPTER, and in this case, l in the formula is not to be less than 1.85 m.
 - (3) Side girders are in general to be fitted not more than three times the spacing of longitudinals apart and are to be extended as far forward as practicable.
- .3 Single bottom framed transversely is to be strengthened as follows:
 - (1) Floors are to be increased gradually in depth towards the fore end as far as practicable. The sectional area of the face plate of floors is to be increased by 50% over the value required in 2.13.1.1 of this Section. In addition, the floor web is to be adequately increased in thickness so as to ensure its stability. Face plates are not to be substituted by flanges.
 - (2) Side girders are in general to be fitted not more than three frame spaces apart, and half-depth flanged side girders are to be fitted midway between the side girders. The side girders and half-depth side girders are to be extended as far forward as practicable.
- .4 Single bottom framed longitudinally is to be strengthened as follows:
 - (1) Plate floors are to be fitted at alternate of one frame space. The floors are to comply with the provisions of 2.13.2.2.3.
 - (2) The section modulus of bottom longitudinals is to be increased by 10% above that obtained from the formula in 2.6.12.2 of this CHAPTER, and in this case, l in the formula is not to be less than 1.85 m.
 - (3) Side girders are in general to be fitted not more than three times the spacing of longitudinals apart and are to be extended as far forward as practicable.

.5 In the Where strengthening is required, the forward bottom plating is to be strengthened as follows:
The thickness t of the forward bottom plating is not to be less than that obtained from the following formula:

$$t = 0.1L + 5 \quad \text{in mm}$$

2.13.3 Aft peak strengthening

2.13.3.1 Plate floors are to be fitted at every frame space, the thickness of which is to be 1.5 mm thicker than that in the fore peak as required in this Section. Thickening is not required if cement is filled. Floors are to be carried well above the stern tube. In way of propeller posts, propeller shaft brackets and rudder horns, the floors are generally to be carried to the top of the space and are to be increased in thickness.

2.13.3.2 Where the side shell is framed transversely, panting beams and side stringers spaced vertically not more than 2.5 m apart are to be fitted above the floors, or alternatively, perforated flats complying with the

requirements of 2.13.1.9 of this Section are to be provided. The panting beams and side stringers as well as the connection of these members to frames are to comply with the requirements for the fore peak.

2.13.3.3 Where the side shell is framed longitudinally, suitable transverses are to be arranged at the top of the tank and the brackets connecting the transverses to web frames are to comply with the requirements of 1.2.6 of this PART.

2.13.3.4 The section modulus of frames in the overhanging part of the stern is not to be less than the requirements of the afterpeak frames when the span is greater than 2.5 m. Web frames and side stringers not greater than 4 spacing of frames are to be provided, or the frame sizes are to be reinforced.

2.13.3.5 The structural strength and stiffness of the stern frames and diversion tube are to be increased accordingly.

2.13.3.6 When the overhanging part of the stern is large, longitudinal wall, ring frame and other longitudinal strengthening measures are to be taken.

2.13.4 Side strengthening above the aft peak

2.13.4.1 Where the side shell of 'tween deck spaces above the after peak tank is transversely framed, web frames are to be fitted not more than 4 frame spaces apart. The section modulus W is not to be less than that obtained from the following formula:

$$W = 3.5Sdh\sqrt{D} \text{ in cm}^3, \text{ and not to be less than } 10\text{cm}^3;$$

Where: S — spacing of web frames, in m;

h — height of 'tween decks, in m;

2.13.4.2 Where the side shell of 'tween deck spaces above the after peak tank is framed longitudinally, web frames supporting longitudinals are to be fitted. The spacing of web frames is not to be greater than 2.5 m. The section modulus W of web frames is not to be less than that obtained from the following formula:

$$W = 4.4Sdh\sqrt{D} \text{ in cm}^3$$

Where: S — spacing of web frames, in m;

h — height of 'tween decks, in m;

Section 14 ENGINE SEATINGS AND SHAFT TUNNELS

2.14.1 Main engine seatings

2.14.1.1 The main engine seating is to be of ample strength and rigidity. It is generally to consist of two longitudinal girders with transverse diaphragms and transverse brackets fitted at every frame space. Transverse diaphragms are to be fitted between longitudinal girders and are to extend to the face plate of girders as far as practicable. Transverse brackets, the width of which is generally not to be less than their depth, are to be fitted at the outside of the longitudinal girders and welded to the face plate of the girders.

2.14.1.2 The longitudinal girders of the seating are to be in line with the bottom side girders. If it is impracticable to do so, partial girders of the same thickness as the bottom side girders are to be fitted under the longitudinal girders. In particular cases, the partial girder may be in the form of a half-depth girder welded to the inner bottom plating and floors only.

2.14.1.3 Scantlings of structural members of main engine seatings

- 1 For main engines having a power of 1,470 kW or less, the web thickness of longitudinal girders is to be increased by 60% above that of the bottom side girders (for double bottom) or side keelsons (for single bottom) in way of the engine room in the case of diesel engines, and by 30% in the case of turbines or propulsion motors. In both cases, the longitudinal girders are to be provided with a continuous horizontal face plate having a thickness 40% greater than their web thickness. The longitudinal girders are to be gradually tapered off at their ends.

The thickness of the transverse diaphragms and transverse brackets is to be increased by 40% above that of the floors in the case of diesel engines, and by 30% in the case of turbines or propulsion motors. The transverse diaphragms and transverse brackets are to be provided with a face plate or flange.

- 2 For large low-speed diesel engines having a power of more than 1,470 kW, the horizontal face plate thickness t and the web thickness

t_1 of longitudinal girders, and the thickness t_2 of transverse diaphragms and transverse brackets are not to be less than the values given below:

$$t = 1.44\sqrt[3]{P} + 10s \quad \text{in mm}$$

$$t_1 = 0.7t \quad \text{in mm}$$

$$t_2 = 0.8t_1 \quad \text{in mm}$$

Where: P —main engine power, in kW;

s —spacing of frames, in m.

2.14.1.4 The horizontal face plates of longitudinal girders are to be stiffened in way of holding-down bolts by a suitable number of vertical brackets, and the depth of the brackets is to be twice their breadth.

2.14.1.5 Where the main engine seating or the thrust seating is directly bolted to the inner bottom, the thickness t_3 of the inner bottom plating in way is not to be less than that required as follows:

.1 for main engines having a power of 1,470 kW or less, t_3 is to be equal to twice the thickness of the inner bottom plating in the region, but is not to be less than 20 mm;

.2 for large low-speed diesel engines having a power of more than 1,470 kW, $t_3 = t$, t as defined in 2.14.1.3.2 of this PART.

The double bottom tanks within the above regions are not to be used for carrying oil fuel or water. Partial or half-depth girders are to be fitted close to holding-down bolts. The longitudinal division bulkheads and side girders in the adjacent oil or water tanks may be regarded as the partial girders at holding-down bolts.

2.14.1.6 The scantlings of auxiliary engine seatings having a power of 1,470 kW and above are to be determined referring to the main engine seatings.

2.14.2 Shaft tunnels

2.14.2.1 For non-aft-engined fishing vessels, shaft tunnels are generally to be fitted between the watertight bulkheads at the rear of the machinery space and afterpeak bulkhead. If no shaft tunnel is provided, other effective protection devices are to be provided.

2.14.2.2 Shaft tunnels are to be of watertight construction. If a door is to be opened on the bulkhead on the machinery space and shaft tunnel, the door is to be of sliding watertight type.

2.14.2.3 The thickness of the shaft tunnel plate is to comply with the requirements for watertight compartment bulkhead in 2.10.3.1 of this PART. If the top plating is curved, the thickness may be reduced by 10%.

2.14.2.4 Stiffeners of shaft tunnels are to be in line with the frames wherever possible, and their section modulus W is not to be less than that obtained from the following formula:

$$W = 6shl^2 \quad \text{in cm}^3$$

Where: s —spacing of stiffeners, in m;

h —the vertical distance, in m, measured from the mid-point of the vertical part of the stiffener to bulkhead deck;

l —the length of the vertical part of the stiffener, in m;

Where the tunnel top is flat, the scantlings of the top beams are not to be less than those required for the beams in way of the steps in watertight bulkheads (see 2.10.6 of this PART).

The lower end of the vertical part of stiffeners is to be welded to adjacent members.

2.14.2.5 Where shaft tunnels pass through or are adjacent to deep tanks, the adjacent bulkheads and their stiffeners are to comply with the requirements of Section 11 of this CHAPTER for deep tanks.

2.14.2.6 The structure of the thrust and tunnel recesses is to comply with the requirements for the steps in watertight bulkheads. Where these recesses are enclosed by deep tanks, the requirements for bulkheads and stiffeners of deep tanks are to be complied with.

2.14.2.7 The shaft tunnel is to be provided with an emergency exit leading to the weather deck, and the construction of the trunk of the exit is to comply with the requirements for watertight bulkheads. The opening/closing appliance for the exit is to be capable of being operated from both sides.

Section 15 SUPERSTRUCTURES AND RAISED QUARTERDECKS

2.15.1 General Requirements

2.15.1.1 All fishing vessels are to be provided with forecastles, stem raised quarterdecks or increased sheer to meet the minimum bow height. The height is to be determined considering the seasonal meteorological conditions, sea conditions in operating areas, vessel types and operating modes.

2.15.1.2 Where superstructures are subject to loading in excess of that as specified in this Section, the

scantlings are to be increased in accordance with the nature of the load.

2.15.2 End bulkheads

2.15.2.1 The thicknesses t of the bridge front end bulkhead or front unprotected poop front bulkhead plating with a length no less than $0.4L$ are not to be less than the values obtained from the following formula, and not to be less than 6 mm:

$$t = 0.05L + 4 \quad \text{in mm}$$

2.15.2.2 The thicknesses t of the poop front end bulkhead with a length less than $0.4L$ or front protected poop front bulkhead plating with a length no less than $0.4L$ are not to be less than the values obtained from the following formula, and not to be less than 5 mm:

$$t = 0.05L + 3 \quad \text{in mm}$$

2.15.2.3 The thickness of the superstructure end bulkhead plating t is not to be less than that obtained from the following formula, nor less than 5 mm:

$$t = 0.035L + 3.5 \quad \text{in mm}$$

2.15.2.4 When the spacing of end bulkhead stiffeners is greater than 750 mm, the end bulkhead plating is to be thickened by 0.5 mm by every increase of 100 mm.

2.15.2.5 The lower strake of end bulkhead is 00 mm above the deck. The plating thickness is to increase by 2 mm above the calculated value, but not necessarily greater than the thickness of the steel deck.

2.15.2.6 The section modulus W of superstructure bulkhead stiffeners is not to be less than that obtained from the following formula:

$$W = 3.5shl^2 \quad \text{in cm}^3$$

Where: s —spacing of stiffeners, in m;

l —spacing of stiffeners, in m; the height of the superstructure is taken as 2.0 m when less than 2.0 m;

h —design pressure head, in m, is to be taken according to Table 2.15.2.6.

Design pressure head

Table 2.15.2.6

Item	Design pressure head h , in m
Front end bulkhead of bridge or front unprotected poop front end bulkhead with a length no less than $0.4L$	$0.001L(0.27L + 68)$
Poop front bulkhead with a length less than $0.4L$ or front protected poop front end bulkhead with a length no less than $0.4L$	$0.001L(0.09L + 25)$
Superstructure rear end bulkhead	$0.0178L$
Note: —the same as , but L is to be taken as 40m for $L > 40m$.	

The section modulus of end stiffeners is not to be less than 10cm^3 , but not necessary to be greater than the section modulus of the main frame.

Both ends of the front bulkhead stiffeners are to be connected by brackets. The scantlings of the brackets are to comply with the provisions of 1.2.5 of this PART. Both ends of the rear bulkhead stiffeners are to be welded to the deck.

2.15.3 Side bulkhead

2.15.3.1 The thickness of the superstructure side bulkhead plating is not to be less than that obtained from the following formula:

$$\text{Forecastle and short bridge } t = 0.045L + 4 \quad \text{in mm}$$

$$\text{Poop } t = 0.04L + 4 \quad \text{in mm}$$

The thickness of the side bulkhead plating of long bridge is not to be less than the provisions of Section 2 of this CHAPTER.

2.15.3.2 The side framing of superstructures is to comply with the requirements of Section 7.

2.15.4 Deck

2.15.4.1 The thickness t of deck plating of superstructures is not to be less than the values obtained from the following formula:

$$\text{Forecastle and short bridge } t = 0.023L + 5 \quad \text{in mm}$$

$$\text{Poop } t = 0.018L + 5 \quad \text{in mm}$$

The thickness of the deck plating of long bridge is not to be less than the provisions of Section 3 of this CHAPTER. When the length of vessel is not less than 60 m, the effects of total longitudinal bending is to be

considered.

2.15.4.2 The framing of superstructure deck is to comply with the relevant requirements in Section 8 of this PART

2.15.5 Local strengthening

2.15.5.1 Pillars, diaphragms, bulkheads or other strength members are to be arranged under the ends of superstructures for support.

2.15.5.2 The side shell plating at the end of the superstructure is to be obliquely extended from the end until the lower deck sheer strake disappears. The length of the extension plating is not to be less than 1.5 times that of the superstructure (See Figure 2.15.5.2). When the length of vessel is less than 60 m or the end bulkhead is outside the $0.4 L$ amidships, the extension length can be appropriately reduced. This plating is to be supported by stiffened brackets and to be efficiently stiffened at the upper edge by a face plate having the same thickness as the extension plating and a breadth not less than 10 times its thickness. The extension plating is to comply with the following requirements:

.1 For bridge, forecastle and poop with a length no less than $0.25 L$, the thickness of the extension plating is to be increased by 25%;

.2 For forecastle and poop with a length no greater than $0.2 L$, the thickness of the extension plating is not to be increased;

.3 When the length of the forecastle and poop is the median mentioned above, the increased thickness of the extension plating is to be obtained by interpolation.

2.15.5.3 The thicknesses of the lower deck side plating and sheer strake from at least 2 frame spaces inwards to superstructure end bulkhead, the thickness of stringer plates and sheer strakes is to be increased (see Figure 2.15.5.3):

.1 Where the end bulkheads of the superstructure are situated within $0.4 L$ amidships, the thickness of stringer plates and sheer strakes is to be increased by 20%;

.2 Where the end bulkheads of the superstructure are situated within $0.2 L$ away from the fore perpendicular and after perpendicular, the thickness of stringer plates and sheer strakes is not to be increased;

.3 Where the end bulkheads of the superstructure are situated within $0.2 L \sim 0.25 L$ away from the fore perpendicular and after perpendicular, the increased thickness of stringer plates and sheer strakes is to be obtained by interpolation.

(1~1.25) t is to be determined according to bridge stern, stem position and length

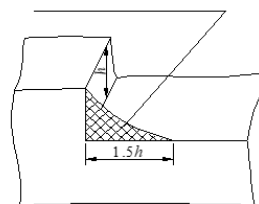
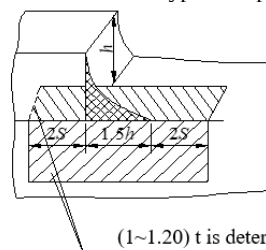


Figure 2.15.5.2 Transitional type of superstructure side shell plating



(1~1.20) t is determined according to the superstructure end bulkhead

Figure 2.15.5.3 Reinforcement of superstructure end deck and side shell plating

2.15.6 Raised quarter decks

2.15.6.1 The scantlings of the main frames in way of the raised quarter deck are to be determined according to the requirements of Section 7 of this CHAPTER. In this case the span of the frame is to be measured to the raised quarter deck, and the moulded depth is to be taken as that at the raised quarter deck.

2.15.6.2 The scantlings of the beams in way of the raised quarter deck are to be determined in accordance with the relevant requirements for the strength deck as specified in Section 8 of this CHAPTER.

2.15.6.3 The thickness of the raised quarter deck sheer strake is to be determined according to the requirements of Section 2 of this CHAPTER.

2.15.6.4 The scantlings of the raised deck plating are to be determined in accordance with the relevant requirements for the strength deck as specified in Section 3 of this CHAPTER.

2.15.6.5 The thickness of break bulkheads and the scantlings of stiffeners are to be determined in accordance with the requirements for end bulkheads of corresponding superstructures.

2.15.6.6 Strengthening at the break within $0.4 L$ amidships

.1 For $L < 60$ m, the strength deck stringer plate and the raised quarter deck stringer plate are to extend respectively for 3 frame spaces on either side of the break bulkhead and are to be gradually tapered off;

.2 For $L \geq 60$ m, the upper and raised deck plating at the break is to overlap for 2 frame spaces, and in this case the stringer plates of both decks are to extend forward for 2 frame spaces beyond the end of overlapped plating. Vertical diaphragm plates spaced not more than 1.5 m apart in parallel with the longitudinal centerline are to be fitted between the overlapped deck plating. The thickness of the diaphragm plates is to be the same as that of the break bulkhead plating, and the diaphragms are to be efficiently stiffened and their free edges are to be flanged or provided with a face plate.

2.15.6.7 Where the break is located outside of $0.4 L$ amidships, the strength deck stringer plate is to extend for 3 frame spaces beyond the break and is to be gradually tapered off. If the height of the raised deck does not exceed 400 mm, and it is difficult to extend the deck stringer plate, other equal strength measures can be adopted.

2.15.6.8 The sheer strake is to be increased in thickness by 30% for a distance of 3 to 5 frame spaces on either side of the break bulkhead. Where a raised quarter deck is connected to a long bridge, the sheer strake of side plating within the raised quarter deck area is to be increased in thickness by 25% for a distance of at least 2 frame spaces on either side of the break, and the side plating of the bridge is to be gradually tapered in a curve line from the end of the bridge deck stringer plate into the sheer strake of side plating within raised quarter deck area over a length more than 1.5 times the height of the bridge above the raised quarter deck.

Section 16 DECKHOUSE AND MACHINERY CASINGS

2.16.1 General Requirements

2.16.1.1 Where deckhouses or machinery casings are subject to loading in excess of that as specified in this Section, the scantlings are to be increased.

2.16.1.2 The deckhouse on the deck of moulded depth D is 1F deckhouse, and 2F, 3F, etc. which are collectively referred to as upper deckhouses.

2.16.2 Boundary bulkhead

2.16.2.1 Thickness of boundary bulkhead

.1 The thickness t of the front bulkhead plating of the 1F deckhouse is not to be less than that obtained from the following formula:

$$t = 0.03L + 4.2 \quad \text{in mm}$$

.2 The thickness t of the side bulkhead and rear bulkhead plating of the 1F deckhouse is not to be less than that obtained from the following formula:

$$t = 0.03L + 3.5 \quad \text{in mm}$$

.3 The thickness of the boundary bulkhead of the upper deckhouse is to be reduced by 0.5 mm layer by layer compared with the calculated values in .1, .2 respectively, but is not to be less than 4 mm;

.4 When $24 \text{ m} \leq L < 30 \text{ m}$, the thickness of the boundary bulkhead can be reduced by 0.5 mm according to the values obtained from formulae .1 and .2;

.5 The height of the lower strake of boundary bulkhead is to be greater than 300 mm, and is to be thickened by 2 mm compared with the values. It is not necessary to exceed the thickness of the steel deck. When the spacing of boundary bulkhead stiffeners is greater than 750 mm, the boundary bulkhead plating is to be thickened by 0.5 mm by every increase of 100 mm.

2.16.2.2 Stiffeners of boundary bulkhead

.1 design pressure head of stiffener h is to be calculated by the following formulae:

$$\text{Lowest layer front end bulkhead stiffener } h = 0.06L + 0.8 \quad \text{in m}$$

$$\text{Stiffeners of boundary bulkhead at other positions } h = 0.0045L + 1.1 \quad \text{in m}$$

.2 The section modulus W of boundary bulkhead stiffener is not to be less than that obtained from the following formula, and is not to be less than 10 cm^3 .

$$W = 4shl^2 \text{ in cm}^3$$

Where: s — spacing of stiffeners, in m;

h — Design head, in m, calculate according to .1;

l — span of stiffener, in m.

For fishing vessels with more than one deckhouses, the section modulus W of the uppermost deckhouse side bulkhead and rear wall stiffener can be reduced compared to the value calculated above, but is not to be less than 10cm^3 .

.3 For boundary bulkhead of each deckhouse within $0.15L$ amidships, the section modulus of stiffeners is to be increased by 50% compared with above; for boundary bulkhead in back unprotected 1F deckhouse within $0.15L$ amidships, the stiffeners are to be appropriately strengthened.

.4 When the length of vessel is less than 30 m, the boundary bulkhead stiffeners can be reduced by 30% according to the calculated values of .2.

2.16.3 Deck

2.16.3.1 The thickness of the deck of the 1F deckhouse is not to be less than that obtained from the following formula:

$$t = 0.025L + 4 \text{ in mm}$$

The deck thickness of the upper deck room can be reduced by 0.5mm one by one, but not less than 4mm.

When the vessel length is less than 30m, the thickness of the first deckhouse deck can be reduced by 0.5mm according to the above formula.

2.16.3.2 The scantlings of deck girders and strength beam of deckhouse are not to be less than the requirements of Section 8 of this CHAPTER.

2.16.3.3 The section modulus W of the deck longitudinals of deckhouse or beams are not to be less than:

$$W = 5shl^2 \text{ cm}^3, \text{ and not less than } 25s$$

Where: s — distance of deck longitudinals or beams, in m;

l — spacing of deck longitudinals or beams, in m;

h — design pressure head, in m, to be selected as follows:

F1: 0.9m;

F2: 0.6m;

F3: 0.45m.

2.16.3.4 When a long deck room is provided and is located in the 0.4 area in the L middle of the vessel, the thickness of the deck plating of the long deckhouse and frame sizes are to increase. When the length of vessel is less than 60 m, the effects of the total longitudinal bending is to be considered.

2.16.4 Local strengthening

2.16.4.1 Adequate support under the ends of deckhouses is to be provided in the form of pillars, diaphragms, bulkheads or other strength members.

2.16.4.2 All openings cut in the sides of long deckhouses are to be adequately strengthened and have well rounded corners. Continuous coamings with adequate height are to be fitted below and above doors or similar openings. House tops are to be strengthened in way of boats and davits. Special care is to be taken to minimize the size and number of openings in the side bulkheads in the region of the ends of deckhouses within $0.4L$ amidships.

2.16.4.3 The sides and ends of the 1F long deckhouses on the lowest tier deck are generally to be strengthened by partial bulkheads or vertical webs spaced about 9 m apart, and these stiffening members are, as far as practicable, to be arranged in line with the strengthening members within the 'tween deck space below the deckhouse.

2.16.5 Machinery casings

2.16.5.1 Machinery space openings in the exposed deck are to be protected by strong steel casings. Machinery casings situated on the working deck or raised quarter deck are to be enclosed in the superstructures or deckhouses so far as practicable.

2.16.5.2 Doors in machinery casings are to be of steel and rigid construction, and are to be capable of being operated from both sides.

2.16.5.3 The scantlings of boundary bulkheads of exposed casings are to be determined in accordance with the requirements for those of the deckhouses in the corresponding positions.

2.16.5.4 The scantlings of boundary bulkheads of non-exposed casings are to comply with the following requirements:

.1 The minimum thickness of boundary bulkheads of the casings is not to be less than 4 mm in way of accommodation spaces;

.2 The section modulus W of the stiffeners of boundary bulkheads of the casings is not to be less than that obtained from the following formula:

$$W = 8sl \text{ in cm}^3$$

Where: s — spacing of stiffeners, in m;

l — span of stiffener, in m.

For vessels of 65 m or over in length L , the depth of stiffeners is not to be less than 60 mm.

2.16.5.5 Where casing stiffeners support the deck transverses or girders or where they are in line with pillars below, they are to be suitably strengthened.

2.16.5.6 When the enclosure wall of the engine room shed supports the deck above it, the openings such as doors and windows on the enclosure wall shall be effectively strengthened, and the part of the engine room shed supporting the chimney or exhaust flue shall also be strengthened.

2.16.6 Connection of stiffener ends

2.16.6.1 The stiffeners of deckhouse front end bulkhead and those of single-layer deckhouse side wall are to be firmly welded to the deck. For fishing vessels provided with two or more deckhouses, both ends of the stiffeners on the 1F deckhouse are to be connected by brackets. The scantlings of brackets are to comply with the provisions in 1.2.5 of this PART. Where such stiffeners are not bracketed but directly welded to the deck, their section modulus is to be increased by 20%.

2.16.6.2 The front end bulkhead stiffeners on amidships casing and all stiffeners on aft end casings which are situated on the deck to exposed machinery casings are connected by brackets. The scantlings of brackets are to comply with the provisions in 1.2.5 of this PART. Where such stiffeners are not bracketed but directly welded to the deck, their section modulus is to be increased by 20%. All other stiffeners on exposed machinery are to be welded to the decks at top and bottom.

Section 17 BULWARKS

2.17.1 Bulwark plating

2.17.1.1 The plating thickness of bulwarks on working deck is not to be less than 4 mm for fishing vessels having a length less than 30 m and not to be less than 6 mm for vessels having a length equal to 65 m or over. For fishing vessels of other lengths, the minimum bulwark plating thickness can be obtained by interpolation.

2.17.1.2 The bulkhead plating at amidships is to avoid welding to the sheer strakes as far as possible.

2.17.1.3 The mounting points of the anchorage plates, fairleads, guide pulleys and other fishing equipment on the bulwark are to be appropriately strengthened.

2.17.1.4 Where bulwarks are cut to form a gangway or other openings, stays of increased strength are to be fitted at the ends of the openings. Bulwarks are not to be cut for gangway or other openings near the breaks of superstructures.

2.17.2 Bulwark face plate

2.17.2.2 Face plates are to be provided at the upper edge of bulwark. Face plates can be made of flat-rolled steel or other profiles. Smooth rounded corners are to be fitted in netting area.

2.17.3 Bulwark bracket

2.17.3.1 Bulwarks are to be provided with supporting brackets on deck beam, and are to be welded to the deck. Support brackets are to be provided with folds or spheres. The spacing of support brackets is not to be greater than 2 frame spaces. Where the bulwarks on the forecastle deck have a great flare the spacing of support brackets is not to be greater than 1 frame space.

2.17.3.2 The section modulus W at the root of support bracket is not to be less than that obtained from the following formula:

$$W = (30 + 0.45L)sh^2 \text{ in cm}^3$$

Where: s — spacing of brackets, in m;

h — height of bulwark, in m.

Where the flange (or bulwark) of support bracket is not welded to the deck, the flange (or bulwark) is not to be considered for the section modulus.

2.17.3.3 The bulwarks at the gallows and bottom bracket at the installation site are to be provided with supporting brackets as specified in 2.17.3.1 of this PART on each beam.

Section 18 HATCH

2.18.1 Hatch coamings

2.18.1.1 The thickness t of exposed hatch coamings is not to be less than that obtained from the following formula:

$$t = 0.05L + 6.5 \quad \text{in mm}$$

When $L < 30$ m, the thickness of hatch coaming can be reduced by 2 mm according to the above formula.

2.18.1.2 Structure of hatch coaming

- .1 if no face plate is fitted at the upper edge of hatch coaming, the positions are to be strengthened with semi-round steel or other profiles that ensure coaming rigidity and smooth upper edge;
- .2 when the hatch coaming protrudes below the deck plating, the height of the hatch coaming below the deck is not to be less than the height of the half beam to ensure the connection of the half beam to the hatch coaming;
- .3 When the deck plating extends into the hatch coaming and the deck opening meets the requirements of 2.3.4 of this PART at the corner, the corners of the hatch coaming may be right-angled.

Section 19 OTHERS

2.19.1 Side reinforcement of fishing vessels moored at sea

2.19.1.1 This clause applies to fishing vessels frequently moored at sea.

2.19.1.2 Side reinforcement area

The reinforcement areas referred to in this Section are side-enclosed areas consisting of the vertical and longitudinal extents described below.

- .1 The vertical area is the range from 0.8m below the lightest operating waterline to the designated deck. Designated deck is defined as the upper deck of single deck vessel or multi-deck vessel with buffer device (if there is no such upper deck, it is still the work deck);

.2 The longitudinal area is the length of vessel with deck breadth B_1 meeting the following requirements:

$$B_1 \geq B - 2 \quad \text{in m}$$

Where: B_1 —breadth of designated deck, in m.

- .3 For vessels moored on one side, the stiffening zone is limited to the berthing side.

2.19.1.3 Side frame of reinforced area

.1 below work deck

- (1) The upper end of the main frame is to be extended and welded to the work deck. The beam is to extend to the inner edge of the frame. The brackets of beam are to be provided with face plates or flanges. The scantlings are to comply with the requirements in 1.2.5 of this PART;
- (2) It is recommended to set middle frames. The middle frame ends are to be welded to longitudinal discontinuous members between main frames with a height no less than 0.75 times the height of the main frame, and are to be welded to side stringers and decks. Inclined cutting is not allowed at the ends of the middle frame;

(3) If no middle frame is provided, the section modulus of the main frame is to be increased by 40% compared with the requirements specified in this CHAPTER;

(4) When the middle frame is increased, the section modulus of the main frame can be reduced by 20% compared with the specified value.

(5) The section modulus of the middle frame is not to be less than 75% of the specified value of the section modulus of the main frame.

.2 Above work deck

Both ends of the frames at the 'tween decks are to be welded to the deck and meet the relevant requirements of 2.19.1.3.1.

2.19.1.4 The thickness of side shell plating in reinforcement areas is to be 1 mm thicker than that required in 2.2.4 of this PART.

2.19.1.5 On the transverse bulkheads in the side reinforcement zone, horizontal stiffeners with a height of not less than 75% of the stiffener height are to be provided between the lateral stiffeners and the side shell plating, and the spacing is not to be greater than 600 mm.

2.19.1.6 Where feasible, the bulwarks or "designated decks" are to be inclined inwardly. The inclination distance is not to be less than 0.1 times the height.

2.19.2 Fish product processing compartment

2.19.2.1 When the distance between the bulkheads at both ends of the fish product processing compartment exceeds 30 m, partial bulkheads or strong frame structures with a spacing of not greater than 9 m are to be provided. The partial bulkheads or strong frames are to be aligned as much as possible with the strong members below.

2.19.2.2 Fish product processing waste and wastewater are to be provided with effective treatment and discharge facilities, and special sewage bilges are to be provided on both sides of the bilge bottom. The thickness of the steel plate constituting the sewage bilges is not to be less than 14 mm. When using corrosion-resistant materials, the thickness of plate can be appropriately reduced.

2.19.2.3 For the compartments used for the processing of catches, the bulkheads, decks and insulation (if provided) are to be taken to reduce the absorption or leakage of oil.

2.19.2.4 The cross-section modulus of deck beams under the catch processing area is to be calculated in accordance with the requirements of 2.8.2.1 of this PART. The design pressure head h used is to be 2 m. Deck thickening and other methods are particularly strengthened.

2.19.2.5 When concentrated loads are applied to the deck, the strong beams and deck girders below the deck are to comply with the requirements of 2.8.3.2.

2.19.3 Live fish tank

2.19.3.1 For fishing vessels equipped with live fish tanks, the sea openings on the bottom and side plates of live fish tanks are not to be arranged on a single cross section. The diameters are not to be greater than 250 mm.

2.19.3.2 Perforation is not to be fitted at flat keel and bilge strake at the bottom of the vessel.

2.19.3.3 The distances between the hole edge and frame on the hull, flat keel, bilge strake and bilge top strake are not to be less than 75 mm; the distance between hole centers is not to be less than 400 mm and is to meet the provisions in 2.1.4.7 of this PART.

CHAPTER 3 OUTFITS

Section 1 RUDDERS

3.1.1 General Requirements

3.1.1.1 This Section applies to ordinary streamline rudders, single plate rudders and high lift rudders.

3.1.1.2 The steering gear is to comply with the relevant requirements of CHAPTER 9, PART THREE.

3.1.1.3 This Section applies to rudder structures made of ordinary strength hull-structural steel. If high-strength steel is used, the material factors specified in 1.5.1 of this PART may be used to reduce rudder component sizes accordingly. The material properties of rudder are to comply with the relevant provisions of PART SEVEN.

3.1.1.4 Steel casting materials for manufacturing rudder stocks, pintles, connecting bolts, keys and rudders are to comply with the relevant provisions of PART SEVEN.

3.1.1.5 For rudder stocks, pintles, keys and bolts the minimum yield stress R_{eH} is not to be less than 200N/mm^2 . When calculating the dimensions of the above parts, the Material factor K_s is to be calculated as follows:

$$K_s = \left(\frac{R_{eH}}{235}\right)^{0.75} \quad \text{When } R_{eH} > 235 \text{ N/mm}^2;$$

$$K_s = \left(\frac{R_{eH}}{235}\right) \quad \text{When } R_{eH} \leq 235 \text{ N/mm}^2$$

Where: R_{eH} —yield stress of the material, N/mm^2 , the value is not to be greater than $0.7 R_m$ or 450N/mm^2 , whichever is the smaller.

R_m —Tensile strength of the material, N/mm^2 .

3.1.1.6 When the rudder stock is made of steel with a yield stress greater than 235N/mm^2 , if the diameter of rudder stock is significantly reduced arising therefrom, CCS may require an evaluation of the rudder stock deformation. Prevent excessive edge stress and large rudder stock deformation at the bearing.

3.1.1.7 The hull structure around the rudder bearing is to be appropriately strengthened, and appropriate measures are to be taken to prevent the rudder from being lifted.

3.1.1.8 The seaward rudderstock sleeve is to be fitted with a sealing device or stuffing box above the maximum waterline to prevent seawater from entering the steering engine room which will flush away the lubricant on the rudder bearing. If the top of the rudderstock sleeve is below the maximum load waterline, two separate stuffing boxes are to be provided.

3.1.2 Rudder force

3.1.2.1 Rudder force is to be determined from the following formula:

$$F = 132K_1K_2K_3AV_d^2 \quad \text{in N}$$

Where: A —area of rudder blade, in m^2 ;

V_d —design rudder speed, in kn, is to be calculated according to 3.1.2.2;

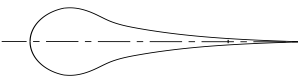
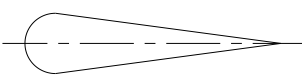
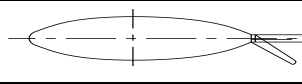
K_1 —factor, is to be calculated according to 3.1.2.3;

K_2 —factor, see Table 3.1.2.1;

K_3 -factor, 0.8 for rudders outside the propeller jet; 1.15 for rudders behind a fixed propeller nozzle; 1.0 otherwise.

Factor K_2 Table 3.1.2.1

Profile Type		K_2	
		Ahead condition	Astern condition
NACA-00 series Göttingen		1.1	0.80

Concaved profile		1.35	0.90
Flat side		1.1	0.90
Flat plate		1.1	0.90
Flap		1.7	1.7

3.1.2.2 The rudder design speed V_d is calculated by the following formula:

$$V_d = V \text{ ahead, when } \geq 10 \text{ kn } V$$

$$V_d = V (+ 20) / 3 \text{ ahead, when } V < 10 \text{ kn}$$

Where: V —maximum service speed, in kn, at summer load draught.

For the astern condition, V_d is the maximum astern speed, not to be taken greater than $0.5V$.

3.1.2.3 The coefficient K_1 is to be calculated according to the following formula:

$$K_1 = \frac{\lambda + 2}{3}$$

Where: $\lambda = \frac{b^2}{A_t}$, in which b is the mean height of rudder blade, in m. Calculate according to 3.1.2.4 of this PART. λ is not necessary to be greater than 2.

A_t Is the sum of the rudder blade area A and rudder post or rudder horn area within the mean height of rudder, in m^2 .

3.1.2.4 The mean breadth c and mean height b of rudder blade are to be calculated according to the following formulas:

$$c = \frac{X_2 + X_3 - X_1}{2} \quad \text{in m}$$

$$b = \frac{Z_4 + Z_3 - Z_2}{2} \quad \text{in m}$$

Where: X_1 , X_2 and X_3 are the coordinate values X of 1, 2 and 3 points, in m. See Figure 3.1.2.4;

Z_2 , Z_3 and Z_4 are coordinate values Z of 2, 3 and 4 points, in m, see Figure 3.1.2.4.

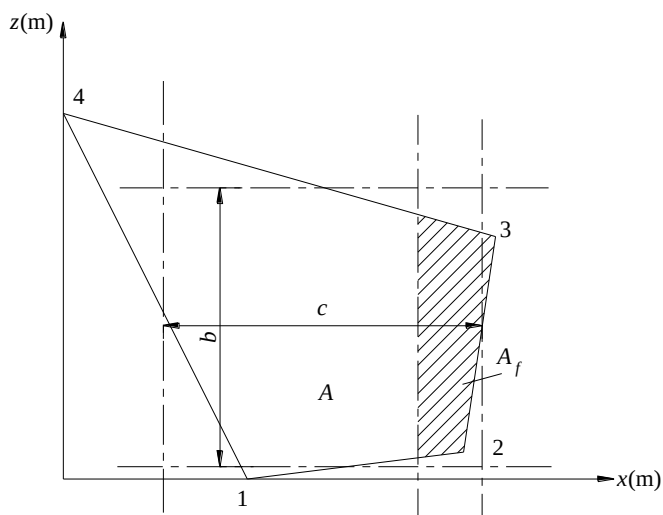


Figure 3.1.2.4 Dimension coordinate system of rudder blade

3.1.3 Rudder torque

3.1.3.1 For the ahead and astern conditions, rudder torque T is to be calculated by the following formula:

$$T = FR \quad \text{in N m}$$

Where: F —rudder force, in N, is to be calculated according to 3.1.2.1 of this PART;

R —arm torque, in m, is to be calculated according to 3.1.3.2 and 3.1.3.3 of this PART.

3.1.3.2 The arm torque R of rudder blades without cut-outs is to be calculated by the following formula:

$$R = c(\alpha - \beta) \quad \text{in m}$$

Where: c —mean breadth of rudder blade, in m, is to be calculated according to 3.1.2.4 of this PART;

α —coefficient, taken as 0.33 for ahead condition and 0.66 for astern condition; special consideration may be given for high lift rudders, and taken as 0.40 for ahead condition and 0.66 for astern condition if no test data may be provided;

β — A_f / A , where, A_f is the rudder blade area before the centerline of the rudder stock, in m^2 ; A is the rudder blade area, in m^2 ; to be taken for unbalanced rudder.

$$\beta = 0.08$$

For the ahead conditions, the arm torque R is to be taken no less than $0.1c$.

3.1.3.3 The arm distance R of rudder blades without cut-outs (semi-spade rudders) is to be calculated by the following formula:

$$R = c_1(\alpha - \beta_1) \frac{A_1}{A} + c_2(\alpha - \beta_2) \frac{A_2}{A} \quad \text{in m}$$

Where: $A = A_1 + A_2$ —area of rudder blade, in m^2 ;

A_1 — A_2 area, in m^2 , see Figure 3.1.3.3;

c_1 and c_2 —mean width of partial area of A_1 and A_2 , in m, to be calculated according to 3.1.2.4 of this PART;

$\beta_1 = \frac{A_{1f}}{A_1}$, where A_{1f} and A_1 are the area before the centerline of the rudder stock. See Figure 3.1.3.3, in m^2 ;

$\beta_2 = \frac{A_{2f}}{A_2}$, where A_{2f} and A_2 are the area before the centerline of the rudder stock. See Figure 3.1.3.3, in m^2 ;

α —coefficient, taken as 0.33 for ahead condition and 0.66 for astern condition; partial rudder after the fixed structure (such as rudder horn), taken as 0.25 for ahead condition and 0.55 for astern condition For

the ahead conditions, the arm distance R is not to be less than $\frac{1}{10A}(A_1c_1 + A_2c_2)$.

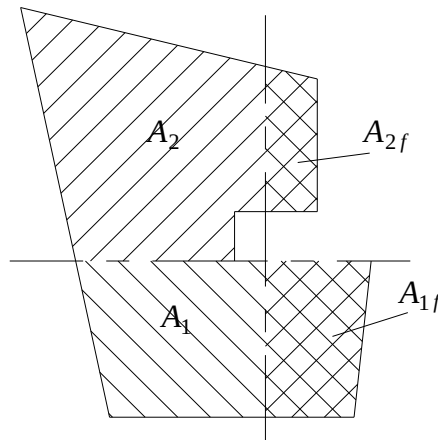


Figure 3.1.3.3 Semi-spade rudder area distribution

3.1.4 Rudder stock--force of rudder blade system

3.1.4.1 Rudder stock—The force analysis of rudder blade system is to solve the bending moment of rudder rod, bending moment of rudder blade, shear force of rudder blade and the supporting force of each bearing.

In the force analysis of the system, $l_1 \sim l_5$ is the length of each component in the system; $I_1 \sim I_5$ is the

moment of inertia of such members.

3.1.4.2 For the double-fulcrum rudder with rudder button as shown in Figure 3.1.4.2-1 and the double-fulcrum rudder with rudder shaft as shown in Figure 3.1.4.2-2, the force is to be calculated according to the following formula:

$$\text{Rudder blade bending moment } M_r : M_r = 0.125Fb \quad \text{N} \cdot \text{m}$$

$$\text{Rudder blade shear force } N_r : N_r = F \left(0.6 - \frac{h}{b} \right) \quad \text{in N}$$

$$\text{Supporting force of the upper rudder } P : P = 0.7F \quad \text{in N}$$

$$\text{Supporting force of the lower rudder } P : P = 0.6F \quad \text{in N}$$

Where: F —rudder force, in N, is to be calculated according to 3.1.2.1 of this PART;

b —mean height of rudder blade, in m, is to be calculated according to 3.1.2.4 of this PART;

h —The rudder height above or below the calculated section, in m, whichever is the lesser.

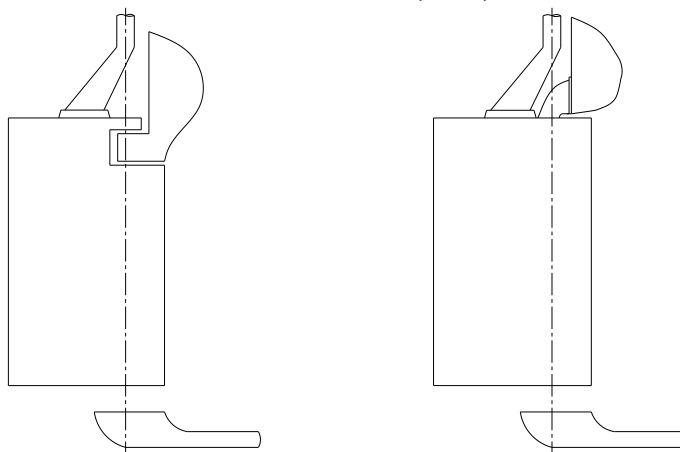


Figure 3.1.4.2-1 Double-fulcrum rudder with rudder button Figure 3.1.4.2-2 Double-fulcrum rudder with rudder shaft

3.1.4.3 For the semi-suspended double rudder button rudder as shown in Figure 3.1.4.3, the force is to be calculated by the following formula:

$$\text{Rudder blade bending moment at the lower pintles (A-A section) } M_r :$$

$$M_r = Fh \frac{A_1}{A} \quad \text{N} \cdot \text{m}$$

$$\text{Rudder blade shear at the lower pintles (A-A section) } N_r :$$

$$N_r = F \frac{A_1}{A} \quad \text{in N}$$

$$\text{Supporting force of the lower pintles bearing } P :$$

$$P = \frac{F}{2} \left[1 + \frac{A_1 b}{A(b - h_1)} \right] \quad \text{in N}$$

$$\text{Supporting force of the upper pintles bearing } P, \text{ but not to be less than } 0.4F:$$

$$P = \frac{F}{2} \left[\frac{A_1 b}{A(b - h_1)} - 1 \right] \quad \text{in N}$$

Where: F —rudder force, in N, is to be calculated according to 3.1.2.1 of this PART;

A —area of rudder blade, in m^2 ;

A_1 — A — rudder area below the section A , in m^2 , see Figure 3.1.4.3;

h —vertical distance from the centroid of the area A_1 to A — A section, in m;

h_1 —Rudder A — A rudder height below the section, in m;

b —mean height of rudder blade, in m, is to be calculated according to 3.1.2.4 of this PART.

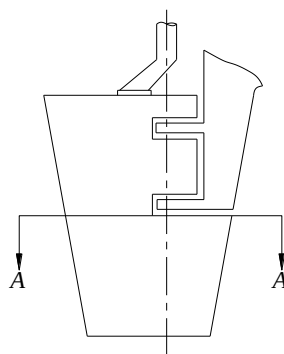


Figure 3.1.4.3 Semi-suspended double rudder button rudder

3.1.4.4 For the suspended rudder as shown in Figure 3.1.4.3, the force is to be calculated by the following formula:

Bending moment M_b of rudder stock at lower rudder bearing:

$$M_b = F[l_2 + \frac{l_1(2C_1 + C_2)}{3(C_1 + C_2)}] \quad \text{N} \cdot \text{m}$$

Rudder blade bending moment M_r :

$$M_r = Fh \frac{A'}{A} \quad \text{N} \cdot \text{m}$$

Rudder blade shear force N_r :

$$N_r = F \frac{A'}{A} \quad \text{in N}$$

Supporting force of the upper rudder bearing P :

$$P = \frac{M_b}{l_3} \quad \text{in N}$$

Supporting force of the lower rudder P :

$$P = F + \frac{M_b}{l_3} \quad \text{in N}$$

Where: l_1 , l_2 , l_3 , C_1 and C_2 are shown in Figure 3.1.4.4, in mm

F —rudder force, in N, is to be calculated according to 3.1.2.1 of this PART;

A —area of rudder blade, in m^2 ;

A' —The rudder area below the calculated section, in m^2 ;

h —vertical distance from the centroid of the area A' to the calculated section, in m;

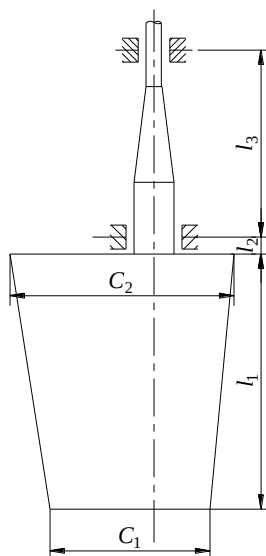


Figure 3.1.4.4 Suspension rudder

$$P = \frac{F}{l_1} \text{ in N/m.}$$
$$P_1 = \frac{FA_1}{l_1 A} \text{ in N/m.}$$

$$P_2 = \frac{FA_2}{l_2 A} \text{ in N/m.}$$

$$P = \frac{Fh}{l_2 + l_3} \quad \text{in N}$$

Figure 1 consists of two schematic diagrams of a two-story frame structure. Diagram (a) shows the structure with dimensions l_1, l_2, l_3, l_4, l_5 and moments I_1, I_2, I_3, I_4, I_5 . Diagram (b) shows the structure with dimensions l_1, l_2, l_3, l_4, l_5 and moments I_1, I_2, I_3, I_4, I_5 , and a horizontal load P .

$$k = 6.18 \frac{I}{l_5^3} \times 10^3 \text{ in N/m.}$$

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l_s —effective length of the sole piece, in m, see Figure 3.1.4.5 in this section.

.2 The support spring constants k of rudder horn are to be calculated as follows:

$$k = \frac{1}{f_b + f_t} \times 10^3 \quad \text{in N/m.}$$

Where: f_b -bending displacement of the rudder horn, in m/N, when 1N applied on the support center, f_b can be calculated according to this .3.

Where: f_t -torsional displacement of the rudder horn, in m/N, when 1N applied on the support center, f_t can be calculated according to this .4.

.3 f_b is to be calculated by the following formula:

$$f_b = \frac{1.3l_h^3}{6.18I} \times 10^{-3} \quad \text{in m/N}$$

Where: l_h —See Figure 3.1.4.6 in this Section, in m;

I —Moment of inertia about the axis of symmetry at the sole piece section, in cm⁴;

.4 f_t is to be calculated by the following formula:

$$f_t = \frac{l_h e^2 \sum \frac{u_i}{t_i}}{3.14A_a^2} \times 10^{-11} \quad \text{in m/N}$$

Where: l_h —See Figure 3.1.4.6 in this Section, in m;

Where: e —See Figure 3.1.4.6 in this Section, in m;

u_i —breadth of each plate forming the average cross-sectional area of the rudder horn, in mm;

t_i —corresponding thickness within the breadth of each plate, in mm;

A_a —average cross-sectional area of rudder horn, in m².

3.1.5 Rudder stock

3.1.5.1 Stock diameter D_t , in mm, at the tiller for transmitting rudder torque, is not to be less than that obtained from the following formula:

$$D_t = 4.2 \sqrt[3]{\frac{T}{K_s}} \quad \text{in mm}$$

Where: T —rudder torque, N · m, is to be calculated according to 3.1.3.1 of this PART;

K_s —material factor of rudder stock, see 1.5.1.3 of this PART;

The corresponding allowable torsional stress is $68K_s$, N/mm².

3.1.5.2 If the steering engine (such as single-plunger dual-cylinder steering engine) generates additional bending moment to the rudder stock at the upper rudder bearing through a tiller or quadrant, the diameter of rudder stock at the tiller is to be calculated according to 3.1.5.4 of this PART, where the bending moment M_b is replaced by an additional bending moment.

3.1.5.3 For the rudder types shown in Figure 3.1.4.2 and Figure 3.1.4.3 in this PART, the diameter of rudder stock below the upper rudder bearing is not to be less than the diameter at the tiller.

3.1.5.4 For the rudder types shown in Figure 3.1.4.4, Figure 3.1.4.5 and Figure 3.1.4.6 in this PART, the diameters of rudder stock D_c at and below the lower rudder bearing are not to be less than the values obtained from the following formula:

$$D_c = D_t \left(1 + \frac{4}{3} \left(\frac{M_b}{T} \right) \right)^{\frac{1}{6}} \quad \text{in mm}$$

Where: D_t —diameter of rudder stock at the tiller, in mm, calculated according to 3.1.5.1 of this PART;

M_b —maximum bending distance of the rudder stock between the lower rudder bearing and the top of the

rudder blade, $N \cdot m$, is to be calculated according to 3.1.4.4, 3.1.4.5 and 3.1.4.6 of this PART;

Where: T —rudder torque, $N \cdot m$, is to be calculated according to 3.1.3.1 of this PART;

3.1.5.5 The diameter of rudder stock above the lower rudder bearing is to be kept as consistent as possible with the diameter of the rudder stock at the lower rudder bearing, and then it can be gradually reduced to the diameter at the tiller, but the length of the cone is not to be less than 3 times the difference to the diameter. Special care is to be taken to avoid any cut-outs at the upper end of the cone.

3.1.6 Rudder blade

3.1.6.1 In order to ensure the overall strength of the rudder blade, the structure of rudder blade should be able to effectively transfer the forces to rudder stocks, rudder shafts and pintles. When a box-shaped structure is used instead of the lower rudder stock, the box-shaped structure is composed of a continuous vertical partition and an effective rudder side plate. The breadth of the effective rudder side plate is not to be greater than 2 times the transverse dimension at the rudder blade, nor greater than 2.5 times the diameter of the rudder stock at the lower rudder bearing or the length of the flange at the top of the rudder. Under the action of the rudder blade bending moment and shear force (see 3.1.4 of this PART), the stress on the horizontal section of the box structure is to comply with the following requirements:

.1 Rudder blades without cut-outs:

Bending stress: $\sigma \leq 110$ in N/mm^2

Shear stress: $\tau \leq 50$ in N/mm^2

Equivalent stress: $\sigma_e = \sqrt{\sigma^2 + 3\tau^2} \leq 120$ in N/mm^2

.2 Rudder blades with cut-outs:

Bending stress: $\sigma < 75$ in N/mm^2 (for the section at the cut-out)

Shear stress: $\tau \leq 50$ in N/mm^2

Equivalent stress: $\sigma_e = \sqrt{\sigma^2 + 3\tau^2} \leq 100$ in N/mm^2

3.1.6.2 The thicknesses t of the rudder side plate, top plate and bottom plate are not to be less than the values obtained from the following formula:

$$t = 5.5s\beta\sqrt{d + \frac{F}{A} \times 10^{-4}} + 2.5 \quad \text{in mm}$$

Where: d —maximum draught, in m;

F —rudder force, in N, is to be calculated according to 3.1.2.1 of this PART;

A —area of rudder blade, in m^2 ;

$$\beta = \sqrt{1.1 - 0.5\left(\frac{s}{b}\right)^2}$$

, where s and b , in m, are the smallest and the greatest unsupported widths of plating respectively; if $b/s \geq 2.5$, then $\beta = 1$.

3.1.6.3 The rudder blades are to be provided with vertical partitions and horizontal partitions, and their thicknesses are not to be less than 0.7 times the thickness of the rudder side plate, and not less than 6 mm.

3.1.6.4 The thickness of the rudder guide plate is not to be less than 1.2 times the thickness of the rudder side plate, but it need not be greater than 22 mm.

3.1.6.5 For the semi-suspended rudder shown in Figure 3.1.4.3 and Figure 3.1.4.6 of this PART, the rudder side plate in the lower pintle area is to be thickened. The thickness is to be increased by 80% from the thickness calculated by formula 3.1.6.2 of this PART. The thickened rudder side plate is to extend beyond the continuous vertical bulkhead and the horizontal bulkhead above and below the lower pintles area, and has as large a fillet as possible at each corner.

3.1.6.6 The inside of the rudder blade is to be coated with rust-proof paint. The upper and lower parts of the rudder are to be fitted with drainage holes and equipped with plugs made of stainless metal.

3.1.7 Horizontal flange coupling of rudder stock and rudder blade

3.1.7.1 The diameter of the coupling flange bolts d_b is not to be less than that obtained from the following formula:

$$d_b = 0.62\sqrt{\frac{D_c^3 K_s}{nE_b K_b}} \quad \text{in mm}$$

Where: D_c —diameter of the rudder stock at the lower rudder bearing, in mm;

n ——total number of bolts, which is not to be less than 6;

E_b -average distance between the center of the bolt and the center of the bolt system, in mm, see 3.1.7.3 of this PART;

K_b ——bolt Material factor, see 3.1.1.5 of this PART;

K_s ——material factor of rudder stock, see 1.5.1.3 of this PART;

3.1.7.2 The thickness of the coupling flange t is not to be less than that obtained from the following formula, but is not to be less than $0.9 d_b$:

$$t = d_b \sqrt{\frac{K_b}{K_f}} \quad \text{in mm}$$

Where: d_b ——bolt diameter calculated according to the number of bolts not exceeding 8, in mm;

K_f ——flange Material factor, see 3.1.1.5 of this PART;

K_b ——bolt Material factor, see 3.1.1.5 of this PART;

3.1.7.3 Mean distance E_b between the center of the bolt and the center of the bolt system is to be obtained from the following formula:

$$E_b = \frac{\sum_{i=1}^n m_i}{n} \quad \text{in mm}$$

Where: n ——the same as 3.1.7.1 of this PART;

m_i -distance between the center of the i^{th} bolt and the center of the bolt system, in mm.

3.1.7.4 Mean distance between the center of the bolt and the center of the bolt system is not to be less than 0.9 times the diameter of rudder stock D_c at the lower rudder stock. If the connecting flange is subject to bending stress, the mean distance between the center of the bolt and the longitudinal centerline of the flange is not to be less than $0.6 D_c$.

3.1.7.5 The breadth outside of the bolt hole is not to be less than 0.67 times the bolt diameter.

3.1.7.6 The bolts of the coupling flanges are reamed bolts. The nuts are to be fitted with a reliable stopping device.

3.1.7.7 The coupling flanges are to be fitted with a fitting key to reduce the load applied on the bolt. If the bolt diameter is further increased by 10% according to the value calculated in 3.1.7.1 of this PART, the fitting key is not to be mounted.

3.1.7.8 If the rudder stock and flange are separately forged and connected by welding, they are to be welded through the entire joint surface and are to comply with the relevant provisions of PART EIGHT.

3.1.8 keyed conical connection of rudder stock and rudder blade

3.1.8.1 The conical coupling is to be of a taper of 1: 8~1:12. The length of cone is not to be less than the rudder stock diameter D_c at the rudder bearing. The lower end of the rudder stock is to be tightened with nuts, and the nuts are to be fitted with a reliable stop device.

3.1.8.2 The conical coupling is to be fitted with a key. The key is to be equipped in the forward and backward direction of the rudder. The shear area A_s of the key is not to be less than that obtained from the following formula:

$$A_s = \frac{16T_f}{D_k R_{eH}} \quad \text{in cm}^2$$

Where: T_f ——designed yield torque of rudder stock, is to be calculated according to 3.1.8.4 of this PART;

D_k -average diameter of the rudderstock cone mounting key, in mm;

R_{eH} ——yield stress of the key material, in N/mm².

3.1.8.3 The extruded area A_k (round edge is not counted) of the key is not to be less than that obtained from the following formula:

$$A_k = \frac{5T_f}{D_k R_{eH}} \quad \text{in cm}^2$$

Where: T_f —designed yield torque of rudder stock, N·m, is to be calculated according to 3.1.8.4 of this PART;

D_k —average diameter of the rudderstock cone mounting key, in mm;

R_{eH} —yield strength of key, rudder stock or bearing material, in N/mm², whichever is smaller.

3.1.8.4 The design yield torque T_f of the rudder stock is to be obtained from the following formula:

$$T_f = 0.02664 D_t^3 K_S \quad \text{in N m}$$

Where: D_t —diameter of the rudder stock, in mm, calculated in accordance with 3.1.5.1 of this PART; if the actual diameter is greater than D_t , the actual diameter is to be taken but not necessary to be greater than $1.15 D_t$;

K_S —material factor of rudder stock, see 1.5.1.3 of this PART;

3.1.8.5 The dimensions of the nuts are shown in Figure 3.1.8.5 and are to comply with the following requirements:

Thread outer diameter: $d_g \geq 0.65 D_c$;

Nut length: $h_n \geq 0.6 d_g$;

Nut outer diameter: $d_n \geq 1.2 D_u$ (D_u is shown in Figure 3.1.8.5) or $1.5 d_g$, whichever is greater.

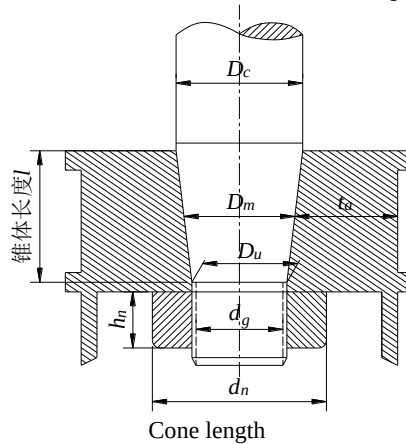


Figure 3.1.8.5 Nut dimensions

3.1.8.6 The thickness of the bearing in the rudder blade at the midpoint of its length (excluding the keyway) is not to be less than 0.5 times the diameter of the rudder stock at the tiller or 0.3 times the diameter of the rudder stock at the lower rudder, whichever is greater. The bearing is to be properly connected with the vertical and horizontal partitions.

3.1.9 Keyless conical connection of rudder stock and rudder blade

3.1.9.1 Where hydraulic fitting or shrinkage fit is adopted for keyless conical connection between the rudder stock and rudder blade, taper of diameter of 1:12~1:20 is required. The length of cone is not to be less than the rudder stock diameter at the rudder bearing.

3.1.9.2 In order to allow the connection between the rudder stock and the rudder blade to transmit torque safely, the push-up length and push-up pressure are to be determined according to the following requirements:

.1 The push-up length S is to comply with the requirements of the following formula:

$$S_1 \leq S \leq S_2$$

$$S_1 = \frac{1}{k_1} \left[\frac{2p D_m k_2^2}{E(k_2^2 - 1)} + 0.02 \right] \quad \text{in mm}$$

Minimum push-up length

$$S_2 = \frac{1}{k_1} \left[1.4 R_{eH} D_m \frac{k_2^2}{E \sqrt{3k_2^4 + 1}} + 0.02 \right] \quad \text{in mm}$$

Maximum push-up length

$$p = \frac{8.5K_s D_t^3}{D_m^2 l f} \quad \text{in N/mm}^2$$

Where: for non-suspended rudder,

$$p = \frac{6M_b}{D_m l^2} \times 10^3 \quad \text{in N/mm}^2$$

for suspended rudder,

$$k_2 = (D_m + 2t_a) / D_m;$$

L —cone length, in mm, see Figure 3.1.8.5 in this Section;

D_m —mean diameter of cone, in mm, see Figure 3.1.8.5 in this Section;

t_a —mean diameter of bearing, in mm, see Figure 3.1.8.5 in this Section;

D_t —diameter of the diameter of rudder stock at the tiller, in mm;

M_b —See 3.1.5.4 of this PART, N·m;

K_s —material factor of rudder stock, see 3.1.1.5 of this PART;

k_1 —taper of the diameter of cone;

R_{eH} —yield stress of bearing material, in N/mm²;

E —elastic modulus, taken to be 2.06×10^5 , in N/mm²

f —friction coefficient, 0.15 for hydraulic connection; 0.18 for dry conical connection.

.2 The push-up pressure P is to be calculated as follows:

$$P = \frac{SE(k_2^2 - 1) k_1}{2D_m k_2^2} \quad \text{in N/mm}^2$$

Where: k_1 , k_2 , D_m and E are the same as .1;

S —Push-up length determined according to .1, in mm.

.3 The push-up force P_e is to be calculated by the following formula:

$$P_e = 3.14PD_m l \left(\frac{k_1}{2} + 0.02 \right) \quad \text{in N}$$

Where: k_1 , l and D_m are the same as .1;

P —Push-up pressure calculated according to .2, in N/mm².

3.1.9.3 The thickness of the bearing in the rudder blade at the midpoint of its length is not to be less than 0.25 times the mean diameter of cone. The bearing is to be properly connected with the vertical and horizontal partitions.

3.1.10 Vertical flange couplings of rudder stock and rudder blades

3.1.10.1 The diameter of the coupling flange bolts d_b is not to be less than that obtained from the following formula:

$$d_b = 0.81D_c \sqrt{\frac{K_s}{nK_b}} \quad \text{in mm}$$

Where: D_c —diameter of the rudder stock at the lower rudder bearing, in mm;

n —total number of bolts, which is not to be less than 8;

K_b —bolt Material factor, see 3.1.1.5 of this PART;

K_s —material factor of rudder stock, see 1.5.1.3 of this PART;

3.1.10.2 The first moment of area of the bolts about the center of the coupling M , m, is to be not less than:

$$M = 4.3 \times 10^{-4} D_c^3 \quad \text{in cm}^3$$

Where: D_c —diameter of the rudder stock at the lower rudder bearing, in mm.

3.1.10.3 The thickness of the coupling flanges is not to be less than the bolt diameter, and the width of the bolt hole is to be not less than 0.67 times the bolt diameter.

3.1.10.4 Coupling bolts are to be fitted bolts and the nuts are to be fitted with a reliable stop device.

3.1.11 Pintles

3.1.11.1 The pintles and seating are to be in conical fitting. The length of the cone is not to be less than the diameter of pintle. Key connection and other manually assembled pintles locked with stop nuts are to be of a taper of 1:8~1:12. Pintles installed with oil filling and hydraulic nuts, they are to be of a taper of 1:12~1:20.

3.1.11.2 The diameter of the pintles D_p is not to be less than that obtained from the following formula:

$$D_p = 0.35 \sqrt{\frac{P}{K_p}} \quad \text{in mm}$$

Where: P —supporting force of pintles on rudder blade (namely the supporting force of pintle bearing), in N, is to be calculated according to 3.1.4.2, 3.1.4.3, 3.1.4.5 and 3.1.4.6.

K_p —material factor of pintles, see 3.1.1.5 of this PART.

The pintles diameter of a fishing trawler is to increase by 5% over the value calculated by the formula.

3.1.11.3 The dimensions of the nuts are to be determined in accordance with the requirements of 3.1.8.5 of this PART, but the pintles diameter D_p is not to be used instead of the rudder stock diameter D_c during calculation.

3.1.11.4 The thickness of seating is not to be less than 0.25 times the diameter of pintle.

3.1.11.5 The length of pintle bearing is not to be less than the diameter of pintle bushing, but is not to exceed 1.2 times the diameter of pintle bushing. The thickness of the rudder knob outside the bearing bushing is not to be less than 0.4 times the diameter of pintle.

3.1.12 Rudder shaft

3.1.12.1 The diameter of the rudder shaft D_1 at the lower bearing is not to be less than that obtained from the following formula:

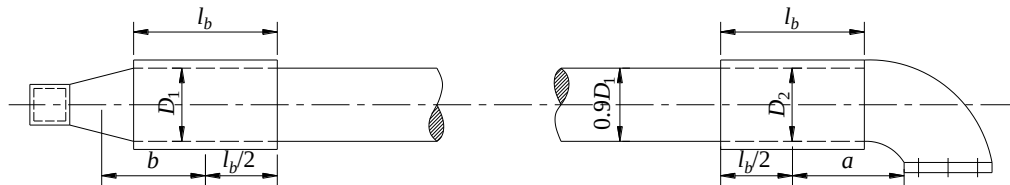
$$D_1 = 20.5 (AV_d^2 E)^{\frac{1}{3}} \quad \text{in mm}$$

Where: A —area of rudder blade, in m^2 ;

V_d —is to be calculated according to 3.1.2.2;

$$E = \frac{1}{2}(a+b), \quad \text{in m;}$$

See a and b in Fig. 3.1.12.1.



3.1.12.1 Lower bearing of rudder shaft

3.1.12.2 The diameter of the rudder shaft at the upper bearing $D_2=1.1D_1$; the diameter of the rudder shaft between the upper and lower bearings is to be $0.9D_1$.

3.1.12.3 There should be at least 6 vertical flange connection bolts on the upper end of the rudder shaft, and the bolt diameter is to be equal to $0.28D_1$. The average distance from the center of the bolt to the center of the flange is not to be less than $0.9D_1$ and not less than 80 mm; the distance from the center of the bolt to the flange edge is not to be less than 1.2 times the bolt diameter. The thickness of the vertical flange is to be equal to 0.9 times the bolt diameter.

3.1.12.4 The dimensions of the cones and nuts at the lower end of the rudder shaft are to comply with the relevant provisions of 3.1.8 of this PART.

3.1.12.5 The bearing length l_b (Figure 3.1.12.1 of this PART) is to comply with the provisions of 3.1.13.2 of this PART.

3.1.13 Rudder stocks, pintles and rudder bearings

3.1.13.1 The bearings are to be sufficiently lubricated. The bearing area A_b (the length of the bearing surface multiply by the diameter) is not to be less than the value calculated by the following formula:

$$A_b = \frac{P}{[P]} \quad \text{in mm}^2$$

Where: P —supporting force of bearing, in N, is to be calculated according to 3.1.4 of this PART;

$[P]$ —allowable surface pressure, in N/mm^2 , see Table 3.1.13.1.

Allowable bearing surface pressure Table 3.1.13.1

Bearing material	[P], in N/mm ²
Lignum vitae	2.5
White metal, oil lubricated	4.5
Synthetic material with hardness between 60 and 70 Shore D ^①	5.5
Steel ^② and bronze and hot-pressed bronze-graphite materials	7
① Indentation hardness test at 23°C and with 50% moisture, are to be carried out according to a recognized standard. Synthetic bearing materials are to be of an approved type.	
② Stainless and wear-resistant steel in an approved combination with stock liner.	

3.1.13.2 The ratio of the length and diameter of the bearing surface is not be greater than 1.2.

3.1.13.3 The radial clearance of metal bearings δ is not to be less than that obtained from the following formula:

$$\delta = \frac{d}{1000} + 1 \quad \text{in mm}$$

Where: d —diameter of bearing surface, in mm.

The radial clearance value can be determined according to the standards accepted by CCS. If non-metallic bearing material is applied, the bearing clearance is to be specially determined considering the material's swelling and thermal expansion properties. This clearance is not to be taken less than 1.5 mm on bearing diameter unless a smaller clearance is supported by the manufacturer's recommendation and there is documented evidence of satisfactory service history with a reduced clearance.

3.1.14 Single plate rudders

3.1.14.1 The rudder stock diameter is calculated according to 3.1.5 of this Section. For spade rudders the lower third may taper down to 0.75 times stock diameter.

3.1.14.2 The blade thickness t is not to be less than:

$$t = 1.5sV_d + 2.5 \quad \text{in mm}$$

Where: s —spacing of stiffening arms, in m not to exceed 1 m;

V_d —speed in knots, see 3.1.2.2 of this Section;

3.1.14.3 The thickness of reinforcing rib is not to be less than blade thickness; the section modulus W of reinforcing rib is not to be less than the value obtained from the following formula:

$$W = 0.5sl^2V_d^2 \quad \text{in cm}^3$$

Where: s and V_d —see 3.1.14.2 of this PART;

l —horizontal distance from the aft edge of the rudder to the centerline of the rudder stock, in m;

3.1.15 Quadrants and tillers

3.1.15.1 The section modulus W of the tiller at any section from the center of the rudder stock about the vertical axis is not to be less than that obtained from the following formula:

$$W = 0.14\left(1 - \frac{2D_t}{R}\right)D_t^3 \quad \text{in cm}^3$$

Where: D_t —stock diameter, in mm, at the tiller, in cm;

R —radius of quadrant or length of tiller, in mm.

For quadrants having more than one arm, the combined section modulus of the arms is not to be less than that required in the above formula.

For tillers of rectangular section, the breadth to depth ratio is not to be more than 2.

3.1.15.2 The section modulus of the tiller can be gradually reduced from the hub to the end point to 40% of the above formula; heights of quadrants or tiller hub, $h = 1.0 D_t$, OD $D_0 = 1.8 D_t$, see Figure 3.1.15.2.

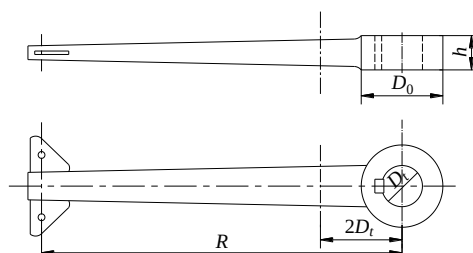


Figure 3.1.15.2 Tiller section type

3.1.15.3 Tillers or quadrants without linkage tiller are to be tightly mounted on the rudder stock and fitted with keys of appropriate sizes.

3.1.15.4 For quadrants loosely mounted on the rudder stock, the section modulus of arms can be reduced to 50% of the section modulus of the point $2D_t$ away from the center of the rudder stock within the entire arm length.

3.1.16 Human steering gear transmission parts

3.1.16.1 The diameter of steering chain d is not to be less than that obtained from the following formula:

$$d = 0.32 \sqrt{\frac{D_t^3}{R}} + 5 \quad \text{in mm}$$

Where: D_t —stock diameter, in mm, at the tiller, in mm;

R —radius of quadrant or length of tiller, in mm.

Rudder chains with a diameter of not more than 15 mm can be replaced by flexible galvanized steel wire ropes with equal breaking load.

3.1.16.2 The diameter of the steering rod is to be 1.2 times the diameter of the steering chain.

3.1.16.3 The diameter of the rudder chain pulley measured from the center of the rudder chain ring is not to be less than 12 times the diameter of the rudder chain. The diameter of the pulley pin is not to be less than twice the diameter of the rudder chain.

3.1.16.4 The transmission line on each side is to be fitted with a turnbuckle which has a locking device.

3.1.16.5 The steering chain on each side is to be fitted with a spring buffer, the dimensions of which are to be selected according to the safe working load of rudder chain or rudder cable.

Section 2 ANCHORING AND MOORING EQUIPMENT

3.2.1 Equipment number

3.2.1.1 The anchoring equipment for fishing vessels are to be provided in accordance with Table 3.2.1.1, based on the ship type and service area as well as the equipment number derived from 3.2.1.2 of this Section.

3.2.1.2 The equipment number N is to be obtained from the following formula:

$$N = \Delta^{2/3} + 2Bh + \frac{A}{10}$$

Where: Δ —moulded displacement, in t, to the summer load waterline;

h —effective height, in m, from the summer load waterline to the top of the uppermost house;

$$h = a + \sum h_i$$

Where: a —vertical distance from the amidships summer load waterline to the upper continuous deck, in m;

h_i —height at the centerline, in m, of each tier of houses having a breadth greater than $B/4$;

A —area, in m², in profile view of the hull, within the length of the vessel, and of superstructures and deckhouses above the summer load waterline, which are within the length of the vessel L , and also having a breadth greater than $B/4$.

Total injection area, in m²

In the calculation of h and A , sheer and trim are to be ignored.

Screens and bulwarks more than 1.5 m in height are to be regarded as parts of superstructures or deckhouses.

3.2.2 Anchors

3.2.2.1 Fishing vessels are to be equipped with two bower anchors according to Table 3.2.1.1 of this PART. The mass of individual bower anchors may vary within +7% of the mass given in Table, provided that the total mass of the bower anchors is not to be less than that would have been required for anchors of equal mass.

Anchors, anchor chains and cables of fishing vessel Table 3.2.1.1

Equipment No. N		Stock-free bower anchors		Stud link chain of bower anchor			Mooring rope			
Exceeding	Not exceeding	Qty	Mass of each anchor, in kg	Total length, in m	Diameter (mm)			Number of ropes	Minimum length of each rope in m	Minimum breaking load kN
					CCSAM1	CCSAM2	CCSAM3			

50	60	2	120	192.5	12.5	11	—	2	60	34
60	70	2	140	192.5	12.5	11	—	2	80	34
70	80	2	160	220	14	12.5	—	2	100	37
80	90	2	180	220	14	12.5	—	2	100	37
90	100	2	210	220	16	14	—	2	110	39
100	110	2	240	220	16	14	—	2	110	39
110	120	2	270	247.5	17.5	16	—	2	110	44
120	130	2	300	247.5	17.5	16	—	2	110	44
130	140	2	340	275	19	17.5	—	2	120	49
140	150	2	390	275	19	17.5	—	2	120	49
150	175	2	480	275	22	19	—	2	120	54
175	205	2	570	302.5	24	20.5	—	2	120	59
205	240	2	660	302.5	26	22	20.5	2	120	64
240	280	2	780	330	28	24	22	3	120	69
280	320	2	900	357.5	30	26	24	3	140	74
320	360	2	1020	357.5	32	28	24	3	140	78
360	400	2	1140	385	34	30	26	3	140	88
400	450	2	1290	385	36	32	28	3	140	98
450	500	2	1440	412.5	38	34	30	3	140	108
500	550	2	1590	412.5	40	34	30	4	160	123
550	600	2	1740	440	42	36	32	4	160	132
600	660	2	1920	440	44	38	34	4	160	147
660	720	2	2100	440	46	40	36	4	160	157
720	780	2	2280	467.5	48	42	36	4	170	172
780	840	2	2460	467.5	50	44	38	4	170	186
840	910	2	2640	467.5	52	46	40	4	170	202
910	980	2	2850	495	54	48	42	4	170	216
980	1060	2	3060	495	56	50	44	4	180	230
1060	1140	2	3300	495	58	50	46	4	180	250

3.2.2.2 The mass of the head, including pins and swivels, of an ordinary stockless anchor is not to be less than 60% of the total mass of the anchor.

3.2.2.3 Stocked bower anchors may be used, but the mass excluding the stock is not to be less than 80% of the mass given in Table 3.2.1.1 of this Section for ordinary stockless bower anchors.

3.2.2.4 When authorized high holding power anchors are used as bower anchors, the mass of each such anchor may be 75% of the mass given in Table 3.2.1.1 of this Section for ordinary stockless bower anchors. The specific requirements of high holding power anchors are shown in CHAPTER 11, PART SEVEN.

3.2.2.5 Under the premise of meeting the use requirements, only one anchor is to be provided, and a spare anchor is kept on the vessel.

3.2.3 Chain cables

3.2.3.1 A swivel is to be provided to the chain cables at the outboard end to which the anchor is connected.

3.2.3.2 The inboard end of the chain cables is to be secured to the hull structure and so arranged that they will be capable of being immediately released from a position easily accessible outside the chain locker.

3.2.3.3 At least one spare anchor shackle and four connecting shackles or connecting links are to be on board.

3.2.3.4 Grade CCSAM1 material having a tensile stress of less than 400 N/mm² is not to be used in association with high holding power anchors.

3.2.4 Mooring lines

3.2.4.1 If the A/N of the fishing vessel is greater than 0.9 (A and N are defined in 3.2.1.2 of this PART). It is recommended to increase the number of mooring lines listed in the table of this Section:

Ratio of A/N	Increased number of mooring lines
$0.9 < A/N \leq 1.1$	1
$1.1 < A/N \leq 1.2$	2
$1.2 < A/N$	3

3.2.4.2 The mooring lines listed in the Table of this Section are to be of 6*24 or 6*37 flexible, galvanized construction having a breaking strength of not less than 1.37 kN/mm² per wire, or natural fiber or synthetic fiber with the same breaking load, or steel cable made of steel wire and fiber core.

Regardless of the breaking load, the diameter of the fiber rope is not to be less than 20 mm.

3.2.5 Cables replacing anchor chains

3.2.5.1 Anchor chains can be replaced by steel cables. Among them, anchor chains with a diameter of not more than 17.5 mm can also be replaced by steel wire ropes or fiber ropes.

The length of the steel cables, steel wire ropes or fiber ropes that replaces the anchor chains is not to be less than 1.5 times the length of the anchor chain specified in Table 3.2.1.1 of this Section. The breaking load is not to be less than breaking load of corresponding anchor chain specified in Table 3.2.1.1 of this Section.

3.2.5.2 The mass of the anchor is not to be less than 1.25 times the mass of the anchor specified in Table 3.2.1.1 of this Section.

3.2.5.3 A short anchor chain is to be fitted between the anchor and the steel cable. The length is to be 12.5 m or the distance from the storage location of the anchor to the anchor machine, whichever is the smaller.

3.2.5.4 The ropes of trawl winches can be used as anchor chains. The guide pulleys and guide rollers are to be properly installed and arranged to prevent the ropes from being worn by deckhouses, superstructures, deck boards and equipment on deck. When the diameter of steel cable is not less than 18 mm, its guide roller is to be installed permanently.

Section 3 OTHERS

3.3.1 Fish tank bottom planks

3.3.1.1 If planks are laid in the fish tank, the thickness is to be selected according to the length of ship L by the following requirements:

Where $L \leq 60$ m, the thickness of plank is not to be less than 50 mm;

Where $L > 60$ m, the thickness of plank is not to be less than 55 mm;

3.3.1.2 If the other side of the fish tank is a fuel tank, a clearance layer not to be less than 50 mm is to be reserved between the heat insulation layer and bulkhead. The clearance is to be properly ventilated; for fully welded bulkheads, the clearance layer can be replaced by on-site polyurethane closed-cell foaming, that is, increasing the thickness of the insulation layer.

3.3.1.3 A clearance layer not less than 50 mm is to be provided between the top of the fuel tank and the fish tank. The wooden foundation supporting the cover is to be arranged laterally to drain to the side bilge suction port. For fully welded tank roofs, the clearance layer can be replaced by on-site polyurethane closed-cell foaming, that is, increasing the thickness of the insulation layer.

3.3.1.4 If the common bulkheads or decks of fish tanks and non-edible oil tanks are increased by 2 mm from the plate thickness required by the relevant regulations in CHAPTER 2 of this PART, and the welds comply with the requirements of 1.4.4 of this PART, they can replace the requirements in 3.3.1.2 and 3.3.1.3 of this PART.

3.3.1.5 The outer surface of the double bottom bilge roofs or shaft tunnel roofs with planks are to be painted with bitumen solution or other effective coatings. The double bottom bilge roofs or shaft tunnel roofs without wooden decking may only be painted.

3.3.2 Movable bulkhead in bulk fish tank

3.3.2.1 The arrangement of movable bulkheads in fish tanks is to extend from the bilge to the deck as much as possible.

3.3.2.2 The distances between the longitudinal partitions of the mobile bulkhead in the fish tank or between the longitudinal partitions and the side are b not to exceed 3 m. The longitudinal partitions should be arranged as symmetrical as possible to the centerline of fishing vessel. When the maximum width in the fish tank reaches 3m, at least one longitudinal partition is to be provided.

3.3.2.3 Movable bulkheads for fish tanks may consist of steel vertical troughs and horizontal planks. The longitudinal distance between vertical tanks or between transverse bulkheads and vertical tanks is generally s not to exceed 2 m. See Figure 3.3.2.3.

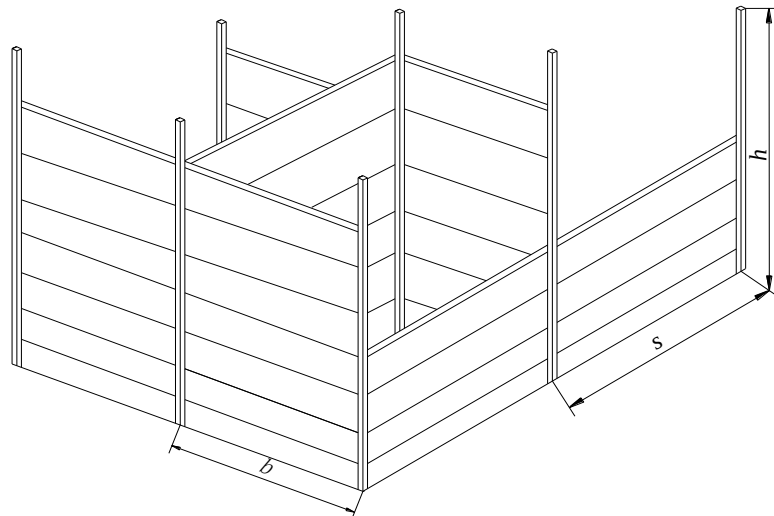


Figure 3.3.2.3 Movable bulkhead of fish tank

3.3.2.4 The section modulus W of the steel vertical trough frame is not to be less than the value calculated by the following formula:

$$W = ch^3(b + s) \text{ in cm}^3$$

Where: c -coefficient, when one vertical partition is set, $c = 1.6$; when two or more vertical partitions are set, $c = 2.0$;

h —span of vertical trough frame, in m;

b -maximum distance between vertical trough frames in the transverse direction, in m;

s -maximum distance between vertical trough frames in the longitudinal direction, in m.

3.3.2.5 The thickness of horizontal plank is not to be less than the values obtained from following formulas:

To longitudinal partitions $t = 15s\sqrt{h}$, in mm

To transverse partitions $t = 15b\sqrt{h}$, in mm

Where: s , b and h are the same as 3.3.2.4 of this PART.

The minimum thickness of horizontal plank is not to be less than 40 mm, not necessary to be greater than 80 mm; generally the width is not to be less than 200 mm. If full-compartment partitions are to be of equal thickness, the thicker one shall prevail.

3.3.2.6 The depth of the slot of the trough is not to be less than 40 mm, and its width is to be 5 mm greater than the thickness of the fish blocking plate; the length of the fish blocking plate is to be approximately 5 mm shorter than the distance from the bottom of the slot, but is not to exceed 10 mm.

3.3.3 Isolation layer

3.3.3.1 Double-bottom tanks, forepeak and afterpeak tanks storing ballast water or fresh water are to be painted with cement or other effective coatings.

3.3.3.2 Generally, the compartments located directly below the living spaces and service spaces are not to be used to store liquid fuel. If there is any difficulty, the top decks of the following compartments are to be covered with an oil-insoluble heat-insulating layer with a thickness of at least 40 mm. There shall be no manholes or other openings on the deck. The compartments below the above mentioned spaced can be used to store liquid fuel with a flash point (closed cup test) no less than 60°C.

CHAPTER 4 STRENGTHENING FOR NAVIGATION IN ICE

Section 1 GENERAL PROVISIONS

4.1.1 General Requirements

4.1.1.1 In addition to complying with the relevant provisions of other Chapters of these Rules, fishing vessels navigating in ice are to comply with the corresponding requirements of this CHAPTER as well.

4.1.1.2 The ice areas where fishing vessels are navigating refer to drift ice sea areas other than large stationary ice, which is the mildest ice condition. If a fishing vessel sails in a sea area where the ice conditions are more severe than the above ice conditions, the enhancement requirements are to be approved by CCS.

4.1.1.3 When the fishing vessel is sailing in ice are, the ballast tank is to be equipped with a device to prevent the ballast water from freezing.

Section 2 SHELL PLATES, SIDE FRAMES AND STEMS

4.2.1 Shell plating

4.2.1.1 For enhancement of ice belt (referring to side anti-ice part) shell plates, the longitudinal area is from the forward perpendicular backward to $0.2L$; the vertical range is from 500 mm above the maximum waterline to 500 mm below the minimum waterline.

4.2.1.2 The thickness of the shell plate of the ice belt is to be increased by at least 25% from the standard value of the thickness of the amidships outer plate, but the thickness needs not be greater than 4 mm.

4.2.2 Side framing

4.2.2.1 If intermediate frames are fitted in the fore peak or within the region from the forward perpendicular backward to $0.075L$, the section modulus of the intermediate frames is to be not less than 75% of that of the forepeak frames. The vertical extent of the intermediate frames is to be from 1,000 mm below the minimum working waterline to 1,000 mm above the maximum waterline, and the frames need not be connected at their ends.

If intermediate frames are not fitted, the frame spacing is to be 60% of the spacing of the amidships frames, but in no case is to be greater than 500 mm.

4.2.2.2 For side stringers, panting beams or perforated platforms in $0.2L$ longitudinal reinforcement zone, tripping brackets are to be fitted at each frame.

4.3.3 Stem

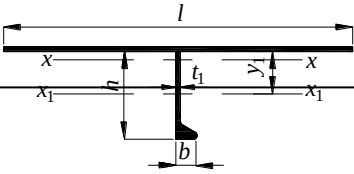
4.2.3.1 The plate thickness of a welded plate stem for 600 mm above the maximum waterline is to be 1.1 times the Rule thickness, but need not exceed 20 mm.

APPENDIX I SECTION ELEMENTS OF ATTACHED PLATE PROFILE STEEL

I SECTION ELEMENTS OF ATTACHED PLATE PROFILE STEEL

Asymmetric spherical flat steel

Table 1

Asymmetric spherical flat steel 							Width of attached plate $l=500$ mm			
	Single profile elements						Elements of joint attached plate profile			
	Profile height h	Sphere Width b	Profile thickness t_1	Profile Sectional area A_1	Moment of inertia I_{x1}	Gravity axis x_1-x_1 distance y_1	Total area A	Moment of inertia for x-x axis I	Minimum profile modulus for x-x axis W	Radius of inertia for x-x axis r
	mm	mm	mm	in cm ²	in cm ⁴	in cm	in cm ²	in cm ⁴	in cm ³	in cm
5.0	50	16	4.0	2.87	6.96	3.13	42.87/52.87	42.46/46.89	8.22/8.84	1.00/0.94
6.0	60	19	5.0	4.27	15.00	3.74	44.27/54.27	83.26/89.89	13.88/14.58	1.37/1.29
7.0	70	21	5.0	5.06	24.10	4.40	45.06/55.06	129.7/138.6	18.91/19.66	1.70/1.59
8.0	80	22	5.0	5.84	36.23	5.07	45.84/55.84	190.8/202.6	24.77/25.59	2.04/1.90
9.0	90	24	5.5	7.03	55.60	5.65	47.03/57.03	276.6/292.9	32.56/33.50	2.43/2.27
10	100	26	6.0	8.63	85.22	6.29	48.63/58.63	405.1/428.7	43.97/45.12	2.89/2.70
12	120	30	6.5	11.15	158	7.55	51.15/61.15	711.2/752.97	66.68/68.25	3.73/3.51
14a	140	33	7	14.05	274	8.82	54.05/64.05	1160/1231	96.64/98.82	4.63/4.38
14b	140	35	9	16.85	321	8.55	56.85/66.85	1273/1357	108.3/111.1	4.73/4.51
16a	160	36	8	17.96	468	9.95	92.96/67.96	2141/1915	145.8/139.4	4.80/5.31
16b	160	38	10	21.16	527	9.75	96.16/71.16	2360/2093	163.5/155.6	4.95/5.42
18a	180	40	9	22.20	724	11.15	97.20/72.20	3164/2815	197.3/188.7	5.71/6.24
18b	180	42	11	25.80	837	10.81	100.8/75.80	3416/3018	216.3/206.0	5.82/6.31
20a	200	44	10	27.36	1078	12.40	102.36	4559	264.5	6.67
20b	200	46	12	31.36	1265	12.06	106.36	4908	289.2	6.79
22a	220	48	11	32.82	1611	13.50	107.82	6261	340.0	7.62
22b	220	50	13	37.22	1795	13.20	112.22	6650	366.9	7.70
24a	240	52	12	38.86	2232	14.70	113.75	8345	428.2	8.57
24b	240	54	14	43.55	2542	14.35	118.55	8838	460.2	8.63
27a	270	55	12	43.82	3265	16.60	118.82	11605	543.5	9.88
27b	270	57	14	49.22	3515	16.30	124.22	12168	579.6	9.90

Continued

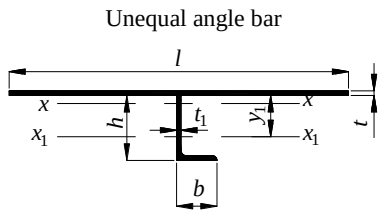
Width of attached plate $l=550\text{mm}$				Width of attached plate $l=600\text{mm}$			
Elements of joint attached plate profile				Elements of joint attached plate profile			
Total area	Moment of inertia for x-x axis	Minimum profile modulus for x-x axis	Radius of inertia for x-x axis	Total area	Moment of inertia for x-x axis	Minimum profile modulus for x-x axis	Radius of inertia for x-x axis
A	I	W	r	A	I	W	r
in cm^2	in cm^4	in cm^3	in cm	in cm^2	in cm^4	in cm^3	in cm
46.87/57.87	42.88/47.49	8.27/8.93	0.96/0.91	50.87/62.87	43.27/48.05	8.32/9.01	0.92/0.87
48.27/59.27	84.06/90.82	13.91/14.66	1.32/1.24	52.27/64.27	84.77/91.66	13.98/14.74	1.27/1.19
49.06/60.06	131.0/139.94	18.97/19.75	1.63/1.53	53.06/65.06	132.1/141.1	19.03/19.83	1.58/1.47
49.84/60.84	192.84/204.6	24.85/25.69	1.97/1.83	53.84/65.84	194.6/206.3	24.92/25.77	1.90/1.77
51.03/62.03	279.8/295.9	32.66/33.62	2.34/2.18	55.03/67.03	282.6/298.6	32.76/33.72	2.27/2.11
52.63/63.63	410.5/433.7	44.12/45.28	2.79/2.61	56.63/68.63	415.2/438.1	44.26/45.41	2.71/2.53
55.15/66.15	722.6/763.3	66.95/68.50	3.62/3.40	59.15/71.15	732.4/772.3	67.19/68.72	3.52/3.30
58.05/69.05	1182/1251	97.11/99.23	4.51/4.26	62.05/74.05	1200/1268	97.50/99.58	4.40/4.14
60.85/71.85	1299/1382	109.0/111.7	4.62/4.39	64.85/76.85	1323/1404	109.5/112.2	4.52/4.27
100.5/72.96	2172/1951	146.4/140.1	4.65/5.17	108.0/77.96	2199/1983	146.9/140.7	4.51/5.04
103.7/76.16	2001/2137	152.7/156.5	4.39/5.30	111.2/81.16	2433/2176	165/157.3	4.68/5.18
104.7/77.20	3217/2875	198.2/189.8	5.54/6.10	112.2/82.20	3263/2928	199.0/190.7	5.39/5.97
108.3/80.80	3479/3088	217.5/207.4	5.67/6.18	115.8/85.80	3534/3150	218.5/208.6	5.52/6.06
109.86	4646	265.9	6.50	117.36	4723	267.1	6.34
113.86	5009	290.9	6.63	121.36	5098	292.3	6.48
115.32	6394	342.0	7.45	122.82	6512	343.8	7.28
119.72	6802	369.4	7.54	127.22	6936	371.5	7.38
121.25	8541	431.1	8.39	128.75	8715	433.6	8.23
126.05	9057	463.7	8.48	133.55	9251	466.6	8.32
126.32	11895	547.4	9.70	133.82	12153	550.7	9.53
131.72	12492	584.3	9.74	139.22	12782	588.5	9.58

Continued

Width of attached plate $l=650\text{mm}$				Width of attached plate $l=700\text{mm}$				Thickness of attached plate
Elements of joint attached plate profile				Elements of joint attached plate profile				
Total area	Moment of inertia for x-x axis	Minimum profile modulus for x-x axis	Radius of inertia for x-x axis	Total area	Moment of inertia for x-x axis	Minimum profile modulus for x-x axis	Radius of inertia for x-x axis	
A	I	W	r	A	I	W	r	
in cm^2	in cm^4	in cm^3	in cm	in cm^2	in cm^4	in cm^3	in cm	mm
54.87/67.87	43.63/48.60	8.37/9.09	0.89/0.85	58.87/72.87	43.97/49.12	8.41/9.17	0.86/0.82	8/10
56.27/69.27	85.41/92.50	14.03/14.82	1.23/1.16	60.27/74.27	85.99/93.18	14.08/14.90	1.19/1.13	8/10
57.06/70.06	133.1/142.2	19.09/19.90	1.53/1.43	61.06/75.06	134.0/143.2	19.14/19.98	1.48/1.38	8/10
57.84/70.84	196.1/207.9	24.99/25.86	1.84/1.71	61.84/75.84	197.5/209.3	25.05/25.93	1.79/1.66	8/10
59.03/72.03	285.1/301.0	32.84/33.82	2.20/2.04	63.03/77.03	287.2/303.1	32.92/33.90	2.14/1.98	8/10
60.03/73.63	419.3/441.9	44.38/45.54	2.63/2.45	64.63/78.63	422.9/445.3	44.48/45.65	2.56/2.38	8/10
63.15/76.15	741.7/780.2	67.39/68.91	3.43/3.20	67.15/81.15	748.7/787.1	67.57/69.08	3.34/3.11	8/10
66.05/79.05	1217/1283	97.85/99.89	4.29/4.03	70.05/84.05	1232/1296	98.15/100.2	4.19/3.92	8/10
68.85/81.85	1343/1422	110.0/112.6	4.42/4.17	72.85/86.85	1362/1439	110.4/112.9	4.32/4.07	8/10
115.5/82.96	2223/2010	147.3/141.2	4.39/4.92	123.0/87.96	2244/2035	147.7/141.6	4.27/4.82	15/10
118.7/86.16	2462/2210	165.5/158.0	4.56/5.06	126.2/91.16	2488/2240	166.0/158.6	4.44/4.96	15/10
119.7/87.2	3303/2975	199.7/191.5	5.25/5.84	127.2/92.2	3339/3017	200.3/192.3	5.12/5.72	15/10
123.3/90.8	3582/3205	219.3/209.7	5.39/5.94	130.8/95.8	3624/3254	220.1/210.6	5.26/5.83	15/10
124.86	4791	268.1	6.19	132.4	4851	269.0	6.05	15
128.86	5177	293.7	6.34	136.4	5247	294.7	6.20	15
130.32	6615	345.3	7.13	137.8	6708	346.6	6.98	15
134.72	7055	373.4	7.24	142.2	7162	375.0	7.10	15
136.25	8869	435.7	8.07	143.8	9008	437.6	7.92	15
141.05	9424	469.2	8.17	148.6	9580	471.4	8.03	15
141.32	12384	553.6	9.36	148.8	12592	556.1	9.20	15
146.72	13042	592.0	9.43	154.2	13277	595.1	9.28	15

Unequal angle bar (1)

Table 2

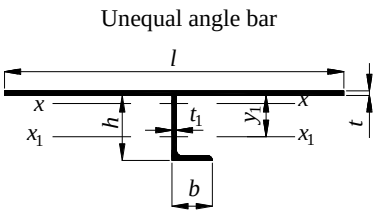
							Width of attached plate $l=500\text{mm}$			
Profile steel number	Single profile elements						Elements of joint attached plate profile			
	Angle edge height	Angle edge Width	Angle edge Thickness	Profile steel Sectional area	Moment of inertia	Gravity axis x_1-x_1 distance	Total area	Moment of inertia for x-x axis	Minimum profile modulus for x-x axis	Radius of inertia for x-x axis
	h	b	t_1	A_1	I_{x1}	y_1	A	I	W	r
	mm	mm	mm	in cm ²	in cm ⁴	in cm	in cm ²	in cm ⁴	in cm ³	in cm
3/2	30	20	3 4	1.43 1.86	1.27 1.61	2.00 1.96	21.43 21.86	8.00 9.82	2.62 3.25	0.61 0.67
4.5/3	45	30	4 6	2.88 4.18	5.81 8.15	3.02 2.94	22.88 24.18	32.18 42.51	7.49 10.23	1.19 1.33
6/4	60	40	5 6 8	4.83 5.72 7.44	17.4 20.3 25.3	4.06 4.00 3.92	24.83 25.72 27.44	88.27 99.03 118.1	15.43 18.81 23.24	1.89 1.96 2.08
7.5/5	75	50	5 6 8	6.11 7.25 9.47	34.9 41.0 52.4	5.11 5.08 4.98	26.11 27.25 29.47	167.1 188.5 225.1	25.88 29.92 37.30	2.53 2.63 2.76
8/5.5	80	55	6 8 10	7.85 10.3 12.6	50.6 64.9 78.2	5.44 5.36 5.28	27.85 40.30 42.60	230.2 311.4 355.4	34.82 45.44 53.44	2.88 2.78 2.89
Jun. 9	90	60	6 8 10	8.78 11.5 14.1	72.4 93.2 113	6.12 6.04 5.95	28.78 41.50 44.10	316.4 423.3 488.6	43.51 56.77 66.91	3.32 3.21 3.33
10/7.5	100	75	8 10	13.5 16.7	135 163	6.89 6.80	43.50 46.70	617.2 704.7	76.50 90.80	3.77 3.89
12/3	120	80	8 10	15.6 19.2	229 279	8.15 8.07	45.60 49.20	962.7 1100	102.3 121.8	4.60 4.73
13/9	130	90	8 10	17.2 21.3	297 362	8.92 8.84	47.20 51.30	1227 1404	123.5 147.7	5.10 5.23

Continued

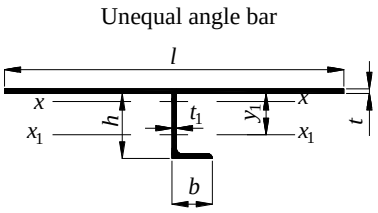
Width of attached plate $l=550\text{mm}$				Width of attached plate $l=600\text{mm}$				Thickness of attached plate t
Elements of joint attached plate profile				Elements of joint attached plate profile				
Total area A	Moment of inertia for x-x axis I	Minimum profile modulus for x-x axis W	Radius of inertia for x-x axis r	Total area A	Moment of inertia for x-x axis I	Minimum profile modulus for x-x axis W	Radius of inertia for x-x axis r	
in cm^2	in cm^4	in cm^3	in cm	in cm^2	in cm^4	in cm^3	in cm	mm
23.43 23.86	8.06 9.91	2.63 3.27	0.59 0.64	25.43 25.86	8.12 9.98	2.64 3.28	0.57 0.62	4 4
24.88 26.18	32.51 43.08	7.51 10.26	1.14 1.28	26.88 28.18	32.79 43.57	7.53 10.29	1.11 1.24	4 4
26.83 27.72 29.44	89.57 100.7 120.5	16.49 18.88 23.35	1.83 1.91 2.02	28.83 29.72 31.44	90.69 102.1 122.5	16.53 18.94 23.45	1.77 1.85 1.97	4 4 4
28.11 29.25 31.47	170.0 192.2 230.3	25.98 30.04 37.51	2.46 2.56 2.71	30.11 31.25 33.47	172.5 195.4 234.9	26.05 30.15 37.68	2.39 2.50 2.65	4 4 4
29.85 43.30 45.60	234.9 317.4 363.1	34.98 45.64 53.73	2.81 2.71 2.82	31.85 46.30 48.60	239.1 322.5 369.9	35.11 45.82 53.97	2.74 2.64 2.76	4 6 6
30.78 44.50 47.10	323.4 437.0 500.0	43.71 57.04 67.29	3.24 3.13 3.26	32.78 47.50 50.10	329.5 444.6 509.9	43.89 57.26 67.61	3.17 3.06 3.19	4 6 6
46.50 49.70	631.3 723.0	76.87 91.35	3.69 3.81	49.50 52.70	643.6 739.2	77.18 91.82	3.60 3.75	6 6
48.60 52.20	980.3 1130	102.9 122.6	4.51 4.65	51.60 55.20	1007 1157	103.4 123.3	4.42 4.58	6 6
50.20 54.30	1259 1444	124.2 148.7	5.01 5.16	53.20 57.30	1288 1481	124.8 149.6	4.92 5.08	6 6

Unequal angle bar (2)

Table 3

							Width of attached plate $l=500\text{mm}$			
Profile steel number	Single profile elements						Elements of joint attached plate profile			
	Angle edge height	Angle edge Width	Angle edge thickness	Profile Sectional area	Moment of inertia	Gravity axis x_1-x_1 distance	Total area	Moment of inertia for x-x axis	Minimum profile modulus for x-x axis	Radius of inertia for x-x axis
	h	b	t_1	A_1	I_{x1}	y_1	A	I	W	r
	mm	mm	mm	in cm ²	in cm ⁴	in cm	in cm ²	in cm ⁴	in cm ³	in cm
2.5/1.6	25	16	3	1.16	0.7	1.64	21.16	4.69	1.80	0.47
3.2/2	32	20	3 4	1.49 1.94	1.52 1.93	2.12 2.06	21.49 21.94	9.27 11.39	2.86 3.56	0.66 0.72
4/2.5	40	25	3 4	1.89 2.47	3.06 3.93	2.68 2.63	21.89/31.89 22.47/32.47	17.67/19.77 21.79/24.40	4.47/4.79 5.60/5.98	0.90/0.79 0.98/0.87
4.5/2.8	45	28	3 4	2.14 2.80	4.41 5.68	3.03 2.99	22.15/32.15 22.81/32.81	24.96/27.59 31.00/34.37	5.69/6.03 7.19/7.61	1.06/0.93 1.17/1.02
5/3.2	50	32	3 4	2.42 3.17	6.17 7.98	3.40 3.35	22.43/32.43 23.18/33.18	34.60/37.93 42.84/47.19	7.19/7.55 9.09/9.53	1.24/1.08 1.36/1.19
5.6/3.6	56	36	3 4 5	3.16 3.58 4.41	10.1 11.4 13.8	3.80 3.78 3.74	22.74/32.74 23.59/33.59 24.42/34.42	48.13/52.44 59.93/65.72 69.99/77.27	9.06/9.44 11.54/12.03 13.75/14.35	1.45/1.27 1.59/1.40 1.69/1.50
6.3/4.0	63	40	4 5 6 7	4.04 4.98 5.90 7.63	16.3 19.9 23.3 29.6	4.27 4.22 4.18 4.10	24.06/34.06 24.99/34.99 25.91/35.91 26.80/36.80	83.86/91.72 98.35/108.37 111.1/123.3 122.8/137.2	14.59/15.14 17.51/18.20 20.20/21.04 22.77/23.75	1.87/1.64 1.98/1.76 2.07/1.85 2.14/1.93
7/4.5	70	45	4 5	5.06 5.59	25.3 27.8	4.75 4.72	24.55/34.55 25.61/35.61	114.6/125.2 134.3/147.9	18.24/18.88 21.93/22.73	2.16/1.90 2.29/2.04
7.5/5	75	50	5 6	6.11 7.25	34.8 40.9	5.11 5.06	36.13/46.13 37.26/47.26	184.08/197.67 210.0/226.4	26.74/27.57 31.08/32.07	2.26/2.07 2.37/2.19
8/5	80	50	5 6	6.36 7.55	41.6 49.0	5.40 5.35	36.38/46.38 37.56/47.56	213.7/229.1 243.2/261.8	29.27/30.13 33.95/34.98	2.42/2.22 2.54/2.35

Continued

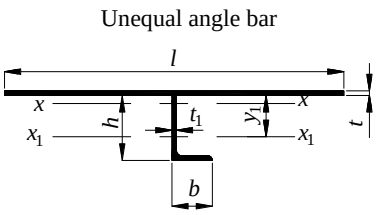
							Width of attached plate $l=550\text{mm}$			
Profile steel number	Single profile elements						Elements of joint attached plate profile			
	Angle edge height	Angle edge Width	Angle edge thickness	Profile Sectional area	Moment of inertia	Gravity axis x_1-x_2 distance	Total area	Moment of inertia for x-x axis	Minimum profile modulus for x-x axis	Radius of inertia for x-x axis
	h	b	t_1	A_1	I_{x1}	y_1	A	I	W	r
	mm	mm	mm	in cm ²	in cm ⁴	in cm	in cm ²	in cm ⁴	in cm ³	in cm
2.5/1.6	25	16	3	1.16	0.7	1.64	23.16	4.72	1.81	0.45
3.2/2	32	20	3	1.49	1.52	2.12	23.49	9.32	2.87	0.63
			4	1.94	1.93	2.06	23.94	11.33	3.52	0.69
4/2.5	40	25	3	1.89	3.06	2.68	23.89/34.89	17.79/19.93	4.48/4.81	0.86/0.76
			4	2.47	3.93	2.63	24.47/35.47	22.01/24.65	5.62/6.02	0.95/0.83
4.5/2.8	45	28	3	2.14	4.41	3.03	24.14/35.14	25.05/27.69	5.68/6.02	1.02/0.89
			4	2.80	5.68	2.99	24.80/35.80	31.25/34.67	7.25/7.62	1.12/0.98
5/3.2	50	32	3	2.42	6.17	3.40	24.42/35.42	34.72/38.03	7.17/7.53	1.19/1.04
			4	3.17	7.98	3.35	25.17/36.17	43.19/47.50	9.09/9.54	1.31/1.15
5.6/3.6	56	36	3	3.16	10.1	3.80	25.16/36.20	54.60/58.60	10.31/10.60	1.47/1.27
			4	3.58	11.4	3.78	25.58/36.58	60.47/66.15	11.53/12.03	1.54/1.35
			5	4.41	13.8	3.74	26.41/37.41	71.12/78.28	13.83/14.43	1.64/1.45
6.3/4.0	63	40	4	4.04	16.3	4.27	26.04/37.04	84.79/92.46	14.60/15.15	1.81/1.58
			5	4.98	19.9	4.22	26.98/37.98	99.53/109.3	17.51/18.19	1.92/1.70
			6	5.90	23.3	4.18	27.90/38.90	112.9/124.8	20.25/21.07	2.01/1.79
			7	7.63	29.6	4.10	29.63/40.63	134.6/150.6	24.97/26.08	2.13/1.93
7/4.5	70	45	4	5.06	25.3	4.75	27.06/38.06	126.4/138.2	20.14/20.85	2.16/1.91
			5	5.59	27.8	4.72	27.59/38.59	136.0/149.3	21.92/22.71	2.22/1.97
7.5/5	75	50	5	6.11	34.8	5.11	39.11/50.11	186.7/200.0	26.84/27.67	2.19/2.00
			6	7.25	40.9	5.06	40.25/51.25	212.7/228.8	31.12/32.10	2.30/2.11
8/5	80	50	5	6.36	41.6	5.40	39.36/50.36	215.8/230.9	29.25/30.11	2.34/2.14
			6	7.55	49.0	5.35	40.55/51.55	246.1/264.4	33.96/34.99	2.46/2.27

Continued

Width of attached plate $l=600\text{mm}$				Width of attached plate $l=650\text{mm}$				Thickness of attached plate t
Elements of joint attached plate profile				Elements of joint attached plate profile				
Total area	Moment of inertia for x-x axis	Minimum profile modulus for x-x axis	Radius of inertia for x-x axis	Total area	Moment of inertia for x-x axis	Minimum profile modulus for x-x axis	Radius of inertia for x-x axis	
A	I	W	r	A	I	W	r	
in cm^2	in cm^4	in cm^3	in cm	in cm^2	in cm^4	in cm^3	in cm	mm
25.16	4.77	1.82	0.44	27.16	4.81	1.83	0.42	4
25.49 25.94	9.39 11.42	2.88 3.53	0.61 0.66	27.49 27.94	9.45 11.50	2.89 3.55	0.58 0.64	4 4
25.89/37.89 26.47/38.47	17.91/20.09 22.19/24.85	4.49/4.84 5.64/6.04	0.83/0.73 0.92/0.80	27.89/40.89 28.47/41.47	18.02/20.24 22.34/25.04	4.50/4.86 5.65/6.07	0.80/0.70 0.89/0.78	4/6 4/6
26.14/38.14 26.80/38.80	25.23/27.89 31.51/34.88	5.69/6.05 7.22/7.65	0.98/0.86 1.08/0.95	28.14/41.14 28.80/41.80	25.39/28.08 31.75/35.13	5.70/6.07 7.23/7.67	0.95/0.83 1.05/0.92	4/6 4/6
26.42/38.42 27.17/39.17	34.98/38.29 43.59/47.87	7.18/7.56 9.11/9.57	1.51/1.00 1.27/1.11	28.42/41.42 29.17/42.17	35.21/38.53 43.94/48.21	7.20/7.58 9.13/9.59	1.11/0.97 1.23/1.07	4/6 4/6
27.16/39.16 27.58/39.58 28.41/40.41	55.10/60.05 61.07/66.68 71.95/79.00	10.33/10.78 11.56/12.06 13.87/14.47	1.42/1.24 1.49/1.30 1.59/1.40	29.16/42.16 29.58/42.58 30.41/43.41	55.53/60.41 61.59/67.15 72.68/79.64	10.35/10.80 11.58/12.09 13.90/14.40	1.38/1.20 1.44/1.26 1.55/1.35	4/6 4/6 4/6
28.04/40.04 28.98/40.98 29.90/41.90 31.63/43.63	85.71/93.24 100.8/110.4 114.5/126.1 131.0/152.6	14.64/15.19 17.56/18.24 20.31/21.13 25.07/26.17	1.75/1.53 1.87/1.64 1.96/1.74 2.08/1.87	30.04/43.04 30.98/43.98 31.90/44.90 33.63/46.63	86.51/93.93 101.9/111.3 115.9/127.3 139.0/154.3	14.67/15.22 17.60/18.28 20.37/21.18 25.16/26.24	1.70/1.48 1.81/1.59 1.91/1.68 2.03/1.82	4/6 4/6 4/6 4/6
29.06/41.06 29.59/41.59	128.0/139.5 137.9/150.8	20.20/20.89 22.0/22.76	2.10/1.84 2.16/1.90	31.06/44.06 31.59/44.59	129.4/140.7 139.5/152.2	20.24/20.94 22.04/22.81	2.04/1.79 2.10/1.85	4/6 4/6
42.11/54.11 43.25/55.25	188.8/201.9 215.4/231.2	26.91/27.74 31.20/32.19	2.12/1.93 2.23/2.05	45.11/58.11 46.25/59.25	190.6/203.6 217.7/233.4	27.00/27.81 31.28/32.27	2.06/1.87 2.17/1.99	6/8 6/8
42.36/54.36 43.55/55.55	218.3/233.1 249.3/267.3	29.32/30.19 34.06/35.08	2.28/2.07 2.39/2.19	45.36/58.36 46.55/59.55	220.4/235.0 252.1/269.8	29.39/30.25 34.14/35.17	2.20/2.01 2.33/2.13	6/8 6/8

Unequal angle bar (3)

Table 4

							Width of attached plate $l=500\text{mm}$			
Profile steel number	Single profile elements						Elements of joint attached plate profile			
	Angle edge height	Angle edge Width	Angle edge thickness	Profile Sectional are	Moment of inertia	Gravity axis x_1-x_2 distance	Total area	Moment of inertia for x-x axis	Minimum profile modulus for x-x axis	Radius of inertia for x-x axis
	h	b	t_1	A_1	I_{x1}	y_1	A	I	W	r
	mm	mm	mm	in cm ²	in cm ⁴	in cm	in cm ²	in cm ⁴	in cm ³	in cm
9/5.6	90	56	5.5 6	7.86 8.54	65.3 70.6	6.08 6.05	40.86/51.86 41.54/52.54	324.7/347.7	40.22/41.30 43.17/44.36	2.82/2.59 2.88/2.66
10/6.3	100	63	6 7 8 10	9.60 11.1 12.6 15.5	98.3 113 127 154	6.77 6.72 6.68 6.60	42.60/53.60 41.10/55.10 48.60/60.60 51.50/63.50	471.0/505.8 523.3/564.7 582.8/629.8 670.8/730.7	54.10/55.48 61.33/62.98 68.64/70.55 81.59/84.07	3.33/3.07 3.45/3.20 3.46/3.22 3.61/3.39
11/7	110	70	7 8	12.3 13.9	152 172	7.43 7.39	42.30/52.30 43.94/53.94	675.2/731.9 734.42/800.0	74.59/76.57 82.86/85.21	4.00/3.74 4.09/3.85
12.5/8	125	80	7 8 10 12	14.1 16.0 19.0 23.4	227 256 312 365	8.49 8.45 8.36 8.28	54.10/64.10 56.00/66.00 59.71/69.71 63.35/73.35	1054/1121 1152/1229 1327/1426 1477/1596	99.57/101.7 111.0/113.5 132.6/135.9 152.3/156.4	4.41/4.18 4.54/4.32 4.71/4.52 4.83/4.66
14/9	140	90	8 10	18.0 22.2	364 444	9.50 9.42	58.04/68.04 62.26/72.26	1586/1695 1827/1965	140.1/143.1 167.8/171.7	5.23/4.99 5.42/5.21
16/10	160	100	10 12 14	25.3 30.0 34.7	667 784 897	10.8 10.68 10.6	65.32/75.32 70.05/80.05 84.71/94.71	2602/2804 2894/3135 3425/3662	215.5/220.5 248.5/254.8 286.5/293.1	6.31/6.10 6.43/6.26 6.36/6.22
18/11	180	110	10 12	28.3 33.7	952 1123	12.1 12.0	78.37/98.37 83.71/104.7	3839/4281 4285/4818	275.5/285.3 318.4/330.8	7.00/6.60 7.15/6.78
20/12.5	200	125	12 14	37.9 43.9	1566 1801	13.5 13.4	87.91/112.9 93.87/118.9	5777/6670 6307/7341	399.0/417.4 450.1/472.5	8.11/7.69 8.20/7.86

Continued

Width of attached plate $l=550\text{mm}$				Width of attached plate $l=600\text{mm}$				Thickness of attached plate
Elements of joint attached plate profile				Elements of joint attached plate profile				
Total area	Moment of inertia for x-x axis	Minimum profile modulus for x-x axis	Radius of inertia for x-x axis	Total area	Moment of inertia for x-x axis	Minimum profile modulus for x-x axis	Radius of inertia for x-x axis	
A	I	W	r	A	I	W	r	t
in cm^2	in cm^4	in cm^3	in cm	in cm^2	in cm^4	in cm^3	in cm	mm
41.56/52.56 44.18/55.18	346.0/371.4 419.3/454.06	43.29/44.48 54.35/55.98	2.89/2.66 3.08/2.87	44.54/56.54 47.20/59.20	350.0/374.8 426.7/460.8	43.31/44.49 54.61/56.22	2.80/2.57 3.00/2.79	6/8 6/8
42.62/53.62 44.11/55.11 45.58/56.58 48.47/59.47	471.2/506.0 524.1/565.5 572.2/620.22 656.2/716.9	54.12/55.51 61.43/63.08 68.34/70.28 81.03/83.56	3.33/3.07 3.45/3.20 3.54/3.31 3.68/3.47	45.59/57.59 47.10/59.10 48.60/60.60 51.50/63.50	477.9/511.8 532.2/572.6 582.8/629.8 670.9/730.7	54.23/55.59 61.56/63.18 68.64/70.55 81.59/84.07	3.24/2.98 3.36/3.11 3.46/3.22 3.61/3.39	6/8 6/8 6/8 6/8
45.30/56.30 46.94/57.94	689.4/744.7 751.2/815.3	74.93/76.86 83.29/85.57	3.90/3.64 4.00/3.75	48.30/60.30 49.90/61.90	700.9/754.8 766.1/828.7	75.12/77.00 83.66/85.87	3.81/3.54 3.92/3.66	6/8 6/8
58.10/69.10 59.99/70.99 63.71/74.71 67.35/78.35	1074/1139 1176/1251 1359/1456 1516/1633	99.98/102.0 111.5/113.9 133.4/136.5 153.3/157.2	4.30/4.06 4.43/4.20 4.62/4.41 4.74/4.57	62.10/74.10 64.00/76.00 67.00/79.00 71.40/83.40	1091/1155 1359/1450 1553/1668	100.3/102.3 112.1/114.6 130.5/133.4 154.4/158.3	4.19/3.95 4.33/4.09 4.50/4.28 4.66/4.47	8/10 8/10 8/10 8/10
62.04/73.04 66.26/77.26	1622/1729 1873/2010	140.8/143.7 168.8/172.6	5.11/4.87 5.32/5.10	66.00/78.00 70.20/82.20	1650/1754 1910/2044	141.0/143.8 169.1/172.9	5.00/4.74 5.22/5.99	8/10 8/10
69.32/80.32 85.05/90.05 89.71/111.71	2672/2871 3219/3420 3523/3964	216.8/221.7 256.5/261.7 288.6/300.5	6.21/5.98 6.15/6.16 6.27/5.86	73.30/85.30 90.00/102.00 94.70/118.70	2748/2944 3289/3487 3611/4046	219.2/223.9 257.5/262.5 290.4/302.3	6.12/5.87 6.05/5.85 6.18/5.84	8/10 10/12 10/14
83.37/105.4 88.71/110.71	3937/4371 4406/4931	277.1/286.6 320.6/332.6	6.87/6.44 7.05/6.67	88.30/112.3 93.70/117.7	4010/4434 4500/5016	277.3/286.5 321.3/333.0	6.74/6.28 6.93/6.53	10/14 10/14
92.91/120.41 98.87/126.37	5949/6831 6507/7534	401.9/419.7 453.7/475.5	8.00/7.53 8.11/7.72	97.90/127.9 103.90/133.9	6124/6999 6704/7726	406.0/423.4 458.3/479.5	7.91/7.40 8.03/7.60	10/15 10/15

Continued

Width of attached plate $l=650\text{mm}$				Width of attached plate $l=700\text{mm}$				Thickness of attached plate t
Elements of joint attached plate profile				Elements of joint attached plate profile				
Total area				Total area				
A	Moment of inertia for x-x axis I	Minimum profile modulus for x-x axis W	Radius of inertia for x-x axis r	A	Moment of inertia for x-x axis I	Minimum profile modulus for x-x axis W	Radius of inertia for x-x axis r	
in cm^2	in cm^4	in cm^3	in cm	in cm^2	in cm^4	in cm^3	in cm	mm
47.54/60.54 50.20/63.20	354.3/378.5 433.1/466.4	43.42/44.59 54.79/56.38	2.73/2.50 2.94/2.72	50.54/64.54 53.20/67.20	358.0/381.9 438.7/471.4	43.52/44.69 54.96/56.53	2.66/2.43 2.87/2.65	6/8 6/8
48.59/51.59 50.10/63.10 51.60/64.60 54.50/67.50	484.2/517.3 540.0/579.5 592.2/638.2 683.3/741.9	54.38/55.72 61.75/63.36 68.89/70.76 81.95/84.37	3.16/2.90 3.28/3.03 3.39/3.14 3.54/3.32	51.59/55.59 53.10/57.10 54.60/58.60 57.50/71.50	489.8/522.2 546.9/585.6 600.5/645.6 694.3/751.9	54.51/55.84 61.92/63.51 69.11/70.95 82.26/84.64	3.08/2.82 3.21/2.95 3.32/3.07 3.48/3.24	6/8 6/8 6/8 6/8
51.30/64.30 52.90/65.90	711.9/764.6 779.2/840.4	75.36/77.22 83.97/86.13	3.73/3.45 3,84/3.57	54.30/68.30 55.90/69.90	721.7/773.3 790.9/850.8	75.58/77.41 84.24/86.38	3.65/3.37 3.76/3.50	6/8 6/8
66.10/79.10 68.00/81.00 71.00/84.00 75.40/88.40	1106/1169 1217/1290 1383/1472 1584/1697	100.6/102.6 112.5/114.8 131.0/133.8 155.2/159.0	4.09/3.84 4.23/3.99 4.41/4.19 4.58/4.38	70.10/84.10 72.00/86.00 75.00/89.00 79.40/93.40	1120/1181 1234/1305 1404/1491 1611/1723	100.8/102.8 112.8/115.1 131.4/134.2 155.8/159.5	4.00/3.75 4.14/3.90 4.33/4.09 4.51/4.30	8/10 8/10 8/10 8/10
70.00/83.00 74.20/87.20	1677/1779 1947/2678	141.5/144.3 169.9/173.5	4.90/4.63 5.12/4.88	74.00/88.00 78.20/92.20	1702/1802 1980/2108	141.9/144.7 170.5/174.1	4.80/4.53 5.03/4.78	8/10 8/10
77.30/90.30 95.00/108.0 99.70/125.7	2805/2998 3355/3550 3690/4120	220.3/224.8 258.7/263.6 292.0/303.3	6.02/5.76 5.94/5.73 6.08/5.73	81.30/95.30 100.0/114.0 104.7/132.7	2856/3046 3415/3607 3761/4185	221.2/225.6 259.8/264.6 293.4/304.5	5.93/5.65 5.84/5.63 5.99/5.62	8/10 10/12 10/14
93.30/119.3 98.70/124.7	4088/4504 4596/5104	278.5/287.5 323.0/334.3	6.62/6.14 6.82/6.40	98.30/126.3 103.7/131.7	4157/4566 4683/5184	279.5/288.4 324.4/335.5	6.50/6.01 6.72/6.27	10/14 10/14
102.9/135.4 108.9/141.4	6264/7126 6869/7880	408.2/425.1 461.1/481.8	7.80/7.26 7.94/7.47	107.9/142.9 113.9/148.9	6391/7241 7020/8020	410.1/426.7 463.6/483.7	7.70/7.12 7.85/7.34	10/15 10/15

2 Calculation methods of section modulus and W moment of inertia I of composite sections

2.1 Section area A_z , moment of inertia I and section modulus W of rolled sections (including bulb flats, cs, and unequal angle bars of unequal thickness) (see attached Figure 1) together with attached plating are to be calculated by the following formulae:

$$A_z = A_1 + A \quad \text{in cm}^2$$

$$I = I_{x1} + (y_1 - y)^2 A_1 + \frac{At^2}{12} \times 10^{-2} + (0.05t + y)^2 A \quad \text{in cm}^4$$

$$W = \frac{I}{0.1h - y} \quad \text{in cm}^3$$

Where: h — height of the sections, in mm;

A_1 — sectional area of the sections, in cm^2

I_{x1} — moment of self-inertia of the sections, in cm^4 ;

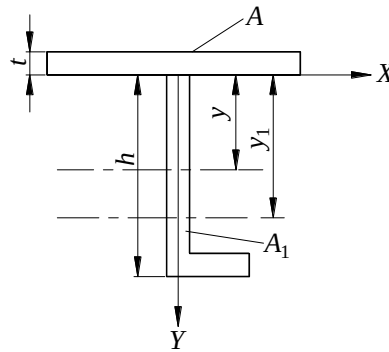
y_1 — neutral axis of the sections, in cm;

A — sectional area of the attached plate, in cm^2 ;

t — thickness of the attached plate in mm;

y — neutral axis with attached plate being considered, to be calculated by the following formula:

$$y = \frac{A_1 y_1 - 0.05At}{A_z} \quad \text{in cm}$$



Attached Figure 1 Schematic diagram of rolled sections with attached plates

2.2 Sectional modulus W and moment of inertia I of T sections with attached plates (Attached Figure 2):

$$W = \frac{d_w}{10} \left[a + \frac{f_s}{6} \left(1 + \frac{2(A - a)}{2A + f_s} \right) \right] \quad \text{in cm}^3$$

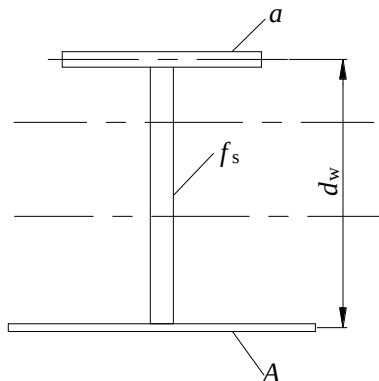
$$I = \left(\frac{d_w}{10} \right)^2 \left[\frac{1}{3} f_s + \frac{Aa - 0.25 f_s^2}{A + a + f_s} \right] \quad \text{in cm}^4$$

Where: a — sectional area of face plate, in cm^2 ;

A — sectional area of attached plating, in cm^2 ;

f_s — sectional area of web plate, in cm^2 ;

d_w — distance between the face plate and the center line of the attached plate, in mm.



Attached Figure 2 Schematic diagram of T-type sections with attached plates

2.3 Sectional modulus W and moment of inertia I of a corrugation breadth s for corrugated stiffened

bulkheads (see attached Figure 3):

$$W = td_w \left(a + \frac{b}{3} \right) \text{ in cm}^3$$

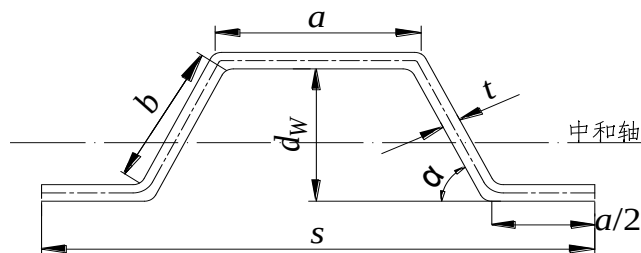
$$I = \frac{td_w^2}{20} (a + 3b) \text{ in cm}^4$$

Where, a -width of corrugation flange, in m;

b —width of corrugation web, in m;

d_w —corrugation depth, in mm;

t — thickness of corrugated bulkhead plating, in mm;



Neutral axis

Figure 3 Schematic diagram of corrugated stiffened bulkheads

2.4 Stiffened plates with triangular or semi-circular cross section as shown in Figure 4 are used. The section elements of the stiffened plates are selected according to Tables 2.4-1 and 2.4-2.

Section elements of triangular stiffened plates

Table 2.4-1

Stiffening height h (in mm)	Spacing of stiffening axis s (in mm)	Top circle radius R (in mm)	Sheet thickness T (in mm)	Maximum section modulus W (in cm^3)	Moment of inertia I (in cm^4)	Radius of inertia r (in cm)
30	390	15	2	2.11	5.10	0.77
			3	3.18	7.67	
			4	4.22	10.29	
			5	5.26	12.86	
30	435	15	2	2.13	5.25	0.75
			3	3.21	7.90	
			4	4.26	10.50	
			5	5.30	13.08	
30	470	15	2	2.14	5.34	0.73
			3	3.22	8.02	
			4	4.28	10.65	
			5	5.32	13.22	
30	500	15	2	2.16	5.36	0.71
			3	3.24	8.05	
			4	4.30	10.68	
			5	5.35	13.32	
30	550	15	2	2.18	5.41	0.68
			3	3.27	8.11	
			4	4.34	10.80	
			5	5.39	13.49	
40	320	15	2	3.14	10.24	1.17
			3	4.61	14.87	
			4	6.01	19.20	
			5	7.36	24.01	
40	370	15	2	3.17	10.60	1.11
			3	4.66	15.39	
			4	6.08	19.85	
			5	7.43	24.01	
40	400	15	2	3.19	10.77	1.05

			3	4.68	15.64	
			4	6.11	20.17	
			5	7.47	24.39	
40	450	15	2	3.21	11.02	1.04
			3	4.71	15.99	
			4	6.15	21.32	
			5	7.52	24.92	
40	500	15	2	3.23	11.22	0.97
			3	4.74	16.27	
			4	6.18	20.98	
			5	7.56	25.35	
40	550	15	2	3.24	11.38	0.93
			3	4.76	16.51	
			4	6.21	21.28	
			5	7.59	25.71	

Section elements of semi-circular stiffened plate

Table 2.4-2

Stiffening height h (in mm)	Spacing of stiffening axis s (in mm)	Top circle radius R (in mm)	Plate thickness t (in mm)	Maximum section modulus W (in cm^3)	Moment of inertia I (in cm^4)	Radius of inertia r (in cm)
15	300	15	2	0.68	0.85	0.35
			3	0.96	1.17	
			4	1.21	1.41	
			5	1.42	1.60	
15	350	15	2	0.68	0.87	0.33
			3	0.97	1.19	
			4	1.21	1.44	
			5	1.42	1.63	
15	400	15	2	0.68	0.88	0.32
			3	0.97	1.21	
			4	1.22	1.46	
			5	1.42	1.60	
15	450	15	2	0.69	0.89	0.30
			3	0.97	1.22	
			4	1.22	1.48	
			5	1.43	1.67	
15	500	15	2	0.69	0.90	0.28
			3	0.97	1.23	
			4	1.22	1.49	
			5	1.44	1.69	
15	550	15	2	0.69	0.91	0.27
			3	0.98	1.24	
			4	1.23	1.51	
			5	1.44	1.70	

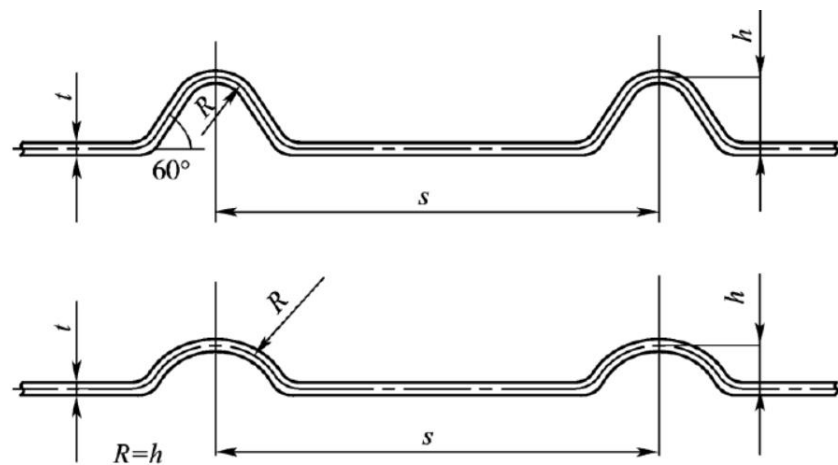


Figure 4 Schematic diagram of triangular and semi-circular stiffeners

APPENDIX II HEIGHT OF WELDING FOOT FOR FILLET WELD

HEIGHT OF WELDING FOOT FOR FILLET WELD

Table 1

W_r	Thickness /mm	Continuous fillet welding on both sides		Automatic deep penetration fillet welding		Intermittent fillet weld			
						$d/l=2.00$		$d/l=4.00$	
		in K/mm		in K/mm		in K/mm		in K/mm	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
0.10	5	4	4	4	4	4	4	4	4
	6	4	4	4	4	4	4	4	4
	8	5	5	4	4	5	5	5	5
	10	5	6	4	5	5	6	6	6
	11	5	7	4	6	5	7	6	7
	12	5	8	4	6	5	7	7	8
	13	5	8	4	7	5	8	7	8
	14	5	9	4	7	5	9	8	9
0.13	15	5	9	4	8	6	9	9	9
	16	5	10	4	9	6	10	9	10
0.16	5	4	4	4	4	4	4	4	4
	6	4	4	4	4	4	4	4	4
	8	5	5	4	4	5	5	5	5
	10	5	6	4	5	5	6	6	6
	11	5	7	4	6	5	7	7	7
	12	5	8	4	6	6	8	8	8
	13	5	8	4	7	6	8	8	8
	14	5	9	4	7	6	9	9	9
0.21	15	5	9	4	8	7	9	9	9
	16	5	10	4	9	7	10	10	10
0.21	5	4	4	4	4	4	4	4	4
	6	4	4	4	4	4	4	4	4
	8	5	5	4	4	5	5	5	5
	10	5	6	4	5	6	6	6	6
	11	5	7	4	6	7	7	7	7
	12	5	8	4	6	7	8	8	8
	13	5	8	4	7	8	8	8	8
	14	5	9	4	7	8	9	9	9
0.21	16	5	9	4	8	9	9	9	9
	16	5	10	4	9	10	10	10	10

Continued

W_r	Thickness /mm	Continuous fillet welding on both sides		Automatic deep penetration fillet welding		Intermittent fillet weld			
		in K/mm		in K/mm		$d/l=2.00$		$d/l=4.00$	
						in K/mm		in K/mm	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
0.27	5	4	4	4	4	4	4	4	4
	6	4	4	4	4	4	4	4	4
	8	5	5	4	4	5	5	5	5
	10	5	6	4	5	6	6	6	6
	11	5	7	4	6	7	7	7	7
	12	5	8	4	6	8	8	8	8
	13	5	8	4	7	8	8	8	8
	14	5	9	5	7	9	9	9	9
	15	6	9	5	8	9	9	9	9
	16	6	10	5	9	10	10	10	10
0.34	5	4	4	4	4	4	4	4	4
	6	4	4	4	4	4	4	4	4
	8	5	5	4	4	5	5	5	5
	10	5	6	4	5	6	6	6	6
	11	5	7	5	6	7	7	7	7
	12	6	8	5	6	8	8	8	8
	13	6	8	5	7	8	8	8	8
	14	7	9	6	7	9	9	9	9
	15	7	9	6	8	9	9	9	9
	16	8	10	7	9	10	10	10	10
0.39	5	4	4	4	4	4	4	4	4
	6	4	4	4	4	4	4	4	4
	8	5	5	4	4	5	5	5	5
	10	6	6	5	5	6	6	6	6
	11	6	7	5	6	7	7	7	7
	12	7	8	6	6	8	8	8	8
	13	7	8	6	7	8	8	8	8
	14	8	9	7	7	9	9	9	9
	15	8	9	7	8	9	9	9	9
	16	9	10	8	9	10	10	10	10
0.44	5	4	4	4	4	4	4	4	4
	6	4	4	4	4	4	4	4	4
	8	5	5	4	4	5	5	5	5
	10	6	6	5	5	6	6	6	6
	11	7	7	6	6	7	7	7	7
	12	8	8	6	6	8	8	8	8
	13	8	8	7	7	8	8	8	8
	14	9	9	7	7	9	9	9	9
	15	9	9	8	8	9	9	9	9
	16	10	10	9	9	10	10	10	10



China Classification Society

RULES FOR CONSTRUCTION OF OCEAN-GOING FISHING STEEL VESSELS

2018

PART 3 ENGINE AND FISHING MACHINERY EQUIPMENT

Effective Date: 1 December 2018

CHAPTER 1 GENERAL

Section 1 GENERAL PROVISIONS

1.1.1 Application

1.1.1.1 Main propulsion and auxiliary machinery installations together with their associated equipment, boilers, pressure vessels, pumping and piping systems, and gearing fitted in fishing vessels are to comply with the relevant requirements prescribed in this PART.

1.1.1.2 Other measures equivalent to those specified in the Rules are to be approved by CCS.

1.1.2 Ambient conditions

1.1.2.1 For the structure and arrangement of the diesel engines and transmission gear of shafting for fishing vessels, as well as mechanical equipment related to the safety of fishing vessels, the structure and arrangement are to ensure normal operation at the inclination angle of fishing vessel specified in Table 1.1.2.1 (horizontal and vertical inclinations may occur simultaneously). Considering the type, size, navigation area and service conditions of fishing vessel, deviation from the inclination angles listed below upon being approved by CCS.

Angle of inclination of fishing vessels

Table 1.1.2.1

Installations and equipment	Angle of inclination			
	Athwartships		Fore-and-aft	
	Static	Dynamic	Static	Dynamic
Main and auxiliary machinery, shaft system	15 °	±22.5 °	5 °	±7.5 °
Emergency power installations Telecontrol system Emergency fire pumps	22.5 °	±22.5 °	10 °	±10 °

1.1.2.2 When determining the power of diesel engine of fishing vessel, the following baseline ambient conditions are to be adopted, namely, 0.1 MPa of absolute atmospheric pressure, 45 °C of intake air temperature, 60% of relative humidity and 32 °C of seawater temperature at the intercooler inlet.

The engine manufacturers are not expected to provide simulated ambient reference conditions at a test bed, but are to provide the correction values of diesel engine power under the reference environmental conditions.

1.1.2.3 For diesel engines of fishing vessels in specific waters, the environmental conditions under which the rated power is used are to be in accordance with the conditions of the operating area and are to be stated.

1.1.3 Vibration

1.1.3.1 The machinery installations are to be so designed, constructed and installed that any mode of their vibrations is not to cause undue stresses in them in the normal operating ranges.

1.1.4 Propulsion device

1.1.4.1 The fishing vessels are to be provided with a propulsion clutch device suitable for the operation requirements.

1.1.4.2 The propulsion devices of trawlers and fishing vessels are to be designed with the performance of slight speed advance. Seine fishing vessels and lighting vessels are to be fitted with a transverse propulsion device.

1.1.5 Astern power

1.1.5.1 In order to maintain secure control of the ship in all normal circumstances, the main propulsion machinery is to be provided with sufficient astern power.

1.1.5.2 For a main machinery without a controllable pitch propeller, gearboxes or reversing clutches are to be adopted for reversing; if restricted by conditions, the main machinery can also be reversed directly.

1.1.5.3 The main machinery capable of direct reversing is to be capable of maintaining in free route astern at least 70% of the ahead revolution for a period of at least 30 min.

1.1.6 Protection against pollution and noise

1.1.6.1 The machinery space is to be provided with collection facilities to prevent oil from leaking into the bilge.

1.1.6.2 The machinery space is to be provided with effective facilities to prevent water pollution from oil.

1.1.6.3 Measures are to be taken to reduce or isolate noise in the machinery space to reduce damage to personnel health and impact on normal work.

1.1.7 Materials

1.1.7.1 The main components of propulsion and auxiliary machinery and the materials used for boilers and pressure vessels are to comply with the relevant provisions of PART SEVEN.

1.1.7.2 Materials not specified in PART SEVEN are to be approved by CCS before being used.

1.1.7.3 All fishing vessels are to be prohibited from newly installation of materials containing asbestos.

1.1.8 Dead ship starting

1.1.8.1 For fishing vessels with a length of not less than 45 m, the machinery is to be so arranged that it can be brought into operation from the dead ship condition using only the facilities available on board without external aid.

“Dead ship” condition is to be understood to mean a condition under which the main power plant, including the main power, is not in operation, and auxiliary energy, such as starting air, starting battery, etc., cannot put the propulsion device into operation and restore the main power supply.

In order to resume operation from the "dead" state, an emergency air compressor or emergency power source can be used for starting, but it should be ensured that the emergency air compressor or emergency power source can start without energy at any time.

1.1.9 Tests

1.1.9.1 After the installation of the propulsion, auxiliary machinery and fishing machinery, the mooring and navigation tests are to be carried out in accordance with the testing schedule agreed by CCS.

The first or first pair of fishing vessels of each type constructed by each shipyard normally are to be subject to fishing trials. The safety-related contents of the fishing trial schedule are to be approved by CCS.

1.1.10 Products

1.1.10.1 All propulsion, auxiliary machinery and important equipment of fishing machinery are to be inspected and approved by CCS.

Section 2 ARRANGEMENT

1.2.1 Entrances and exits

1.2.1.1 The machinery space is to be provided with at least two entrances and exits to the open deck, and they should be as far away from each other as possible for easy access. When the length of the vessel is less than 45 m, only one entrance can be set, but the skylight can be another means of escape. When the skylight works as a means of escape, corresponding climbing measures are to be taken.

1.2.2 Skylights of machinery casings

1.2.2.1 The skylights of machinery casings serving as an escape port can be opened and closed from inside and outside the room casing.

1.2.3 Boiler arrangement

1.2.3.1 The bottom of the water-tube boiler is to be at least 600 mm away from the top plate of the double-bottom fuel tank, and at least 450 mm between the outer bulkhead and fuel bulkhead. When the length of the vessel is less than 45 m, it may be appropriately reduced with the agreement of CCS.

1.2.3.2 The bottom of the fire tube boiler is to be at least 450 mm away from the top plate of double-bottom fuel tank, and the rear head is to be at least 600 mm away from the fuel bulkhead. When the length of the vessel is less than 45 m, it may be appropriately reduced with the agreement of CCS.

1.2.3.3 Oil-fired boilers installed on the platform or intermediate deck of machinery spaces are to be provided with oil-tight enclosures with a height of 200 mm. When the length of the vessel is less than 45 m, it may be appropriately reduced with the agreement of CCS.

1.2.4 Communication

1.2.4.1 At least two independent means are to be provided for communicating orders from the navigating bridge to the position in the machinery space or in the control room from which the propulsion device is normally controlled: one of these provides visual indication of the orders and responses both in the machinery space and in the navigation bridge. When the length of vessel is less than 45 m and the propulsion device is directly controlled by the control station, only one set of communication facilities may be provided. If an electric telegraph is installed, it is to comply with the requirements of PART FOUR.

1.2.4.2 At least one set of communication facilities is to be provided between the control station and any other station rooms capable of controlling the propulsion.

1.2.5 Ventilation and lighting

1.2.5.1 Machinery spaces and control rooms are to be adequately ventilated.

1.2.5.2 All spaces, where flammable or toxic gases or vapors may accumulate, are to be provided with adequate ventilation. The space where the refrigeration compressor locates is to be provided with a dedicated suction opening.

1.2.5.3 Machinery spaces and control rooms are to be adequately illuminated.

1.2.6 Protective facilities

1.2.6.1 In places where the working of machinery and equipment may cause injuries to the operating personnel, handrails, protecting casings or screens are to be provided. Where an upper grille platform is provided in the machinery space, railings of appropriate height are to be provided as well.

1.2.6.2 The floor and platform of the machinery space are to be fixed and adopt effective non-slip metal plates. The edge seal height is not to be lower than 50 mm.

1.2.6.3 When the surface temperature of all mechanical equipment and pipelines may hurt people, effective protective measures are to be taken. When the surface temperature may exceed 220°C, effective protection facilities are to be provided on the surface to avoid contact with flammable liquid. If the surface of the protective facility is oil-absorbing or may be penetrated by oil, it is to be wrapped properly with thin steel plates or equivalent materials.

1.2.6.4 In order to avoid misoperation of mechanical equipment and systems, safety operation signs are to be provided at appropriate locations when necessary.

1.2.6.5 Evacuation and excretion facilities shall be able to ensure safe discharge of excrements.

1.2.7 Anti-corrosion

1.2.7.1 Parts exposed to corrosive environment are to be made of anti-corrosive materials or provide effective anti-corrosion protection.

1.2.8 Accessibility

1.2.8.1 Accessibility, for the purposes of maintenance, inspection and repair of various machinery and equipment, is to be provided in machinery and boiler spaces.

1.2.8.2 The installation and arrangement of machinery and equipment should be such that their instrument clusters and observation windows are within reach and reach at any time.

1.2.9 Maintenance access

1.2.9.1 The machinery spaces are to be provided with access to facilitate the operation, maintenance and repair of various mechanical equipment.

1.2.10 Stuffing boxes for shafting

1.2.10.1 Stuffing boxes are to be fitted on the watertight bulkhead of the engine room where the shafts pass through. They are to be so arranged as to be convenient for tightening and renewing the packings from the engine room side. The fore sealing ends of the stern tubes as well as the plumber blocks are to be easily accessible for maintenance.

1.2.11 Fixing of lifting equipment and spare parts

1.2.11.1 Proper lifting equipment are to be provided in the machinery space for disassembling the components of the propulsion and auxiliary machinery, and can also be used normally during navigation.

1.2.11.2 Various spare parts of propulsion, auxiliary machinery and other devices are to be firmly fixed in appropriate spaces.

CHAPTER 2 GENERAL PROVISIONS FOR PUMPS AND PIPING SYSTEMS

Section 1 GENERAL PROVISIONS

2.1.1 Design pressure

2.1.1.1 The design pressure for piping is the maximum permissible working pressure, and it is to comply with the following requirements:

- .1 For pipes with a safety valve, the maximum adjustment pressure of the safety valve is the design pressure of the pipe. The pressure fuel pipes of boiler is to be taken at least 1.6 MPa;
- .2 The design pressure of the discharge end pipeline of air compressors and positive displacement pumps is the maximum adjustment pressure of the safety valve; and the design pressure of the pipeline at the centrifuge pump is to be the maximum pressure on the performance curve;
- .3 The design pressure of the boiler outlet steam pipe shall be the design pressure of the boiler; the design pressure of the water supply pipe and the sewage pipe is to be 1.25 times the design pressure of the boiler, but is not to be less than the boiler design pressure plus 0.7 MPa.

2.1.2 Design temperature

2.1.2.1 The design temperature is to be taken as the maximum temperature of the internal fluid, but not be lower than 50°C.

2.1.3 Classes of pipes

2.1.3.1 For the purpose of assigning appropriate testing requirements, types of joints to be adopted, heat treatment and weld procedure, pressure piping systems are divided into three classes in accordance with their design pressure and design temperature, as indicated in Table 2.1.3.1.

Piping system class

Table 2.1.3.1

Piping system	Class I		Class II		Class III	
	Design pressure, in MPa	Design temperature, in °C	Design pressure, in MPa	Design temperature, in °C	Design pressure, in MPa	Design temperature, in °C
Steam	> 1.6	Or > 300	≤ 1.6	and ≤ 300	≤ 0.7	and ≤ 170
Fuel oil, lub-oil, flammable hydraulic oil	> 1.6	Or > 150	≤ 1.6	and ≤ 150	≤ 0.7	and ≤ 60
Other media	> 4.0	Or > 300	≤ 4.0	and ≤ 300	≤ 1.6	and ≤ 200

Note: 1) For Class I piping, one parameter for design pressure and design temperature of Class I specified in the Table is to be met; For Class II and III piping, one parameter for design pressure and design temperature of Class II and III specified in the Table is to be met;
 2) Other media mean air, water, and non-flammable hydraulic oil.
 3) Class III pipes may be used for open ended piping, e.g. drains, overflows, vents boiler waste steam pipes, etc.

2.1.3.2 The design pressure of the fuel piping system may be taken in accordance with Table 2.1.3.2.

Design pressure of fuel oil piping system

Table 2.1.3.2

Working temperature in °C Working pressure in MPa	$T \leq 60$	$T > 60$
$P \leq 0.7$	0.3 MPa or maximum working pressure, whichever is greater	0.3 MPa or maximum working pressure, whichever is greater
$P > 0.7$	Maximum working pressure	1.4 MPa or maximum working pressure, whichever is greater

2.1.4 Piping arrangement and liquid tank separation

2.1.4.1 All pipes are to be properly secured, and provision is to be made to avoid excessive stresses caused by thermal expansion in pipes or due to deflection of ship structure. For easy maintenance, an appropriate number of flange connections are to be provided.

2.1.4.2 Penetration pieces or steel pads are to be provided for pipes passing through watertight or gastight structures.

2.1.4.3 Fresh water pipes are not to be led through oil tanks, nor oil pipes through fresh water tanks. Where it

is impracticable to do so, the pipes are to be led inside an oil-tight pipe tunnel. When other pipes pass through the fuel oil tank, the pipe walls are to be thickened and there should be no detachable joints.

2.1.4.4 The fuel oil tank is to be part of the hull structure as much as possible, and at least one vertical plane is adjacent to the boundary bulkheads of the machinery space, and the common boundary area with the machinery space is to be kept to the minimum.

2.1.4.5 The valves in the pipeline are to be arranged for easy operation and maintenance. For valves that are inconvenient to operate below the metal pattern plate, the valve stem are to be lengthened or equipped with easy-to-operate tools. The metal pattern plate are to be opened and covered accordingly.

2.1.5 Corrosion protection and coloring

2.1.5.1 Steel pipes are to be protected against corrosion, and protective coatings are to be applied on completion of all fabrication, i.e. bending, forming and welding of the steel pipes.

2.1.5.2 Piping systems for different media are to be painted with identification paint in accordance with relevant standards.

2.1.6 Fire protection

2.1.6.1 Air, overflow and sounding pipes for fuel oil tanks are not to be led through living quarters. Where this is not practicable, no detachable pipe joint is permissible in these spaces.

2.1.6.2 All steam, oil and water pipes as well as oil and other liquid tanks are not to be placed above or behind the switchboard. If this is not practicable, suitable protective means are to be provided. In addition, oil pipes and oil tanks are not to be directly placed above the boilers, uptakes, steam pipes, exhaust gas pipes and silencers. If this is impracticable, effective means are to be made to prevent oil dropping onto the hot surfaces of the above-mentioned pipes or equipment. There should be no detachable joints for the oil pipes on the above parts.

2.1.7 Protection

2.1.7.1 Pipes in positions where they are liable to mechanical damage are to be efficiently protected by removable casings.

2.1.7.2 All pipes, fittings, pumps, filters and other equipment of piping systems are to be provided with drain valves or cocks where necessary.

2.1.7.3 The pipes which may be subject to a pressure greater than the design value are to be fitted with relief valves at the delivery side of pumps. The discharge from relief valves fitted in oil pipelines is to be led to the suction side of pumps or tanks. Heaters and air compressor coolers are also to be fitted with relief valves. The releasing pressure of relief valves is, in general, not to be greater than the design pressure of pipelines.

2.1.7.4 Where pressure-reducing valves are fitted in the pressure piping, a relief valve and a pressure gauge are to be fitted behind the pressure-reducing valve and a by-pass pipe is to be provided.

2.1.8 Insulation

2.1.8.1 All steam pipes, exhaust pipes and high-temperature pipelines are to be wrapped with thermal insulation materials. The surface temperature of the insulation layer is generally not to exceed 60°C. The insulation materials at the detachable joints and valves are to be easy to remove.

2.1.8.2 Pipes of non-refrigerated devices passing through refrigerated fish hold, are to be well insulated to prevent freezing and from the steel structure.

2.1.9 Compensation for expansion and heat treatment

2.1.9.1 Suitable provision for compensation is to be made for all pipes subject to expansion, contraction or other strain, such as bends, loops, or expansion joints as required.

2.1.9.2 Expansion joints used in the piping system are to be of approved types. The adjoining pipes are to be suitably aligned and anchored. Where necessary, expansion pieces of bellows type are to be protected against mechanical damage.

2.1.9.3 Carbon steel and carbon-manganese steel pipes of class I piping system are to be heat treated if the bending radius after cold bending is less than three times the outer diameter of the pipe.

2.1.9.4 Copper and copper alloy pipes hardened due to cold bending are to be appropriately heat-treated according to their material composition to eliminate internal stress before hydraulic testing after completion of manufacturing.

2.1.9.5 The post-weld heat treatment of pressure pipes are to meet the relevant requirements of Section 4, CHAPTER 7, PART EIGHT.

2.1.10 Nondestructive inspection

2.1.10.1 Nondestructive inspection of piping systems are to comply with the relevant requirements of Section 3, CHAPTER 7, PART 8.

Section 2 CARBON AND LOW ALLOY STEEL

2.2.1 Carbon and low alloy steel pipes

2.2.1.1 Classes I and II pipes are to be seamless steel pipes or welded pipes fabricated with a welding procedure approved by CCS.

2.2.2 Calculation of wall thickness

2.2.2.1 The minimum wall thickness of steel pipes subject to internal pressure is not to be less than that determined by the following formula;

$$\delta = \delta_0 + b + c \quad \text{mm}$$

Where: δ_0 —the basic wall thickness, in mm, see 2.2.2.2 of this PART;

b —allowance for bending, in mm, see 2.2.2.3 of this PART;

c —additional corrosion allowance, in mm, in Table 2.2.2.1.

Additional corrosion allowance c for steel pipes (in mm)

Table 2.2.2.1

Usage of piping	c	Usage of piping	c
Steam piping	0.8	Lubricating oil piping	0.3
Fuel steam heating piping	2.0	Fuel oil piping	1.0
Boiler open-type feed piping	1.5	Refrigerant piping of refrigerating installation	0.3
Boiler blow-off piping	1.5	Fresh water piping	0.8
Compressed air piping	1.0	Sea water piping	3.0
Hydraulic oil piping	0.3	Salt water piping in refrigerated hold	2.0

Note: For pipes passing through tanks, an additional corrosion allowance is to be taken, depending on the external medium, in order to account for the external corrosion. Where pipes are efficiently protected, the corrosion allowance may be reduced by not more than 50%. In the case of use of special alloy steel with sufficient corrosion resistance, the corrosion allowance may be reduced, even to zero.

2.2.2.2 The basic wall thickness δ_0 for steel pipes is to be determined by the following formula:

$$\delta_0 = \frac{pD}{2[\sigma]e + p} \quad \text{mm}$$

Where: p —design pressure, in MPa, see 2.1.1 of this PART;

D —outside diameter of steel pipes, in mm;

$[\sigma]$ —permissible stress of steel pipes, in N/mm^2 , see 2.2.2.4 of this PART;

e —welding efficiency factor. For seamless steel pipes and electric resistance or induction welded steel pipes, e is to be taken as 1; for pipes made by other methods, e will be specially considered.

2.2.2.3 Bending allowance b is not to be less than that determined by the following formula:

$$b = 0.4 \frac{D\delta_0}{R} \quad \text{mm}$$

Where: R —average bending radius, in mm; usually R is not to be less than 3 ;

D —outside diameter of steel pipes, in mm;

δ_0 —the basic wall thickness, in mm, see 2.2.2.2 of this PART;

2.2.2.4 Permissible stress $[\sigma]$ of steel pipes is to be taken as the lowest of the following values:

$$[\sigma] = \frac{R_m}{2.7} \quad \text{N/mm}^2$$

$$[\sigma] = \frac{R_{eH}^T}{1.6} \quad \text{N/mm}^2$$

$$[\sigma] = \frac{R_{100000}^T}{1.6} \quad \text{N/mm}^2$$

Where: R_m —minimum tensile strength of material at ambient temperature, in N/mm^2 ;

R_{eH}^T —yield stress or 0.2% proof stress ($R_{p0.2}$) of material at design temperature, in N/mm^2 ;

R_{100000}^T —average stress of material to produce rupture in 100,000 h at design temperature, in N/mm^2 ;

R_m , R_{eH}^T and R_{10000D}^T are to comply with the relevant requirements of Section 2, CHAPTER 7, PART SEVEN.

2.2.2.5 The minimum wall thickness mentioned in 2.2.2.1 above has not taken into account the negative manufacturing tolerance. Where there is any negative tolerance allowable in manufacture, the nominal thickness δ_m of pipes is not to be less than that determined by the following formula:

$$\delta_m = \frac{\delta}{1 - \frac{a}{100}} \quad \text{mm}$$

Where: δ —minimum calculated wall thickness, in mm. See 2.2.2.1 of this PART;

a —percentage of the ratio of manufacturing negative tolerance to the nominal wall thickness of the pipe.

2.2.2.6 Where the minimum thickness calculated by the formula specified in 2.2.2.1 to 2.2.2.5 is less than that shown in Table 2.2.2.6, the minimum nominal thickness for the appropriate standard pipe size shown in the Tables is to be used.

For threaded pipes, the thickness is to be measured at the bottom of the thread.

Minimum nominal thickness of steel pipe (mm)

Table 2.2.2.6

External diameter, D	General pipe ^{①②}	Air pipe, overflow pipe and sounding pipe of tank related to hull structure ^{②③}	Bilge and ballast pipe, general sea water pipe ^{①②③}	Bilge pipe, air pipe, overflow pipe and sounding pipe through ballast tank and fuel oil tank. Ballast pipe through fuel oil tank and fuel oil pipe through ballast tank ^{①②③}
10.2~12	1.6			
13.5~17.2	1.8			
20	2.0			
21.3~25	2.0		3.2	
26.9~33.7	2.0		3.2	
38~44.5	2.0	4.5	3.6	6.3
48.3	2.3	4.5	3.6	6.3
51~63.5	2.3	4.5	4.0	6.3
70	2.6	4.5	4.0	6.3
76.1~82.5	2.6	4.5	4.5	6.3
88.9~108	2.9	4.5	4.5	7.1
114.3~127	3.2	4.5	4.5	8.0
133~139.7	3.6	4.5	4.5	8.0
152.4~168.3	4.0	4.5	4.5	8.8
177.8	4.5	5.0	5.0	8.8
193.7	4.5	5.4	5.4	8.8
219.1	4.5	5.9	5.9	8.8
244.5~298	5.0	6.3	6.3	8.8

Note 1: The minimum wall thickness for bilge lines and ballast lines through deep tanks will be subject to special consideration.

Note 2: When the diameter of the pipe is large, the wall thickness is to be considered separately.

Note 3: Where pipes are efficiently protected against corrosion, the minimum wall thickness may be reduced by an amount up to 1 mm.

2.2.2.7 The minimum wall thickness of the scuppers and discharge pipes is to comply with the relevant requirements of Statutory Inspection Rules for Fishing Vessels (Ocean-going Fishing Vessels 2018).

2.2.2.8 The minimum wall thickness of the air pipes above the weather deck is to comply with the relevant requirements of Statutory Inspection Rules for Fishing Vessels (Ocean-going Fishing Vessels 2018).

2.2.2.9 The wall thickness of the injection pipe is to be calculated based on the steel pipe subjected to internal pressure, and its corrosion allowance above the weather deck is generally not be less than 2 mm.

2.2.3 Connection of pipe lengths

2.2.3.1 Connection of pipe lengths may be obtained by:

- .1 threaded connection flange;
- .2 welding flange;
- .3 butt welding between pipes;
- .4 casing welding joints;
- .5 threaded socket joints.

If any other connection methods are adopted, they are to be approved by CCS.

2.2.4 Threaded connection flange

2.2.4.1 Threaded connection flanges are shown in Figure 2.2.4.1. The pipe and flange are to be screwed with

a tapered thread and the diameter of the screw portion of the pipe over the thread is not to be appreciably less than the outside diameter of the unthreaded pipe. After the flange has been screwed hard home, the pipe is to be expanded into the flange.

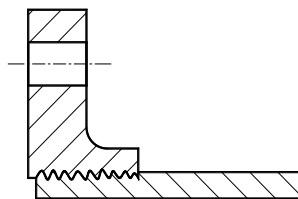


Figure 2.2.4.1 Threaded connection flange

2.2.4.2 The length of the gradually closing thread on the pipe is not to be less than three pitches. The diameter of the root of the thread is to be uniformly increased from the diameter of the standard root to the diameter of the top of the thread, and the flange shall be gradually reduced in the opposite direction.

2.2.4.3 The above threaded connection flanges can be used for steam pipes with a maximum design pressure of less than 1.6 MPa and a maximum design temperature of less than 250 °C, and other media piping systems other than oil and refrigerant with a maximum design pressure of less than 4 MPa.

2.2.5 Welding flange

2.2.5.1 The typical joints of welding flange are shown in Figure 2.2.5.1. The maximum design temperature of A, B and C flanges in the figure is not limited. Type D can be used for class II piping systems with a maximum design temperature not exceeding 250°C except oil pipes.

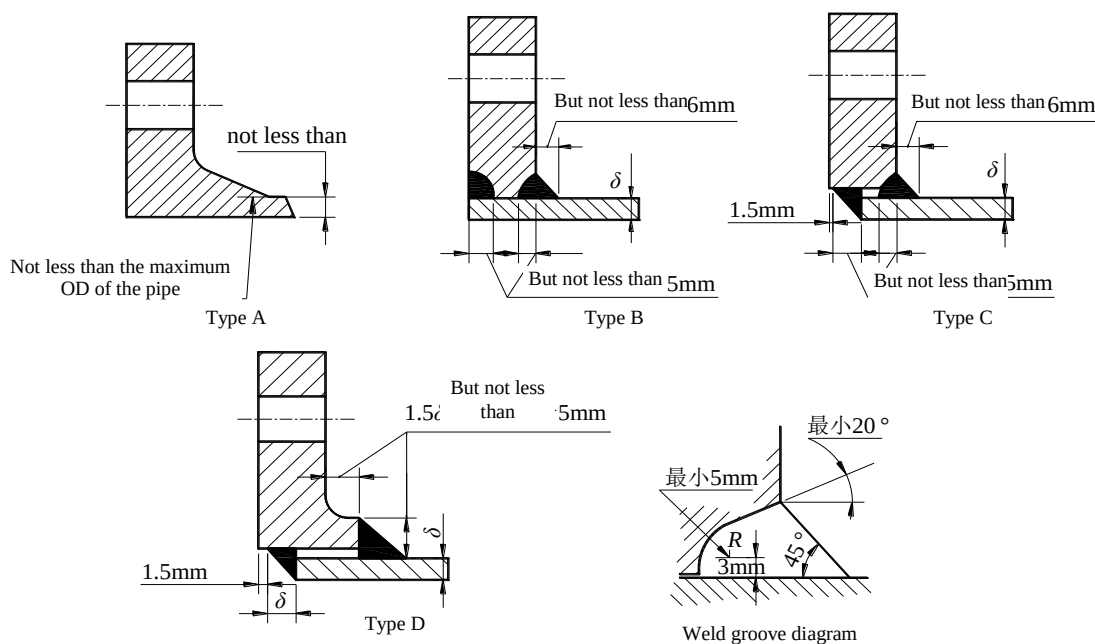


Figure 2.2.5.1 Typical joints of welding flange

2.2.5.2 Welding flanges do not need to fit tightly with the pipes. The maximum gap between the flange inner hole and the outer diameter of the pipe is generally not to exceed 2 mm.

2.2.5.3 If D-type or C-type welding flanges with a pipe outer diameter less than 32 mm are used for Class III piping systems other than oil pipes, single-sided welding is allowed on the outside, but the gap between the inner hole of the flange and the pipe is to be minimized as much as possible.

2.2.5.4 The use of other types of welding flanges is to be approved by CCS.

2.2.6 Butt welding between pipes

2.2.6.1 When the pipes are connected by butt welding, the hole diameters of adjacent pipe fittings shall match. If the diameters of the pipe fittings are different, methods such as punching and expanding or machining can be used, but the thickness of the pipe wall after processing is not to be less than the designed wall thickness. If the thicknesses of the adjacent pipes are different, the thicker wall thickness is to be gradually reduced to the thinner wall thickness at the joint.

2.2.6.2 If the branch pipe and the main pipe are connected by welding, the branches are to be strengthened by

using compensation plates or other methods approved by CCS, or by increasing the thickness of the pipe wall of the main pipe.

2.2.6.3 If butt welding is used for all classes of piping systems, measures to improve the quality of the root of the weld are to be adopted; otherwise, butt welding may only be used for Class II and III.

2.2.7 Casing welding joints;

2.2.7.1 Casing welded joints can be used for all class III piping systems. The casing material is to be the same as the material of the pipe being welded. This connection is not applicable to locations where fatigue or severe erosion may occur.

2.2.7.2 Casing welded joints can also be used for Class I and II piping systems with an outer diameter ≤ 88.9 mm, except for toxic media or piping systems that are expected to cause fatigue and severe corrosion during work.

2.2.7.3 The throat thickness of the fillet weld between the pipe and the casing is not to be less than the nominal thickness of the pipe.

2.2.8 Threaded socket joints

2.2.8.1 Threaded sleeve joints can be used for Class III piping systems with a pipe outer diameter not greater than 50 mm, except for flammable media.

Section 3 COPPER AND COPPER ALLOYS

2.3.1 Copper and copper alloy pipes, valves and fittings

2.3.1.1 Copper and copper alloy pipes used in Classes I and II piping systems are to be seamless.

2.3.1.2 In general, copper and copper alloy pipes, valves and fittings are not be used for media having a temperature above the following limits:

- .1 copper and aluminum brass: 200°C;
- .2 Copper-nickel alloy: 300°C;
- .3 special bronze suitable for high temperature services: 260°C.

2.3.2 Calculation of wall thickness

2.3.2.1 The minimum wall thickness δ of copper and copper alloy pipes subject to internal pressure is not to be less than that determined by the following formula:

$$\delta = \delta_0 + b + c \quad \text{mm}$$

Where: δ_0 —the basic wall thickness, in mm, see 2.3.2.2 of this PART;

b —allowance for bending, in mm, see 2.3.2.3 of this PART;

c —additional corrosion allowance,

copper, aluminum brass and copper-nickel alloys where the nickel content is below 10%, $c = 0.8$ mm;

copper-nickel alloys where the nickel content is 10% or above, $c = 0.5$ mm;

where the media are non-corrosive relative to the pipe material, $c = 0$.

2.3.2.2 The basic wall thickness δ_0 of copper and copper alloy pipes is to be determined by the following formula:

$$\delta_0 = \frac{pD}{2[\sigma] + p} \quad \text{mm}$$

Where: p —design pressure, in MPa, see 2.1.1 of this PART;

D —outside diameter of pipe, in mm;

$[\sigma]$ —Permissible stress, in N/mm^2 , obtained from Table 2.3.2.2. The intermediate value of stress can be obtained by interpolation.

Allowable stress of copper and copper alloy pipes

Table 2.3.2.2

Pipe material	Test conditions	Allowable stress Design	50	75	100	125	150	175	200	225	250	275	300
		Tensile strength Lower limit											
Copper	Annealing	215	41	41	40	40	34	27.5	18.5	—	—	—	—
Aluminum brass	Annealing	325	78	78	78	78	78	51	24.5	—	—	—	—
Copper-nickel alloy 90/10	Annealing	275	68	68	67	65.5	64	62	59	56	52	48	44
Copper-nickel alloy 70/30	Annealing	365	81	79	77	75	73	71	69	67	65.5	64	62

Note: The allowable stresses of materials not covered by the Table are to be approved by CCS.

2.3.2.3 Bending allowance b is not to be less than that determined by the following formula:

$$b = 0.4 \frac{D}{R} \times \delta_0 \quad \text{mm}$$

Where: R — radius of curvature of a pipe bend at the center line of the pipe, in mm. In general, R is not to be less than $3D$;

D — outside diameter of pipe, in mm;

δ_0 — the basic wall thickness, in mm, see 2.3.2.2 of this PART.

2.3.2.4 The minimum wall thickness mentioned in 2.3.2.1 has not taken into account the negative manufacturing tolerance. Where there is any negative tolerance allowable in manufacture, the nominal thickness δ_m of pipes is not to be less than that determined by the following formula:

$$\delta_m = \frac{\delta}{1 - \frac{a}{100}} \quad \text{mm}$$

Where: δ — minimum calculated wall thickness, in mm. See 2.3.2.1 of this PART;

a — percentage of the ratio of manufacturing negative tolerance to the nominal wall thickness of the pipe.

2.3.2.5 Where the minimum thickness calculated by the formula specified in 2.3.2.1 to 2.3.2.4 is less than that shown in Table 2.3.2.5, the minimum nominal thickness for the appropriate standard pipe size shown in the Tables is to be used. For threaded pipes, the thickness is to be measured at the bottom of the thread.

Minimum nominal thickness of copper and copper alloy pipes (mm)

Table 2.3.2.5

Outside diameter of pipe	Minimum nominal wall thickness δ_m	
	Copper	Copper alloy
8~10	1.0	0.8
12~20	1.2	1.0
25~44.5	1.5	1.2
50~76.1	2.0	1.5
88.9~108	2.5	2.0
133~159	3.0	2.5
193.7~267	3.5	3.0
273~470	4.0	3.5
508	4.5	4.0

Note: 1) The outside diameters and the thickness have been selected from ISO Standards.

2) If the pipe diameter and wall thickness are selected according to other standards, the approval of CCS shall be adopted.

Section 4 OTHER MATERIALS

2.4.1 Grey cast iron pipes, valves and fittings

2.4.1.1 Grey cast iron pipes, valves and fittings are not to be used in Class I and Class II piping systems. Grey cast iron valves and fittings may be used in Class II steam piping but the design pressure or temperature does not exceed 1.3 MPa or 220°C respectively.

2.4.1.2 Grey cast iron pipes, valves and fittings may, in general, be accepted in Class III piping systems, in cargo lines within cargo tanks of tankers, but grey cast iron is not to be used for the following:

- .1 piping may be subjected to pressure shock, excessive strains and vibration;
- .2 ship-side valves and fittings and sea valves;
- .3 valves fitted on the collision bulkhead;
- .4 valves under static head fitted on the outside of fuel tank walls;
- .5 boiler blow-off systems;
- .6 pipes for steam, fire extinguishing, bilge and ballast systems.
- .7 piping intended for conveying media having temperatures above 220°C.

2.4.2 Nodular graphite cast iron pipes, valves and fittings

2.4.2.1 Ferritic nodular graphite iron castings for pipes, valves and fittings in Class II and Class III piping systems are to be made in a grade having a specified minimum elongation not less than 12% on a gauge length of $5.65 \sqrt{A}$, where A is the cross-sectional area of the test piece. When the elongation is lower than this value, it should be treated as grey cast iron.

2.4.2.2 Ferritic nodular graphite cast iron pipes, valves and fittings are not to be used in piping systems for conveying media having temperatures exceeding 350°C.

2.4.2.3 Where ferritic nodular graphite iron castings are used for ship-side pipes, valves and fittings, the

properties of this material are to comply with the relevant requirements of CHAPTER 6, PART 7.

2.4.3 Plastic pipes

2.4.3.1 The plastic pipes used on vessels are to be of approved types and are to be selected in relation to their chemical composition, physical and mechanical properties, and temperature limits. The maximum allowable working pressure of the plastic pipe is not to be greater than 1/4 of the burst pressure at its service temperature.

2.4.3.2 Plastic pipes are not to be used in the following piping systems:

- .1 fire piping;
- .2 bilge piping;
- .3 power piping and piping to carry oil or other flammable liquids;
- .4 seawater piping systems which can increase the risk of flooding of fishing vessels when pipes are leaked or damaged.

2.4.3.3 Plastic pipes are not to pass through watertight bulkheads.

2.4.3.4 All plastic pipes are to have appropriate free supports. Measures are to be taken at each section of the pipe to allow the plastic pipe to expand or contract.

2.4.3.5 Plastic pipes are generally not used for piping systems with medium temperatures above 60°C or below 0°C.

2.4.4 Flexible hoses

2.4.4.1 When relative movement is required between the machine and the fixed pipeline, an approved hose can be used for connection.

2.4.4.2 Non-metallic hoses used in piping systems carrying flammable liquids or seawater are to have at least one layer of wire braid inside.

2.4.4.3 Flexible hoses are to be fitted with approved end fittings.

2.4.4.4 Generally, pipe clamps can be used as a method of pipe end fixing only in the cooling pipe of diesel engine and air compressor when the short straight hose is connected to the two metal pipes between the two fixed points of the machine.

2.4.4.5 New types of non-metallic hoses are to be subjected to a prototype pressure test. The burst pressure is not to be less than 4 times the maximum allowable working pressure.

2.4.4.6 Under any circumstances, the flexible hose shall be free of phenomena such as suction, bending, etc. that affect the smooth flow of the fluid. The use of non-metallic hoses in bilges and ballast piping systems is to be agreed by CCS.

2.4.4.7 Each flexible hose is to be subjected to hydraulic test. The test pressure is not to be less than 1.5 times the maximum allowable working pressure.

Section 5 HYDRAULIC TEST AND TIGHTNESS TEST

2.5.1 Tests prior to installation on board

2.5.1.1 All Classes I and II pipes and their associated fittings and, all steam pipes, feed pipes, compressed air pipes, hydraulic pipes and fuel oil pipes having a design pressure greater than 0.35 MPa together with their fittings are to be hydraulically tested after completion of manufacture and before insulating and coating. The test pressure P_s is not to be less than 1.5 times the design pressure; the test pressure of fuel oil pipe is not to be less than 2 times the design pressure.

2.5.1.2 For steel pipes and integral fittings for use in systems where the design temperature exceeds 300°C, test pressure P_s is to be determined by the following formula, but need not exceed $2P$.

$$P_s = 1.5 \frac{[\sigma]_{100}}{[\sigma]_t} P \quad \text{MPa}$$

Where: P —the same as 2.5.1.1;

$[\sigma]_{100}$ —permissible stress for 100°C, in N/mm²;

$[\sigma]_t$ —permissible stress for the design temperature, in N/mm².

The test pressure may be reduced to $1.5P$ where it is necessary to avoid excessive stress in way of bends and T-connections approved by CCS.

2.5.1.3 When the hydraulic test of piping is carried out on board, it may be carried out concurrently with the tightness tests required after assembly on board.

2.5.1.4 For pipes with an internal diameter less than 15 mm, the hydraulic test may be waived approved by CCS.

2.5.2 Testing after assembly on board

2.5.2.1 All piping systems are to be checked for leakage under working conditions.

2.5.2.2 Fuel piping, heating coils in tanks, bilge pipes in way of double bottom tanks or deep tanks and hydraulic piping are to be tested by hydraulic pressure in accordance with Table 2.5.2.2.

Hydraulic tests after assembly on board

Table 2.5.2.2

Piping system	Test pressure
Fuel piping	1.5 times design pressure, but not less than 0.4 MPa
Heating coils in tanks	
Bilge pipes in way of double bottom tanks or deep tanks	Not less than test pressure of the tank
Hydraulic pipe system	1.25 times design pressure, but no need to exceed design pressure plus 7 MPa

2.5.2.3 Where Classes I and II pipes are butt welded together during assembly on board, the hydraulic test may be omitted provided non-destructive tests by ultrasonic or radiographic methods are carried out on the entire circumference of all butt welds with satisfactory results.

2.5.3 Hydraulic test of pumps, valves and fittings

2.5.3.1 All pressured parts of pumps are to be hydraulically tested in the workshop before assembly. The test pressure is 1.5 times the design pressure, but it need not be greater than the design pressure plus 7 MPa.

2.5.3.2 All pressured parts of valves and fittings are to be hydraulically tested in the workshop before assembly. The test pressure is 1.5 times the design pressure, but it need not be greater than the design pressure plus 7 MPa.

2.5.3.3 The test pressure of side valves and their connections is not to be less than 0.5 MPa.

CHAPTER 3 VESSEL'S PIPING AND VENTILATING SYSTEMS

Section 1 GENERAL PROVISIONS

3.1.1 Materials

3.1.1.1 Except where otherwise stated in this CHAPTER, pipes, valves and fittings are to be made of steel, cast iron, copper, copper alloy, or other approved material suitable for the intended service. Materials sensitive to heat, such as aluminum, lead or plastics, are not to be used in systems essential to the safe operation of the fishing vessel, or in systems conveying combustible liquids or sea water where leakage or failure could result in fire or in flooding of watertight compartments.

3.1.2 Valves

3.1.2.1 All valves are to be so constructed as to prevent the possibility of valve bonnets or glands being slackened back or loosened when the valves are operated.

3.1.2.2 Valves on board vessels are to be of such construction that the closing of which is obtained by clockwise rotation of the hand wheel, and the opening by counter-clockwise rotation.

3.1.2.3 Valves and cocks not easily identifiable are to be fitted with nameplates to indicate their purposes.

3.1.2.4 All valves which are provided with remote control are to be arranged for local manual operation, independent of the remote operating mechanism. Opening and/or closing of the valves by local manual means is not to render the remote control system inoperable. Sea valves, ship-side valves and valves on collision bulkhead are to be permanently arranged for local manual operation.

3.1.2.5 Where valves, cocks, pipes or other fittings attached direct to the plating of tanks, and to bulkheads, flats or tunnels which are required to be of watertight construction, generally the bulkhead plating is to be welded with seat plates of appropriate thickness, are to be secured by means of studs screwed into but not penetrating through the pads welded on the plating.

3.1.3 Installation of ship-side valves and fittings (other than those on scuppers and sanitary discharges)

3.1.3.1 All sea inlet are to be fitted with valves or cocks secured direct to the plating of fabricated steel sea chests attached to the shell plating.

3.1.3.2 All valves or cocks on the outboard outlets are to be installed directly on the side shells or on the short pipes welded to the side shells. The wall thickness of short tube is not to be less than the thickness of the side shell plating.

3.1.3.3 When the valves or cocks are directly mounted on the shell plates or the tank wall of the seawater tank, they are to be connected to the seat plate welded to the shell plate or box plate and fixed by the studs screwed into the seat plate. But the studs are not to be drilled into the shell plate.

3.1.3.4 All valves or cocks that are directly fixed on the shell plate shall be provided with spigots passing through the plate. The spigots on the valves or cocks may be omitted if spigots are formed by seat plate or in way of the shell plate and connection pipes. Blow-off valves or cocks are also to be fitted with a protection ring through which the spigot is to pass, the ring being on the outside of the shell plating.

3.1.3.5 Sea inlet and overboard discharge valves and cocks are in all cases to be fitted in easily accessible positions and, so far as practicable, are to be readily visible. Indicators are to be provided local to the valves and cocks, showing whether they are open or shut. The manual operating device of main sea inlet valve is to be situated not less than 450 mm above the metal pattern plate. When the length of the vessel is less than 45 m, it may be appropriately reduced with the agreement of CCS.

3.1.3.6 It is to be avoided to locate the overboard discharges in way of the areas where the lifeboats and accommodation ladders are lowered. Where this is not practicable, suitable means are to be provided to prevent any discharge of water into the lifeboats or onto the accommodation ladders.

3.1.3.7 Detachable and properly fixed gratings are to be fitted at all openings in the ship's side for sea chests. The net area through the gratings is not to be less than twice that of the valves connected to the sea inlets. The direction of grating bars is to be in line with the length of the ship. Effective clearing gratings are to be provided. When the length of vessel is less than 30 m, if it is not practicable to set cleaning equipment, it can be omitted, but the flow area of the valve box is to be appropriately increased.

3.1.3.8 Ship-side valves and fittings as well as sea chests, if made of steel, are to be suitably protected against wastage.

3.1.3.9 Sea chests are to be so designed and arranged as to avoid the formation of air pocket. Where a vent pipe is fitted on the top of the sea chest, a screw-down valve is to be fitted at the root of the vent pipe. The open end of the vent pipe is to be extended to a position above the bulkhead deck or to be led overboard in the vicinity of the bulkhead deck and a ship-side screw-down valve is to be fitted.

3.1.3.10 In the machinery space, the seawater suction and discharge valves related to the operation of the

machine are to be convenient for local control and inspection, and the valves are to be provided with open and close status indicator.

Section 2 DRAINAGE OF COMPARTMENTS, OTHER THAN MACHINERY SPACES

3.2.1 General requirements

3.2.1.1 All fishing vessels are to be provided with efficient bilge pumping systems capable of pumping from and draining watertight compartments other than liquid compartments.

3.2.1.2 The suctions and means for drainage are to be so arranged that any water within any compartment of the ship, or any watertight section of any compartment, can be pumped out through at least one suction when the ship is on an even keel and is either upright or has a list of not more than 5°.

3.2.2 Fish tanks

3.2.2.1 Generally, two bilge suctions are to be provided in each fish tank, locating at the longitudinal section in center plane at the front and rear ends respectively. In any case, they should be able to continuously drain water at each site in the tank to the bilge suction. Sewage bilges are to be set when necessary. If the length of fish tank is not more than 9 m, only one bilge suction is fitted at the back. The bilge suctions are to be set at actual effective locations according to the specific loading conditions.

3.2.2.2 For fishing vessels less than 30 m in length, only one bilge suction is allowed in each fish tank.

3.2.2.3 Fish tanks are not to be provided with drainage facilities specified in 3.2.3.4 of this PART.

3.2.2.4 Fish tanks are to be provided with bilge water level measuring devices. If no measuring devices are provided, an effective water level alarm device is to be installed. For fishing vessels with a length of not less than 45 m, it is generally necessary to have both.

3.2.2.5 Each bilge suctions in the fish tank are to be connected to the bilge main pipe through closing check valve boxes.

3.2.3 Fore peaks, after peaks, cofferdams and other compartments

3.2.3.1 Where the peaks are used as dry compartments, the drainage of both peaks is to be effected either by a power pump branch bilge suction or a hand pump suction. In the latter case, the suction lift is in no case to exceed 7 m.

3.2.3.2 The collision bulkhead may be pierced below the bulkhead deck by not more than one pipe. If the forepeak is divided to hold two different kinds of liquids, the collision bulkhead of each compartment may be allowed to be pierced below the bulkhead deck for passenger vessels by one pipe. The pipe piercing the collision bulkhead is to be fitted with check valves which are to be secured at the bulkhead inside the forepeak and means being provided for indicating whether the valve is open or shut. The above-mentioned valve may be fitted on the after side of the collision bulkhead provided that the valves are readily accessible under all service conditions. In this case, deck control mechanism is not needed.

3.2.3.3 Cofferdams are to be provided with discharge pipes, check valves or other drainage facilities to the bilge.

3.2.3.4 For peaks, after peaks, cofferdams and other aft compartments used as dry tanks may also be drained by scuppers of not less than 38 mm bore, discharging to the shaft tunnels (or machinery space in the case of vessels with machinery aft) and fitted with self-closing cocks or shut-off valves situated in well lighted and easily visible positions. When the length of vessel is less than 30 m, the inner diameter of the drainage pipe can be appropriately reduced but not to be less than 32 mm.

3.2.3.5 The chain locker and the watertight compartments above the fore peak tank are to be drained by hand pump or power pump bilge suctions. Other effective means of drainage are also acceptable.

3.2.3.6 Watertight compartments for the treatment or processing of catches are to be provided with adequate drainage and water traps on both sides to allow drainage of water from all parts of the compartment under any circumstances.

3.2.3.7 Where a shaft tunnel is provided, a branch bilge suction at the after end of the tunnel is to be set.

Section 3 BILGE DRAINAGE OF MACHINERY SPACES

3.3.1 General requirements

3.3.1.1 The bilge drainage arrangements in the machinery space are to be such that any water which may enter this compartment can be pumped out through at least two bilge suctions when the ship is on an even keel, and is either upright or has a list of not more than 5°. One of these suctions is to be branch bilge suction, and the other is to be direct bilge suction.

3.3.2 Bilge suction arrangements in machinery spaces

3.3.2.1 Generally, the bilge water suctions and direct bilge suctions arranged appropriate to the conditions of machinery space are generally arranged at the middle and longitudinal sections. If the bottom shell at machinery space slopes down to the center line for less than 5°, a suction is to be set at the longitudinal section in center plane and both sides. In addition, a direct bilge suction is to be provided at the longitudinal section in center plane. When slopping down at both sides is not to be less than 5°, suctions at both sides can be waived.

3.3.2.2 Where the machinery space is of double bottom at the full length and forms bilge, a bilge suction and a direct bilge pump suction are to be provided on each side. Where the machinery space is of double bottom at full length and full width, a bilge is to be provided at each side. A bilge suction and a direct suction are to be set in each bilge.

3.3.2.3 In the machinery space of stern-type fishing vessels, a bilge suction is usually provided on each side and rear end of the forward end, and a direct bilge suction is provided on each side and rear end of the forward end. When it is less than 45m, it can be appropriately reduced, but it should not affect continuous drainage.

3.3.2.4 When the length of the vessel is less than 30 m, the machinery space may be provided with only two suctions, one of which is a direct bilge suction. The arrangement is to ensure continuous drainage.

3.3.3 Emergency bilge suctions

3.3.3.1 When the length of the vessel is less than 45 m, an emergency bilge suction is to be provided as low as possible in the machinery space. The suction is generally connected to the main engine cooling water pump; when the main engine cooling water pump is not suitable for pumping bilge water, the emergency bilge suction can be connected to the largest power water pump other than the bilge pump. The suction pipe is to be provided with a stop check valve and marked with a nameplate indicating "for emergency purpose only". The control handwheel of the valve is to be at least 450 mm above the metal pattern plate.

Section 4 BILGE PUMPS AND BILGE PIPING

3.4.1 Number of bilge pumps

3.4.1.1 Fishing vessels are to be provided with at least two power bilge pumps, at least one of which is an independent power pump, and the others can be driven by main engine.

3.4.1.2 Independent power sanitary, ballast and general service pumps may be accepted as independent power bilge pumps, provided they are of the required capacity of the self-priming type or with the self-priming arrangement and connected to the bilge main.

3.4.1.3 An ejector used in conjunction with an independent high-pressure seawater pump can replace an independent power pump as required by 3.4.1.1.

3.4.2 Type and capacity of bilge pumps

3.4.2.1 Except for cooling water pumps connected to the emergency bilge water suctions, all power bilge pumps are to be self-priming type.

3.4.2.2 Each power bilge pump is to be capable of giving a speed of water through the required main bilge pipe of not less than 2m/s. When the length of vessel is less than 30 m, the speed can be reduced to 1.5 m/s.

3.4.2.3 The displacement Q of each bilge pump is not to be less than the value calculated according to the following formula:

When the length of vessel is not less than 30 m: $Q = 5.66d_1^2 \times 10^{-3} \text{ m}^3/\text{h};$

When the length of vessel is less than 30 m: $Q = 4.24d_1^2 \times 10^{-3} \text{ m}^3/\text{h};$

Where: d_1 —— internal diameter of bilge main, obtained from the formula in 3.4.3.1 of this Section, in mm.

3.4.2.4 If the displacement of a bilge pump is less than the value calculated in accordance with 3.4.2.3, and the difference in displacement is not greater than 15% of the calculated displacement, other bilge pumps may be used for compensation.

3.4.3 Bilge piping

3.4.3.1 The internal diameter d_1 of the bilge main is to be less than the value calculated according the following formula.

$$d_1 = 25 + 1.68 \sqrt{L(B + D)} \quad \text{mm}$$

Where: L ——length of ship, in m (measured between perpendiculars taken at the extremities of the deepest subdivision load line);

Where the engine room bilge pumps are fitted primarily for serving the engine room and they do not serve

cargo space bilges, L may be reduced by the combined length of the cargo tanks or cargo holds. In such cases, the cross sectional area of the main bilge line is not to be less than twice the required cross sectional area of the engine room branch bilge lines;

B -breadth of vessel, in m;

D — molded depth of ship to bulkhead deck, in m.

3.4.3.2 In no case is the internal diameter of the bilge main to be less than that required for the largest branch bilge line.

3.4.3.3 The internal diameter d_2 of the bilge pipe of fish tank and machinery space is to be less than the value calculated according the following formula.

$$d_2 = 25 + 2.15 \sqrt{l(B + D)} \quad \text{mm}$$

Where: l -length of compartment, in m;

B -breadth of vessel, in m;

D — molded depth of ship to bulkhead deck, in m.

3.4.3.4 In general, no branch bilge suction pipe is to be less than 50 mm bore. 3.4.3.4 The branch bilge suction pipe to the tunnel well is, in general, not to be less than 65 mm bore. When the length of the vessel is less than 60 m, it may be appropriately reduced to 50 mm.

3.4.3.5 In no case is the internal diameter of the direct bilge suction to be less than that required for the main bilge line.

3.4.3.6 The section area of each branch pipe connecting the bilge main to a distribution chest is not to be less than the sum of the areas required for the two largest branch bilge suction pipes connected to that chest, but need not be greater than that required for the main bilge line.

3.4.4 Bilge pumps and pipe connections

3.4.4.1 The connections at the bilge pumps are to be such that at least one of the pumps may continue in operation when the other pumps are being opened up for overhaul.

3.4.4.2 Pumps for pumping oil are not to be connected to the bilge system.

3.4.4.3 The arrangements of pump and pipelines are such that the working of any of the pumps so connected is unaffected by the other pumps being in operation at the same time.

3.4.4.4 All bilge suction pipes are to be independent of other piping up to the bilge pump suction valve chest.

3.4.5 Non-return arrangements

3.4.5.1 For the purpose of preventing the possibility of one watertight compartment being placed in communication with another, or of dry cargo spaces, machinery spaces or other dry compartments being placed in communication with the sea or with tanks, screw-down non-return valves are to be provided in the following fittings:

- .1 bilge valve distribution chests;
- .2 bilge suction hose connection, whether fitted direct to the bilge pump or on the main bilge line;
- .3 direct bilge suction;
- .4 bilge pump connections to main bilge line.

3.4.6 Bilge pipes in way of deep tanks and double bottom tanks

3.4.6.1 Bilge suction pipes are not to be led through double bottom tanks as far as practicable, and is preferred to pass through pipe tunnels in the deep tank. Otherwise, bilge pipes which have to pass through these tanks are to have a wall thickness in accordance with Table 2.2.2.6 of this PART. If welded joints or other reliable joints are adopted, the number of joints is to be kept to a minimum.

3.4.6.2 Expansion bends, not glands, are to be fitted to these pipes within the double bottom tanks.

3.4.6.3 The pipes are to be tested after installation, to a pressure not less than that required for the deep or double bottom tanks through which they pass.

3.4.7 Bilge fittings

3.4.7.1 Generally, the bilge wells are not to be less than 0.1m^3 in capacity. When the length of vessel is less than 45 m, it can be appropriately reduced but not to be less than 0.05m^3 . Fish tank bilge wells are to be equipped with grille covers. The flow area is not to be less than five times the flow area of the suction pipe.

3.4.7.2 When the length of the vessel is not less than 45 m, each branch bilge suction and each direct bilge suction in machinery spaces and tunnels (excluding emergency suction) are to be led from easily accessible mud boxes fitted with straight tail pipes to the wells or bilges. Strum boxes are not to be fitted to the lower ends of these tail pipes or to the emergency bilge suction.

When the length of the vessel is less than 45 m, a dirt filter with a check valve may be installed at the end of

the bilge suction of the machinery space to replace the strum box. The filter hole on the sewage filter is a circular hole with a diameter of 8-10 mm. The total flow area of filter hole is not be less than 3 times the cross-sectional area of the suction pipe. The sewage filter is to be disassembled and cleaned without disassembling the suction pipe. The check valve in the dirt filter cannot replace the check valve.

3.4.7.3 Bilge valves, cocks and mud boxes are as far as possible to be fitted at, or above, the machinery space and tunnel platforms. Where they are situated just below the platform, provided readily removable traps or covers are to be fitted, and nameplates are to be fitted to indicate the presence of these fittings, indicating the marks of the above fittings.

3.4.8 Others

3.4.8.1 The bilge water system shall be installed in accordance with the regulations on the prevention of water pollution caused by fishing vessels.

3.4.8.2 The design, construction and arrangement of standard discharge joints for oil tanks and oils shall be in accordance with the provisions of the relevant international conventions.

Section 5 BALLAST AND SCUPPER SYSTEMS

3.5.1 Ballast piping

3.5.1.1 The arrangement of ballast piping and the number of suctions are to be such that any ballast tank can be filled or emptied under normal service conditions, whether the ship is upright or listed.

3.5.1.2 The arrangement of ballast piping is to be such as to prevent the possibility of water passing from the sea or from ballast tanks into dry cargo and machinery spaces or other compartments.

3.5.1.3 Ballast water pipes are not to pass through drinking water, fuel oil or lubricating oil tanks. Where it is unavoidable, the wall thickness of ballast pipes in drinking water, fuel oil or lubricating oil tanks is to comply with the provisions in Table 2.2.2.6 of this PART and welded joints are to be adopted only.

3.5.1.4 The ballast piping is not to be in connection with the bilge pipes from fish tank and machinery spaces, nor with the pipes from oil tanks. However, this requirement need not be applied to the pipes located between distribution boxes and pump suctions or between pumps and overboard discharges.

3.5.2 Scuppers and sanitary discharges

3.5.2.1 The scuppers and sanitary discharges are to comply with the relevant requirements of Statutory Inspection Rules for Fishing Vessels (Ocean-going Fishing Vessels 2018).

Section 6 AIR, OVERFLOW AND SOUNDING PIPES

3.6.1 General requirements

3.6.1.1 Air, overflow and sounding pipes are to be made of steel or other equivalent approved materials.

3.6.1.2 Nameplates or labels are to be affixed to the upper ends of all air and sounding pipes.

3.6.2 Arrangement of air pipes

3.6.2.1 Air pipes are to be provided for tanks intended to carry liquid, and also for cofferdams and pipe tunnels. The shaft and pipe tunnels are to be provided with air pipes if necessary. Air pipes are to be fitted at the highest part of the tanks and far apart from the filling pipes.

3.6.2.2 Where the tank top is of unusual or irregular profile, the number and positions of the air pipes will be decided in each case.

3.6.2.3 Tanks with cathodic protection are to have air pipes fitted forward and aft.

3.6.2.4 All double bottom tanks are to be fitted with air pipes. The double bottom tanks extending from side to side of the ship are to be fitted with air pipes led from both sides.

3.6.2.5 Air pipes are not to be used as filling pipes. However, for tanks with more than one air pipes, one of them is allowed to be used as the filling pipe as well. But the sizes of the remaining air pipes of the tank are to comply with the requirements of 3.6.4.1 of this PART.

3.6.3 Termination of air pipes

3.6.3.1 The air pipes of double-bottom bilges, deep tanks extending to the outer plate and tanks in which seawater may invade are to be led above the bulkhead deck. Fuel tanks, heated oil tanks and hydraulic oil tanks, as well as cofferdams adjacent to the above oil tanks and the air pipes of all tanks that can be filled with pumps, shall be led to the bulkhead deck.

3.6.3.2 The ends of all air pipes extending to open spaces above the deck are to be provided with effective and appropriate closing devices to prevent seawater from flowing into the tank.

3.6.3.3 Air pipes for oil tanks and hydraulic oil storage tanks are generally to be led to open spaces above the bulkhead deck. If the oil spill at the outlet end of the air pipe does not come into contact with electrical equipment and hot surfaces, it may be terminated at a suitable height in the machinery space and, as far as possible, in the cabin of the machinery space above the bulkhead deck. Air pipes from lubricating oil tanks or fuel oil draining tanks with a volume less than 0.5m^3 , provided that the open ends are so situated that issuing oil cannot come into contact with electrical equipment or heated surfaces.

3.6.3.4 The open ends of air pipes to oil fuel and cargo tanks are to be situated on the open deck where no danger will be incurred from issuing oil or vapor.

3.6.3.5 The open ends of air pipes to oil fuel and cargo tanks are to be furnished with a wire gauze diaphragm of corrosion-resistant material which can be readily removed for renewal.

3.6.3.6 The wire gauze diaphragm at the open ends of air pipes is to have a clear area not less than the cross-sectional area required for the air pipe.

3.6.3.7 The air pipes of fresh water and distilled water tanks may terminate in appropriate spaces above the injection openings in the machinery space.

3.6.4 Size of air pipes

3.6.4.1 In the case of all tanks which can be pumped up, either by the ship's pumps or by shore pumps through a filling main, the total cross-sectional area of the air pipes to each tank is not to be less than 25% greater than the effective area of the respective filling pipes. In any case, the internal diameter of air pipes is not to be less than 50 mm. When the length of the vessel is less than 30m, it may be appropriately reduced to 38 mm. For tanks with a volume not greater than 0.5m^3 , it can also be reduced to 38 mm.

3.6.4.2 Where overflow pipes are fitted as specified in this Section, the sectional area of the air pipes is to be at least 20% of that of the filling pipes. But the internal diameter is not to be less than 38 mm. Where several tanks share the overflow pipes as specified in this Section, sectional area of the air pipe is to be at least 20% of the combined area of the two largest filling pipes for the separate tanks.

3.6.4.3 Air pipes to shaft tunnels and pipe tunnels are to have an internal diameter not less than 75 mm.

3.6.4.4 Where tanks form part of the structure of the ship, the wall thickness of air pipes is to comply with Table 2.2.2.6 of this PART.

3.6.5 Arrangement of overflow pipes

3.6.5.1 Fuel sedimentation tanks, fuel daily tanks and when the liquid head corresponding to the height of the air pipe is greater than the pressure that the tank can withstand or the cross-sectional area of the air pipe is less than that required by 3.6.4.1 All tanks capable of being filled with pumps are to be fitted with overflow pipes.

3.6.5.2 In the case of oil fuel and lubricating oil tanks, the overflow pipe is to be led to an overflow tank of adequate capacity or to a storage tank having a space reserved for overflow purposes. Overflow pipes of other tanks are to be led to the open places.

3.6.5.3 A well illuminated sight glass is to be provided in the overflow pipe. The sight glass is to get as close as possible to places where the transfer pump can be stopped.

3.6.5.4 Shut-off valves or cocks are not allowed to be fitted to the overflow pipes.

3.6.6 Size of overflow pipes

3.6.6.1 The sectional area of overflow pipe(s) from each tank is not to be less than 1.25 times that of the filling pipe(s). The inner diameter of the overflow pipe is not to be less than 50 mm. When the length of the vessel is less than 30m, it may be appropriately reduced to 38 mm.

3.6.7 Prevention of air and cross flow through the overflow pipes

3.6.7.1 The arrangement of the air and (or) overflow system is to be such that in the event of any one of the tanks being bilged, tanks situated in other watertight compartments of the ship cannot be flooded from the sea through the overflow main.

3.6.7.2 For air pipes that serve as overflow pipes as well, means should be provided to prevent overpressure or vacuum in the compartment when the air pipes are closed.

3.6.8 Sounding pipes and devices

3.6.8.1 Sounding pipes are to be provided for all tanks, cofferdams and pipe tunnels as well as the bilges or bilge wells which are not at all times readily accessible. All sounding pipes, except for short sounding pipes, are to be led to positions above the bulkhead deck which are at all times accessible. For oil tanks, the sounding pipes are to be led to a safe place on the open deck. The sounding pipes are to be fitted as near the suctions as practicable.

3.6.8.2 Electronic, instrument or other liquid level sounding devices may be used as sounding pipes for tanks

after being approved by CCS. These devices are to be tested satisfactorily, after fitting on board.

3.6.8.3 If fuel tanks, oil or other combustible liquid tanks use heat-resistant flat glass level meters with appropriate protection facilities, self-closing valves or cocks are to be fitted at the upper and lower end connections. If the upper end connection is higher than the highest liquid level of the tank, the self-closing valves or cocks at the upper end can be omitted. For small oil tanks with a volume not greater than 0.5 m³, glass level meters can be used if appropriate protection facilities are provided to prevent mechanical damage; and self-closing valves or cocks are to be installed.

3.6.8.4 In order to balance the pressure inside and outside the pipe, vent holes should be appropriately provided in the sounding pipes.

3.6.8.5 All sounding pipes exposed to sea and weather are to be provided with permanently attached effective means of closing to prevent the free entry of water.

3.6.8.6 When a slot type sounding pipe closed at the bottom is used, the closed structure is to be solid.

3.6.8.7 The bottom plating under open ended sounding pipes is to be protected by striking plates of adequate thickness and size.

3.6.9 Short sounding pipes

3.6.9.1 In machinery spaces and shaft tunnels where it is not practicable to extend the sounding pipes as mentioned in 3.6.8.1 of this PART, short sounding pipes extending to readily accessible positions above the metal pattern plate may be fitted.

3.6.9.2 Short sounding pipes are to be easily accessible. The short sounding pipes of fuel and lubricating oil tanks are to be kept as far away as possible from hot surfaces or electrical equipment. Where necessary, the above hot surfaces and / or electrical equipment are to be fitted with protection facilities.

3.6.9.3 The short sounding pipes of fuel oil and lubricating oil tanks are to be fitted with cocks permanently attached to the handle. Heavy blocks are provided on the handle so that when the handle is released, the cock can be closed automatically; the short sounding pipes of other tanks are to be fitted with cocks or screw caps connected to pipes through links.

3.6.10 Size of sounding pipes

3.6.10.1 Sounding pipes are not to be less than 32 mm in bore. Sounding pipes passing through compartments or spaces where the temperatures contemplated are 0°C or below, are not to be less than 65 mm in bore.

Section 7 VENTILATION

3.7.1 General requirements

3.7.1.1 The ventilation piping system is not to be arranged so as to destroy the integrity of watertight bulkheads and fire partitions. When the ventilation tube passes through the bulkhead deck, it shall be provided with steel or other equivalent materials. Its structure shall be strong and effectively connected with the deck.

3.7.1.2 Any machinery space is to be adequately ventilated to ensure full power operation of machines or boilers in various climate conditions and ensure safety and comfort of personnel.

3.7.1.3 Effective means of ventilation are to be provided for all paint lockers and other compartments used for the storage of inflammable substances, explosives or where toxic or inflammable gases may accumulate.

3.7.1.4 The compartments are to be provided with air supply openings through appropriate protective facilities to enable effective ventilation in any climatic condition.

3.7.1.5 When natural ventilation is adopted, at least two air buckets are to be provided in each space as far as possible. The arrangement is to be such that one is used to suck in fresh air and the other is used to discharge contaminated air.

3.7.2 Ventilators

3.7.2.1 The ventilators are to comply with relevant provisions of Statutory Inspection Rules for Fishing Vessels (Ocean-going Fishing Vessels 2018).

3.7.3 Ventilator cowls

3.7.3.1 Ventilator cowls are to be placed on the exposed deck and located as far from exhaust outlets, sky-lights and companionways as possible.

CHAPTER 4 MACHINERY PIPING SYSTEM

Section 1 GENERAL PROVISIONS

4.1.1 Application

4.1.1.1 Unless stated otherwise, the requirements of this CHAPTER apply to machinery piping systems for various fishing vessels.

4.1.1.2 In addition to the provisions of this CHAPTER, the machinery piping system is to comply with the relevant provisions of CHAPTER 2 and Sections 1 and 6 of CHAPTER 3 of this PART.

Section 2 FUEL OIL SYSTEMS

4.2.1 General requirements

4.2.1.1 Generally, the flash point of the fuel oil (closed cup test) is not to be lower than 60°C; the flash point of the fuel oil used by the prime mover of the emergency generator set is not to be lower than 43°C. If it is really necessary and the ambient temperature of the space where the fuel is stored and used does not rise above the flash point of the fuel above 10 °C, after taking precautionary measures and approval by CCS, fuel with a flashpoint lower than 60°C but not lower than 43°C can be used.

4.2.1.2 The oil fuel systems of diesel engines for heavy oil are to be provided with immediate change-over devices for diesel oil.

4.2.1.3 Drip trays are to be provided under the oil tanks which do not form part of the hull structure, pumps, filters, boiler burners and all other oil fuel appliances which are required to be opened up frequently for cleaning or adjustment. Oils in the drip trays are to be drained to special sludge tanks, and if the sludge tanks are situated in double bottom tank, shut-off valves are to be fitted to the drain pipes.

4.2.1.4 For fishing vessels burning oil fuel which has to be purified by purifiers, the primary and spare fuel separation equipment are to be provided. For fishing vessels equipped with a sufficient amount of light diesel oil, the above-mentioned spare separation equipment may be omitted.

4.2.1.5 In addition to the local controls, the power supply to all independently driven oil fuel transfer pumps, boiler oil fuel pumps, diesel engine fuel pumps and oil separators is to be capable of being stopped from a readily accessible position outside the spaces in which they are situated.

4.2.1.6 The gaskets of manhole plugs and fuel pipe flange joints of fuel tanks are to be made of oil-resistant rubber or other oil-resistant and heat-resistant materials.

4.2.2 Oil burning units of boilers

4.2.2.1 A quick-closing master valve is to be fitted to the oil supply to each boiler manifold, suitably located so that the valve can be readily operated in an emergency, either directly or by means of remote control. In the case of oil-fired boilers of automatic controls, the relevant requirements of CHAPTER 12, PART 7 of the Rules are also to be complied with.

4.2.2.2 In systems where oil is fed to the burners by gravity, duplex filters are to be fitted in the supply pipeline to the burners.

4.2.2.3 The burner arrangements are to be such that a burner cannot be withdrawn unless the oil fuel supply to that burner is shut out.

4.2.2.4 In the case of top-fired boilers, means are to be provided so that, in the event of flame failure, the oil fuel supply to the burners is shut off automatically, and audible and visual warnings are given. For small auxiliary top-fired boilers, this requirement may be dispensed with as being approved by CCS.

4.2.2.5 Provision is to be made, by suitable non-return arrangements, to prevent oil from spill systems being returned to the burners when the oil supply to these burners has been shut off.

4.2.2.6 For dual-use fired furnaces of boilers using exhaust gases and oil fuel, the exhaust gas inlet pipe is to be provided with an isolating device and interlocking arrangements whereby oil fuel can only be supplied to the burners when the isolating device is closed to the boiler.

4.2.3 Fuel oil pumps and filters

4.2.3.1 Where an fuel oil booster pump is fitted, one main supply pump and one standby pump are to be provided. Such a standby pump is ready for immediate use. Where two or more main engines are fitted, only one standby pump connected ready for immediate use is needed, or alternatively, a complete spare pump may be

accepted, provided that it is readily accessible and can easily be installed.

4.2.3.2 Where pumps are provided for fuel valve cooling, the arrangements of standby ones are to be in accordance with 4.2.3.1 of this Section.

4.2.3.3 A double filter or equivalent device with a switching cock is to be fitted on the main engine fuel supply line so that any filter can be cleaned without interrupting the supply of filtered fuel oil to the engines. When multiple auxiliary diesel engines are fueled by a fuel main, the above-mentioned filter can be fitted on the fuel main; a filter can also be installed on a separate fuel supply pipe for each auxiliary diesel engine; however, the above-mentioned dual filter is also to be provided for continuous use.

A filter is to be provided on the suction side of the fuel delivery device.

4.2.3.4 Where a power driven pump is necessary for transferring oil fuel, a standby pump is to be provided. Any suitable pump in connection with fuel transfer system may be accepted as the standby pump. For fishing vessels with a total output not exceeding 750 kW, the backup pump can be a manual pump.

4.2.3.5 All pumps which are capable of developing a pressure exceeding the design pressure of the system are to be provided with relief valves. Each relief valve is to be so arranged as to discharge back to the suction side of the pump, and to effectively limit the pump discharge pressure to the design pressure of the system.

4.2.3.6 Valves or cocks are to be interposed between the pumps and the suction and discharge pipes, in order that any pump may be shut off for opening up and overhauling.

4.2.4 Fuel oil piping

4.2.4.1 Fuel oil piping is to be entirely separate from other piping systems.

4.2.4.2 Fuel pressure pipes are to be kept as far away from hot surfaces and electrical equipment as possible. If it is impracticable, pipes are to be placed in well lighted parts, and the detachable pipe connectors are to keep a minimum distance of 200 mm away from the heating surface and electrical equipment. Cover the connectors by facilities with appropriate discharge devices.

4.2.4.3 Pipes conveying heated oil to boilers under pressure are to be of seamless steel or other approved material having flanged or welded joints, and are to be placed in sight above the platform in well lighted parts. The number of flanged joints is to be kept to a minimum. The flanges are to be machined. The jointing material is to be oil proof and impervious to oil heated to 150°C, and is to be as thin as possible. The scantlings of the pipes and their flanges are to be suitable for a pressure of at least 1.37 MPa.

4.2.4.4 Every oil fuel suction pipe from a double bottom tank is to be fitted with a valve or cock.

4.2.4.5 When flexible hoses are used, they are to comply with the requirements of 2.4.4 of this PART, and are equipped with sufficient number of flexible hoses.

4.2.4.6 Valves and cocks of fuel oil installations are to be capable of being operated at easily accessible locations above the metal pattern plate.

4.2.5 Fuel oil tanks

4.2.5.1 Each fuel supply pipe of the storage, settling or daily service tank situated above the double bottom are to be fitted with a cock or valve. Such valves or cocks are to be capable of being closed locally as well as cable of being closed from safe and easily accessible positions outside the spaces where these tanks are situated. When the volume of the tank is less than 0.5m³ or the length of the vessel is less than 45 m, only the daily service tank is to be provided with a remote closing device. If the volume of the tank is less than 0.05m³, the remote closing device may be omitted.

4.2.5.2 The settling tank, daily service tank and fuel filter are not be located directly above the operating position or above other hot surfaces. If unavoidable, effective protective measures are to be taken and comply with the provisions of 2.1.6.2 of this PART.

4.2.5.3 Settling tanks are to be provided with means for draining water from the bottom of the tanks. If settling tanks are not provided, the oil fuel bunkers or daily service tanks are to be fitted with water drains. Drain valves or cocks fitted to the fuel oil tanks are to be of self-closing type, and suitable provision is to be made for collecting the oily discharge.

4.2.5.4 If daily service tanks, settling tanks and other oil tanks independent from the hull structure are used, an oil-tight spill tray of ample size having a suitable drain pipe leading to a suitably sized spill oil tank is to be provided. The thickness of the steel plate of the oil tank is to be selected according to the size of the oil tank, but not less than 3 mm. If necessary, the above fuel tanks is to be equipped with stiffeners. If the length of the stiffeners exceeds twice the width of the panel, lateral supports or support rods are to be installed between the stiffeners on opposite sides of the oil tank.

The tanks are to be subjected to a hydraulic test. The test pressure is to be equivalent to the maximum water column height that can be achieved in the tank or its air pipe or overflow pipe. Fuel tanks with a flash point below 60°C, the height is not to be less than 3.6 m.

4.2.5.5 Oil is not to be carried in a forepeak tank.

4.2.6 Filling piping

4.2.6.1 Fuel filling is to be effected by means of permanently installed lines. The filling pipes are to be led to a level as low as practicable inside the tank.

4.2.6.2 The filling piping is to be seamless steel pipe and is to comply with the provisions of 2.2.2.9 of this PART.

4.2.6.3 The filling piping is to be fitted with relief valves if necessary. The oil spilled from the relief valve is to discharge to a safe position.

4.2.7 Fuel oil (lubricating oil) heating

4.2.7.1 The heating media used for oil fuel (lubricating oil) tanks, heaters or oil separators are not to be more than 220°C in temperature. Fuel oil (lubricating oil) in storage tanks is not to be heated to temperatures within 10°C below the flash point of the fuel oil (lubricating oil), except that where oil fuel in service tanks, setting tanks and any other tanks in supply system is heated and the following arrangements are provided.

4.2.7.2 The exhaust drains from steam or hot water pipes used for heating the oil fuel (lubricating oil) are to be led to a separate observation tank in a well-lighted and accessible position where it can be readily seen whether or not it is free from oil.

4.2.7.3 A relief valve and a pressure gauge is to be fitted at the fuel side of the heater. The turn on-off pressure of the safety valve is to be regulated to 0.34 MPa above the opening pressure of the relief valve (or the maximum output pressure of the fuel pump). The oil discharged from the relief valves is to be led to a safe position.

4.2.7.4 Fuel oil (lubricating oil) tanks in which oil is heated and heaters are to be provided with suitable means for ascertaining the temperature of the oil.

4.2.7.5 The exhaust gas of diesel engines is not to be directly used for heating oil fuel.

4.2.7.6 When heating fuel oil with hot water, its heating coil shall not have any detachable joints in the fuel tank. An easily accessible drain valve or cock is to be installed on the heating pipeline, so that the fishing vessel can effectively discharge water when it is at normal trim, normal float or 5°.

4.2.7.7 When electric heaters are fitted, means are to be provided to ensure that heating elements are permanently submerged during operation. In order to avoid in any case element surface temperature of 220°C and above, a safety temperature switch, independent from the automatic control sensor, is to be provided. The safety switch is to cut off the electrical power supply in the event of excessive temperature, and is to be provided with manual reset. Heaters shall be approved.

Section 3 STEAM PIPING SYSTEMS

4.3.1 Arrangement

4.3.1.1 The design and arrangement of steam pipelines shall ensure that any expansion and contraction will not cause abnormal stress to the pipes.

4.3.1.2 Steam pipes are not to be led through fish tanks, paint lockers and battery spaces, otherwise, necessary protective measures are to be taken.

4.3.1.3 Where steam pipes subject to a working pressure exceeding 0.98 MPa are placed near to the fuel oil tank, the distance is to be no less than 150 mm. When the steam pipeline is arranged close to the cable, appropriate protective measures are to be taken.

4.3.1.4 Steam pipes are to be arranged in visible and accessible positions in the machinery spaces. Steam pipes, except those used for preheating and sea chest blow-off services, are in general not to be led under the floor plates in machinery spaces.

4.3.1.5 The steam pipes should be effectively insulated. The supporting points are to be arranged in a place with sufficient rigidity.

4.3.2 Draining condensate

4.3.2.1 The slope of the pipes and the number and position of the drain valves or cocks are to be such that water can be efficiently drained from any portion of the steam piping system when the ship is in normal trim and is either upright or has a list of up to 5°. Arrangements are to be made for ready access to the drain valves or cocks. A by-pass line is to be provided where the condensate trap is installed.

4.3.3 Relief piping

4.3.3.1 The pipeline on the low pressure side of the pressure reducing valve is to be installed with pressure gauges and relief valves with sufficient discharge capacity. The pipeline to be provided with reducing valves are to be fitted with a bypass pipeline.

4.3.4 Steam processing pipeline

4.3.4.1 Steam processing pipelines connected to oil-bearing equipment or pipes are to prevent oil from penetrating into the steam pipeline.

Section 4 Boiler FEED SYSTEM

4.4.1 Feed pumps

4.4.1.1 Two or more power driven feed pumps are to be provided for boilers for essential services. These feed pumps are to be of sufficient capacity to supply the boilers under full load conditions with any one pump out of action. Auxiliary boilers for domestic use and boilers heated by exhaust gas from diesel engines can be provided with only one feedwater pump.

4.4.1.2 For fishing vessels less than 45 m in length, when a water supply pump is provided for installation and connection, only one feedwater pump is to be provided.

4.4.2 Feed piping

4.4.2.1 Two feed water systems are to be provided for boilers for essential services. When one of them fails, the other piping system shall ensure the normal operation of the boiler. For auxiliary boilers which can meet the requirements of 4.4.1.2 of this PART, only one feed water pump may be provided.

4.4.2.2 Valves or cocks are to be interposed between the pumps and the suction and discharge pipes, in order that any pump may be shut off for opening up and overhauling.

4.4.3 Reserve feed water

4.4.3.1 Boilers for important purposes are to be provided with boiler feed tanks of sufficient capacity, and seawater desalination devices are to be provided as required to ensure continuous water supply.

Section 5 COOLING WATER SYSTEMS

4.5.1 Cooling water pumps

4.5.1.1 The main engine is to be provided with a main cooling water pump and a standby cooling water pump with sufficient displacement. The backup cooling water pump is to be an independent power pump. When the total output of the main engine is less than 750 kW, other pumps with sufficient displacement can also be used instead. Where more than one main engine is fitted, each with its own cooling water pump, a complete spare pump may be accepted as a standby cooling water pump.

4.5.1.2 Where fresh water cooling is employed for main and/or auxiliary engines, a standby fresh water pump need not be fitted if there are suitable emergency connections from a salt water system.

4.5.1.3 Where each essential auxiliary engine is fitted with a built-in cooling water pump, the standby pump may be dispensed with. If two or more auxiliary engines are supplied with cooling water from a common system, a standby cooling water pump is needed.

4.5.2 Piping and fittings

4.5.2.1 The cooling water piping for diesel engines is to be capable of effectively regulating the inlet cooling water temperature. For closed circuit fresh water cooling system, expansion tanks are to be provided and it is recommended that an alarm for high temperature be fitted. The expansion water tank is to be provided with a filling pipe, an air pipe, a water level indicator and a discharge device.

4.5.2.2 Where cooling water pumps can develop a pressure head greater than the design pressure of the system, they are to be provided with relief valves on the pump discharge. When discharge from the relief valves is to find its way into the bilge, the valves are to be fitted in readily visible positions above the floor.

4.5.2.3 Not less than two sea inlets, which are to be fitted on both sides of the ship as far as practicable, are to be provided for the cooling water pumps of sea water cooling system or circulating system arranged by height.

4.5.2.4 Provision is to be made for the protection of all equipment cooled by sea water against corrosion.

4.5.2.5 Strainers are to be provided to the suction pipes between the sea inlets and the suctions of sea water cooling pumps. The strainers are to be so arranged that they can be cleaned without interrupting the cooling water supply.

4.5.2.6 The discharge of the cooling water pump is to be provided with a pressure gauge. Observation windows and thermometers are to be set at the cooling water outlet of the main engine.

4.5.2.7 The inlet and outlet of all heat exchangers are to be provided with stop valves.

4.5.2.8 The main engine closed cooling water piping system is to be equipped with preheating equipment for cooling fresh water, or it may be connected with the auxiliary machine fresh water cooling piping system as appropriate.

4.5.2.9 A drain valve or cock should be provided at the lowest obvious position of the cooling water piping

system.

4.5.2.10 The piping system for supplying cooling water to the main engine is to be provided with a cock to remove air.

4.5.2.11 In the case of small diesel engines cooled by evaporative water, the steam is to be directed to the open deck as much as possible. The evaporating water tank is to be provided with a water level indicating device.

4.5.2.12 The connection of diesel engine seawater cooling piping to other seawater piping systems shall not affect the supply of sufficient cooling water to the diesel engine.

Section 6 LUBRICATING OIL SYSTEMS

4.6.1 Lubricating oil pumps

4.6.1.1 When the stand-alone power of the main engine is greater than 441 kW, a standby oil pump driven by independent power is to be provided. If the oil pump is an easy-to-remove belt pump, an independent power-driven backup oil pump may be replaced by a complete spare pump with the agreement of CCS. If the stand-alone power of the host is not greater than 441 kW, the spare oil pump can be omitted.

4.6.1.2 The displacement and piping arrangement of the above-mentioned oil pump should be able to ensure that when any one oil pump is deactivated, the other pump can still meet the needs of the main engine running at maximum power.

4.6.1.3 When there are more than one diesel generator sets, the pump may not be used for the equipment, but it is still to be installed if a common oil pipe system is used.

4.6.2 Piping and fittings

4.6.2.1 The lubricating oil piping is to be entirely separate from other piping systems. A common lubricating oil system is not to be in use for diesel engines and gear boxes.

4.6.2.2 The oil pipe system is to be provided with a filter. The structure of the filter is to ensure that the internal cleaning is performed without stopping the machine and reducing the supply of filter oil to the diesel engine. A pressure gauge is to be installed behind the oil filter. For diesel engines with a power greater than 441 kW, pressure gauges are to be provided before and after the filter. For gearboxes with a transmission power of not less than 750 kW, the oil filters are to be equipped with magnetic devices.

4.6.2.3 Where two or more diesel engines are fitted, the drain pipes leading from the engine sumps to the lubricating oil drain tanks are to be independent to avoid intercommunication between crankcases.

4.6.2.4 If the filter is located on the discharge side of the oil pump, a safety valve is to be provided in front of the filter on that side. Oil spilled from the safety valve should be directed to the suction side of the pump or other suitable location.

4.6.3 Lubricating oil tanks

4.6.3.1 The capacity of lubricating oil drain tanks is to be sufficient to hold the oil in the whole system.

4.6.3.2 The oil inlet pipe of the drain tank is to be extended to an adequate depth below the lowest working level and is to be located as wide apart from the outlet as practicable.

4.6.3.3 Lubricating oil storage tank(s) having an adequate capacity is to be provided.

4.6.3.4 The oil tank is to be provided with a liquid level measuring device that complies with the provisions of 3.6.8 of this PART.

4.6.3.5 Each oil supply pipe of the oil storage cabinet and oil circulation cabinet arranged above the double bottom is to be provided with a valve or cock on the cabinet wall. For oil tanks with a ^{capacity} of more than 0.5m³, in addition to the above-mentioned valves or cocks that can be closed on-site, generally, remote-control closing devices should also be provided in safe spaces easily accessible outside of their locations. Under special circumstances, if the designers confirm that an unauthorized operation of the remotely controlled closing valves on the lubricating tanks will jeopardize safe running of the main or eventful auxiliary engines, the remotely controlled device may be omitted.

Section 7 HYDRAULIC TRANSMISSION PIPING SYSTEMS

4.7.1 Materials

4.7.1.1 All components in the hydraulic transmission piping systems are to be made of materials which are not corrodible and have no chemical reaction with the hydraulic fluid.

4.7.1.2 The hydraulic fluid is to be of high chemical stability and of good viscosity-temperature property, and its flash point should generally be higher than 157 °C.

4.7.1.3 Hydraulic power cylinders shall not be made of ordinary cast iron.

4.7.2 Piping

4.7.2.1 The hydraulic transmission piping is not to be used for the lubrication of other equipment.

4.7.2.2 The strength of hydraulic pipes and fittings is to be sufficient to withstand the pressure fluctuations which might occur in the system.

4.7.2.3 A reliable oil filtering device is to be provided in the hydraulic transmission piping system. If necessary, a magnetic filter should be provided.

4.7.2.4 Strainers and relief valves are to be provided in the hydraulic transmission piping systems. The discharge from the relief valves is in general to be led to the hydraulic fluid tanks.

4.7.2.5 Provision is to be made for de-aeration in the hydraulic piping systems. The hydraulic piping is to be so arranged as to avoid the formation of air pockets.

4.7.2.6 Where hydraulic accumulators are provided in the hydraulic systems, relief valves are to be fitted on the liquid side. For hydro-pneumatic accumulators, relief valves or fuse plugs are to be fitted on the gas side, otherwise they are to be fitted in the pipe line.

4.7.2.7 The flexible hoses are to be so arranged that abrupt bends and twisting will not occur in the laying of the hoses and they are to be far away from vibration and hot sources.

4.7.2.8 Hydraulic remote control valves for essential service are to be capable of being operated with a hand pump in emergency condition, and indicators showing whether the valves are open or closed are to be provided at their operating positions.

4.7.2.9 The hydraulic piping system is to be cleaned strictly before installation.

4.7.2.10 The hydraulic transmission piping system for essential services is to be provided with a standby power pump which is to be capable of immediate use.

4.7.3 Hydraulic oil tank cabinet

4.7.3.1 The storage of hydraulic oil and the arrangement of its tanks are to comply with the requirements of 4.6.3.1 to 4.6.3.4 of this PART.

Section 8 THERMAL OIL SYSTEM

4.8.1 Design and manufacture

4.8.1.1 Each circulation system is to be equipped with at least two circulation pumps. One pump runs continuously and the other is an automatic backup pump. Start the backup pump by opening the contacts of the running pump.

4.8.1.2 The inlet and outlet valves of oil-fired hot oil heaters and exhaust gas-fired hot oil heaters are to be capable of being closed from outside the space where the hot oil heater is located, in addition to being able to be operated locally. Or as an alternative to closing the valve outside the space, a device can also be provided to quickly drain the hot oil in the system into the collection cabinet by gravity.

4.8.1.3 Devices are to be provided so that the oil in the expansion tank can be quickly discharged to the appropriate oil tank by gravity from the inside and outside of the space where the hot oil heater is situated.

4.8.1.4 Hot oil pipes are to be of seamless steel pipes or welded steel pipes.

4.8.1.5 The casings of pumps, valves and similar equipment in hot oil systems are to be made of steel or equivalent plastic materials. Parts in direct contact with hot oil on the surface are not to be made of copper or copper alloy materials to avoid oxidation of hot oil.

4.8.1.6 Thermal oil piping is to have welded connections except that flanges may be used to the limited number necessary for inspection and maintenance. If necessary, suitable devices are to be provided for avoiding oil splash in case of leakage in way of the flanges. Marine steel recess type or plane flanges having a nominal pressure not less than 1.6 MPa are to be used for inlet and outlet pipe connection of thermal oil heaters. In the case of steel plane flanges, wire-reinforced graphite gaskets or expanded graphite composite gaskets are to be used.

4.8.1.7 Screw joints are not to be used for thermal oil piping. The piping system is to be designed and constructed to permit expansion and contraction without abnormal stressing.

4.8.1.8 Particular attention is to be paid to the insulation of thermal oil piping and heater. Flanges are not permitted to be protected by the insulation material. Insulation material of thermal oil heater and piping is to be of an approved type and, as far as possible, it does not lower than the auto-ignition point of the thermal oil when impregnated by it.

4.8.2 Arrangement

4.8.2.1 Fuel oil and hot oil heaters are generally to be situated in separate compartments separated from the main and auxiliary machinery spaces. The arrangement is to be such that all parts of the equipment are easily accessible and can be easily operated, inspected, repaired and cleaned.

4.8.2.2 If the fuel oil and hot oil heaters are not installed in a separate compartment, coamings not lower than 150 mm and drain pipes vented to a closed oil tank are not to be provided surrounding.

4.8.2.3 The oil pipes arranged in the area of exhaust hot oil heater is to be arranged so that the oil mist on the foldable pipe and valve cannot contact the heater and the exhaust pipe, nor flow under the machinery space.

4.8.2.4 Drip trays are to be installed under the components of the installation where leakage is liable to occur. These drip trays are to be drained to an appropriate sludge tank.

4.8.2.5 The thermal oil circulating pumps are to be arranged for emergency stopping from a position outside the space where they are situated.

4.8.2.6 The thermal oil system is to be fitted with an expansion tank of sufficient capacity. The thermal oil expansion tank and pumping plants are to be located in the same space as the thermal oil heaters.

4.8.2.7 Vents from expansion tanks and thermal oil storage tanks of the thermal oil heating plants are to be led to open deck.

4.8.2.8 Thermal oil piping and pumping system are to comply with the relevant requirements of Section 2 of this CHAPTER.

4.8.2.9 Thermal oil pipes are not to pass through accommodation spaces nor control stations.

4.8.3 Control and monitoring system

4.8.3.1 Circulating pumps and heaters are to be capable of starting and stopping in situ and remotely stopping from an easily accessible place outside the space where the hot oil heater is situated.

4.8.3.2 The adjustment of the heater and the operation of the burner is to ensure that under all operating conditions, the temperature of the hot oil anywhere in the heater does not exceed the temperature that would cause the hot oil to deteriorate at an unacceptable rate.

4.8.4 Tests

4.8.4.1 Thermal oil system and installation are to be subject to hydraulic and tightness tests according to the relevant requirements contained in Chapters 2 of this PART.

4.8.4.2 On completion, working tests of the thermal oil system are to be carried out in accordance with the test program.

Section 9 EXHAUST PIPELINES

4.9.1 Arrangement and structure

4.9.1.1 The exhaust system of each diesel engine is to be independent. For example, when the exhaust of two or more diesel engines leads to a common muffler, exhaust boiler or water heater, each exhaust pipe is to be provided with a fume isolation device. .

4.9.1.2 The distance from the exhaust pipe to the fuel piping system and the fuel tank bulkhead is not to be less than 450 mm. Oil tanks and oil pipes are not to be arranged above the exhaust and smoke exhaust pipes. Where it is not practicable, effective protective measures are to be taken in accordance with the provisions of 2.1.6.2 and 4.2.5.4 of this PART.

4.9.1.3 Uptakes of boilers except exhaust gas boilers are not to be connected with exhaust pipelines of diesel engines.

4.9.1.4 Uptake governors or other means for closing the uptakes are not to be fitted within uptakes or funnels of oil-fired boilers.

4.9.1.5 For boilers that alternately use fuel oil and exhaust gas, their exhaust gas inlets are to be fitted with isolation devices that cannot simultaneously use fuel oil and exhaust gas.

4.9.1.6 When arranging pipelines and their supports, compensation for thermal expansion is to be taken into account.

4.9.1.7 If the exhaust gas boiler cannot be dry-burned, an exhaust gas bypass pipe is to be provided at the place where the exhaust gas enters the boiler.

4.9.1.8 Normally, exhaust gas is to be introduced into the atmosphere from a sufficient height above the deck. If the exhaust pipe is led from the side or stern, it is to be avoided to cause excessive exhaust back pressure, and effective facilities is to be provided to prevent seawater from entering the engine and hull.

4.9.1.9 The inner bulkhead of an exhaust pipe with a cooling water interlayer is to be appropriately thickened.

4.9.2 Muffler

4.9.2.1 The exhaust pipe of a diesel engine is to be provided with an effective muffler, and the muffler is to be capable of extinguishing fire.

4.9.2.2 The structure of the muffler is to be convenient for internal cleaning and inspection. If necessary, air or steam flushing devices and drain cocks are to be provided.

4.9.2.3 The external portion of silencers are to be packed with thermal insulation materials.

4.9.3 Water heaters

4.9.3.1 Water heaters fitted on the ducts for exhaust gas and smoke are, in general, to be of open type. If close type (if any) water heaters are fitted, the strength calculation is to be in accordance with the relevant requirements in CHAPTER 8 of this PART.

4.9.3.2 Close type water heaters are to be fitted with relief valves, pressure gauges, water level indicators, etc.

4.9.3.3 On construction, the close type water heaters are to be subject to a hydraulic test of 1.5 times the design pressure and the test pressure is not to be less than 0.4 MPa.

4.9.3.4 Open type water heaters are to be fitted with a vent pipe of sufficient diameter and the vent pipe is not to be fitted with any closing appliances.

Section 10 COMPRESSED AIR PIPING

4.10.1 Air tanks and air compressors

4.10.1.1 Air tanks are to comply with the relevant requirements of Section 4 of CHAPTER 8.

4.10.1.2 The arrangement of air tanks on a vessel is to enable the discharging pipe to effectively discharge the residual water under the normal tilt of the fishing vessel. The drainage device of air tank is not to pose a danger to the operator.

4.10.1.3 The air tanks are to be installed firmly. Cushions are to be lined between the tank body and fasteners.

4.10.1.4 After the air tanks are installed on board, the whole system air tightness test is to be carried out with compressed air piping system and accessories under working pressure. The test time is not to be less than 2 h, and the pressure is not to decrease significantly.

4.10.1.5 The air compressor is to comply with the relevant requirements of Section 5, CHAPTER 5.

4.10.1.6 The arrangement of the air compressor is to be such that the suction is as far as possible from the space where oil and gas can be easily sucked.

4.10.2 Starting air line

4.10.2.1 The starting air line from the air bottle to the diesel engine is to be completely separated from the discharge pipe of air compressor.

4.10.2.2 A check valve or equivalent is to be provided on the starting airline leading to the diesel engine to protect the compressed air line from being affected by explosive gas in the cylinder.

4.10.3 Exhaust pipe of compressed air pipe

4.10.3.1 The exhaust pipe of each air compressor is to be directly connected to each starting air cylinder, and a check valve is to be provided in between. The compressed air pipeline is to be equipped with a bleed cock or unloading equipment, and equipment separating oil and water from compressed air.

4.10.4 Relief piping

4.10.4.1 The pipeline on the low pressure side of the pressure reducing valve is to be installed with pressure gauges and relief valves with sufficient discharge capacity. The pipeline to be provided with reducing valves are to be fitted with a bypass pipeline.

CHAPTER 5 DIESEL ENGINES

Section 1 GENERAL PROVISIONS

5.1.1 Application

5.1.1.1 The design and construction of the diesel engines for fishing vessels, including main and auxiliary diesel engines are to comply with the requirements of this Chapter.

5.1.2 Nominal output and rated output

5.1.2.1 The nominal output means the output marked on the nameplates of diesel engines. The nameplates of diesel engines for fishing vessels shall indicate the continuous output and one-hour output. Before marked, the outputs above measured on the test bench are to be corrected based on the ambient conditions specified in 1.1.2.2 or 1.1.2.3 of this PART. The nominal speed is defined as the speed corresponding to the nominal output.

5.1.2.2 The rated output is defined as the continuous output marked on the nameplates.

5.1.2.3 The continuous output is defined as the maximum effective power outputted by the diesel engines during continuous running.

5.1.2.4 The diesel engines for fishing vessels are to be capable of continuously running at 110% of the rated output and at the corresponding speed for one hour.

5.1.2.5 The one-hour output is defined as the maximum effective power outputted by the diesel engines during continuous running for one hour.

5.1.3 Clutch

5.1.3.1 For main engine not equipped with a gearbox, the clutch is to serve as a component of main engine and be located on the whole engine base.

5.1.4 Astern

5.1.4.1 The astern output (measured on the test bench) of directly reversible main engines is generally not to be less than 70% of rated output.

5.1.5 Vibration

5.1.5.1 The calculation and measurement of diesel engine vibration are to comply with the requirements of Section 4, Chapter 7 of this PART.

5.1.6 Minimum steady speed

5.1.6.1 Main engines are to have good performance at low speeds. In general, the minimum steady speed of diesel engines is to satisfy the following provisions:

- (1) for low-speed engines, not more than 30% rated speed;
- (2) for medium-speed engines: not more than 40% rated speed;
- (3) for high-speed engines: not more than 45% rated speed.

5.1.7 Front-end Power Output

5.1.7.1 The front-end power output shaft of the main engine, together with its output connection flange, is generally to be capable of transmitting no less than 65% of the rated torque.

5.1.8 Manoeuvring

5.1.8.1 The time required for reversing main engines is not to exceed 15s. The time for main engine reversal is defined as, when the main engine is running at the minimum steady speed, the time elapsed from the beginning of manoeuvring till starting of running in the opposite direction.

5.1.8.2 An index indicating the "Ahead" and "Astern" directions of the lever or the hand-wheel is to be fitted to the control station of main engine. As a common practice, for navigating the fishing vessel ahead, the lever is to be pushed forward, or the hand-wheel is to be turned clockwise.

5.1.8.3 Devices for quickly cutting off oil fuel supply or other effective arrangements for emergency stopping are to be provided near the main engine control station.

5.1.8.4 An indicator showing the crankshaft rotational direction is to be fitted to the control station, but it may be dispensed with provided the tachometer is of a dual-rotation type.

5.1.9 Interlocking between turning gear and starting arrangement

5.1.9.1 A safety interlocking device is to be fitted between the turning gear and the starting arrangement of the main engine.

5.1.10 Instrumentation

5.1.10.1 Tachometers and other necessary measuring instruments are to be fitted to diesel engines. Restricted speed ranges are to be marked red on tachometers.

5.1.11 Test

5.1.11.1 The material test, non-destructive testing and ultrasonic test of diesel engine parts and components are to comply with the relevant requirements of PART 7.

5.1.11.2 Bench trials of diesel engines are to be carried out in accordance with relevant national standards or the test programs approved by CCS.

Section 2 CRANKSHAFT

5.2.1 Scope

5.2.1.1 The calculation is applicable to crankshafts of in-line and V-diesel engines. These crankshafts have an equal span of bearings adjacent to cranks, and are made of forged steel, cast steel, alloy steel or nodular graphite cast iron.

5.2.2 Materials

5.2.2.1

The specified tensile strength of forgings and castings for crankshafts is in general to be selected within the following scope and in compliance with the relevant requirements of PART 7.

- .1 Carbon and carbon-manganese steel 400 to 600 N / mm²;
- .2 Alloy steel 600 to 1,000 N / mm²;
- .3 Nodular graphite cast iron 490 to 780 N / mm².

5.2.3 Journals and crankpins

5.2.3.1 The minimum diameter d of the crankpins or the journals of forged, cast, fully-built or semi-built crankshafts is to be calculated by the following: .1 For crankshafts made of forged steel, cast steel and alloy steel:

$$d = \sqrt[3]{\frac{D^2[A\alpha_B p_z(L - L_p) + C\alpha_T p_i S]}{65\left(\frac{\sigma_b + 160}{590}\right)}} \quad \text{mm}$$

.2 For crankshafts made of nodular graphite cast iron:

$$d = \sqrt[3]{\frac{D^2[A\alpha_B p_z(L - L_p) + C\alpha_T p_i S]}{59\left(0.3 + \frac{0.7R_m}{490}\right)}} \quad \text{mm}$$

Where, D — cylinder diameter, in mm;

S — piston stroke, in mm;

L — span of adjacent bearings measured from center to center, in mm;

L_p — length of crankpin, in mm;

p_z — maximum combustion pressure, in MPa;

p_i — mean indicated pressure, in MPa;

R_m — tensile strength of the material used, in N/mm²;

A — coefficient::

for single acting in-line diesel engines, $A = 0.50$;

for two-stroke V-diesel engines, A is to be selected in accordance with 5.2.3.1-1;

for four-stroke V-diesel engines, A is to be selected in accordance with Table 5.2.3.1-2;

C —

coefficient:

for single acting in-line diesel engines, C is to be selected in accordance with Table 5.2.3.1-3;

for two-stroke V-diesel engines, C is to be selected in accordance with Table 5.2.3.1-4;

for four-stroke V-diesel engines, C is to be selected in accordance with Table 5.2.3.1-5;

α_B — bending stress concentration factor, calculated as follows:

$$\alpha_B = 0.625 f_1(r) f_2(h) f_3(e_k, h) f_4(b) f_5(d_0)$$

Where, $f_1(r)$, $f_2(h)$, $f_3(e_k, h)$, $f_4(b)$, $f_5(d_0)$ may be obtained from Figures 5.2.3.1-1, 5.2.3.1-2, 5.2.3.1-3, 5.2.3.1-4,

5.2.3.1-5, 5.2.3.1-6 and 5.2.3.1-7. Where the transition fillets of the crankpins or journals are filleted arc and the recess depth is P (as shown in Figure 5.2.3.1-9), α_r value is to multiply $f_6(\delta)$ value obtained from Table 5.2.3.1-6.

α_r — torsional stress concentration factor, is to be obtained from Figure 5.2.3.1-8.

Coefficient A for two-stroke V-diesel engines

Table 5.2.3.1-1

Coefficient	Firing interval between two cylinders on one crankpin			
	36 °	45 °	60 °	90 °
A	0.70	0.66	0.615	0.585

Coefficient A for four-stroke V-diesel engines

Table 5.2.3.1-2

Coefficient	Firing interval between two cylinders on one crankpin							
	45 °	60 °	75 °	90 °	275 °	285 °	300 °	315 °
A	0.665	0.630	0.610	0.599	0.594	0.596	0.597	0.598

Coefficient C for single acting in-line diesel engine

Table 5.2.3.1-3

Two-stroke		Two-stroke		Four-stroke		Four-stroke	
Number of cylinders	C	Number of cylinders	C	Number of cylinders	C	Number of cylinders	C
1	2.043	7	3.446	1	1.872	7	2.915
2	2.069	8	3.960	2	1.872	8	2.915
3	2.616	9	4.148	3	2.082	9	2.933
4	2.933	10	4.661	4	2.082	10	2.933
5	3.273	11	4.782	5	2.553	11	3.300
6	3.300	12	4.840	6	2.553	12	3.300

Coefficient C for two-stroke V-diesel engines

Table 5.2.3.1-4

Number of cylinders	Firing interval between two cylinders on one crankpin			
	36 °	45 °	60 °	90 °
2×3	3.768	3.464	3.546	3.675
2×4	4.138	3.800	4.400	5.630
2×6	5.469	5.684	6.563	5.286
2×8	6.504	7.010	6.469	7.003

Coefficient C for four-stroke V-diesel engines

Table 5.2.3.1-5

Number of cylinders	Minimum firing interval between two cylinders on one crankpin							
	45 °	60 °	75 °	90 °	270 °	285 °	300 °	315 °
2×3	2.934	2.833	2.648	2.511	3.307	3.309	3.380	3.309
2×4	3.224	3.103	3.056	3.159	3.105	3.183	3.150	2.848
2×6	3.859	3.613	3.404	3.471	3.864	4.146	4.155	4.187
2×8	4.274	4.035	4.500	4.455	4.706	4.314	3.648	3.480

The recess influence coefficient $f_6(\delta)$ of the transition fillets

Table 5.2.3.1-6

δ	0	0.15	0.25	0.35	0.45	0.55	0.60	0.65
$f_6(\delta)$	1	0.993	0.989	0.996	1.020	1.072	1.110	1.158

In Figures 5.2.3.1-1~5.2.3.1-9,

$r = \frac{R}{d}$ — relative radius of transition fillet, $0.03 \leq r \leq 0.10$;

$h = \frac{H}{d}$ — relative thickness of crank arm, $0.25 \leq h \leq 0.60$;

$b = \frac{B}{d}$ — relative width of crank arm, $1.30 \leq b \leq 2.00$;

$e_k = 1 - \frac{E}{d}$ — crankpin eccentricity, $0.50 \leq e_k \leq 1.50$; $0.25 \leq h \leq 0.60$;

E — overlap of crankpin; E may be equal to zero or negative;

$\alpha_0 = \frac{d_0}{d}$ — ratio of crankpin or journal center bore diameter and outer diameter, $0 \leq \alpha_0 \leq 0.70$;

$\delta = \frac{\rho}{R}$ —relative depth of fillet recess part, $0 \leq \delta \leq 0.65$.



Figure 5.2.3.1-1 Coefficient

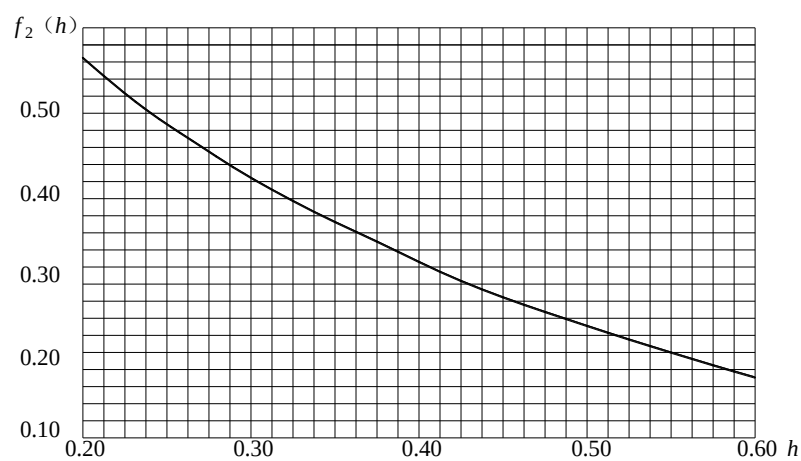


Figure 5.2.3.1-2 Coefficient

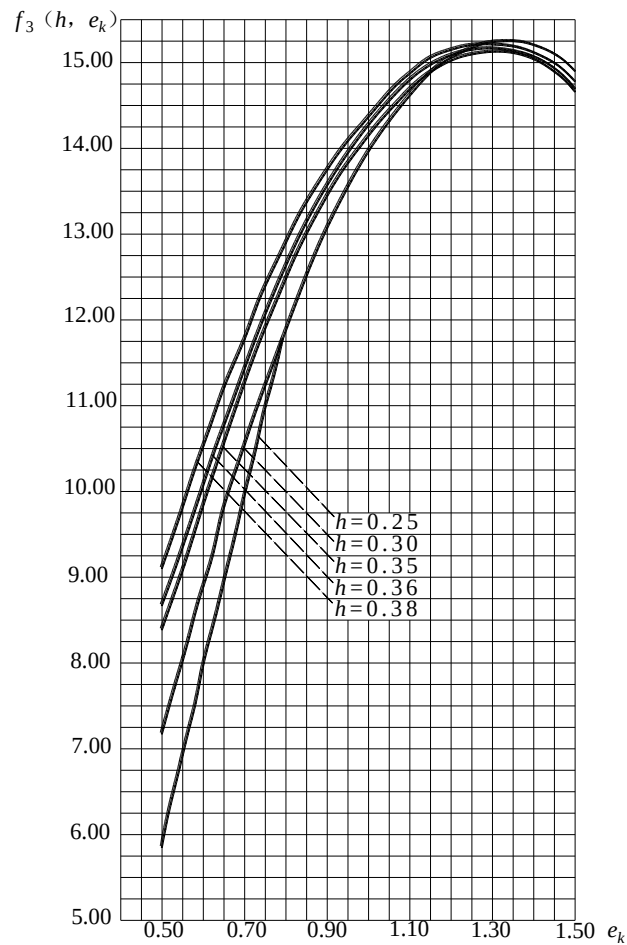


Figure 5.2.3.1-3 Coefficient

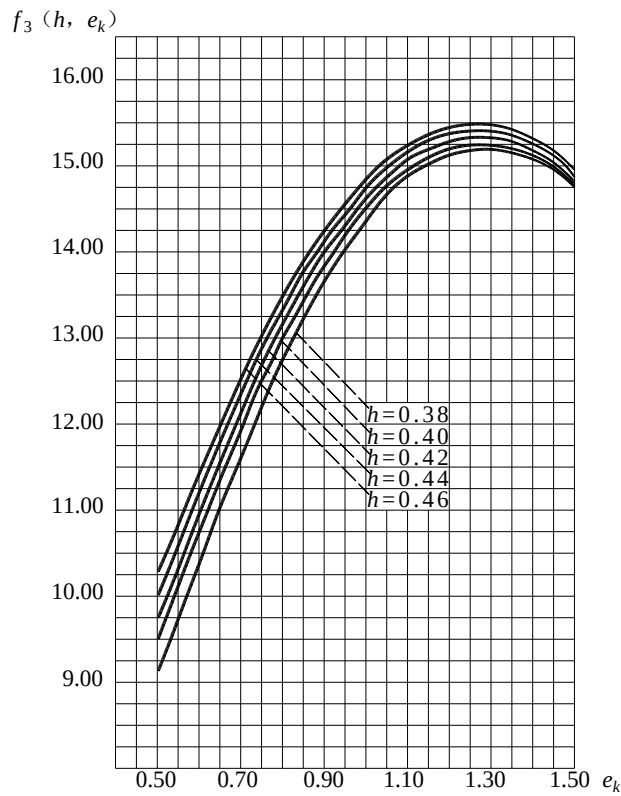


Figure 5.2.3.1-4 Coefficient

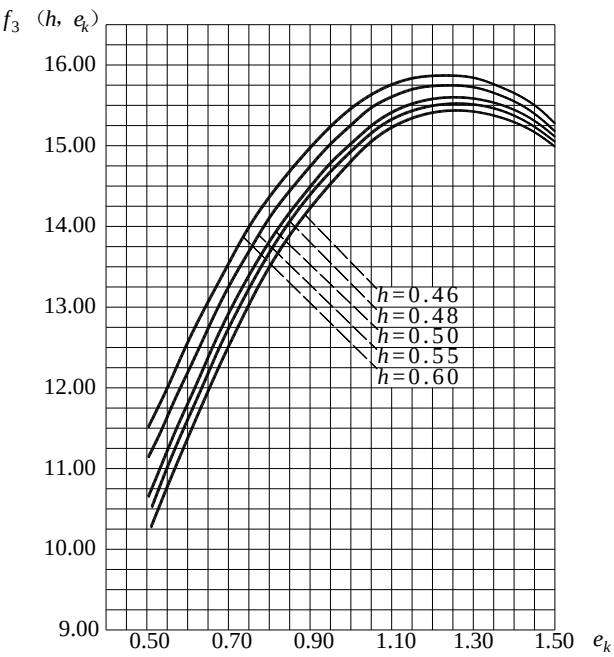


Figure 5.2.3.1-5 Coefficient

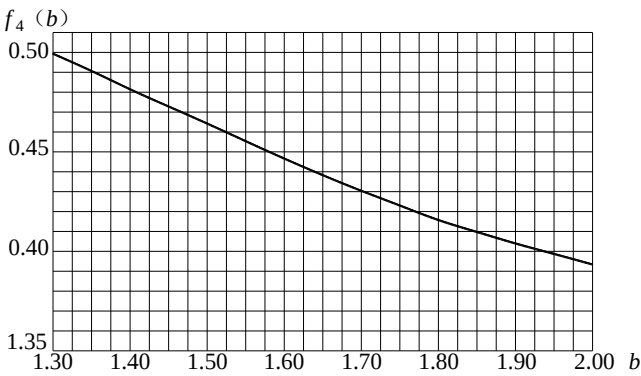


Figure 5.2.3.1-6 Coefficient

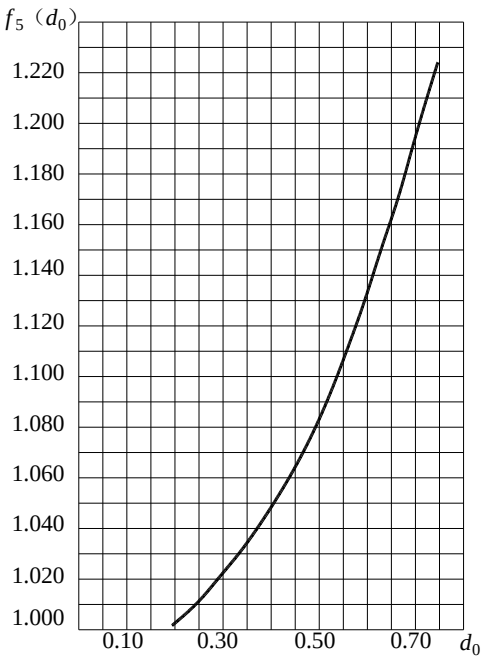


Figure 5.2.3.1-7 Coefficient

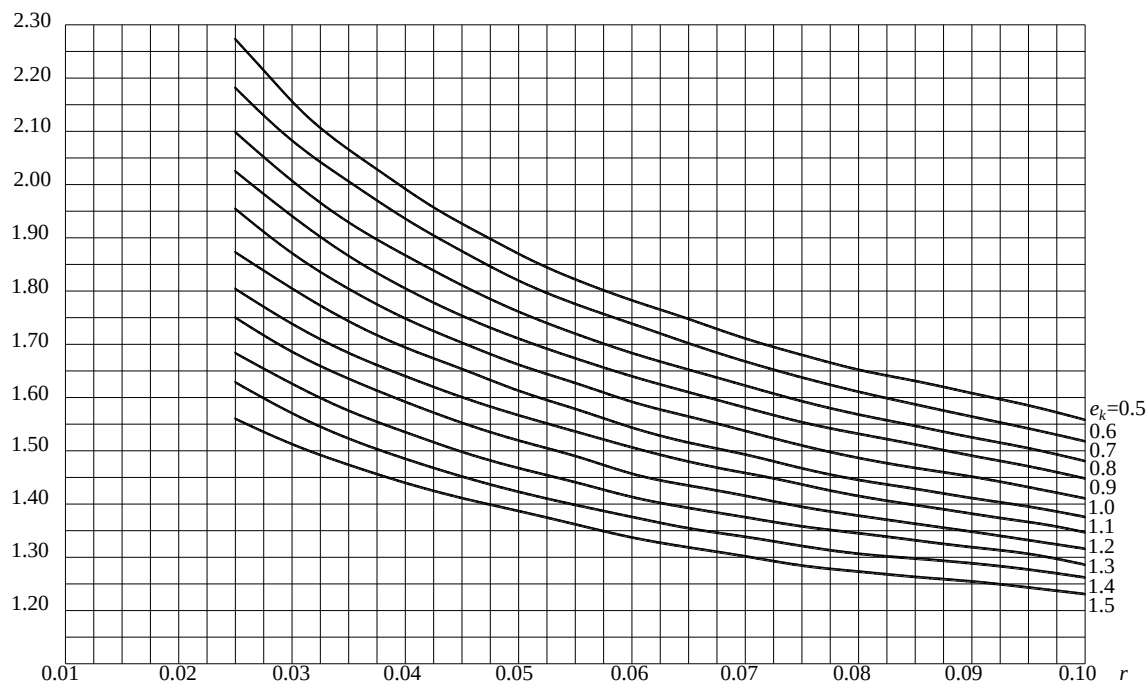


Figure 5.2.3.1-8 Coefficient

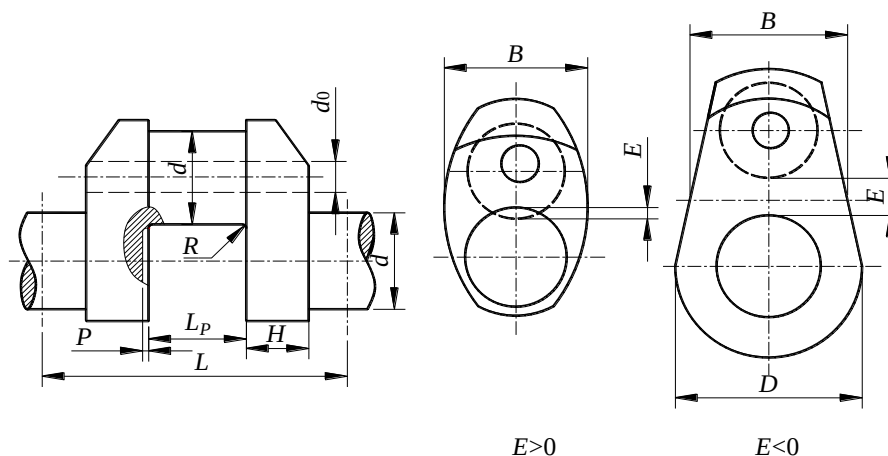


Figure 5.2.3.1-9 Overall Dimensions of Crankshaft

5.2.3.2 When the stress concentration coefficient of the crankshaft is calculated, the limit value may be taken for calculation if the individual relative dimensions of the crankshaft exceed the range specified in 5.2.3.1 of this PART.

5.2.4 Shrink fits offully-built crankshafts

5.2.4.1 When the shrink fit is employed, the radial oversize is to be limited to be within the range $\delta_{\min} \sim \delta_{\max}$.

Minimum oversize:

$$\delta_{\min} = 0.765 \times 10^{-4} \frac{M_{\max} d_s (D^2 - d_0^2)}{h(D^2 - d_s^2)(d_s^2 - d_0^2)} \quad \text{mm}$$

Maximum oversize:

$$\delta_{\max} = 6.83 \times 10^{-6} \frac{R_{eH} d_s^3 (D^2 - d_0^2)}{D^2 (d_s^2 - d_0^2)} \quad \text{mm}$$

Where, d_s —diameter of shrink fit bore, in mm;

h —axial thickness of shrink fit bore; it is to be no less than $0.45 d$ and d is the minimum crankshaft diameter determined according to 5.2.3.1 of this part, in mm;

D —outer diameter of crank arm, in mm;

d_0 —center bore diameter of fitting journal, in mm;

R_{eH} —yield point of crank arm material, in N/mm^2 ;

$M_{\max}$ —maximum instantaneous impact torque of engine, in $\text{N}\cdot\text{mm}$; calculated according to the following formula:

$$M_{\max} = T_{\max} R \text{ N}\cdot\text{mm}$$

$T_{\max}$ —maximum total instantaneous tangential force of engine, in N;

R —turning radius of crankshaft, in mm.

5.2.5 Fillet and oil bore

5.2.5.1 The transition fillet between the crank arm of the forged and cast crankshaft and the crank pin or journal is to be smooth.

5.2.5.2 The oil bore on the surface of the crankpin and the journal is to be rounded, and the fillet is to be smooth.

5.2.6 Miscellaneous

5.2.6.1 Where the structural dimensions of the crankshaft do not meet the requirements of this Section, relevant information such as the design and test of the crankshaft is to be provided, or the basis proven as safe and reliable in practice is to be submitted to CCS for review.

5.2.6.2 When necessary, other calculation methods approved by the CCS may be also adopted to calibrate the crankshaft diameter or determine the oversize of the fully-built crankshaft fit.

Section 3 MAIN FITTINGS

5.3.1 Frames and bedplates

5.3.1.1 Diesel engine frames and bedplates are to be subject to the aging heat treatment to eliminate the internal stress. The welded structure is to comply with relevant requirements of Chapter 6, PART 8 when employed.

5.3.1.2 Bedplates of main diesel engines are to be reasonably rigid, and are to be securely fixed to the engine seatings of reasonable rigidity by means of holding-down bolts, or bolts and chocks. When holding-down bolts only are used, the number of fitting bolts is in general not to be less than 15% of the total number, but it is to be no less than four pieces. The gaskets at the fitting bolts are to be overall brushed type. Where cast epoxy gaskets are fitted, the material formulation and casting process are to be approved by CCS.

5.3.2 Indicator valves

5.3.2.1 An indicator valve is to be fitted to each cylinder head of diesel engines having cylinder bore over 230 mm.

5.3.3 Cylinder safety valves

5.3.3.1 A safety valve is to be fitted to each cylinder head of diesel engines having cylinder bore over 230 mm. The safety valve is to be set at a pressure not more than 1.40 times the maximum combustion pressure and is to be so arranged that personal injury will not be caused by the outburst gas. For auxiliary engines, consideration will be given to the replacement of the relief valve by an efficient warning device of overpressure in the cylinder.

5.3.4 Crankcases and crankcase relief valves

5.3.4.1 Crankcases and their doors are to be of robust construction and the doors are to be securely fastened so that they will not be readily displaced by an explosion.

5.3.4.2 The crankcase relief valves are to be approved type, and their structures are to be quickly closed after the gas is exhausted to prevent the air from being burst into thereafter. The opening pressure of relief valve is to be as low as possible and is to be no more than 0.02MPa. Means such as baffle installation is to be taken to make the air in the crankcase flow out at the bottom along the refraction direction, to prevent causing harm due to the flame coming from the relief valves.

5.3.4.3 Relief valves may be dispensed for diesel engines with cylinder bore not exceeding 200mm and total crankcase volume not exceeding 0.6m^3 .

In engines having cylinders exceeding 200 mm but not exceeding 250 mm bore, at least one relief valve is to be fitted near respectively each end of crankcase and an additional relief valve is to be fitted near the middle of the engine.

In engine having cylinders exceeding 250 mm but not exceeding 300 mm bore, at least one relief valve is to be fitted in way of each alternate crank throw with a minimum of two valves. Relief valves are to be arranged from

each end, where the cranks are of odd number.

In engines having cylinders exceeding 300 mm bore, at least one relief valve is to be fitted on each crank.

Additional relief valves are to be fitted for separate spaces on the crankcase, such as gear or chain cases for camshaft or similar drives, when the gross volume of such spaces exceeds 0.6 m³.

The combined free area of the crankcase relief valves fitted on an engine is not to be less than 115 cm² per m³ of the volume of the crankcase. The free area of each relief valve is not to be less than 45 cm².

5.3.4.4 When the crankshaft volume is determined, the occupied volume of fixed parts in the crankcase is to be deducted.

5.3.4.5 It is recommended to install an oil mist indicating device of crankcase or bearing temperature control and alarm system.

5.3.4.6 The crankcase oil drain pipes of two or more diesel engines are not to be interconnected.

5.3.5 Vent Pipes

5.3.5.1 Vent pipes and any device which may make eternal air flow into the crankcase are not to be used for crankcase generally. Vent pipes, where provided, are to be as small as practicable in diameter to reduce the entering air after explosion and the vent pipes are to be connected to a safe position above the deck.

5.3.5.2 If provision is made for the extraction of gases from within the crankcase, e.g. for oil mist detection purpose, the vacuum within the crankcase is not to exceed 25 mm of water column.

5.3.5.3 Vent pipes of all diesel engines are to be independent and are not to be interconnected.

5.3.6 Warning notice

5.3.6.1 A warning notice is to be fitted in a prominent position at the engine room control station. This warning notice is to specify that whenever overheating is suspected in the crankcase, the crankcase doors or sight holes are not to be opened until a reasonable time has elapsed after stopping the engine, sufficient to permit adequate cooling within the crankcase.

Section 4 PIPING SYSTEMS

5.4.1 General requirements

5.4.1.1 The piping systems of diesel engines are to comply with relevant requirements of Chapter 4 of this PART.

5.4.1.2 Diesel engines greater than 37 kW are to be provided with an audible and visible alarm device giving an indication of failure of lubricating oil systems.

5.4.1.3 For diesel engines greater than 220kW, the lubricating oil system is to be provided with a low-pressure audible and visible alarm device and relevant automatic stop devices. The alarm device is to first provide the alarm for low oil pressure. Where it is not handled timely, the alarm device will alarm for excessively low oil pressure and stop automatically. The cooling system is to be provided with an audible and visible alarm device.

5.4.1.4 In diesel engines having cylinders no less than 200 mm bore, each cylinder is to be provided with an exhaust gas temperature measuring instrument whose type and specification are to ensure the measuring accuracy.

5.4.1.5 In diesel engines having cylinders no less than 250 mm bore, each cylinder is to be provided with an outlet cooling water temperature measuring instrument and a device for adjusting the cooling water volume of each cylinder.

5.4.1.6 In diesel engines having cylinders no less than 250 mm bore, high-pressure fuel delivery lines are to be reliably secured and shielded by approved metal hose, to is 250 mm and above, the fuel injection piping is to be effectively secured and shielded so as to prevent oil fuel or oil fuel mist from reaching a source of ignition on the engine or its surroundings. Any oil fuel leakage is to be drained to the appropriate collecting tank.

5.4.1.7 Fuel filters and lubricating oil filters directly mounted on the diesel engines are not to be installed near hot parts.

5.4.1.8 Convertible filter is to be provided with a drain valve and a vent valve. The oil supply chamber and non-operating chamber are to be clearly identifiable. A drainable oil drip tray is to be equipped below such oil filter.

5.4.1.9 The cooling water inlet main pipe of diesel engine or the engine body is to be equipped with a valve for draining the cooling water.

Section 5 STARTING ARRANGEMENTS

5.5.1 Air receivers and capacity

5.5.1.1 The design and construction of air receivers are to comply with the relevant requirements contained in Chapter 8 of this PART.

5.5.1.2 Main engines arranged for starting are to be provided with at least two air receivers. The total capacity of air receivers is to be sufficient to provide, without their being replenished, not less than 12 consecutive starts alternating between ahead and astern of each main engine of the reversible type, and not less than 6 starts of each main non-reversible type engine. The capacity of air receiver may be reduced where appropriate if there are more than two main engines. Its capacity is to be increased if the air receiver serves other functions in addition to starting.

5.5.1.3 The air receiver for starting of auxiliary engine is to be capable of starting the auxiliary engine with the maximum output for no less than 6 times in cold condition without inflation air replenished.

5.5.1.4 The air receivers are to be so fitted with drain arrangement as to permit effective drainage when the vessel is under normal inclination conditions.

5.5.2 Air charging devices

5.5.2.1 At least two sets of air charging devices for starting main engines are to be installed, including at least one set driven independently of the main engine. The total capacity of the air charging device is to increase the atmospheric pressure to the pressure needed for continuous starting as specified in 5.5.1.2 of this PART within one hour.

5.5.2.2 In addition to compliance with the provisions of 5.5.2.1 in this PART, the fishing vessel with length no less than 45 m is to be provided with an emergency charging device driven independently of the vessel. The diesel engine started manually or other effective driving device can be used as such emergency equipment. The manual air compressor with capacity approved by CSS can also serve as the emergency charging device. The emergency charging device may be dispensed if complying with the provisions of 5.5.2.3 in this PART.

5.5.2.3 Where the air compressor is driven electrically, an emergency power source may be also used as the initial starting facility as long as practical.

5.5.3 Air compressors

5.5.3.1 Pressure gauges and safety valves are to be fitted to air compressors. The safety valves are to be set at a pressure not more than 1.1 times the working pressure. Casings of the cooling water space of compressed air coolers are to be provided with relief valves or corresponding safety devices.

5.5.3.2 Air compressors are to be so designed that the exhaust air temperature will not be too high, and are to be provided with fusible plugs or equivalent facilities at the outlet ends.

5.5.3.3 Relief valves are to be fitted to the crankcase of air compressors when the crankcase has a volume exceeding 0.6 m³.

5.5.4 Compressed air starting main pipes

5.5.4.1 Compressed air starting main pipes are to be provided with non-return devices and discharge facilities.

5.5.4.2. In diesel engines having cylinders more than 230 mm bore, starting air systems are to be fitted with flame arresters; for directly reversible diesel engines, such device is to be installed at each starting valve; for non-reversible diesel engine, it may be installed on the starting air main pipes.

5.5.5 Electric starting installations

5.5.5.1 Where the main engine is arranged for electric starting, two separate batteries are to be fitted. The combined capacity of the batteries is to be sufficient without recharging to provide no less 12 continuous starts of each main engine in cold condition, and each battery is to be capable of starting the main engine independently and can be charged with the on-board charging equipment at any moment.

5.5.5.2 The combined capacity of the batteries is to be sufficient to provide no less 3 continuous starts of each auxiliary engine.

5.5.6 Starting arrangements for emergency generating sets

5.5.6.1 The prime mover of emergency generating sets is to be capable of being started in cold condition at a temperature of 0°C. If this is impracticable, or if lower temperatures are likely to be encountered, an accessory heating arrangement may be fitted so as to ensure low-temperature starting of the emergency generating sets.

5.5.6.2 Each emergency generating set arranged to be automatically started is to be equipped with starting devices with a stored energy capability of at least three consecutive starts. In addition, a second source of energy is to be provided for an additional three starts within 30 min unless manual starting can be demonstrated to be effective.

5.5.6.3 The stored starting energy is to be maintained at all times as follows:

.1 Electrical and hydraulic starting systems are to be maintained from the emergency switchboard.

.2 Compressed air starting systems may be maintained by the main or auxiliary compressed air receivers through a suitable non-return valve or by an emergency air compressor which, if, electrically driven, is supplied from the emergency switchboard;

.3 All of these starting, charging and energy storing devices are to be located in the emergency generator space; these devices are not to be used for any purpose other than the operation of the emergency generating set. This does not preclude the supply to the air receiver of the emergency generating set from the main or auxiliary compressed air system through the non-return valve fitted in the emergency generator space.

5.5.6.4 Where automatic starting is not required, manual starting is permissible, such as manual cranking, inertia starts, manually charged hydraulic accumulators, or powder charge cartridges, where they can be demonstrated as being effective.

5.5.6.5 The emergency generator used to restore operation from the dead vessel condition is to be recovered to run in case of no starting energy.

Section 6 SCAVENGING AND SUPERCHARGING ARRANGEMENTS

5.6.1 Lubricating oil systems

5.6.1.1 The lubricating oil system of exhaust gas turbochargers may be separate from, or in common with, that of the main engine. If an independent circulating system not directly driven by turbocharger is adopted, an independent standby pump is to be fitted.

5.6.2 Instruments and alarm devices

5.6.2.1 Exhaust gas turbochargers are generally equipped with instruments for measuring parameters such as exhaust gas temperature at each turbocharger inlet, supercharging air pressure and lubricating oil temperature. In addition to the independent system directly driven by turbocharger, the lubricating oil pressure gauge, lubricating oil high temperature and low pressure alarm devices are to be also installed. Thermometers are to be fitted before and after intercooler.

5.6.2.2 The structure of turbocharger is to facilitate the speed measurement.

5.6.3 Air filters and silencers

5.6.3.1 Turbochargers are to be fitted with inlet air filters and silencers.

5.6.4 Rotor locking devices

5.6.4.1 Turbocharger rotors are to be provided with locking devices. If not, by-pass connections or other suitable devices are to be fitted to the pipes before and after the turbines to ensure the normal operation of main engines in case of turbocharger breakdown.

5.6.5 Critical speeds

5.6.5.1 Critical speeds of the turbocharger rotor are to be determined by calculation. In the case of rigid rotor shafts, critical speeds are not to be less than 1.3 times the rated speed.

5.6.6 Rotors and rotor shafts

5.6.6.1 After assembly, rotors are to be dynamically balanced.

5.6.7 Protection

5.6.7.1 For two-stroke loop-scavenged and cross-scavenged diesel engines, grids or other suitable devices are to be fitted before turbine nozzles to prevent broken piston rings from entering into the turbines.

5.6.7.2 It is undesirable to connect vent pipes of crankcase with turbocharger inlets. Otherwise, effective oil vapor separating devices are to be fitted before the turbocharger inlets.

5.6.7.3 When the inlet air temperature reaches or approaches dew point at the corresponding pressure and humidity after cooled by intercoolers, a gas water separator is to be fitted after intercoolers.

5.6.7.4 The assembly of exhaust gas turbochargers and main engines is to avoid surge in anticipated operating conditions.

5.6.8 Emergency blowers

5.6.8.1 Two-stroke turbocharged diesel engines not equipped with scavenge pumps are to be provided with independent emergency blowers, except that the scavenging air systems arranged in series are available.

5.6.9 Relief valves of scavenging air receivers

5.6.9.1 Scavenging air receivers of two-stroke diesel engines with rated output more than 220kW are to be fitted with relief valves as well as devices for removing dirty oil and condensate. Relief valves are to be set generally at a pressure not more than 1.1 times the maximum scavenging air pressure.

Section 7 GOVERNORS AND OVERSPEED PROTECTIVE DEVICES

5.7.1 Governors

5.7.1.1 Main engines are to be provided with reliable speed governors to ensure that the transient speed variation does not exceed nominal speed by 10%.

5.7.2 Overspeed protective devices

5.7.2.1 In addition to governors as described in 5.7.1 of this PART, main engines with rated output more than 220kW are to be also fitted with overspeed protective devices, to prevent the speed of main engines from exceeding 120% of the nominal speed.

5.7.3 Governors for generating sets

5.7.3.1 Diesel engines intended for driving generating sets are to be provided with speed governors, which are to meet the following requirements:

When the rated load is suddenly taken off, a transient speed variation is not to exceed 10% of the nominal speed. When 50% of the rated load is suddenly applied from no-load condition, followed by the remaining 50% load after an interval sufficient to restore the speed to steady state, the momentary variation in speed is not to exceed 10% of the nominal speed, and permanent variation in speed is not to exceed 5% of the nominal speed. The recovery time for the engine speed (i.e. the time for speed fluctuation ratio to return to $\pm 1\%$) is not to exceed 5 s.

Emergency generating sets must satisfy the governor conditions above, even when their total consumer load is applied suddenly or in steps, subject to:

- .1 emergency generating sets are to be started and supply power to emergency power grid within 45 seconds since power failure on the main switchboard;
- .2 the maximum step load is declared and demonstrated;
- .3 the power distribution system is designed such that the declared maximum step loading is not exceeded;
- .4 the compliance of time delays and loading sequence with the above is to be demonstrated at vessel's trials.

5.7.3.2 For diesel engines driving electric generators and having a rated power of 220 kW and above, separate overspeed protective devices are to be provided in addition to the governors prescribed in 5.7.3.1 of this PART, so as to prevent the speed of diesel engines exceeding 115% of the nominal speed.

5.7.3.3 If the generating sets are arranged to operate in parallel, their permanent speed variations are to be the same as far as possible, and their construction and performance are to be comply with relevant provisions of Chapter 4, PART 4.

5.7.3.4 Mechanical overspeed protective devices mentioned in 5.7.2 and 5.7.3.2 of this Section are to be independent of the governors.

Section 8 HYDRAULIC TESTING

5.8.1 Testing pressure

5.8.1.1 Spaces of diesel engine parts bearing pressure are to be subject to the hydraulic testing in accordance with Table 5.8.1.1.

The cooling chamber and air cooler test pressure of cylinder heads and cylinder sleeves of air compressors is to be 1.5 times the working pressure of cooling water.

Hydraulic Testing Pressure

Table 5.8.1.1

SN	Item	Testing pressure ^{note 1}
1	Cooling chamber of cylinder head	0.7MPa
2	Cylinder sleeve (in the overall length of cooling chamber)	0.7MPa
3	Cooling chamber of cylinder body	1.5, but no less than 0.4MPa
4	Cooling chamber of vent valve	1.5, but no less than 0.4MPa
5	Top cooling chamber of piston (test after an enclosed space is formed with the piston rod)	0.7MPa
6	High-pressure fuel injection system: Pressure surface of high-pressure oil pump body Oil atomizer High-pressure oil pipeline	1.5or+30MPa, whichever is smaller 1.5or+30MPa, whichever is smaller 1.5or+30MPa, whichever is smaller

7	Hydraulic high-pressure pipeline of hydraulic system for driving the vent valve	1.5
8	Cylinder of scavenging pump	0.4MPa
9	Cooling chamber of turbosupercharger	1.5, but no less than 0.4MPa
10	Cooling chamber of exhaust pipe	1.5, but no less than 0.4MPa
11	Engine driven air compressor (cylinder, cylinder head, intermediate cooling chamber, aftercooling chamber): Air side Water side	1.5 1.5, but no less than 0.4MPa
12	Each side of cooler ^{note 2}	1.5, but no less than 0.4MPa
13	Engine driven pumps (oil, water, fuel and sewage)	1.5, but no less than 0.4MPa

Note 1: P means the maximum operating pressure of tested part.

Note 2: Only water side needs to be tested for air cooler.

CHAPTER 6 TRANSMISSION GEARING

Section 1 GENERAL PROVISIONS

6.1.1 Application

6.1.1.1 The requirements of this Chapter are applicable to transmission gearing for propulsion of fishing vessels where the power transmitted by involute cylindrical gear exceeds 100kW and transmission gearing for main engines front-end output and auxiliary engines.

6.1.1.2 The torsional vibration of transmission gearing is to comply with relevant provisions as prescribed in Section 4 of CHAPTER 7 in this PART.

6.1.1.3 For transmission gearing above with transmitted power no more than 100kW, some requirements may be broadened where appropriate according to the operation conditions and applications, provided that the overall security is put into priority.

6.1.2 Fixing

6.1.2.1 The transmission gearing is to be rigid enough, and reliably secured on the foundation of hull with bolts or other appropriate methods. Generally, there shall be no less than four fitting bolts.

Section 2 MATERIALS

6.2.1 Material properties

6.2.1.1 Shafts, gear, wheel's rim, if any, couplings, etc. of the transmission gearing are to be made of steel forgings, and the materials for forgings are to be in accordance with the relevant requirements of CHAPTER 4 of PART 7.

6.2.1.2 For through-hardened gears, provision is to be made for a hardness differential between pinion teeth and wheel teeth. For this purpose, the specified tensile strength of the wheel material is not to be more than 85% of that of the pinion and not to be less than 490 N/mm².

6.2.1.3 The minimum tensile strength of the core is to be 800 N/mm² for induction-hardened or nitrided gearing and 750N/mm² for carburized gearing.

6.2.2 Non-destructive tests

6.2.2.1 The gear forgings with diameter exceeding 200 mm after machining shall be subjected to ultrasonic inspection before cutting teeth.

6.2.2.2 Magnetic particle or liquid penetrant examination is to be carried out on all surface-hardened teeth. This examination may also be requested on the finished machined teeth of through-hardened gears.

Section 3 Load-Carrying Capacity Calculation of Gears

6.3.1 Symbols and definitions

a —center distance, in mm;

b —face width, two bevel wheels width $b = 2b_B$ for double helical tooth, of which b_B means the single bevel wheel width of double helical tooth. When the wheel width is different from that of pinion, the smaller value is to be taken, in mm;

d —reference diameter, in mm;

d_a —tip diameter of pinion, wheel, in mm;

d_b —base diameter, in mm;

d_f —root diameter of pinion, wheel, in mm;

h_a —addendum, in mm;

h_f —dedendum, in mm;

ρ_F —root fillet radius at the 30 °tangent point, in mm;

h_{ao} —addendum of cutter (see Figure 6.3.4.2), in mm;

ρ_{ao} ——root fillet radius of cutter (see Figure 6.3.4.2), in mm;

ρ_{ro} ——protuberance of cutter (see Figure 6.3.4.2), in mm;

h ——tooth depth, in mm;

m_n ——normal module, in mm;

m_t ——transverse module, in mm, $m_t = \frac{m_n}{\cos \beta}$;

β ——helix angle at reference cylinder, °;

α_n ——normal pressure angle at reference cylinder, °;

β_b ——helix angle at base cylinder, °; $\tan \beta_b = \tan \beta \cos \alpha_t$;

α_t ——transverse pressure angle at reference cylinder, $\tan \alpha_t = \frac{\tan \alpha_n}{\cos \beta}$;

α_{tw} ——transverse pressure angle at pitch diameter, °; $\cos \alpha_{tw} = \frac{m_t(Z_1 + Z_2) \cos \alpha_t}{2a}$;

Z ——number of teeth;

Z_n ——virtual number of teeth, $Z_n = \frac{Z}{\cos^2 \beta_b \cos \beta}$;

u ——gear ratio, $u = \frac{Z_2}{Z_1} > 1$;

V ——linear velocity at pitch diameter, in m/s;

X ——addendum modification coefficient of pinion, wheel;

F_t ——nominal tangential load, N, $F_t = \frac{2000T_1}{d_1} = \frac{2000T_2}{d_2}$;

T ——rated torque transmitted by gear; during calculation, T1 and T2 means the value of pinion and wheel respectively, in N m;

ε_α ——transverse contact ratio, $\varepsilon_\alpha = \frac{g}{\pi m_t \cos \alpha_t}$;

Where, $g = 0.5\sqrt{d_{a1}^2 - d_{b1}^2} \pm 0.5\sqrt{d_{a2}^2 - d_{b2}^2} - a \sin \alpha_{tw}$, “+” for external gearing and “-” for internal gearing;

ε_β ——overlap ratio, $\varepsilon_\beta = \frac{b \sin \beta}{\pi m_n}$; $b = 2b_B$ in case of double helical tooth

6.3.2 Calculation of surface contact stress

6.3.2.1 The calculated surface contact stress σ_H at the pitch diameter of gear is not to exceed the permissible surface contact stress σ_{Hp1} and σ_{Hp2} of pinion and wheel.

6.3.2.2 Surface contact stress σ_H is to be determined as follows:

$$\sigma_H = 189.8 Z_H Z_\varepsilon Z_\beta \sqrt{\frac{F_t}{d_1 b} \frac{u+1}{u}} \sqrt{K_A K_v K_{H\beta} K_{H\alpha}} \quad \text{N/mm}^2$$

Where, Z_H ——zone factor, $Z_H = \sqrt{\frac{2 \cos \beta_b \cos \alpha_{tw}}{\cos^2 \alpha_t \sin \alpha_{tw}}}$;

Z_ε ——contact ratio factor,

$$Z_\varepsilon = \sqrt{\frac{1}{\varepsilon_\alpha}} \quad \text{for } \varepsilon_\beta \geq 1;$$

$$Z_\varepsilon = \sqrt{\frac{4 - \varepsilon_\alpha}{3} (1 - \varepsilon_\beta) + \frac{\varepsilon_\beta}{\varepsilon_\alpha}} \quad \text{for } \varepsilon_\beta < 1;$$

Z_β — helix angle factor, $Z_\beta = \sqrt{\cos \beta}$;

K_A — application factor, see Table 6.3.2.2:

Application Factor K_A

Table 6.3.2.2

Prime motor	Type of prime motor and transmission gearing coupler	K_A	
		Main engine	Auxiliary engine
Turbine, motor	Any type	1.00	1.00
Diesel engine	Hydraulic coupler or electromagnetic coupler	1.00	1.00
	High-elastic coupler	1.30	1.20
	Elastic coupler	1.40	1.30
	Rigid coupler	1.50	1.40

K_V — internal dynamic factor, for the gear with straight tooth $Z_1 V \leq 1000 \text{ m/s}$ and skewed tooth $Z_1 V \leq 1400 \text{ m/s}$, K_V value is: $K_V = 1 + 3.5 Q_{II}^2 Z_1 V (2 + \sqrt{\varepsilon_\beta})^{-1} 10^{-5}$; for the gear with higher $Z_1 V$ value, K_V value is to be provided by the manufacturer.

Where, Q_{II} means the accuracy grade of tolerance group II of gear; the greater value of wheel and pinion is to be taken;

$K_{H\beta}$ — face load distribution factor; for the gear without helical modification, $K_{H\beta}$ value is:

$$K_{H\beta} = 1 + 0.02 Q_{III} + \frac{(Q_{III}^2 - 14)b}{10^5} + 0.18 \left(\frac{b}{d_1}\right)^2$$

Where, Q_{III} means the accuracy grade of tolerance group III of gear; the greater value of wheel and pinion is to be taken, and the double helical gear $b = b_B$;

$$K_{H\alpha} \text{ — Transverse load distribution factor, } K_{H\alpha} = 1 + \frac{10 b f_{pb}}{F_t K_A K_V K_{H\beta}},$$

Whereof, f_{pb} means the base circle pitch deviation; the greater value of wheel and pinion is to be taken, μm ;

If f_{pb} is smaller than the tooth error f_f , f_f value is to be taken;

If the teeth of pinions and wheels are to be suitably relieved on flanks, the 1/2 value of f_{pb} (or f_{pb}) is to be taken.

$$\text{If } K_{H\alpha} > \frac{1}{Z_\varepsilon^2}, \quad K_{H\alpha} = \frac{1}{Z_\varepsilon^2}.$$

6.3.2.3 Permissible contact stress σ_{Hp} is to be determined as follows:

$$\sigma_{Hp} = \frac{\sigma_{H\lim}}{S_H} Z_L Z_R Z_V Z_W \quad \text{N/mm}^2$$

Where, $\sigma_{H\lim}$ — endurance limit for contact stress, N/mm^2 ; as specified in curves in Figures 6.3.2.3-1 ~

6.3.2.3-3 according to the gear materials, thermal treatment method and surface hardness, etc.

S_H — safety factor for contact stress, see Table 6.3.2.3;

Contact Stress and Bending Stress Safety Factors S_H and S_F

Table 6.3.2.3

	S_H	S_F

Main engine gear	1.20	1.55
Auxiliary engine gear	1.15	1.40

Z_L ——lubrication factor:

$Z_L = 0.83 + 0.68v_f$ (for through-hardened steel);

$Z_L = 0.91 + 0.36v_f$ (for surface-hardened steel);

Where, $v_f = \frac{1}{(1.2 + \frac{80}{v_{50}})^2}$, v_{50} means the kinematic viscosity of lubricating oil at 50℃, mm²/s;

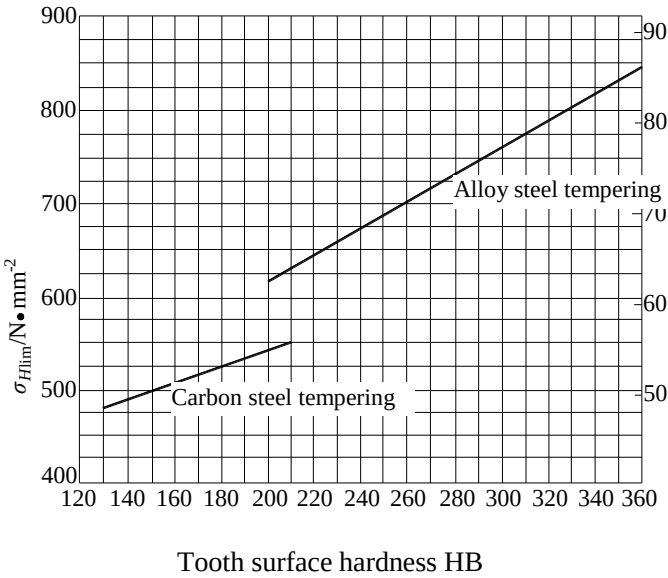


Figure6.3.2.3-1 Contact Fatigue Limiting Stress

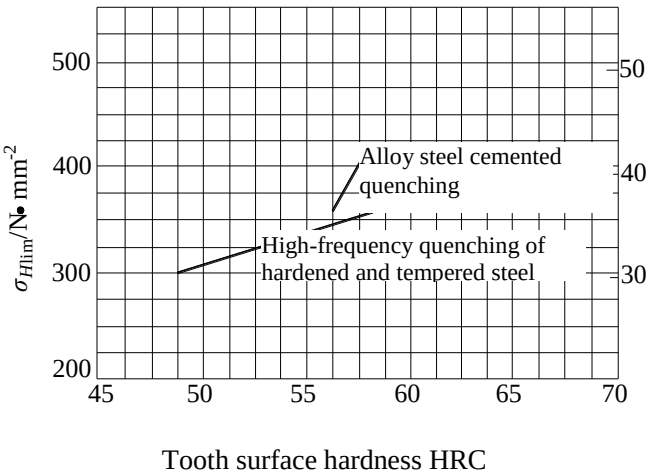
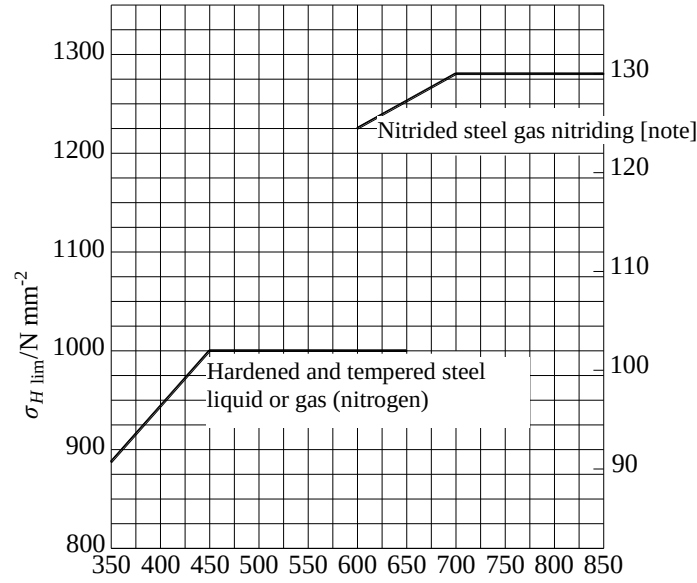


Figure6.3.2.3-2 Contact Fatigue Limiting Stress



Tooth surface hardness HV

Note: including aluminum steel gas nitriding HV ≤ 750

Figure 6.3.2.3-3 Contact Fatigue Limiting Stress

Z_R —roughness factor, $Z_R = \left(\frac{3}{R_{zm}}\right)^c$, where $R_{zm} = \frac{R_{Z_1} + R_{Z_2}}{2} \cdot \sqrt[3]{\frac{100}{a}}$, μm ;

Where, R_{Z_1} and R_{Z_2} mean the average roughness of tooth surface after wheel and pinion running-in, m; for surface hardening steel, $c=0.08$; for through-hardened steel, $c=0.15$;

Z_V —velocity factor:

$$Z_V = 0.93 + 0.14V_p \quad (\text{for surface-hardened steel});$$

$$Z_V = 0.85 + 0.3V_p \quad (\text{for through-hardened steel});$$

Where, $V_p = \frac{1}{\sqrt{0.8 + \frac{32}{V}}}$;

Z_w —working hardening factor of tooth surface:

When the wheel tooth surface thickness HB_2 is 130~400, and the arithmetic mean value of pinion tooth surface average roughness $R_a < 1 \mu m$, $Z_w = 1.2 - \frac{HB_2 - 130}{1700}$; $Z_w = 1$ in other conditions.

6.3.3 Tooth root bending strength calculation

The tooth root bending stress for pinion and wheel σ_{F1} and σ_{F2} is not to exceed the permissible bending stress of pinion and wheel

6.3.3.2 The tooth root bending stress is to be calculated as follows: (see Figure 6.3.3.2):

$$\sigma_F = \frac{F_t}{bm_n} Y_{FS} Y_\varepsilon Y_\beta K_A K_V K_{F\beta} K_{F\alpha} \quad N/mm^2$$

Where: Y_{FS} —composite tooth form factor, $Y_{FS} = Y_{Fa} Y_{sa}$

$$\text{Tooth form factor: } Y_{Fa} = \frac{6\left(\frac{h_{Fa}}{m_n}\right) \cos \alpha_{Fan}}{\left(\frac{S_{Fn}}{m_n}\right)^2 \cos \alpha_n};$$

$$E = \frac{\pi}{4} m_n - h_{ao} \tan \alpha_n + h_k (tg \alpha_n - tg \alpha_{pro}) - (1 - \sin \alpha_{pro}) \frac{\rho_{ao}}{\cos \alpha_{pro}} \quad \text{mm}$$

For non-convex cutter, $\alpha_n = \alpha_{pro}$;

$$G = \frac{\rho_{ao}}{m_n} - \frac{h_{ao}}{m_n} + X;$$

$$H = \frac{2}{Z_n} \left(\frac{\pi}{2} - \frac{E}{m_n} \right) - \frac{\pi}{3} \quad \text{rad}$$

$\theta = \frac{2G}{Z_n} \tan \theta - H$, rad; the initial value of $\theta = \pi/6$ can be substituted into the formula for trial calculation;

$$\frac{S_{Fn}}{m_n} = Z_n \sin \left(\frac{\pi}{3} - \theta \right) + \sqrt{3} \left(\frac{G}{\cos \theta} - \frac{\rho_{ao}}{m_n} \right);$$

$$d_n = \frac{d}{\cos^2 \beta_b} \quad \text{mm};$$

$$d_{bn} = d_n \cos \alpha_n \quad \text{mm};$$

$$d_{an} = d_n + d_a - d \quad \text{mm};$$

$$\alpha_{an} = \arccos \left(\frac{d_{bn}}{d_{an}} \right) \quad \text{rad};$$

$$\text{inv} \alpha_n = \tan \alpha_n - \alpha_n \quad \text{rad};$$

$$\text{inv} \alpha_{an} = \tan \alpha_{an} - \alpha_{an} \quad \text{rad};$$

Where, α_n, α_{an} are in the unit of rad.

$$\gamma_a = \frac{1}{Z_n} \left(\frac{\pi}{2} + 2X \tan \alpha_n \right) + \text{inv} \alpha_n - \text{inv} \alpha_{an} \quad \text{rad};$$

$$\alpha_{Fan} = \alpha_{an} - \gamma_a \quad \text{rad};$$

$$\frac{h_{Fn}}{m_n} = \frac{1}{2} \left[(\cos \gamma_a - \sin \gamma_a \tan \alpha_{Fan}) \frac{d_{an}}{m_n} - Z_n \cos \left(\frac{\pi}{3} - \theta \right) - \frac{G}{\cos \theta} \right] + \frac{\rho_{ao}}{m_n};$$

For internal meshing gear:

$$\frac{S_{Fn2}}{m_n} = 2 \left(\frac{\pi}{4} + \tan \alpha_n \frac{h_{f2} - \rho_{ao2}}{m_n} + \frac{\rho_{ao2} - P_{ro}}{m_n \cos \alpha_n} - \frac{\sqrt{3} \rho_{ao2}}{2m_n} \right);$$

$$\frac{h_{Fn2}}{m_n} = \frac{d_{a2} - d_{f2}}{2m_n} - \left[\frac{\pi}{4} + \left(\frac{h_{f2}}{m_n} + \frac{d_{a2} - d_{f2}}{2m_n} \right) \tan \alpha_n \right] \tan \alpha_n - \frac{\rho_{ao2}}{2m_n};$$

The stress correction factor $Y_{sa} = (1.2 + 0.13L_a)Q_s^A$ is to be calculated as follows:

$$L_a = \frac{S_{Fn}}{h_{Fa}};$$

For external meshing: $\rho_F = \rho_{ao} + \frac{2m_n G^2}{\cos \theta (Z_n \cos^2 \theta - 2G)}$, mm; for internal meshing: $\rho_F = \rho_{ao}$, mm;

$$Q_s = \frac{S_{Fn}}{2\rho_F};$$

$$A = \frac{1}{1.21 + \frac{2.3}{L_a}};$$

Y_ε — contact ratio factor, $Y_\varepsilon = 0.25 + \frac{0.75}{\varepsilon_\alpha}$;

Y_β — helical angle factor, $Y_\beta = 1 - \frac{\beta}{120}$, for $\varepsilon_\varepsilon \geq 1$;

$Y_\beta = 1 - \frac{\beta}{120} \varepsilon_\beta$, for $\varepsilon_\varepsilon < 1$; when $\beta > 30^\circ$; take $\beta = 30^\circ$;

K_A — see 6.3.2.2 of this PART;

K_V — see 6.3.2.2 of this PART;

$K_{F\beta}$ — load distributing factor along tooth, $K_{F\beta} = K_{H\beta}$; see 6.3.2.2 of this PART for $K_{H\beta}$;

K_{Fa} — load distributing factor between teeth, $K_{Fa} = K_{Ha}$, but $K_{Fa} \leq \frac{1}{Y_\varepsilon}$; see 6.3.2.2 of this PART for

K_{Ha} .

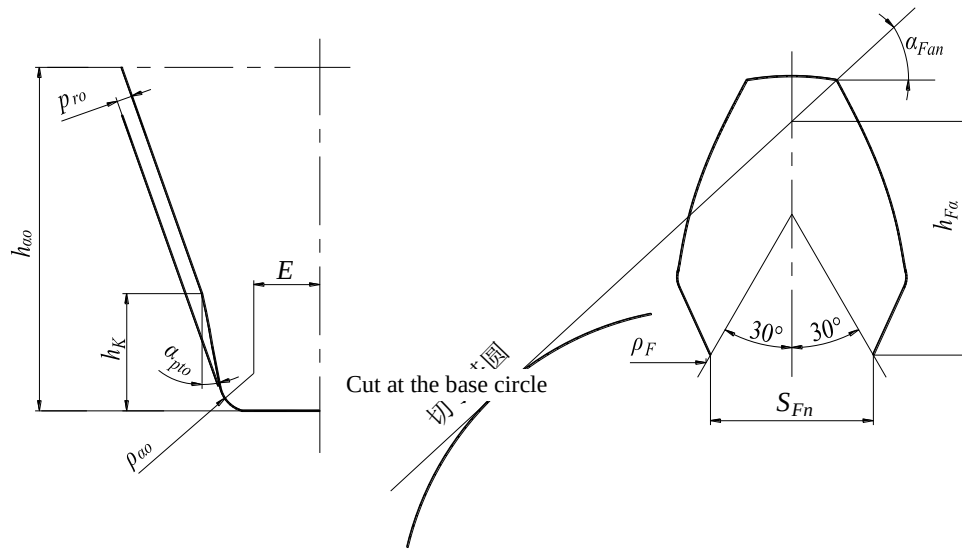


Figure 6.3.3.2 Cutter Basic Tooth Profile Size, Tooth Root Chordal Tooth Thickness S_{Fn} and Bending Moment

Arm h_F

6.3.3.3 The permissible tooth root bending stress σ_{FP} is to be determined as follows:

$$\sigma_{FP} = \frac{2\sigma_{F\lim}}{S_F} Y_D Y_\delta Y_R Y_X \quad \text{N/mm}^2$$

Where, $\sigma_{F\lim}$ — bending fatigue limiting stress, N/mm^2 is as specified in Figures 6.3.3.3 (1)~ (3) according to gear materials, thermal treatment and surface hardness. For alloy steel cemented quenching gears containing Cr, Ni and Mo elements, the $\sigma_{F\lim}$ can be increased by 5%~10% (the increased value is applicable to gears containing two or more than two of the elements aforesaid).

S_F — bending stress safety factor; see Table 6.3.2.3 of this PART;

Y_D — device factor:

For gears bearing the one-directional (pulsating) load, $Y_D = 1$;

For gears bearing alternating load, $Y_D = 0.70$;

For gears bearing full double-directional torque, $Y_D = 0.75$;

For gears with ahead and astern functions, $Y_D = 0.90$;

For shrink-fit gear rings, $Y_D = 0.80$;

Y_δ ———relative sensitivity factor of tooth root fillet;

$$Y_\delta = 0.96 + \frac{0.08}{\rho_F} \quad (\text{for carburized hardening and high-frequency quench hardening gears});$$

$$Y_\delta = 0.8 + \frac{0.3}{\sqrt{\rho_F}} \quad (\text{for nitrided gears});$$

$$Y_\delta = 1 + \frac{80 - 40\rho_F}{R_{eH}\rho_F} \quad (\text{for through-hardened gears});$$

Where, R_{eH} means the yield point of gear material or specified non-proportional elongation stress, N/mm^2 ;

When $\rho_F < 1\text{mm}$, take $\rho_F = 1\text{mm}$;

$$Y_R \text{ ———relative surface state factor: } Y_R = 1 - \lg\left(\frac{R_z}{10}\right)^k ;$$

Where, $k = 1/6$ (for tempering gears), $k = 1/25$ (for nitrided gears), $k = 1/10$ (for soft tooth surface gears or non-nitrided surface-hardened gears);

R_z means the average surface roughness of tooth root fillet, μm ;

When $R_z \leq 15 \mu\text{m}$, $Y_R = 1$;

Y_x ———size factor:

$$Y_x = 1.03 - 0.006 m_n \quad (\text{for through-hardened gears}), \text{ but } 0.85 \leq Y_x \leq 1;$$

$$Y_x = 1.05 - 0.01 m_n \quad (\text{for surface-hardened gears}), \text{ but } 0.75 \leq Y_x \leq 1.$$

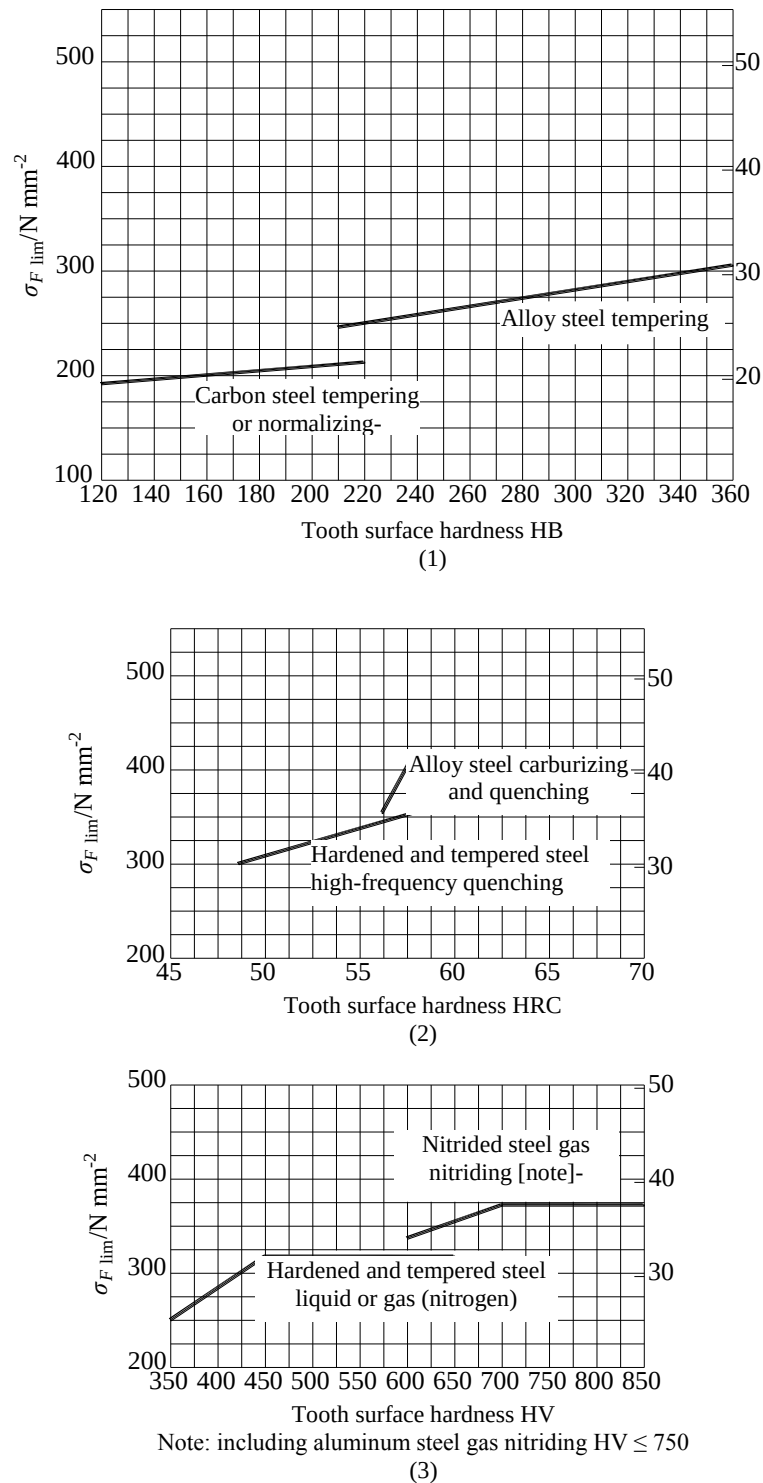


Figure 6.3.3.3 Materials, Thermal Treatment and Surface Hardness of Gear

6.3.4 Miscellaneous

6.3.4.1 Where the gear load bearing capacity is calculated with other methods, the detailed technical data is to be submitted to CCS for review.

Section 4 MAIN STRUCTURE

6.4.1 Tooth form

6.4.1.1 The roots of teeth are to be formed with smooth fillets of radius not less than $0.38 m_n$.

6.4.1.2 Where $b/d_1 > 1.5$, the ends of the teeth are to be chamfered.

6.4.1.3 The teeth of pinions and wheels are to be suitably relieved on flanks in cases where any of the following conditions applies:

- (1) normal module of teeth exceeds 6 mm;
- (2) ratio of addendum of pinion teeth to total working depth of engagement exceeds 0.65;
- (3) ratio of total working depth of engagement to normal pitch of teeth exceeds 0.75.

6.4.2 Tooth surface

6.4.2.1 The hardened layer of the surface-hardened gear is to be distributed over and extended to the whole tooth surfaces and fillets.

6.4.2.2 For nitrided gear, generally, the depth of nitrided layer is to be more than 0.5mm, and the hardness at the depth of $0.25 m_n$ is to be no less than HV500.

6.4.2.3 For surface-hardened gears (except the nitrided), the depth of hardened layer is not to be less than $0.15 m_n$.

6.4.2.4 For carburized gears, the surface hardness is not to be less than HRC 56.

6.4.3 Gears

6.4.3.1 The manufacturing accuracy of gears transmitting power for diesel engines is not to be less than grade 7.

6.4.3.2 Where rim and boss of the wheels are secured with bolts, the bolts are to be tight fit in holes and suitably locked.

6.4.4 Gear shafts

6.4.4.1 The diameter d of the torsion shafts is not to be less than the value obtained from the following formula:

$$d = 100 \sqrt[3]{\frac{400 N_e}{n_e R_m}} \quad \text{mm}$$

Where, N_e —the maximum continuous output transmitted by the shaft, in kW;

n_e —speed of the shaft at N_e , in r/min;

R_m —tensile strength of shaft material, N/mm², but not exceeding 1,100 N/mm².

6.4.4.2 The diameter of gear shafts is to be calculated in accordance with 7.2.2.1 of this PART.

6.4.4.3 Where the gear is fitted on the gear shaft by key or shrink-fit, the diameter of gear shafts at the fitting area is to be increased by 5% over the value determined in 6.4.4.2.

6.4.4.4 Where the wheel shaft is driven by only one pinion or by two pinions arranged to subtend an angle at the centre of the shaft of less than 120 °, the diameter of the wheel shaft between bearings is at least to be increased by 15% over the value determined by 6.4.4.1 of this PART. Where it is driven by two pinions arranged to subtend an angle at the centre of the shaft of equal to or more than 120 °, the diameter of the wheel shaft between bearings is to be increased by 10%.

6.4.5 Gear casings

6.4.5.1 Gear casings of welded construction are to be in accordance with the relevant requirements of CHAPTER 6, PART 8.

6.4.5.2 Main thrust bearings for propulsion are to be installed in the gear casings.

6.4.5.3 Gear casings are to be of sufficient strength and rigidity, and are to be provided with inspection openings and adequate venting devices.

6.4.6 Connections

6.4.6.1 Where the coupling of the output shaft is fitted by means of the oil pressure injection method without shrink fit, the actually selected axial thrust amount S (mm) or interference amount δ (mm) is to comply with the provisions of 7.3.2.4 in this PART. Where shrink-fit is employed, 0.03 in the formula may be ignored.

6.4.6.2 For the fit of rim to boss, boss to shaft and the fit of other transmission items, the appropriate interference amount and thrust amount are to be provided.

6.4.6.3 Clutches and flange, flexible couplings in the transmission gearing are to comply with the requirements of Section 3, Chapter 7 of this PART.

6.4.7 Accuracy of meshing

6.4.7.1 Tooth faces are to be evenly meshed. The contact marking of gear pair is not to be less than Grade 7.

6.4.8 Lubricating and cooling

6.4.8.1 Lubricating oil is to be efficiently conveyed to all bearings, meshed gears and other portions requiring lubrication. The arrangement of oil pockets of sliding bearings is to be such that the effect of combined dynamic force of bearings is taken into account.

6.4.8.2 The lubricating oil system of transmission gearing for diesel engines is to be independent. Thermometers and pressure gauges are to be provided in the pressure lubricating oil systems, and working oil pressure gauge is to be fitted in addition when hydraulic system is employed. An oil level indicator is to be provided for the oil sump of splash lubrication.

6.4.8.3 Where an independent circulating lubrication system is fitted to the gear casing, a standby lubricating oil pump is to be installed.

For fishing vessels with multiple engines and propellers, lubricating oil pumps are to be fitted.

For gear casings with transmitted power no more than 441kW, standby lubricating oil pumps may be dispensed.

6.4.8.4 Filters are to be fitted in the pressure lubricating oil systems and their construction is to guarantee internal cleaning in case of continuous filter oil supply.

For filters in gear casings with transmitted power no more than 220 kW, bypass pipes may be fitted so that the lubricating oil can be still supplied in the emergency state of blocked filter.

For gear casings with transmitted power no less than 750kW, magnetic filters may be fitted in the lubricating oil systems.

6.4.8.5 Gear casings for propulsion with transmitted power no more than 220 kW are to be fitted with low pressure alarm devices of lubricating oil. Gear casings for propulsion with transmitted power more than 441kW are to be also fitted with high pressure alarm devices of lubricating oil.

6.4.8.6 The lubricating oil temperature in the transmission gearing is not to exceed 70°C, and not to exceed 80°C if roller bearing is fitted.

6.4.8.7 Cooling pipes passing through gear casings are not to have any detachable joint.

6.4.9 Emergency devices

6.4.9.1 For hydraulically controlled transmission gearing, emergency mechanical means are to be provided to ensure that the fishing vessel can run at a reasonable speed in the event of failure of hydraulic control systems.

6.4.10 Tachometers

6.4.10.1 Gear casings with transmitted power more than 441kW and slip devices are to be fitted with tachometers of output shafts.

6.4.11 Hydraulic multiple-disc clutches

6.4.11.1 Hydraulic multiple-disc clutches and their control systems are to be so designed and constructed to ensure stable clutching and fast declutching.

6.4.11.2 The margin coefficient of torque transmitted by multiple-disc clutches is to be no less than 1.5.

6.4.11.3 The construction and arrangement of hydraulic multiple-disc clutches are to facilitate the replacement of quick-wear parts such as friction tooth piece and oil-sealing ring without disassembly of shafts or casings as far as possible.

6.4.11.4 In gear casings with transmitted power more than 441kW where multiple-disc clutches are fitted are to be generally provided with standby working oil pumps. If the working oil pumps are engine driven pumps easy to be assembled and disassembled, they may be replaced with complete standby pumps.

6.4.12 Astern power

6.4.12.1 The astern power transmitted by transmission gearing is to be no less than 70% of rated output during ahead running.

6.4.13 Reversal speed and time

6.4.13.1 The maximum speed of any gear change is to be no less than 65% of nominal speed of main engines. Fast gear change at no less than 90% of nominal speed of main engines in case of emergency is to be taken into account during design.

6.4.13.2 The reversal time of transmission gearing is not to be more than 12s. The reversal time means the duration from start of ahead running (reversal) to start of reversal (ahead running).

6.4.14 Speed ratio switching

6.4.14.1 Dual-speed-ratio gear casings are to switch the speed ratio at the nominal speed of main engines.

6.4.15 Manoeuvring

6.4.15.1 For transmission gearing with dual engines and single propeller, the manoeuvring mechanism is to be provided with interlocking to prevent two main engines from clutching at different propulsion directions.

6.4.15.2 The transmission gearing with transmitted power more than 441kW is to be provided with an indicator of output shaft rotation direction. The indicator may be dispensed if a two-way tachometer is fitted on the output shaft in accordance with the requirements of 6.4.10 of this PART.

6.4.16 Markings

6.4.16.1 For reversible gearing, the directions of lever or handwheel for ahead and astern running are to be marked at control station. As a common practice, to push the lever forward or to turn the handwheel clockwise is the way to move the fishing vessel ahead.

Section 5 TESTS

6.5.1 Balance tests

6.5.1.1 All gears are to be subject to balance tests. Where the linear velocity at the reference circle exceeds 25 m/s, dynamic balance test is to be made. reference circle exceeds 25 m/s, dynamic balance test is to be made. Driven parts of the coupling are to be attached to the gear before balancing.

The residual dynamic unbalance is not to exceed $60/n \times 10^4 \text{ N}\cdot\text{mm/t}$, where n means the maximum working speed (r/min) of test components.

6.5.1.2 Balance test may, however, be omitted for diesel engine gearing, provided that the rotating components are of solid forged construction or have a solid forged centre with shrunk-on rim, and in both cases are machined to give a concentric and uniform cross-section.

6.5.2 Bench trials

6.5.2.1 The transmission gearing is to be tested according to the test programs approved by CCS during bench trials.

CHAPTER 7 SHAFTING AND PROPELLERS

Section 1 GENERAL PROVISIONS

7.1.1 Application

7.1.1.1 This Chapter is applicable to the propulsion and front-end output shafting of fishing vessels propelled by diesel engines.

7.1.2 General requirements

7.1.2.1 Where the couplings are integrated with the thrust shafts, intermediate shafts, tube shafts, screwshafts and front-end output shafts of main engines, no axial displacements of the couplings relative to the shafts shall occur, and excessive stress concentration on the shafts is to be avoided.

7.1.2.2 Materials for shafting and propellers are to comply with the relevant requirements of PART 7.

The specified tensile strength of forgings for steel shafts is to be selected within the following general limits:

- .1 for carbon and manganese steel, 400 to 760 N/mm²;
- .2 for alloy steel, not exceeding 800 N/mm²;
- .3 for austenitic stainless steel, 500 to 600 N/mm²;
- .4 for martensitic stainless steel, 850 to 1000 N/mm²;
- .5 for ferritic-austenitic (duplex alloy) stainless steel, 600 to 750 N/mm²;

For hot-rolled round steels for manufacturing intermediate shafts, tube shafts and screwshafts, etc., the diameter is not to exceed 250 mm.

Shafts resistant to seawater corrosion may be made of forged copper alloy under exceptional circumstances upon approval by CCS.

For shaft couplings, nodular graphite cast iron may also be accepted.

7.1.2.3 The main propulsion shafting together with its transmission gears are to be capable of withstanding sufficient astern power, but are not to lead to overload running of main engines.

7.1.2.4 The sliding bearing temperature in the propulsion shafting, front-end output shafting of main engine and transmission gearing is not to exceed 70°C, and not to exceed 80°C if roller bearing is fitted.

7.1.2.5 In addition to reversing clutch which generates the friction transmission torque based on the thrust force of propellers, propulsion shafting and its transmission gears are to be designed and installed to avoid the axial thrust force on main engine crankshaft from propellers. The front-end output shafting of main engine and its transmission gears are not to limit the axial free movement and stretching of main engine crankshaft.

7.1.3 Alignment of Shafting

7.1.3.1 The number and arrangement of bearings of propulsion shafting and front-end output shafting are to be such as to give reasonable bending moments and bearing reactions. For shafting fitted with transmission gearing, flexible couplings are to be fitted at the input end of gear casing.

7.1.3.2 Where the shafting is aligned by the installation technology with flange bending and deviation, the impact of shaft self-weight is to be taken into account.

7.1.3.3 For propulsion shafting with diameter exceeding 250 mm, the alignments and calculations are to be reasonably conducted and submitted for approval by CCS. The alignment of shafting is to comply with following requirements in hot condition:

- .1 The maximum load carrying capacity of bearing is not to exceed the permissible specific pressure of bearing;
- .2 The positive reaction on each bearing is not to less than 20% of the sum of all weights between two adjacent spans.
- .3 The additional bending stress of shaft is not to exceed the specified value;
- .4 The bending moment and shearing force applied to the output flange of diesel engine is not to exceed the designed value of diesel engine.

7.1.3.4 When necessary, CCS may require submitting “Shafting Alignment Calculation” and “Shafting Alignment Measurement Record”. The actual load error of bearing is not to exceed $\pm 20\%$ of calculated value generally.

7.1.4 Shafting vibration

7.1.4.1 The torsional vibration of shafting is to be calculated in accordance with the requirements of Section 4 in this CHAPTER. Unless particularly required by CCS, the longitudinal vibration and rotational vibration calculations may be exempted.

Section 2 SHAFTING

7.2.1 General requirements

7.2.1.1 The minimum diameter of shafts determined by the formulae in this Section is to be checked for the allowable torsional vibration stress as specified in Section 4 of this CHAPTER.

7.2.2 Diameter of shafts

7.2.2.1 The shaft diameter d is not to be less than the value determined by the following formula:

$$d = FC \sqrt[3]{\frac{N_e}{n_e} \left(\frac{560}{R_m + 160} \right)} \quad \text{mm}$$

Where: F —factor for the type of propulsion installation:

$F = 95$ for intermediate shafts in electric propulsion installation;

$F = 100$ for all other diesel engine propulsion devices and all screwshafts;

N_e ——rated power transmitted through the shaft (losses of gear casings and bearings may be negligible), in kW;

n_e ——speed in revolution of shaft at rated power, in r/min;

R_m ——tensile strength of shaft material. For intermediate shaft, when carbon and manganese steel is used, it is to be taken as 760 N/mm^2 for $R_m > 760 \text{ N/mm}^2$; when alloy steel is used, it is to be taken as 800 N/mm^2 for $R_m > 800 \text{ N/mm}^2$. For screwshaft and tube shaft, it is to be taken as 600 N/mm^2 for $R_m > 600 \text{ N/mm}^2$.

C ——factor for the particular shaft design features, selected according to Table 7.2.2.1;

Factor C for different design features ^{Note 7}

Table 7.2.2.1

Intermediate shafts with					Thrust shafts external to engines		Following types of tube shafts and screwshafts			
Integral coupling flange	Keyless couplings fitted by hydraulic pressure method	keyway	Radial and transverse holes	Longitudinal slot	The portion of thrust shafts outside the thrust collar at a length equal to the thrust shaft diameter, the remainder may be tapered down to the diameter required for the intermediate shaft	In way of axial bearings where roller bearing is used as thrust bearing	The portion of the screwshaft and tube shaft forward of the length of screwshaft required by 7.2.2.4 of this PART till it reaches the aft peak bulkhead	Oil lubrication, with approved oil sealing device, the distance from the stern tube stern section or stern shaft bracket bearing to propeller boss no less than 0.25 d ^{note 6} , or continuous shaft liners are fitted or there is an appropriately protected screwshaft in keyless fitting by oil shrink method are between liners; or propeller with screwshaft integrated to flange section by bolts	Oil lubrication, with approved oil sealing device, or continuous shaft liners are fitted or there is an appropriately protected key-fitted screwshaft between liners; where the seawater can be prevented from ingress between shaft and liner, it also applicable to water lubrication	The tube shaft lubricated with grease in the stern tube
1.0 Note 1	1.0	1.10 Note 2	1.10 Note 3	1.20 Note 4	1.10	1.10	1.15	1.22	1.26	1.40

Note 1: The fillet radius at the base of the flange is not to be less than $0.08d$.

Note 2: For over a length of at least $0.2d$ of the shaft from the ends of keyway and, the diameter of the shaft is to be increased by taking $C = 1.10$. The diameter of the shaft is to be decreased by taking $C = 1.0$ for the range beyond. The fillet radius in the transverse section at the bottom of the keyway is not to be less than $0.0125d$.

Note 3: For over a length of at least $0.2d$ of the shaft from the ends of hole and, the diameter of the shaft is to be increased by taking $C = 1.10$. The diameter of the shaft is to be decreased by taking $C = 1.0$ for the range beyond. The diameter of the hole is not to

be greater than $0.3d$.

Note 4: For over a length of at least $0.3d$ of the shaft from the longitudinal slot and its ends, the diameter of the shaft is to be increased by taking $C=1.20$. The diameter of the shaft is to be decreased by taking $C=1.0$ for the range beyond. The keyway length is not to more than $1.4d$, and the width is not to be more than $0.2d$.

Note 5: For shaft having several design features, the factor is to be the product of several factors.

Note 6: Where, d is calculated with $C=1.0$.

Note 7: The edge of slots or holes on shafts is to be smooth.

7.2.2.2 Screwshafts or tube shafts forward of the aft peak bulkhead may be gradually reduced to the diameter calculated according to $C=1.0$.

The diameter d_0 of front-end output shaft of main engine is not to be less than the value calculated according to formula in 7.2.2.1 of this PART;

Where, N_e —rated power transmitted through the shaft, in kW;

n_e —speed in revolution of shaft at rated power, in r/min;

$C=1.15$ —for the front-end output shaft without transverse transmission load;

$C=1.20$ —for the front-end output shaft bearing the transverse transmission load

7.2.2.4 The diameter of the screwshaft at the shaft section from the front of propeller boss to the front end of stern tube ear bearing is to be no less than the C value calculated according to 7.2.2.1 of this PART. Where such part of shaft section length is less than 2.5 times the diameter of the screwshaft calculated above, the shaft section with calculated diameter conforming to calculation requirements is to extend forward from the front end of bearing after the stern tube, so that the shaft section length with diameter conforming to calculation requirements is no less than 2.5 times specified diameter value.

7.2.3 Shaft correction

7.2.3.1 For hollow shafts where the actual bore d_0 is greater than $0.4d$, the actual bore d_0 is to be corrected according to the following formula:

$$d_c = d \sqrt[3]{\frac{1}{1 - \left(\frac{d_0}{d_a}\right)^4}} \quad \text{mm}$$

Where: d_0 —actual bore diameter of shaft, in mm;

d_c —corrected bore diameter of shaft, in mm;

d_a —actual outer diameter of shaft, in mm;

d —shaft diameter calculated according to the formula 7.2.2.1, in mm.

7.2.4 Shaft liners

7.2.4.1 Tube shafts or screwshafts made of non-corrosive materials are to be provided with seawater corrosion protection facilities.

7.2.4.2 The thickness t of bronze shaft liners shrunk on tube shafts or screwshafts, in way of the bushes, is not to be less than:

$$t = 0.03d + 7.5 \quad \text{mm}$$

where: d — diameter of tube shaft or screwshaft in way of the bushes, in mm.

The thickness of stainless steel liners, where fitted, is to be one-half that obtained above, but not less than 6 mm.

Where other liner materials are used, the thickness and fit with bearing materials, including fitting performance, are to be approved by CCS.

7.2.4.3 The thickness of a continuous liner between the bushes may be somewhat reduced, but is not to be less than $0.75t$.

11.2.4.3 Liners consisting of two or more pieces are to be welded into one piece before fitted, or butt-welded by reliable methods to prevent seawater ingress. The connection portions are not to be located within the bearing range.

7.2.4.5 Where the portion of the shaft between any two lengths of the liner is protected with glass-reinforced plastics or other industrial plastics, the protection at the junction of the liner ends is to be of such a construction as to prevent the shaft from water ingress.

7.2.4.6 Liners are to be fitted on shafts by shrinkage fit or oil pressure method rather than pins.

7.2.4.7 Effective means are to be provided for preventing water from reaching the shaft at the part between the after end of the liner and the propeller boss.

7.2.4.8 For the outboard free surface of screwshafts with multi-engine and multi-propeller propulsion system,

the sealing means protecting seawater erosion is to be particularly taken into account.

7.2.5 Stern tubes and bearings

7.2.5.1 Stern tubes are to have sufficient strength and rigidity and to be easy to install. Bearing pedestals are to be provided with boring margin. Nuts for securing stern tubes are to be locked appropriately.

7.2.5.2 Stern tubes are generally fitted with two bearings.

7.2.5.3 The length of the bearing supporting the Screwshafts is to be as follows:

.1 For water lubricated back and front bearings which are lined with lignum vitae, synthetic rubber or phenolic graphite base plastics, the length of the front and back bearings is not to be less than 4 times and 1.5 times the required diameter for the screwshaft respectively. According to the calculation results of reasonable alignment of shafting, the length of the bearings may be appropriately reduced, upon review and approval by CCS;

.2 The length of the oil lubricated back and front white-metal bearings is not to be less than 2 times and 0.9 time the required diameter of screwshaft respectively;

.3 For oil-lubricated bearings of synthetic rubber, reinforced resin or plastics materials, the length of the bearing is to be not less than twice the diameter of the screwshaft as required. If the normal bearing pressure is less than 0.6 MPa as determined by static bearing reaction calculation taking into account shaft and propeller weight, the length of the bearings may be appropriately reduced. However, the minimum length is to be not less than 1.5 times the actual diameter;

.4 Where other bearing materials or lubrication methods are used, the bearing length shall be approved by CCS;

.5 For the multi-engine and multi-propeller propulsion system, the bearing length of outboard support is not to be less than 4 times of screwshaft diameter.

7.2.5.4 Bearings which are oil lubricated are to be fitted with an approved oil sealing gland. To protect the oil sealing gland, a baffle plate protecting net and cable from being twined is to be provided.

7.2.5.5 The lubricating oil pipe of oil lubricated stern tube bearing shall be arranged to ensure the effective lubrication of front and back bearings. Where the oil gravity tank lubrication system is fitted, the oil tank is to be installed at the appropriate position above the full load water line.

7.2.5.6 The seawater lubricated stern tube bearing is to be provided with a forced water injection device. Such device is to be fitted with a valve or plug cock controlling the water volume on the lubrication pipelines at entrance to aft peak or front bearing of bulkhead and is to be provided with sufficient water. The water supply is to enter the stern tube forward of the bulkhead.

7.2.5.7 The oil lubricated stern tube bearing is to be provided with oil injection, test and discharge connections and vent pipes.

7.2.5.8 Where bearings are oil lubricated, provision is to be made for cooling the oil by maintaining water in the after peak tank above the level of the stern tube or by other suitable means when necessary.

7.2.5.9 Stern tubes may be installed by epoxy resin casting method. The technical standard is to comply with CB*/Z321-81 Epoxy Resin Positioning of Stern Shaft Tubes and Stern Tube Bearings, and the construction technologies are to be approved by CCS.

Section 3 SHAFT TRANSMISSION UNITS

7.3.1 Application

7.3.1.1 The requirements of this Section apply to couplings, clutches, controllable pitch propeller blade actuators. For transmission gearing, see Chapter 6 of this PART.

7.3.2 Couplings

7.3.2.1 The thickness of coupling flanges is not to be less than 20% of the intermediate shaft diameter required, nor is it to be less than the diameter of the fitting coupling bolts whose minimum tensile strength is equivalent to that of the shafts. The fillet radius at the base of the coupling flange is not to be less than 8% of the actual diameter of the shaft at the coupling. Transition fillets are to be smooth and no grooves are to be formed at nuts and bolt heads. Multiple circular arc transitions may be permitted upon approval by CCS.

7.3.2.2 Where the propeller is attached to the screwshaft by means of a coupling flange, the thickness of the flange is not to be less than 25% of the actual diameter of the adjacent part of the screwshaft. The fillet radius at the base of coupling flange is not to be less than 12.5% of the actual diameter of the shaft at the coupling.

7.3.2.3 Where the coupling is fitted to the shaft with a key and the torque is transmitted through the key, the effective sectional area of the key in shear is not to be less than that determined by the following formula, and the tensile strength of the key material is to be equal to or greater than that of the shaft material:

$$BL = \frac{d^3}{2.6d_m} \quad \text{mm}^2$$

Where: B — breadth of key, in mm;

L — effective length of key, in mm;

d — diameter of intermediate shaft determined in 7.2.2.1 of this PART, in mm;

d_m — diameter of shaft at mid-length of the key, in mm.

7.3.2.4 Keyless couplings fitted by hydraulic pressure method are to meet the following requirements:

For general couplings fitted by hydraulic pressure method, the pull-up S (mm) or shrinkage allowance δ (mm) is to meet the following requirements:

$$S_1 \leq S \leq S_2 \text{ mm};$$

$$\delta_1 \leq \delta \leq \delta_2 \text{ mm};$$

$$S_1 = \frac{\delta_1}{K} = \frac{1}{K} [1672 \frac{N_e}{A n_e} (c_1 + c_2) + 0.03] \text{ mm};$$

$$S_2 = \frac{\delta_2}{K} = \frac{0.034 \times 10^{-4}}{K} R_{eH} d_1 (c_1 + c_2) \frac{K_2^2 - 1}{\sqrt{3K_2^4 + 1}} \text{ mm};$$

Where: S_1 — minimum axial pull-up, in mm;

S_2 — maximum axial pull-up, in mm;

δ_1 — minimum shrinkage allowance, in mm;

δ_2 — maximum shrinkage allowance, in mm;

K — taper of the shaft for shrink-fit;

N_e — rated power transmitted by the shaft, in kW;

n_e — speed of the shaft at N_e , in r/min;

A — theoretical contact area of the shrinkage surface, in mm²;

$$C_1 = \frac{1 + K_1^2}{1 - K_1^2} - \mu_1;$$

$$C_2 = \frac{K_2^2 + 1}{K_2^2 - 1} + \mu_2;$$

$$K_1 = \frac{d_0}{d_1};$$

$$K_2 = \frac{d_2}{d_1};$$

$$u_1 = u_2 = 0.3;$$

d_0 — bore diameter of the shaft, in mm;

d_1 — mean diameter of the shaft within the contact length, in mm;

d_2 — mean outside diameter of the coupling within the contact length, in mm;

R_{eH} — specified yield stress of the coupling material, in N/mm².

7.3.2.5 Muff couplings are to have a capacity of transmitting a torque which is 2.7 times the mean torque and their equivalent stress of the maximum shrinkage allowance is not to be more than 70% of the yield stress of the muff material.

7.3.2.6 Where other types of couplings are used, detailed descriptions and calculations are to be submitted to CCS for the purpose of examining their reliability.

7.3.3 Coupling bolts

7.3.3.1 For coupling bolts on the mating surface of couplings, the diameter d_f is not to be less than that given by the following formula:

$$d_f = 0.65 \sqrt{\frac{d^3(R_m + 160)}{DZR_{mb}}} \quad \text{mm}$$

Where: d —diameter calculated according to 7.2.2.1 of this PART, in mm;

Z —number of bolts;

D —pitch circle diameter, in mm;

R_m —tensile strength of the intermediate shaft material, in N/mm²;

R_{mb} —tensile strength of bolt materials, no less than that of intermediate shaft materials, no more than 1.7 times that of intermediate shaft material, but no more than 1,000 N/mm².

7.3.3.2 Where it is proposed to use ordinary bolts for connections, the diameter d_n at the root of thread of the bolts is not to be less than that determined by the following formula:

$$d_n = 25.0 \sqrt{\frac{N_e \times 10^6}{n_e Z D R_m}} \quad \text{mm}$$

Where: N_e —rated output transmitted by the shaft, in kW;

n_e —speed of the shaft at N_e , in r/min;

Other symbols are as defined in 7.3.3.1 of this PART.

The prestressing force and workmanship of ordinary bolts are to be provided for information.

7.3.3.3 Bolts connecting propellers and screwshafts are to be fitting bolts, the diameter of which is to be increased by 5% of that determined in 7.3.3.1 of this PART. The diameter of the fitting bolts at the couplings within the crankshaft and thrust shaft is to be also increased by 5%.

7.3.4 Flexible couplings

7.3.4.1 The manufacturer or designer is to provide the following relevant data of highly flexible couplings adopted: permissible average torque, permissible maximum torque, permissible alternate torque for continuous running, permissible alternate torque for transient running, static torsion angle and rigidity value.

7.3.4.2 Where excessive torque may be generated during main engine start or stop, a torque limiting device may be fitted.

7.3.5 Clutches and control devices

7.3.5.1 The friction elements of clutches for reversible gearing are not to give any slip in normal running. While the clutch is disengaged, the propulsion shafting is not to be dragged along by the driving shaft.

7.3.5.2 The maximum torque transmitted by the clutch is, in general, not to be less than 1.5 times the rated torque of the main engine.

7.3.5.3 The elastic clutches controlled by air pressure are to be provided with air charging pressure gauges, signal devices for indicating clutching and declutching of the clutches and alarm devices for giving warning of high and low air pressures. An emergency device for air charging is to be fitted to the system which supplies air to the pneumatic elastic clutch.

7.3.5.4 For reversible and smooth transmission clutches, the time required for reversal is not to be more than 12 s.

7.3.5.5 Pneumatically or hydraulically operated clutches of single-propeller fishing vessels having main engine output more than 220kW are to comply with provisions of CHAPTER 6 of this PART. A mechanical coupling mechanism is to be fitted to ensure certain navigation capacity of fishing vessels in case of emergency.

7.3.5.6 The pneumatic tyre materials of pneumatic elastic clutches shall be resistant to corrosion and oil, and pneumatic elastic clutches are to operate normally in the temperature range of -5°C to $+60^{\circ}\text{C}$.

7.3.5.7 The force required for manually operating clutches is generally not to be more than 147 N.

7.3.6 Transmission devices for controllable pitch propeller

7.3.6.1 The hydraulic transmission system of controllable pitch propeller blade actuators is to be provided with a separate stand-by pump having a capacity of not less than that required for normal operation of one propeller. The hydraulic system pipeline is to be arranged to facilitate switching of pump sets. Where a pump or pipeline is faulted, the system is to run normally.

7.3.6.2 Where the pitch angle can be remotely controlled by the bridge, the control system is to comply with relevant requirements in CHAPTERS 11 and 12 of this PART.

7.3.6.3 The control system in the engine room is to be interlocked with that in the bridge. For control systems other than those actuated by mechanical devices, a stand-by manual control is to be fitted near the pitch adjustment mechanism.

7.3.6.4 The hydraulic control system is to be fitted with alarm devices, which operate in case of power source failure, in the engine room and bridge.

7.3.6.5 The control system of hydraulic controllable pitch propeller blade actuators is to be such that the blade pitch can be altered efficiently and accurately and is to be fitted with limiters of positive and negative full-load pitch angle.

7.3.6.6 Under any working conditions, the blade position of controllable pitch propellers is to be stable. Its fluctuation at 0° pitch angle is not to exceed $\pm 0.5^\circ$.

7.3.6.7 At the rated speed of the propeller, the time required for the change of pitch angle from 1/3 positive maximum (or 1/3 negative maximum) to 1/3 negative maximum (or 1/3 positive maximum) is not to exceed 15 s.

7.3.6.8 For the hydraulic transmission and control system with controllable pitch propeller, the piping and power elements are to be subject to the hydraulic test at 1.5 times working pressure before installed and subject to the tightness test at 1.25 times working pressure after installed.

7.3.6.9 Generally, a screw pitch emergency control device is to be provided, so screw pitch will be locked at certain position when the power controlling the screw pitch fails.

7.3.7 Transverse propulsion arrangement

7.3.7.1 Transverse propulsion arrangement is to have sufficient transverse thrust to satisfy the working requirements of transverse propulsion of fishing vessels at low speed.

7.3.7.2 Material and test of transverse propulsion arrangement and its components are to comply with the relevant requirements of the Rules.

7.3.7.3 Diesel engines driving transverse propulsion arrangement and power distribution systems are to comply with the relevant requirements of PART 4.

7.3.7.4 The hydraulic system driving transverse propulsion arrangement is to be fitted with alarm devices which operate in case of power source failure, in the engine room and bridge.

7.3.7.5 The design of shafting together with its parts and propeller is to comply with the relevant requirements of this Chapter.

7.3.7.6 The thickness of tunnel of transverse propulsion arrangement is not to be less than the adjacent part of the hull.

7.3.7.7 The shaft sealing device is to be installed to prevent seawater and sand so as to protect steel shafts from sea water.

7.3.7.8 The driving failure is to be alarmed in the bridge.

7.3.7.9 Alarm is to be in the bridge with individual indicators for the following faults:

- .1 overload of prime mover and servounit;
- .2 propeller pitch for controllable pitch propeller plants;
- .3 direction of rotation and r.p.m. for fixed propeller plants;
- .4 power failure of alarm system.

7.3.7.10 It is to be possible to stop the transverse propulsion arrangement from the bridge by means of a system independent of the remote control system.

7.3.7.11 Instrumentation and automation are also to comply with the relevant requirements of CHAPTER 12 of this PART.

Section 4 TORSIONAL VIBRATION

7.4.1 General requirements

7.4.1.1 The requirements of this Section are applicable to the following systems:

- .1 main diesel engine propulsion systems and front-end output power transmission shafting when fitted with engines having rated output no less than 200 kW;
- .2 Shafting of auxiliary engines having rated output no less than 200 kW for significant applications.

7.4.1.2 Diesel engine, absorber and flexible coupling manufacturers are to provide accurate, tested and calibrated torsional vibration parameters.

7.4.2 Torsional vibration calculation

7.4.2.1 In general, the calculation is to cover the resonant conditions arising from all harmonic torque excitation up to order 12, in a speed range of $0.8 n_{\min}$ to $1.2 n_e$ ($n_{\min}$ means the minimum steady speed, r/min; n_e means the rated speed, r/min).

7.4.2.2 The torsional vibration calculation and analysis, including the following main contents and data, are to be submitted to CCS for review:

- .1 All original parameters and system layout required for calculation;
- .2 Equivalent torsional vibration parameters and equivalent system diagram;
- .3 Calculated inherent vibration frequency value and corresponding resonance speed of single node, double nodes and three nodes by Holzer tables;
- .4 Calculated relative amplitude vector sum of all simple harmonics in the speed range;

.5 Torsional vibration stress curves generated by main simple harmonics and strong secondary simple harmonics in the calculated speed range and vibration torques of transmission gearing and flexible couplings (if fitted).

7.4.2.3 The resonance calculation calculations at single node, double nodes and three nodes are to be made for all working conditions of fishing vessels.

7.4.2.4 Where the equivalent torsional vibration system in astern condition is greatly varied with that in ahead condition, the single-node inherent frequency is to be calculated in the astern condition.

7.4.2.5 Generally, 25% of absorbed water volume may be taken for the propeller. 10% of absorbed water volume may be taken for the controllable pitch propeller is to be taken to calculate the single-node inherent frequency at zero-screw pitch.

7.4.2.6 For shafting fitted with flexible couplings or transmission gear, the torsional vibration calculation is to be made for the flameout of one cylinder.

7.4.2.7 The stress superimposed by simple harmonics is to be included in the torsional vibration and used for the system evaluation.

7.4.3 Allowable stresses

7.4.3.1 The allowable torsional vibration stresses for shafting are to be calculated based on the basic diameters of the shafts, i.e. the crankpin diameter for crankshafts, the minimum diameter for intermediate shafts and the minimum diameter between the aft bearing and the bulkhead gland for screwshafts, and the effect of the stress concentration on the plain sections of the shafting may be neglected.

7.4.3.2 The allowable torsional vibration stresses for main engine crankshafts, propeller shafts and front-end output shaft of main engine bearing the transverse transmission load are not to exceed the values given by the following formulae:

Continuous running ($0 < r \leq 1.0$):

$$[\tau_c] = \pm [(52 - 0.031d) - (33.8 - 0.02d)r^2] \text{ N/mm}^2$$

($1.0 < r \leq 1.15$):

$$[\tau_c] = \pm [(18.1 - 0.0113d) + (87.6 - 0.052d)\sqrt{r-1}] \text{ N/mm}^2$$

Transient running ($0 < r < 0.8$):

$$[\tau_t] = \pm 2.0[\tau_c] \text{ N/mm}^2$$

The symbols used in 7.4.3.2 to 7.4.3.4 are defined as follows:

$[\tau_c]$ — allowable torsional vibration stress for continuous running, in N/mm^2 ;

$[\tau_t]$ — allowable torsional vibration stress for transient running, in N/mm^2 ;

d — basic diameter of shafts, mm;

$$r = \frac{n_c}{n_e}$$

n_c — resonance speed, in r/min;

n_e — rated speed, in r/min.

7.4.3.3 The allowable torsional vibration stresses for thrust, intermediate, stern tube shafts, screwshafts and front-end output shafts of main engines without transverse transmission load are not to exceed the values given by the following formulae:

Continuous running ($0 < r < 0.9$),

$$[\tau_c] = \pm C_w C_K C_D (3 - r^2) \text{ N/mm}^2$$

($0.9 < r < 1.15$),

$$[\tau_c] = \pm 1.38 C_w C_K C_D \text{ N/mm}^2$$

Transient running ($0 < r \leq 0.8$),

$$[\tau_t] = \frac{1.7[\tau_c]}{\sqrt{C_K}} \text{ N/mm}^2$$

Where: C_w — material factor: $C_w = (\sigma_b + 160)/18$;

σ_b — tensile strength of shaft, it is to be taken as 600 N/mm^2 for $R_m > 600 \text{ N/mm}^2$;

C_K — shape coefficient, see Table 7.4.3.3;

C_D — size factor, $C_D = 0.35 + 0.9d^{-0.2}$.

Shape coefficient C_K

Table 12.2.3.3

Intermediate shafts			Thrust shafts		Propeller shafts and tube shafts
Integral coupling flange	Shrink fit coupling	Keyway	On both sides of thrust collar	In way of axial bearings where roller bearing is used as thrust bearing	—
1.0	1.0	0.6	0.85	0.85	0.55

7.4.3.4 The allowable torsional vibration stresses for the crankshafts and transmission shafts of diesel engines for generators and of auxiliary diesel engines for essential services and for the crankshafts of propulsion diesel engines running with constant speed are not to exceed the values given by the following formulae:

Continuous running ($0.95 \leq r \leq 1.10$):

$$[\tau_c] = \pm(21.59 - 0.0132d) \quad \text{N/mm}^2$$

Transient running ($0 < r < 0.95$):

$$[\tau_t] = \pm 5.5[\tau_c] \quad \text{N/mm}^2$$

7.4.4 Additional requirements for generators

7.4.4.1 In case of alternating current generators, the resultant vibration amplitudes at the rotor are not to exceed $\pm 2.5^\circ$ electrical degrees under rated load working conditions; not to exceed $\pm 5^\circ$ electrical degrees generally.

7.4.4.2 The vibratory inertia torques imposed on the generator rotors are to be limited to $\pm 2M_e$ over the speed range of $r = 0.95$ to 1.10 (M_e being the mean average torque at the rated speed), and to $\pm 6M_e$ over the range of $r < 0.95$.

7.4.5 Allowable vibratory torques for gearing and flexible coupling

7.4.5.1 The vibratory torque at gear engagement of the transmission gearing arrangements is not, in general, to exceed $1/3$ of the rated full load mean torque in the range of $r = 0.9$ to 1.03 . In cases where tooth surface contact stress and root bending stress of gears are less than the allowable values specified in CHAPTER 6 of this PART, special consideration will be given to the acceptance of higher vibratory torque.

7.4.5.2 Flexible couplings are to be of such design that vibratory torque of the elastic elements is not to exceed the allowable alternating torque for continuous running and not to exceed the allowable alternating torque for transient running.

7.4.6 Restricted speed ranges

7.4.6.1 Restricted speed ranges will be imposed in the regions of resonant speeds n_c , where amplitudes or stresses or torques resulting from shaft vibration exceed the limiting values for continuous running. The engine is not to be run continuously in such restricted speed ranges. There shall be no restricted speed ranges in the range $r = 0.8$ to 1.03 .

7.4.6.2 The following speed range is to be avoided:

$$\frac{16n_c}{18-r} \sim \frac{(18-r)n_c}{16}$$

The restricted speed ranges specified for running are not to cause difficulty to manoeuvring.

7.4.6.3 The restricted speed range may be suitably extended where stresses resulting from torsional vibration approach the τ_t value; may be adequately reduced where they marginally exceed the $[\tau_c]$ value.

7.4.6.4 Restricted speed ranges may also be ascertained by measurements, i.e. the corresponding speed resulting from vibration in excess of allowable stress $[\tau_c]$ for continuous running can be taken, having regard to the tachometer accuracy.

7.4.6.5 Where the torsional vibration causes hammering of transmission gears or where the alternating torque of the elastic elements exceeds the allowable value for continuous running, restricted speed ranges are also to be imposed.

7.4.6.6 Single-node $Z/2$ (four strokes diesel engines) and Z -th simple harmonic (two strokes diesel engines) (Z means the number of cylinders) are not to be led to generally in the speed ranges for ordinary navigation and operation speed. In the working condition of drag net, the torsional vibration stress resulting from resonance and its wave slope is generally not to exceed the $[\tau_c]$ value when $r = 1$; the restricted speed ranges are to be eliminated by reducing the amplitudes as far as possible in the range $r = 0.9$ – 1.03 .

7.4.6.7 Where restricted speed ranges are imposed, the tachometer accuracy is to be within $\pm 2\%$ in way of the restricted speed range.

7.4.6.8 Restricted speed ranges are to be marked red on the tachometer, and notice boards are to be fitted in front of the control stations.

7.4.6.9 The details on restricted speed ranges are to be indicated in the certificates of marine engines.

7.4.7 Measurement

7.4.7.1 The crankshaft flexibility or rigidity value of diesel engines may be calculated by measuring the inherent vibration frequency of crankshaft vibration mode.

7.4.7.2 CCS may decide whether to verify the measurement according to the calculation method and torsional vibration stress (or torque) provided for resonance calculation.

7.4.7.3 Where the error between the measured and calculated inherent vibration frequency is less than $\pm 5\%$, the amplitude and stress (torque) at each position of the system may be calculated by the measured amplitude and stress (torque) according to the vibration type for calculation.

Section 5 PROPELLERS

7.5.1 General requirements

7.5.1.1 Propellers are to be subject to surface mass and size inspection as well as to static balancing test. For built-up propellers and controllable pitch propellers, the static balancing test is to be carried out respectively after machining and assembling with boss and all accessories.

7.5.1.2 Blade fastening studs of built-up propellers are to be made of forged steel having a tensile strength not less than 400 N/mm^2 and not less than that of propeller blade.

7.5.1.3 Fasteners (studs, nuts, etc.) for propellers and for their accessories are to be fitted with reliable devices to prevent loosening and corrosion.

7.5.2 Thickness of propeller blades

7.5.2.1 The thickness of propeller blades t (at $0.25 R$ and $0.6R$ for fixed pitch propellers, and at $0.35 R$ and $0.6 R$ for controllable pitch propellers) is not to be less than that calculated by the following formula:

$$t = \sqrt{\frac{Y}{K - X}} \quad \text{mm}$$

Where: Y — power coefficient, to be obtained from 7.5.2.2 of this PART;

K — material coefficient given in Table 7.5.2.1;

X — Speed coefficient, to be obtained from 7.5.2.3 of this PART.

7.5.2.2 Power coefficient is to be calculated by the following formula:

$$Y = \frac{1.36 A_1 N_e}{Z b n_e}$$

Where: $A_1 = \frac{D}{P} (K_1 - K_2 \frac{D}{P_{0.7}}) + K_3 \frac{D}{P_{0.7}} - K_4$;

For aerofoil sections with trailing edge washback, the value of A_1 obtained from above formula is to be increased by 30%;

D — propeller diameter, in m;

P — pitch at the section under consideration, in m;

$P_{0.7}$ — pitch at $0.7 R$, in m;

R — propeller radius, in m;

K_1, K_2, K_3, K_4 — coefficients given in Table 7.5.2.2;

N_e — rated power of the main engine, in kW;

Z — number of blades;

b — blade width at the section under consideration, in m;

n_e — speed of the propeller at rated power of main engine, in r/min.

Propeller material coefficient K

Table 7.5.2.1

Material	Tensile strength R_m	Material density $G(\text{g/c m}^3)$	Material coefficient K

	(MPa)		
Carbon steel and alloy steel	400	7.9	0.57
Ferritic and martensitic stainless steel	500	7.7	1.04
Austenitic stainless steel	450	7.9	1.04
Cu1 manganese bronze	440	8.3	1
Cu2 nickel-manganese bronze	440	8.3	1
Cu3 nickel-aluminum bronze	590	7.6	1.38
Cu4 manganese-aluminum bronze	630	7.5	1.17

Note 1: For materials other than specified in the above Table, the value K may be determined by making reference to those given in the Table and is to be submitted to CCS for approval.

Note 2: The performance of materials is to comply with relevant requirements of PART 7.

Coefficient K values in way of different diameters of propeller

Table 7.5.2.2

	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8
0.25	634	250	1410	4	82	34	41	380
0.35	520	285	1320	16	64	28	57	420
0.60	207	151	635	34	23	12	65	330

7.5.2.3 Speed coefficient is to be calculated by the following formula:

$$X = \frac{A_2 G A_d n_e^2 D^3}{10^{10} Z b}$$

Where: $A_2 = \frac{D}{P} (K_5 + K_6 \varepsilon) + K_7 \varepsilon + K_8$

D , P , n_e , Z and b as defined in 7.5.2.2 of this PART;

ε —rake angle of propeller blade, °;

K_5 , K_6 , K_7 and K_8 —the coefficient as defined in Table 7.5.2.2;

G —density of the propeller material, in g/cm³;

A_d —expanded area ratio of propeller.

7.5.2.4 The radius of transition fillet between propeller blade and propeller boss is to be no less than 2% and 4% of propeller diameter respectively, and the thickness of propeller boss is to be no less than 90% of blade thickness at the shaft centerline.

7.5.2.5 The thickness of propeller blades is permitted to be calculated by some other appropriate methods for propellers specially designed, but background of test results or service experience is to be provided to CCS for approval.

7.5.3 Fitting of propellers to screwshafts (except for keyless installation by oil shrink method)

7.5.3.1 Where it is proposed to fit the propeller to the screwshaft with a flange, the diameter of flange bolts is to comply with the requirements of 7.3.3.1 and 7.3.3.3 of this PART, and the thickness of flanges is to comply with the provisions of 7.3.2.2 of this PART.

7.5.3.2 Where it is proposed to fit the propeller to the screwshaft with a key, the propeller boss is to have an accurate taper, so that it can be a good fit on the screwshaft cone.

The taper of the coned end of screwshaft is to be from 1/10 to 1/15, and for keyless propellers fitted by oil shrink method, such taper is from 1/15 to 1/18.

The intersection of cylindrical and conical portions of screwshafts is not to be shouldered or rounded. The forward end of the keyway in the screwshaft is to be smoothed and sled-runner shaped. In general, the shape and size may be in accordance with Figure 7.5.3.2, where $r_1 < r_2 < r_3 < r_4$, $AB = BC = CD = DF = x$ (x being depth of keyway).

For $r_1 = x/8$; $r_2 = 3x/8$; $r_3 = 3x/4$; $r_4 = x$; r_5 , refer to Figure 7.5.3.2.

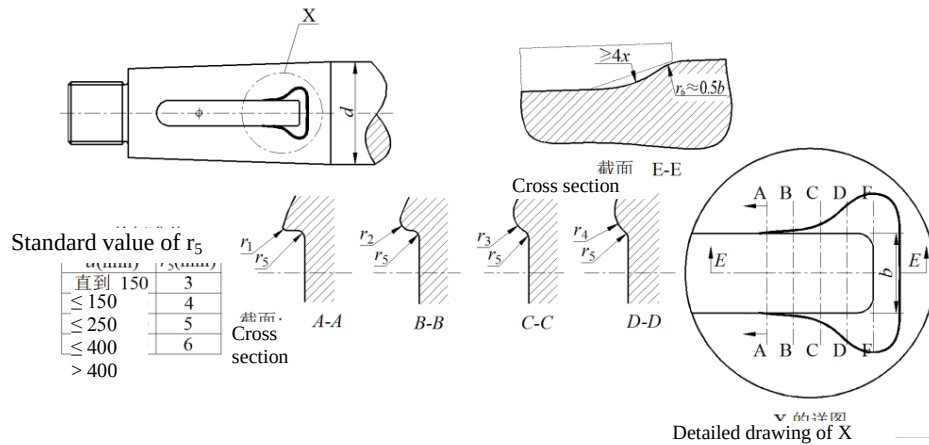


Figure 7.5.3.2 Keyway Shape on Propeller Shaft

The distance from the forward end of the keyway to the big end of conical portion of the shaft is not to be less than 0.2 times the diameter of the big end.

There is to be a clearance between the top of the key and the boss. The lateral sides of the key are to be in close contact with those of the keyways in the screwshaft and the propeller boss. The bottom of the keyways are to be provided with a smooth fillet, and the fillet radius is not to be less than 1.25% of the diameter of the big end of the cone.

Keys are to be generally secured to the shafts by screws. The forward screw is to be placed at least 1/3 of the length of the key from the end. The depth of the screw holes is not to exceed the diameter of screw holes, and the edges of the holes are to be beveled.

7.5.3.3 The outside diameter of the threaded end for the propeller retaining nut is not to be less than 60% of the calculated major taper diameter; threads are to be opposite to the ahead direction of propeller and secured reliably.

7.5.3.4 Where the torques are transmitted completely by the keys, the effective sectional area of the key in shear is not to be less than the value determined by the following formula, and the tensile strength of the key material is to be equal to or greater than that of the shaft material:

$$BL = \frac{d^3}{2.35d_m} \quad \text{mm}^2$$

Where: B — breadth of the key, in mm;

L — effective length of the key, in mm;

d — diameter determined for the intermediate shaft according to 7.2.2.1 of this PART, in mm;

d_m — diameter of shaft at mid-length of the key, in mm.

7.5.4 Fitting of keyless propeller by oil shrink method

7.5.4.1 Where keyless fitting propellers with oil pressure, the axial pull-up length from propeller boss to shaft is to be in compliance with the following requirements:

The maximum equivalent uniaxial stress in the boss at 0°C based is not to exceed 70% of the yield point or 0.2% proof-stress (0.2% offset yield strength) for the propeller material based on the test piece value. For cast iron, the value is not to exceed 30% of the nominal tensile strength.

Where keyless fitting propellers with oil pressure, the axial pull-up length S from propeller boss to shaft may also meet the formulae given below:

Minimum required surface pressure at 35°C:

$$P_{35} = \frac{S_F T}{AB} \left(-\frac{S_F K}{2} + \sqrt{u^2 + B \left(\frac{F_v}{T} \right)^2} \right) \quad \text{MPa}$$

Minimum pull-up length at 35°C:

$$S_{35} = P_{35} \frac{d_1}{K} \left[\frac{1}{E_2} \left(\frac{K_2^2 + 1}{K_2^2 - 1} + u_2 \right) + \frac{1}{E_1} (1 - u_1) \right] \quad \text{mm}$$

Minimum pull-up length at temperature t ($t < 35^\circ\text{C}$):

$$S_t = S_{35} + \frac{d_1}{K} (a_2 - a_1) (35 - t) \quad \text{mm}$$

Corresponding minimum surface pressure at temperature t :

$$P_t = P_{35} \frac{S_t}{S_{35}} \quad \text{MPa}$$

Minimum push-up load at temperature t :

$$W_t = AP_t \left(u + \frac{K}{2} \right) \quad \text{N}$$

Maximum permissible surface pressure at 0°C :

$$P_{\max} = \frac{0.7 R_{eH} (K_2^2 - 1)}{\sqrt{3K_2^4 + 1}} \quad \text{MPa}$$

Maximum pull-up length at 0°C :

$$S_{\max} = \frac{P_{\max}}{P_{35}} S_{35} \quad \text{mm}$$

Maximum pull-up length at 35°C :

$$S_{\max} = \frac{P_{\max}}{P_{35}} S_{35} - \frac{35(a_2 - a_1)d_1}{K} \quad \text{mm}$$

Where, $B = u^2 - \frac{S_F^2 K^2}{4}$

$$F_v = \frac{2000 C M_e}{d_1} \quad \text{N}$$

$$T = 1762 \frac{N_e}{V} \quad \text{N}$$

S_F — factor of safety against friction slip at 35°C , not to be less than 2.8;

T — rated thrust developed for free running fishing vessels, in N;

V — vessel speed at rated horsepower, in kn;

u — coefficient of friction between mating surfaces. For the oil injection method, the coefficient of friction is to be 0.13 for bosses made in bronze, copper or steel;

F_v — shear force at interface, in N;

M_e — rated torque corresponding to N_e and n_e , in Nm;

C — constant

$C = 1$ for turbines, geared diesel engines, electric controls and for direct diesel engines with a hydraulic or an electromagnetic or high elasticity coupling;

$C = 1.2$ for a direct diesel engine.

K — taper of the propeller shaft cone, $K \leq 1/15$;

N_e — rated output transmitted to the propeller shaft, in kW;

n_e — speed at rated output N_e , in r/min;

A — theoretical contact area of propeller boss and propeller shaft, in mm²;

$$K_2 = \frac{d_2}{d_1};$$

d_1 — mean diameter of the shaft within the contact length, in mm;

d_2 — mean outside diameter of the propeller boss, in mm;

$u_1 = 0.30$;

u_2 — Poisson's ratio for propeller material. For copper propeller, in general, $\mu_2 = 0.34$;

E_1 — modulus of elasticity of propeller shaft material, $E_1 = 20.6 \times 10^5 \text{ N/mm}^2$;

E_2 — modulus of elasticity of propeller material. For copper propeller, in general, $E_2 = 1.177 \times 10^5$

N/mm²;

t — temperature at time of fitting propeller on shaft, in $^\circ\text{C}$;

a_1 — coefficient of linear expansion of propeller shaft material, $a_1 = 11 \times 10^{-6} \text{ } 1/^\circ\text{C}$;

a_2 — coefficient of linear expansion of propeller material. For copper propeller, in general, $a_2 = 18 \times 10^{-6}$

$1/^\circ\text{C}$;

R_{eH} — specified yield stress of propeller material, in N/mm².

7.5.4.2 Prior to the fitting of propeller on propeller shaft, the actual contact area of the propeller boss and conical portion of the shaft is not to be less than 70% of the theoretical contact area.

7.5.4.3 The propeller boss is to be marked externally with the following contents:

- .1 Installation methods;
- .2 Axial pull-up of shaft at 0°C and 35°C.

7.5.4.4 A copy of the fitting curve relative to temperature, and data of corresponding loads are to be kept on board. Special tools for fitting and dismantling purposes are also to be provided on board.

7.5.5 Protection of controllable pitch propeller

7.5.5.1 The controllable pitch propeller is to be provided with a sealing device between the blade and boss to protect against water and sand ingress and lubricating oil and grease leakage.

7.5.5.2 Lubricating grease is to be filled in the propeller boss.

Section 6 PRESSURE TEST

7.6.1 Shaft liners

7.6.1.1 Shaft liners are to be subject to the hydraulic tightness test under 0.2 MPa prior to installation after machining.

7.6.2 Stern tubes

7.6.2.1 Stern tubes are to be subject to the hydraulic test under 0.2MPa before installed on board.

CHAPTER 8 BOILERS AND PRESSURE VESSELS

Section 1 GENERAL PROVISIONS

8.1.1 Application

8.1.1.1 The requirements of this Chapter apply to auxiliary boilers and pressure vessels of welded construction:

8.1.2 Classification

8.1.2.1 For the purpose of the Rules, boilers and pressure vessels are classified in accordance with Table 8.1.2.1.

Classes of Boilers and Pressure Vessels

Table 8.1.2.1

	Class I	Class II	Class III
Boilers	$P > 0.35$	$P \leq 0.35$	—
Pressure vessels	$P > 3.92$ or $\delta > 40$ or $t > 350$	P, δ and t all are less than the values in class I, but $P > 1.57$ or $\delta > 16$ or $t > 150$	$P \leq 1.57$ and $\delta \leq 16, t \leq 150$

Note : P means design pressure, MPa; δ means cylindrical shell wall thickness, mm; t means cylindrical wall temperature, °C.

8.1.3 Design pressure

8.1.3.1 Strength calculations for boilers and pressure vessels are to be based on the design pressure. The design pressure is the maximum permissible working pressure for boilers and pressure vessels and not to be less than the opening pressure of safety valve.

8.1.4 Metal temperature

8.1.4.1 The metal temperature is to be taken as the actual metal temperature expected under operating conditions for the pressure part concerned, and is to be stated in the relevant plans of design.

8.1.4.2 The metal temperature of boiler parts is, in any case, not to be less than the value given in Table 8.1.4.2, nor less than 250°C.

Metal Temperature of Boiler Parts

Table 8.1.4.2

	Working condition	Not heated	Heated but well insulated	Subject to convective heat	Subject to radiant heat
Components	Steam or water drum, header	t	$t + 10^\circ\text{C}$	$t + 50^\circ\text{C}$	—
	Boiler generating tube	—	—	$t + 25^\circ\text{C}$	$t + 50^\circ\text{C}$
	Wet back combustion chamber	—	—	—	$t + 50^\circ\text{C}$
	Furnace, smoke duct and back tube sheet in dry back combustion chamber	—	—	—	$t + 90^\circ\text{C}$

Note : t — working medium temperature, °C; for pressure vessels in direct contact with thermal medium the maximum working temperature is to be taken as the metal temperature of the parts.

8.1.5 Allowable stress

8.1.5.1 The allowable stress $[\sigma]$ of boiler and pressure vessel parts is to be determined by the following formulae, and the lower value is to be taken:

.1 Metal temperature equal to or less than 50°C:

$$[\sigma] = R_m/2.7 \text{ or } [\sigma] = R_{eH}/1.8$$

.2 Metal temperature more than 50°C:

$$[\sigma] = R_m/2.7 \text{ or } [\sigma] = R_{eH}/1.8$$

$$[\sigma] = R_{eH}^T/1.6 \text{ or } [\sigma] = R_{m100000}^T/1.5$$

Where: R_m ——specified tensile strength of material at room temperature, in N/mm^2 ;

R_{eH} ——specified yield stress of material at room temperature, in N/mm^2 ;

R_{eH}^T ——specified yield stress or proof stress of material at metal temperature, in N/mm^2 ;

$R_{m100000}^T$ ——average stress to produce rupture in 10^5h of material at metal temperature, in N/mm^2 .

The allowable stress for steel castings is to be taken as 80% of the value determined by the method indicated above, using the appropriate value for cast steel.

8.1.6 Strength factor of welded seam

8.1.6.1 For welded seams welded on both side or on one side with a sealing run, the strength factor ϕ' used in the equations in this Chapter is given in Table 8.1.6.1 based on the method of examination employed.

Strength factor ϕ' of welded seam

Table 8.1.6.1

Class	Strength factor of welded seam	Perspective inspection	Conventional welded seam test plate		Heat treatment
Class I	1	To be done, see CHAPTER 5 of PART 8	To be done		To be done, see CHAPTER 5 of PART 8
Class II	0.85	To be done, see CHAPTER 5 of PART 8	To be done		To be done, see CHAPTER 5 of PART 8
Class III	0.60	—	—		—

8.1.6.2 For boilers of Class II and pressure vessels of Classes II and III where higher joint factor of welded seam than that required for the respective class is selected, the welded seams are to be examined in accordance with the requirements for the higher joint factor of welded seam.

8.1.7 Materials

8.1.7.1 The materials used in the construction of boilers and pressure vessels are to be in compliance with the relevant provisions of PART 7 of the Rules. Where it is proposed to use materials other than those specified in the aforesaid, details of the mechanical properties (including mechanical property values used for the calculation of allowable stresses), chemical compositions and heat treatment are to be submitted to CCS for approval.

8.1.8 Welding and heat treatment

8.1.8.1 The welding, welds examination and post-welding heat treatment of all pressure parts of boilers and pressure vessels are to comply with the requirements of CHAPTER 5, PART 8 of the Rules.

8.1.8.2 Cold-formed cylindrical shells of boilers and pressure vessels are to be subject to stress relief heat treatment, which may be carried out together with the post-welding heat treatment. For cylindrical shell having an inner diameter greater than or equal to 20 times the thickness of shell plate, the heat treatment may be dispensed with.

8.1.8.3 Hot formed parts of boilers or pressure vessels are to be normalized provided that hot forming is not carried out at a temperature within the normalizing range. Parts made of alloy steel are, in addition, to be tempered as necessary.

8.1.9 Miscellaneous

8.1.9.1 Boilers are to be so designed and installed to prevent boilers from moving after installed on board. The legs of boilers are to be secured to adapt to thermal expansion at all parts.

8.1.9.2 Boilers are to be adequately insulated. The insulation is to have a metallic sheathing. When the boiler is under working conditions, the external temperature of the sheathing is generally not to exceed 60°C .

8.1.9.3 Accessories of boilers are to be installed to facilitate safe operation and inspection.

Section 2 AUXILIARY BOILERS

8.2.1 Application

8.2.1.1 This section applies to auxiliary boilers having an evaporating capacity not exceeding 1000kg/h and a design pressure not exceeding 0.78MPa , including vertical auxiliary boilers, horizontal auxiliary boilers and

exhaust boilers.

8.2.2 Cylindrical shells

8.2.2.1 The minimum thickness δ of cylindrical shell and tube plate of auxiliary boiler is to be determined by the following formula:

$$\delta = \frac{pD_0}{2[\sigma]\phi - p} + 0.75 \quad \text{mm}$$

Where: p — design pressure, MPa, as specified in 8.1.3 of this PART;

D_0 — inner diameter of tube hole, mm;

$[\sigma]$ — allowable stress, N/mm², as specified in 8.1.5 of this PART;

ϕ — minimum strength factor of cylindrical shell, as specified in 8.2.3.1 of this PART.

8.2.2.2 The minimum thickness of cylindrical shell of auxiliary boiler is generally to be no less than 5 mm.

8.2.2.3 Where the cylindrical shell is fitted with expansion water piping, the thickness of cylindrical shell and tube plate are not to be less than 12mm; where the piping is welded on the tube plate, the thickness of cylindrical shell and tube plate are not to be less than 10 mm.

8.2.3 Strength factor of cylindrical shell

8.2.3.1 The strength factor ϕ of cylindrical shell is to be determined as follows:

.1 For welded cylindrical shell unweakened by the tube holes, the strength factor ϕ is to be the same as the strength factor ϕ' of the welded seam given in Table 8.1.6.1 of this PART; for seamless cylindrical shell, ϕ is equal to 1;

.2 Strength factor of cylindrical shell weakened by the tube holes:

(1) For tube holes of same diameter disposed with regular staggered spacing or regular drilling and having the same pitch in longitudinal direction as shown in Figure 8.2.3.1.2 (1) and Figure 8.2.3.1.2 (3), the strength factor ϕ_1 of cylindrical shell is to be determined by the following formula:

$$\phi_1 = \frac{t_1 - d}{t_1}$$

(2) For tube holes of same diameter disposed with regular staggered spacing (the holes in any row are shifted by $t_1/2$) and having the pitch both in longitudinal and transverse directions as shown in Figure 8.2.3.1.2 (1), the strength factor ϕ_2 of cylindrical shell in longitudinal direction converted from that in diagonal direction is to be determined by the following formula:

$$\phi_2 = K\phi_K$$

Where: $K = \frac{1}{\sqrt{1 - \frac{0.75}{(1 + m^2)^2}}}$, or to be taken according to Figure 8.2.3.1.2 (2) ②;

$$m = \frac{t_1}{t_2}; \phi_K = \frac{t_K - d}{t_K}.$$

The strength factor ϕ of cylindrical shell is to be selected from either of the above two values obtained from 8.2.3.1.1 and 8.2.3.1.2 of this PART, whichever is the smaller.

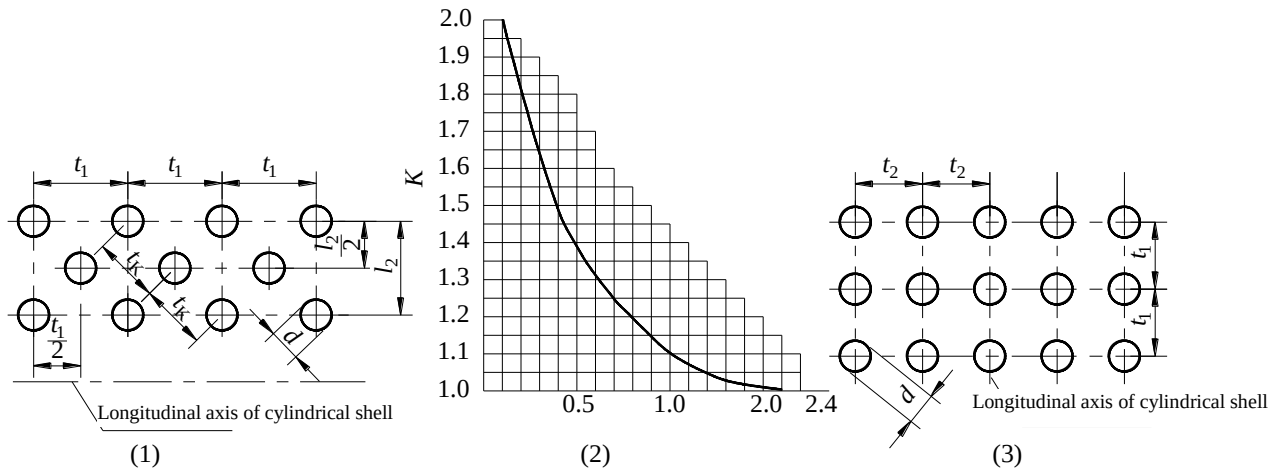


Figure 8.2.3.1.2 Cylindrical Shell Unweakened by Tube Holes

(3) For tube holes of same diameter disposed with regular drilling as shown in Figure 8.2.3.1.2 (3), if the pitch t_2 in transverse direction is smaller than pitch $t_1/2$ in longitudinal direction, the strength factor φ of cylindrical shell is to be taken as $2\varphi_3$ instead of φ_1 as determined by 8.2.3.1.2-1. φ_3 is to be determined by the following formula:

$$\varphi_3 = \frac{t_2 - d}{t_2}$$

The tube pitch t_2 in transverse direction is to be the pitch in way of the centre surface of tube holes.

8.2.3.2 For tube holes of same diameter with distance between centres adjacent tube holes not constant, as shown in Figure 8.2.3.2, the strength factor φ of cylindrical shell is to be determined by the following formula:

$$\varphi = \frac{t_1 + t'_1 - 2d}{t_1 + t'_1}$$

In such a case, the double pitch $t_1 + t'_1$ chosen is to be that which makes a minimum φ , and in no case t'_1 is to be taken as greater than $2t_1$.

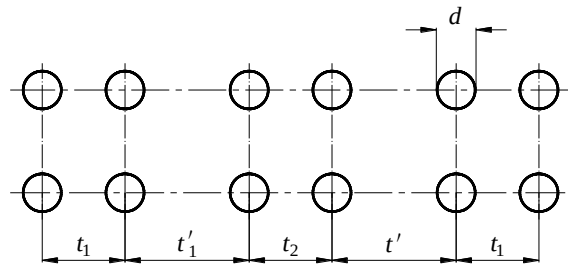


Figure 8.2.3.2 Pipe Hole Diameter Arrangement

8.2.3.3 Where tube holes of two different diameters are alternately disposed, the diameter of tube holes is to be replaced by the mean value of the diameters.

8.2.4 Dish ends subject to internal pressure

8.2.4.1 The minimum thickness δ of dish ends subject to pressure on the concave surface, as shown in Figure 8.2.4.1-1 (1) to (3), is to be determined by the following formula:

$$\delta = \frac{pD_1 Y}{2[\sigma]} + 0.75 \text{ mm}$$

where: δ —minimum thickness of end plate, mm; it is to be no less than 9.5 mm where they are exposed to flame, no less than 5 mm where they are not exposed to flame, and the thickness at the flanged edge area is to be no less than the thickness of cylindrical shell;

D_1 —outside diameter of end plate, in mm;

p — design pressure, as specified in 8.1.3 of this PART, in MPa;

$[\sigma]$ — allowable stress, to be determined in accordance with 8.1.5 of this PART, in N/mm²;

Y — shape factor, to be obtained from Figure 8.2.4.1-2:

For ends without openings, the value of y is to be selected from the group of solid curves, dependent on the ratio of δ/D_1 and H/D_1 ;

For ends with unreinforced openings, the value of y is selected from the group of dotted curves, dependent on the ratio of $d/\sqrt{D_1\delta}$ and H/D_1 .

where: d —the diameter of the largest opening in the end plates, in mm (in the case of an elliptical opening, the major axis of the ellipse is to be taken);

For openings with effective reinforcement, the opening factor may be determined according to 8.6.4.1 of this PART;

For the welded ends, the weakening impact is to be taken into account according to the weld seam strength factor as specified in 8.1.6 of this PART

For ends which are butt welded to the drum shell, the thickness of the edge of the flange for connection to the shell is not to be less than the thickness of an unpierced seamless or welded shell, whichever is applicable, determined in 8.2.2. of this PART.

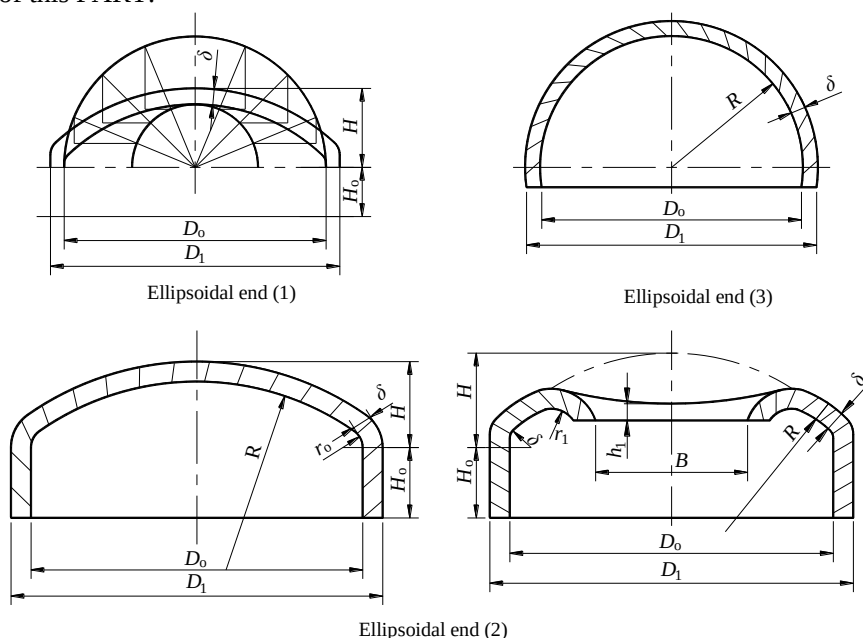


Figure 8.2.4.1-1 Dish Ends Subject to Pressure on Concave Surface

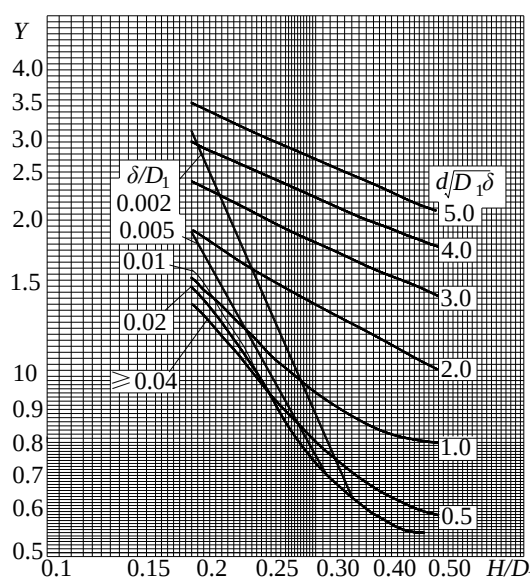


Figure 8.2.4.1-2 Y — Shape Factor

8.2.4.2 Openings in ellipsoidal and torispherical ends are to be in accordance with the following requirements, as shown in Figure 8.2.4.2.

.1 The projectional distance from the edge of hole to the outside edge of the end plate is not to be less than $0.1D_1$;

.2 The projectional distance between two adjacent openings is not to be less than the diameter of the smaller opening.

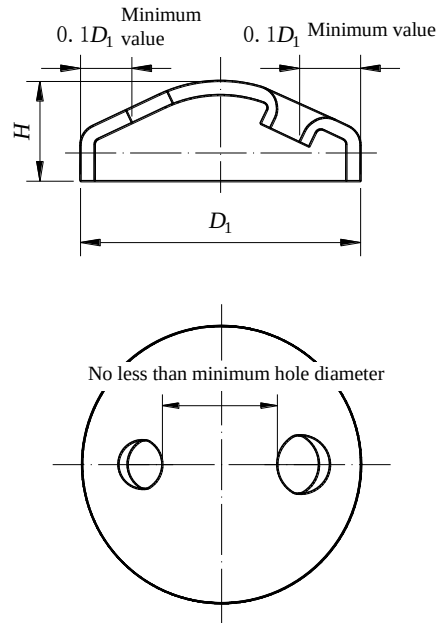


Figure8.2.4.2 Openings in Ellipsoidal and Torispherical Ends

8.2.4.3 The construction of dished ends is to comply with the following requirements:

.1 For torispherical ends, see Figure8.2.4.1 (2):

$$r_b \geq 0.1D_1 \text{ or } r_b \geq 3\delta, \text{ whichever is the greater;}$$

$$R \leq D_1; H \geq 0.18D_1 \text{ and } H_0 \geq 2;$$

.2 For ellipsoidal ends, see Figure8.2.4.1 $H \geq 0.20 D_1$ and $H_0 \geq 2 \delta$;

.3 For manhole flanges in ellipsoidal, torispherical and hemispherical ends, see Figure8.2.4.1 (2):

$$h_1 = \sqrt{B\delta}, B \text{ is the minor axis of manhole;}$$

$$r = (1.5 \sim 2) \delta$$

Note : The flanged edge of manhole is not to be used as the opening reinforcement material

8.2.5 Conical ends subject to internal pressure

8.2.5.1 For the construction of conical ends or conical ends with conical reducing sections, see 8.2.5.1 (1)~(4).

Connections between cylindrical shell and conical ends or conical ends with conical reducing sections as well as connections between conical reducing sections are preferably to be by means of a knuckle transition radius. Alternatively, conical sections and ends may be butt welded to cylinders without a knuckle radius where the change in angle of slope φ between the two sections under consideration does not exceed 30° .

Conical ends may be constructed of several ring sections of decreasing thickness, as determined by the corresponding decreasing diameter.

The minimum thickness of conical ends or conical ends with conical reducing sections at all conical parts and knuckle parts is to be determined by the formulae specified in 8.2.5.2 and 8.2.5.3 of this PART, but the thickness

at the knuckle and within the distance L from the knuckle is not to be less than the thickness of the section or cylindrical shell to which it is connected.

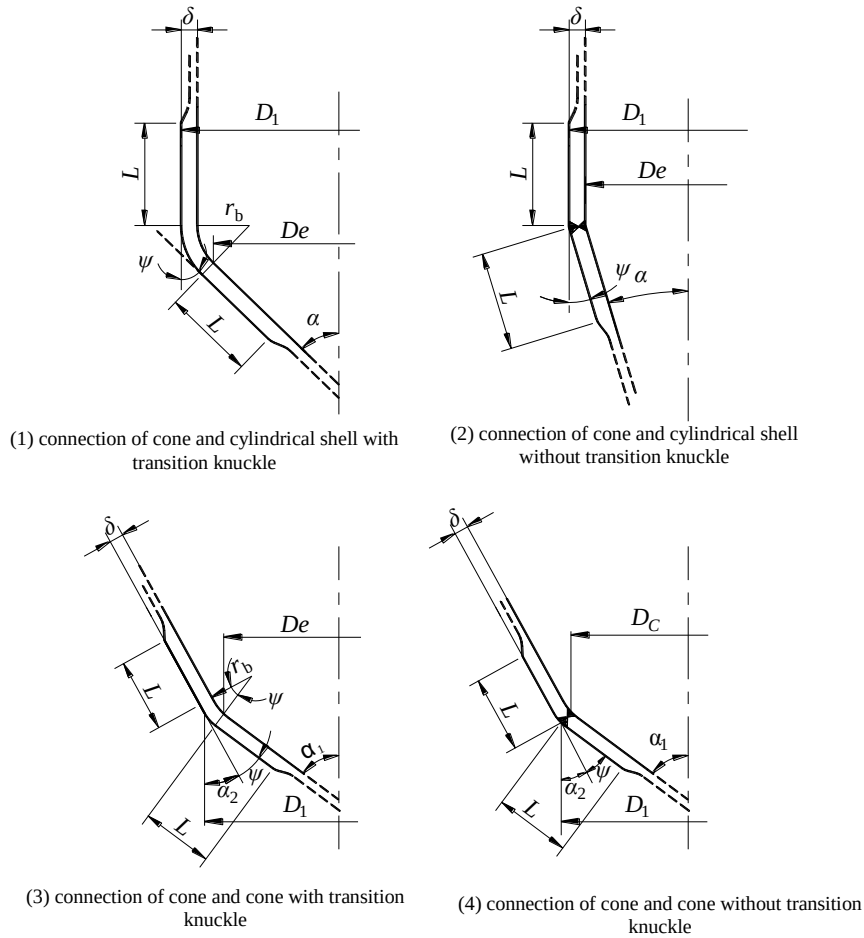


Figure 8.2.5.1 Connections of Cones

8.2.5.2 The minimum thickness δ of conical ends connected to the cylindrical shell or conical sections beyond the L length range is to be determined by the following formula:

$$\delta = \frac{pD_c}{2[\sigma]\varphi' - p} \cdot \frac{1}{\cos \alpha} + 0.75 \text{ mm}$$

Where: D_c —inside diameter, in mm, of conical section or end at the position under consideration, see Figure 8.2.5.1 (1) to (4);

p —design pressure of boiler, as specified in 8.1.3 of this PART, in MPa;

φ' —strength factor of welded seam, to be selected in accordance with Table 8.1.6.1 of this Chapter;

$[\sigma]$ —allowable stress, to be determined in accordance with 8.1.5 of this PART, in N/mm^2 ;

α —angle of slope of conical section to the vessel center axis e.g., α , α_1 and α_2 as shown in Figures 8.2.5.1 (1) to (4). The formula above only applies to the conical end having an angle α of inclination no more than 75° . Where the angle α of inclination is more than 75° , the thickness of conical sections is to be determined as for a flat plate.

8.2.5.3 The minimum thickness δ of the knuckle of cylinder, conical end or section and of the knuckle at the junction within the distance L (see Figure 8.2.5.1) is to be determined by the following formula:

$$\delta = \frac{pD_1K}{2[\sigma]\varphi'} + 0.75 \text{ mm}$$

Where: P —design pressure, as specified in 8.1.3 of this PART, in MPa;

D_1 —outside diameter of the cylinder, conical end or section, in mm, see Figures 8.2.5.1 (1) to (4);

φ' —strength factor of welded seam, to be selected in accordance with Table 8.1.6.1 of this PART.
Where the distance of a circumferential seam from the knuckle or junctions is not greater than L , φ' is to be taken as the weld strength factor appropriate to the circumferential seam;

K —a factor, determined according to ψ and $\frac{r_0}{D_1}$, see Table 8.2.5.3;

$[\sigma]$ —allowable stress, to be determined in accordance with 8.1.5 of this PART, in N/mm^2 .

The distance L mentioned in this paragraph, as shown in Figure 8.2.5.1, is to be determined by the following formula:

$$L = 0.5 \sqrt{\frac{D_1 \delta}{\cos \psi}} \quad \text{mm}$$

ψ —angle of slope of two adjoining conical sections, see Figure 8.2.5.1;

r_0 —inside radius of transition knuckle, in mm, which is to be taken R_0 as $0.01 D_c$ in the case of conical sections without knuckle transition.

Factor K

Table 8.2.5.3

$K \ r_0/D_1 \ \psi$	0.01	0.02	0.03	0.04	0.06	0.08	0.10	0.15	0.20	0.30	0.40
10	0.70	0.65	0.60	0.60	0.55	0.55	0.55	0.55	0.55	0.55	0.55
20	1.00	0.90	0.85	0.80	0.70	0.65	0.60	0.55	0.55	0.55	0.55
30	1.35	1.20	1.10	1.00	0.90	0.85	0.80	0.70	0.65	0.55	0.55
45	2.05	1.85	1.65	1.50	1.30	1.20	1.10	0.95	0.90	0.70	0.55
60	3.20	2.85	2.55	2.35	2.00	1.75	1.60	1.40	1.25	1.00	0.70
75	6.80	5.85	5.35	4.75	3.85	3.50	3.15	2.70	2.40	1.55	1.00

8.2.6 Flat end plates

8.2.6.1 The minimum thickness δ of flat end plates is to be determined by the following formula:

$$\delta = CD \sqrt{\frac{p}{[\sigma]}} + 0.75 \quad \text{mm}$$

Where: p —design pressure, as specified in 8.1.3 of this PART;

$[\sigma]$ —allowable stress, to be determined in accordance with 8.1.5 of this PART, in N/mm^2 ;

D —calculated diameter of cylindrical shell, in mm; in the case of rectangular flat end plates, the diameter D for calculations to be replaced by an equivalent diameter determined by the following formula:

$$D = a \sqrt{\frac{2}{1 + \left(\frac{a}{b}\right)^2}} \quad \text{mm}$$

a —length of short side of rectangular end plate, in mm;

b —length of long side of rectangular end plate, in mm;

C —a factor, selected according to Table 8.2.6.1.

Factor C

Table 8.2.6.1

Type of end plate		Figure8.2.6.1 (1)	Figure8.2.6.1 (6) l/D specific value			Figure8.2.6.1 (2)	Figure8.2.6.1 (3)、(4)、(5)
			0.05	0.10	0.15		
Factor C value	Circular end plate	0.38	0.57	0.62	0.67	0.43	0.52
	rectangular end plate	—	—	—	—	0.50	0.57

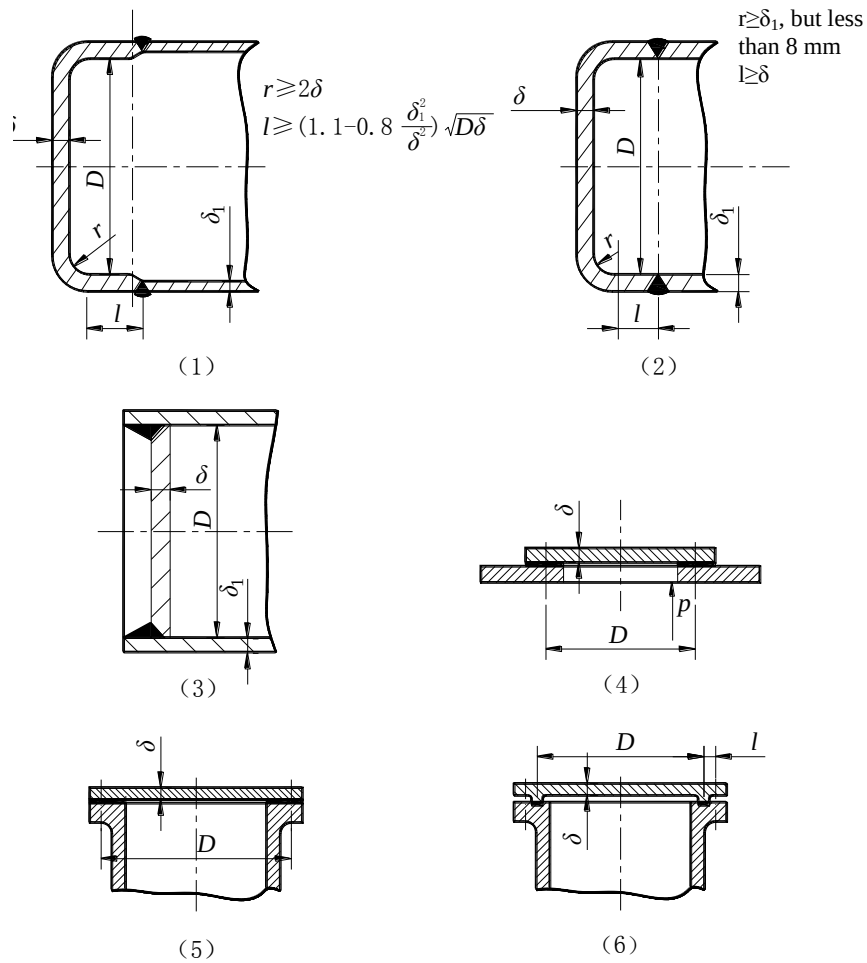


Figure 8.2.6.1 Type of End Plate

8.2.6.2 For circular flat end plates with openings, the minimum thickness of flat end plates is to be increased by 12% of the thickness required in 8.2.6.1 of this PART.

8.2.7 Stayed flat surfaces of horizontal smoke tube boilers

8.2.7.1 For flat plates supported by welded-in stays or by welded-in stays and flange connection, the minimum thickness δ is to be determined by the following formula:

$$\delta = Ct \sqrt{\frac{p}{[\sigma]}} + 0.75 \quad \text{mm}$$

Where: P — design pressure, MPa, as specified in 8.1.3;

$[\sigma]$ — allowable stress, to be determined in accordance with 8.1.5 of this PART, in N/mm^2 ;

C — a factor, to be selected in accordance with Table 8.2.7.1;

t — calculated pitch of points of support, in mm.

.1 Where the stays are regularly pitched, see Figure 8.2.7.1 (1):

$$t = \sqrt{a^2 + b^2}$$

.2 Where the stays are irregularly pitched, or within the area enclosing the stays and flanges: When a circle is drawn through three points of support with a result of centre of the circle being situated inside the triangle formed by these three points, $t = d$, see Figure 8.2.7.1 (2).

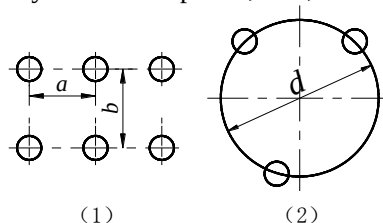


Figure 8.2.7.1 Stays Arrangement

Factor C

Table 8.2.7.1

Serial No.	Method of support	Factor ^{Note 2}	
		Not exposed to flame	Exposed to flame
1	Flange or fillet welding ^{Note 1}	0.38	0.41
2	Stays, with gasket reinforcement, diameter of gasket $\geq$ 0.67 times stay spacing	0.36	—
3	Stays, with gasket reinforcement, diameter of gasket $>$ 3.5 times diameter of stay	0.38	—
4	Stays, without gasket reinforcement, double-side welded	0.40	0.44
5	Stays, without gasket reinforcement, single-side welded	0.42	0.46
6	Stay tubes	0.46	0.51
7	Smoke tubes (within tube nests)	0.55	0.61

Note 1: Where a flat plate is provided with two or more methods of support, the factor C is to be taken as the mean of the values for the respective methods adopted.

Note 2: See 8.2.8.8 (2), (3) and (4).

8.2.8 Tube plates

8.2.8.1 The minimum thickness δ of the flat tube plates within the tube nests is to be determined by the following formula:

$$\delta = Ct \sqrt{\frac{P}{[\sigma]}} + 0.75$$

Where: P — design pressure, MPa, as specified in 8.1.3;

$[\sigma]$ — allowable stress, to be determined in accordance with 8.1.5 of this PART, in N/mm²;

C — a factor, to be selected in accordance with Table 8.2.7.1;

t — mean pitch of tray tube or smoke tube, in mm.

The minimum thickness of tube plate is not to be less than the following values in any case:

.1 10mm where the tube is welded on the tube plate;

.2 14mm where the tube is in connected on the tube plate by expansion.

8.2.8.2 The minimum thickness δ of the flat tube plates in the wide water spaces between tube nests or around tube nests is to be determined by the following formulae:

.1 For wide water spaces between tube nests:

$$\delta = Ct \sqrt{\frac{P}{[\sigma]}} + 0.75 \quad \text{mm};$$

.2 For flat tube plates around tube nests:

$$\delta = Cd \sqrt{\frac{P}{[\sigma]}} + 0.75 \quad \text{mm};$$

Where: P — design pressure, as specified in 8.1.3 of this PART, in MPa;

$[\sigma]$ — allowable stress, to be determined in accordance with 8.1.5 of this Chapter, in N/mm²;

C — constant, to be selected in accordance with Table 8.2.7.1;

$$t = \sqrt{a^2 + b^2}$$

a — horizontal pitch of stay tubes, in mm;

b — vertical pitch of stay tubes, in mm;

d — diameter of the maximum circle passing through three points of support of stay tubes and flanges, or of stay tubes and stays, or of stay tubes, stays and flanges, with a result of the centre of the circle being situated inside the triangle formed by these three points, in mm.

8.2.8.3 For tube plates the support afforded by the smoke tubes is not to be taken to extend beyond the line enclosing the outer surfaces of the tubes. If the distance between the outside of the wing row of smoke tubes and point of support of flanges is no more than the width of margin of flat plate determined in accordance with the formula in 8.2.8.4 of this PART, stay tubes may not be fitted in the wing row.

8.2.8.4 For a plate supported by the flues, furnaces or shell, the range from the point of support to the width of margin b obtained by the following formula may be regarded as being supported by the flues, furnaces or shell to which the flat plate is attached:

$$b = \frac{C(\delta - 1)}{\sqrt{p}} \quad \text{mm}$$

Where: p — design pressure, as specified in 8.1.3 of this PART, in MPa;

δ — thickness of flat plates, in mm;

$C = 9.7$ for plates not exposed to flame; $C = 9.1$ for plates exposed to flame;

Where an unflanged flat plate is welded directly to the flues, furnaces or shell and it is not practicable to effect the full penetration weld from both sides of the flat plate, the constant C used in the formula mentioned above is to be:

$C = 7.5$ for plates not exposed to flame; $C = 7.1$ for plates exposed to flame.

8.2.8.5 In addition to the requirements of this Section, the minimum thickness δ of combustion chamber tube plates, due to the load on the top plates, is to be checked by the following formula:

$$\delta = \frac{pLt}{196(t - d)}$$

Where: p — design pressure, as specified in 8.1.3 of this PART, in MPa;

L — length at the top of combustion chamber along axis of the boilers, measured from the tube plate to the back chamber plate, in mm;

t — horizontal pitch of smoke tubes, in mm;

d — diameter of tube hole, mm.

8.2.8.6 The minimum pitch t of the smoke tubes secured in tube plate is to be determined by the following formula:

$$t = 1.125d + 12.5 \quad \text{mm}$$

Where: d — outside diameter of smoke tubes, in mm.

8.2.8.7 Where flat end plates are flanged for connection to the shell, the inside radius of flanging is not to be less than 1.75 times the thickness of plate, with a minimum of 38 mm. Where tube plates or flat plates of combustion chambers are flanged for connection to the wrapper plates, the inside radius of flanging is not to be less than thickness of the plate, with a minimum of 25 mm.

8.2.8.8 The points of support of boiler flat plates are to comply with the following:

.1 Long stays, short stays, stay tubes, welded-in smoke tubes (within the tube nests only) and flanges may be taken as points of support;

.2 Points of support of flanges:

(1) Where the inner radius of flange curvature does not exceed 2.5 times the thickness of the plate, the commencement of the flange curvature is to be taken as the point of support;

(2) Where the inner radius of flange curvature exceeds 2.5 times the thickness of the plate, the point of support is to be taken at the position of 2.5 times the plate thickness measured from the inner surface of the flange;

(3) Where the furnace and front end plate are jointed by fillet welding, the outer surface of furnace is to be taken as a point of support;

(4) Where smoke tubes are fitted by means of roller expansion, the flanges of manholes or sight-holes are not to be taken as points of support.

8.2.8.9 In addition to complying with the requirements of 8.2.8.1 to 8.2.8.4 in Appendix 2 of this Chapter, the minimum thickness δ of flat tube plates of vertical boilers having horizontal smoke tubes is to be determined by the following formula, whichever is the greater:

$$\delta = \frac{2pDt}{R_{eH}(t - d)} + 0.75 \quad \text{mm}$$

Where: p — design pressure, MPa, as specified in 8.1.3;

D — twice the radial distance measured from the centre of cylindrical shell to the centre of tubes holes in the outer row, in mm;

t — vertical pitch of tubes, in mm;

d — tube hole diameter, mm;

R_{eH} — tensile strength of tube plate material, N/mm².

8.2.9 Smoke tubes

8.2.9.1 The minimum wall thickness δ of plain smoke tubes is to be determined by the following formula or is to be selected in accordance with Table 8.2.9.1, but in no case is to be less than 3 mm:

$$\delta = \frac{pd_1}{69} + 2 \quad \text{mm}$$

Where: p — design pressure, as specified in 8.1.3 of this PART, in MPa;

d_1 — outside diameter of smoke tubes, in mm.

Minimum wall thickness of smoke tubes

Table 8.2.9.1

Outside diameter of tube, in mm	Wall thickness of tube, in mm				
	3	3.2	3.5	4.0	5.0
	Allowable design pressure, in MPa				
38	1.76	—	—	—	—
44.5	1.52	1.81	—	—	—
51	1.32	1.57	2.01	—	—
57	1.18	1.42	1.77	—	—
63.5	1.08	1.28	1.62	2.16	—
70	0.98	1.18	1.47	1.96	—
76	0.88	1.08	1.32	1.77	—
83	0.78	0.98	1.23	1.62	—
89	—	0.88	1.13	1.52	2.3

8.2.9.2 The smoke tubes may be fitted by means of roller expansion or by welding to the plates. Where the smoke tubes are fitted by welding, they are to be in compliance with Figure 8.2.9.2.

8.2.10 Stray tubes

8.2.10.1 The cross-sectional area F of welded-in stay tubes supporting tube plates is to be determined by the following formula, but in no case is the thickness of stay tubes to be less than 3.5 mm.

$$F = \frac{pA}{[\sigma]} \quad \text{mm}^2$$

Where: p — design pressure, MPa, as specified in 8.1.3 of this PART;

A — area of tube plate supported by one stay tube, in mm²;

$[\sigma]$ — allowable stress, 67N/mm².

8.2.10.2 The stay tubes are to be welded to the tube plates in accordance with Figure 8.2.10.2.

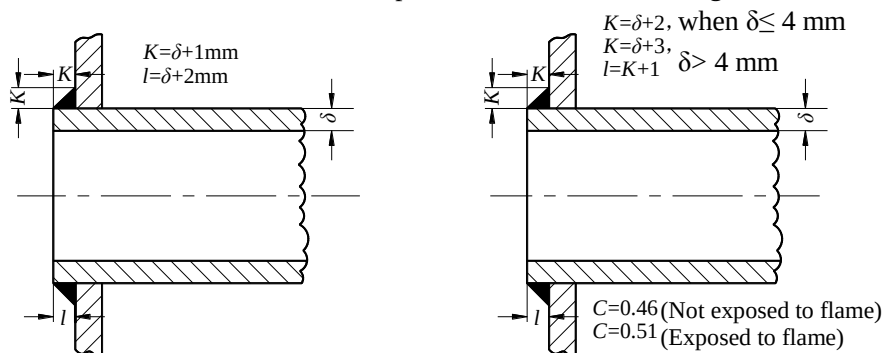


Figure 8.2.9.2 Smoke Tube Welded to Tube Plate

Figure 8.2.10.2 Stray Tube Welded to Tube Plate

8.2.11 Strays

8.2.11.1 The minimum cross-sectional area F of welded-in strays supporting the flat plates is to be determined by the following formula:

$$F = \frac{pA}{[\sigma]} \quad \text{mm}^2$$

Where: p — design pressure, MPa, as specified in 8.1.3 of this PART;

A — maximum area of tube plate supported by one stay tube, in mm²;

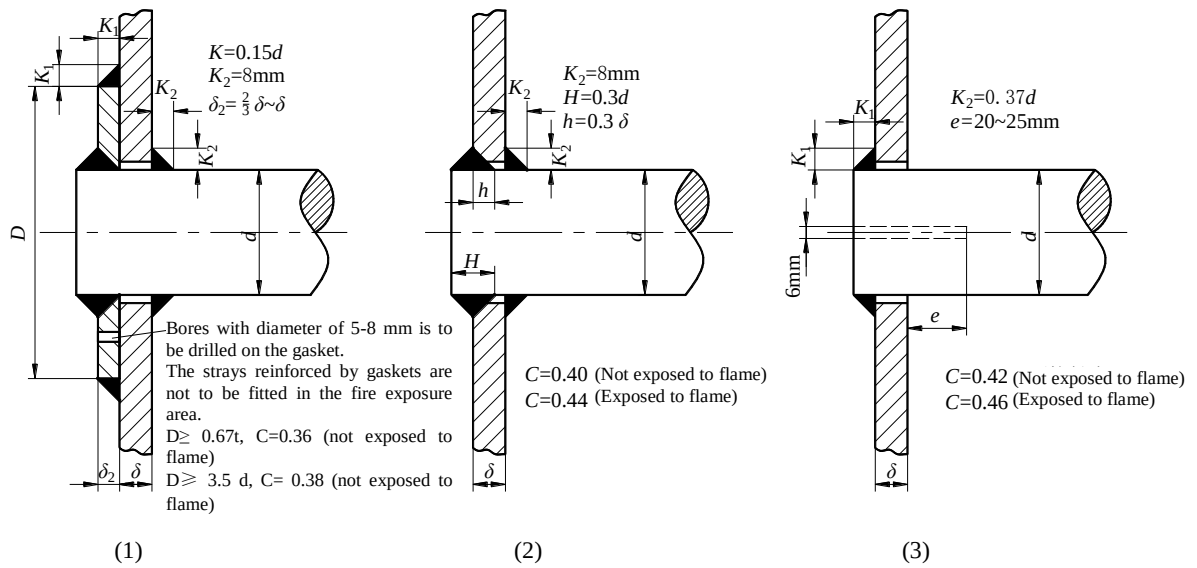
$[\sigma] = \frac{R_m}{5.3}$ N/mm², for long strays;

R_m — tensile strength of material, N/mm²;

$[\sigma] = 62$ MPa, for short strays.

8.2.11.2 The structural type of welded strays is to comply with Figures 8.2.11.2 (1), (2) (for long strays) and

(3) (for short strays).



8.2.12 Boiler tubes subject to internal pressure

8.2.12.1 The minimum wall thickness δ of boiler tubes subject to internal pressure is to be determined by the following formula, but is in no case to be less than that required in 8.2.12.2 of this PART:

$$\delta = \frac{2pD_1}{2[\sigma] + p} + 0.75 \quad \text{mm}$$

Where: p — design pressure, MPa, as specified in 8.1.3 of this PART;

$[\sigma]$ — allowable stress, to be determined in accordance with 8.1.5 of this Chapter, in N/mm^2 ;

D_1 — outside diameter of tubes, in mm;

8.2.12.2 For boiler tubes calculated by 8.2.12.1 of this Appendix, the thickness is in no case to be less than the minimum thickness as given in Table 8.2.12.2, and in addition, provision is to be made for minus tolerances of tubes, bending allowances and abnormal corrosion which might be expected in service.

Minimum thickness of boiler tubes

Table 8.2.12.2

Outside diameter of tubes	Minimum thickness	Outside diameter of tubes	Minimum thickness
$D_1 \leq 38$	1.75	$76 < D_1 \leq 95$	3.05
$38 < D_1 \leq 50$	2.16	$95 < D_1 \leq 100$	3.28
$50 < D_1 \leq 70$	2.40	$100 < D_1 \leq 125$	3.50
$70 < D_1 \leq 76$	2.67		

Note: For water tubes subject to internal pressure used for smoke tube boilers and vertical auxiliary boilers, the minimum thickness is not to be less than 3.

8.2.13 Horizontal shelves of tube plates

8.2.13.1 For vertical boilers having horizontal smoke tubes, the horizontal shelves of the tube plates are to be supported by gussets as follows:

$$K = \frac{10.2ADp}{t}$$

Where: A — maximum width of horizontal shelves of tube plates, measured from inside of shell to outside of tube plate, in mm;

D — shell inner diameter, mm;

p — design pressure, N/mm^2 , as specified in 8.1.3 of this PART;

t — thickness of tube plate, mm.

.1 For the combustion chamber tube plate (rear tube plate) the minimum number of gussets is to be: 1gusset, when $261000 < K \leq 357000$;

- 2 gussets, when $357000 < K \leq 428000$;
 3 gussets, when $K > 428000$;
 .2 For the smoke box tube plate (front tube plate) the minimum number of gussets is to be:
 1 gusset, when $261000 < K \leq 428000$;
 2 gussets, when $K > 428000$.

8.2.13.2 The shell plates to which the sides of the tube plates are connected are to be 1.6 mm thicker than that required in the formula applicable to shell plates. Where gussets are not fitted to the shelves, the strength of the parts of the circumferential seams at the top and bottom of these plates (not including tube plate parts) is to be sufficient to withstand the whole load on the boiler end with a factor of safety of not less than 4.5 related to the specified minimum tensile strength of the shell plate material.

8.2.14 Vertical furnace or internal uptake

8.2.14.1 The minimum thickness δ of the vertical furnace or internal uptake of the vertical boiler is to be determined by the following two formulae, whichever is the greater:

$$.1 \quad \delta = \sqrt{\frac{pD(L + 610)}{10300}} + C \quad \text{mm}$$

$$.2 \quad \delta = \frac{KpD + 0.34L}{110} + C \quad \text{mm}$$

Where: P — design pressure, MPa, as specified in 8.1.3 of this PART;

D — external diameter of the cylindrical furnace or internal uptake, in mm; where the furnace is tapered, the diameter D is to be taken at the middle point of the calculated length L of the furnace;

L — calculated length of the cylindrical furnace or internal uptake, in mm, i.e. the length between two points of substantial support (see Figure 8.2.14 (1)). The connection with the cylindrical furnace (see Figure 8.2.14 (2)) or connection with the bottom of U-shaped bottom ring (see Figure 8.2.14 (3)) is to be regarded as the point of substantial support at the bottom of boiler furnace; 0.4H above the flanging of furnace top plate is to be regarded as the point of substantial support (H means the height of top plate). Where the furnace is supported by a circumferential row of regularly arranged stays with a diameter not less than 2.25δ , and a pitch not exceeding 14δ , these stays may be regarded as a point of support of calculated length (see Figure 8.2.14 (1));

C — allowance;

$C = 2 \text{ mm}$; $C = 2 \text{ mm}$ for furnace;

$C = 4 \text{ mm}$; $C = 4 \text{ mm}$ for internal uptake;

$$K = \frac{X}{[R_{eH}^T]};$$

Where: X — specified proof stress, in MPa, for carbon and carbon-manganese steel with the material grade of 400 MPa, at a temperature of 90°C above the saturated steam temperature corresponding to the design pressure;

R_{eH}^T — specified proof stress, in N/mm^2 , for the materials actually used, at a temperature of 90°C above the saturated steam temperature corresponding to the design pressure, in N/mm^2

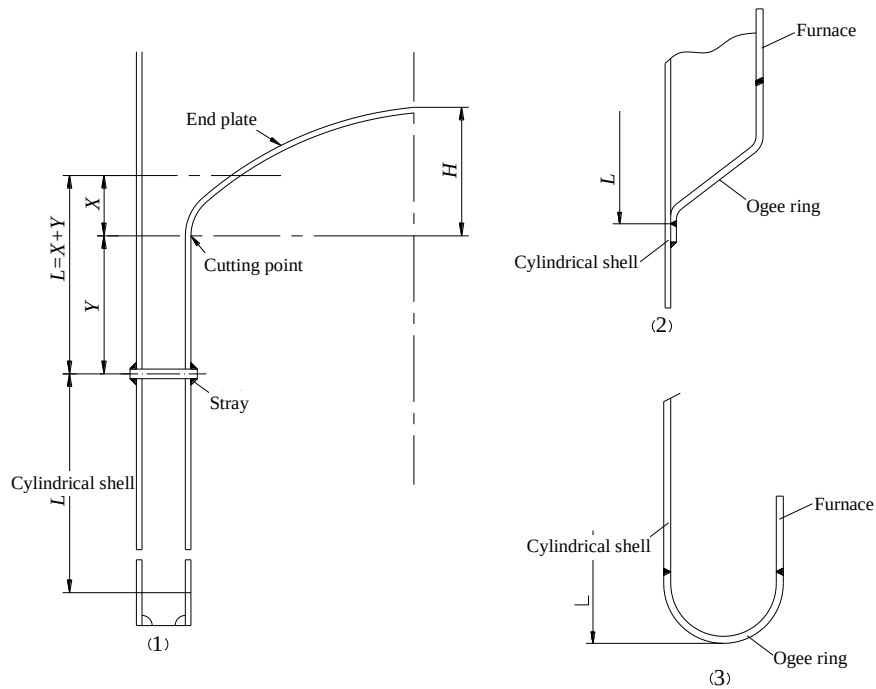


Figure 8.2.14 Calculated Length of Cylindrical Furnace or Internal Intake

8.2.15 Hemispherical furnaces

8.2.15.1 The minimum thickness δ of unsupported hemispherical furnaces subject to pressure on the convex side is to be determined by the following formula:

$$\delta = \frac{KpR}{61} + 0.75 \text{ mm}$$

Where: p — design pressure, as specified in 8.1.3 of this Chapter, in MPa;

R — outside radius of curvature of the furnace, in mm;

K — as defined in 8.2.14 of this PART.

8.2.16 Torispherical furnaces subject to pressure on the convex side

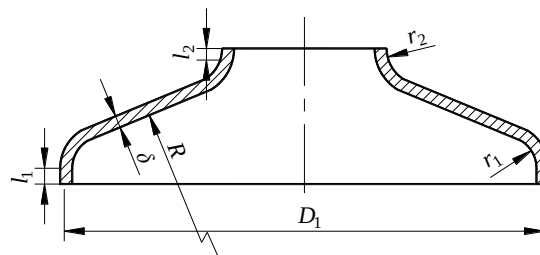
8.2.16.1 The minimum thickness δ of vertical furnace end plates which are subject to pressure on the convex side and are supported by central uptakes (see Figure 8.2.16.1) is to be determined by the following formula:

$$\delta = \frac{pR}{[\sigma]} + 0.75 \text{ mm}$$

Where: p — design pressure, MPa, as specified in 8.1.3 of this PART;

R — outside radius of curvature of the end plates, in mm;

$[\sigma]$ — allowable stress, to be determined in accordance with 8.1.5 of this Chapter, in N/mm^2 .



$$R < D_1;$$

$$r_1 > 4\delta, \text{ and } > 50 \text{ mm}$$

$$r_2 > 2\delta, \text{ and } > 25 \text{ mm}$$

$$l_1 \text{ and } l_2, \text{ butt welding structure } > 2\delta$$

Figure 8.2.16.1 Vertical Furnace Ends

8.2.16.2 The minimum thickness δ of dished and flanged ends for vertical boiler furnaces that are subject to pressure on the convex side and are without support from stays, is to be determined by the following formula, but

$$\delta = \frac{KpR}{66} + 0.75 \quad \text{mm}$$

8.2.17 Ogee rings

$$\delta = \sqrt{\frac{pD(D-d)}{990}} + 0.75 \quad \text{mm}$$

The diagram illustrates a furnace shell with an ogee ring. Key components and dimensions are labeled:

- Furnace**: The upper part of the structure.
- Shell**: The main vertical structure.
- Ogee ring**: A curved reinforcement ring.
- Reinforcement**: Indicated by hatching in the shell and ogee ring.
- Dimensions**:
 - δ_1 : Thickness of the shell at the top.
 - D : Diameter of the shell at the top.
 - d : Thickness of the ogee ring.
 - δ : Thickness of the shell at the bottom.
 - 12δ : Vertical distance from the bottom of the shell to the center of the ogee ring.
 - 50 : Vertical distance from the bottom of the shell to the center of the ogee ring.
- Reinforcement Detail**: A note states "Not less than four $\Phi 10$ holes uniformly arranged" with a diagram showing four holes in a square pattern.

Unit: mm

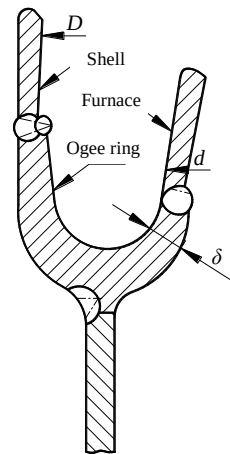


Figure 8.2.17.2 U-shaped ring

Section 3 BOILER MOUNTINGS AND FITTINGS

8.3.2.1 Each feed check valve is to consist of a screw-down valve and a non-return valve, the lift of non-return valve is to be adjustable. The screw-down valve is to be attached direct to the boiler. The non-return valve is to be adjacent to the screw-down valve wherever practicable. For water tube boilers, the feed check valves

are to be fitted with efficient gearing, whereby they can be satisfactorily operated from the stoke hold floor or other convenient position.

8.3.2.2 For water tube boilers, at least one of the feed water systems is to be fitted with a feed water regulator for automatically controlling the water level.

8.3.3 Feed internal pipes

8.3.3.1 The internal pipes for feed inlets are to be so arranged that no feed water impinges directly on the inner surfaces of the boiler parts.

8.3.4 Water level indicators

8.3.4.1 Each boiler is to be fitted with at least a water level indicator in direct reading gauge glass type and a set of gauge cock. The water level indicator is generally to be plate glass water level indicator or glass tube water level indicator. Water gauge cocks are to be so arranged that they can be easily operated without danger when the glass is damaged.

8.3.4.2 The water gauges are to be readily accessible and so located that the water level is clearly visible. The lowest visible part of the glass water gauge is to be situated at the lowest safe working water level, but for water tube boilers, this level is to be situated at 50 mm below the lowest safe working water level.

8.3.4.3 Each water gauge is to be separately connected with boiler. Water gauges are to be directly fitted on boilers by means of short connecting branches having the inner diameter no less than 25 mm, or fitted on pipe columns having inner diameter no less than 40 mm. Pipe columns are to be connected on boilers by means of short connecting branches.

8.3.4.4 Water gauges are also to be provided with blow-off devices.

8.3.4.5 Water gauges are to be provided with sufficient lighting to enable observing the water level.

8.3.4.6 The distance from minimum water level of boilers to the highest heated surface is to be that the heated surface will not be above the water level where fishing vessels run athwartships.

8.3.5 Safety valves

8.3.5.1 Boilers are to be fitted with at least a safety valve.

8.3.5.2 The diameter d of safety valve seatings is to be determined by the following formula, but is to be no less than 25 mm.

$$d = \sqrt{\frac{DA}{n(10.2p + 1)}} \quad \text{mm}$$

Where: n —number of valves;

p —design pressure of boiler, as specified in 8.1.3 of this PART;

D —maximum design evaporation of boiler, in kg/h;

A —coefficient, as given in Table 8.3.5.2.

Coefficient A

Table 8.3.5.2

Lift	d/24	d/20	d/16	d/12	d/4
Coefficient A	27	23	18.5	14	6.6

The diameter of full lift safety valves determined by the formula specified above is based on the area not including that of the guides or other obstructions. Then, for full lift safety valves with guides or other obstructions, the diameter of safety valves is to be determined by the total area of valve seatings and guides or other obstructions.

In any case, the valve seating diameter of a safety valve is not to be greater than 100 mm, nor less than 25 mm.

8.3.5.3 Safety valves are to be fitted with easing gears.

8.3.5.4 The opening pressure of boiler safety valves more than 5% of the actual permissible working pressure is acceptable, but not greater than the design pressure of the boiler.

8.3.5.5 For full lift safety valves (lift $\geq d/4$), the passage area of connection between safety valves and boilers

is not to be less than the total area of safety valves; for other type of safety valves, it is not be less than 1/2 of total passage area of safety valves. The passage area of the waste steam pipe is not to be less than twice the total area of safety valves, and not to be less than 1.1 times the total area of safety valves.

8.3.5.6 Test of boiler safety valves:

.1 For smoke tube boilers with all stop valves closed and under full firing conditions, for a duration of 15 min after the safety valve blows, the maximum pressure value attained is not to exceed 110% of the design pressure.

.2 For water tube boilers under the same conditions described above, for a duration of 7 min after the safety valve blows, the maximum pressure value attained is not to exceed 110% of the design pressure of boiler;

.3 The opening and closing pressure difference of safety valves is not to be generally exceed 5% of opening pressure or 0.1MPa, whichever is smaller;

8.3.5.7 The construction of boiler safety valves is to comply with the following requirements:

.1 The safety valves are to be so locked or sealed that they cannot be tampered with or overloaded in service, and that they are to be so designed that in the event of fracture of springs they cannot lift out of their seats;

.2 The waste steam is not to come into direct contact with the loading springs;

.3 Each safety valve chest is to be drained by a pipe led with a continuous fall to the bilge, and no valves or cocks are to be fitted to these drain pipes;

.4 Safety valves are to be provided with easing gears which are to be operable at a safe position from the boiler or engine room platforms;

.5 Two safety valves are to be installed in the same valve chest.

8.3.6 Blow-off and scum valves

8.3.6.1 Each boiler is to be fitted with blow-off valves and, if needed, scum valves. Both blow-off and scum valves (if fitted) are to be secured direct to the boiler shell. Where it is not practicable to attach the blow-off valve direct to water tube boilers, the valve may be connected with thick short pipes.

8.3.6.2 Scum valves and blow-off valves are not to be less than 20 mm in diameter, nor to exceed 40 mm.

8.3.6.3 The top edge of scum pans for the surface blow-off is to be placed in the boiler within a range from 25 mm above the lowest water level to 25 mm below the working water level.

The number and arrangement of the scum pans are to be such as to ensure the possibility of blowing off the scum and oil from the entire evaporating surface.

8.3.7 Pressure gauges

8.3.7.1 Each boiler is to be fitted with at least one pressure gauge in an easily seen position.

8.3.7.2 Pressure gauges are to be marked with a red line for indicating the working pressure of the boiler. The scale of pressure gauges is to be suitable for the hydraulic test pressure of boilers.

8.3.8 Stop valves

8.3.8.1 The main and auxiliary stop valves are to be secured direct to the boiler shell; steam stop valves are to be self-closing or non-return type.

8.3.9 Air cocks

8.3.9.1 An air valve or cock is to be fitted to the top of steam space of the boiler or drum and is to be, in general, 10 to 15 mm in diameter.

8.3.10 Sampling valve or cock

8.3.10.1 Each boiler is to be provided with a sampling valve or cock secured direct to the boiler shell. The valve or cock is not to be fitted on the water gauges or standpipes.

Section 4 PRESSURE VESSELS

8.4.1 Strength calculation

8.4.1.1 The strength calculation of pressure vessels is to comply with the strength calculation of relevant structure for water tube boilers, contained in Section 2 of this Chapter; however, the allowable stresses used in the calculation are to be determined in accordance with 8.1.5 of this PART.

8.4.1.2 For the design pressure of pressure vessels, see 8.1.3 of this Chapter.

8.4.1.3 Where an accumulator works at frequently fluctuating working pressure, the allowable stress for its parts is to be appropriately lowered according to the fluctuation condition of pressure.

8.4.1.4 In addition to complying with 8.4.1.1, the minimum thickness t of cylindrical shell of the pressure vessels is in no case to be less than that determined by the following formula:

$$t = D_0 / 1500 + 3 \quad \text{mm}$$

Where: D_0 — inside diameter of pressure vessels, in mm.

8.4.2 Fittings

8.4.2.1 For pressure vessels having the design pressure greater than 0.98 MPa or working temperature higher than 220°C, valve chests are to be made of steel or other approved materials.

8.4.2.2 Each pressure vessel is to be provided with the following fittings (for air receivers, see 8.4.2.3 of this PART):

.1 stop valves are to be fitted at the inlet and outlet of the pressure vessels, which are to be secured direct to the cylindrical shell as far as possible;

.2 drain devices including valves and internal pipes (where applicable);

.3 safety devices for preventing overpressure;

.4 pressure gauges indicating the medium pressure;

.5 level indicators showing the working level of medium (where applicable).

8.4.2.3 Each air receiver is to be provided with the following fittings:

.1 stop valves and pressure gauges as described in 8.4.2.2 of this PART;

.2 drain devices as specified in 8.4.2.2 of this PART, which are to be so arranged that they can drain completely the water from the lowest portion of the air receiver;

.3 safety valves. Where the air inlet pipe or the air compressor is fitted with a safety valve capable of preventing the pressure in the air receiver under charging conditions from exceeding the design pressure, the safety valve on the air receiver may be dispensed with, provided that a fusible plug with a melting point approximately at 100°C and of a size capable of releasing the air in the event of fire is provided. However, air receivers for operating remote control valves are to be fitted with safety valves. The capacity of safety valves is to ensure that the air pressure is not to exceed 110% design pressure. Where outlet valves are closed, control valves are to be provided with safety valves.

Section 5 THERMAL OIL HEATERS

8.5.1 General provisions

8.5.1.1 This Section applies to thermal oil heaters in which thermal oils are heated to temperatures below their initial boiling point at atmospheric pressure.

8.5.1.2 The detailed requirements for thermal oil systems are given in Section 8, Chapter 4 of this PART.

8.5.2 Materials and welding

8.5.2.1 The materials and welding of thermal oil heaters are to comply with the requirements for boilers in this Chapter.

8.5.2.2 Copper and copper alloys are not to be used so as to prevent oxidation of thermal oil.

8.5.3 Design and manufacture

8.5.3.1 Thermal oil heaters are to be designed and manufactured in accordance with the requirements for boilers in this Chapter.

8.5.3.2 The surfaces which come into contact with the thermal oil are to be designed for the maximum allowable working pressure, subject to a minimum gauge pressure of 0.6 MPa.

8.5.3.3 Different thermal oil heaters are to be provided with inspection holes as follows:

- .1 oil fired heaters are to be provided with inspection holes for examination of the combustion chamber;
- .2 exhaust-gas thermal oil heaters are to be provided with manholes serving as inspection holes at the exhaust gas intake and outlet.

8.5.4 Fittings of thermal oil heaters

8.5.4.1 Each heater is to be equipped with at least one safety valve complying with the following:

- .1 having a blow-off capacity at least equal to the increase in volume of the thermal oil at the maximum heating power. During blow-off, the pressure is not to exceed 110 % of the design pressure of the heater;
- .2 the discharge pipe of safety valves is to be led to a thermal oil collecting tank with suitable capacity.

8.5.4.2 Thermal oil heaters are to be provided with means enabling the thermal oil to be completely drained.

8.5.4.3 Thermal oil heaters are to be provided with means to sample the thermal oil.

8.5.4.4 Thermal oil heaters are to be fitted with the following temperature and flow (or pressure) indicators:

- .1 thermal oil temperature measuring devices are to be fitted at the thermal oil discharge line of both oil fired heaters and exhaust-gas thermal oil heaters;
- .2 devices indicating the flow or pressure of the thermal oil are to be fitted in the thermal oil circulation system.

8.5.4.5 The gas outlet of exhaust-gas thermal oil heaters are to be provided with a temperature sensor and an alarm device for fire detection.

8.5.4.6 Heating surfaces of exhaust-gas thermal oil heaters are to be provided with a fixed fire-extinguishing system and a cooling system. Where a pressure water spray system is fitted for this purpose, the following requirements are to be complied with:

- .1 the flow rate of the water spraying system is to be at least 3.5 l/min for each square meter of the heating surface, and water supply is to be available for at least 20 min;
- .2 nozzles are to be so arranged that the required amount of water is sprayed on the entire heating surface;
- .3 suitable means for water collection and drainage are to be provided for the exhaust gas line below the heater so as to prevent water entering into engines;
- .4 all means of starting valves and pumps necessary for the operation of the water spraying system are to be fitted in an easily accessible place at a safe distance from the heater so as to facilitate the operation by the personnel in case of the heater catching fire;
- .5 concise operating instructions are to be permanently displayed at the operating position of the system.

8.5.5 Monitoring and protection

8.5.5.1 Monitoring and protective measures are to be provided for thermal oil heaters according to Table 8.5.5.1.

Monitoring and Alarm Items for Thermal Oil Heaters

Table 8.5.5.1

Items to be monitored	Local control			Remark
	Indication	Alarm	Automatic shutoff	
Thermal oil expansion tank level	×	Low	×	
Thermal oil flow or pressure	×	Low	×	
Thermal oil outlet temperature	×	High	×	
Combustion air pressure or forced ventilation ^{Note 1}		Low or shutoff	×	
Oil fuel pressure ^{Note 1}	×	Low		Standby pumps to start automatically
Heavy oil fuel temperature or viscosity ^{Note 1}	×	Low and great		For heavy oil fuel only
Uptake temperature ^{Note 1}	×	High	×	
Burner flame or ignition ^{Note 1}		Flameout/ Failure	×	Each burner to be monitored
Exhaust temperature ^{Note 2}	×	High		
Note : ×——functional requirement. Note 1: Applicable for oil-fired heaters. Note 2: Applicable for exhaust gas heaters.				

Section 6 PADS AND STANDPIPES

8.6.1 Pads

8.6.1.1 The pads for securing the mountings and fittings to boilers and pressure vessels are to be of sufficient thickness to permit the studs being screwed into them with a length not less than the diameter of the studs without penetrating the pads. The pads and cylindrical shell are to be tightly fitted.

8.6.2 Standpipes

8.6.2.1 The minimum wall thickness δ of standpipes welded direct to the boilers and pressure vessels is not to be less than that determined by 8.2.12.1 of this PART, making such additions as may be necessary on account of bending, static loads and vibration. The wall thickness, however, is not to be less than:

$$\delta = 0.04D + 0.25 \text{ mm}$$

Where: D — outside diameter of the standpipes, in mm.

8.6.2.2 In general, the wall thickness of the standpipes need not exceed that of the shell. Where a standpipe is connected by screwing, the thickness is to be measured at the root of the thread.

Section 7 OPENINGS AND COMPENSATION

8.7.1 Arrangement of manholes and sight holes

8.7.1.1 Boilers and pressure containers are to be provided with manholes or other openings, in order to internally inspect and clean the shell, steam and water drums.

8.7.1.2 Doors of manholes and sight holes are to be made of steel plate or forged steel, and the minimum thickness δ of which is to be determined by the following formula:

$$\delta = 0.8ab \sqrt{\frac{p}{(a^2 + b^2)[\sigma]}} + 0.75 \text{ mm}$$

Where: a — length of major axis of the door, in mm, measured from the centre of jointing surface;

b — length of minor axis of the door, in mm, measured from the centre of jointing surface, mm;

p — design pressure, as specified in 8.1.5 of this Chapter, in MPa;

$[\sigma]$ — allowable stress, to be determined in accordance with 8.1.5 of this PART, in N/mm².

8.7.2 Structure attachment

8.7.2.1 Where cylindrical shell consists of shell plates and/or tube plates which differ in thickness, the shell plates and/or tube plates are to be so butt welded that their centerlines form a continuous circle (see Figure 8.7.2.1). At the welded joint, the thicker plate is to be reduced in thickness by machining to a taper for a distance not less than two times the difference in the thickness.

8.7.2.2 For the attachment of torispherical or ellipsoidal ends to cylindrical shells, see Figure 8.7.2.2. Where the difference in thickness is the same throughout the circumference, the thicker plate is to be reduced in thickness by machining to a taper for a distance not less than four times the offset, so that the two plates are of equal thickness at the position of the circumferential weld. A flat portion may be provided between the end of the taper and the weld edge preparation after thicker plates are tapered; alternatively, if so desired, the weld edge preparation may be included as part of the taper length. The thickness of the plates at the position of the circumferential weld is not to be less than that required for cylindrical shell of seamless or welded construction of the same diameter and material in any case.

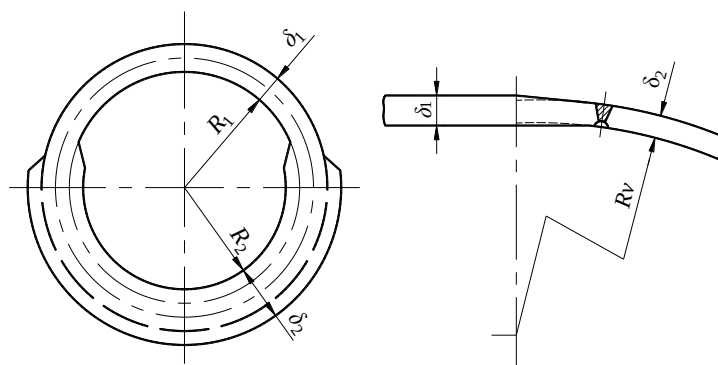


Figure 8.7.2.1 Butt welding of shell tube plate and shell plate Figure 8.7.2.2 Tapering of thicker end and shell plates

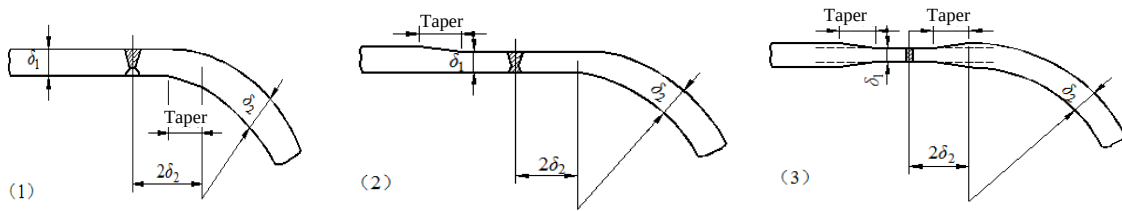


Figure 8.7.2.3 Tapering transition of shell portion

8.7.2.3 Where hemispherical ends are butt welded to cylindrical shells, the thickness of the shell is to be tapered to that of the end, and the centre of the hemisphere is to be so located that the entire tapered portion of the shell and the butt weld are within the hemisphere, see Figure 8.7.2.3.

If the hemispherical end is provided with a parallel portion to be butt welded to the shell, the thickness of this portion is not to be less than that required for a seamless or welded shell.

8.7.2.4 The typical acceptable methods of attaching flat ends to cylindrical and rectangular headers are as shown in Figure 8.7.2.4.

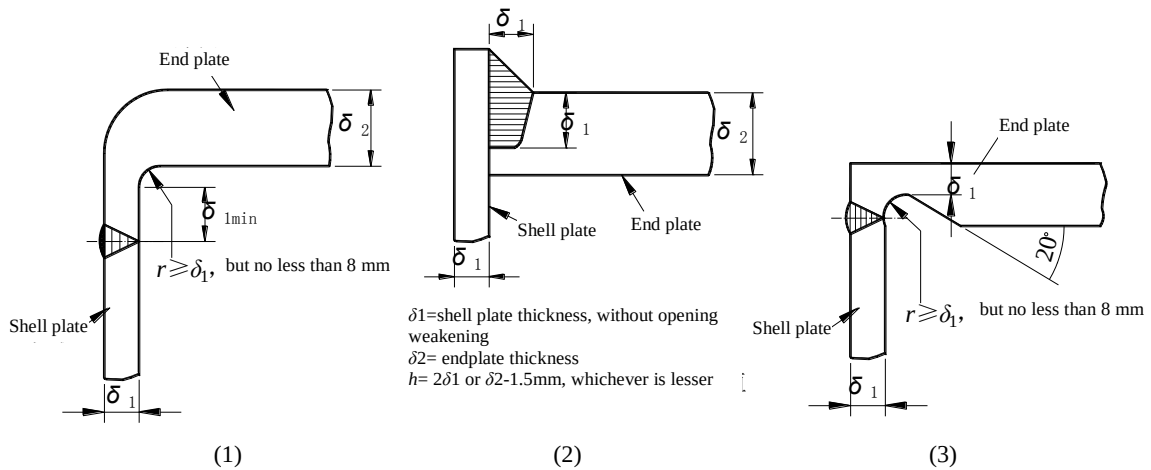


Figure 8.7.2.4 Attachment of flat ends to cylindrical and rectangular headers

8.7.3 Opening and compression of cylindrical shells

8.7.3.1 Any openings in cylindrical shells, including manholes, hand-holes, openings for standpipes or connecting branches and tube holes, having diameters exceeding those obtained from the formula below, are to be reinforced in accordance with the requirements as specified in 8.7.3.2, but the maximum hole diameter is not to exceed 200 mm.

$$d = 8.1 \sqrt[3]{D_1 \delta (1 - K)} \quad \text{mm}$$

Where: δ —actual thickness of cylindrical shell, mm;

D_1 —outside diameter of cylindrical shell, in mm;

$$K = \frac{p D_1}{1.82 [\sigma] \delta}, \text{ but no more than } 0.99;$$

Where: p —design pressure, MPa, as specified in 8.1.3 of this PART;

$[\sigma]$ —allowable stress, to be determined in accordance with 8.1.5 of this Chapter, in N/mm^2 .

For elliptical holes arranged with their major axes in longitudinal direction, the major axes are to be taken as the diameter of the opening; for elliptical holes arranged with their minor axes in longitudinal direction, the mean of the major and minor axes are to be taken as the diameter of the openings.

8.7.3.2 Openings in cylindrical shells larger than those permitted by 8.7.3.1 of this PART are to be reinforced by the methods shown in the Figure 8.7.3.2 (1) Reinforcement by stand-pipe or compensating ring and Figure 1.3(2) Reinforcement by compensating plate. Reinforcement will be considered adequate when the effective reinforcement section area is equal to or more than the sectional area in way of the openings.

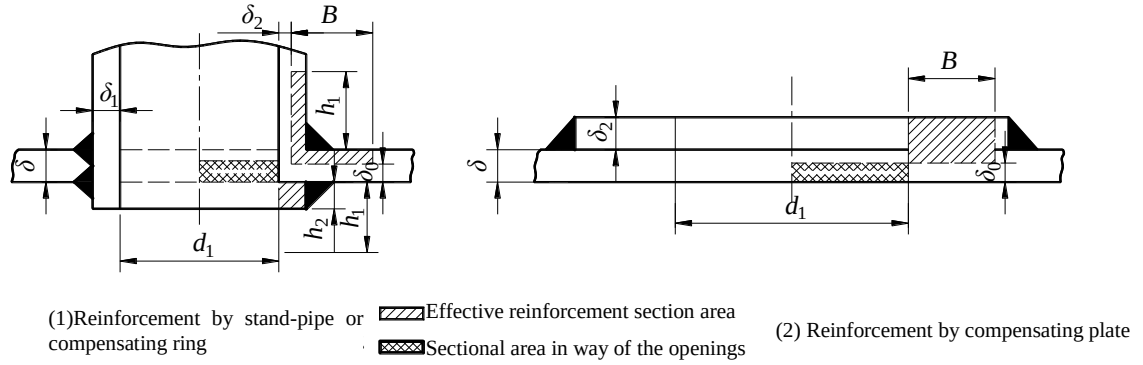


Figure 8.7.3.2 Reinforcement of Shell Holes

.1 The effective compensating sectional area A , shown in Figures 8.7.3.2 (1) to (2) of this Appendix, is to be taken respectively as the total of the following relevant sectional areas:

(1) Surplus thickness of cylindrical shell multiplied by effective width, i.e.,

$$A_1 = (\delta - \delta_0)B \quad \text{mm}^2$$

(2) Thickness of compensating plate multiplied by effective width, i.e.,

$$A_2 = \delta_2 B \quad \text{mm}^2$$

(3) Surplus thickness of standpipe or compensating ring multiplied by effective height, i.e.,

$$A_3 = (\delta_1 - \delta_3)h_1 \quad \text{mm}^2$$

(4) Sectional area of that portion of the standpipe or compensating ring which projects inside the shell, i.e.,

$$A_4 = \delta_1 \cdot h_2 \quad \text{mm}^2$$

.2 Half the sectional area requiring compensating in way of the opening, i.e.:

$$\frac{d_1}{2} \cdot \delta_0 \quad \text{mm}^2$$

.3 The symbols used in 8.7.3.1.1-1 to 8.7.3.1.1.5 above are defined as follows:

δ — actual thickness of the shell, in mm;

δ_0 — thickness, in mm, to be determined in accordance with 8.2.2.1 of this PART, where the strength factor φ of the shell is equal to 1;

δ_1 — actual thickness of standpipes or compensating rings, in mm;

δ_2 — thickness of compensating plates, in mm;

δ_3 — thickness of standpipes, as determined by 8.2.12.1 of this PART, in mm;

d_1 — inside diameter of standpipes or compensating rings, in mm;

$B = \sqrt{D_0 \delta}$, but not more than $0.5d_1$, in mm;

$h_1 = 0.8\sqrt{d_1 \delta_1}$, mm;

h_2 — effective height above the inner side of the shell, in mm, taken as the actual one, but not greater than h_1 , mm;

D_0 — inside diameter of cylindrical shell, in mm.

.4 Where the material for the standpipe, compensating ring or compensating plate has an allowable stress lower than that of the shell, the effective compensating sectional area as prescribed in (1) above is to be corrected by multiplying the ratio of allowable stress of standpipe, compensating ring or compensating plate and the allowable stress of shell.

8.7.4 Dished end plates

8.7.4.1 For openings with effective reinforcement in dished end plates, the opening factor $\frac{d}{\sqrt{D_1 \delta}}$ is to be calculated as described in 8.2.4.1 of this PART, but d in the formula is to be replaced by the equivalent diameter d' of openings, which is determined by the following formula:

$$d' = d - \frac{A}{\delta} \text{ mm}$$

Where: d —actual diameter of opening in dished end plate, in mm;

A —sectional area of the effective reinforcement, in mm^2 , to be determined in accordance with 8.7.4.2 of this PART.

8.7.4.2 Openings in dished end plates may be reinforced with standpipe, compensating ring or compensating plate, or with compensating ring combined with compensating plate, see Figure 8.7.4.2 (1).

The effective compensating sectional area A is to be taken as the total of the following sectional area:

.1 thickness of compensating plate multiplied by effective width, in mm^2 , i.e.;

$$A_1 = 2\delta_2 B \text{ mm}^2$$

.2 surplus thickness of standpipe or compensating ring multiplied by effective height, in mm^2 , i.e.

$$A_2 = 2(\delta_1 - \delta_3)h_1 \text{ mm}^2$$

.3 thickness of standpipes or compensating ring multiplied by effective height of that portion of standpipe or compensating ring which projects inside the end, mm^2 ; i.e.,

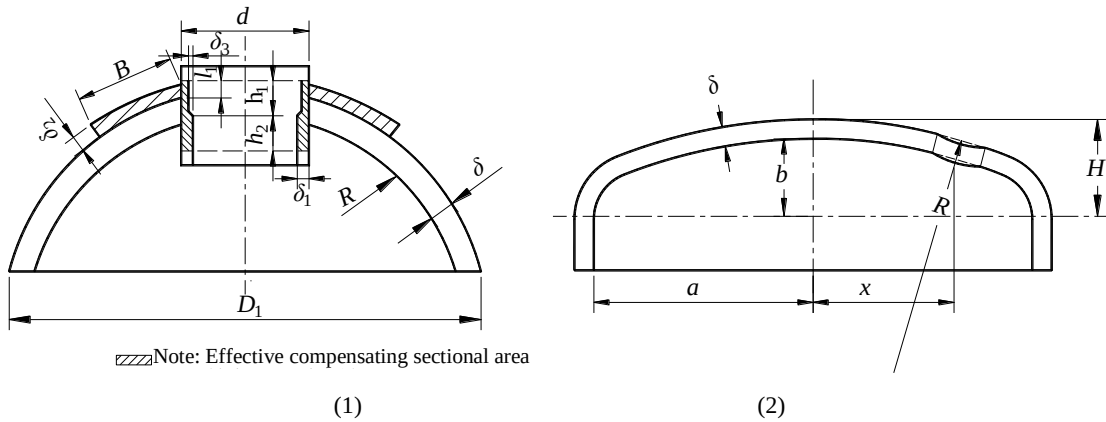
$$A_3 = 2h_2\delta_1 \text{ mm}^2$$

Where: B —effective breadth, $B = \sqrt{2R\delta}$ or $B = 0.5d$, in mm, the smaller value being taken;

R —inside radius of the spherical portion of the torispherical end, or inside radius of the meridian of the ellipse at the center of the opening for ellipsoidal end, in mm, to be determined by the following formula:

$$R = \frac{[a^4 - x^2(a^2 - b^2)]^{\frac{3}{2}}}{a^4 b}$$

where, a , b and x are as shown in Figure 8.7.4.2 (2);



Note: Effective compensating sectional area

Figure 8.7.4.2 Reinforcement for Openings on Dished End Plates

h_1 —effective height, $h_1 = l + \delta + \delta_2$, mm;

h_2 —effective height, $h_2 = l = \sqrt{d \times \delta_1}$, mm;

δ —thickness of dished end plate, in mm;

δ_1 —thickness of standpipe or compensating ring, in mm;

δ_2 —thickness of compensating plate, in mm;

δ_3 —minimum thickness as required in 8.2.2.1 of this PART, in mm.

Where the reinforcement material for openings in dished end plates has an allowable stress lower than that of the end plate, the effective sectional area of compensating material is to be corrected by multiplying the ratio of allowable stress of compensating material and allowable stress of dished end plate.

Section 8 HYDRAULIC TESTS

8.8.1 General provisions

8.8.1.1 On completion of manufacture or assembly, boilers, boiler components and mountings, fittings and pressure vessels are to withstand hydraulic tests in accordance with Table 8.8.1.1,

		Hydraulic Test		Table 8.8.1.1
SN	Part	Test pressure (MPa)		
		After manufactured or assembled	After fittings installed	
1	Drums	$1.5P$	$1.25P$	
2	Boiler gas pipes and water pipes	$2P$ (after bending and machining)	—	
3	Boiler valves and fittings	$2P$	$1.25P$	
4	Pressure vessels	$1.5P$	$1.25P$ (Air receiver may be used for gastight test under work pressure)	

Note: P –design pressure, MPa.

CHAPTER 9 STEERING GEAR AND WINDLASSES

Section 1 STEERING GEAR

9.1.1 Definitions

9.1.1.1 For the purpose of this Section:

.1 Main steering gear means the machinery, rudder actuators, the steering gear power units, if any, and ancillary equipment and the means of applying torque to the rudder stock (e.g. tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the fishing vessels under normal service conditions.

.2 Auxiliary steering gear means the equipment other than any part of the main steering gear necessary to steer the fishing vessels in the event of failure of the main steering gear but not including the tiller, quadrant or components serving the same purpose.

.3 Steering gear power unit means:

(1) in the case of electric steering gear, an electric motor and its associated electrical equipment;

(2) in the case of electro-hydraulic steering gear, an electric motor and its associated electrical equipment and connected pump;

(3) in the case of other hydraulic steering gear, a driving engine and connected pump.

.4 Steering gear control system means a whole set of equipment by which orders are transmitted from the navigating bridge to the steering gear power units.

.5 Maximum ahead service speed means the greatest speed which the ship is designed to maintain in service at sea at her deepest seagoing draught.

.6 Maximum astern speed means the speed which it is estimated the fishing vessels can attain at the designed maximum astern power at the deepest sea-going draught.

9.1.2 Equipment requirements

9.1.2.1 Each fishing vessel is to be provided with a main steering gear and an auxiliary steering gear. The main steering gear and the auxiliary steering gear are to be so arranged that the failure of one of them will not render the other one inoperative.

9.1.2.2 For the main steering gear composed of two sets of steering gear power units, the auxiliary steering gear may be dispensed where requirements of 9.1.3.2 of this PART will be still met in the event of breakdown or failure of either set of steering power unit.

9.1.2.3 The auxiliary steering gear may be dispensed where the main gearing device is a manual steering gear, provided that an emergency steering gear directing acting upon rudder is fitted.

9.1.2.4 The bridge is to be fitted with a rudder angle indicator capable of correctly indicating the rudder position, and the rudder chamber is to be fitted with a rudder angle indicating device.

9.1.2.5 Where the main steering gear is driven by power, a rudder angle indicator is to be fitted in the bridge independently of steering gear control system.

9.1.2.6 Manually operated gears are only acceptable when the operation does not require an effort exceeding 160 N under normal conditions and their constructions are to ensure that the hand wheels of the gears will not be damaged by counter-forces.

9.1.2.7 The steering gear compartment is to be readily accessible, and provided with suitable arrangements to ensure working access to steering gear machinery and controls.

9.1.3 Basic performance

9.1.3.1 The main steering gear is to be of adequate strength and capable of putting the rudder over from 35° on one side to 35° the other side with the vessel at its deepest seagoing draught and running ahead at maximum ahead service speed and under the same conditions, from 35° either side to 30° the other side in not more than 28 s.

The main steering gear and rudder stock is to be so designed that they will not be damaged at maximum astern speed under the fishing operation conditions.

9.1.3.2 The auxiliary steering gear is to be capable of putting the rudder over from 15° one side to 15° the other side in not more than 60 s with the ship at its deepest seagoing draught and running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater.

9.1.3.3 The steering gear is to be fitted with a brake device to keep the rudder steady. For hydraulic steering gear, such brake device may be dispensed where an isolating valve is fitted between the hydraulic cylinder and piping.

9.1.3.4 Steering gears are to be provided with rudder angle limiters which are to be so installed that the steering angle is more than the maximum working angle by 1.5°.

Power-operated steering gears are to be fitted with limit switches or similar devices, for stopping the gear before the rudder stops are reached. These arrangements are to be synchronized with the gear itself and not with the steering gear control.

9.1.3.5 The main steering gear as described in 9.1.2.2 of this PART is to be fitted with two sets of independent control systems, each of which is to be separately operated from the bridge. For hydraulic steering gear, only one set is to be fitted.

9.1.3.6 Where the auxiliary steering gear is fitted in the steering gear compartment, a means of communication is to be provided between the navigation bridge and the steering gear compartment.

9.1.3.7 For the main steering gear in vessels with length no less than 75 m, a control system is to be fitted in the bridge and steering gear compartment, and the functions of control system at the steering gear compartment is not be affected where the control system of the bridge fails.

9.1.3.8 Source of electrical power and cable installation:

.1 Each electrical or electrohydraulic steering gear comprising one or more power units is to be served by at least two exclusive circuits fed directly from the main switchboard, however, one of the circuits may be supplied through the emergency switchboard. Each power unit of electrical or electrohydraulic main steering gear complying with the requirements of this Section is to be served by one exclusive circuit fed directly from the main switchboard, and one of the afore-mentioned circuits may be fed from the emergency switchboard. An auxiliary electric or electrohydraulic steering gear associated with a main electrical or electrohydraulic steering gear may be connected to one of the circuits supplying this main steering gear. The circuits supplying an electrical or electrohydraulic steering gear are to have adequate rating for supplying all motors which can be simultaneously connected to them and may be required to operate simultaneously.

.2 Where the auxiliary steering gear operated by power is not electrically powered or is powered by an electrical motor primarily intended for other services, the main steering gear may be fed by one circuit from the main switchboard.

.3 Each main and auxiliary steering gear control system, if electrical and operable from the navigating bridge, is to be served by its own separate circuit supplied from a steering gear power circuit from a point within the steering gear compartment. Or alternatively, this control system may be supplied by a separate circuit directly from the same section of main or emergency switchboard bus-bars at a point on the switchboard adjacent to that supplying the said steering gear power circuit.

.4 The electrical power circuits and the steering gear control systems with their associated components, cables and pipes required in this Section are to be separated as far as practicable throughout their length range. For vessels with length less than 45 m, such range may be extended.

9.1.4 Monitoring and alarms

9.1.4.1 The alarm device is to alarm according to relevant requirements of Chapter 12 in this PART in the event of steering gear failures. The alarm and monitoring requirements for the steering gear are to be in accordance with Table 9.1.4.1.

Alarm Requirements

Table 9.1.4.1

	Item	Alarm	Note
1	Power of steering gear power unit	Failure	—
2	Steering gear circuit and motor	Broken connections and overload	Navigation bridge and main control position in engine room are to be provided with running indications when each motor operates.
3	Steering gear control system	Failure	—
4	Hydraulic oil tank level of steering gear	Low	Each oil tank is to be fitted with a monitoring device, and it may be dispensed for vessels with length less than 45 m
5	Angular position of rudder		Indicated in accordance with 9.1.2.4 of this PART
6	Automatic rudder arrangement	Failure	Operation indication
7	Hydraulic oil temperature	High	At the location where the oil cooler is installed
8	Pressure difference of hydraulic oil filter	High	When the oil filter is fitted

9.1.4.2 Short circuit protection and an overload alarm are to be provided for the circuits and motors referred to in 9.1.3.8 .1 of this Section. Protection against excess current, including starting current, if provided, is to be for not less than twice the full load current of the motor or circuit so protected, and is to be arranged to permit the passage of the appropriate starting currents. Where a three-phase supply is used, an alarm is to be provided that will indicate failure of any one of the supply phases. The alarms required in this Article are to be both audible and visual and are to be situated in a conspicuous position in the main machinery space or control room from which the main machinery is normally controlled. Audible and visual alarms are also required to be provided in the navigation bridge.

9.1.4.3 For any main and auxiliary steering gear control system operable from the navigation bridge an audible and visual alarm is to be given in the navigation bridge in the event of failure of electrical power supply to the control system, or in the event of a power failure to any one of the steering gear power units.

9.1.4.4 For any main and auxiliary steering gears operable in the bridge, the power wires of control systems are to be only provided with short circuit protection.

9.1.4.5 For fishing vessels with length less than 45 m, the short-circuit protection and power failure alarm can only comply with requirements of 9.1.4.2 in this PART.

9.1.5 Materials and tests

9.1.5.1 Components of steering gear are to be generally made of steel or ductile materials approved by CCS. In general, such material is not to have an elongation of less than 12%, nor a tensile strength in excess of 650 N/mm². In addition, such components are to be subject to tests in compliance with relevant provisions of PART 7.

9.1.5.2 The performance requirements of steering gears as specified in 9.1.3.1 and 9.1.3.2 of this PART are to be verified in Z-shape navigation tests.

9.1.6 Construction and design

9.1.6.1 The pressure taken is not to be less than 1.25 times maximum allowable working pressure under the operation conditions as specified in 9.1.3.1 of this PART when the strength of components, pipes and accumulators, subject to the internal pressure, is calculated. The pulsating pressure arising from the dynamic load is to be taken into account when necessary.

9.1.6.2 Steering gear components, subject to the internal pressure, are to be designed in accordance with the relevant requirements of Chapter 8 of this PART for pressure vessels.

9.1.6.3 Where the components subject to pressure are designed in accordance with the requirements of 9.1.5.2 of this PART, the permissible stress is not to exceed the lower of the following values:

$$\frac{R_m}{A} \quad \text{or} \quad \frac{R_{eH}}{B}$$

Where: specified tensile strength of material at ambient temperature, in N/mm²;

R_{eH} —specified yield stress or proof stress of the material at ambient temperature, in N/mm²;

A and B are safety coefficients given by Table 9.1.6.3.

Safety Coefficients A and B

Table 9.1.6.3

Safety coefficient	Low carbon steel	Cast steel	Nodular graphite cast iron
A	3.5	4	5
B	1.8	2	3

9.1.6.4 Relief valves are to be fitted to any part of the hydraulic system which can be isolated and in which pressure can be generated from the power source or from external forces, and are to comply with the following:

.1 the setting pressure is not to be less than 1.25 times the maximum working pressure and not to be more than the design pressure;

.2 the discharge capacity of the relief valve(s) is not to be less than 110% of the total capacity of the pumps which can deliver through it (them). Under such conditions the rise in pressure is not to exceed 10% of the setting pressure. In this regard, due consideration is to be given to extreme foreseen ambient conditions in respect of oil viscosity.

9.1.6.5 All the steering gear components and the rudder stock are to be of sound and reliable construction. Any essential component which is not duplicated, is to be taken into account where appropriate.

9.1.6.6 Hydraulic power steering gears are to comply with the following requirements:

.1 Effective filters are to be fitted for purifying hydraulic oil;

.2 The circulating oil tank of hydraulic system is to be provided with low-level audible and visual alarms;

.3 The storage tank is to be permanently connected by piping in such a manner that the hydraulic systems can be readily recharged from a position within the steering gear compartment and provided with a content gauge;

.4 Two pieces of oil seal gland are to be fitted between moving parts to enable the actuator to function where one oil seal gland fails;

.5 Arrangements for bleeding air from the hydraulic system are to be provided.

9.1.7 Hydraulic piping

9.1.7.1 The hydraulic piping of steering gear is to be installed to be easily accessible and is to be provided with sufficient protection against external mechanical damage or rust.

9.1.7.2 The hydraulic piping of steering gear is to comply with relevant provisions of Section 5 in CHAPTER 2 and of Section 7 in CHAPTER 4.

9.1.7.3 The hydraulic piping of steering gear is to be apart from the hull and is not to pass through fish hold. Where it has to pass through fish hold in arrangement, it is to be approved by CCS beforehand and provided with necessary actions.

9.1.7.4 The hydraulic piping is not to be connected with other hydraulic systems.

Section 2 WINDLASSES

9.2.1 Definitions

9.2.1.1 For the purpose of this Section:

- .1 Rated pull means the pull measured at wildcat or anchor cable.
- .2 Overload pull means the capability of the windlass necessary to withstand an overload pull for a short time.
- .3 Mean speed means the speed for raising 1 length of cable chains when two lengths of cable chains are in the water with the anchor hanged free.

9.2.2 General requirements

9.2.2.1 For vessels with length no less than 45 m or anchor mass exceeding 450 kg, the windlass is to be driven by independent prime mover or motor. For hydraulic windlasses, oil pumps may be driven by main engines with clutch. Where the oil pump driven by the main engine is shared by windlass and winch, a dividing valve easy to operate and correctly controlling the flow rate is to be fitted at the piping separation. The piping is to be so connected and arranged to avoid affecting the normal running of the windlass.

9.2.2.2 Power windlasses are to be reversible. Hydraulic pipes of hydraulic windlasses are to be so connected to other hydraulic systems to avoid affecting the reversal of windlasses when necessary.

9.2.2.3 Prime movers and transmission gearing are to be protected against over-moment and impact.

9.2.2.4 Where applicable, hand-operated windlasses may be accepted for vessels having anchors of not more than 250 kg, and provision is to be made for prevention of injuring persons by levers.

9.2.2.5 The piping of hydraulic windlass is to comply with relevant requirements of Section 5 in CHAPTER 2 and of Section 7 in CHAPTER 4.

9.2.3 Working capacity of windlasses

9.2.3.1 Windlasses are to be capable of working continuously for a period of 30 min. The rated pull and overload pull are to comply with the following:

.1 The rated pull is generally not to be less than 42.5 N for graded anchor chain made of high-quality steel and 37.5 N (d being anchor chain diameter, in mm) for graded anchor chain made of ordinary steel at the mean speed as specified in 9.2.3.2 of this PART; it may be reduced for non-graded anchor chain where appropriate.

.2 Windlasses are to be capable of working continuously for a period of at least 2 min under an overload pull (without any requirements for hoisting speed) for breaking out the anchor. The overload pull is not to be less than 1.5 times the working load

9.2.3.2 For fishing vessels, when carrying out the trial of hoisting anchors by the windlass at the depth of more than 55 m, a mean speed of hoisting one anchor from a depth of 55 m to a depth of 27.5 m is not to be less than 9 m/min. Other equivalent methods may be also adopted for the test upon approval by CCS.

9.2.4 Protection and brake devices

9.2.4.1 Windlasses are to be provided with a clutch located between wildcats or reels and driving shafts, and the clutches are to be provided with efficient locking devices.

9.2.4.2 Windlasses with anchor chains are to be fitted with effective chain cable stoppers and self-locking devices for unmooring. Steel cable windlasses are to be provided with disconnectable ratchet gears, and rope stoppers or ferrules are to be fitted at the bow area beyond windlasses, so that the pull will not directly act on windlass. Chain stoppers or rope stoppers are to hold the test load equivalent to the mass of anchor chain or anchor cable, and the stress is not to be more than 90% of minimum yield point of material.

9.2.4.3 The wildcats or reels of windlasses are to be provided with reliable brakes which are to withstand a static pull equivalent to 45% of breaking strength of anchor chains or anchor cables when fully applied.

9.2.4.4 Reels are to be provided with cable arrangements to enable uniform reeling of cables.

9.2.5 Deepwater anchoring devices

9.2.5.1 Fishing vessels often sailing in sea area with a depth of more than 100 m are generally to be fitted with deepwater anchoring devices in which anchor chains may be replaced with steel cables.

9.2.5.2 Deepwater anchoring devices are generally to be fitted with buffer devices before rope stoppers, and are to be provided with equipment for drying anchor cables and oil coating if possible.

9.2.5.3 Generally, the unmooring speed of deepwater anchoring devices is to be no less than 30m/min.

9.2.5.4 Bow sheaves of deepwater anchoring devices are to have wheel diameter generally no less than 13 times anchor cable diameter. Bow sheaves are to be in a construction to prevent anchor cables against damage.

9.2.5.5 Reels of deepwater anchoring devices are to be fitted with cable arrangements, and provided with devices for keeping uniform tension of steel cables when possible. The cable arrangements may be dispensed upon approval by CCS where reels are in a construction where steel cables are arranged smoothly.

9.2.5.6 Deepwater anchoring devices are to be designed in compliance with the anchor cable characteristics of engineering suspended chains, and the relation of rendering anchor cable length and water depth:

$$s = \sqrt{\frac{2TY}{w} - Y^2} \quad \text{m}$$

Where: s —length of anchor cable to be rendered, m;

T —maximum allowable pull of anchor cable, N, decided by load carrying and safety coefficients;

w —weight of anchor cable in water in the unit length, N/m;

Y —water depth, m.

CHAPTER 10 FISHING MACHINERY

Section 1 GENERAL PROVISIONS

10.1.1 Application

10.1.1.1 The provisions of this Chapter apply to the design, manufacturing, installation and tests of fishing machinery (e.g., net winches, steel winches and fish pumps). The hydraulic transmission and mechanical systems are to comply with requirements of relevant sections in this PART; the electrical transmission and control systems are to comply with requirements of PART 4.

10.1.2 Design and arrangements

10.1.2.1 Fishing machinery is to be so designed and arranged to facilitate observation, operation and maintenance.

10.1.2.2 Consoles of fishing machinery are to be so arranged that operators can clearly see net hauling and release as well as liaison signals.

10.1.2.3 Where consoles are apart from fishing machinery, operating gears are to be still fitted nearby, and safe interlocking devices are to be fitted between them. Necessary instruments are to be fitted to the consoles for display.

10.1.2.4 Bases of fishing machinery are to be of sufficient strength and rigidity and firmly connected with the hull structure.

10.1.2.5 Where main engine shafts drive the hydraulic oil pumps of winches, clutches and flexible couplings are to be fitted. The clutches are to have a margin coefficient no less than 1.5.

10.1.3 Protection and overload protection

10.1.3.1 Means of protection are to be provided for moving parts of fishing machinery where appropriate to avoid accidental injury to people.

10.1.3.2 Where the height of working platform exceeds 1.5 m, railings with the height of no less than 1 m are to be provided.

10.1.3.3 Fishing machinery is to be provided with load protection devices such as slip clutches, overflow valves and relief valves, to limit the maximum torque of driving. Such protection devices are to be in a construction and position facilitating inspection and maintenance.

10.1.4 Reversal and speed variation

10.1.4.1 Fishing machinery is generally to have performance of reversal and speed variation.

Section 2 WINCH

10.2.1 Definitions

10.2.1.1 For the purpose of this Section, winch means power machinery for hauling and releasing net, e.g., net winches and steel winches.

10.2.2 Materials

10.2.2.1 Vital components in the power transmission system are to be made of steel, cast iron or spheroidal or nodular graphite cast iron in compliance with PART 7.

10.2.2.2 High-pressure hose components may be connected by branches if complying with relevant requirements of Chapter 2.

10.2.3 Design

10.2.3.1 Winches are to generally be independent of other deck machinery. Pipes of hydraulic systems may be connected to other hydraulic systems other than steering gears, provided that no mutual interference is resulted in.

10.2.3.2 For overflow valves of hydraulic winches, the regulated pressure is not to exceed the maximum working pressure of hydraulic system.

10.2.3.3 The rated output of power units is to meet the demand of rated load and corresponding winch speed. Generally, the maximum torque of power units is not to be less than 1.5 times rated torque.

10.2.3.4 Load transmission components are to be designed based on the maximum torque aforesaid.

10.2.3.5 Consideration is to be given to the load to be withstood by reel brake during the reel shaft calculation.

10.2.3.6 Hydraulic systems of hydraulic winches are to be fitted with strict hydraulic purification devices, and magnetic devices are to be fitted for filters at the inlet of oil pump.

10.2.3.7 Hydraulic motors are to have self-locking function.

10.2.3.8 Facilities are to be provided to prevent fishing tools from entering the destination at excessively high speed, but such facilities are not to disconnect the power unit.

10.2.3.9 The calculated stress applied on components is to be less than 40% of yield point of used material and to be no more than 23% of the breaking strength of the material.

10.2.4 Controls

10.2.4.1 Winches with double reels are to be provided with independent controls.

10.2.4.2 The hand wheel or levers are to be operated clockwise or forward when the winch is lifted and anti-clockwise or backward when the winch is released. A locking device preventing automatic shift is to be fitted to the hand wheel or lever.

10.2.4.3 Where remote control is provided, reels are to be operated simultaneously to operate in synchronization, and an interlocking device is to be fitted between the remote control and control at the engine side.

10.2.5 Clutches and brakes

10.2.5.1 Clutches easy to operate are to be fitted between winches and driving shafts.

10.2.5.2 Reel brakes of winches are to be capable of fully braking when winches are released or maximum load is lifted, and the margin coefficient is to be no less than 1.5.

10.2.5.3 Brakes of winches are to prevent steel cables from being released automatically in the event of a fault. Automatic emergency stop devices are to be fitted when necessary.

10.2.5.4 For mechanically driven winches, interlocking devices may be fitted between brakes and clutches when possible.

10.2.5.5 Where automatic brakes are fitted, manual release devices are to be provided.

10.2.6 Reels

10.2.6.1 The reel diameter is not to be less than 14 times diameter of reeled steel cable.

10.2.6.2 The diameter of marginal plates at both ends of reel is to be at least greater than the diameter of the outmost-layer circle plus two times diameter of steel cables. It may be increased where appropriate in case of no cable arrangement device.

10.2.6.3 Means are to be provided to prevent all steel cables from being completely released.

10.2.7 Cables arrangement devices

10.2.7.1 Reels of winches are to be fitted with automatic cable arrangement devices to ensure uniform cables reeling. Cable arrangement devices are to be fitted with manual regulating mechanisms, and manual reels may be dispensed.

10.2.7.2 Clutches are to be fitted between cable arrangement devices and transmission gears.

10.2.8 Friction bosses

10.2.8.1 All power-driven friction bosses for pulling ropes are to be of sufficient strength and rigidity.

10.2.8.2 The working surface of friction bosses is to be smooth and be of sufficient rigidity to prevent steel cables from being ground to grooves.

10.2.8.3 The working surface of friction bosses is to be in a construction to prevent steel cables from rolling out when pulled.

10.2.8.4 Safety facilities are to be fitted at the direction where cables enter friction bosses to prevent injuring operators due to cables overlaying.

10.2.8.5 Friction bosses are to be fitted with some cooling facilities.

Section 3 DELIVERY MECHANISMS

10.3.1 General requirements

10.3.1.1 Where a conveyor system is composed of multiple conveyors, emergency switches for stopping all conveyors are to be fitted at an interval of no more than 10 m. when the length of conveyor system is greater than 15 m, audible and visual alarm devices for startup are to be fitted.

Section 4 TESTS

10.4.1 General requirements

10.4.1.1 Fishing machinery is to be subject to bench test at the manufacturer's works. The heavy-duty test is to be carried out for 3 min at no less than 125% of nominal load and rated speed.

10.4.1.2 Fishing machinery is to be subject to tests in compliance with relevant requirements of CHAPTER 1 in this PART.

CHAPTER 11 REMOTE CONTROL SYSTEM OF PROPULSION MACHINERY

Section 1 GENERAL PROVISIONS

11.1.1 Application

11.1.1.1 The provisions of this chapter apply to fishing vessels with remote control systems for propulsion devices and with the duty of the owner of the machinery; When the vessel is less than 30 m , the requirements may be relaxed as appropriate subject to the approval of the Society.

11.1.2 Definitions

11.1.2.1 For the purposes of this chapter and Chapter 12:

.1 Remote control means control of a device by an operator from a distance. Facilities for mutual connection are to be fitted between control and controlled devices.

.2 Automatic control means the self-regulating control without directly operating the final-stage control equipment by an operator.

.3 Centralized control means control of all operations by a control station.

.4 Local control means operation of controlled device by the device per se or a mechanism nearby.

.5 Manual control means direct operation of final-stage control device by an operator.

.6 Control station means a combination for determining, controlling the set values and sending control instruction signals by an operator. Appropriate signal systems are to be fitted at the control station to ascertain whether the control system is operated as required.

.7 Monitoring station means a space or position where the propulsion machinery and other mechanical and electrical equipment are to be controlled and monitored.

.8 Monitoring: means monitoring the actual operations of controlled devices and systems and providing necessary indicated data.

.9 Override means the special control measures for the skipping of a certain procedure or a certain safeguard action so as to effect compulsory operation to the machinery or electrical equipment for a short period to ensure the safety of the fishing vessel.

.10 Fail safe: means that upon failure or malfunction of a component or system, the output automatically reverts to a predetermined design state of least critical consequence. For fail safe, considerations are to be given to systems and machinery thereof as well as the safety of the whole device or even fishing vessels.

11.1.3 Automatic control devices

11.1.3.1 For remote control systems automated to some extent, automatic control devices are to comply with relevant requirements of Chapter 12 in this PART.

11.1.4 Tests

After installed on board, remote control systems are to be subject to the mooring and sea tests in accordance with a test program approved by CCS.

Section 2 CONSTRUCTION AND DESIGN

11.2.1 Control station

11.2.1.1 For fishing vessels with propulsion machinery remotely controlled by navigation bridges or machinery spaces, local control stations are to be still fitted at the machinery spaces. Local control stations are to be located near the mechanical and electrical equipment to facilitate the direct manual operation of the equipment.

11.2.1.2 Relative to the control station of navigation bridge, the local control station of machinery space is to generally serve as the main control station. However, in fishing vessels of less than 45 m in length, local control systems of machinery spaces may only serve as emergency control stations upon approval by CCS where monitoring, alarm and control equipment of the bridge comply with running requirements. In this case, the control station of navigation bridge shall serve as the main control station, and number of testing instruments in the machinery space may be reduced based on primary parameters where appropriate. Where a centralized control station of machinery space is fitted, it may serve as the main control station, provided that it complies with requirements of Section 4 in this CHAPTER.

11.2.1.3 Where the local control station of machinery space only serves as the emergency control station, an emergency release device of remote control system is to be fitted in the machinery space and is to be locked at ordinary times.

11.2.1.4 An interlocking device is to be fitted between the bridge or control station and local control station of machinery space, so that the propulsion machinery can be only controlled by a control station at any moment. Each control station is to be fitted with an indicator to show the controlling station.

11.2.1.5 Control stations are to be switched only in the main control station, but the bridge and other non-main control stations may be switched in the bridge. Generally, control stations may be switched upon mutual communication.

11.2.1.6 Considerations are to be given to the convenience of operation, monitoring, maintenance and personal safety protection for the arrangement of monitoring equipment, signal display position, operating lever, switches and buttons in control stations.

11.2.1.7 The design, equipment and installation of remote control stations are to ensure the safe and reliable operation and local control of propulsion machinery.

11.2.1.8 For the design of propulsion machinery control systems, considerations are to be given to watch officers' unfamiliarity with machinery performance. Therefore, a control program is to be provided to control equipment to run according to the correct sequence and time so as to guarantee the safe running of fishing vessels.

11.2.2 Performance requirements

11.2.2.1 Remote control systems are to be generally designed based on the fail-safe principle.

11.2.2.2 Remote control systems are to be of excellent control quality and accuracy, so that the propulsion machinery is to have satisfactory dynamic characteristics in all working conditions ranges.

11.2.2.3 Remote control systems are to enable comprehensive control of the speed and propulsion direction, e.g., controlling the screw pitch of propellers under all navigation and operation conditions. Remote control systems are to be fitted with devices preventing the overload of the propulsion machinery when necessary.

11.2.2.4 The remote control systems and control devices thereof are to be so designed that alarm will be triggered in case of the system failure, and the preset speed and propulsion direction are to remain unchanged till the local control.

11.2.2.5 The propulsion machinery is to enable the control lever to be re-started after passing by the stop position after emergency stop or automatic stop.

11.2.2.6 Override is to be generally indicated when implemented. The override button is to be so arranged to preclude inadvertent operation.

11.2.2.7 Where the remote control is executed by mechanisms such as steel cable or chain cable, the compensation clearance and blackwash margin are to be provided to guarantee the equipment allocation, and reliable locking devices are to be fitted at the connections of mechanism to prevent dislocation.

Section 3 REMOTE CONTROL OF BRIDGE

11.3.1 General requirements

11.3.1.1 The control station of the bridge is to control the speed, reversal, gear change, clutch, speed ratio switching and stop of the propulsion machinery, and is to be fitted with necessary interlocking devices to prevent mechanical damage. Where the remote control system fails, operations aforesaid are to be made at the local control station. Where a remote control starting system is fitted, a low air pressure alarm device is to be provided, and the main engine is to be still started at such set pressure. In addition, the side thruster (if fitted) is to be also controlled effectively.

11.3.1.2 The remote control system is to generally control each independent propeller with single lever. In fishing vessels less than 30 m in length, each independent propeller is permitted to be controlled with two levers which are to be so arranged that the speed control lever is on the right and the reversal lever is on the left. The lever controlling the operation of fishing vessels is to be operated at a direction consistent with the predicted running direction of fishing vessels.

11.3.1.3 Sensory identifications other than visual ones are to be generally provided at the center of the control lever.

11.3.1.4 The lever only for speed control may be provided with red marks.

11.3.1.5 The remote control system is to be provided with override in compliance with the requirements of safety system in CHAPTER 12 of this PART.

11.3.1.6 The remote control station of the bridge is to be so arranged to facilitate operation, monitoring and maintenance. Operation switches, instruments, indicators and visual signal, etc. are to be provided with appropriate lighting without hindering navigation at nights.

11.3.2 Equipment

The bridge is to be generally provided with following equipment:

- .1 An emergency stopping device on the navigating bridge independent of the normal remote control system or an emergency shafting declutching device (measures are to be taken to preclude inadvertent operation);
- .2 An indicator showing the rotation direction of propeller shaft; or an indicator showing the pitch angle of blade for controllable pitch propeller;
- .3 An indicator showing the clutching or declutching position of clutch;
- .4 The following audible and visual faults pre-alarming devices:
 - (1) Low-pressure alarm of lubricating oil (two types of alarm, i.e., “Low” and “Too Low” preferably)
 - (2) Low-pressure alarm of gear casing lubricating oil;
 - (3) High-temperature alarm of cooling water;
 - (4) Low-pressure alarm of controllable pitch propeller hydraulic oil (if fitted);
 - (5) Control power failure alarm (if fitted);
 - (6) Low starting air pressure alarm (if started by remote control);
 - (7) Overload load alarm and display system running indicator of side thruster (if fitted).
- .5 An indicator showing the functioning control station;
- .6 Instruments showing following parameters:
 - (1) Lubricating pressure;
 - (2) Lubricating temperature;
 - (3) Cooling water temperature;
 - (4) Cooling water pressure;
 - (5) Lubricating oil pressure of gear casing;
 - (6) Hydraulic oil pressure of controllable pitch propeller (if fitted);
 - (7) Control air pressure (if fitted);
 - (8) Tachometer of main engine (restricted speed ranges are to be indicated if any).

Section 4 Remote Control Room (Station) at Machinery Spaces

11.4.1 General requirements

11.4.1.1 Centralized control rooms (stations) of machinery spaces are to comply with requirements on control functions and control switching of propulsion machinery as specified in Section 3 of this CHAPTER.

11.4.1.2 Centralized control rooms (stations) of machinery spaces are to be generally located in the machinery spaces; otherwise, its position is to be subject to the approval by CCS.

11.4.1.3 Centralized control rooms (stations) of machinery spaces are to be located in positions with small vibration and wide horizon as far as practical.

11.4.1.4 Centralized control rooms (stations) of machinery spaces are to be sound-proof, and provided with breakage-proof window glass. In addition, two accesses far away from each other are to be provided as far as practical, one of which is to be near the means of escape of machinery spaces.

11.4.1.5 Where the remote control of propulsion machinery is exclusively performed by centralized control rooms (stations) of machinery spaces, such centralized control rooms (stations) of machinery spaces are to also comply with the requirements on control and equipment as specified in Section 3 of this CHAPTER. However, some requirements may be lowered where appropriate upon approval by CCS based on the positions of centralized control rooms, visibility of propulsion machinery, size of navigation area and fishing vessel dimensions.

11.4.1.6 Control stations nearby may be dispensed where the main engine and other mechanical and electrical equipment are remotely controlled by mechanical connection mechanism of centralized control rooms (stations) of machinery spaces.

11.4.1.7 When the propulsion machinery is running normally, the centralized control room (station) is to be constantly attended and serve as the local control station.

11.4.1.8 In fishing vessels less than 45 m in length, “duty rooms” independent of centralized control rooms (stations) may be established at positions with high visibility in machinery spaces without hindering the alarm detection.

CHAPTER 12 ENGINE AUTOMATION

Section 1 GENERAL PROVISIONS

12.1.1 General requirements

12.1.1.1 Turbines automation applies to the following:

.1 Centralized control stations remote control of navigation bridges and machinery spaces, attended centralized control stations of machinery spaces;

.2 Periodically unattended machinery spaces (remote control of navigation bridges).

12.1.1.2 The automated systems in this PART cover control, safety and alarm systems (including displays).

12.1.1.3 The automated systems of turbine cover the following mechanical and electrical equipment:

.1 Propulsion machinery and important auxiliary equipment thereof;

.2 Electric generating plants;

.3 Auxiliary boilers;

.4 Other mechanical devices and systems;

.5 Fire control, detection and extinguishing systems.

12.1.1.4 All remote controls of bridges are to be performed in the centralized control stations of machinery spaces.

12.1.1.5 The safety of turbine automated control systems is to be same as that of fishing vessels in which mechanical and electrical equipment is attended directly, i.e., the mechanical and electrical equipment will be effectively operated by hand in case of automated systems failure.

12.1.1.6 All components of automated control systems are to operate normally and stably in the long term with correct characteristics and accuracy.

12.1.2 Environmental conditions

12.1.2.1 Electrical and electronic components and equipment for turbines automated systems are to adapt to the environmental conditions for navigation and operation of fishing vessels, e.g., vibration resistance, salt mist, oil mist and mould.

12.1.2.2 Electrical equipment in the remote control and automated systems are to comply with relevant requirements of environmental conditions in PART 4.

12.1.2.3 Electronic equipment in the remote control and automated systems are to normally operate at the following environmental conditions:

.1 Temperature range:

(1) Machinery spaces and centralized control stations: $+5^{\circ}\text{C}$ to $+55^{\circ}\text{C}$;

(2) Bridges and other compartments: 0°C to $+55^{\circ}\text{C}$;

(3) Electronic equipment are not to fail at $+70^{\circ}\text{C}$ generally in the cabinet where heating parts are installed;

(4) Electronic equipment are to operate normally at -25°C when installed at a position which may be affected by cold conditions.

.2 Vibration:

(1) Generally, the displacement amplitude is to be $\pm 1\text{mm}$ where the vibration frequency is 2-13.2Hz; the acceleration amplitude is to be $\pm 6.86\text{ m/s}^2$ where the frequency is 13.2~100.0Hz.

(2) For the equipment installed in diesel engines, compressors and steering gear spaces, the displacement amplitude is to be $\pm 1.6\text{mm}$ where the vibration frequency is 2~25Hz; the acceleration amplitude is to be 39.2 m/s^2 where the vibration frequency is 25.0~100.0Hz.

Where the equipment is installed in positions where the vibration frequency exceeds the range above, damping actions are to be taken.

.3 Inclination and swing: 22.5° at each direction (cycle: 10 s).

.4 Vertical linear acceleration: $\pm 9.8\text{ m/s}^2$.

.5 Humidity:

(1) The relative humidity is $95\% \pm 3\%$ where the temperature is no more than 40°C ;

(2) The relative humidity is $70\% \pm 3\%$ where the temperature is more than 40°C .

12.1.3 Working conditions

12.1.3.1 The equipment in the remote control and automated systems is to normally work in the following variation ranges of voltage and frequency:

.1 The steady-state voltage variation is to be in the range from +6% to -10% of rated value and the steady-state frequency variation is to be $\pm 5\%$ of the rated value; the recovery time is to 1.5 s where the transient voltage variation is $\pm 20\%$ of rated value, and is to be 5s where the transient frequency variation is $\pm 10\%$ of the rated value.

.2 The battery supply voltage variation is to +30% and -25% of rated value.

12.1.3.2 Pneumatic and hydraulic control equipment is to normally work where the power source pressure variation is within the range of $\pm 20\%$ of rated value, and is not to be damaged at 1.5 times rated pressure value.

12.1.4 Tests

12.1.4.1 Automated systems are to be subject to the mooring and navigation tests together with the monitored electrical and mechanical equipment, to check whether the automated systems are correctly installed and whether the whole system works appropriately.

12.1.4.2 Automated systems are to be subject to tests together with monitored electrical and mechanical equipment according to the test program approved by CCS.

Section 2 CONTROL SYSTEMS

12.2.1 General requirements

12.2.1.1 Control systems include automatic and remote control systems.

12.2.1.2 Control systems are to work stably. Mechanical and electrical equipment is not to be affected by harmful mechanical load and thermal load, and is to have necessary control accuracy.

12.2.1.3 Control systems are to be designed according to the fail safe principles, taking into account control systems and related mechanical and electrical equipment thereof as well as safety of the whole turbine and whole vessel.

12.2.1.4 Control systems are to be so designed to minimize the risks caused by possible individual failures of equipment and prevent the failure of standby automatic and (or) manual controls.

12.2.1.5 All mechanical and electrical installations essential for the safe operation of the fishing vessel are, in the case of failure in or out-of-action of any part of automatic or remote control system including failure of power supply, to be capable of:

- .1 sending out alarm signals;
- .2 replacing immediately faulty component(s) in time for recovering normal operation (if applicable);
- .3 transferring to local manual control, and the transfer of control is not to seriously affect the operating conditions of the mechanical and electrical equipment.

12.2.2 Independence

12.2.2.1 Control systems are to be designed to function independently of safety and alarm systems so that a failure or malfunction in other systems will not prevent the other system(s) from operating. Where means can be provided to ensure effective monitoring, local switching is to be permitted.

12.2.2.2 Control systems for propulsion machinery, boilers and electric generating plants are to be independent of each other. The control system for each independent propulsion unit is to be provided separately. The propulsion machinery with double engines and single propeller is to be controlled by uniform control system, including load distribution balance system and system control and tracking system, after two transmission clutches of parallel-running gear casing are clutched.

12.2.3 Inspection of control systems

12.2.3.1 Functions of control system is to be inspected. Where the sensibility and limit values, etc. of control equipment are adjustable, the set value is to be easily inspected and locked.

12.2.4 Power sources of control systems

12.2.4.1 An alarm is to be given when the power supply of control systems fails. Automated systems with automated generating plant are to automatically switch to the independent battery pack and an indication is to be given when the main power supply fails.

12.2.4.2 Hydraulic power sources and piping of control systems are to comply with relevant requirements of CHAPTERS 2 and 4 of this PART. The standby hydraulic pump is to be automatically started up and operated when the pressure is lower than the specified value, and is to give an alarm when the pressure is lower than the value required for normal working.

12.2.4.3 Pneumatic control systems are to comply with the following:

- .1 A standby air compressor is to be provided where the air is supplied by air compressor.
- .2 A relief valve is to be fitted in the air supply system, and its opening pressure is to be 1.1 times working pressure;

- .3 Means are to be provided to keep the air purified and dry and free from oil content;
- .4 The air is to be provided by a special air receiver or an air receiver for starting main compressor.

Section 3 SAFETY SYSTEMS

12.3.1 Classification of failures

12.3.1.1 In the event of failures endangering the main engine and other important mechanical and electrical equipment in varying degrees, system systems are to enable failed mechanical and electrical equipment to automatically or manually generate protective action according to the following three categories:

- .1 Class I: The equipment stops running immediately and is not allowed to be automatically operated without manual reset;
- .2 Class II: The equipment is temporarily regulated to operable state, e.g., running at reduced output or speed;
- .3 Class III: Corresponding actions of class I or class II are not required. Generally, the equipment will stop running and the standby equipment will be started and operated.

12.3.2 Fail safe, inspection and power sources

12.3.2.1 Safety systems are to be designed according to the fail safe principle and requirements of 12.2.1 of this PART.

12.3.2.2 The inspection of safety systems is to comply with requirements of 12.2.3 of this PART.

12.3.2.3 Power sources of safety systems are to comply with requirements of 12.2.4 of this PART.

12.3.3 Independence of Safety Systems

12.3.3.1 Safety systems class I as specified in 12.3.1 of this PART are to be independent of control systems and alarm systems.

12.3.3.2 Safety systems class II and class III as specified in 12.3.1 of this PART are to be independent of other systems as far as practicable.

12.3.4 Overriding

12.3.4.1 The safety protection action class I as specified in 12.3.1 of this PART is not to be generally provided with overriding. However, special considerations are to be given to the emergency stop of propulsion machinery.

12.3.4.2 Relevant control stations are to be provided with light display when an overriding action is operated. The safety systems are to automatically recover functions.

12.3.5 Special performance

12.3.5.1 Safety systems are to be so designed that safety and alarm systems will not function once stop is triggered due to unnecessary interference.

12.3.5.2 When two or more safety actions are caused by single failure, the safety actions are to be carried out in sequence as follows:

- .1 Operation of standby functions and switching indication alarms;
- .2 Alarm signals are to be triggered by the alarm equipment which will act in sequence according to the failures classification in 12.3.1 of this PART, and is to trigger the emergency stop or reduce output or transmit an instruction to the safety system to reduce the output.

12.3.5.3 Safety systems of propulsion machinery are to work based on the open circuit principle. Safety systems of boilers and combustors are to generally work based on the closed circuit principle. Auxiliary machinery is to be designed based on the working principle to fully guarantee safety according to the design of the machinery.

Section 4 ALARM SYSTEMS (INCLUDING DISPLAYS)

12.4.1 General requirements

12.4.1.1 All faults of the controlled and monitored mechanical and electrical equipment and control and monitoring systems thereof are to be indicated with alarm signals at the relevant control stations.

12.4.1.2 All alarms are to be provided with both audible and visual signals simultaneously. The audible signal is to be clear and visible. Signals for failures class I and class II as specified in 12.3.1 of Section 3 are to be red, and signals for class III are to be yellow. Audible signal is to be of an adequate sound level and to be clearly distinguishable from the fire alarms, telephones and other sound signals. Alarm signals may be classified according to the priority.

12.4.1.3 The alarm system is to be capable of indicating all faults occurred at the same time without causing mutual interference, including transponder.

12.4.1.4 After the alarm signal is acknowledged, the audible signal is to be silenced and the visual signal (e.g., from flickering to steady light) may be changed. The silencing button for the audible alarms in machinery spaces is permitted to be arranged only in the machinery space or at the engine room centralized control station and the visual alarm signals are to be retained until the fault has been rectified. When the fault has been rectified, the alarm system is to be automatically reset to its normal operating condition.

12.4.2 Inspection and self-monitoring of alarm systems

12.4.2.1 The alarm system is to be designed with self-monitoring properties, and to automatically detect and alarm its own faults to ensure timely alarming or prevent false alarm.

12.4.2.2 The alarm system is to be capable of self-inspection if having equipment shared with the control and safety systems.

12.4.2.3 The alarm system is to be detected when the monitored mechanical and electrical equipment is running.

12.4.2.4 The alarm system is to be capable of blockading meaningless signals during certain processes. Manual blockading is to be indicated when the interlocking is performed manually.

12.4.3 Displays

12.4.3.1 Parameters may be clearly displayed by instrumentation or display units. Parameter displays may be performed separately or selectively, and may be alphanumeric or in the form of graphics or diagrams. But all displays or indications are to be clearly distinguishable. The color of indicating lamps is normally to be green or white.

12.4.4 Power supply of alarm systems

12.4.4.1 Where the main power supply fails, the independent standby battery pack is to be automatically switched and an alarm will be given.

Section 5 REQUIREMENTS FOR AUTOMATION OF CENTRALIZED CONTROL STATION REMOTE CONTROL OF BRIDGE AND MACHINERY SPACES, ATTENDED CENTRALIZED CONTROL STATION OF MACHINERY SPACES

12.5.1 General requirements

12.5.1.1 Fishing vessels to be controlled remotely in this mode to some extent are to be provided with control stations (rooms) of navigation bridges, centralized control stations (rooms) of machinery spaces and local control stations. When mechanical and electrical equipment is running normally, the centralized control stations (rooms) of machinery spaces are to be attended continuously. Generally, control stations are to be switched at the centralized control station (room) of machinery space

12.5.1.2 Control stations of bridges are to effectively monitor the propulsion direction and speed of propulsion machinery and side propellers (if fitted) and other relevant devices (if fitted). When necessary, the functions of the control stations are to be transferred to central control stations (rooms) and local control stations of machinery spaces at any moment, except for monitoring of steering gears.

12.5.1.3 Control stations of bridges (rooms) are to monitor, control and switch devices as specified in 12.5.1.2. in addition, remaining automatic mechanical and electrical equipment is to be monitored as far as practicable. Such monitoring is to be equivalently effective as directly managing the mechanical and electrical equipment by operators at machinery spaces.

12.5.1.4 Where equivalent actions are to be taken for fishing vessels in length less than 45 m to enable bridge control stations and local control stations to undertake the monitoring functions of centralized control stations of machinery spaces, centralized control stations of machinery spaces may be dispensed upon approval by CCS.

12.5.1.5 Bridge control stations and centralized control stations of machinery spaces are to be independent of main engine emergency stop or emergency de-clutching buttons of automated systems and emergency oil stop buttons of boilers, and are to be fitted to prevent false action.

12.5.1.6 Local control stations are to be provided with actions to guarantee effective manual operation of mechanical and electrical equipment nearby when automated systems fail.

12.5.2 Control of propulsion machinery

12.5.2.1 The remote control of main engines are to be fitted with interlocking devices, including safety interlocking devices between startup and turning gear meshing or shafting brake (if any) functioning and low lubricating oil pressure. Reversible main engines are to be also fitted with safety interlocking devices between startup and reversal, to prevent starting main engines when the mechanical equipment may be damaged.

12.5.2.2 Where main engines are provided with automated systems, number of startup failures is to be limited,

generally no more than three times. When the third automatic startup fails, automatic startup is to be stopped, and an alarm is to be given.

The low starting air pressure alarm value of automatic startup and remote control manual startup is to be provided with a large margin, to ensure that it can be still started at such pressure.

12.5.2.3 Where the lubricating oil pump of main engine is independently driven, the standby lubricating oil pump is to be started automatically or remotely when the outlet pressure of the pump drops to be lower than the alarm value. However, the faulted lubricating oil pump is to stop running after delayed appropriately to guarantee the safe operation of main engine.

The main engine is to be fitted with an automatic stop device at excessively low pressure of lubricating oil, and an alarm is to be given before stop.

12.5.2.4 Where the rated output of main engine is no less than 2200kW or the cylinder bore is no less than 300 mm, an oil mist detector or bearing temperature alarm apparatus is to be fitted in the crankcase.

12.5.2.5 The remote control system of main engine is to be so designed to automatically prevent thruster from running in the restricted speed ranges in the long term regardless of the position of the lever or hand wheel of the operating gear, or is to be provided with alternative actions to give an alarm when the speed is in the restricted speed ranges.

12.5.2.6 An alarm is to be given in the control station when the main engine runs at the overspeed, and the fuel supply will be disconnected automatically to stop the main engine when the overspeed reaches the limit speed.

12.5.2.7 For the propulsion machinery reversed by gear casing or controllable pitch propeller, the control system is to be provided with devices to prevent the torque or other mechanical load from being excessive during reversal of main engine or shafting.

12.5.2.8 For the propulsion machinery reversed by gear casing, the remote control system is to be so designed that the reversal is performed at reduced speed of main engine, and the maximum speed of any reversal is to be no less than 65% of the nominal speed of main engine.

For the propulsion machinery only fitted with clutches, the clutching and de-clutching are to be carried out when the main engine speed is lower than the pre-set value.

12.5.2.9 The control system of double-engine, single-propeller unit is to be so designed that the main engine is separated from the clutch at the moment of emergency stop.

12.5.2.10 For hydraulic systems controlling the pitch angle of blade, standby pumps are to be automatically started and operated when the outlet pressure of the hydraulic pump drops to be alarm value. The low-pressure alarm value of hydraulic system is to have certain safety margin, under which the control system can be still operated.

12.5.2.11 The clutching and de-clutching of propulsion machinery clutches are to be generally performed at the zero position of blade of controllable pitch propeller.

12.5.3 Control of generating sets

12.5.3.1 Generating sets of fishing vessels are to be so designed that centralized control stations enable remote control or automatic control during the normal operation of generating sets. When generating sets fail, centralized control stations are to start and regulate the standby generating sets for power supply by remote control or automatic control.

12.5.3.2 Where generating sets are started automatically, interlocking devices are to be fitted to prevent prime movers from being started when the damage may be caused. In control systems, the number of continuous automatic re-startup is to be limited after startup failure. Where an automatic re-closer is fitted, automatic re-closing is only permitted to be performed once, to prevent power losing due to short circuit, which may aggravate the damage of electrical system.

12.5.3.3 Where two or more than two generating sets running in parallel are often used in fishing vessels, devices are to be fitted in the generating sets to automatically remove non-essential loads during overload. When unloading devices act, an alarm is to be given in the centralized control stations of machinery spaces.

12.5.3.4 Where emergency generating sets are provided with overspeed protection devices, other emergency stop protection devices do not need to be fitted.

12.5.4 Control of auxiliary boilers

12.5.4.1 Each boiler is to be fitted with a general automatic fuel shut-off valve on the fuel manifold. The general automatic fuel shut-off valve is to be automatically closed where all combustors of boiler are flamed out, the boiler water reaches the limit water level or the forced draft of furnace fails. In addition, a limiter for automatic control is to be fitted in the control system of the general fuel shut-off valve of the control station, and is to prevent ignition of boiler after the general fuel shut-off valve is closed.

12.5.4.2 Control systems of boilers are to ensure that the ignition is safely performed in the set temperature and pressure range after normal flameout of boilers, and are to comply with following requirements:

.1 The spark of combustor ignition appears before the fuel valve is opened;

.2 For automatic ignition boilers, all air governing valves are to be opened for scavenging before combustors are ignited;

.3 Where all combustors are flamed out, combustors initially ignited are to return to the low combustion position before automatic ignition.

12.5.4.3 Each combustor is to be fitted with a flame monitoring device which is to automatically cut off the fuel supply during flameout of the combustor. Where the flame monitoring device fails, the fuel supply of such combustor is to be also automatically cut off. Scavenging is to be preformed after all combustors are flamed out.

12.5.4.4 When the outlet pressure of boiler fuel pump drops to the alarm value, the standby pump of fuel is to be started automatically.

12.5.4.5 Each boiler is to be provided with a high water level alarm apparatus and a low water level alarm apparatus. The sensor of low water level alarm apparatus is to automatically close the general fuel shut-off valve while giving an alarm where the boiler water level drops to the limit water level. The set limit water level is not to be lower than the allowable minimum safety water level of boiler. The low-level sensor is to be fitted with a delay device to avoid being affected by swing of fishing vessels.

12.5.4.6 The standby feed pump is to be started automatically when the outlet pressure of boiler feed pump drops to the alarm value.

12.5.5 Control of other devices

12.5.5.1 The display and alarm items of refrigeration devices in centralized control stations (rooms) of machinery spaces are to comply with relevant provisions of PART 4.

12.5.5.2 Machinery spaces and fish holds are to be fitted with water level alarm apparatuses. Bilge pumps may not be fitted with automatic starting devices. If fitted, indicators displaying the running are to be provided. The sewage at the bilge is to comply with requirements of pollution prevention.

12.5.5.3 Where the fuel is heated electrically, the arrangement, control and alarm are to comply with relevant requirements of CHAPTER 4 of this PART.

12.5.5.4 Air compressors are to be automatically started and stopped according to the set pressure.

12.5.5.5 Where side propellers are fitted, audible and visual alarms are to be given in the bridge, and necessary protective devices are to be fitted.

12.5.6 Fire detection and accident fire alarm systems of machinery spaces

12.5.6.1 Machinery spaces are to be generally provided with automatic fire detection and accident fire alarm systems. Manual alarm buttons are to be fitted at accesses of machinery spaces, bridges and centralized control stations of machinery spaces. Accident fire alarms are to be audible at control stations and living rooms. Accident fire alarms may be dispensed for fishing vessels less than 45m in length where the position of machinery spaces enables on-board personnel to monitor fire easily.

12.5.6.2 Fire detection systems are to be based on self-inspection principle.

12.5.6.3 Detectors are to generally cover all hazardous areas. However, the detectors may be dispensed in the visible range of centralized control stations.

12.5.6.4 Fire detection systems are to guarantee continuous power supply. Where the normal power supply fails, they are to be connected with the emergency power supply.

12.5.7 Fire control

12.5.7.1 High-pressure fuel injection pipes of diesel engines are to be enclosed by metal hoses or sheath, and oil leakage is to be alarmed.

12.5.7.2 High and low oil level alarm devices are to be fitted where the fuel oil service tank is provided with an automatic refueling device.

Section 6 PERIODICALLY UNATTENDED MACHINERY SPACES

12.6.1 General requirements

12.6.1.1 This Chapter applies to fishing vessels controlled by bridge control stations and centralized control stations (rooms) of machinery spaces which are periodically unattended during remote control of bridge.

Fishing vessels are to be provided with files suitable for operation at periodically unattended machinery spaces, and such files are to be subject to approval by CCS.

12.6.1.2 For fishing vessels less than 45 m in length which are controlled by bridge control stations and are not provided with centralized control stations, control stations (rooms) of machinery spaces may be also periodically unattended where requirements of 12.5.1.4 in this PART are complied with.

12.6.1.3 Fishing vessels referred to herein are to be provided with control, monitoring, alarm and safety systems of mechanical and electrical equipment in compliance with relevant requirements in this CHAPTER to ensure the manoeuvring of bridges regardless of the unattended period length.

12.6.1.4 For fishing vessels referred to herein, unattended period of machinery spaces may be designed according to the navigations and operations of fishing vessels and requirements of vessels users, e.g., 16 h or 24 h.

12.6.1.5 In the unattended period, automated systems are to ensure the normal continuous operation of the

following mechanical and electrical equipment:

- .1 main propulsion machinery;
- .2 essential auxiliary machinery serving the main propulsion machinery;
- .3 electric generating plant;
- .4 main and auxiliary boilers;
- .5 other machinery and electrical equipment.

12.6.1.6 In the unattended period, the safety level of fishing vessels is to be the same as the safety level requirements for attended machinery spaces.

12.6.2 Main propulsion machinery

12.6.2.1 In addition to complying with requirements of 12.5.2 of this CHAPTER, the control of main propulsion machinery are to start main engines at bridge control stations and centralized control stations (rooms) of machinery spaces.

12.6.3 Electric generating sets

12.6.3.1 The control of generating set is to comply with requirements of 12.5.3 of this PART.

12.6.3.2 Where the power is supplied by one generating set, the standby set is to be automatically started and closed within 45 s in the event of failure of such set.

12.6.3.3 Where the power is supplied by two or more than two generating sets, means are to be provided to ensure the continuous power supply for important load in the event of failure of a set.

12.6.3.4 The standby set is only permitted to be automatically closed once after the power fails due to short circuit. An alarm is to be given after the closure fails.

12.6.3.5 When the generating set runs at overload, non-essential loads are to be automatically shed to ensure supplying power to important loads, or the standby generating set is to be automatically started to supply the power by connecting to the grid.

12.6.3.6 The bridge is to enable starting and switching the standby generating set remotely.

12.6.4 Auxiliary boilers

12.6.4.1 The control of auxiliary boilers is to comply with requirements of 12.5.4 in this PART. In addition, pumps driven by motor are to be automatically started successfully in case of power recovery after power failure.

12.6.5 Other devices

12.6.5.1 The control of other devices is to comply with relevant requirements of 12.5.5 of this PART.

12.6.5.2 The bilge water alarm level is to be such that the bilge water will not rise to the inner bottom plate or corresponding height of double-layer bilge. Water level sensors are to be so arranged to prevent false alarm during normal inclination and swing. The bilge water pump is to be automatically put into operation

12.6.5.3 Valves of bilge water and seawater systems are not to make valves and fishing vessels unsafe in the event of power source failure, and are to be manually operated.

12.6.5.4 Control stations controlling valves are to indicate the valves opening or closing.

12.6.5.5 Air receivers for starting and control are to be automatically charged.

12.6.6 Calling system of marine engineer

12.6.6.1 The on-duty mariner of bridge is to be able to call each marine engineer living in the compartment respectively. The bi-directional internal communication system may be used as such calling system. Such system, including portable or fixed devices, is to still work effectively once the main power supply fails.

12.6.6.2 Audible and visual alarms of centralized control stations (rooms) of machinery spaces are to be extended to centralized alarm monitoring rooms (if provided) of compartments or areas where marine engineers live.

12.6.7 Fire detection and accident fire alarm systems of machinery spaces

12.6.7.1 Fire detection and accident fire alarm systems of periodically unattended machinery spaces are to comply with relevant requirements of 12.5.6 of this PART.

12.6.7.2 Automatic fire detection systems are to be fitted at periodically unattended machinery spaces, and the detectors are to be so arranged to cover all hazardous areas.

12.6.8 Fire control and fighting

12.6.8.1 Fire control and fighting are to comply with relevant requirements of 12.5.7 of this PART.

12.6.8.2 Periodically unattended machinery spaces are to be provided with a main fire pump which can be started by the bridge remotely.

12.6.9 Locking devices of automatic starting

12.6.9.1 Main and auxiliary engines started automatically or remotely are to be provided with locking devices preventing false automatic or remote startup during the overhaul.

Section 7 AUTOMATIC CONTROL AND MONITORING ITEMS

12.7.1 General requirements

12.7.1.1 Automatic control and monitoring items are to comply with relevant requirements of this Section based on specific control mode, and other items may be also added when necessary.

12.7.1.2 In the event of abnormal running state or serious faults which cannot be resolved by on-duty personnel, safety systems are to function as follows:

According to the requirements of Tables 12.7.1-1 to 12.7.1-4, the equipment will be braked and disconnected for alarms class I to protect the equipment against damage; the equipment will be temporarily adjusted to the operable state for alarms class II; the equipment is to be regulated or the standby function is to be enabled to recover the normal running state of equipment for alarm class III.

12.7.1.3 “Alarms of machinery spaces” in Tables 12.7.1-1 to 12.7.1-4 are to mean the alarms of the control stations (rooms) where centralized control stations (rooms) are provided.

Automatic Control and Monitoring Items of Propulsion Machinery with Output Less Than 750 kW ^{Note 2}

Table 12.7.1-1

Alarms of machinery space ×: means that an independent alarm is to be provided			Alarms of bridge Class I: main engine stop, red Class II, reduced output of main engine, red Class III, yellow		
Monitored parameters: l=lower limit h=upper limit	Limit	Machinery Space ^{Note 1}	Bridge		Note
			Independent alarm	Alarm category	
Lubricating oil pressure of main engine	l	×	...	I	
Cooling water temperature of main engine	h	×	...	II	
Cooling water pressure of main engine	l	×	...	II	
Exhaust pressure in the exhaust pipe of main engine	h	×	...	II	
Action of overspeed protection device of main engine		×	...	I	
Pressure of cooling seawater	l	×	...	III	
Starting air pressure	l	×	...	III	
Oil level of fuel oil service tank	l+h	×	...	III	When the oil is refueled automatically or remotely, high-order position is to be adopted.

Lubricating oil pressure of gear casing	l	×	...	I	
Hydraulic oil pressure of controllable pitch propeller	l	×	×	...	Jointly displayed in bridge with "Remote system failure".
Failure/ Overload of steering gear	l	×	×	...	
Failure of remote control system		×	×	...	
Catching a fire at machinery space		×	×	...	
Bilge water level of machinery space	h	×	...	III	
Oil level of oil drain tank	h	×	...	III	
Failure of general power supply		×	...	III	Only applicable to the propulsion machinery with non-electrically driven main auxiliary machinery.
Lubricating oil pressure of diesel engine generating set	l	×	...	III	
Cooling water temperature of diesel engine generating set	h	×	...	III	

Note 1: Where all independent alarms are provided in the bridge, monitoring devices may be dispensed at the machinery space.

Note 2: Where further monitoring is required in the range of turbine devices, e.g., using heavy oil for running, all monitoring devices required for 24 h unattended machinery spaces of boilers are to be equipped according to requirements in Tables 12.7.1-2 to 12.7.1-4.

Automatic Control and Monitoring Items of Propulsion Machinery with Output No Less Than 750 kW

Main Engines, Gear Casings and Bearings

Table 12.7.1-2

Alarms of machinery space × means that an independent alarm is to be provided			Alarms of bridge Class I: main engine stop, red Class II, reduced output of main engine, red Class III, yellow		
Monitored parameters: l=lower limit h=upper limit	Limit	Machinery Space Note 1	Bridge		Note
			Independent alarm	Alarm category	
Main engine Inlet lubricating oil pressure	l	×	...	I	
Pressure difference at both ends of lubricating oil pressure filter	h	×	...	III	

Failure of automatic lubricating oil filter		×	...	III	
Engine lubricating oil inlet temperature	h	×	...	II	
Bearing temperature or oil mist concentration of main engine	h	×	...	II	Power no less than 2200kW, or cylinder bore no less than 300 mm.
Cooling water pressure of cylinder	l	×	...	II	
Cooling water outlet temperature	h	×	...	II	
Oil pollution of main engine cooling water system		×	...	III	When the cooling water is used for heat exchanges driven by fuel or carrying hot oil.
Coolant pressure of piston	l	×	...	II	
Coolant pressure of oil atomizer	l	×	...	III	
Coolant temperature of oil atomizer	h	×	...	III	
Seawater cooling pressure	l	×	×	III	
Closed-loop cooling system fresh water pressure	l	×	...	III	
Closed-loop cooling system fresh water temperature	h	×	...	III	
Fuel pressure of fuel injection pump	l	×	...	III	
Heavy oil inlet temperature or viscosity of main engine	l+h	×	...	III	
Fuel oil level (air cushion type) in the closed oil conservator	l	×	...		Not applicable to automatic ventilation.
Failure of automatic fuel filter		×	...	III	
Charge air temperature	l+h	×	...	III	For “water in the air charging pipe”, it can be used to replace the lower limit.

Difference of exhaust temperature or exhaust temperature deviated mean value	l+h	×	...	II	
Starting air pressure	l	×	...	III	For main engines started remotely controlled by bridge, independent alarms are to be provided in the bridge.
Action of overspeed protection device		×	...	I	
Gear casing Lubricating oil temperature	h	×	...	III	No less than 1500kW.
Lubricating oil inlet pressure	l	×	...	I	
Shafting Rear bearing temperature of tail pipe	h	×	...	III	Sensors may be fitted near rear bearings.
Shafting bearing temperature	h	×	...	I	No less than 1500kW.
Lubricating oil temperature of thrust shaft or temperature of thrust piece	h	×	...	III	
Controllable pitch propeller system Hydraulic oil pressure	l	×	×	...	Jointly displayed in bridge with "Remote system failure".
Hydraulic oil level or oil pump backpressure of gravity tank	l	×	...	III	
Clutch Control power of clutch	l	×	×	...	If caused by manoeuvring failure.

Automatic Control and Monitoring Items of Propulsion Machinery with Output No Less Than 750 kW
Auxiliary Machinery, Tank and Miscellaneous Items Table 12.7.1-3

Alarms of machinery space ×: means that an independent alarm is to be provided			Alarms of bridge Class I: main engine stop, red Class II, reduced output of main engine, red Class III, yellow		
Monitored parameters: l=lower limit h=upper limit	Limit	Machinery Space	Bridge Independent alarm	Alarm category	Note
Diesel engine generating set Lubricating oil pressure	l	×	...	III	
Cooling water pressure or flow	l	×	...	III	
Cooling water/ Cooling air temperature	h	×	...	III	Where local indication is provided, only combined alarmed devices may be fitted at the central alarm

Starting air pressure	l	×	...	III	control panel.
Fuel pressure of electric-driven oil supply pump	l	×	...	III	
Heavy oil viscosity or temperature	l+h	×	...	III	
Pressure difference at both ends of heavy oil filter	h	×		III	
Action of overspeed protection device		×	...	III	
Voltage	l+h	×	...	III	
Frequency	l	×	...	III	
Release of non-essential electric equipment		×	...	III	
Failure of general power supply		×	...	III	Only applicable to the propulsion machinery not electrically driven by main auxiliary machinery.
Oil purifier Oil temperature	l+h	×	...	III	Where local indication is provided, only combined alarmed devices may be fitted at the central alarm control panel.
Accidental discharge of drum/ water seal failure/ output oil containing water or similar conditions		×	...	III	
Steering gear Steering gear failure		×	×	...	
Phase fault / overload		×	×	...	
Control system failure		×	×	...	
Tank liquid level Common fuel tank	l	×	...	III	All tanks charged automatically or remotely are to be fitted with high liquid level alarm devices additionally.
Expansion tank	l	×	...	III	
Sump oil, oil drain tank and fuel overflow tank	h	×	...	III	
Gravity oil tank of tail pipe	l	×	...	III	
Main engine lubricating oil is collected at the chassis/ tank	l	×	...	III	
Hydraulic oil tank of steering gear	l	×	...	III	
Fire detection system Accident fire alarm		×	×	...	
Fault		×	...	III	
Others Remote control system failure		×	×	...	

Alarm system failure	_____	×	...	III	_____
Safety system failure	_____	×	...	III	_____
Safety system tripping	_____	×	...	III	_____
Automatic switching of auxiliary equipment	_____	×	...	III	_____
Bilge water level/ sewage/bilge hat position of machinery space	h	×	...	III	Each machinery space is to be provided with two sensors and detection closed circuit at least.

Automatic Control and Monitoring Items of Propulsion Machinery with Output No Less Than 750 kW

Auxiliary Steam Boilers

Table 12.7.1-4

Alarms of machinery space ×: means that an independent alarm is to be provided			Alarms of bridge Class I: main engine stop, red Class II, reduced output of main engine, red Class III, yellow		
Monitored parameters: l=lower limit h=upper limit	Limit	Machinery Space	Bridge		Note
			Independent alarm	Alarm category	
Steam boilers Safety system release	_____	×	_____	III	_____
Steam pressure	l+h	×	...	III	_____
Water level	l+h	×	...	III	_____
Circulating water pump failure	h	×	...	III	_____
Condensate water including salinity	h	×	...	III	_____
Condensate oil stain	h	×	...	III	_____

12.7.2 Automatic switching of essential auxiliary machinery

12.7.2.1 The automatic switching of essential auxiliary machinery is as specified in Table 12.7.2.1. The display during switching is to comply with requirements of 12.4.4 of this PART.

Automatic Switching of Essential Auxiliary Machinery

Table 12.7.2.1

Auxiliary equipment	Automatic switching	Starting and power supply recovery after whole vessel power	Note

		failure	
Main engine ¹⁾ Lubricating oil pump	×	×	Applicable to all independent circuits.
Piston coolant	×	×	
Cylinder cooling water pump	×	×	Only applicable to electric-driven pump.
Coolant pump of fuel injector	×	×	Only applicable to electric-driven pump.
Fuel feed pump	×	×	
Fuel booster pump	×	×	
General power supply	×		
Diesel generating set Fuel oil booster pump	×	×	If driven independently.
Cylinder cooling water pump	×	×	If driven independently and provided with independent circuits.
Reduction gear casing lubricating oil pump	×	×	
Hydraulic oil pump of controllable pitch propeller	×	×	
Hydraulic oil pump of steering gear	...	×	Remotely started by the bridge.
Starting air compressor	...	...	Automatically set and stop according to the set pressure
Control air compressor	...	...	
Main fire pump	...	...	Remotely started by the bridge.

Note: For fishing vessels with two or more main engines, automatic startup requirements may be dispensed when the standby pump in the auxiliary system is independent of each main engine or all main engines.

12.7.3 Independent alarms

Independent alarm referred to in Table 12.7.3.1, i.e., each alarm is to be provided with independent audible and visual signals.



CHINA CLASSIFICATION SOCIETY

**RULES FOR CONSTRUCTION OF
OCEAN-GOING STEEL FISHING
VESSELS**

2018

PART 4 ELECTRICAL INSTALLATIONS

Effective From 1 December 2018

CHAPTER 1 GENERAL

Section 1 GENERAL PROVISIONS

1.1.1 General requirements

1.1.1.1 The requirements of this PART apply to electrical installations intended for sea-going fishing vessels.

1.1.1.2 Electrical propelling machinery and associated equipment together with auxiliary services essential for the safety of the fishing vessel are to be constructed and installed in accordance with the relevant requirements of this PART. In addition, construction and testing of the electrical equipment are to comply with relevant standards accepted by CCS, such as *International Electrotechnical Commission Standards* (IEC standards).

1.1.1.3 The design and installation of the electrical equipment other than those specified in 1.1.1.2 of this PART is to be such that risk of fire due to its failure is minimized, and it is at least to comply with standards accepted by CCS.

1.1.1.4 The electrical installations are to be such that:

- .1 all electrical auxiliary services necessary for maintaining the fishing vessel in normal operational and habitable conditions will be ensured without recourse to the emergency source of electrical power;
- .2 electrical services essential for safety will be ensured under various emergency conditions;
- .3 the safety of passengers, crew and ship from electrical hazards will be ensured.

1.1.2 Essential equipment

1.1.2.1 Essential equipment is the equipment necessary for the propulsion, steering and safety of the fishing vessel to ensure the safety of crew, including primary essential equipment and secondary essential equipment.

1.1.2.2 Primary essential equipment which need to be in continuous operation for maintaining propulsion and steering:

- .1 steering gear;
- .2 controllable pitch propeller installation;
- .3 air blowers, diesel fuel oil supply pumps, fuel valve cooling pumps, lubricating oil pumps and cooling water pumps for main and auxiliary engines;
- .4 forced draught fans, feed water pumps, water circulating pumps, vacuum pump, condensate pumps and oil burning installations for auxiliary steam boilers for the operation of primary essential equipment;
- .5 azimuth thrusters which are the sole means for propulsion/steering with lubricating oil pumps and cooling water pumps;
- .6 electrical equipment for electric propulsion plant with attached cooling water pumps;
- .7 electric generators and associated power sources supplying the equipment mentioned in .1 to .6 above;
- .8 hydraulic pumps supplying the equipment mentioned in .1 to .6 above;
- .9 viscosity control equipment for heavy fuel oil;
- .10 bilge pump, fire pumps and other extinguishing medium pumps;
- .11 navigation lights, aids and signals;
- .12 internal safety communication equipment;
- .13 lighting system;
- .14 control, monitoring and safety devices/systems for equipment mentioned in .1 to .13 above.

1.1.2.3 secondary essential equipment which need not necessarily be in continuous operation for maintaining propulsion and steering, but which are necessary for maintaining the fishing vessel's safety, e.g.:

- .1 windlasses;
- .2 fuel oil transfer pumps and fuel oil treatment equipment;
- .3 lubricating oil transfer pumps and lubricating oil treatment equipment;
- .4 pre-heaters for heavy fuel oil;
- .5 starting air and control air compressors;
- .6 ballast and heeling pumps;
- .7 ventilating fans for engine and boiler rooms;
- .8 equipment necessary for maintaining dangerous spaces in a safe condition;
- .9 automatic water sprinkler system and pressure water spray fire extinguishing system;
- .10 fire detection and alarm systems;
- .11 watertight closing appliances;
- .12 cooling equipment for lowering ambient air temperature;
- .13 electric generators and associated power sources supplying the equipment mentioned in .1 to .12 above;
- .14 hydraulic pumps supplying the equipment mentioned in .1 to .12 above;

.15 control, monitoring and safety devices/systems for equipment mentioned in .1to .14 above.

1.1.3 Emergency equipment

1.1.3.1 Emergency consumer is a consumer which, after loss of the main source of electrical power, must be supplied by the emergency source of electrical power.

1.1.4 Testing

1.1.4.1 Electrical equipment specified in 1.1.1.2 and 1.1.2.1(1) of this Section is to be tested in accordance with the requirements of Chapter 3 of this PART at the manufacturer. Tests other than those specified in this PART may be required as deemed necessary by CCS.

1.1.4.2 On completion of installation on board, the electrical installations are to be subject to mooring and sea trials in accordance with the test programmes approved by CCS.

Section 2 Environmental and Working Conditions

1.2.1 Environmental conditions

1.2.1.1 Unless otherwise specified (e.g. in 1.2.1.2 of this Section), all electrical installations are to operate satisfactorily under the following environmental conditions:

.1 The ambient air temperatures and primary cooling water temperatures areas given in Table 1.2.1.1(1), however, the upper limit of ambient air temperatures for the electronic equipment is to be 55°C.

Ambient Temperature

Table 1.2.1.1(1)

Medium	Location	Temperature, (°C)	
		Unrestricted service	Restricted service except in tropical zones
Air	In enclosed spaces	0~45	0~40
	In spaces subject to temperatures over 45°C(or 40°C) or below 0°C	According to temperatures in such spaces	According to temperatures in such spaces
	On the open deck	−25~45	−25~40
Water		32	25

.2 The inclination and roll of the ship is as given in Table 1.2.1.1.2;

.3 Vibration and shock likely to arise in fishing operation or navigation;

.4 Moisture, sea air, oil vapour and mould.

Angle of Inclination

Table 1.2.1.1.2

Installations, components	Angle, °			
	Athwartships		fore-and-aft	
	Inclination	Roll	Inclination	Roll
Emergency power installations, switchgear, electrical and electronic appliances	22.5	22.5	10	10
Electrical installations excluding items stated above	15	22.5	5	7.5
Note: Athwartship and fore-and-aft inclinations may occur simultaneously.				

1.2.2 Harmonic content

1.2.2.1 AC electrical equipment is to operate satisfactorily with a supply voltage containing a total harmonic content of the voltage waveform not exceeding 5%. Where the power is supplied by semiconductor convertors, the equipment is to operate satisfactorily in case of high harmonic content.

1.2.3 Voltage and frequency variations

1.2.2.1The electrical equipment supplied from the main or emergency systems.

1.2.3.1 The electrical equipment is to operate satisfactorily with the variations in voltage and frequency from the rated value shown in Table 1.2.3.1.

Voltage and Frequency Variations

Table 1.2.3.1

Equipment	Parameters	Permanent, %	Transient	
			%	Recovery time, s
General equipment	Voltage	+6~−10	±20	1.5

	Frequency	± 5	± 10	5
Direct current equipment supplied by DC generators or rectifiers	Voltage	± 10	—	—
	Voltage cyclic variation deviation	5	—	—
	Voltage ripple	10	—	—
Equipment supplied by batteries: Connected to batteries during charging① Not connected to the batteries during charging	Voltage Voltage	+30 ~ -25 +20 ~ -25	—	—

Section 3 DESIGN, CONSTRUCTION AND INSTALLATION

1.3.1 General requirements

1.3.1.1 Electrical equipment is to be so designed, constructed and installed as to ensure safe operation and facilitate inspection and repair.

1.3.1.2 The distance between live parts of different potential and between live parts and earthed metal, whether across surfaces or in air, is to be adequate for the working voltage, having regard to the nature of the insulating material and the conditions of service.

1.3.1.3 Equipment is not to remain alive through the control circuits or pilot lamps when switched off by the control switch. This does not apply to synchronizing switches and/or plugs.

1.3.1.4 All nuts and screws used for the connection and fastening of electrical equipment are to be provided with means to ensure that they cannot work loose by vibration and shock.

1.3.1.5 The material used to make electrical equipment is to comply with the following requirements:

.1 It is, in general, to be durable, flame-retardant, moisture resistant unless it is adequately protected against the atmospheric environment and temperatures to which it is likely to be exposed;

.2 Insulating materials and insulated windings are to be resistant to moisture, sea air and oil vapour unless special precautions are taken to protect them;

.3 The current carrying parts of electrical equipment are, in general, to be made of copper or copper alloys;

.4 Metal parts of electrical equipment are to be covered with proper protective coating against corrosion unless they are made of satisfactory corrosion-resistant material;

.5 New installation of materials which contain asbestos is to be prohibited.

1.3.1.6 If electrical fittings, not of aluminum, are connected to aluminum, suitable means is to be taken to prevent electrolytic corrosion.

1.3.1.7 All electrical equipment with internal wiring is to be attached with schematic or wiring diagrams in which wiring codes are indicated. All terminals of electrical equipment are to be provided with durable markings or symbols corresponding to those indicated in the diagrams.

1.3.1.8 The controls for emergency alarms are to be marked in red and provided with durable nameplates indicating their purposes.

1.3.1.9 For the fitting of brake, rheostats, starting and charging resistors, heating appliances and other electrical apparatus likely to cause high temperatures, means are to be provided against overheating or igniting of adjacent objects.

1.3.1.10 All electrical equipment is not to be fitted close to the external surfaces of oil compartments, oil tanks or double bottom tanks intended for carrying oils. If this is necessary, electrical equipment is to be installed at a minimum distance of 50 mm from these surfaces, provided that the electrical apparatuses mentioned in 1.3.1.9 are strictly prohibited to be installed on such surfaces.

1.3.1.11 Sockets are not permitted to be installed below the steel plate of machinery space and in the enclosed fuel and lubricating oil separator room.

1.3.1.12 Generating sets are to be installed with their shafts in parallel with the fore-and-aft direction of the ship, and horizontal motors are also to be installed, as far as practicable, with their shafts in parallel with the fore-and-aft direction of the ship.

1.3.1.13 For the electrical equipment other than that installed in a dedicated compartment, the live parts having a working voltage or a voltage to earth exceeding 36 V are to be so protected that they cannot be inadvertently touched.

1.3.1.14 Where the temperature of the enclosures of the electrical equipment is in excess of 75 °C, suitable means are to be provided or suitable arrangement is to be made so as to protect the operators from injurious heating due to inadvertent touching.

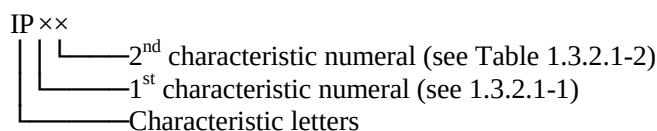
1.3.1.15 Holes are not to be drilled in watertight bulkheads, decks or boundary plating of deckhouses for the purpose of fitting the screws used to securing the electrical equipment and cables.

1.3.1.16 Electrical equipment and cables are not to be fitted on the shell plating of fishing vessels.

1.3.1.17 Conductors and equipment are to be placed at a suitable distance from the magnetic compass, or are to be so screened that the interfering external magnetic field is negligible.

1.3.2 Protective enclosures

1.3.2.1 The type of protective enclosures for electrical equipment is to comply with Refer to IEC Publication 60529: Classification of Degrees of Protection Provided by Enclosures or equivalent standards. The designation indicating the degree of protection consists of the characteristic letters IP followed by two numerals as follows:



Degrees of Protection Indicated by the First Characteristic Numeral

Table 1.3.2.1-1

First characteristic numeral	Degree of protection	
	Brief description	Definition
0	Non-protected	No special protection
1	Protected against solid objects greater than 50mm	A large surface of the body, such as a hand (but no protection against deliberate access). Solid objects exceeding 50mm in diameter
2	Protected against solid objects greater than 12 mm	Fingers or similar objects not exceeding 80mm in length. Solid objects exceeding 12mm in diameter
3	Protected against solid objects greater than 2.5 mm	Fingers or similar objects not exceeding 2.5 mm in length. Solid objects exceeding 2.5 mm in diameter
4	Protected against solid objects greater than 1.0 mm	Fingers or similar objects not exceeding 1 mm in length. Solid objects exceeding 1 mm in diameter
5	Dust protected	Ingress of dust is not totally prevented, but dust does not enter in sufficient quantity to interfere with satisfactory operation of the equipment
6	Dust tight	No ingress of dust

Degrees of Protection Indicated by the Second Characteristic Numeral

Table 1.3.2.1-2

Second characteristic numeral	Degree of protection	
	Brief description	Definition
0	Non-protected	No special protection
1	Protected against dripping water	Dripping water (vertically falling drops) is to have no harmful effect
2	Protected against dripping water when tilted up to 15 °	Vertically dripping water is to have no harmful effect when the enclosure is tilted at any angle up to 15 ° from its normal position
3	Protected against spraying water	Water falling as a spray at an angle up to 60 ° from the vertical is to have no harmful effect
4	Protected against splashing water	Water splashed against the enclosure from any direction is to have no harmful effect
5	Protected against water jets	Water projected by a nozzle against the enclosure from any direction is to have no harmful effect
6	Protected against heavy seas	Water from heavy seas or water projected in powerful jets is not to enter the enclosure in harmful quantities
7	Protected against the effects of immersion	Ingress of water in a harmful quantity is not to be possible when the enclosure is immersed in water under defined conditions of pressure and time
8	Protected against submersion	The equipment is suitable for continuous submersion in water under conditions specified by the manufacturer
		Note: Normally, this will mean that the equipment is hermetically sealed. However, with certain types of equipment, it can mean that water can enter but only in such a manner that it produces no harmful effects

1.3.2.2 The type of protective enclosures selected for electrical equipment is to be appropriate to the condition of the location at which such equipment is installed. The lowest degree of protection is to comply with the requirements given in Table 1.3.2.2 unless otherwise specified.

Minimum Requirements for the Degree of Protection by Enclosure**Table 1.3.2.2**

(1)	(2)	(3)	(4)							
Location	Condition of location	Degree of protection	switchboards, control gears and motor starters	Generators	Motors	Transformers, semiconductor converters	Lighting fixtures	Heating appliances	Cooking appliances	Accessories (e.g. switches, connection boxes)
Dry accommodation spaces	Danger of touching live parts only	IP20	×	—	×	×	×	×	×	×
Dry control rooms			×	—	×	×	×	×	×	×
Control rooms (bridges)	Danger of dripping water and/or moderate mechanical damage	IP22	×	—	×	×	×	×	×	×
Engine rooms (above floor plates)			×	×	×	×	×	×	×	IP44
Steering gear rooms			×	×	×	×	×	×	—	IP44
Refrigerating machinery rooms (excluding ammonia plants)			×	—	×	×	×	×	—	IP44
Emergency machinery rooms			×	×	×	×	×	×	—	IP44
General storage rooms			×	—	×	×	×	×	—	×
Pantries			×	—	×	×	×	×	×	IP44
Provision rooms			×	—	×	×	×	×	—	×
Bathrooms and shows	Increased danger of water and/or mechanical damage	IP34	—	—	—	—	×	IP44	—	IP55
Engine rooms (below floor plates)			—	—	IP44	—	×	IP44	—	IP55
Closed fuel oil separator rooms			IP44	—	IP44	—	×	IP44	—	IP55
Closed lube oil separator rooms			IP44	—	IP44	—	×	IP44	—	IP55
Ballast pump rooms	Increased danger of water and mechanical damage	IP34	×	—	×	×	×	×	—	IP55
Refrigerated rooms, fish processing rooms			—	—	×	—	×	×	—	IP55
Galleys and laundries			×	—	×	×	×	×	×	×
Shaft or pipe tunnels in double bottom	Danger of water spraying, presence of cargo dust, serious mechanical damage, aggressive fumes	IP55	×	—	×	×	×	×	—	IP56
Holds for dry cargo			—	—	—	—	×	—	—	×
Open decks	Danger of water ingress in massive quantities	IP56	×	—	×	—	IP55	×	—	×
Underwater	Underwater running	IP68	—	—	—	—	×	—	—	—

Note 1: “×” means that the requirements of column (3) are to be complied with, or if impossible, the requirements of note 2 are to be satisfied; “—” means that such equipment is generally not to be installed.

Note 2: Where the protection is not achieved by the equipment itself, other means are to be taken or the condition of the location for installing the equipment is to be improved to ensure the degree of protection required in the Table.

Note 3: Where the main and emergency switchboards are constructed in accordance with the requirements of Section 2 of Chapter 3 and installed in accordance with Section 4 of Chapter 2, the requirements of this Table may be dispensed with.

1.3.3 Explosion protection

1.3.3.1 Where electrical equipment is installed in areas where explosive gas or vapour atmospheres may be present, it is to be of a certified safe type complying with the following requirements:

.1 The construction and type testing of the safe type electrical equipment is to be in accordance with the IEC publication 79 *Electrical Apparatus for Explosive Gas Atmospheres*, or other equivalent Chinese national standards such as GB3836 *Electrical Apparatus for Explosive Gas Atmospheres* and IEC publication 92-502 *Special Issue- Oil Tanker -Annex A*;

.2 The safe type electrical equipment is to be certified by a competent testing authority approved by CCS.

1.3.3.2 The certified safe type equipment normally used on board ships includes the following types of protection:

- .1 Intrinsically safe Ex “i”;
- .2 Flameproof Ex “d”;

.3 Increased safety Ex “e”;

.4 Pressurized enclosure Ex “p”;

.5 In addition, lighting fixtures with pressurized enclosures and internally installed turbine generators (hereinafter referred to as air driven lighting fixtures) may be deemed as explosion-proof lighting fixtures.

1.3.3.3 The electrical equipment allowed to be fitted in spaces subject to an explosion hazard, e.g. battery rooms, lamp stores, paint lockers (including ventilation ducts) and liquefied petroleum gas (LPG) steel cylinders storage rooms, is to comply with the following requirements:

.1 The electrical equipment of certified safe types listed in 1.3.3.2 of this section may be fitted, and the explosion groups and temperature classes of such equipment are at least to comply with the requirements in Table 1.3.3.3.1;

Explosion Group and Temperature Class

Table 1.3.3.3.1

Location	Group ^{Note 1}	Temperature class ^{Note 1}
Battery rooms	II C ^{Note 2}	T1
Paint lockers	II B	T3
Ammonia plant rooms	II A	T1
LPG and acetylene storage rooms	II C	T2

Note 1: The explosion groups and temperature classes of electrical equipment listed in this Table and hereinafter in this PART are according to the relevant requirements of IEC Publication 79 *Electrical Apparatus for Explosive Gas Atmospheres* or of GB3836 *Electrical Apparatus for Explosive Atmospheres*.

Note 2: Explosion groups II A, II B and II C of electrical equipment listed in this PART are applicable only to intrinsically safe apparatus and flame-proof apparatus. For other types of explosion-proof electrical equipment, Group II is to be used.

.2 Cables (through runs or terminating cables) of armoured type or installed in metallic conduits are to be used.

.3 The switches, protective devices and motor control gear for the electrical equipment installed in such spaces are to interrupt all poles or phases and are to be located in non-hazardous spaces;

.4 In addition, refer to 1.3.3.4, 1.3.3.5 of this PART and Section 12 of CHAPTER 2 for relevant requirements of ventilation opening of paint lockers and LPG cylinder storage rooms as well as requirements of battery rooms.

In addition, the relevant requirements for ventilation openings of paint locker and LPG steel cylinder storage rooms and battery rooms are given in 1.3.3.4, 1.3.3.5 of this PART and Section 12 of CHAPTER 2.

1.3.3.4 In the areas on open deck within 1 m of inlet and exhaust ventilation openings or within 3 m of exhaust mechanical ventilation outlets of paint lockers and LPG steel cylinder storage rooms, the following electrical equipment may be installed:

.1 certified safe type electrical equipment and cables listed in 1.3.3.3 of this PART;

.2 explosion-proof equipment of non-sparking construction (Ex “n”);

.3 appliances which do not generate arcs in service and whose surface does not reach unacceptably high temperature;

.4 appliances with simplified pressurized enclosures or vapor-proof enclosures (minimum degree of protection IP55) whose surface does not reach unacceptably high temperature.

1.3.3.5 The enclosed spaces giving access to paint lockers and LPG cylinder storage rooms may be considered as non-hazardous, provided that:

.1 the doors to or of paint lockers and LPG steel cylinder storage rooms are to be gastight doors with self-closing devices (watertight doors may be regarded as tight doors) without holding back arrangements;

.2 the paint locker is provided with an acceptable, independent, natural ventilation system ventilated from a safe area;

.3 warning notices are fitted adjacent to entrances of paint lockers and LPG steel cylinder storage room stating that the lockers and rooms contain flammable liquids.

1.3.3.6 Socket outlets are, unless expressly specified otherwise, not to be installed in spaces subject to an explosion hazard.

1.3.4 Earthing

1.3.4.1 All accessible metal parts of the electrical equipment, other than current-carrying ones, are to be earthed, except for:

.1 lamp caps;

.2 shades, reflectors and guards supported on lampholders or lighting fittings constructed of, or shrouded in, non-conducting material;

.3 metal parts on, or screws in or through, non-conducting material, which are separated by such material from current-carrying parts and from earthed non-current-carrying parts in such a way that in normal use they cannot become live or come into contact with earthed parts;

.4 portable appliances having double and/or reinforced insulation, provided that the appliances conform with recognized safety requirements;

.5 bearing housings which are insulated in order to prevent circulation of current in the bearings;

.6 clips for fluorescent lamps;

.7 apparatus supplied at a working voltage not more than 50 V. For the alternating current, this voltage is a value of root mean square. Autotransformers are not to be used for the purpose of achieving this voltage;

.8 cable clips.

1.3.4.2 When the electrical equipment is directly fixed on the metal hull of the ship or securely fixed on bedplates (or supports) which have a good electrical contact with the metal hull of the ship, a special earthing conductor may not be required.

1.3.4.3 Whether the earthing is achieved through a special conductor or by bedplates (or supports) of the equipment, the surfaces in contact are to be clean, flat and bright so as to ensure an effective contact, and measures are to be taken to prevent the connection from loosening and corrosion.

1.3.4.4 When special earthing conductors are used, they are to be of copper or other corrosion-resistant materials of good conductivity, and are to be protected against mechanical damage and corrosion where necessary. The nominal cross-sectional area of various copper earthing conductors is not to be less than required in Table 1.3.4.4.

1.3.4.5 Bare metal parts of movable or portable appliances, other than current-carrying ones, are to be earthed by means of an earth-continuity conductor in the flexible cable or cord through the associated plug and socket outlet, and the cross-sectional area of the earth conductor is to comply with the requirements of Table 1.3.4.4.

Size of Earthing Conductors

Table 1.3.4.4

Type of earthing conductor	Cross-sectional area of associated current-carrying conductor S, mm ²	Minimum cross-sectional area of copper earthing conductor Q, mm ²
Earth-continuity conductor in flexible cable or flexible cord	$S \leq 16$	$Q = S$
	$S > 16$	$Q = S/2$, but at least 16
Earth-continuity conductor incorporated in fixed cable	$S \leq 16$	$Q = S$, but at least 1.5
	$S > 16$	$Q = S/2$, but at least 16
Special fixed earthing conductor	$S \leq 2.5$	$Q = S$, but at least 1.5
	$2.5 < S \leq 120$	$Q = S/2$, but at least 4
	$S > 120$	$Q = 70$

1.3.4.6 Metal sheathings or coverings of cables are to be effectively earthed at both ends of the run, except that final sub-circuits may be earthed at the supply end only. This does not necessarily apply to control and instrumentation cables where single point earthing is permitted for technical reasons.

1.3.4.7 The metal sheathings or coverings of cables may be earthed by one of the means described below:

.1 gripped by metal clamps and connected to the metal hull of the ship by dedicated copper earthing conductors. The relationship between the cross-sectional area Q of the copper earthing conductors and the cross-sectional area S of the current-carrying conductors of the cables is to be as follows:

$$Q \geq 1.5 \text{ mm}^2 \text{ for } S \leq 25 \text{ mm}^2,$$

$$Q \geq 4 \text{ mm}^2 \text{ for } S > 25 \text{ mm}^2.$$

.2 by means of glands intended for this purpose and so designed as to ensure an effective earth connection;

.3 by means of clamps or clips made of corrosion-resistant metal, enabling a good contact between the metal sheathings or coverings of cables and the earthed metal.

1.3.4.8 The electrical continuity of metal sheathings or coverings of cables is to be ensured throughout the length of the cables, particularly at joints and tapings.

1.3.4.9 The cross-sectional area of working earth wire with hull as the loop is to be the same as that of conductor with insulated electrode or phase. 1.3.4.10

The cross-sectional area of earthing conductors which do not normally carry current in service is to be 50% of that of the current-carrying conductors, but not less than 1.5 mm².

1.3.4.11 The system earthing of earthed distribution systems is to be effected by means independent of any earthing arrangements of non-current-carrying parts of the electrical equipment.

1.3.4.12 Every connection of an earth-continuity conductor or a special earthing conductor to the hull structure is to be made in an accessible position, and is to be secured by a screw of brass or other corrosion-resistant material and having a diameter not less than 4 mm, which is to be used for this purpose only.

1.3.5 Electromagnetic compatibility

1.3.5.1 Appropriate measures are to be taken to reduce the interference due to electromagnetic energy so that all electrical and electronic equipment can operate normally in a fishing vessel's electromagnetic environment.

1.3.5.2 The allowable value of the voltage (current) of the interference induced by electrical and electronic equipment and the means of interference suppression are to comply with the IEC Publication 533: *Electromagnetic Compatibility of Electrical and Electronic Installations in Ships*, or corresponding standards.

1.3.6 Visual and audible signals

1.3.6.1 Except those required in 1.3.6.2 of this Section, the color of visual signals is to comply with the requirements of Table 1.3.6.1.

1.3.6.2 Except those required above, the visual and audible signals are to comply with the *Code on Alerts and Indicators* adopted by IMO resolution A.1021(26).

Colors of Visual signals

Table 1.3.6.1

Color	Meaning	Explanation	Example
Red	Danger or alarm	Warning of danger or a situation which requires immediate action	Operation failure of essential equipment; Temperature or pressure of water, oil, etc. reaching a critical value; Power failure of essential circuits
Yellow	Caution	Change or impending change of conditions	Temperature or pressure is abnormal, but not reaching a critical value
Green	Safety(normal operating or normal working conditions)	Indication of a safe situation	Normal operation of machinery; Normal circulation of liquids; Pressure, temperature and currents within limits
Blue	Instruction/information (specific meaning assigned according to the need in the case considered)	Blue may be given a meaning which is not covered by the three above colors: red, yellow and green	Motor begins to start; Unloading generator begins to switch on; Heating circuit of stopping motor is connected
White	No specific meaning assigned	Any meaning, used if red, yellow or green is considered not applicable	Earthing insulation indication; Synchronizing lamp; Telephone calling; Automated equipment

CHAPTER 2 ELECTRICAL SYSTEMS AND INSTALLATIONS

Section 1 POWER DISTRIBUTION SYSTEMS

2.1.1 Power distribution systems

2.1.1.1 The following power distribution systems may be used:

.1 DC

- (1) two-wire insulated system;
- (2) two-wire system with negative pole earthed;
- (3) single-wire system with negative to hull return.

.2 AC single phase

- (1) two-wire insulated system;
- (2) two-wire system with one pole earthed;
- (3) single-wire system with hull return;

.3 AC three phases

- (1) three-wire insulated system;
- (2) four-wire system with neutral insulated;
- (3) four-wire system with neutral earthed;
- (4) three-wire system with neutral earthed and the hull serving as neutral wire.

2.1.1.2 Three-phase, four-wire distribution systems with neutral insulated are not to be installed in fishing vessels (except for those with generating set load power less than 20 kW), unless approved by CCS where special arrangements such as light trapping devices.

2.1.1.3 The hull return system of distribution is not to be used for power, heating or lighting in fishing vessels no less than 75 m in length, but not excluding the following:

.1 impressed current cathodic protective systems;

.2 limited and locally earthed systems, provided that any possible resulting current will not directly flow through any hazardous areas;

.3 insulation level monitoring devices provided the circulation current does not exceed 30 mA under the most unfavourable condition.

2.1.1.4 Where the hull return system is used, all final sub-circuits, i.e., all circuits behind the final protective electrical device are to be powered by two-wires.

2.1.2 Voltage and frequency

2.1.2.1 The maximum supply voltages of DC and AC distribution systems are not to exceed the values given in Table 2.1.2.1.

2.1.2.2 For distribution systems operating at a voltage above 500 V, the control voltage is to be limited to 250 V, except where all control devices of the distribution systems operating at a voltage not exceeding 1000 V are enclosed in appropriate control boxes..

2.1.2.3 The standard frequency of AC distribution systems is to be 50Hz or 60Hz.

Maximum Voltage of Power Distribution Systems

Table 2.1.2.1

Serial No.	Application	Max. voltage, V	
		DC	AC
1	1) For power, heating and cooking equipment permanently installed and connected by permanent wiring, except space heaters. 2) For power and heating equipment (except space heaters) permanently installed where connection by flexible cable is necessary because of the application, e.g. movable cranes. 3) For portable equipment, which is not hand-held during operation, and with connection by socket outlet and flexible cable which incorporates an earth continuity conductor of a size in accordance with 1.3.4.4 of this PART, e.g. welding transformer	500	1000
2	1) For lighting and heaters in accommodation and public spaces; 2) For socket outlets supplying the following: a) equipment with double insulation; b) equipment earthed by earth continuity conductors of a size in accordance with 1.3.4.4 of this PART	250	250
3	For socket outlets used in spaces where particular risks due to exposure and conductivity may exist, e.g. exceptionally damp or confined spaces: 1) supplied with or without the use of isolating transformers; 2) Where a safety isolating transformer is used supplying one consumer device only, both wires of such systems are to be insulated from the earth	36 250	36 250

2.1.3 Balance of loads

2.1.3.1 For AC three-wire or four-wire systems, the electrical consumers are to be so grouped in the final sub-circuits that the load in each phase will, under normal conditions, be balanced as far as possible within 15% of its rated load at the individual distribution and section boards as well as the main switchboard.

2.1.4 Monitoring of insulation resistance to earth

2.1.4.1 The insulated distribution systems for power, heating and lighting circuits, whether primary or secondary, are to be provided with a device capable of continuously monitoring the insulation level to earth and of giving an audible or visual indication in case of abnormally low insulation values.

2.1.4.2 For fishing vessels less than 45m in length, whether primary or secondary, may be provided with megohmmeters or indicator lights indicating insulation level to earth only, and the indicator lights are to have a power no more than 15 W and are to be only controlled by buttons.

Section 2 DIVERSITY FACTORS**2.2.1 General requirements**

2.2.1.1 Circuits supplying two or more final sub-circuits are to be rated in accordance with the total connected load subject, where justified, to the application of a diversity factor. Where spare ways are provided on a section or distribution board, an allowance for future increase of load is to be added to the total connected load before application of any diversity factor.

2.2.2 Applications

2.2.2.1 The diversity factor may be applied to the calculation of the cross-sectional area of conductors and the rating of switch gear and fuse gear.

Section 3 SYSTEM PROTECTION**2.3.1 General requirements**

2.3.1.1 Electrical installations are to be suitably protected against overcurrents including short circuits, and other electric faults. The selection, performance and arrangement of the protective devices are to provide complete and coordinated automatic protection to ensure:

- .1 the continuity of power supply for non-fault circuits, particularly those including important equipment, through the discriminative action of the protective devices in the event of a fault elsewhere;
- .2 the elimination of the effects of the fault to reduce damage to the system and hazard of fire;
- .3 coordination is to be provided:
 - (1) between main generator protective device, main bus-bar section breakers, protective devices (if fitted) of feeders connected to the main bus-bar, and protective devices of feeders from the main bus-bar;
 - (2) between protective devices of feeders and branch circuits of the distribution board containing essential services;
 - (3) between protective devices of feeders from the emergency generator and the emergency bus-bar;
 - (4) between protective devices of feeders interconnecting main and emergency switchboards and feeders from the emergency bus-bar.
- .4 All components in systems shall be capable of withstanding the thermal effect and mechanical stress of possible overcurrent (including short circuit) in the allowable time through the coordinated protection between protective devices.

2.3.1.2 Short-circuit protection is to be provided in each non-earthed pole or phase of distribution systems.

2.3.1.3 Overload protection is to be provided in:

- .1 insulated two-wire DC or single-phase AC systems: at least one pole or phase;
- .2 insulated three-phase AC systems: at least two phases;
- .3 earthed systems: each non-earthed pole or phase.

2.3.1.4 No fuse or non-linked switch is to be inserted in an earthed conductor of distribution systems.

2.3.2 Calculations of short-circuit current

2.3.2.1 In the calculation of the maximum prospective short-circuit current, consideration is to be given to:

- (1) all generators which are possibly connected in parallel to reach the maximum required power;
- (2) all motors which are normally simultaneously connected in the system.

2.3.2.2 When necessary, the prospective short-circuit power factor of the AC system is to be calculated. If the power factor so obtained is less than the specified one corresponding to the rated short-circuit making or breaking capacity of the selected switch gear, then the breaking capacity of such switch gear is to be reduced accordingly.

2.3.2.3 Short-circuit calculations are to be performed by methods acceptable to CCS.

2.3.2.4 In general, short-circuit calculations are to be carried out for the following:

- .1 short circuit at the output terminal of generators;
- .2 short circuit at the main bus-bar;
- .3 short circuit at the bus-bars of the emergency switchboard, section switchboards and distribution switchboards;
- .4 short circuit at the secondary side of power and lighting transformers.
- .5. For the determination of the discriminative action of protective devices, short-circuit calculations are, if necessary, to be additionally performed for short-circuit at terminals of the protected circuit, when only the smallest generator is in supply.

2.3.2.5 In case of lack of accurate data, the following assumptions may be made for the short-circuit at the main bus-bar:

- .1 DC systems----10 times rated current of all generators possibly in parallel connection meeting the maximum demand power, plus 6 times rated current of all motors required to be put into operation simultaneously;
- .2 AC systems---- 10 times rated current of all generators possibly in parallel connection meeting the maximum demand power, plus 3 times (symmetric root-mean-square value) rated current of all motors required to be put into operation simultaneously. The power factor of short-circuit loop is to be assumed as 0.1.

2.3.2.6 The calculations of short-circuit current may be waived for power plants with the total capacity less than 250kVA.

2.3.3 Choice of protective devices against short-circuit

2.3.3.1 Protection against short-circuit currents is to be provided by fuses or circuit-breakers.

2.3.3.2 Unless otherwise specified in 2.3.3.4, the breaking capacity of protective devices against short-circuit is not to be less than the maximum prospective short-circuit current at the point of installation. For the AC systems, the rated short-circuit breaking capacity is not to be less than the prospective symmetrical short-circuit current (root mean square value) at the point of installation.

2.3.3.3 Unless otherwise stated in 2.3.3.4 of this Section, the rated short-circuit making capacity of every circuit breaker or switch which will possibly be initiated for a short-circuit is not to be less than the maximum peak value of the prospective short-circuit current at the point of installation.

2.3.3.4 The use of a circuit-breaker having a short-circuit breaking and/or making capacity less than the maximum prospective short-circuit current at the point of installation is permitted, provided that it is backed up on the generator side by a fuse or by a circuit-breaker (not the generator circuit-breaker) having the necessary rated short-circuit breaking/making capacity.

The short-circuit performance of the back-up protective arrangement is to be at least as that required for a single circuit-breaker by IEC Publication 60947-2: Low-Voltage Switch Gear and Control Gear-Part 2: Circuit-Breakers. The circuit-breaker is to have the same utilization category as the circuit-breaker on the load side of the back-up arrangement and a rated short-circuit breaking/making capacity for the maximum prospective short-circuit current at the supply terminal of the arrangement.

2.3.3.5 The same fuse or circuit-breaker may be used to back up more than one circuit-breaker when essential services are not involved.

2.3.3.6 Circuit-breakers with fuses connected to the load side may be used, provided the back-up fuse and circuit-breaker are designed for coordinated action, so as to ensure that the operation of the fuse takes place in due time to prevent arcing between poles or between poles and metal parts of the circuit breaker when they are subjected to an overcurrent involving the operation of the fuse.

2.3.3.7 When determining the short-circuit performance requirements for the above-mentioned back-up protection arrangement, the impedance of the elements of the arrangement may be taken into account, such as the impedance of a cable connection when the circuit-breaker on the load side is far away from the back-up circuit-breaker or fuse.

2.3.4 Choice of protective devices against overload

2.3.4.1 Circuit breakers provided for overload protection are to have a tripping characteristic (overcurrent-trip time) adequate for the overloading ability of protected elements and for any discrimination requirement of the system.

2.3.4.2 The use of fuses for overload protection is permissible up to 320 A, provided they have suitable characteristics, but the use of circuit breakers or similar devices for protection against overload above 200 A is recommended.

2.3.5 Protection of generators

2.3.5.1 Generators are to be protected against short-circuit and overloads by circuit breakers arranged to interrupt simultaneously all insulated poles, and the overload protection is to be adequate for the thermal capacity of the generator. In addition, the following requirements are to be complied with:

.1 for overloads less than 10%, it is recommended to provide an acoustic alarm with delay of less than 15 min. The maximum setting value is to be 1.1 times rated current of generator;

.2 for overloads between 10% and 50%, the circuit breaker is to be tripped with a time delay of less than 2 min. It is recommended that the circuit breaker be set within the limits of 125 to 135% of the rated current of the generator and with a time delay of 15 to 30 s;

.3 for overcurrents in excess of 50% but less than the steady short-circuit current of the generator, the circuit breaker is to be tripped after a short-time delay required for the discriminative protection of the system. It is recommended that the pick-up current for tripping of the circuit-breaker after a short-time delay be set at 200% to 250% of the rated current of the generator and with a maximum time delay of 0.2 s (DC) or 0.6 s (AC);

.4 circuit breakers for three or more generators connected in parallel are also to be provided with instantaneous releases which are to be set slightly greater than the maximum short-circuit current of the generators protected so that the circuit-breaker may break instantaneously.

2.3.5.2 For generators less than 50kW in unit capacity and not arranged to operate in parallel, a multi-pole linked switch with a fuse in each insulated pole may be fitted for protection.

2.3.5.3 Reverse power protection

.1 AC generators arranged to operate in parallel are to be provided with a reverse-power protection, with a time delay set within 3 to 10 s.

.2 DC generators arranged for parallel operation are to be provided with instantaneous or short-time delayed (less than one second) reverse current protection.

.3 For generators with diesel engines are prime movers in parallel operation, 8% to 15% of rated output (current) is to be set as the protective value of reverse power (or reverse current);

.4 A fall of 50% in the applied voltage is not to render the reverse power (or reverse current) protection inoperative, although it may alter the amount of reverse power required to open the breaker.

.5 For the reverse-current protection, due consideration is to be given to the reverse current resulting from the fishing vessel's electric network (e.g. cranes);

.6 Where equalizing cables are provided, the reverse current protection is to be connected to the positive pole of DC generators.

2.3.5.4 Generators arranged to operate in parallel are to be provided with undervoltage protection as follows:

.1 the operation of undervoltage release is to be instantaneous, if used to prevent the circuit-breaker from closing when the generator is not generating electrical energy;

.2 when the voltage drops down to 70% ~ 35% of the rated voltage, the undervoltage release is to operate with a time delay for discrimination purpose.

2.3.5.5 Protective devices for generators protection are to comply with following requirements:

.1 In the case of substantial reduction of speed of generators, the protective devices associated with generators are to remain effective.

.2 After the overload protective devices act, generators are to recover power supply immediately.

2.3.6 Automatic load shedding

2.3.6.1 Proper load shedding or other equivalent arrangements are to be provided to automatically shed non-essential services, services for habitable conditions and where necessary, secondary essential services to ensure that the connected generator(s) is/are not overloaded. This load shedding may be carried out in one or more stages according to the overloading ability of the generator. In such case, the non-essential services are to be shed firstly.

2.3.7 Protection of power and lighting transformers

2.3.7.1 The primary windings of power and lighting transformers are to be protected against short-circuit and overload by multi-pole circuit-breakers or fuses. Overload protection may also be provided in the secondary windings.

2.3.7.2 When transformers are arranged to operate in parallel, means of isolation are to be provided on the secondary windings. Switches and circuit breakers used for this purpose are to be capable of withstanding surge currents.

2.3.8 Protection of feeder circuits

2.3.8.1 Each feeder circuit is to be protected against overload and short circuits by a multi-pole circuit breaker arranged to interrupt simultaneously all insulated poles, or a multi-pole switch with fuses, but for a transitional emergency lighting feeder circuit, it may also be accepted to use fuses only.

2.3.8.2 When a multi-pole switch with fuses is used, the following requirements are to be complied with:

.1 the fuse in the feeder sub-circuit from the main switchboard is to be fitted between the bus-bar and the

switch;

.2 where the final sub-circuit from the distribution board has a rated current not exceeding 60 A and the consumers supplied by it can be disconnected at a nearby position, the switch may be omitted.

2.5.8.3 Circuits supplying consuming devices protected individually against overload (e.g. motors) may be provided with short-circuit protection only.

2.5.8.4 The protection of the steering gear circuits is to comply with Section 1 of CHAPTER 9 of PART THREE.

2.5.8.5 Permanently fixed cables between the shore connection box and the main switchboard are to be protected by a circuit-breaker or an isolating switch and fuses. Such protection is to be fitted in the shore connection box.

2.5.8.6 In general, the interconnector feeder supplying the emergency switchboard from the main switchboard is to be protected at the main switchboard against overload and short-circuit. Where the system is arranged also for reverse power supply, the interconnector feeder is to be additionally protected at the emergency switchboard at least against short-circuit.

2.3.9 Protection of motors

2.3.9.1 Motors rated at 0.5kW or above and all motors for essential services are to be protected individually against overload and short-circuit, and against undervoltage as required in 2.3.9.6 of this Section. The short-circuit protection can be provided by the same protective device for both the motor and its supply cable.

2.5.9.2 Protection of steering gear motors is to comply with Section 1 of CHAPTER 9 of PART THREE.

2.5.9.3 The protective devices are to be designed to allow the flow of currents during the normal accelerating period of motors under normal conditions of service. When the time-current characteristics of the overload protective device of a motor are not adequate for the starting period of the motor, the overload protecting device may be rendered inoperative during the accelerating period provided that the protection against short-circuit remains operative and that the suppression of the overload protection is only temporary.

2.3.9.4 For continuous duty motors, protective devices are to have a time delay characteristic which ensures reliable thermal protection of the motors for overload conditions. The maximum continuous current of the protective device is not to exceed 125% of the rated current of the protected motor.

2.5.9.5 For intermittent duty motors, the current setting and the delay characteristics for protective devices are to be chosen after considering the actual service condition.

2.5.9.6 Motors are to be provided with either:

.1 undervoltage protection, operative on the reduction or failure of voltage, to cause and maintain the interruption of power in the circuit until the motor is deliberately restarted; or

.2 undervoltage release, operative on the reduction or failure of voltage, to cause and maintain the interruption of power in the circuit, but so arranged that the motor restarts automatically and without excessive voltage drop or starting current on restoration of voltage.

.3 The protective devices are to allow the motor to start when the voltage is above 85% of the rated voltage, and are without fail to intervene when the voltage is lower than approximately 20% of the rated voltage, at the rated frequency and with time delay when necessary.

2.3.9.7 When fuses are used to protect poly-phase motor circuits, consideration is to be given to protection against single phasing.

2.3.10 Protection of lighting circuits

2.3.10.1 Each lighting circuit is to be protected against overload and short-circuit.

2.3.11 Protection of storage batteries

2.3.11.1 Storage batteries, other than starting batteries of internal combustion engines, are to be protected against short-circuit with devices placed as near as practicable to the batteries.

2.3.12.2 Each battery charger is to be properly protected against discharging of the battery due to the reduction or loss of charging voltage.

2.3.12 Protection of meters, pilot lamps and control circuits

2.3.12.1 Voltmeters, voltage coils of measuring instruments, earthing indicators and pilot lamps together with their connecting leads are to be protected by fuses. A pilot lamp need not be individually protected provided the following conditions are satisfied:

.1 the pilot lamp is installed with the equipment in the same enclosure;

.2 the pilot lamp is supplied from the interior circuit of the enclosure of the equipment;

.3 the protection device in the circuit is rated less than 25 A;

.4 a fault in the pilot lamp would not jeopardize the supply to essential equipment.

2.3.12.2 The voltage coils of control and protective devices and equipment are to be protected by fuses. The coils themselves need not be protected, provided that the following conditions are satisfied:

.1 the coils are installed with the equipment in the same enclosure and protected by a general protective device;

.2 the coils are supplied from circuits of the equipment and the protective devices of such circuits are rated to be less than 25 A.

2.3.12.3 For the light trapping equipment, the power supply and supply cables above water surface are to be connected with fixed method. Where the equipment needs to be operated underwater according to the actual working demand, the cables connection of subsea equipment is to be ensured water tightness and continuity. Movable cables are to be stored on decks of fishing vessels in centralization.

2.3.13 Protection of semiconductor equipment

2.3.13.1 Semiconductor equipment is to be protected against overload and short circuit.

Section 4 MAIN SOURCE OF ELECTRICAL POWER

2.4.1 Generating sets

2.4.1.1A main source of electrical power having sufficient capacity to supply all services mentioned in 1.1.1.4.1 of this PART is to be provided, and the following requirements are to be complied with.

.1 The main source of electrical power is to consist of at least two generating sets, one of which may be driven by the main engine.

(1) The number and ratings of these generating sets are to be such that in the event of any one generating set being stopped, it will still be possible to supply those services necessary to provide normal operational conditions of propulsion, safety of the fishing vessel and equipment essential for fish refrigeration rooms; equipment essential for safety of running fishing vessels. Furthermore, minimum comfortable conditions of habitability are also to be ensured, which include at least adequate services for cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water;

(2) The generating sets are to be such as to ensure that with any one generator or its prime mover out of operation, the remaining generating sets are still capable of providing the electric services necessary to start the main propulsion plant from a dead ship condition;

(3) Where the main source of electrical power is necessary for propulsion and steering of the fishing vessel, the power supply is to be maintained or recovered as soon as possible for the equipment essential for the propulsion, manoeuvring and fishing vessel safety assurance;

(4) Where the main source of electrical power is necessary for propulsion of the vessel and the total capacity of main generator exceeds 400kW, the bus-bar is to be subdivided into at least two independent sections which are normally be connected by a circuit breaker or other devices approved by CCS. So far as is practicable, the connection of generating sets and other duplicated equipment is to be equally divided between the sections.

.2 Only a generating set can be provided for the main power supply, but it is to comply with the following requirements:

(1) The total power consumption of electric equipment is to be less than 20kW;

(2) Various auxiliary machinery and steering gear oil pump serving main engines may be driven by main engines;

(3) Storage batteries are to be fitted as the standby power sources. Their capacity is to be capable of ensuring the power supply for electric equipment essential for propulsion and safety of fishing vessels.

2.4.1.2 Other power source devices equivalent to those in 2.4.1.1 of this PART is to be subject to approval by CCS.

2.4.1.3 The alternating current system is to be such that with one generating set out of action, the remaining sets have sufficient reserve capacity to permit the starting of the largest motor without causing any motor to stall or any other device to fail due to excessive voltage drop on the system. Motors which have a very large capacity and are not essential to the safe navigation of the vessel, such as thruster motors, may be started when all generators are put into operation without causing any essential equipment to stop.

2.4.1.4 The arrangement of the vessel's main source of electrical power is to be such that the operation of the services referred to in 1.1.1.4.1 of this PART can be maintained regardless of the speed and direction of the propulsion machinery and shafting.

2.4.1.5 Where the main source of electrical power is necessary for propulsion and steering of the ship, the continuity of the power supply to the equipment necessary for the propulsion and steering and for ensuring the safety of the fishing vessel is to comply with the following requirements:

.1 Where the electrical power is normally supplied by more than one generating set simultaneously in parallel operation, means of protection, including automatic shedding of non-essential services and if necessary, automatic shedding of the arrangements for habitability and secondary essential services, are to be provided to ensure that in case of loss of any of these generating sets, the remaining ones are kept in operation to supply equipment necessary for propulsion and steering and for ensuring the safety of the vessel;

.2 Where the electrical power is normally supplied by one generator, provision is to be made, upon loss of power, for automatic starting and connecting to the main switchboard of a stand-by generator of sufficient capacity with automatic restarting of the essential auxiliaries, in sequential operation if required. The stand-by generator is to be automatically started and connected to the main switchboard within 45 s after loss of power.

2.4.2 Shaft-driven generators

2.4.2.1 A generator, driven by the fishing vessel's main engine and capable of operating at approximately constant speed under all sailing conditions may be considered as part of the fishing vessel's main source of electrical power as required in 2.4.1.1 of this PART upon approval by CCS, provided that the propulsion machinery can be still started and operated continuously in the event of faults of any generator not driven by shaft.

2.4.2.2 Main engine driven generators with speed changed during sailing of fishing vessels is not to be considered as part of the vessel's main source of electrical power as required in 2.4.1.1 of this PART. However, shaft-driven generators, equipped with frequency and voltage stabilizers, capable of ensuring the normal operation of electric equipment in trawling and sailing conditions may be considered as part of the fishing vessel's main source of electrical power as required in 2.4.1.1 of this PART upon approval by CCS, provided that the propulsion machinery can be still started and operated continuously in the event of faults of any generator not driven by shaft.

2.4.2.3 Where main engine driven generators with speed changed during sailing of fishing vessels are used, following requirements are to be complied with:

.1 Basic properties of shaft-driven generators are to comply with requirements of 3.1.6.6 (DC) or 1.7.5 (AC) of this PART;

.2 To recover normal power supply for essential equipment as soon as possible in case of sudden maneuvering of main engines, one of the following standby power sources (part of main power source required by 2.4.1.1 of this PART) is to be provided:

(1) A generating set capable of automatically starting and supplying power and independent of main propulsion machinery where the speed of shaft-driven generators drops to a level not sufficient for outputting rated power;

(2) A generating set capable of automatically starting and supplying power in the bridge, independent of main propulsion machinery;

(3) Storage batteries, capable of automatically supplying power, equivalent to devices in 2.4.1.1.

2.4.2.4 Standby power sources as required in 2.4.2.3.2 of this PART are to be capable of supplying power to following equipment:

.1 Standby electric auxiliaries serving main propulsion machinery and standby electric auxiliaries required for starting main engines;

.2 Steering gears and electrical rudder angle indicators, except for steering gears continuously operated by manual hydraulic equipment in the bridge;

.3 Electrical parts of electrical equipment remote control systems, electrohydraulic or electrical pneumatic equipment remote control systems;

.4 Control and monitoring systems of engines;

.5 Navigation lights, important signal lights and navigation equipment;

.6 Lighting for machinery spaces, control stations, accommodations, aisles and stairways.

2.4.2.5 All equipment listed in 2.4.2.4 of this PART is to be automatically reconnected after shaft-driven generators switch off power supply and standby power sources function. The reconnection is to be completed within 45 s in a sequence relying on the importance of electric equipment after shaft-driven generators switch off power supply.

2.4.3 Transformers

2.4.3.1 The number, capacity and arrangement of transformers are to meet the following requirements if they constitute the necessary parts of main electric power source system as required in 2.4.1.1 of this Section:

.1 Fishing vessels no less than 45 m in length are to be provided with two transformers at least. Fishing vessels less than 45 m in length are to be provided with a three-phase, four-winding transformer having a standby winding. The transformers are to be such that, with any one transformer (or any winding) out of operation, the remaining transformers are sufficient to ensure the safe operation of the equipment necessary for normal propulsion and for safety of the vessel. Furthermore, minimum comfortable conditions of habitability are also to be ensured, which include at least adequate services for cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water;

.2 Each transformer is to be located as a separate unit with separate enclosure or equivalent, and is to be served by separate circuits on the primary and secondary sides;

.3 Each primary circuit is to be provided with switchgear and protection devices in each phase. Transformer protection is to comply with requirements of 2.3.7 of this PART.

2.4.3.2 A transformer may be provided where the transformer serves as a necessary part of main power source system as required in 2.4.1.1.2. The transformer is to be fitted with switch in each phase of primary circuit. The transformer protection is to comply with requirements of 2.3.7 of this PART.

2.4.4 Installation of switchboards

2.4.4.1 The main switchboard is to be so placed relative to the main power plant that, as far as is practicable, the integrity of the normal electrical supply will be affected only by a fire or other casualty in one space. An environmental enclosure for the main switchboard, such as may be provided by a machinery control room situated within the main boundaries of the space, is not to be considered as separating the switchboard from the generators.

2.4.4.2 Water, oil or steam pipes, oil tanks or other liquid containers are not to be installed above or behind the switchboard. If this is unavoidable, suitable protection is to be provided in these positions.

2.4.4.3 Passages of an adequate width are to be left in front of and behind switchboards. The width of the front passage is to be at least 0.8 m. The width of passage behind the switch gear is to be at least 0.6 m, and at least 0.5 m at frames. Where the construction of a switchboard is such as to permit maintenance, inspection and replacement of parts from the front or from the ends, the passageway behind the switchboard may be dispensed with.

2.4.4.4 Where the length of the main switchboard is greater than 4 m, passageways are to be, as far as possible, provided at both ends of the switchboard. Except that the main switchboard is installed in the machinery control room, doors with locking devices are to be provided at both ends of the passageway behind the switchboard.

2.4.4.5 The passageways in front of and behind the main switchboard are to be covered by non-slipping and oil-proof insulating mats or insulated wood gratings.

Section 5 EMERGENCY SOURCES OF ELECTRICAL POWER

2.5.1 General requirements

2.5.1.1 Fishing vessels no less than 45 m in length are to be provided with self-contained emergency source of electrical power.

2.5.1.2 The emergency source of electrical power is to be so arranged as to comply with the following:

.1 The emergency source of electrical power, associated transforming equipment (if any), transitional source of emergency power, emergency switchboard and emergency lighting switchboard are to be located above the uppermost continuous deck and are to be readily accessible from the weather deck. They are not to be located forward of the collision bulkhead, except where permitted by CCS for cargo ships in exceptional circumstance;

.2 The location of the emergency source of electrical power, associated transforming equipment (if any), the transitional source of emergency power, the emergency switchboard and the emergency lighting switchboard in relation to the main source of electrical power, associated transforming equipment (if any), and the main switchboard is to be such as to ensure that a fire or other casualty in spaces containing the main source of electrical power, associated transforming equipment (if any), and the main switchboard or in any machinery space of category A will not interfere with the supply, control and distribution of emergency electrical power. As far as practicable, the space containing the emergency source of electrical power, associated transforming equipment (if any), the transitional source of emergency electrical power and the emergency switchboard is not to be continuous to the boundaries of machinery spaces of category A or those spaces containing the main source of electrical power, associated transforming equipment (if any), or the main switchboard.

Note: Refer to Statutory Inspection Rules of Fishing Vessels (Sea-going Fishing Vessels 2018) for machinery space of category A.

2.5.1.3 The emergency source of electrical power may be a generator, which is to comply with the following requirements:

.1 driven by a diesel engine with independent cooling system and supply of fuel as well as starting arrangements complying with the requirements of 5.5.6.1 of Chapter 5, PART THREE of the Rules;

.2 started automatically upon failure of the electrical supply from the main source of electrical power and connected automatically to the emergency switchboard, and those services referred to in 2.5.2 of this Section then transferred automatically to the emergency generating set, except for vessels fitted with a transitional source of emergency electrical power in accordance with 2.5.1.5 of this Section. The automatic starting system and the characteristics of the prime mover are to be such as to permit the emergency generator to carry its full rated load as quickly as is safe and practicable, subject to a maximum of 45 s.

2.5.1.4 The emergency source of electrical power may also be an accumulator battery, which is to comply with the following requirements:

.1 carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage;

.2 automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power; and

.3 supplying those services referred to in 2.5.2 of this PART.

2.5.1.5 Where the emergency source of electrical power is a generator, a transitional source of emergency electrical power which consists of an accumulator battery is to be provided in compliance with the following requirements, except for vessels fitted with an emergency generator capable of automatic starting in accordance with 2.5.1.3.2:

.1 carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12% above or below its nominal voltage;

.2 so arranged as to supply immediately and automatically in the event of failure of either the main or emergency source of electrical power those services referred to in 2.5.4 of this Section.

2.5.1.6 The emergency switchboard is to be installed as near as is practicable to the emergency source of electrical power and to comply with the following requirements:

.1 Where the emergency source of electrical power is a generator, the emergency switchboard is to be located in the same space unless the operation of the emergency switchboard would thereby be impaired;

.2 Where the emergency source of electrical power is an accumulator battery, the accumulator battery is not to be installed in the same space as the emergency switchboard;

.3 The passages in front and behind the emergency switchboard, etc. are to comply with the requirements given in 2.4.4.2 to 2.4.4.5 of this PART.

2.5.1.7 An indicator is to be mounted in a suitable place on the main switchboard or in the machinery control room to indicate that the batteries constituting either the emergency source of electrical power or transitional source of emergency electrical power are being discharged.

2.5.1.8 The emergency switchboard is to be supplied during normal operation from the main switchboard by an interconnector feeder which is to be protected according to the requirements of 2.3.8.6 of this PART and which is to be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power.

2.5.1.9 In order to ensure ready availability of the emergency source of electrical power, arrangements are to be made, where necessary, to disconnect automatically non-emergency circuits from the emergency switchboard to ensure that electrical power is to be available to the emergency circuits. Auxiliary switches are to be also fitted on the emergency switchboard, to switch on the power manually in the event of faults of automatic connection system.

2.5.1.10 Provided that suitable measures are taken for safeguarding independent emergency operation under all circumstances, the emergency generator may be used exceptionally, and for short periods, to supply non-emergency circuits.

2.5.2 Scope and period of supply of the emergency source

2.5.2.1 The electrical power available is to be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. The emergency source of electrical power is to be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for the periods specified hereinafter, if they depend upon an electrical source for their operation:

.1 emergency lighting at every muster and embarkation station and over the sides for 3h;

.2 for a period of 3h, emergency lighting:

(1) in all service and accommodation alleyways, stairways and exits, personnel lift cars;

(2) in the machinery spaces and main generating stations including their control positions;

(3) in all control stations, machinery control rooms, and at each main and emergency switchboard;

(4) at all stowage positions for firemen's outfits;

(5) at the steering gear; and

(6) at the emergency fire pump (if fitted) and the sprinkler pump (if fitted) and at the starting position of their motors;

(7) fish processing spaces.

.3 for a period of 3 h:

(1) the navigation lights and other signal lights;

(2) VHF radio equipment, MF radio installation (if any), vessel earth station (if any) and MF/HF radio equipment (if any);

.4 for a period of 3 h:

(1) all internal communication equipment required in an emergency;

(2) the fire detection and fire alarm system, and the fire door holding and release system;

(3) for intermittent operation of the daylight signaling lamp, the ship's whistle, the manually operated call points and all internal signals that are required in an emergency (e.g. general emergency alarm system, alarms for warning of the release of extinguishing media);

- (4) emergency fire pump (if any);
- (5) automatic sprinkler pump (if any).

.5 power is to be supplied to steering gears according to requirements in CHAPTER 9 of PART 3.

2.5.3 Scope and period of supply of transient emergency source

2.5.3.1 The transitional source of emergency electrical power required in 2.5.1.5 of this Section is to be of sufficient capacity to supply at least the following services for half an hour, if they depend upon an electrical source for their operation:

.1 the lighting required in 2.5.2.1.1, 2.5.2.1.2 and 2.5.2.1.3; for this transitional phase, the required emergency electric lighting, in respect of the machinery space and accommodation and service spaces may be provided by permanently fixed, individual, automatically charged, relay operated accumulator lamps; and

.2 all services required in (1), (2) and (3) of 2.2.3.1, unless such services have an independent supply for the period specified from an accumulator battery suitably located for use in an emergency.

2.5.4 Miscellaneous

2.5.4.1 For fishing vessels less than 45 m in length, emergency power sources as required in this Section may be waived, but independent storage batteries are to be fitted as the standby source at the area free from high fire hazards outside the engine room. When the main power source fails, power is to be supplied to the following equipment for 3 h:

.1 general emergency alarm systems;

.2 navigation lights, out-of-control lights, anchor lights and other lights as required the SOLAS Convention in force;

.3 VHF radio installations, MF radio installations and MF/HF radio installations, such source may be dispensed with where special standby power sources are provided for radio communication equipment;

.4 Emergency lighting at following locations:

(1) at every muster and embarkation station and over the sides;

(2) all alleyways, stairways and exits;

(3) machinery spaces and emergency switchboards;

(4) all control stations.

Section 6 ELECTRIC CONTROL OF MACHINERY AND EQUIPMENT

2.6.1 General requirements

2.6.1.1 Motors rated at 0.5kW or above and motors required for essential services are to be supplied from distribution boards by separate final sub-circuits.

2.6.1.2 Every electric motor is to be provided with efficient means of starting and stopping which are, in general, placed near the motor, so as to be easily operated by the person controlling the motor.

2.6.1.3 Means are to be provided for the disconnection of the full load from all live poles of supply of every motor rated at 0.5 kW or above and its control gear. Where the control gear is mounted on or adjacent to a main or other distribution switchboard, a disconnecting switch in the switchboard may be used for this purpose. Otherwise, a disconnecting switch within the control gear enclosure or a separate enclosed disconnecting switch is to be provided.

2.6.1.4 When the starter or any other apparatus for disconnecting the motor is remote from the motor, it is required that either:

.1 provision be made for locking the circuit disconnecting in the OFF position; or

.2 an additional disconnecting-switch be fitted near the motor; or

.3 the fuse in each live pole or phase be so arranged that it can be readily removed and retained by an authorized person.

2.6.1.5 Where a single master-starter system (i.e. a starter used for controlling a number of motors successively) is used, undervoltage and over-current protection, means of isolation and a running indicator are to be provided for each motor, not less effective than those required for systems using a separate starter for each motor. Where the starter system is of an automatic type, suitable alternative means are to be provided for manual operation. Where the starter is used for motors for essential services, the starting portion is to be duplicated, and means are to be provided for change-over in the event of failure of one of the starters.

2.6.1.6 All motors with field adjustment for speed control are to be provided with a device which renders the motors to be started only when the field is fully excited.

2.6.1.7 The undervoltage, overload and short-circuit protection for motors are to comply with the requirements of Section 3 of this PART.

2.6.2 Steering gears

2.6.2.1 Electrical or electrohydraulic steering gears are to comply with the relevant requirements of Chapter 9 in PART THREE in power source, cables laying, monitoring and alarm.

2.6.3 Fishing appliances

2.6.3.1 Electromagnetic brakes for electrical deck machinery are to have, in addition, a hand release device.

2.6.3.2 If not otherwise specially required in their specifications, the duty of windlass motors and winch motors is to be rated for no less than 30 min. Windlass motors and winch motors are to be provided with overload protection, but overload protection is not to be provided in case of rotor locking for less than 1 min.

2.6.3.3 Boat winch motors are to be provided with limit switches for cutting off the power supply upon returning of the boat to its original position.

2.6.3.4 The electric control device of boat winch motors is to be interlocked with the manual drive and manual brake.

2.6.3.5 The main switchgear is to be provided with a separate feeder to supply power to anchor windlass motors and fish pump motors.

2.6.3.6 Fishing appliances is to comply with relevant requirements of CHAPTER 10 of PART 3.

2.6.4 Fish processing machinery

2.6.4.1 The electric control devices of fish processing machinery are to be provided with reliable protection means. Emergency stop devices are to be fitted at appropriate positions in addition to effective control devices fitted at the operation position.

2.6.5 Fire safety equipment

2.6.5.1 The electrical power supply to fixed emergency fire pump motors and automatic water-spraying systems is to comply with the relevant requirements of this PART.

2.6.6 Emergency stop of ventilating fans and oil pumps

2.6.6.1 The stop of power ventilating fans is to comply with the following requirements:

.1 Power ventilating fans of accommodation spaces, fish processing spaces, control stations and machinery spaces is to be capable of being stopped from an easily accessible position outside the space being served;

.2 Stop devices of power ventilating fans at machinery spaces are to be separated from those at other spaces;

.3 Exhaust fans of kitchen exhaust air duct are to be stopped in the kitchen.

2.6.6.2 Emergency stopping devices are to be fitted outside machinery spaces where forced and induced draught fans, oil fuel transfer pumps, boiler fuel pumps are located and spaces of other similar fuel pumps.

2.6.6.3 Emergency stopping devices of fans and oil pumps aforesaid are to be so located that the fire at those spaces will be isolated, and are to be located at one or a few positions as far as practical.

Section 7 LIGHTING

2.7.1 General requirements

2.7.1.1 Where bulkhead luminaires are used for lighting, illuminating windows are to be solid and airtight in structure, and provided with protective grids protecting against mechanical damage, and its surface temperature is not to exceed the allowable temperature at the installation site.

2.7.1.2 Requirements of lighting fixtures

.1 Lighting fixtures installed at fish holds, refrigerated fish holds, fish processing spaces, freezer rooms, external aisles and other areas where they are liable to mechanical damage are to be provided with robust protective grids;

.2 Lighting fixtures installed at spaces with large vibration are to be provided with vibration absorption means.

.3 Lighting fixtures directly fixed on wooden plates and other flammable materials are to be provided with means for fire control and thermal insulation.

2.7.1.3 Lighting switches of fish holds, refrigerated fish holds, fish processing spaces, freezer rooms, fire equipment control stations and other similar compartments are not to be installed indoors. Lighting switches of moist spaces and explosion-hazard spaces are to switch off all insulating pole.

2.7.1.4 The warning signs showing "DANGER! HIGH VOLTAGE!" are to be provided in the spaces adjacent to discharge lamps operating at a voltage over 250 V and elsewhere as necessary.

2.7.1.5 High-voltage triggering devices of gas discharge lamps used for light fish trapping operation are to be installed in special accommodations and provided with excellent ventilation facilities.

2.7.2 Power supply and control, etc.

2.7.2.1 The lighting point supplied by each final sub-circuit of rating of more than 16 A at the lighting distribution board is not to exceed one. The number of lighting points supplied by each final sub-circuit of rating 16 A or less at the lighting distribution board is not to exceed:

- 10 for circuits of rating 55 V or less;
- 14 for circuits of rating 56 ~ 120 V circuits;
- 24 for circuits of rating 121 ~ 250 V circuits.

In final sub-circuits for cornice lighting, panel lighting and electrical signs where lampholders are closely grouped, the number of points supplied is unrestricted provided that maximum operating current in the sub-circuit does not exceed 10 A.

Final sub-circuits for lighting are not to supply heating and power appliances, except for small galley equipment (e.g. toasters, mixers, coffee makers), small motors (e.g. of desk and cabin fans, refrigerators) and similar items.

2.7.2.2 The lighting for main propulsion machinery spaces, refrigerated fish holds, freezer rooms, large fish processing rooms, public spaces, passageways (including accesses) and stairways leading to boat decks, is to be supplied by at least two final sub-circuits, one of which may be the final sub-circuit for emergency lighting so that in the event of failure of any one of the sub-circuits the other one could still maintain the necessary lighting for such spaces. For fishing vessels less than 45 m in length, only lighting for main propulsion machinery spaces needs to be supplied. The lighting points for main propulsion machinery are to be distributed alternately.

In machinery spaces, the oil fuel system containing heated oil under pressure exceeding 0.18 MPa are to be adequately illuminated so that defects and leakage will readily be observed. In machinery spaces of category A and whenever practicable in other machinery spaces, the arrangements for storage, distribution and utilization of oil used in pressure lubrication systems are also to be adequately illuminated. The net lifting and release equipment spaces are to be also adequately illuminated.

2.7.2.3 Where the hull return system of distribution is used, each sub-circuit led from the lighting switchboard is to be provided with double-core cables, and the earthed pole is to be generally connected to the earth by the busbar of switchboard.

2.7.2.4 Each main fire zone is to be provided with at least two separate lighting feeders, one of which may be an emergency light feeder.

2.7.2.5 The fixed lighting in fish holds (including registered fish holds) are to be generally controlled by special lighting control box located in a suitable position outside the fish holds. The lighting for each fish hold is to be provided with separate sub-circuit, each of which is to be provided with a power switching-in indicator in addition to switches and fuses capable of switching off all switches at insulated poles and fuses.

2.7.2.6 The degree of protection of lighting fittings located in various spaces in vessels is to comply with the requirements of Table 1.3.2.2 of this PART. Lighting switches for spaces with special requirements are to be installed in accordance with the requirements of 2.7.1.2 of this Section.

2.7.2.7 Lighting circuits are to be provided with protections according to the requirements of 2.3.10.

2.7.2.8 Main lighting systems are to be so arranged that they will not be damaged in the event of a fire or other incidents in spaces where emergency power sources and switch-over devices (if any), emergency switchboards and emergency lighting switchboards are fitted.

2.7.2.9 Special requirements for emergency lighting:

.1 The arrangements of emergency lighting are to comply with the relevant requirements of Section 5 of this Chapter;

.2 All emergency lighting fittings are to be provided with a prominent mark or structurally different from other luminaries;

.3 No switch is to be installed in the transitional emergency lighting feeders;

.4 No local switch is to be installed in the emergency lighting circuits in the spaces except for the emergency lights in the navigation bridge, outboard lifeboats and life rafts.

.5 Emergency lighting systems are to be so arranged that they will not be damaged in the event of a fire or other incidents in spaces where emergency power sources and switch-over devices (if any), emergency switchboards and main lighting switchboards are fitted.

2.7.3 Portable lighting

2.7.3.1 Portable lighting fittings are to be so arranged to protect the operator against electric shock hazard.

2.7.3.2 Any one of the following methods may be adopted for portable lighting fittings;

.1 Portable lighting fittings are earthed with continuous earth wire of power supply cable;

.2 Double insulation or strengthened insulation;

.3 The power is supplied by a voltage no more than 36V;

.4 The power is supplied by the safety isolating transformer only to a lighting fixture.

2.7.3.3 Intrinsically safe, increased safety type, explosive-proof or positive pressure type portable fixtures with self-contained batteries are to be provided in spaces having explosion hazards.

Section 8 NAVIGATION LIGHTS AND OTHER SIGNAL LAMPS

2.8.1 Power supply and control of navigation lights

2.8.1.1 Each navigation light is to be supplied by a sub-circuit connected separately to the control box fitted at an easily accessible position on the navigation bridge and is to be controlled and protected in each insulated pole by a switch and a fuse or by a circuit breaker fitted in the control box.

2.8.1.2 The control box for navigation lights is to be supplied directly from the main switchboard and emergency switchboard. Where the transitional source of emergency power is provided according to Section 5 of this Chapter, the control box is to be supplied directly from the emergency switchboard and transitional emergency charging and discharging switchboard. For fishing vessels less than 45 m in length, the control boxes of navigation lights are to be directly supplied by main switchboard and standby battery discharge plate.

2.8.1.3 The change-over switch for the supply sources required in 2.8.1.2 of this Section is to be installed on the control box or at a suitable position on the navigation bridge.

2.8.1.4 Each navigation light is to be provided with an automatic indicator giving an audible and visual indication of failure of the light. If a visual signal is used and connected in series with the navigation light, means are to be provided to prevent extinction of the navigation light due to failure of the signal, and the audible and visual alarms for failure of the power source of the control box are to be provided.

2.8.2 Power supply and control of other signal lights

2.8.2.1 Signal lights refer to other signal lights than navigation lights according to current International Regulations for Preventing Collisions at Sea (COLREGS).

2.8.2.2 Each signal light is to be supplied by separate sub-circuit led from the control box, and insulated plates of these sub-circuits are to be controlled and protection by switches and fuses or circuit breakers installed in the control box.

2.8.2.3 The signal light control box is to be supplied by the emergency switchboard (or indirectly) and transient emergency power source (if provided according to requirements of Section 5 of this CHAPTER), or emergency switchboard and main switchboard (or indirectly); or by main switchboard and standby power source (for fishing vessels less than 45 m in length).

2.8.2.4 Portable daylight signal lights are to be supplied by emergency switchboards and transient emergency power sources (if provided according to requirements of Section 5 of this CHAPTER) or emergency lighting switchboards provided with self-contained batteries.

Section 9 RADIO AND NAVIGATION EQUIPMENT

2.9.1 Power supply of radio and navigation equipment

2.9.1.1 The distribution board of supplies to the radio equipment is to be independent of that of supplies to the navigation equipment. (except for centralized power supply for navigation bridge). The distribution switchboard of the radio equipment is to be supplied by separate feeders from main and emergency switchboards, and the distribution switchboard of the navigation equipment is to be supplied by the main power source.

2.9.1.2 One or more reserve power sources independent from the fishing vessels's propulsion and electric systems are to be provided to supply the radio equipment for the purpose of distress and safety radio communications in the event of failure of the ship's main and emergency sources of electrical power.

Section 10 INTERNAL COMMUNICATION AND SIGNAL EQUIPMENT

2.10.1 General requirements

2.10.1.1 Internal communication equipment for various applications is to be provided with varied sounds and colors for identification.

2.10.2 Telegraph system

2.10.2.1 A main engine telegraph system is to be fitted on vessels to communicate orders from the navigation bridge to the machinery spaces of main propulsion machinery, and the main engine telegraph system is to be provided with a signal repeater.

2.10.2.2 Audible and visual alarms are to be provided on the navigation bridge for the purpose of indicating the failure of main engine telegraph, and such alarms are to be generally supplied by storage batteries. Where the alarms are supplied by the source on vessels, they are not to be connected to the same wire with telegraph system.

2.10.2.3 Internal communication and signal equipment are to be supplied by separate final sub-circuits.

2.10.3 Important telephone systems and other communication equipment

2.10.3.1 Telephone systems are to be sound-powered telephones or commanding telephones supplied by storage batteries if used as main communication tools between following spaces:

- .1 Bridge- machinery spaces;
- .2 Bridge- emergency steering station and steering gear compartment;
- .3 Bridge- station/room for controlling propulsion;

The telephone systems required in .1, .2 and .3 above are to be individual links, although following telephone system may be used if it is ensured that the bridge can cut into existing conversations.

- Bridge—
 - └─machinery spaces;
 - └─station/room for controlling propulsion;
 - └─emergency steering station and steering gear compartment;
- .4 Bridge—fire alarm signal station and fire equipment centralized control station, bow and stern;
- .5 Bridge—radio room (Where the bridge is adjacent to the radio room and effective communications can be ensured, the telecommunications between bridge and radio room may be dispensed with).

Note: Where there are other communication tools between bow, stern and bridge, telephones between bow and stern may be dispensed with.

2.10.3.2 Telephone systems installed in a cabin with large noise are to be provided with sound proofing measures where the telecommunication is affected.

2.10.3.3 Fixed, portable or combined type emergency communication equipment is to be provided for bidirectional communication between strategic positions, i.e. the emergency control station, the muster and embarkation station of survival craft, navigation bridge and fire control station.

2.10.4 General emergency alarm systems

2.10.4.1 General emergency alarm system communicating from single direction is to be provided to ensure that the system is to be audible throughout all the accommodation and normal crew working spaces, including open decks in passenger ships. The alarm is to continue to function after it has been triggered until it is manually turned off or is temporarily interrupted by a message from the public address system.

2.10.4.2 Where the general emergency alarm system is in operation, the acoustic system for entertainment is to be interrupted automatically.

2.10.4.3 The general alarm system is to be supplied from special feeders, being capable of automatically converting to the emergency source of electrical power in the event of failure of the main source of electrical power.

2.10.4.4 General emergency alarm systems are to be controlled by the bridge and fire control station.

2.10.4.5 Distributing switchboards of general emergency alarm systems are to be fitted at appropriate positions above bulkhead decks and provided with fuse protection on insulated pole of each sub-circuit led from distributing switchboards.

2.10.4.6 The minimum sound pressure level for the emergency alarm tone in accommodation spaces and in 1 m away from sound source is to be 75dB (A) where all doors and passages are closed, and at least 10 dB(A) above ambient noise levels existing during normal equipment operation with the fishing vessel underway in moderate weather. The sound pressure levels are to be within one third of octave frequency band near fundamental frequency. The sound alarm signal sound level at any position is not to exceed 120dB (A).

2.10.4.7 The frequency of alarm acoustic signal is to be from 200Hz to 2000Hz except for electric bell.

2.10.5 Public address system

2.10.5.1 A public address system capable of effectively broadcasting messages to accommodation spaces, control stations and open decks.

2.10.5.2 Where the main power source fails, the public address system is to be automatically supplied by emergency or standby power source.

2.10.5.3 Where the public address system complies with the following requirements and requirements for general emergency alarm system, it may serve as the general emergency alarm system and may transmit fire alarm signals:

- .1 the system is capable of transmitting clear and undistorted acoustic alarm signal, and automatically stopping transmitting other signals while transmitting the alarm signal;
- .2 Where loudspeakers with built-in volume controls are used, the volume controls are to be disabled by the release of the alarm signal to ensure transmitting the alarm signal at the maximum volume;
- .3 at least two amplifiers are to be provided, each of which is to be protected against short circuit;
- .4 for power supply of multiple amplifiers, the failure of one amplifier is not to result in the failure of other amplifiers;

.5 Where circuits of several loudspeakers are connected to an amplifier, the short circuit failure of one loudspeaker circuit is not to affect the normal operation of other loudspeaker circuits;

.6 Each fire zone and (or) deck is to be provided with two continuous loudspeaker circuits, and they are to be connected to independent amplifiers; loudspeaker circuits are to be arranged appropriately to ensure that the alarm signal still can be received with but the volume reduced somewhat even if an amplifier or loudspeaker fails;

.7 Multiple electronic acoustic signal generators are to be used;

.8 The system is to be so arranged to prevent feedback or other interference.

2.10.6 Other alarms

2.10.6.1 Audible and visual alarms are to be fitted in the galley, so that accidentally locked personnel can transmit a Mayday from the food refrigerated warehouse. However, the alarms may be dispensed with where the door of the food refrigerated warehouse can be opened from the inside.

2.10.6.2 Audible and visual alarms or other effective means are to be provided in the bridge to enable accidentally locked personnel to transmit a Mayday from fish holds and freezer rooms.

2.10.6.3 The warning signal for release of fire extinguishing medium and other audible and visual alarms are to comply with relevant requirements for working for 20 s at least prior to the release of fire extinguishing medium.

2.10.6.4 Fixed fire detection and fire alarm systems in automatic sprinkler system are to comply with relevant fire control requirements as described in Statutory Inspection Rules of Fishing Vessels (Sea-going Fishing Vessels 2018).

2.10.6.5 Alarms of main engines and auxiliary diesel engines are to comply with relevant alarm requirements as described in PART 3.

2.10.6.6 Alarms of refrigerating systems are to comply with relevant requirements as described in PART 5.

2.10.6.7 Water level alarms of fish holds are to comply with relevant requirements as described in PART 3.

2.10.6.8 Alarms of side thrusters are to comply with relevant requirements as described in 7.3.7 of PART 3.

2.10.6.9 Alarms of oil heaters are to comply with relevant requirements as described in 8.5.5 of PART 3.

Section 11 HEATING AND COOKING EQUIPMENT

2.11.1 General requirements

2.11.1.1 All electric space heaters are to be installed permanently. However, movable heating appliances capable of automatically switching off power in case of inclination can be used

2.11.1.2 Heating appliances are not to be installed in positions where combustible gases and dusts are likely to accumulate.

2.11.1.3 Heating appliances are to be so mounted that there will be no risk of excessive heating of adjacent decks, bulkheads or other surroundings.

2.11.2 Control and installation of heating and cooking equipment

2.11.2.1 Each item of heating or cooking equipment is to be controlled as a complete unit by a multi-pole linked switch mounted in the vicinity of the equipment.

2.11.3 Supply of heating equipment

2.11.3.1 Each heater is to be connected to a separate final sub-circuit for heating except that up to ten small heaters of total connected current rating not exceeding 16 A may be connected to a separate final sub-circuit for heating.

Section 12 STORAGE BATTERIES

2.12.1 General requirements

2.12.1.1 Where diesel engines are started by storage batteries, at least two sets of storage batteries with total capacity as specified in 5.5.5 of PART 3 at least.

2.12.1.2 Appropriate charging equipment is to be fitted.

2.12.1.3 Where the equipment is charged by high voltage system in the DC system, storage batteries are to be separated from low-voltage systems.

2.12.1.4 Automatic discharge devices of emergency storage batteries are to be such that power will be supplied to emergency circuits at all times regardless of storage batteries are being charged.

2.12.1.5 Any emergency storage batteries are to be so designed and installed to comply with requirements of 3.6.3.3 of this PART.

2.12.2 Protection

2.12.2.1 Storage batteries and charging equipment thereof are to be provided with means of protection according to the requirements of 2.3.11 in this PART.

2.12.3 Arrangement**2.12.3.1 Storage batteries storage area**

.1 Storage batteries connected to a charging device with a power output of more than 2 kW are to be housed in a room assigned to the batteries only, or in a box or a locker on open deck;

.2 Storage batteries connected to a charging device with a power output of no more than 2 kW are to be installed in a box or a locker within a suitable space, or may be installed in an open position in a well ventilated location where the machinery space does not comply with the installation requirements;

.3 Storage batteries are not to be installed in living spaces.

Note: Power output of the charging device is to be calculated from the maximum charging current multiplied by the rated voltage of batteries.

2.12.3.2 A gap of more than 20 mm is to be provided around each battery, and non-hygroscopic and electrolyte-resistant insulating material is to be used for the separation, dunnage and fixing of the battery. Measures are to be taken to prevent any leaking electrolyte from entering in contact with the ship's structure.

2.12.3.3 Storage batteries are to be installed at locations easy for replacement, test, liquid charging and cleaning.

2.12.3.4 Acid and alkaline storage batteries are not to be installed in the same compartment, box or cabinet.

2.12.3.5 Prime mover starter batteries are to be installed as close as practicable to the prime mover served.

Where storage batteries cannot be fitted in battery rooms, appropriate ventilation is to be ensured at the installation position.

2.12.3.6 Emergency power sources (including transient emergency power sources) and storage batteries for commanding telephones are to comply with requirements of Section 5.

2.12.4 Equipment of battery room

2.12.4.1 The installation of electrical equipment is to be avoided in battery rooms. Where this is necessary, the explosion-proof electrical equipment is to be selected, but its lighting is to comply with the requirements on bulkhead luminaire in 2.7.1.1 of this PART.

2.12.4.2 Other cables than those of storage batteries are not to pass through battery rooms. If unavoidable, pipes are to be laid or other means for ensuing safety are to be provided.

2.12.5 Ventilation

2.12.5.1 Dedicated battery rooms, boxes, cabinets and ventilating ducts, etc. all are to be provided with means for corrosion protection on surfaces which may be subject to corrosion due to electrolyte or gas escaped from electrolyte.

2.12.5.2 Except for boxes and cabinets installed on open decks or spaces as specified in 2.12.3.1 of this PART, ventilation systems of battery rooms, boxes or cabinets are to be independent of other ventilation systems. The exhaust air ducts are to lead to locations where inflammable gas can be safely diluted and there are no ignition sources, and the air intake is to lead to locations where inflammable gas may be accumulated. Air outlets are to be fitted at the top and air outlets are to be fitted at the bottom. In addition, means are to be provided to protect against water and flame.

2.12.5.3 Natural ventilation may be employed if the required number of air changes is small and the duct can be run directly from the top of the battery room, box or locker to the open deck above, with no part of the duct more than 45° from the vertical.

2.12.5.4 For natural ventilation of the battery room, the cross-sectional area A of the inlet is to be equal to that of the outlet, not less than:

— for vented type batteries

$$A = \frac{50 \times U_n \times Q \times n}{1000} \text{ cm}^2$$

— for valve-regulated sealed batteries

$$A = \frac{20 \times U_n \times Q \times n}{1000} \text{ cm}^2$$

Where: U_n — nominal voltage of the battery, in V;

Q — battery capacity, in Ah;

n — number of cells in series.

2.12.5.5 Mechanical ventilation is to be provided for the battery room, box or locker containing vented type

batteries with a total charging power higher than 2kW.

2.12.5.6 Axial-flow type mechanical ventilation devices are not to be used for battery rooms, boxes or lockers, except for explosion-proof devices. Where other types of mechanical ventilation devices are used, means are to be provided to prevent sparking in case of the impeller touching the casing. 2.12.5.7 All openings of battery rooms, other than ventilation openings, are to be effectively sealed to prevent the explosive gas from entering adjacent compartments.

2.12.5.8 The quantity Q of air expelled from the rooms, boxes or lockers containing vented type batteries is not to be less than:

$$Q = 0.11In \text{ m}^3/h$$

Where: I —the maximum charging current during the development of gas, but not less than 25% of the maximum charging current output by the charging device, in A;

n —number of battery cells.

2.12.5.9 The quantity of air expelled from the rooms, boxes or lockers containing valve-regulated sealed batteries may be reduced to 25% of that required in 2.12.5.8.

2.12.6 Warning notices

2.12.6.1 A warning notice of “NO SMOKING ORNAKED LIGHTS” is to be displayed adjacent to doors of battery rooms and covers of battery boxes or lockers.

Section 13 CABLES

2.13.1 General requirements

2.13.1.1 Cables are to be selected according to the environmental conditions of the space where the cables will be installed, methods of installation, rated current, duty, diversity factor, permissible voltage drop, etc.

2.13.1.2 The rated voltage of any cable is not to be lower than the nominal voltage of the circuit for which it is used. Special considerations are to be given to cables easily subject to the impulse voltage arising from high inductance circuits such as crane circuits operated by contactors.

2.13.1.3 Portable electrical equipment is to be provided with movable flexible cables.

2.13.2 Choice of insulating material and voltage rating

2.13.2.1 The rated maximum operating temperature of the insulating material is to be at least 10°C higher than the maximum ambient temperature liable to be produced in the space where the cable is installed.

2.13.2.2 The insulating material of cables is generally to be selected in accordance with Table 2.13.2.2. The selection of other insulating materials is to be subject to approval by CCS.

Maximum Rated Conductor Temperature of Insulating Material

Table 2.13.2.2

Insulating material		Max. rated conductor temp. (°C)	Max. ambient temperature, °C
Flexible compound	Ethylene propylene rubber	85	75
	Crosslinked polyvinyl chloride	85	75
	Silicon rubber	95	85
Thermoplastic compound	PVC	60	50
Other materials	Mineral	95	85
Note 1: Where silicon rubber and mineral insulations are at locations not accessible to crew members, higher temperature (150°C for silicon rubber; unlimited for mineral insulation) is allowed upon approval by CCS.			
Note 2: The temperature of conductor refers to the ambient temperature plus the temperature rise arising from the load.			

2.13.3 Choice of protective covering

2.12.3.1 Cables permanently fitted on decks exposed to the weather, in bathrooms, fish holds, refrigerated spaces, machinery spaces or in any other location where water condensation or harmful vapour (e.g. oil vapour) may be present are to have a metallic impervious sheath (of copper or lead alloy) or a nonmetallic impervious sheath (of polyvinyl chloride, polychloroprene, chlorosulphonated-polyethylene, etc.). The nature of the impervious sheath is to comply with the requirements for environmental conditions.

2.12.3.2 All cables and wiring external to electrical equipment are to be at least of a flame-retardant type. When cables, with flame-retardant properties in compliance with IEC Publication 332-1: Tests on electric and optical fiber cables under fire conditions—Part 1: Test for vertical flame propagation for a single insulated wire or cable, are used and need to be bundled, means are to be provided to limit the propagation of fire along the bunched cables (see 2.13.9.11 of this PART).

2.12.3.3 Where cables for services, required to be operable under fire conditions, e.g., cables connecting emergency fire pumps to emergency switchboards, pass by areas with high risk of fire hazard, such cables are to be fire proof in compliance with IEC Publication 331 Test method on electric wires or cables under fire conditions.

2.13.3.4 Services required to be operable under fire conditions include:

- .1 general emergency alarm system;
- .2 fire detection and fire alarm system;
- .3 fire extinguishing system and fire extinguishing medium release alarm;
- .4 public address system;
- .5 control and power systems of power operated fire doors and status indication systems for all fire doors;
- .6 control and power systems of power operated watertight doors and their status indication systems;
- .7 emergency lighting;
- .8 low location lighting;
- .9 remote emergency stop/shutdown arrangements for systems which may support the propagation of fire and/or explosion;
- .10 emergency fire pump.

2.13.3.5 The electrical cables to the emergency fire pump are not to pass through the machinery spaces containing the main fire pumps and their source(s) of power and/or prime mover(s). When cables of fire pump have to pass through these machinery spaces due to the arrangement of fishing vessels, the cables are to be of a fire resistant type and protected against mechanical damage (e.g., laying in thick-wall pipes).

2.13.3.6 Where necessary for particular applications, CCS may permit the use of special types of cables which do not comply with the requirements of 2.13.3.3 of this Section, such as radio frequency cables or digital computer information transmission system cables.

2.13.3.7 In choosing different types of protective coverings, due consideration is to be given to the mechanical actions to which each cable may be subjected during installation and in service. If the mechanical strength of the protective covering is considered insufficient, the cable is to be fitted in pipes or conduits or trunking or otherwise protected.

2.13.4 Determination of the cross-sectional area of conductors

2.13.4.1 The maximum continuous load carried by a cable is not to exceed its current rating corrected by correction factors. The diversity factor of the individual loads and the duration of the maximum load may be taken into account in estimating the maximum continuous load.

2.13.4.2 The voltage drop from the main switchboard or emergency switchboard bus-bars to any point in the installation, when the cable is carrying the maximum current under normal conditions of service, is not to exceed 6% of the rated voltage. Where the supply is from batteries with a voltage not exceeding 50 V, this voltage drop may be increased to 10%.

For circuits of navigation lights, it is necessary to limit voltage drops to lower values in order to maintain required lighting and color.

2.13.4.3 In assessing the current rating of lighting circuits, every lampholder is to be assessed at the maximum load likely to be connected to it, with a minimum of 60 W, unless the fitting is so connected as to take only a lamp rated at less than 60 W.

Two lampholders are to be counted for each lighting socket.

2.13.4.4 Cables supplying cargo winches, revolving cranes, windlasses and capstans are to be suitably rated for their duty.

2.13.4.5 The cross-sectional area of the conductors of equalizer leads for DC generators is not to be less than 50% of that of the main circuit cables. The cross-sectional area of neutral conductors in three-phase four-wire distribution systems is to be equal to at least 50% of that of phase conductors. If the cross-sectional area of phase conductors is 16 mm² or less, the cross-sectional area of the neutral conductors is to be the same.

2.13.5 Continuous service current rating

2.13.5.1 The maximum continuous load carried by a cable is not to exceed the values as given in Tables 2.13.5.1-1-3.

Current Ratings for PVC Insulated Cables with Maximum Working Temperature 60°C

(Based on Ambient Temperature of 45°C)

Table 2.13.5-1

(Based on Ambient Temperature of 15 °C)							
Number of cores Nominal cross-sectional area	Single core	Double cores	Three cores or four cores	Number of cores Nominal cross-sectional area	Single core	Double cores	Three cores or four cores
	A			mm ²	A		
mm ²							
1	8	7	6	95	165	140	116
1.5	12	10	8	120	190	162	133

2.5	17	14	12	150	220		187		154	
4	22	19	15	185	250		213		175	
6	29	25	20	240	290		247		203	
10	40	34	28	300	335		285		235	
16	54	46	38		DC	AC	DC	AC	DC	AC
25	71	60	50	400	390	380	332	323	273	266
35	87	74	61	500	450	430	383	365	315	301
50	105	89	74	625	520	470	442	400	364	329
70	135	115	95							

Current Ratings for Ethylene-propylene Rubber and Crosslinked Polyethylene Insulated Cables with Maximum Working Temperature 85°C

(Based on Ambient Temperature of 45°C)

Table 2.13.5.1-2

Number of cores Nominal cross-sectional area	Single core	Double cores	Three cores or four cores	Number of cores Nominal cross-sectional area	Table A1 - Nominal Temperature of 90 °C					
					Single core		Double cores		Three cores or four cores	
mm ²	A			mm ²	A					
1	16	14	11	95	275		234		193	
1.5	20	17	14	120	320		272		224	
2.5	28	24	20	150	365		310		256	
4	38	32	27	185	415		353		291	
6	48	41	34	240	490		417		313	
10	67	57	47	300	560		476		392	
16	90	77	63		DC	AC	DC	AC	DC	AC
25	120	102	84	400	650	630	553	536	445	441
35	145	123	102	500	740	680	629	578	518	476
50	180	153	126	625	840	740	714	629	588	518
70	225	191	158							

Current Ratings for Silicone Rubber and Mineral Insulated Cables with Maximum Working Temperature 95°C

(Based on Ambient Temperature of 45°C)

Table 2.13.5.1-3

Number of cores Nominal cross-sectional area mm ²	Single core	Double cores	Three cores or four cores	Number of cores Nominal cross-sectional area mm ²	Single core	Double cores	Three cores or four cores
	A				A		
1	20	17	14	50	200	175	140
1.5	24	20	17	70	255	217	179
2.5	32	27	22	95	310	264	217
4	42	36	29	120	360	306	252
6	55	47	39	150	410	349	287
10	75	64	53	185	470	400	329
16	100	85	70	240	570	485	400
25	135	115	95	300	660	560	460
35	165	140	116				

Note: The current ratings given in the Table are based on maximum operating temperatures of insulating material given in Table 2.13.2.2. Where a more precise evaluation of current rating has been carried out based on empirical or calculated data, details may be submitted to CCS for approval.

2.13.6 Correction factors for current rating

2.13.6.1 Correction factors for different ambient temperatures:

When it is known that the ambient temperature is different from 45°C, correction factors given in Table 2.12.6.1 are to be applied.

Correction Factor for Ambient Temperature

Table 2.13.6.1

Ambient temperature Max. temperature of conductor, °C	35	40	45	50	55	60	65	70	75	80	85
60	1.29	1.15	1.00	0.82	-	-	-	-	-	-	-
65	1.22	1.12	1.00	0.87	0.71	-	-	-	-	-	-
70	1.18	1.10	1.00	0.89	0.77	0.63	-	-	-	-	-
75	1.15	1.08	1.00	0.91	0.82	0.71	0.58	-	-	-	-

80	1.13	1.07	1.00	0.93	0.85	0.76	0.65	0.53	-	-	-
85	1.12	1.06	1.00	0.94	0.87	0.79	0.71	0.61	0.50	-	-
90	1.10	1.05	1.00	0.94	0.88	0.82	0.74	0.67	0.58	0.47	-
95	1.10	1.05	1.00	0.95	0.89	0.84	0.77	0.71	0.63	0.55	0.45

2.13.6.2 Correction factors for bunched cables:

.1 For cables laid in one of the following manners and so arranged as to ensure free circulation of cooling air around each bunch, the current ratings in Tables 2.13.5.1-1 to 2.13.5.1-3 may be directly applied:

- (1) not more than six cables bunched together on cable trays, in cable conduits, pipes or trunking;
- (2) more than six cables arranged in the following manners:

a. distance between any two sextuplets is at least equal to the diameter of the thickest cable

○○○○○○ ○○○○○○ ○○○○○○

b. or distance between any two triplets both horizontally and vertically is at least equal to the diameter of the thickest cable

○○○ ○○○ ○○○
○○○ ○○○ ○○○

.2 Where more than six cables, which may be expected to operate simultaneously at their rated capacity, are laid close together in a cable bunch in such a way that there is an absence of free air circulation around them, a correction factor of 0.85 is to be applied.

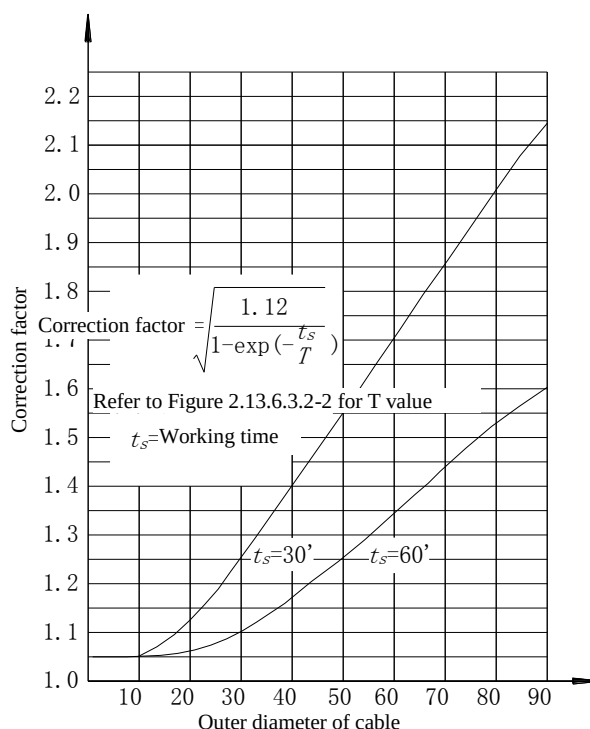
Note 1: Cables are said to be bunched when two or more are contained within a single conduit, trunking or duct, or if not enclosed, are not separated from each other.

Note 2: Where a correction factor of 0.85 is applied, care is to be taken that there are in general not more than two layers in each cable bunch.

2.13.6.3 Correction factors for non-continuous service

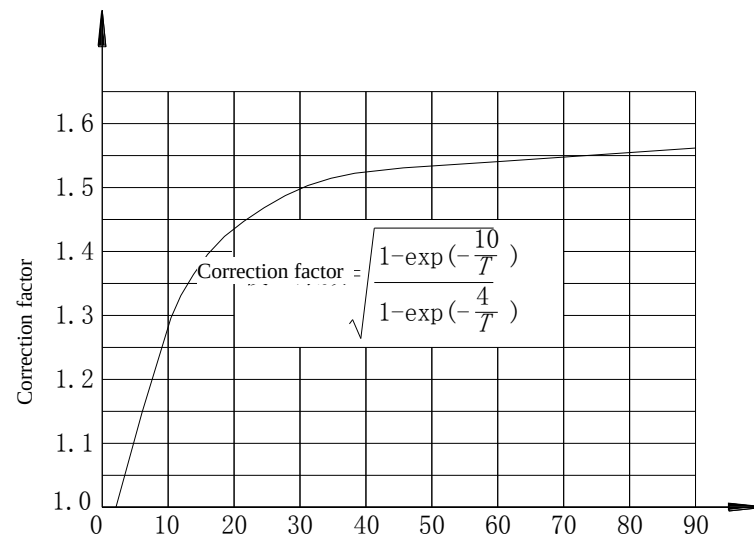
.1 For half-hour and one-hour services, the corresponding correction factors given by Figure 2.13.6.3.1 may be applied.

.1 For repetitive short-time services, the corresponding correction factors given in Figure 2.13.6.3.2-1 may be applied. Refer to Figure 2.13.6.3.2-2 for the time constant T .

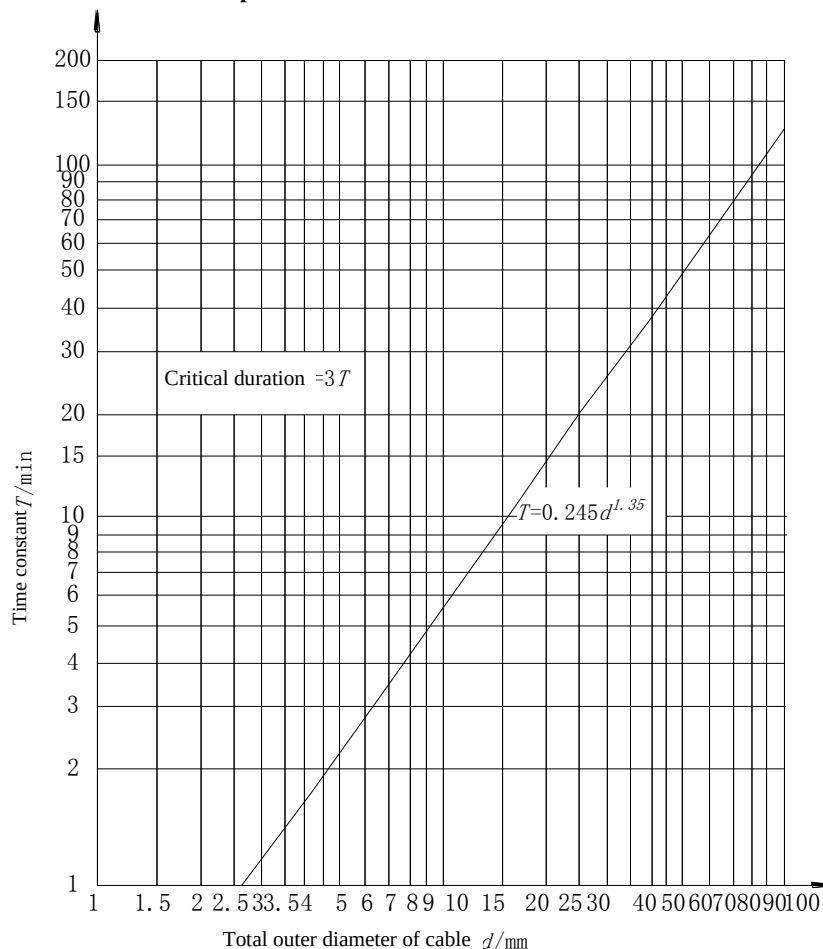


Note: This figure is applicable only when the down time is longer than the critical duration (critical duration is equal to three times time constant of cable).

Figure 2.13.6.3.1 Correction Factors for Half-Hour and One-Hour Services



Note: The correction factors given in the Figure are roughly calculated for periods of 10 min, with a constant load for 4 min and without load for 6 min.

Figure 2.13.6.3.2-1 Correction Factors for Repetitive Short-Time Services**Figure 2.13.6.3.2-2 Relations of Time Constant T and Total Outer Diameter of Cable****2.13.7 Parallel connection of cables**

2.13.7.1 Parallel connection of cables will be permitted only for cables having a cross section of 10 mm² or more. The current rating of cables connected in parallel is the sum of the current ratings of all parallel conductors, provided the cables have equal impedance, cross section and rated maximum operating conductor temperature.

2.13.8 Short-circuit capacity

2.13.8.1 Cables and their insulated conductors are to be capable of withstanding the mechanical and thermal effects of the maximum short-circuit.

2.13.9 Cable runs

2.13.9.1 Cable runs are to be, as far as possible, straight and accessible for inspection.

2.13.9.2 Cable runs are to be so arranged as to avoid the harmful effects from moisture or condensed water.

2.13.9.3 Cable runs are to be, as far as possible, away from the sources of heat such as boilers, hot pipes, resistors, etc., and are to be protected against mechanical damage.

2.13.9.4 Cables are not to be installed across expansion joints in any structure. Where this is unavoidable, a loop of cable having a length sufficient to accommodate the expansion of the joint is to be provided. The internal radius of the loop is to be at least 12 times the external diameter of the cable.

2.13.9.5 Cables having different maximum rated conductor temperatures are not to be bunched together. Where this is unavoidable, the cables are to be so installed that no cable reaches a temperature higher than that permitted for the cable with the lowest temperature rating in the bunch.

2.13.9.6 Cables having a protective covering or sheathing which may damage the covering or sheathing of other cables are not to be bunched together.

2.13.9.7 Where a duplicate supply is required for essential electrical equipment, such as the two cables for the supply of the control box of navigation lights, the two cables are to follow different routes which are to be as far apart as practicable, both vertically and horizontally.

2.13.9.8 In the case of duplicated essential equipment, or systems which could operate as each other's stand-by for an essential function (such as duplicated power equipment of steering gears), the supply and any

associated control cables are to follow different routes which are to be as far apart as practicable, both vertically and horizontally.

Note: Where the main switchboard is installed in the independent closed compartment (e.g., main engine control room), such requirements may not be applicable to the equipment and cables installed in such closed compartment.

2.13.9.9 Cables serving essential equipment or emergency power equipment, emergency lighting and internal communications or signals used in an emergency are to be as far as practicable routed clear of galleys, laundries, machinery spaces and their casings and other high fire risk areas, except for supplying equipment in these spaces.

Where possible, these cables are to be run in such a manner as to preclude their being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.

2.13.9.10 Main cable runs and cables for the supply and control of essential services are to be kept away from the machinery and machinery parts having an increased fire risk unless:

- the cables serve such installations;
- the cables are separated by a steel bulkhead or deck from such installations;
- the cables are of a fire-resisting type.

Note: Machinery, mechanical parts or equipment containing inflammables are regarded as having an increased fire risk.

2.13.9.11 Where cables are bundled, one of the following means is to be adopted to limit the flame from spreading along the cable bundle:

- cables passing the tests as specified by IEC publication 332—2 *Tests of Bundled Cables*;
- providing fire stop metal plates at the appropriate positions on the route of cable bunch or applying fireproof paints approved by CCS.

2.13.9.12 Where trunk cables are laid in concealed manner, the paneling in way of which is to be arranged for easy removal.

2.13.9.13 Cables are not to be directly embedded in the thermal or sound insulation made of combustible material. Where cables are separated by non-combustible covering, they may be laid in the insulation, but the load carried is to be reduced accordingly.

2.13.10 Means to limit the propagation of fire along bunched cable

2.13.10.1 Where cables which have individually passed the test of a single flame-retardant cable in accordance with acceptable standards (see 2.13.3.3) are to be bunched, means are to be provided to limit the propagation of fire along the bunched cables, as required in 2.13.10.2 to 2.13.10.4.

The bunched cables mentioned here are 5 or more cables from machinery spaces and high fire hazard spaces and more than 10 cables from other spaces are laid close together in the cable trunking.

2.13.10.2 Fire dampers are to be provided (see Figure 2.13.10.2):

.1 Cables laid vertically in enclosed or semi-enclosed spaces are to be provided with fire dampers in the following locations:

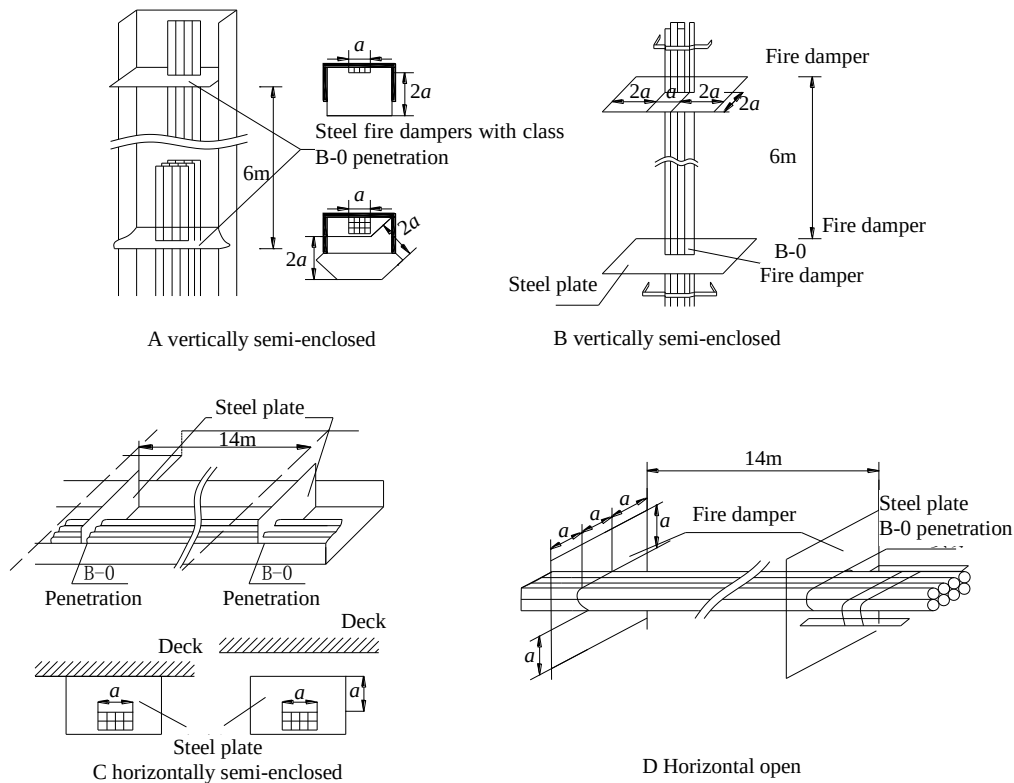
- (1) at every second deck or approximately 6m, except cables installed within the fully-closed trunking;
- (2) at cable entrances of main switchboard and emergency switchboard;
- (3) at cable entrances of engine control room;
- (4) at cable entrances of centralized control panels for propulsion machinery and essential auxiliary machinery;
- (5) at each end of the fully-closed cable duct.

.2 Cables laid horizontally in closed or semi-enclosed spaces are to be provided with fire dampers in the same locations required in 2.13.10.2.1, but the maximum spacing of fire dampers may be increased to 14 m.

.3 In the passageways having a height lower than the neck of a standing person within cargo holds and cargo areas, fire dampers can only be fitted on the boundaries of compartments.

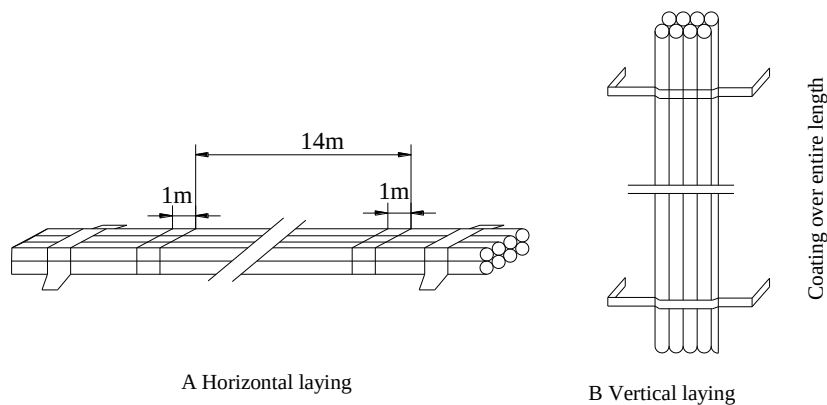
2.13.10.3 The fire dampers are to be designed to meet the following requirements:

- (1) The fire resistance of cables passing through fire stops must meet the requirements for class B-0 divisions.
- (2) Fire dampers are to be made of steel plate with the thickness of at least 3 mm.
- (3) Where cables are laid vertically in the non-fully-closed trunking, the fire damper is to cover the sectional area of the trunking.
- (4) Where cables are laid open, the fire damper is to extend around to twice the maximum laying size of cables, but not to penetrate ceilings, decks, bulkheads or the rigid sidewall of trunking.

**Figure 2.13.10.2 Locations of Fire Dampers**

2.12.10.4 Instead of the fire dampers required above, installed cable bunches may be provided with flameproof coating:

- .1 over a length of 1 m in every 14 m for horizontal cable runs (see Figure 2.13.10.4);

**Figure 2.13.10.4 Locations of Flame-proof Coating**

- .2 over the entire length of vertical cable runs (see Figure 2.13.10.4).

2.13.11 Mechanical protection of cables

2.13.11.1 Cables exposed to risk of mechanical damage are to be protected by metal channels or casings or enclosed in steel conduits, unless the protective sheathing of cables is sufficient to withstand the possible damage.

2.13.11.2 Cables in cargo holds and other spaces where there is exceptional risk of mechanical damage are to be suitably protected, even if armoured.

2.13.11.3 Metal casings for mechanical protection of cables are to be efficiently protected against corrosion.

2.13.11.4 Where cables are placed underneath the floor plates in machinery spaces, reliable precautions are to be taken to prevent such cables from being soaked in oil or water, or being exposed to mechanical damage.

2.13.12 Radius of bend

2.13.12.1 The minimum internal radius of bend of installed cables is to be generally in accordance with Table 2.13.12.1.

Minimum Internal Radius of Bends in Cables for Fixed Wiring**Table 2.13.12.1**

Cable construction		Overall diameter of cable <i>D</i> (mm)	Minimum internal radius of bend (mm)
Insulation	Outer covering		
Thermoplastic materials and elastic materials	Metal sheathed, braided or armoured	Any	6D
		≤25	4D
	Other protective layers	>25	6D
Mineral	Hard metal sheathed	Any	6D

2.13.13 Securing of cables

2.13.13.1 Cables are to be effectively supported and secured with the exception of cables for portable appliances and of those installed in pipes, conduits, trunking or special casings.

2.13.13.2 Clips or straps are to be robust and are to have a sufficient surface area and a certain shape, so that the cables may remain tight without their covering or sheathing being damaged.

2.13.13.3 Clips, supports and accessories are to be made of corrosion-resistant material or suitably corrosion inhibited before erection.

2.13.13.4 The distance between supports is to be suitably chosen according to the type of cables and the possible vibration, and is generally to be in accordance with Table 2.13.13.4.

External Diameter of Cable and Distance between Supports, mm**Table 2.13.13.4**

External diameter of cable		Distance between supports	
Exceeding	Not exceeding	Non-armoured cables	Armoured cables
—	8	200	250
8	13	250	300
13	20	300	350
20	30	350	400
30	—	400	450

2.12.14 Penetration of bulkheads and decks by cables

2.12.14.1 Penetration of watertight bulkheads or decks maybe carried out with either individual watertight glands or with packed watertight boxes carrying several cables, provided that the watertight integrity of the bulkheads or decks is to be maintained.

2.13.14.2 Where cables pass through non-watertight bulkheads or structural steel, the holes are to be bushed with lead or other approved material. Where the steel is 6 mm or more in thickness, adequately rounded edges may be accepted as the equivalent of bushing.

2.13.14.3 Penetration of bulkheads and decks requiring a certain fire integrity is to be so effected as to ensure that the required fire integrity is not impaired.

2.13.14.4 Cables passing through decks are to be protected by deck tubes or ducts having a suitable height.

2.13.14.5 Materials used for glands and bushings are to be such that there is no risk of corrosion to cables or hull structures.

2.13.14.6 Where rectangular holes are cut in bulkheads or structural steel, the corners of the holes are to be radiused.

2.13.15 Installation of cables in pipes, conduits or trunking

2.13.15.1 When cables are installed in metal pipes, conduits or trunking, the following requirements are to be complied with:

.1 The internal surfaces of the pipes, conduits or trunking are to be smooth and protected against corrosion;

.2 Provision is to be made at the ends of pipes, conduits or trunking so as to protect the sheathing or covering of cables from being damaged;

.3 The internal sectional area and radius of bend of pipes or conduits are to be such as to permit easy drawing in and out the cables contained therein; the internal radius of bend of pipes or conduits is not to be less than that allowed for cables, provided that for pipes equal to or above 63 mm in external diameter, the internal radius of bend is not less than twice the external diameter of the pipe;

.4 The drawing-in factor (ratio of the sum of the cross-sectional areas of the cables to the internal cross-sectional area of the pipes or cables) is not to exceed 0.4;

.5 Pipes, conduits or trunking are to be effectively earthed and are to be mechanically and electrically continuous across joints;

.6 Pipes, conduits or trunking are to be so arranged that water will not accumulate inside them;

.7 If necessary, ventilation openings are to be provided, preferably at the highest and lowest points, so as to permit air circulation and to prevent possible accumulation of water at any part of the pipes, conduits or trunking. This may be done only if the fire risk will not be increased thereby;

.8 Expansion joints are to be provided where necessary for long pipe run;

.9 Lead-sheathed cables without any outer covering are not to be laid in pipes, conduits or trunking.

2.13.15.2 Where cables are laid in trunks, the trunks are to be so constructed as not to afford passage for fire

from one 'tween deck or compartment to another.

2.13.15.3 Cables used for cold cathode luminous discharge lamps are not to be installed in metal conduits unless protected by metal sheathing or screen.

2.13.16 Installation of cables in fish holds, refrigerated spaces, fish processing rooms and freezer rooms

2.13.16.1 Cables not serving fish holds, refrigerated spaces, fish processing rooms and freezer rooms are not to pass through such spaces.

2.13.16.2 Cables installed in fish holds, refrigerated spaces, fish processing rooms and freezer rooms are to have a watertight or impervious sheath and are to be protected against mechanical damage. If an armoured cable is used, the armour (unless galvanized) is to be protected against corrosion by a further moisture-resisting covering.

2.13.16.3 Cables are to be generally run in the open in fish holds, refrigerated spaces, fish processing rooms and freezer rooms.

2.13.16.4 Cables laid in fish holds, refrigerated spaces, fish processing rooms and freezer rooms are to be provided with means to the placing of hooks along the cables as a casual means of suspension.

2.13.16.5 Metal supports used for securing the cables are to be galvanized or otherwise protected against corrosion.

2.13.16.6 Where it is necessary for the cables to pass through the thermal insulation of refrigerated spaces, they are to do so at right angles in metal tubes sealed watertight at both ends.

2.13.16.7 PVC insulated or covered cables are generally not to be used in refrigerated spaces unless the PVC compounds are appropriate to low temperature service.

2.13.17 Relief of tension

2.13.17.1 Cables are to be so installed that the tension stress applied to them either by their own weight or for any other reason is minimized. This is particularly important for cables of small cross-sections and for cables laid vertically or in vertical pipes.

2.13.18 Electrodynamic forces

2.13.18.1 In order to guard against the effects of electrodynamic forces in the event of short-circuit, single-core cables are to be firmly fixed and the strength of supports is to be sufficient to withstand the electrodynamic forces corresponding to the prospective short-circuit currents.

2.13.19 Installation of single-core cables for alternating current

2.13.19.1 For AC power systems, two-core or multi-core cables are to be used as far as practicable. Where it is necessary to use single-core cables for circuits rated in excess of 20 A, the following requirements are to be complied with:

- .1 Cables are to be either non-armoured or armoured and covered with non-magnetic material;
 - .2 Cables belonging to the same circuit are to be contained in the same pipe, conduit or trunking. Cable clips are to include cables of all phases of a circuit, unless the clips are of non-magnetic material;
 - .3 In the installation of two, three or four single-core cables forming respectively single-phase, three-phase, or three-phase four-wire circuits, the cables are to be as far as possible in contact with one another. In any event, the distance between adjacent cables is not to be greater than single cable diameter;
 - .4 When it is necessary to install single-core cables of current rating greater than 250 A near a steel bulkhead, the clearance between the cables and the bulkhead is to be at least 50 mm, unless the single-core cables belonging to different phases are installed in trefoil formation;
 - .5 Magnetic material is not to be placed between single-core cables of a group for the same circuit. Where cables pass through steel plates, all conductors of the same circuit are to pass through a plate or gland so constructed that there is no magnetic material between the cables, and the clearance between the cables and the magnetic material is not to be less than 75 mm, unless single-core cables belonging to different phases are installed in trefoil formation;
 - .6 In order to equalize to some degree the impedance of three-phase circuits of considerable length consisting of single-core cables having a cross sectional area of 185 mm² or over, the phases are to be transposed at regular intervals of not exceeding 15 m. Alternatively, the three single-core cables of different phases may be installed in a trefoil formation. The above precautions are, however, not necessary when the length of the run is less than 30 m;
 - .7 In circuits with several single-core cables in parallel for each phase, all cables are to follow the same route and have the same cross-sectional area.
- In addition, cables belonging to the same phase are, as far as practicable, to be alternated with those of other phases, so that an unequal division of current is avoided. For instance, in the case of six cables for each phase, the correct dispositions are as shown in Table 2.13.19.1.7;
- .8 The metal sheaths or coverings of single-core cables are to be earthed at one point only.

Dispositions of Cables**Table2.13.19.1.7**

Cables in parallel for each phase	1-layer disposition	2-layer disposition
2	ABC CBA	ABC ABC
3	—	ABCA BCABC
4	—	ABCABC CBACBA
5	—	ABCABCA BCABCABC
6	—	ABCABCABC CBACBACBA

2.13.20 Installation of cables with respect to prevention of electromagnetic interference

2.13.20.1 In order to minimize the effects of unwanted electromagnetic interference, cables are to be installed in accordance with IEC Publication 533 *Electrical and Electronic Installations in Ships–Electromagnetic Compatibility*, or relevant standards.

2.12.21 Earthing of metal sheathings or coverings of cables

2.12.21.1 The earthing of metal sheathings or coverings of cables is to be in accordance with the relevant requirements of Section 3, Chapter 1 of this PART.

2.13.22 Cable ends

2.13.22.1 The ends of all conductors of a cross-sectional area greater than 4 mm² are to be fitted with soldered sockets, compression type sockets or mechanical clamps. Corrosive fluxes are not to be used.

2.13.22.2 The temperature of cable sockets and terminals is, in general, not to exceed the maximum operating temperature of insulated cables.

2.13.22.3 Cables with a supplementary insulating tape beneath the protective sheath are to have additional insulation for each core having or possibly having contact with earthed metal where the insulating tape is stripped at cable ends.

2.13.22.4 The fixing of conductors in terminals at joints and at tappings is to be capable of withstanding the thermal and dynamic effects of short-circuit currents.

2.13.22.5 The ends of mineral insulated cables are to be prepared in accordance with the instructions by the manufacturer of cables.

2.13.22.6 Cables having hygroscopic insulation (e.g. mineral insulated) are to have their ends sealed against ingress of moisture.

2.13.23 Joints and tappings of cables

2.13.23.1 Cable runs are normally not to include joints. If a joint is necessary in the case of repair or sectional construction of the ship, the joint is to be such that the electrical continuity, insulation, mechanical strength and protection, earthing and fire-resisting or flame-retardant characteristics are not inferior to those required for the cables.

2.13.23.2 Tappings are to be made in suitable boxes of such a design that the conductors remain suitably insulated, protected from atmospheric action and fitted with terminals or bus-bars of dimensions appropriate to the current rating.

2.13.23.3 Joints and tappings are to be clearly marked.

2.13.24 Connection boxes

2.13.24.1 Connection boxes are to be made of flame-retardant material. Mountings of live parts are to be robust, durable, flame-retardant and moisture-resistant, having permanently insulation resistance with high dielectric strength.

2.13.24.2 Live parts within the box are to be suitably spaced or provided with shielding by flame-retardant insulating material, so that a short-circuit will not occur between conductors of different polarity or between conductors and earthed metal.

2.12.24.3 Each connection box is to be provided with a nameplate indicating its purpose or a durable no. mark corresponding to the wiring diagram. Where the connection boxes are installed in a concealed manner, the paneling in way of the boxes is to be arranged for easy removal.

Section 14 SHORE POWER SOURCE

2.14.1 Shore power source

2.14.1.1 Where arrangements are made for the supply of electricity from a source on shore or elsewhere, a connection box complying with the requirements of 3.2.1.12 of this PART is to be installed in a position in the ship suitable for the convenient reception of flexible cables from the external source. Suitable cables having adequate ratings, permanently fixed, are to be provided for connection between the shore connection box and the main switchboard or emergency switchboard.

2.14.1.2 When a three-phase AC system with neutral earthed is adopted for shore and/or ship power, an earth terminal is to be provided for connecting the ship's hull to shore. In the case of DC systems with hull return, the negative terminal of the shore power must be connected to hull.

2.14.1.3 The shore connection is to be provided with an indicator at the main switchboard or emergency switchboard in order to show when the cables are energized.

Section 15 Lightning Protective Devices

2.15.1 General requirements

2.15.1.1 Fishing vessels having non-metallic masts are to be provided with reliable lightning protective devices.

2.15.1.2 Fishing vessels in metal structure are to be provided with reliable earthing devices.

2.15.2 Structure

2.15.2.1 Air terminals are to be made of copper bars with diameter no less than 12 mm or steel bars with diameter no less than 25 mm. Air terminals are to project at least 300 mm beyond the electrical equipment on the top of the mast. 2.15.2.2 Air terminals on non-metallic masts are to be in reliable electrical connection with hull by copper bars or cables having a minimum cross-section of 70 mm² or steel bars having a minimum cross-section 100 mm². Copper bars or cables (steel bars) are to be run as straight as possible.

2.15.2.3 Flexible masts are to be in reliable electrical connection with hull, and flexible copper wires connected to them are to have a minimum cross-section of 70 mm².

2.15.2.4 The resistance between air terminals and earth terminations is not to exceed 0.02 Ω.

2.15.2.5 Air terminals in lightning protective systems are to comply with the following requirements:

- .1 An air terminal is to be fitted to each non-metallic mast;
- .2 An air terminal is to be made of copper or copper alloy conducting bar of not less than 12 mm in diameter, and are to project at least 300 mm beyond the top of the mast. Other materials may be used, e.g., stainless steel or aluminum alloys, or steel bar effectively protected against corrosion, subject to the requirement of 2.13.1.7. The material is to be resistant to sea water.

2.15.2.6 Down conductors of the protective system are to comply with the following requirements:

.1 Down conductors are to be made of copper, or copper alloy tape or cable. Cable is preferred as both the insulation and the circuit shape inhibit surface discharge. Other materials may be used, for example stainless steel or aluminum alloys, subject to the requirement of 2.15.2.4. The material is to be resistant to sea water.

.2 Down conductors of copper are to have a minimum cross-section of 70 mm², be firmly secured to the structure and be run as straight as possible between the lightning rod and the earth termination. Bends, where necessary, are to have a minimum radius of at least 10 times the equivalent diameter of the conductor.

2.15.2.7 The ends of down conductors are to be reliably bonded to the earth terminations of the metallic construction of the vessel nearby. Where necessary, measures are to be taken for preventing electrochemical corrosion.

Section 16 ADDITIONAL REQUIREMENTS FOR ELECTRICAL PROPULSION INSTALLATIONS

2.16.1 General requirements

2.16.1.1 In addition to this Chapter, electrically propelled fishing vessels are to comply with the applicable provisions of other Parts and Chapters of the Rules.

2.16.1.2 This Chapter applies to the design, manufacturing and test of electrically propelled fishing vessels having rated voltage no more than 1 kV. MV and HV electrically propelled fishing vessels beyond the limits are to comply with relevant requirements of the *RULES FOR CLASSIFICATION OF SEA-GOING STEEL VESSELS* of CCS.

2.16.1.3 Electrical propulsion installations must be so designed to comply with using and working requirements, and considerations are to be given to the short-term overload, manoeuvring and impact of sea conditions.

2.16.1.4 The propulsion system is mainly composed of generating set, power distribution device, converter device, motor, control equipment and monitoring system.

2.16.1.5 The lubrication of bearings of propulsion motors, gearing and shafting is to be effective at all normal speeds from creep speed upwards, either ahead or astern. The above shafts and bearings are not to be damaged by slow rotation caused by motor(s) or propeller(s) under all predictable oil temperature conditions.

2.16.1.6 The electric power for the propulsion system may be derived from generating sets dedicated to propulsion duty. Where the propulsion system can be supplied by the common power plant capable of supplying power to propulsion and routine duty, such plant is to be composed of 2 or more power frequency generating sets, so that the remaining generating sets are to be still capable of supplying power to the propulsion system and essential devices in the event of failure of one set.

2.16.1.7 Parameters of composing devices of the electric propulsion system are to be matching to ensure the normal operation of equipment. The electric propulsion system is to have the overload capacity for continuously running for 1h at 110% of rated output within 12 h.

2.16.1.8 The electric propulsion system must be provided with fault redundancy. Where one device fails, the fishing vessel is to be still propelled effectively at a speed no less than 50% of the designed one to ensure the operation safety.

2.16.1.9 All main electrical equipment of electric propulsion system is to be provided with effective measures to protect against moisture and condensate water accumulation to ensure reliable operation in humid environments.

2.16.1.10 The main propulsion circuit is to be provided with an earth leakage current testing device, and is to be capable of giving an alarm in the event of earthing fault. A release device is to be fitted where such earth leakage current may lead to damage.

2.16.1.11 The electric propulsion system is to have the power limitation function to protect the power plant of fishing vessel against power failure due to overload protection.

2.16.1.12 The electric propulsion system can be started only when the speed controller is at zero position and the system is at standby state.

2.16.1.13 The electric propulsion system is to absorb partial regenerative brake energy, and the system transition is to be stable without abnormality when the propeller is manoeuvred from full-speed ahead running to full-speed astern running during the normal operation of fishing vessels.

2.16.1.14 The electric propulsion system is to be provided with a control station at the engine room and is to be performed control operations near the engine when the bridge control fails.

2.16.1.15 Each control station of the electric propulsion system must be provided with a separate emergency stop device.

2.16.1.16 The electric propulsion system is to be stable in the normal operation range, and is to be capable of weakening the load fluctuation of propeller caused by waves. The control system is to ensure that the propulsion motor will not cause dangerous overspeed in case of sudden load shedding.

2.16.1.17 The operation function of the electric propulsion system is to be simple and logic to prevent false operation. The arrangement of control equipment is to be clearly marked.

2.16.1.18 No harmful torsional vibrations are to be observed in all rotational parts and shaftings in normal running speed.

2.16.1.19 The temperature rise of electric and electronic devices and connecting wires, etc. is not to exceed the limits given in Table 2.16.1.19.

Temperature Rise Limits of Electric, Electronic Devices and Connecting Wires **Table 2.16.1.19**

Components and devices	Materials and covering layer	Temperature rise, K
Electric semi-conductor device and other electrical components	—	Not exceeding the value as specified in the instructions for use
Bus and wiring terminal connected to general low-voltage devices	Red copper, no covering layer	60
	Red copper, tin coating	65
	Red copper, silver plating	70
	Aluminum, ultrasonic tin coating	55
Buses and wiring terminals connected to power semiconductor devices	Red copper, no covering layer	45
	Red copper, tin coating	55
	Red copper, silver plating	70
	Aluminum and ultrasonic tin coating	35
Plastic insulated conductors or rubber insulated conductors and wiring terminals connected to semiconductor devices	—	45

2.16.1.20 The electric installations are to be so designed as to prevent the harmful effects of electromagnetic interference generated by semiconductor converters. AC electrical devices supplied by daily power grid are to operate normally when the total voltage harmonic component of power source is no more than 5%.

2.16.1.21 For an electrical network fitted with semiconductor converters, single order harmonics distortion and up to 15th harmonic are not to exceed 5% of the rated voltage, and the distortion is to be reduced with the higher order and gradually reduced to 1% at 100th harmonic. The total harmonic distortion at dedicated systems (e.g. switchboard for electrical propulsion) is not to exceed 10%.

2.16.1.22 The total harmonic distortion (THD) of the voltage waveform is the ratio of the rms value of the harmonic content to the rms value of the fundamental, expressed in per cent and may be calculated using the expression:

$$V_{\text{THD}} = \frac{\sqrt{\sum_{h=2}^{\infty} V_h^2}}{V_1} \times 100\%$$

Where: V_{THD} — the total harmonic distortion;

V_h — rms amplitude of a harmonic voltage of order h ;

V_1 — rms amplitude of the fundamental voltage.

2.16.2 Generating sets

2.16.2.1 Prime movers

.1 Prime movers and their governors are to comply with the requirements of Section 7, CHAPTER 5, PART THREE of the Rules. The rated power in conjunction with the overloading and load built-up capabilities are to be adequate to supply the power needed during transitional changes under operating conditions of the electrical equipment due to manoeuvring and the heavy sea and weather conditions.

.2 In addition to governors nearby, prime movers are to be provided with remote control speed governance ports. The speed is to be governed stably and fast in the range of minimum speed for stable operation to 105% rated speed; The speed of speed governing is to be sufficient stability and certain rapidity, and the range of speed governing is from minimum stable speed to 105% of rated speed.

.3 Machinery piping systems for the prime movers of generating sets for propulsion are to comply with all the requirements specified in CHAPTER 5 of PART 3 of the Rules applicable to main engines.

.4 In the case of parallel operation of generators, the governing systems used are to permit stable operation to be maintained over the entire operational speed range of the prime movers.

2.16.2.2 Generating set

.1 Prime movers and engines are to be installed on the same common base with the coaxiality to be controlled in certain range, to ensure the vibration intensity of unit during bench test;

.2 Generating sets are to stably run for a long term in the connected network at the rated output;

.3 Generating sets are to be provided with communication ports to achieve externally transmitting generating set data, running state and signal;

.4 In addition to the operation nearby, generating sets are to be provided with remote control ports for connecting with power distribution devices to operate remotely;

.5 Generating sets are to be subject to the multi-unit shunt load test according to the actual running conditions before delivery.

2.16.3 Power plants, power distribution devices and power management systems

2.16.3.1 Public power plants are to comply with the following requirements:

.1 The control system of the plant is to ensure a safe distribution of power between propulsion and ship services, with tripping of non-essential loads and/or reduction in the propulsion power if necessary.

.2 Where one generating set is out of action, the remaining sets are to be capable of providing all essential and normal service loads while maintaining an effective propulsion of fishing vessels at a navigation speed no less than 50% of the designed one to ensure safe operation.

.3 Where two or more generating sets supply power in parallel normally, the remaining running units are to ensure the continuous operation and effective propulsion of essential services when one generating set suddenly fails.

2.16.3.2 The power management system of the power distribution device is to be so designed that the standby generating set is to be automatically started to automatically supply power to the power grid when the power grid fails or one generating set suddenly stops due to major failure. In the event of a general fault which will not lead to stop immediately, an alarm signal is to be given to start the standby generating set to enable grid connection, load transfer and failed equipment removal.

2.16.3.3 The power management system is to be automatically enable the startup, parallel operation, removal, stop and running protection of generating sets to ensure safe power distribution between units.

2.16.3.4 Where the total load power is close to the sum of rated outputs of ongrid generating sets, the power management system is to be capable of automatically starting the standby generating sets and enabling grid

connection and load transfer; where the load power is far lower than the rated outputs of on-line generating sets, the power management system is to automatically transfer and remove the loads of generating sets.

2.16.3.5 The power management system is to have classified load shedding function. Where the power capacity fails to comply with the load requirement, the power management system is to control the electric propulsion system to run at reduced capacity or shed some non-essential loads to ensure the safe operation of power plant.

2.16.3.6 The power management system is to be capable of monitoring the startup of main load equipment to provide sufficient reserve capacity for the startup and running, and transmit a signal of permitting startup or limiting the power.

2.16.3.7 The power management system is to share data with the monitoring, alarm and propulsion systems of the engine compartment.

2.16.3.8 The busbar of the power distribution device is to be provided with at least two independent sections which are to be connected by circuit breakers or other devices accepted, the generators and other essential services are to be evenly distributed to these sections.

2.16.3.9 The power distribution device is to be provided with automatic, semi-automatic and manual three operation modes, and mode selector switch.

2.16.4 Converters

2.16.4.1 The technical properties, electrical ports, control characteristics and cooling modes of converters are to comply with general technical requirements of the electric propulsion system.

2.16.4.2 Converters are to be provided with functions for protection against overcurrent, overvoltage, input/output phase loss, short circuit and power device overheating, etc.

2.16.4.3 Intermediate DC circuits of converters are to be provided with energy release devices to prevent electric shock accident caused by energy storing devices, energy storing devices are to be quickly discharged to the level below the safe voltage after DC dropout.

2.16.4.4 Converters are to be provided with power device overvoltage release devices.

2.16.4.5 Converters are to be reliably earthed. The resistance at accessible metal parts and enclosure earthing point is to be no more than 0.1Ω. The earthing point is to be provided with clear earthing marks.

2.16.4.6 Converters are to be designed based on various running and maneuvering states of fishing vessels, and converters will not be subject to permanent damages in case of propulsion machine overload and short circuit.

2.16.4.7 Converters are to be so designed to facilitate inspection, repair and maintenance. Where power devices may be removed from the equipment, the whole equipment does not need to be disassembled.

2.16.4.8 Converters are to be additionally provided with corresponding filtering devices to limit harmonics when necessary.

2.16.5 Propulsion machines

2.16.5.1 Propulsion machines are to be provided with sufficient torque to ensure the reversal time of propulsion machines is to be no more than 15s from the start of manoeuvring to initial astern running under the minimum stable speed of propulsion machines.

2.16.5.2 Propulsion machines are to be provided with no less than 10% of torque margin, so that motors will not fall out of step during navigation in severe weather conditions, fishing operation or multi-propeller fishing vessel reversal.

2.16.5.3 Propulsion machines are to drive the propulsion machinery to run stably for a long term in various running conditions as specified, and are to run appropriately during forward-to-astern change.

2.16.5.4 Propulsion machines are to be designed based on the impact of current and voltage harmonics.

2.16.5.5 Stator windings supplied by converters are to be capable of withstanding the transient voltage variation caused by frequent switching action of converters.

2.16.5.6 Stator windings and bearings at both ends are to be provided with embedded temperature sensors to provide control signals for overtemperature protection.

2.16.5.7 Enclosures of propulsion machines are to be provided with earthing bolts and labels. The enclosure earthing bolts are to be so designed to ensure good connection and sufficient contact with earthing conductors.

2.16.5.8 Propulsion machines are to be provided with means to protect against harmful effects of shaft current (insulated bearings are recommended) to improve the running reliability.

2.16.5.9 Propulsion machines may be double-armatured, double-winding or multi-phase type to achieve fault redundancy.

2.16.5.10 Propulsion machines are to still run at the limited power in case of failure of cooling systems (e.g., fan and cooling water pump).

2.16.5.11 Propulsion machines must be capable of withstanding the transient short-circuit current at rated working output prior to the action of protective devices without being damaged in case of sudden short circuit at the machine wiring terminal or other parts in the system.

2.16.6 Monitoring instruments

2.16.6.1 The electric propulsion system is to monitor the running parameters and states of essential services.

2.16.6.2 The protection and alarm of electric propulsion system are to be reminded by sound and light.

2.16.6.3 Conventional monitoring devices are to be used for the electric propulsion system. Generally, monitoring and alarm are to be made by instruments and indicators. Refer to Table 2.16.6.3 for relevant displays and alarm items.

Monitoring and Alarm of Electric Propulsion System**Table 2.16.6.3**

System	Monitored parameter	Alarm	Display	Automatic stop	Remark
Propulsion generator	Bearing lub. oil inlet pressure – low or bearing temperature – high	√	√	√	Prime mover automatic shutdown
	Voltage – off-limits (high/low)	√	√		To read all phases
	Frequency – off-limits (high/low)	√	√		
	Current		√		To read all phases
	Power		√		To indicate power consumed and power available for propulsion in bridge and centralized control station
	Stator windings temperature – high	√	√		To read all phases
	Main generator circuit breakers – open/close		√		
	Generator running		√		
	Generator cooling medium temperature – high	√	√		If applicable
Propulsion motor	Bearing lub. oil inlet pressure – low or bearing temperature – high	√	√	√	
	Armature current		√		To read all phases
	Stator windings temperature – high	√	√		To read all phases
	Motor running		√		
	Motor overspeed	√	√	√	
	Motor cooling medium temperature – high	√	√		If applicable
	Differential protection or similar protection	√			Motor capacity ≥1500kW
Propulsion semiconductor converter	Voltage (input)		√		
	Current (input)		√		
	Overload (high current)	√			Alarms before protective device is activated
	Open/close position for assignment switches		√		
Propulsion Transformer	Transformer windings temperature – high	√	√		
Others	Main propulsion circuit earth fault		√		

2.16.7 Cables

2.16.7.1 Variable frequency marine cables are to be used as the main cables between converters and propulsion motors. Control cables are to be shielded to reduce harmonic interference and improve the system reliability.

2.16.7.2 The carrying capacity of main cables of electric propulsion system is to be selected based on the additional heating effect caused by harmonics in the system.

2.16.7.3 Internal connecting wires of main control equipment, including connecting wires of switchboard, are to be flame-retardant.

2.16.8 Cables laying and equipment installation requirements

2.16.8.1 Variable frequency cables and control cables are to be arranged separately with the spacing no greater than 100 mm, rather than being arranged in parallel, to reduce electromagnetic interference and affect the running reliability. Variable frequency cables and control cables are to be intersected at 90° preferably if necessary.

2.16.8.2 Shielding layers of control cables are to be earthed reliably at both ends. Shielded twisted pair cables are to be used for transmission of simulation signals. Simulation signals of different loops are not to be located in the same public return line.

2.16.8.3 All cables of the propulsion system are not to have other joints than terminals. Power cables terminals of the propulsion system are to be provided with means for sealing.

2.16.8.4 Means are to be provided for vibration absorption when main equipment of the electric propulsion system is installed, to adapt to the working environment of engine compartment of fishing vessels.

2.16.8.5 The locations (e.g. engine compartment, electrical room and central control room) where equipment of electric propulsion system is installed are to be well-ventilated to ensure that the ambient operating temperature of equipment does not exceed 45°C. Where the temperature exceeds the requirement above, the user is to consult with the manufacturer to determine the specific installation method.

2.16.8.6 Devices of electric propulsion system are to be connected firmly, safely and reliably, to avoid loose connection and rupture.

2.16.8.7 Connecting cables between converters and propulsion motors are to be as short as possible.

2.16.9 Tests

2.16.9.1 Tests are to be carried out according to the test programs approved by CCS.

CHAPTER 3 CONSTRUCTION AND TESTING OF ELECTRICAL EQUIPMENT

Section 1 ROTATING MACHINES

3.1.1 General requirements

3.1.1.1 The characteristics of the prime movers of generators and their governors are to comply with the relevant requirements of Chapter 5, PART 3 of the Rules.

3.1.1.2 For generating sets operating in parallel, the governing characteristics of the prime mover are to be such as to ensure the load sharing specified in 3.1.6.5 and 3.1.7.6 of this Section. Facilities are to be provided to adjust the governor sufficiently fine to permit an adjustment of load not exceeding 5% of the rated output at normal frequency.

3.1.1.3 Materials of electrical machine shafts for essential services are to comply with relevant requirements of PART 7.

3.1.1.4 Electrical machines are to be protected against harmful effects of shaft current.

3.1.1.5 Grease cups or oil holes, and corresponding oil drainage are to be fitted to electrical machines to ensure efficient lubrication.

3.1.2 Temperature rise

3.1.2.1 The limits of temperature rise of air-cooled machines based on an ambient air temperature of 45°C are given in Table 3.1.2.1.

Limits of Temperature Rise (K) of Air-Cooled Machines (Reference Ambient Temperature: 45 °C)

Table 3.1.2.1

Item	Part of machine	Insulation class ^{Note 7}														
		Class A			Class E			Class B			Class F			Class H		
		T	R	E	T	R	E	T	R	E	T	R	E	T	R	E
1	a. AC windings of machines having output above 200 kW (or kVA), but less than 5,000 kW (or kVA)	-	55	60	-	70	-	-	75	85 ^{Note 1}	-	95	100 ^{Note 1}	-	115	120 ^{Note 1}
	b. AC windings of machines having output of 200 kW (or kVA) or less, other than those of items 1d) or 1e) ^{Note 2}	-	55	-	-	70	-	-	75	-	-	95	-	-	115	-
	c. AC windings of machines having rated output of less than 600 W (or VA) ^{Note 2}	-	55	-	-	70	-	-	80	-	-	100	-	-	120	-
	d. AC windings and/or encapsulated windings of self-cooled machines without a fan (IC410) ^{Note 2}	-	55	-	-	70	-	-	80	-	-	100	-	-	120	-
2	Windings of armatures having commutators	45	55	-	60	70	-	65	75	-	80	100	-	100	120	-
3	Field windings of AC and DC machines other than those of item 4	45	55	-	60	70	-	65	75	-	80	100	-	100	120	-
4	a. Field windings of synchronous machines with cylindrical rotors having DC excitation windings embedded in slots.	-	-	-	-	-	-	-	85	-	-	105	-	-	130	-
	b. Stationary field windings of DC machines having more than one layer	45	55	-	60	70	-	65	75	85	80	100	105	100	120	-
	c. Single-layer low-resistance field windings of AC and DC machines and compensating windings of DC machines having more than one layer	55	55	-	70	70	-	75	75	-	95	95	-	120	120	-
	d. Single-layer windings of AC and DC machines with exposed bare or varnished metal surfaces and single-layer compensating windings of DC machines ^{Note 3}	60	60	-	75	75	-	85	85	-	105	105	-	130	130	-
5	Permanently short-circuited windings ^{Note 4}	55	-	-	70	-	-	75	-	-	95	-	-	120	-	-

Table 3.1.2.1 (Continued)

6	Permanently short-circuited uninsulated windings	The temperature rise of any part is not to be detrimental to the insulation of that part or any other part adjacent to it or other materials

7	Iron core and other parts not in contact with windings															
Item	Part of machine	Insulation class														
		Class A			Class E			Class B			Class F			Class H		
		T	R	E	T	R	E	T	R	E	T	R	E	T	R	E
8	Iron core and other part in contact with windings	55	-	-	70	-	-	75	-	-	95	-	-	120	-	-
9	Opened or closed commutator or collecting ring ^{Note 5}	55	-	-	65	-	-	75	-	-	85 ^{Note 6}	-	-	95 ^{Note 6}	-	-

Note 1: The correction of high-voltage AC windings is applicable to these items.

Note 2: With application of the superposition test method to windings of machines rated 200 kW (or kVA) or less with insulation classes B,E and F, the limits of temperature rise given for the resistance method may be exceeded by 5 K.

Note 3: Multi-layer windings are also to be included where the under layers are all in contact with the circulating primary coolant.

Note 4: The thermometer can be replaced with the thermosensitive test tape.

Note 5: The temperature rise limits in item 9 are only permitted only when the insulation suitable to limits is adopted for the commutator or collecting ring. However, where the commutator or collecting ring approaches the winding, the temperature rise is not to exceed the limits of insulation class for adjacent winding, and the temperature rise can only be measured by the expansion thermometer. Where the thermocouple or electrical resistance thermometer is used, the manufacturer is to consult with the user for the temperature rise limits. In this case, electrical machines with output of 600kW (or kVA) and below, the temperature rise limits of classes E and B can be increased by 5K, and the temperature rise limits of classes F and H can be increased by 10K.

Note 6: Where 85K or higher temperature rise is adopted, special attention is to be paid to the selection of brush materials.

Note 7: T means thermometer method, R means resistance method, E means embedded thermometer method.

3.1.2.2 Main and emergency generators, including their exciters, and continuously rated motors are to be suitable for continuous duty at their full rated output at maximum cooling air temperature for an unlimited period, without the limits of temperature rise in Table 3.1.2.1 being exceeded.

Other generators and motors are to be rated in accordance with the duty which they have to perform and when tested under rated load conditions, the temperature rise is not to exceed the values given in Table 3.1.2.1.

3.1.3 Sparking

3.1.3.1 Direct current motors and generators are to work with fixed brush setting from no load to the momentary overload specified without injurious sparking.

3.1.1.2 Alternating current commutator motors are to work over the specified range of load and speed without injurious sparking.

3.1.4 Overloads

3.1.4.1 Electrical machines are to withstand, on test, the following overcurrents or excess torques without injurious deformation:

.1 DC generator	50% overcurrent 15s
.2 AC generator	50% overcurrent 2min
.3 DC motor	50% excess torque 15s.
.4 Polyphase asynchronous motors	60% excess torque 15s.

3.1.5 Short circuits

3.1.5.1 Vessel's service generators are to be capable of withstanding the mechanical and thermal effects of a short-circuit current for the duration of any time delay for discrimination purposes when tripping a protective device. AC generators and their excitation systems are to be capable of maintaining, under steady-state short-circuit conditions, a current of at least 3 times the full load rated current for a duration of 2 s or where precise data are available, for the duration of any time delay which may be provided by a tripping device.

3.1.6 DC generators

3.1.6.1 All DC generators other than charging generators are, in general, to be of compound-wound or shunt-wound with automatic voltage regulator, or stabilized shunt-wound (shunt-wound with few turns of series windings).

3.1.6.2 Manual voltage regulators are to be provided at the control panel to enable the voltage of each DC generator to be adjusted separately. For each DC generator, at any temperature within the working range and at any load between no load and full load, and when the voltage varies from 80% to 105% of the rated value, the accuracy of voltage adjustment is to be as follows:

- .1 $\pm 0.5\%$ of rated voltage for generators of rating exceeding 100 kW;
- .2 $\pm 1.0\%$ of rated voltage for generators of rating not exceeding 100 kW;

.3 The circuit of manual voltage regulators is in general to be capable of being opened and means are to be provided to protect against over-voltage when the circuit is opened. Non-opened circuit is permitted only in such a case where the manual voltage regulator could adjust the no-load voltage to a value approaching to the remanence voltage.

.4 The handwheel of manual voltage regulators is to be so arranged that when it is turned clockwise, the generator voltage will rise and vice versa.

3.1.6.3 Equalizer leads are to have a cross-sectional area appropriate to the system but in no case less than 50% of that of the negative lead from the generator to the switchboard.

3.1.6.4 Based on the governor control characteristics of prime movers, the voltage load characteristics of compound-wound DC generators at the thermal state are to be such that: voltage variations are within 1% of the rated voltage for 20% of the rated output; voltage variations are within 2.5% of the rated voltage for the full rated load; average of the ascending and descending curves of voltage regulation characteristics between 20% load and full load does not vary more than 4% from the rated voltage.

3.1.6.5 All DC generating sets arranged to run in parallel are to be stable in operation. When the combined load on the sets is varied between 20% and 100% of the combined ratings, the individual load on each machine is not to differ from the theoretical load (proportional to rating) by an amount greater than:

- .1 $\pm 12\%$ of the rated full load of the largest machine; or;
- .2 $\pm 25\%$ of the rating of the smallest machine when the rating of the smallest machine is less than 50% of that of the largest one.

Such a load sharing is not to result in overloading the smaller set.

3.1.6.6 Main engine driven DC generators with speed changed in navigation of fishing vessels are to be provided with control devices, which are to comply with the following requirements:

- .1 The variations of terminal voltage are to still ensure the reliable operation of electric equipment during the variations in the whole designed speed range of generators;
- .2 The generators are to output rated power in the range of 70 to 100% of rated speed of main engine;
- .3 The control devices are to have overload capacity to some extent;
- .4 In addition to requirements of 2-3 above, shaft-driven generators regarded as main power source in 2.4.2.2 of this PART are to comply with the following requirements: the steady-state voltage variation is not to exceed $\pm 4\%$ of rated voltage when the main engine varies in the range of 70% to 104% of rated speed and from no load to rated load.

3.1.7 AC generators

3.1.7.1 Each AC generator, unless of the self-regulated type, is to be provided with separate automatic and manual voltage regulators at the generator control panel.

3.2.7.2 Each AC generator driven by the prime mover having governing characteristics complying with Section 7, CHAPTER 5 of PART 3 together with its excitation system is to be capable of maintaining the voltage under steady conditions within $\pm 2.5\%$ of the rated voltage from zero to full load at rated power factor. These limits may be increased to $\pm 3.5\%$ for emergency generators.

3.2.7.3 When the generator is driven at rated speed and a voltage close to its rated voltage on no-load, and is subjected to a sudden change of symmetrical load within the limits of 60% of the rated current with a power factor not exceeding 0.4 (lagging), the transient voltage is not to fall below 85% during voltage drop nor exceed 120% of the rated voltage during voltage rise. The voltage of the generator is then to be restored to within plus or minus 3% of the rated voltage in not more than 1.5 s.

3.1.7.4 For AC generators, the sinusoidal distortion of the voltage waveform under no-load conditions is not to exceed 5%, except for small (e.g. less than 24 kW) generators.

3.1.7.5 Main engine driven AC generators with speed changed in the navigation of fishing vessels are to be provided with control devices which are to comply with the following requirements:

- .1 The variations of terminal voltage and frequency are to still ensure the reliable operation of electric equipment during the variations of generators in the whole designed speed range;
- .2 The generators are to output rated power in the range of 70 to 100% of rated speed of main engine;
- .3 The waveform sinusoidal distortion rate of line voltage can be higher than 5%, but means are to be provided to avoid disturbing the electric equipment or other equipment such as radio and navigation equipment;
- .4 The control devices are to have overload capacity to some extent;
- .5 In addition to requirements of 2-4 above, shaft-driven generators regarded as main power source in 2.4.2.2 of this PART are to comply with the following requirements: the steady-state voltage variation is not to exceed $\pm 2.5\%$ of rated voltage when the main engine varies in the range of 70% to 104% of rated speed and from no load to rated load. The steady-state frequency variation is not to exceed $\pm 5\%$ of rating.

3.1.7.6 All AC generating sets arranged to run in parallel are to be stable in operation. In the range between 20% and 100% of the combined rated load of all generators, the load sharing is to be as follows:

- .1 The active load on any individual generator is not to differ from the proportionate share of the total active load by more than the lesser of the following:
 - (1) $\pm 15\%$ of the rated active output of the largest generator; or
 - (2) $\pm 25\%$ of the rated active output of the individual generator.
- .2 The reactive load on any individual generator is not to differ from the proportionate share of the total reactive load by more than the lesser of the following:

- (1) $\pm 10\%$ of the rated reactive output of the largest generator;
- (2) $\pm 25\%$ of the rated reactive output of the smallest generator.

3.1.8 Testing

3.1.8.1 All electrical machines for essential service are to be subject to the following tests:

.1 Temperature rise test: The temperature rise limits are not to exceed the values of Table 3.1.2.1 in this PART after the electric rotating machine continuously runs at the rated load till the temperature becomes stable at last.

.2 Insulation resistance test: After the electric rotating machine is subject to the temperature rise test, The insulation resistance is to be measured by a DC megger no less than 500 V after the temperature rise test of the electric rotating machine, and the value is not to be lower the following specification:

- (1) No less than $1\text{M}\Omega$ for the capacity no more than 100 kW (DC) or kVA (AC);
- (2) No less than the value calculated by the following formula for the capacity more than 100 kW (DC) or kVA (AC):

$$\text{Insulation resistance} = \frac{3 \times \text{Rated voltage (V)}}{1000 + \text{Rated capacity (kVA or kW)}} \quad \text{M}\Omega$$

- (3) The insulation resistance of single shunt-excitation or other excitation winding is to be no less than 1 $\text{M}\Omega$.

.3 Overcurrent or overtorque test: After the temperature rise test, the electrical rotating machine is to withstand the overcurrent or overtorque test as specified in 3.1.4 of this PART. During test, the voltage, speed and frequency are to be maintained at rated values.

.4 Short circuit test: Marine generators are to be subject to the short-circuit test and steady state short circuit test in case of AC generators and their excitation systems according to the demands.

.5 Reversal test: The commutator electrical rotating machine is not to generate harmful sparks when the electric brush is set at the fixed position and operates from no load to 50% overload.

.6 Withstand voltage test: All electrical machines are to be subject to the following withstand voltage tests:

- (1) Between winding and enclosure;
- (2) Between windings.

Test voltage values are as specified in Table 3.1.8.1.6. The test voltage frequency is to be any frequency between 25Hz and 100Hz. The test is to last for 1 min without breakdown or flashover. However, the test is not to be repeated for the same electrical machine. If necessary, an additional test is allowed to be carried out at the test voltage not exceeding 80% of the value as specified in the table below. Electrical machines are to be dried before the test.

.7 Voltage regulation factor test: Generators are to be also subject to voltage regulation factor test.

.8 Parallel running test: Generators in parallel operation are to be also subject to parallel running test.

Test Voltage

Table 3.1.8.1.6

No.	Electrical machine or part	Test voltage (effective value)
1	Except for items 3-7, insulated windings of electrical machines with power less than 1kW (or 1kVA) and rated voltage less than 100 V; Motors with rated voltage of 36V and below supplied by independent power source (e.g., storage battery or dry battery)	500V+2 times rated voltage Specified by standards for such type of product
2	Except for item 1 and items 3-7, insulated windings of electrical machines with power less than 10000kW (or 10000kVA) ^{Note 2}	1000V+2 times rated voltage, minimum value: 1500V ^{Note 1}
3	Separate excitation-field windings of DC electrical machines	1000V+2 times max. rated exciting voltage, minimum value: 1500V
4	Field windings of synchronous generators a. Rated exciting voltage: 500V and below 500V above b. The field winding is short circuited or connected to a resistor with resistance value 10 times less than winding resistance in parallel when the electrical machine is started c. The field winding is connected to a resistor with resistance value 10 times more than (or 10 times) winding resistance in parallel or field winding is open circuit and provided with (or not provided with) the field section switch when the electrical machine is started	10 times rated exciting voltage, but the minimum value is 1500 V 4000V + 2 times rated exciting voltage 10 times rated exciting voltage, but the minimum value is 1500 V, and the maximum value is 3500V 1000V+2 times effective value of maximum voltage (such voltage appears at the terminal of field winding, or terminal of any section where the field winding is sectioned), but the minimum value is 1500 V ^{Note 3}
5	Asynchronous motor winding of non-permanent short circuit (e.g., started by resistor) a. Irreversible motors or motors reversible after stop	1000V +2 times open circuit of rotor winding at the static state, i.e., the voltage measured between collecting rings or secondary winding terminals when the rated voltage is

	b. Motors which will be reversed or braked by reversely connecting the power source during operation	applied to primary windings 1000V+ 4 times open circuit of rotor winding at the static state (see item a for the definition)
6	a. Exciter b. Separate exciting field winding of exciter	Voltage 1000V of winding connected to it + 2 times max. rated exciting voltage, but the minimum value is 1500V
7	Assemblies	Test items 1-6 above are to be avoided as far as practicable. Where the complete set of new equipment is tested and each component has passed the withstand voltage test beforehand, the test voltage is to be 80% of the minimum test voltage for any component of assemblies ^{Note 4}
Note 1: For two-phase windings with the same leading-out terminal, the rated voltage in the formula means the maximum voltage between any two terminals during operation. Note 2: Electrical machines with classified insulation are to be subject to the dedicated protocol. Note 3: The voltage generated between terminals of field winding or its sections can be measured by reducing the supply voltage where appropriate at the specified startup conditions, and then the measured voltage is to be converted according to the ratio of the specified starting voltage and reduced voltage. Note 4: For the winding serving as the electric connection for one or more electrical machines, the voltage is to be the actual maximum winding-to-earth voltage.		

Section 2 SWITCHGEAR ASSEMBLIES

3.2.1 Design and construction of switchgear assemblies

3.2.1.1 The construction of main and emergency switchboards is to comply with the following requirements:

.1 The top of switchboards is to have a degree of protection of IP22, and where the switchboard is installed in the control room complying with the requirements of 2.4.4.2 of this PART, a protection of IP21 at the top may be accepted. The sides of switchboards are to have at least a degree of protection of IP2X. For switchboards having a rated voltage in excess of 500 V, a protection of at least IP2X at the rear is to be provided.

.2 For switchboards having a voltage to earth or a working voltage above 50 V, the front shielded structure is to be adopted;

.3 Robust insulated handrails are to be provided at the front and the rear of all switchboards. Where the switchboards are accessible at the rear, insulated handrails on the rear are to be fitted horizontally;

.4 Provision is to be made at the cable entry to switchboards so that there is no water leakage into the switchboard along the cables.

.5 Terminals for systems having a rated voltage above 500 V are to be separated from terminals for lower voltages and are to be clearly marked.

3.2.1.2 Section and distribution boards are to be enclosed according, unless they are installed in the cabinet or compartment only accessed by full-time personnel. All enclosures are to be constructed of flame-retardant and non-hygroscopic material, and are to be of robust construction.

3.2.1.3 The arrangement of protection of electrical installations and the choice of protective devices are to comply with the relevant requirements of Section 3 of Chapter 2 of this PART.

3.2.1.4 All instruments, switchgear, pilot lamps, push buttons, operating handles or handwheels fitted on switchboards are to be provided with durable labels indicating their purposes and operating positions.

3.2.1.5 A durable label indicating the purpose of each circuit and the rating or appropriate setting of its overload protective device is to be provided at the location of the protective device. For fuses above 500 V where the fuse holders permit the insertion of fuses for lower rated voltages, special warning labels are to be placed, for example, "CAUTION: 660 V FUSES ONLY!".

3.2.1.6 Devices for monitoring the insulation, which are in compliance with the requirements of 2.1.4 of this PART, are to be provided on the main and emergency switchboards.

3.2.1.7 Pilot lamps are to be provided at the generator control panels to indicate whether the generator circuit breakers are at the on or off position.

3.2.1.8 Means are to be provided at the control panel of DC generators to enable the voltage to be regulated in accordance with the requirements of 3.1.6.2 of this PART.

3.2.1.9 For each AC generator arranged to operate in parallel, a remote control device is to be provided at the control panel to enable the speed of the prime mover to be adjusted within 10% of its rated value.

3.2.1.10 Means are to be provided at the control panel for magnetization of the generator.

3.2.1.11 Main generators are to be interlocked with shore supply to avoid supplying power simultaneously.

3.2.1.12 Shore connection boxes of shore supply or other external sources are to be provided with the following:

.1 suitable terminals for connecting the flexible cables;

.2 an earth terminal for connecting the hull to the shore;

.3 switches with necessary protection complying with the requirements of 2.3.8.5 of this PART;

- .4 a lamp or voltmeter to indicate the terminal voltage;
- .5 means for checking the polarity (for direct current) or the phase sequence (for three-phase AC) of the incoming supply in relation to the vessel's system;
- .6 a nameplate giving full information on the system of supply, the rated voltage and frequency (for AC) of the ship's system.
- .7 means to prevent the imposing of excessive mechanical forces on cable terminals.

3.2.2 Bus-bars

3.2.2.1 Bus-bars are to be made of conducting cathode copper or copper-sheeted aluminum alloy. The maximum permissible temperature rise for bus-bars is 45 K.

3.2.2.2 Bus-bars and their supports are to be designed to withstand the mechanical stresses which will arise during short-circuits.

3.2.2.3 Bare main bus-bars in main and emergency switchboards (excluding the conductors between the main bus-bar and the supply side of outgoing units) are to have the minimum clearances and creepage distances as given in Table 3.2.2.3.

Minimum Clearances and Creepage Distances

Table 3.2.2.3

Inter-pole or interphase rated voltage, V	Minimum clearance, mm	Minimum creepage distance, mm
250 and below	15	20
251 to 660	20	30
660 above	25	35
Note : Values given in the Table apply to clearances and creepage distances between live parts as well as between live parts and exposed conductive parts.		

3.2.2.4 The current rating of equalizer bus-bars is not to be less than 50% of the rated full load current of the largest generator in the generating plant.

3.2.2.5 The cross sectional area of neutral bus-bar in AC three-phase four-wire systems is not to be less than 50% of that of the bus-bar in the corresponding phase.

3.2.2.6 Polarities of DC bus-bars and bare wires are to be distinguished by following colors:

Positive pole.....red

Negative pole.....blue

Earth wire..... green alternated with yellow

3.2.2.7 Phases of AC bus-bars and bare wires are to be distinguished by following colors:

Phase 1.....green

Phase 2.....yellow

Phase 3..... brown or purple

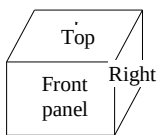
Earth wire..... green alternated with yellow

Neutral wire.....light blue

3.2.2.8 The arrangement of bus-bars in the switchboard as per the phase sequence (DC) or the polarity (AC) is to be arranged in accordance with Table 3.2.2.8 (as viewed from the front of the assembly).

Arrangement per Phase Sequence or Polarity

Table 3.2.2.8

Arrangement per Phase Sequence or Polarity					Table Overview
Bus-bar	Phase sequence or polarity	Position of bus-bars			Sketch
		Vertically	Horizontally	Outgoing	
AC	Phase 1	Top	Front	Left	As viewed from the front of switchboard assembly 
	Phase 2	Middle	Middle	Middle	
	Phase 3	Bottom	Back	Right	
DC	Positive pole	Top	Front	Left	
	Equalizer pole	Middle	Middle	Middle	
	Negative pole	Bottom	Back	Right	
Note : AC neutral bus-bars may be located at suitable positions.					

3.2.3 Measuring instruments

3.2.3.1 The precision grade of instruments is to be selected according to the service of the instruments, but in no case is the precision grade to be inferior to 2.5.

3.2.3.2 The range and scale of the measuring instruments are to comply with the following requirements:

.1 The upper limit of the scale of every voltmeter is to be approximately 120% of the normal voltage of the circuit;

.2 The upper limit of the scale of every ammeter is to be approximately 130% of the normal rating of the circuit in which it is installed.

.3 The upper limit of the scale of every wattmeter is to be approximately 120% of the normal rating of the circuit in which it is installed. Ammeters for use with direct current generators operating in parallel and

wattmeters for use with alternating current generators operating in parallel are to be capable of indicating 15% reverse current or power respectively.

.4 The frequency meter is to have a scale range of approximately $\pm 10\%$ of the rated frequency;

.5 Ammeters, voltmeters and wattmeters are to be clearly marked on the scale to indicate their rated values.

3.2.3.3 Generator control panels are to be provided at least with the measuring instruments as required in Table 3.2.3.3

3.2.3.4. The secondary windings of potential and current transformers are to be effectively earthed.

Measuring Instruments of Generator Control Panel

Table 3.2.3.3

Generator	Operating condition	Type of instrument	Quantity
DC	Not in parallel	Ammeter	1 for each generator (connected to positive pole)
		Voltmeter	1 for each generator
	In parallel	Ammeter	1 for each generator (connected to positive pole)
		Voltmeter	2 (1 for measuring the bus-bar voltage, 1 for measuring the voltage of each generator)
AC	Not in parallel	Ammeter	1 for each generator (to be capable of measuring the current in each phase or each line separately)
		Voltmeter	1 for each generator (to be capable of measuring the voltage in each phase or each line separately)
		Wattmeter	1 for each generator (excluding generators rated less than 50 kW (kVA))
		Frequency meter	1 for each generator
		Excitation ammeter	1 for each generator (to be fitted only when necessary)
	In parallel	Ammeter	1 for each generator (to be capable of measuring the current in each phase or each line separately)
		Voltmeter	2 (1 for measuring the voltage in each phase or each line of the generator separately, 1 for measuring the bus-bar voltage)
		Wattmeter	1 for each generator
		Frequency meter	2 (1 for measuring the bus-bar voltage, 1 for measuring the frequency of each generator)
		Synchronous meter	1 for all generators
		Excitation ammeter	1 for each generator (to be fitted only when necessary)
Note: Where generators are used for the standby power sources in 2.4.1.1.2 (3) of this PART, the instruments may share them with main generators.			

3.2.4 Circuit breakers and switches

3.2.4.1 Circuit breakers are to be trip-free type.

3.2.4.2 Circuit breakers and switches are to be so arranged that when in the OFF position, they cannot accidentally move to close the circuit.

3.2.4.3 The protective performance of circuit breakers for generators is to comply with the requirements of 2.3.5 of this PART. The overcurrent trip setting of these circuit breakers is to be adjustable, or if not adjustable, the set values are to be readily replaceable by different ones.

3.2.4.4 Where circuit breakers are operated by a power operating device, a hand operated mechanism is to be provided to operate the circuit breaker in case of failure of the electrical driven gear and is to be operated at the front of panels.

3.2.4.5 The fused circuit breakers are to be so constructed that single phasing does not occur in the event of blowing of fuses and that the fuses can be replaced easily without the risk of accidental touch to their live parts.

3.2.4.6 Durable labels are to be fitted on circuit breakers to indicate their rated voltage, and the rated current and setting of their overcurrent trip devices, etc.

3.2.5 Fuses

3.2.5.1 Fuses are to be of enclosed type and the construction is to be such that the enclosure is not broken or burnt and the adjacent insulation is not deteriorated by melted metal or emitted gases, when the fuse element has blown out.

3.2.5.2 Fuses are to be easily replaceable for their spare parts without the risk of getting electrical shock or burn on removing and replacing of fuses.

3.2.5.3 When fuses are operating for long periods at rated current, the temperature rise at the terminals is to be such that the maximum permissible operating temperature of the connected cable is not exceeded.

3.2.5.4 Fuses are to be durably marked to indicate their rated voltage, rated current and rated breaking capacity.

3.2.6 Testing

3.2.6.1 Switchboards are to be tested at the manufacturer in accordance with the provisions of 3.2.6.2 to 3.2.6.5 of this Section. However, the test required in 3.2.6.2 may be omitted for batch products of the same type.

3.2.6.2 Switchboards are to be subjected to temperature rise test at the specified load current.

3.2.6.3 Switchboards are to be subjected to functional testing for verifying the function of instruments and switchgear.

3.2.6.4 Switchboards are to be subject to withstand voltage test as required in Table 3.2.6.4.

3.2.6.5 After the withstand voltage test, the insulation resistance between all current carrying parts and earth and between poles or phases of current carrying parts is to be measured by at least 500V DC megger immediately, and the insulation resistance is to be no less than 1MΩ.

Test Voltage

Table 3.2.6.4

Rated voltage, V	Test voltage	Test requirements
≤60	500V	Withstand voltage test at AC 25Hz to 100Hz: no breakdown or flashover for 1 min.
>60	1000V+2 times rated voltage, but no less than 2000V	

Note 1: Semiconductor devices are to be removed during withstand voltage test. Meanwhile, accessory devices such as measuring instruments, capacitors and indicators are not allowed to be connected.

Note 2: The withstand voltage test is to be carried out between all live parts and enclosure and between poles (phases).

Section 3 CONTROL GEAR

3.3.1 General requirements

3.4.1.1 The operating wheels or handles of the control gear are to comply with the following requirements:

.1 The temperature is not to exceed 55°C for those made of metal, and not to exceed 65°C for those made of insulating material.

.2 They are to be provided with mechanically locking devices so that their operating positions will not be changed due to shock or vibration.

.3 They are to be provided with durable labels to indicate their purposes, positions and directions of movement.

3.3.1.2 The hand wheels of the control gear are to be arranged to rotate clockwise to “increase the speed of electrical machine”, “raise”, “heave anchor”, “winch reel”, “haul in rope”, and counterclockwise to “reduce the speed of electrical machine”, “lower”, “drop anchor”, “release reel”, “pay out rope”.

The handles of control gear are to be arranged to move forward to “drop anchor”, “release reel”, “pay out rope”, “lower”, and reversely to “heave anchor”, “winch reel”, “haul in rope” and “raise”.

3.3.1.3 The control gear is to be provided with protective devices complying with the relevant requirements of Section 3, Chapter 2 of this PART.

3.3.1.4 Suitable means are to be provided for the control push buttons against wrong action due to inadvertent touching.

3.3.1.5 Parallel field windings which allow an open circuit are to be provided with discharge circuits to protect against induced overvoltage.

3.3.2 Motor control gear

3.3.2.1 The motor control gear is to be provided with an indicating device to show that the motor is running.

3.3.2.2 The control gear of motors used for various services is also to comply with the relevant requirements of Section 6, Chapter 2 of this PART. The control gear of the steering gear is also to comply with the relevant requirements of Chapter 9, PART THREE of the Rules.

3.3.2.3 The control gear of windlasses, warping winches, and cargo winches is to be provided with a device for emergency disconnection of the circuits. In the event of power source failure, the brake is to automatically act.

3.3.2.4 Where windlass motors and warping winch motors have rating equal to or more than 10 kW, their control gears are to be provided with an ammeter to monitor the operating current of the motors, and this ammeter is to be properly illuminated or to be of fluorescent type.

3.3.3 Testing

3.3.3.1 Temperature rise test: Control gear is to be subjected to temperature rise test under normal working conditions.

3.3.3.2 Functional test: All control gears are to be subjected to functional testing.

3.3.3.3 Withstand voltage test: Control gears and resistors are to be subject to withstand voltage test at the manufacturer. The following test voltage is to be applied between earthed framework and all live parts during the test:

- .1 The test voltage is 500V where the rated voltage is $\leq 60V$;
- .2 The test voltage is to be equal to $1000V + 2 \text{ times rated voltage}$ but to be no less than 2000 V where the rated voltage is $>60V$.
- .3 The frequency of test voltage may be any frequency between 25Hz and 100Hz, and is to be maintained for 1 min without breakdown or flashover. Instruments and auxiliary devices may be switched off during the withstand voltage test.

3.3.3.4 Insulation resistance test: Immediately after the high voltage test, the insulation resistance is not to be less than $1 M\Omega$, tested at least with a DC500V megameter.

Section 4 CABLES

3.4.1 General requirements

3.4.1.1 Cables are to comply with the requirements of this Section. Those not covered in this Section are to comply with the relevant requirements of IEC Publication 92.

3.4.1.2 Insulation and sheath thickness of cables are to generally comply with relevant requirements of IEC Publication 92. Marine cables with other specifications and dimensions complying with requirements may be also used upon approval by CCS.

3.4.1.3 The quality of cable materials is to comply with the requirements of IEC Publication 92. Cables complying with other accepted standards may be also used.

3.4.2 Conductors

3.4.2.1 Conductors can be only made of annealed red copper with high conductivity. For rubber-insulated conductors, copper wires are to be tin-plated or alloy-plated, and bright on the surface.

3.4.2.2 Conductor composition and stranding is to be so selected that adequate flexibility of the finished cable is assured. Cores of multi-core cables are to be readily identifiable.

3.4.3 Insulating materials

3.4.3.1 Permitted insulating materials and maximum rated conductor temperatures are to comply with the requirements of 3.4.3.1 of this PART.

Max. Working Temperature of Insulating Materials and Conductors

Table 3.4.3.1

Insulating materials		Max. working temperature of conductor, °C
Flexible compound	Ethylene propylene rubber	85
	Crosslinked polyethylene	85
	Silicone rubber	95
Thermoplastic compound	PVC	60
Other material	Mineral	95
Note 1: When silicone rubber and mineral insulators are to be installed at locations not easily accessible to crew members, a little higher temperature (150°C for silicone rubber; unlimited for mineral insulation) is allowed upon approval by CCS.		
Note 2: The temperature of conductor means the sum of temperature rise caused by ambient temperature and load.		

3.4.3.2 Cables with different maximum rated conductor temperatures are to be readily identifiable.

3.4.3.3 Other insulating materials than those listed in Table 3.4.3.1 must be subject to the approval by CCS.

3.4.4 Insulation

3.4.4.1 For elastomeric or thermoplastic compound insulation, the use of a single layer of compounds is permitted only when applied by the extrusion process. With other processes the insulation is to consist of at least two layers of compounds equal in quality, and the layers are to be bonded together. The insulating wall is to be close fitting but not adherent to the conductor.

3.4.4.2 Mineral insulation is to consist of powdered mineral material, i.e. magnesium oxide, highly compressed between conductors and copper sheath. It is to be temperature-stable and non-corrosive to copper.

3.4.5 Construction

3.4.5.1 Regardless of the insulating material used, the belted or non-belted construction may be used for cables having two, three and more cores.

3.4.5.2 For non-belted cables, the clearances between cores are to be filled with fibrous or rubber-like fillers and the cylindrical assembly is to be sheathed with an appropriate protective covering. Fillers may be omitted in

multi-core cables having conductor sections of 4.5 mm² or less. Alternatively, elastomeric or thermoplastic insulated cables may have a compatible compound extruded over the cable cores so as to form, in one body, the fillers and a continuous covering similar to a sheath.

3.4.5.3 Belted cables are to be constructed as non-belted cables, except that an insulating wall is to be applied to the cable cores before applying the protective covering. For elastomeric or thermoplastic insulated cables, the common belt is to be elastomeric or thermoplastic respectively, which may or may not form one body with the fillers.

3.4.5.4 When fibrous fillers are used they are to consist of jute or similar rovings (including glass filament, etc.) and are to be resistant to moisture.

3.4.5.5 When rubber-like fillers are used, they are to consist of rubber (including regenerated and/or unvulcanized rubber) compounds or plastic compounds.

3.4.6 Sheaths and protective coverings

3.5.6.1 Cables are to be protected by one or more of the following, and the sheath or protective covering is to be compatible with the insulation:

.1 Sheath: Lead alloy sheath

Copper sheath

Non-metallic sheath

.2 Protective covering: Steel wire armour

Steel tape armour

Metal braid armour;

Impregnated fibrous braid

3.4.6.2 The lead-alloy sheath is to be one of lead alloys recommended in the IEC publication 92.

3.4.6.3 Copper sheath is permitted only for mineral-insulated cables.

3.4.6.4 Metal braid armour is to be made of galvanized steel, copper or copper alloy, or aluminum alloy wires. Aluminum alloy is to be corrosion resistant. The coverage density of the braid is to be such that the weight of the braid is at least 90% of the weight of a tube of the same metal, having an internal diameter equal to the internal diameter under the braid and a thickness equal to the nominal diameter of the wires forming the braid.

3.4.6.5 Steel wire armour is to consist of galvanized annealed steel wires having an elongation at break of at least 12%. The wires are to be applied over the bedding to form a uniform and cylindrical layer and to ensure a sufficient flexibility for the finished cable.

3.4.6.6 Steel tape armour is to be made of annealed steel tapes. In general, the armour is to be formed of two tapes wound over the bedding in the same direction so that the gap in the first layer is not more than half the tape width and the second layer covers this gap with an overlap.

3.4.6.7 Armour is to be protected against corrosion where necessary. A protective bedding is to be inserted beneath armour (of any type). This may be textile tape or braid, chloroprene rubber tape or other suitable material. Textile materials are to be treated against moisture.

3.4.6.8 Polychloroprene, polyvinyl chloride compound and chlorosulphonated polyethylene may be used for non-metallic impervious sheath. Other compounds will be considered.

3.4.6.9 Textile braid is to be of cotton, hemp, glass filament, or other equivalent fibre, and is to be of a strength suitable for the size of the cable. It is to be effectively impregnated with a compound which is resistant to moisture, and flame retardant.

3.4.7 Testing

3.4.7.1 Tests in accordance with IEC publication 92 or relevant acceptable standards are to be made at the manufacturer prior to delivery.

Section 5 POWER AND LIGHTING TRANSFORMERS

3.5.1 General requirements

3.5.1.1 The requirements of this Section apply to single phase transformers rated at 1 kVA or more and 3-phase transformers rated at 5 kVA or more.

3.5.1.2 All transformers, except those used for motor starting, are to be double wound, with no electrical connection between primary and secondary windings.

3.5.1.3 In general, transformers are to be of dry air-cooled type. The use of liquid-cooled transformers is to be subject to approval by CCS.

3.5.2 Voltage regulation

3.5.2.1 The voltage drop of transformers supplying secondary distribution systems from no load to rated load at resistive load is not to exceed the following:

- .1 2.5% for single phase transformers rated more than 5 kVA or 3-phase transformers rated more than 15 kVA;
- .2 5% for single phase transformers rated up to 5 kVA or 3-phase transformers rated up to 15 kVA.

3.5.3 Parallel operation

3.5.3.1 Transformers in parallel operation are to comply with the following requirements:

- .1 Windings of transformers are to be the same connection set;
- .2 Transformers are to have the same rated voltage ratio (with deviation in the allowable range);
- .3 Transformers are to have the same impedance voltage (the ratio of resistance voltages between transformers is to be in the range of 0.9 to 1.1);
- .4 The rated capacity of the smallest-capacity transformers is not to be less than half of rated capacity of largest-capacity transformer in case of multiple transformers in parallel operation.

3.5.4 Temperature rise

3.5.4.1 The temperature rise of transformers at any part is not to exceed the values given in Table 3.5.4.1 during continuous operation at the maximum rating, where the ambient air temperature for cooling is 45°C.

Limit of Temperature Rise

Table 3.5.4.1

Part of transformer		Limit of temperature rise, K	Method of measurement
Windings	Class A insulation	55	Resistance method
	Class E insulation	70	
	Class B insulation	75	
	Class F insulation	95	
	Class H insulation	120	
Iron core and structural part surface		Not to exceed the permissible temperature rise of the insulating material in contact	Thermometer or thermocouple

3.5.5 Short circuits

3.5.5.1 All transformers are to be capable of withstanding, without damage, the thermal and mechanical effects of a short-circuit at the terminals of any winding for 2 s.

3.5.6 Tests

3.5.6.1 The tests in 3.5.6.2 to 3.5.6.6 of this Section are at least to be carried out to all transformers at the manufacturer.

3.5.6.2 Temperature rise test: Transformers are to be tested for temperature rise at rated output. The limits of temperature rise are not to exceed the values given in Table 3.5.4.1.

3.5.6.3 Withstand voltage test: Transformers are to be subjected to withstand voltage test at any frequency between 25Hz and 100Hz and 1000V+2 times maximum voltage between lines (minimum value: 2000 V) between primary and secondary windings and between windings and the earth for 1 min without breakdown and flashover.

Note 1: For transformers subject to temperature rise test, such test item is to be carried out immediately after the temperature rise test is completed.

Note 2 The test above is not to be repeated generally. However, the test voltage drop is to be 75% of the initial test voltage when it is necessary to repeat the test.

3.5.6.4 Induced withstand voltage test: Transformers are to withstand an induced high voltage test with a voltage twice the rated voltage. If the frequency is greater than twice the rated frequency, the duration t of the test is to be obtained from the following formula with a minimum of 15 s:

$$t = \frac{60 \times 2 \times \text{Rated frequency}}{\text{Test frequency}} \text{ s}$$

For transformers subject to temperature rise test, the induced withstand voltage test is to be carried out immediately after the temperature rise test.

3.5.6.5 Insulation resistance test: The insulation resistance of each winding to earth is to be measured, with all other windings, magnetic core, frame and casing or enclosure connected together to earth, and recorded together with the temperature of the transformer at the test.

3.5.6.6 Voltage regulation test: Transformers are to be subjected to voltage regulation test and the requirements of 3.5.2 of this Section are to be complied with.

3.5.6.7 Short-circuit test: Short-circuit test is to be carried out as necessary and in accordance with the requirements of 3.5.5 of this Section.

Section 6 STORAGE BATTERIES

3.6.1 General requirements

3.6.1.1 This Section is applicable to the permanently installed batteries.

3.6.2 Type

3.6.2.1 Storage batteries for vessels may be of lead-acid or nickel-alkaline type. Other types of batteries are to be subject to approval by CCS.

3.6.3 Construction

3.6.3.1 All pole plates are to be of rigid construction, and are to be designed to reduce the shedding of active material to a minimum. The cells are to be so constructed as to prevent spilling of electrolyte due to an inclination of 40° from the normal, and to prevent emission of acid or alkaline spray.

3.6.3.2 The cells are to be grouped in crates or trays of rigid construction and suitable material and equipped with means to facilitate handling. The weight and volume of the storage batteries are to be appropriate.

3.6.3.3 Emergency accumulator batteries are to be so designed and installed as to ensure that they will function at full rated power when the fishing vessel is upright or when inclined at any angle of list up to 22.5° or when inclined up to 10° either way in the fore or aft direction, or is in any combination of angles within those limits.

3.6.4 Nameplate

3.6.4.1 Each crate or tray is to be provided with a durable nameplate securely attached, indicating the manufacturer's name, type designation and date of delivery, the ampere-hour rating at a specific rate of discharge (preferably that corresponding to the duty for the specific application 5h, 10h or 20 h rating) and the specific gravity of the electrolyte (when the battery is fully charged in the case of a lead-acid battery).

Section 7 POWER SEMICONDUCTOR CONVERTORS

3.7.1 General requirements

3.7.1.1 This Section is applicable to power semiconductor convertors composed of elements such as semiconductor diode and reverse blocking triode thyristor ("thyristor"), and does not apply to convertors for communication and the ancillary apparatus for instrumentation. The conversion may be from AC to DC, from DC to AC, from DC to DC and from AC to AC.

3.7.1.2 Unless otherwise specified by the manufacturer, the maximum permissible junction temperature of the rectifier cells is not to exceed the following values:

Selenium diodes: 70°C;

Silicon diodes: 150°C;

Silicon thyristor: 100°C (up to 50 A);

125°C (more than 50 A).

3.7.1.3 Semiconductor convertors are preferably to be of the dry air-cooled type.

3.7.1.4 Liquid-cooled semiconductor convertors are preferably to be hermetically sealed. If provision is made for breathing, suitable desiccants are to be provided.

3.7.1.5 Transformers used in combination with semiconductor convertors are to be of two-winding transformers and are to comply with the relevant requirements of Section 5 of this Chapter.

3.7.1.6 Semiconductor convertors or semiconductor components are to be mounted in such a manner that they may be removed from a unit without dismantling the complete unit.

3.7.1.7 Mercury-based fungicides are not to be used in the vicinity of the selenium rectifiers.

3.7.2 Protection

3.7.2.1 Where forced cooling is provided, the circuit is to be so designed that the convertor cannot remain in operation unless effective cooling is maintained.

3.7.2.2 Semiconductor convertors are to be capable of withstanding the effects of transient over-voltage from the fishing vessel's network and the effects of DC voltage rise due to regenerated power.

3.7.2.3 Semiconductor convertors are to be protected against overload and short-circuit in accordance with the requirements of 2.3.13 of this PART.

3.7.2.4 For liquid-cooled semiconductor convertors, consideration is to be given to the provision of an alarm for excessive liquid temperature and of pneumatic protection devices.

3.7.3 Testing

3.7.3.1 Semiconductor convertors are to be tested at the manufacturer in accordance with the requirements of 3.7.3.2 to 3.7.3.5 of this Section. However, the test required in 3.7.3.2 may be omitted for the products produced in series.

3.7.3.2 Semiconductor convertors are to be subjected to temperature rise test under normal working conditions.

3.7.3.3 Semiconductor convertors are to be subjected to functional test.

3.7.3.4 Semiconductor convertors are to withstand a high voltage test at the following testing voltage (with a minimum of 2000 V):

$$U_p = 2 \times \frac{U_m}{\sqrt{2}} + 1000$$

Where: U_p —the effective value of testing voltage, V ;

U_m —the maximum no-load peak value between any pair of terminals of semiconductor convertors. If the voltage to earth is higher than the voltage between two terminals (e.g. the convertors are connected in series), the higher voltage, in V, is to be taken.

If $U_m/\sqrt{2}$ is less than 90 V, U_p is to be taken as 1,000 V.

This testing voltage is to be alternating at any frequency between 25 and 100 Hz and is to be applied between the live parts and any non-current carrying metal part which may be earthed for a period of 1 min without breakdown or flashover.

The insulation resistance between live parts of convertors or their accessories and earth is not to be less than 1 MΩ when tested with a DC 500 V megameter.

3.7.3.5 The insulation resistance between live parts of convertors or their accessories and earth is not to be less than 1 MΩ when tested with a DC 500 V megameter.

Section 8 LIGHTING LAMPS AND LANTERNS

3.8.1 General requirements

3.8.1.1 Essential lighting lamps and lanterns related to the safety and operation of fishing vessels are to comply with requirements of this Section.

3.8.2 Incandescent lighting

3.8.2.1 The voltage and load of tungsten filament lamps and lampholders are not to exceed the values specified in Table 3.8.2.1.

Voltage and Load of Tungsten Filament Lamps

Table 3.8.2.1

Type of lampholders		Voltage, V	Load
Bayonet cap	B22	250	200W / 4A
	B15d	250	15W / 2A
	B15s	50	15W / 2A
Screw cap	E40	250	3000W / 16A
	E27	250	200W / 4A
	E14	250	15W / 2A

3.8.2.2 Lampholders are to be constructed of flame-retarding and non-hygroscopic material. All metal parts are to be of robust construction. E40 lampholders are to be provided with means for locking the lamp in the holder.

3.8.2.3 The lighting fittings are to be so constructed that the temperature of the incoming cables will not exceed the maximum rated conductor temperature given in Table 2.13.2.2 of this PART.

3.8.3 Discharge lamps operating at voltages below 250 V

3.8.3.1 All independent ballasts, capacitors and other auxiliaries mounted separately are to be enclosed in an earthed metal casing.

3. 8.3.2 Capacitors of 0.5 μ F and above are to be provided with a means of prompt discharge on disconnection of the supply.

3.8.3.3 The voltage and load of the fluorescent lamps and lampholders are not to exceed the values specified in Table 3.8.3.3.

Voltage and Load of Fluorescent Lamps**Table 3.8.3.3**

Type of lampholders	Voltage, V	Load (W)
G13	250	80
G5	250	13

3.8.3.4 The construction of fluorescent lampholders is to comply with the requirements of 3.8.2.2 of this Section.

3.8.4 Discharge lamps operating at voltages above 250 V

3.8.4.1 Discharge lamps are to be of robust construction.

3.8.4.2 All live parts are to be so designed, placed and installed that they cannot be touched accidentally or inadvertently, and the creepage distance along the discharge tube is to be taken into consideration.

3.8.4.3 Transformers for discharge lamps are to have their primary and secondary windings electrically separated and are not to contain flammable liquid.

3.8.4.4 The transformers is to be placed within the discharge lamp or located as closely as possible to the lamp.

3.8.4.5 Warning notices calling attention to “DANGER! HIGH VOLTAGE!” are to be provided in accordance with 2.7.1.4 of this PART.

3.8.5 Portable lamps

3.8.5.1 The portable lamps are to be in a structure protecting operators against electric shock risks. All portable lamps are to be provided with robust protective gratings.

3.8.5.2 Portable lamps on decks, fish holds, machinery spaces or similar spaces are to be provided with lifting hooks or rings for suspension to avoid stress on feeder cables.

Section 9 NAVIGATION LIGHTS AND OTHER SIGNAL LIGHTS

3.9.1 General requirements

3.9.1.1 Navigation lights and other signal lights are to comply with relevant requirements of current COLREGS.

3.9.1.2 Navigation lights are to have the protection grade of IP 55.

3.9.1.3 Control boxes of navigation lights are to be in a construction complying with requirements of 2.8.1 of this PART.

Section 10 INTERNAL COMMUNICATION AND SIGNAL EQUIPMENT

3.10.1 General requirements

3.10.1.1 Where the internal communication equipment is composed of two or more devices in parallel operation, the operation of remaining device(s) is not to be affected in the event of power-off or failure of one (or more) device(s).

3.10.1.2 Automatic audible and visible alarms are to be provided with devices for switching off audible signal rather than light-emitting signal.

3.10.1.3 Automatic alarm and indicating signal systems are to be provided with test devices for checking the action.

3.10.1.4 Essential indicators installed in the bridge are to be provided with appropriate lighting and brightness regulators or light shields

3.10.2 Telegraph

3.10.2.1 Where the main engine telegraph is provided with two or more transmitters, mechanical or electrical linkage or interlocking devices are to be fitted between transmitters.

3.10.2.2 The main engine telegraph is to be generally provided with the main engine wrong direction alarm near the console of main engine.

3.10.3 Telephones

3.10.3.1 Telephones are to be such as to ensure clear vocal intercommunication in all conditions of the vessel.

Section 11 HEATING AND COOKING APPLIANCES**3.11.1 General requirements**

3.11.1.1 Heating elements are to be substantially guarded. The holes of the protective guard are to be sufficiently narrow to prevent foreign bodies from falling in.

3.11.1.2 Heating and cooking appliances are to be so constructed that the temperature of supply cable terminals will not exceed the maximum working temperature of conductor given in Table 2.13.2.2 of this PART.

3.11.1.3 Internal connection wires of heating and cooking appliances are to be continuously insulated with incombustible material. Connections between heating elements are not to be effected by soldering.

3.11.1.4 The insulation resistance of heating and cooking appliances in hot condition is not to be less than 0.5MΩ.

3.11.1.5 Heating and cooking appliances are to be so constructed that the parts which must be hand-held in use cannot be heated to a temperature exceeding the values given in Table 3.11.1.5.

Maximum Temperature of Hand-Held Parts**Table 3.11.4.5**

Material of handles, grips and the like	Maximum temperature for normal hand-held operation, °C	
	Long period	Short period
Metal	55	60
Porcelain, vitreous material, moulded material, rubber or wood	65	70

3.11.2 Heating and cooking appliances of galley

3.11.2.1 Heating and cooking appliances and their control gear fitted in galley spaces are to have a degree of enclosure protection of at least IP44. Their enclosures are to be corrosion-resistant and provided with one or more drainage holes.

3.11.2.2 Cooking appliances are to be so constructed that spilling or overflowing of liquid or food will not cause insulation failures or short-circuits.

3.11.3 Space heater

3.11.3.1 Space heaters are to be so constructed, protected and installed that clothing, bedding or other combustible materials cannot come in contact with them in such a manner as to cause risk of fire. Furthermore, they are to be so constructed that combustible materials cannot be placed on the top of their enclosures.

Section 12 ACCESSORIES**3.12.1 General requirements**

3.12.1.1 Accessories are to be so designed and constructed that the passages for the insulated conductors are of ample size and free from rough projections, sharp angles, and abrupt bends. All outlets for cables are to have well-rounded edges or be suitably bushed.

3.12.1.2 Accessories are to be so designed and insulated conductors are to be so installed that stress cannot be applied by the conductors to any terminal to which the conductors may be connected.

3.12.1.3 Accessories are to be so designed and fixed that dust and moisture will not readily accumulate on live parts and their insulation.

3.12.2 Enclosure

3.12.2.1 Enclosures are to be made of metal or flame-retardant insulating material.

3.12.3 Inspection and cable stay boxes

3.12.3.1 Where metal conduit system is used, inspection and cable stay boxes are to be made of metal, and are to be firmly in electrical and mechanical connection with conduits.

3.12.4 Plugs and socket outlets

3.12.4.1 The construction of plugs and socket outlets is to comply with the following requirements:

- .1 The temperature rise of the live parts of plugs and socket outlets is not to exceed 30°C;
- .2 They are to be so constructed that the live parts cannot be touched by the operator when the plug is being inserted in, and that it is impossible to insert only one pin of the plug into the socket outlet;

.3 They cannot be readily short-circuited whether the plug is in or out, and a pin of the plug cannot be made to earth either pole of the socket outlet;

.4 Plugs and socket outlets operating at a voltage exceeding 50 V are to be provided with a pin and jack for earthing connection. The cross section and length of the earthing pin of the plug are to be greater than those of other pins;

.5 Plugs and sockets operating at different voltages and/or frequencies are to be of different types.

3.12.4.2 Socket outlets of current rating in excess of 16 A are to be interlocked with a switch such that the plug cannot be inserted or withdrawn when the switch is in the “on” position.

3.12.4.3 Socket outlets and plugs with protection degree of IP56 are to be provided with means to maintain the same degree of protection whether the plug is inserted or withdrawn.



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RULES FOR CONSTRUCTION OF OCEAN-GOING STEEL FISHING VESSELS

2018

PART 5 REFRIGERATING AND QUICK-FREEZING INSTALLATIONS

Effective from 1 December 2018

CHAPTER 1 GENERAL

1.1.1 Application

1.1.1.1 The provisions of this PART apply to:

- .1 Refrigerating installations for storing fish catches, including chilling and insulating installations;
- .2 Quick-freezing installations for processing fish catches.

The use of other types of refrigerating and quick-freezing installations other than those described in this PART is to be approved by CCS.

1.1.2 Refrigerants

1.1.2.1 The following refrigerants are permitted for use:

- .1 R717: Ammonia (NH_3);
- .2 R22: Monochlorodifluoromethane (CHClF_2);
- .3 R404A: Mixture of R125 (44%) + R143a (52%) + R134a (4%). R125 is pentafluoroethane (CHF_2CF_3); R143a is trifluoroethane (CH_3CF_3); R134a is tetrafluoroethane (CH_2FCF_3).

The use of chlorofluorocarbons (CFCs) as refrigerants is also to comply with the relevant national regulations.

1.1.2.2 Where other refrigerants are to be used, relevant information is to be submitted to CCS for approval.

1.1.3 Operating conditions

1.1.3.1 Refrigerating systems are to operate normally under the following conditions:

- .1 angle of inclination: permanent list up to 15° and permanent trim up to 5° ;
- .2 rolling: 22.5° , and pitching: 10° .

1.1.3.2 Where the refrigerating units are provided with centralized control or automatic controlling and monitoring systems, the equipment of such systems is to comply with the relevant provisions of Chapter 12, PART 3.

1.1.4 Direct evaporative grid cooling system

1.1.4.1 The use of R717 as the refrigerant in a direct evaporative pipe grid system is to comply with the relevant provisions of this PART.

1.1.5 Protection

1.1.5.1 Refrigerating and quick-freezing installations are to be provided with adequate protection against vibration, shaking, expansion, shrinkage and corrosion.

1.1.5.2 In the design, manufacture, installation, test and use of refrigerating and quick-freezing installations, the possible harm of their refrigerants to human bodies is to be considered for taking corresponding safety protection measures.

1.1.6 Novel arrangement and construction

1.1.6.1 Where the proposed construction of the refrigerating unit or refrigerated fish holds is novel in design or involves the use of unusual material, it is to be approved by CCS.

1.1.7 Others

1.1.7.1 Except with the consent of CCS, refrigerating units of refrigerating fish catches are to be completely separated from air-conditioning or household refrigerating machinery.

1.1.7.2 Where R717 is used as the refrigerant, the following drawings are to be attached for review:

- (1) R717 Refrigerant Piping Diagram;
- (2) Arrangement of Gas Detector ;
- (3) General Arrangement of Refrigerating Machinery Space.

1.1.7.3 Spare parts for sailing

- .1 Fishing vessels are to be provided with necessary amounts of refrigerants, calcium chloride and refrigerator oil when sailing.
- .2 Standby refrigerants can only be stored in the approved special steel cylinders, and are to be fixed vertically and protected from overheating. Generally, refrigerants are to be stored in a special place with good ventilation. Only when the refrigerant storage capacity is not greater than 20% of the total system capacity can refrigerants be stored in the machinery space.

CHAPTER 2 REFRIGERATING PLANT

Section 1 REFRIGERATING UNIT

2.1.1 Definition of a refrigerating unit

2.1.1.1 A refrigerating unit comprises one (or a group of) independent refrigeration compressor(s), its prime motor and one gas condenser. Where brine refrigerant is employed, the unit is also to include a brine cooler. It is usual for the compressor and the condenser of the refrigerating unit to be permanently connected to the installation with all necessary pipelines, fittings and electrical equipment.

Two or more refrigeration compressors driven by one prime motor or having only one condenser or brine cooler, are to be regarded as one unit. If a refrigerating unit is provided for sub-cooling the liquid refrigerants of other units rather than used independently for cooling the fish holds, it will not be regarded as one unit.

2.1.2 Number of units and refrigerating capacity

2.1.2.1 Usually, a refrigerated fishing vessel of not less than 45m in length is to be at least fitted with two refrigerating units. If it is only fitted with two refrigerating units, the working parts are to be interchangeable.

2.1.2.2 A refrigerated fishing vessel of less than 45m but not less than 30m in length can be only fitted with one refrigerating unit, but one standby compressor and its prime motor is to be added as far as possible.

2.1.2.3 A fishing vessel of less than 30m in length can be only equipped with one refrigerating unit.

2.1.2.4 The refrigerating capacity of a fishing vessel equipped with two or more refrigerating units is to be maintained at the minimum temperature specified by the design institute in the fully loaded refrigerated fish hold when one unit stops working and other units continue working for 24 hours.

2.1.2.5 The refrigerating capacity of a refrigerating unit described by 2.1.2.2 in this PART is to be sufficient to maintain the minimum design temperatures in the refrigerated fish holds when one refrigeration compressor stops working and its standby compressor continues working for 24 hours.

2.1.2.6 In order to compensate for possible deterioration of the refrigerating capacity of compressors and the performance of insulation material over the life of the installation, the actual capacity of the refrigerating units is to have at least 10% excess capacity over that required for maximum design output.

2.1.2.7 Where the units are not connected in common to all refrigerated fish holds, the refrigerating capacity of the unit serving each fish hold (or a group of fish holds) is to comply with the provisions of 2.1.2.4 and 2.1.2.6 in this PART.

2.1.2.8 If refrigeration compressor is driven by main engine shaft, a clutch is to be provided.

Section 2 REFRIGERATION COMPRESSOR

2.2.1 Design requirements for refrigeration compressor

2.2.1.1 The design pressure of refrigeration compressor parts directly subjected to the refrigerants described by 1.1.2.1 in this PART is to be not less than the values given in Table 2.2.1.1.

Minimum Design Pressure of Refrigeration Compressor Parts

Table 2.2.1.1

Refrigerant	Design pressure at high pressure side ^{Note 1} (MPa)	Design pressure at low pressure side ^{Note 2} (MPa)
R717	2.2	1.72
R22	2.2	1.72
R404A	2.5	1.82

Note 1: High pressure side means the pressurized parts of the compressor between its exhausting side and expansion valve;

Note 2: Low pressure side means the pressed parts from behind the expansion valve to suction valve of the compressor. Where the change-over of the plant (e.g. for defrosting) will put these parts under high pressure, they are to be designed and tested to the specified pressure of high pressure side.

2.2.1.2 When any other refrigerant is used, the design pressure of high pressure side and low pressure side of the refrigerating plant is to be the saturated vapor pressure of the refrigerant at 56 °C and 46 °C respectively.

2.2.2 Pressure at the suction side

2.2.2.1 The maximum working pressure at the suction side of a refrigerating unit is to be determined according to the pressure generated after the unit stops. The pressure is not to exceed the design pressure described by 2.2.1.1 in this PART.

2.2.3 Reciprocating compressors

2.2.3.1 The diameter d of the crankshaft of a reciprocating compressor is not to be less than that determined by the following formula, when all cranks are located between two main bearings:

$$d = C \sqrt[3]{\frac{D^2 P \left(\frac{S}{16} + \frac{ab}{a+b} \right) Z}{7.55}} \quad \text{mm}$$

Where: D -- diameter of compressor cylinder, in mm;

P -- design pressure as defined in Table 2.2.1.1 in this PART, in MPa;

S -- length of piston stroke, in mm;

a -- distance between inner edge of one main bearing and the centreline of the crankpin nearest the center of the span, in mm;

$a + b$ -- span between inner edges of two main bearings, in mm;

Z -- strength coefficient of material, to be determined by the following formula:

For steel:

$$Z = \frac{560}{R_m + 160}$$

For spheroidal or nodular graphite cast iron:

$$Z = \frac{700}{R_m + 260 - 0.059d_p}$$

For grey cast iron:

$$Z = \frac{700}{R_m + 260 - 0.69d_p}$$

Where: R_m -- tensile strength of crankshaft material, in N/mm²;

d_p -- estimated minimum diameter of crankshaft, in mm;

C -- constant, to be determined according to the specific arrangement of crankshafts and cylinders, as shown in Table 2.2.3.1.

For shafts having one cylinder per crank: $C=1.0$;

For shafts having several cylinders, with 90 ° between adjacent cylinders on the same crankpin: $C=1.05$;

For shafts having several cylinders, with 60 ° between adjacent cylinders on the same crankpin: $C=1.18$;

For shafts having several cylinders, with 45 ° between adjacent cylinders on the same crankpin: $C=1.25$;

The arrangement of cranks and cylinders to which the Rules apply is as shown in Table 2.2.3.1.

Arrangement of Cranks and Cylinders

Table 2.2.3.1

Number of crankpins	Number of cylinders per crank	Angle between adjacent cylinders (°)
1 or 2	2	45 60 90
3	2	45 60
4	2	45 60
1	3	45 60 90
2	3	45 60
3	3	45
1	4	45 60
2	4	45

2.2.3.2 Where the shaft is supported additionally by a centre bearing, the diameter is to be evaluated from the half shaft between the inner edges of the centre and outer main bearings. The diameter so found for the half shaft is to be increased by 6% for the full length shaft diameter.

2.2.3.3 The dimensions of crankwebs are to be such that bt^2 is to be not less than given by the following formulae:

For the web adjacent to the main bearing: $bt^2 = 0.4d^3$;

For intermediate webs: $bt^2 = 0.75d^3$;

Where: b -- breadth of crankweb, in mm;

t -- axial thickness of web which is to be not less than 0.45d for the web adjacent to the main bearing, or 0.60d for intermediate webs, in mm;

d -- minimum diameter of crankshaft as required in 2.2.3.1 of this PART, in mm.

2.2.3.4 Fillets at the junction of crankwebs with crankpins or journals are to be machined to a radius r not less than $0.05d$. Smaller fillets, but of a radius not less than $0.025d$, may be used provided the diameter of the shaft is not less than the product of c and d .

Where: $C=1.1-2r/d$, but not to be taken as less than 1.0; d is minimum diameter of crank obtained by 2.2.3.1 in this PART.

2.2.3.5 Fillets and oil holes on the crankshafts are to be rounded to an even contour and smooth finish.

2.2.3.6 The crankcase of a trunk piston type compressor is to be designed to withstand an internal pressure at least equal to the maximum working pressure of the refrigerating system. The crankcase of a crosshead compressor separated from the refrigerant may be designed at low pressure, but the crankcase is to be fitted with a safety valve. The opening pressure of the valve is to be adjusted to be not more than the design pressure, and the discharge is to be brought into a safe location. Any crankcase is also to be provided with a safety valve when the design pressure is below the maximum working pressure of the compressor, and the discharge is to be brought into a safe location.

2.2.4 Strength of materials for the compressor crankshafts

2.2.4.1 The specified minimum tensile strength of castings and forgings for crankshafts is to be selected within the following limits:

- .1 carbon and carbon-manganese steel forgings (normalized and tempered): 400 to 600 N/mm²;
- .2 carbon and carbon-manganese steel forgings (quenched and tempered): not exceeding 700 N/mm²;
- .3 spheroidal or nodular graphite iron castings: 370 to 800 N/mm²;
- .4 carbon and carbon-manganese steel castings: 400 to 550 N/mm²;
- .5 grey iron castings: not less than 300 N/mm².

The use of alloy steel castings and forgings is to be approved by CCS.

2.2.5 Dismounting requirements

2.2.5.1 The main bearings of refrigeration compressors are to be removed, checked and replaced without dismantling crankshafts, pistons and connecting rods.

2.2.6 Screw refrigeration compressors

2.2.6.1 The materials for screw refrigeration compressor rotors are to comply with the relevant provisions of CHAPTER 4 "Steel Forgings for Machinery" in PART 7.

2.2.6.2 If the bearing guard material of the rotors is locally hardened, it is not allowed to extend to the fillets. Treatment technology is to be submitted to CCS for review.

2.2.6.3 Gear box is to comply with the relevant provisions of CHAPTER 6, PART 3.

Section 3 PRESSURE VESSELS, PIPING AND ACCESSORIES

2.3.1 Pressure vessels

2.3.1.1 Welded steel cylindrical pressure vessels for refrigerants R22 and R404A are to be constructed in accordance with the relevant provisions for Class II pressure vessels specified in PART 3 (Chapter 8) and PART 7. Welded steel cylindrical pressure vessels for refrigerant R717 are to be constructed in accordance with the relevant provisions for Class I pressure vessels specified in PART 3 (Chapter 8) and PART 7. The design pressure is to comply with Table 2.2.1.1 in this PART. The tensile strength of the cylinders and heads of the above pressure vessels is to be not greater than 430 N/mm².

2.3.1.2 Pressure vessel cylinders can be made of seamless, electric resistance welded, or longitudinally submerged arc welded steel pipes rather than butt forged or spirally welded steel pipes.

2.3.1.3 For pressure vessels with a design temperature below 0 °C, the impact toughness value of the material at a corresponding temperature is to be reviewed by CCS.

2.3.2 Pressure piping

2.3.2.1 The wall thickness of all pressure pipes for the refrigerating plant is to be determined in accordance with the relevant provisions of CHAPTER 2, PART 3.

2.3.2.2 Refrigerant piping is to comply with the provisions, related to piping grade, of CHAPTER 2, PART 3:
· Class I, for R717 or toxic substances

- Class II, for other refrigerants
- Class III, for brine

2.3.2.3 Materials used for refrigerant, brine or seawater cooling piping and accessories are to be suitable for use with the liquids flowing within the pipes. High corrosive materials (copper, zinc, cadmium and other alloys) and mercuric materials are not to be used at the locations in contact with ammonia. Nickel steel is not to be used for pressure vessels and piping with ammonia as the refrigerant. Magnesium alloy is not to be used for fluorine-substituted hydrocarbon refrigerant, and zinc is not to be used for ammonia and fluorine-substituted hydrocarbon refrigerants.

2.3.2.4 Pipes for the condensers are to be made of corrosion-resistant material. Condensers with R22 and R404A as the refrigerants are to adopt corrosion-resistant seamless copper or titanium pipes.

2.3.2.5 Refrigerant and brine pipelines are to be seamless, of which the ammonia and brine pipes are to be of seamless steel. Pipe fittings for the ammonia unit are to be made of steel, but malleable cast iron may be accepted. Pipe fittings for the fluorine-substituted hydrocarbon unit are to be made of steel or bronze.

2.3.2.6 The joints of steel refrigerant pipes are to be butt welded. Where the piping is galvanized in lengths and then joined by welding, the galvanizing is to be removed in way of the pipe ends before welding. Butt joints of copper pipes are to be brazed. If necessary, a particular length of piping may be connected by means of welded-on flanges having grooves in a raised face and with gaskets fitted between them, or by means of screw joint sleeves. With respect to the gaskets for the pipe joints, aluminum sheet or polytetrafluoroethylene is to be used for ammonia pipes; red copper ring or polytetrafluoroethylene is to be used for fluorohydrocarbon refrigerant pipe; rubber gaskets are to be used for brine or seawater pipes. The use of other new materials for gaskets of various refrigerants is to be approved by CCS.

2.3.2.7 Where there are stop valves between safety valves and pressure vessels, stop valves are to be locked in the open positions at ordinary times. Safety valves and their disks are to be located above the liquid levels.

2.3.2.8 No closure is to be installed between safety valve and reservoir.

2.3.2.9 R717 refrigerant piping is to adopt cast iron valves.

2.3.2.10 R717 refrigerant piping is not to pass through living spaces and control spaces, service spaces.

2.3.2.11 The stop valves in the refrigerant piping are to be so constructed and arranged as to ensure safe renewal of the packings in the valve stuffing boxes without removing the refrigerant. The stop valves in the R22 and R134a refrigerant piping are to be constructed without stuffing boxes. If safety valves with soft stuffing boxes are adopted, they are to be provided with sealing glands, and the renewal of the packings is to be easy

2.3.3 Oil separators

2.3.3.1 Appropriate oil separators with drain lines are to be fitted in refrigerant pipelines. If wire gauzes are used in oil separators, they are to be made of a material resistant to corrosion by refrigerants, and are also to be sufficiently robust and well supported to prevent disintegration.

2.3.3.2 Oil separators are to be installed in pressure pipes in front of condensers or intercoolers (if any).

2.3.4 Filters

2.3.4.1 Usually, the following positions of refrigerant pipelines are to be fitted with filters that have a sufficient flow passage area and are easy for disassembly:

- .1 suction lines to compressors;
- .2 liquid lines before expansion valves; wire gauze in filters is to be sufficiently robust, well supported, and resistant to corrosion by refrigerants.

2.3.5 Driers

2.3.5.1 Driers are to be fitted in the liquid lines behind the condensers of halohydrocarbon refrigerant systems, and their arrangement is to be such that a drier can be by-passed, isolated and opened up without interrupting plant operations.

2.3.6 Thermometers

2.3.6.1 Thermometers are to be provided in systems of the refrigerating plant in the following positions:

- .1 suction and delivery lines to compressors;
- .2 inlet and outlet cooling water lines to condensers;
- .3 brine inlet and outlet lines;
- .4 refrigerant return pipes to air coolers of direct expansion type.

2.3.7 Pressure gauges

2.3.7.1 Pressure gauges are to be provided in systems of the refrigerating plant in the following positions:

- .1 suction and delivery lines to compressors;
- .2 delivery lines to brine pumps;
- .3 all refrigerant return lines to air coolers;
- .4 lubricating oil inlets to compressors with pressure lubrication.

2.3.8 Liquid level indication

2.3.8.1 Refrigerant liquid receivers are to be provided with liquid level indicators. The indicator is to be provided with a valve which is capable of being closed so as to prevent the loss of refrigerant in the event of breakage of the indicator.

Where liquid level is displayed by observation mirror, self-closing device may be omitted.

2.3.9 Cooling appliances

2.3.9.1 Refrigerated fish holds may be refrigerated by pipe grids on the ceiling, bulkheads and sides or by the circulation of air over air coolers.

2.3.9.2 If brine circulation is used for the cooling of refrigerated fish holds, the brine pipe grids in each refrigerated fish hold are to be arranged in not less than two sections. Each section is to be provided with valve(s) or cock(s) for closing. For a refrigerated fish hold with a capacity of less than 300m³, one section may be permitted.

2.3.9.3 Steel piping used to convey brine or primary refrigerants within the refrigerated fish holds, or where embedded in insulation, is to be galvanized externally. Alternative equivalent methods of protecting the brine piping against corrosion are to be approved by CCS.

Brine piping and tanks are not to be galvanized on the brine side. However, if any parts of the brine system have been galvanized, the brine cooling and return tanks, if closed, are to be provided with a ventilating pipe or pipes led to the atmosphere in a location where no damage will arise from the gas discharged, and the ventilating pipes are to be fitted with wire gauze diaphragms which can readily be renewed. Where brine tanks are not closed, the compartments in which they are situated are to be efficiently ventilated.

2.3.9.4 Where the steel pipes used to convey primary or secondary refrigerants are connected by butt welds or by screwed couplings, the ungalvanized portion of the joints is to be suitably coated and taped after hydraulic testing to reduce the incidence of corrosion. The locations of the joints are to be marked on the outside of the insulation.

2.3.9.5 Where cooling pipes pass through watertight bulkheads or decks, the construction of penetrations and packings are to be in accordance with the relevant requirements of 3.1.1.3 and 3.1.1.4 of this PART.

2.3.9.6 Either brine or direct expansion of the refrigerant may be employed in the coils of air coolers for each of the chambers. The coils are to be arranged into not less than 2 sections, and each of which is to be fitted with a valve capable of being readily isolated when necessary.. If the coils are not arranged in sections, at least 2 air coolers are to be provided.

A single coil cooler may be provided for a chamber with a net capacity of less than 200 m³.

2.3.9.7 Means are to be provided for effectively defrosting air coolers. Air coolers are to be provided with trays arranged to collect all condensate. The trays are to be provided with drains at their lowest points to enable the condensate to be drained away when the chambers are in service.

2.3.9.8 Air coolers including fans and motors are to be, as far as practicable, separated from the refrigerated fish holds, and adequate space is to be provided such that both the fan and the motor may be readily removed for repair or renewal. Access for servicing only is required where several fans and motors are installed in a refrigerated fish hold.

2.3.9.9 For indirect evaporative cooling systems, it is suggested that the design of its refrigerating plant should ensure that the maximum temperature difference between cooling mediums and refrigerated fish holds is not more than 4.5 °C, and the minimum temperature required for refrigerated fish holds is maintained under this condition.

2.3.9.10 If refrigerated fish holds are cooled and refrigerated with low temperature seawater, the filtration of sea water service systems must be enhanced, and the circulating seawater must not freeze under any circumstances.

2.3.10 Pumps

2.3.10.1 The refrigerating units are to be provided with at least two separate cooling water pumps, one of which may be a standby pump. This pump may be used for other purposes provided that it is of adequate capacity

and its use on other services does not interfere with the supply of cooling water to the units. when the total displacement of all other pumps can meet the normal cooling water supply for the refrigerating units, they can also be used as standby cooling water pumps.

2.3.10.2 Where the primary and/or secondary refrigerants are circulated in the system by pumps, a standby pump, which is not to be used for other purposes and capable of operating on all refrigeration equipment and facilities, is to be provided.

2.3.11 Sea connections

2.3.11.1 The water for cooling water pumps of condensers is to be supplied by two sea valves, one of which is provided on the port side and the other on the starboard side, and the piping arrangement is to ensure that the water supply for cooling water pumps is not affected by the working of other pumps.

2.3.12 Power

2.3.12.1 If the refrigerating plant is electrically driven, when any one of the generators stops working, the power of the remaining generators should be maintained at the minimum temperature specified in the design of refrigerated fish hold, while other important equipment necessary for the propulsion and safety of the fishing vessel should work normally.

2.3.13 Automatic control of refrigerating plant

2.3.13.1 Where refrigerating plants are operated automatically, efficient manual controls are also to be provided so that manual control can be effected in the event of failure of the automatic control.

2.3.13.2 The basic performances of all equipment in the refrigerating plant automatic control systems are to comply with the relevant provisions of Chapter 12, Part 3.

2.3.13.3 The refrigerating plant automatic control system is to cover the following:

- .1 the control of the temperature in the refrigerated fish holds within the predetermined temperature limits;
- .2 the control of the temperature of cooling air at the outlet not less than the minimum permissible temperatures when the fish catches are cooled by air;
- .3 the automatic prevention of the power station from overloading when the refrigerating plant is temporarily under a high load.

2.3.13.4 When the automatic thermostatic control is changed over to manual control, the arrangement is to be such that thermostatic controls can be bypassed and isolated. As an alternative, duplicate thermostatically operated refrigerant control valves may be fitted, each valve is to be capable of the required duty and operable with the other out of action.

2.3.13.5 Audible and visual fault alarms for the refrigerating plant are to be given at the control station or engine room (in case of no independent control station). The items of monitoring and alarms are not to be less than those given in Table 2.3.13.5.

Items of Monitoring and Alarms for the Refrigerating Plant

Table 2.3.13.5

Item	Display by master control station	Alarm	Remark
(1) Air temperature in the refrigerated fish holds	Temperature	High	Not to be set when the vessel length is less than 45m
(2) Air cooler fans	—	Failure	
(3) Bilge water level in the refrigerated fish holds	—	High	
(4) Refrigerant liquid evaporation pressure	Pressure	—	
(5) Lubricating oil pressure of compressors	Pressure	Low	Compressors will automatically stop
(6) Suction pressure of compressors	Pressure	Low	Compressors will automatically stop
(7) Exhaust pressure of compressors	Pressure	High	Compressors will automatically stop

(8) Seawater circulating pump	—	Failure	Compressors will automatically stop
(9) Ammonia (refrigerant) in refrigerating machinery spaces	—	Leakage	Proper time delay is to be provided for alarm so that compressors will automatically stop under the impact of fishing vessel's rocking
(10) Brine circulating pumps	—	Failure	See 2.3.13.6.4 in this PART
(11) Refrigerant pumps	—	Failure	Proper time delay is to be provided for alarm so that compressors will automatically stop under the impact of fishing vessel's rocking
(12) Refrigeration compressors	—	Failure	Proper time delay is to be provided for alarm so that compressors will automatically stop under the impact of fishing vessel's rocking

Note: Where the refrigerating machinery space is unattended, the fault alarms are to be relayed to the engineers' accommodation or other location where an engineer on duty stays.

2.3.13.6 The refrigerating plant is to be provided with safety systems to automatically shut down the compressors in the following events:

- .1 excessively low pressure at the suction side of compressors;
- .2 excessively high pressure at the delivery side of compressors and excessively high pressure in condensers;
- .3 excessively low lubricating oil pressure in compressors;
- .4 gas concentration exceeding 5,000ppm in the event of ammonia leakage in the refrigerating machinery space with detection devices, which may be omitted if the refrigerating machinery space is manned;
- .5 failure of seawater circulating pumps.

Section 4 LOCATION OF REFRIGERATING MACHINERY SPACE OR UNIT

2.4.1 Refrigerating machinery spaces

2.4.1.1 Refrigerating unit with R717 as the refrigerant is to be provided with a separate refrigerating machinery space, which should be separated from engine room, shaft tunnel and living area or other working space by gastight bulkheads or decks.

2.4.1.2 When the vessel length is not less than 60m, refrigerating unit with R22 or R404A as the refrigerant is to be installed in a separate refrigerating machinery space as far as possible.

2.4.1.3 The arrangements of the refrigerating machinery are to be such that all components are to be easily accessible for inspection or overhaul. Sufficient space is to be provided for cleaning and renewal of the tubes in brine coolers and condensers.

2.4.1.4 R717 refrigerating machinery space is not to be adjacent to living areas, wards or control rooms.

2.4.1.5 R717 refrigerating machinery space should have at least two outwards-opening doors as separate as possible from each other, exits should be as far away from living areas as far as possible, and at least one exit should be directly connected to the open deck. Entrance and exit doors that are not connected to the open deck should be highly airtight and self-closed. The upper part of the access door is to be provided with a water curtain for manual operation from the outside.

2.4.1.6 Access to R717 refrigerating machinery space is to be adjacent to living areas, wards or control rooms and is to be separated by gastight bulkheads or decks.

2.4.1.7 The location of ammonia refrigerating machinery in R717 refrigerating machinery space is to be protected by water spray system.

2.4.1.8 A separate drainage system is to be provided in R717 refrigerating machinery space so that the drained water will not be discharged into the open bilge well or the bilge channel in other compartments.

2.4.1.9 At least 2 filtered gas masks are to be provided at the entrance and exit of R717 refrigerating unit. The gas mask is to be placed in a box with a glass door for immediate access. With the consent of CCS, respirators can be used to replace gas masks.

2.4.1.10 The penetrations of the cables and pipes from refrigerating machinery space into gastight bulkheads and decks are to be gastight construction.

2.4.1.11 The platform of R717 refrigerating unit is to be fitted with appropriate coaming of not less than 150mm in height.

2.4.2 Ventilation and lighting

2.4.2.1 Refrigerating machinery space is to be provided with sufficient lighting. R717 refrigerating machinery space is to be equipped with explosion-proof emergency lighting.

2.4.2.2 Any refrigerating machinery space is to be provided with an efficient mechanical ventilation system. The ventilation is to provide at least 30 air changes per hour in the refrigerating machinery space.

The R717 refrigerating machinery space is to adopt a negative pressure ventilation system separated from other ventilation systems thoroughly. The suction ducts of the ventilation systems are to be constructed of steel or other equivalent material, and the exhaust ports of the ventilation systems are to be away from air inlet ports in other spaces and commonly occupied areas and located in positions where no danger will arise.

In the case of R22 or R134a refrigerating machinery spaces, power exhaust ventilation systems are to be fitted with the suction inlets located at the lowest part of such spaces.

2.4.2.3 The mechanical ventilation for the refrigerating machinery space is to be capable of being controlled from two positions, and one of which is to be situated in a suitable position outside such space.

2.4.2.4 In the ventilated R717 refrigerating machinery space or in the ventilation system, the ventilator is not to be the ignition source of ammonia, the ventilator and its duct are to be of non-spark structure, and the ventilator is to be explosion-proof.

2.4.2.5 If R22/R404A refrigerating unit is installed in the machinery space, at least one suction port of the exhaust duct is to be installed in the adjacent lower part. It can be relaxed when the vessel length is less than 30m.

2.4.3 R717 gas absorption system

2.4.3.1 The scrubber is to be capable of reducing the concentration of R717 going towards the exhaust fan to a value less than 25ppm and fully absorbing R717 in the receiver with a maximum capacity within 30 minutes.

2.4.3.2 If the concentration of R717 in the division device is more than 300ppm, the scrubber pump will start automatically.

2.4.4 Water spray system of R717 refrigerating machinery space

2.4.4.1 Water spray system should run independently, but can also be used for water curtain system. The water spray system is to be provided with fresh water through the pressurization system.

2.4.4.2 The nozzles in the protected area are to be arranged at the locations that enable the mist to be sprayed directly to the entire area fitted with ammonia refrigerating machinery.

2.4.4.3 The pressurization system is composed of two pumps and a water tank that can maintain 30-minute capacity of all nozzles at the same time, and the water tank must be equipped with the required safe relief device, pressure gauge, water level controller and liquid level gauge.

2.4.4.4 The equipment is used to automatically maintain the required water pressure and level. Under the condition of low pressure and low water level, auditory alarm will appear in refrigerating machinery space and engine room.

2.4.4.5 When the concentration of ammonia exceeds 300ppm in space, the deluge system will automatically start.

2.4.4.6 The waterproof grade of the electrical installations in the room where the water spray system is arranged is to be IP55.

2.4.4.7 When the devices with ammonia water are installed in refrigerating machinery space, the area where ammonia machinery is installed is to be provided with a cover with a negative pressure ventilation system. Around the cover, it is to be provided with a water sprinkling system which can be operated in place and outside the refrigerating machinery space.

2.4.5 R717 gas detection and alarm system

2.4.5.1 There should be fixed ammonia detection systems with alarm devices inside and outside the refrigerating machinery space. There should also be manual leakage alarm transmitters outside the refrigeration compressor room.

2.4.5.2 The detectors should be explosion-proof and should be suitable for low temperature working environment and be calibrated consistently.

2.4.5.3 The installation location of R717 gas detector is as follows:

- (1) Refrigerating space: a detector is to be installed every 36m² in the installation space.
- (2) A detector is to be arranged in the exhaust line of the ventilation system of refrigerating machinery space.
- (3) Each passageway to ammonia cooler space is to be provided with a detector.
- (4) Ammonia storage space is to be provided with a detector.

2.4.5.4 Detector should be explosion-proof and should be able to be set with 3 levels of alarm:

- (1) When the ammonia concentration is more than 25ppm, detector will start Level 1 alarm system;
- (2) When the ammonia concentration exceeds 300ppm, the detector is to automatically stop the ammonia refrigeration compressor and ammonia pump, close the quick-closing valve on the ammonia conveying pipeline, open the secondary auditory and visual alarm system, and activate the monitoring and alarm system of the gas discharge system to send auditory and visual alarms in the central control room and outside the refrigerating machinery space.
- (3) When the gas concentration reaches 4.5%, the electrical installations in freezing equipment room can be cut off and the three-level alarm system can be turned on.

2.4.6 Safety protection equipment

2.4.6.1 At least the following safety protection equipment are to be provided outside the R717 refrigerating machinery space, and the storage locations are to be marked to facilitate identification and repair in case of refrigerant leakage:

- (1) 2 sets of respirator and protective clothing (helmet, safety boots, gloves, etc);
- (2) 2 sets of independent respirator (at least available for 30 min);
- (3) 2 goggles;
- (4) 2 barrels of boric acid, 30 kg/barrel;
- (5) 2 emergency flashlights;
- (6) 1 electrical insulation resistance meter.

Section 5 SAFETY DEVICES

2.5.1 Relief valves and safety valves

2.5.1.1 A pressure relief valve and/or safety disc is to be fitted between each compressor and its gas delivery stop valve. The safety devices are to come into action in case of excessive refrigerant pressure, the discharge being led to the suction side of the compressor. No closing appliances are to be permitted in the backflow pipes. The opening pressure or bursting pressure of the above relief valves and/or safety discs is to be not greater than the following values:

.1 R717 compressor	1.72MPa;
.2 R22 compressor	1.72MPa;
.3 R404A compressor	1.82MPa.

However, in any event, the opening pressure or bursting pressure of relief valves and/or safety discs at the delivery side of compressors is to be not greater than the opening pressure or bursting pressure of relief valves and/or safety discs of pressure vessels specified by 2.5.1.3 in this PART. Where the power of the compressor prime mover does not exceed 10 kW, the relief valves and/or safety discs at the delivery side of the compressors may be omitted.

2.5.1.2 All pressure vessels or other components of refrigerant systems which could become filled with liquid refrigerant and isolated are to be provided with safety discs and relief valves in series, the discharge being led to a safe place above deck. Pressure gauges showing intermediate pressure are to be fitted between the safety discs and relief valves in series.

In the fluorine-substituted hydrocarbon systems, the relief valves and safety discs may be substituted by fusible plugs having a fusion point of 65 °C, provided that the individual capacity of the above-mentioned pressure vessels is less than 100L.

The opening pressure or bursting pressure of relief valves and/or safety discs of refrigerant pressure vessels is to be not greater than the values given in Table 2.5.1.3. The delivery capacity is to comply with the requirements of Subparagraph .3, Paragraph 8.4.2.3, Chapter 8, Part 3.

Opening Pressure or Bursting Pressure of Relief Valves and/or Safety Discs of Pressure Vessels

Table 2.5.1.3

Refrigerant Pressure vessel name	R717	R22	R404A
Condenser and liquid receiver	1.72	1.72	1.82
Intermediate pressure vessel and evaporator	1.37	1.37	1.57

2.5.1.4 When safety discs are positioned in front of relief valves, the rears of safety discs are to be provided

with swash plates to ensure the function of relief valves.

2.5.1.5 Suitable safety valves are to be provided to the cooling water side of condensers and the brine side of evaporators where the discharge pressure from any cooling water pump or brine circulating pump in the circuit could exceed the design pressure of the piping or any component forming part of the cooling system.

2.5.2 Emergency drainage

2.5.2.1 The refrigerant system of R717 refrigerating plant is to be provided with emergency drain pipes so as to immediately drain off the ammonia overboard in case of accident. Stop valves fitted in such pipes are to be situated outside the refrigerating machinery spaces and to be placed in a sealed box with glass window. The outlets of the drain pipes at the ship's side are to be placed below the light ballast waterline, and are to be provided with non-return valves.

2.5.2.2 The devices and pressure vessels of R22 and R404A refrigerating plants are to be equipped with facilities for emergency drainage of refrigerants into the atmosphere.

2.5.3 Emergency stopping devices

2.5.3.1 For a refrigerating plant using R717 refrigerant, the prime mover of the compressors is to be provided with an emergency stopping device which is to be situated outside the refrigerating machinery space, and provision is to be made for preventing the inadvertent touching by unauthorized persons.

2.5.4 Alarm buttons in refrigerated fish holds and safe operation rules

2.5.4.1 Alarm buttons are to be fitted in refrigerated fish holds for seeking help from cabs and refrigerating machinery spaces.

2.5.4.2 Nameplates detailing the safety and emergency operation rules for refrigerating systems are to be installed at appropriate locations on board.

Section 6 QUICK-FREEZING INSTALLATIONS

2.6.1 Design requirements

2.6.1.1 For fishing vessels with quick-freezing installations, in addition to the provisions of 2.1.2.4 and 2.1.2.5 in this PART, the refrigerating capacity of their refrigerating plants is also to be designed according to the quick-frozen processing and cold storage needs.

2.6.2 Heat insulation and protection

2.6.2.1 In order to reduce the heat exchange between quick-freezing rooms and the outside, the entrances of quick-freezing rooms are to be provided with buffer areas or air curtains.

2.6.2.2 Valves and accessories on the pipelines of quick-freezing tunnels are to be installed outside the tunnels. The heat-insulating surfaces of quick freezing tunnel walls are to be protected by steel sheets or other metal sheets.

2.6.3 Plate freezers

2.6.3.1 The plates of plate freezers are to be provided with sufficient stiffness so that there will be no obvious deformation when they bear the clamping force of jacking load.

2.6.3.2 The hydraulic lifts of plate freezers are to be kept synchronized when jacking. If the refrigerant inlet and outlet pipes of plate freezers are metal pipes with movable joints, and their joint structures are to be kept reliable and airtight. If non-metallic hoses are used, R717 refrigerant is not to be used in plate freezers. The material for the hoses is to feature refrigerant dissolution resistance. The bursting pressure of the hoses is to be not less than four times of working pressure. The hose-to-joint connection strength is to be not less than the required strength corresponding to 1/2 of the bursting pressure of the hoses, and only the approved hose assemblies can be used.

2.6.3.3 The refrigerant inlet and outlet pipes of plate freezers are to be provided with stop valves at the appropriate locations so that the refrigerant will not be consumed when the hose assemblies are replaced.

2.6.3.4 The defrosting of plate freezers are to be provided with effective control measures to prevent liquid from flowing back.

2.6.4 Lighting

2.6.4.1 The quick-freezing room is to be provided with sufficient lighting.

CHAPTER 3 REFRIGERATED FISH HOLDS

Section 1 Constructions and Accessories of Refrigerated Fish Holds

3.1.1 General requirements

3.1.1.1 Each individual refrigerated fish hold is to be of steel airtight construction.

3.1.1.2 Where hatch covers or plugs are exposed to ambient conditions, they are to be provided with a double seal.

3.1.1.3 Refrigeration pipes passing through refrigerated fish holds or decks are not to be in direct contact with the steelwork, and the holes through which they pass are to be carefully processed and effectively sealed. The temperature of ship's steelwork close to low temperature refrigeration piping is not to be lower than that acceptable for the steel grade.

3.1.1.4 The watertightness and fire separation integrity of bulkheads and decks are to be ensured if the refrigeration pipes passes through the watertight bulkheads or decks. All cryogenic refrigeration pipes outside refrigerated fish holds are to be effectively insulated.

3.1.1.5 The closing appliances, access doors, manhole plugs and bilge of refrigerated fish holds are to be made airtight. The airtight doors can be opened both inside and outside.

3.1.2 Temperature measuring

3.1.2.1 Each refrigerated fish hold is to be provided with a suitable number of thermometers, of which the exact number and positions are to be approved by CCS. The inside diameter of thermometer tubes is not to be less than 50 mm, and the tubes are not to be in contact with cold decks. Thermometer tubes with their flanges and covers are to be insulated from the bulkhead or deck plating.

3.1.3 Temperature measuring accuracy

3.1.3.1 The temperature measured in a refrigerated fish hold is to be accurate to within $\pm 0.5^\circ\text{C}$. The scale division of the thermometer is to be not less than 5mm/ $^\circ\text{C}$.

3.1.4 Installation requirements for distant thermometers

3.1.4.1 Where telemetry is used, at least two instruments are to be provided, with the sensing elements so connected that in the event of a failure of any one instrument, at least one sensing element will be operative for each hold either in the hold or in its air circulating system. Where a data logger is installed and all the sensing elements are connected to this single instrument, at least one sensing element in each hold or in its circulating air system is to be connected to a separate instrument.

The display of data loggers is to be in digital form or other equally effective visual indication, registering to $\pm 0.1^\circ\text{C}$ of a degree.

Where the equipment controlling the temperature of the air delivered from the cooler is equipped with a temperature indicator, this indicator will be given consideration as a standby instrument provided that the readings are accurate to within $\pm 0.5^\circ\text{C}$ of the true temperature.

3.1.4.2 Where galvanometers are fitted, two are to be provided for each indicating instrument and a checking resistance is to be fitted.

3.1.4.3 Where the instruments have individual power supply units, a spare power unit (e.g. transformer and rectifier or battery) is to be provided for each instrument.

3.1.5 Fixtures

3.1.5.1 All fasteners, hooks, supports, trays, and other fixtures that support or fasten cooling appliances, heat-insulating layers and guide rails for the transportation of fish catches are to be galvanized.

3.1.6 Drainage and liquid sealed traps

3.1.6.1 Residual water of fish catches and cooler trays must be able to be continuously drained.

3.1.6.2 Residual water from the lower fish catches and the cooler trays on the double bottom are to be sealed with non-return valves where it enters the bilge drains. Residual water from the upper fish catches and the cooler

trays with a sufficient height from the inner bottom plating is also to be provided with liquid sealed traps, but non-return valves may be omitted if desired.

3.1.6.3 The liquid sealed traps are to be of adequate depth, and arrangements are to be made for ready access to the traps for cleaning and refilling with brine.

3.1.6.4 Sewage from other locations is not permitted to be led into the bilge of refrigerated fish holds.

3.1.7 Refrigerated seawater fish holds

3.1.7.1 The liners of refrigerated seawater fish holds are to be firmly supported.

3.1.7.2 The lower parts of the liners of refrigerated seawater fish holds are to be equipped with appropriate air change facilities to remove toxic gases from the parts.

Section 2 HEAT INSULATION

3.2.1 Laying of heat-insulating layers

3.2.1.1 Heat-insulating layers are to be laid on all the bulkheads, plankings and decks of refrigerated fish holds and pre-cooled seawater holds, and thermal bridges are to be avoided. Adequate heat insulation is to be provided for hull members capable of acting as thermal bridges. If organic foam plastic is used as heat-insulating material, organic foam plastic is to be self-extinguishing. If cork or any other combustible heat-insulating material is used, the outer surfaces are to be protected by tightly arranged non-combustible material overburden layers. If local sprayed and foamed plastic is used, the technology is to be reviewed by CCS.

3.2.1.2 Heat-insulating layers are to be laid tightly, and the gaps are to be filled with heat-insulating materials. The outer surfaces of heat-insulating layers are to be provided with protective overburden layers. Detachable panels are to be provided at suitable locations for spot check of heat-insulating layers.

3.2.1.3 All heat-insulating materials, doubling plates, sealing members and coatings are not to release any smell that can cause fish catches to corrupt and deteriorate, and are also not to absorb the smell of fish catches in the holds.

3.2.1.4 The doubling plates and cold air net plates of heat-insulating layers and their supports are to be provided with sufficient strength.

3.2.1.5 The manholes on double bottom tank top plating and the heat-insulating layers at bilge wells are to be provided with 100mm high watertight steel coaming to prevent water from infiltrating into the heat-insulating layers.

3.2.1.6 Additional protection is to be given to the double bottom tank top plating under the hatches and the heat-insulating layers extending within 0.5m around the plating. Shaft tunnels are also to meet this requirement.

3.2.1.7 Where the insulants are to be of low flame spread. The materials used and their adhesives are to comply with the relevant national provisions, and are also to be subject to approval by CCS.

3.2.2 Heat-insulating blocks

3.2.2.1 Insulated removable plugs are to be provided in the insulation where required for easy access to the bilge, bilge suction wells, cooler and fish catch drains and manhole lids. Insulated removable panels are to be provided in the insulation above.

3.2.2.2 Insulation linings, bilge limbers and plugs, hatch covers and plugs and chamber access doors are to be made of water-vapour resisting material, or covered with such material. Their edges are to be protected from damage, and the sides exposed to the bilges or the outside are to be sealed.

3.2.3 Oil resistant coating of inner bottom plating

3.2.3.1 When a heat-insulating layer is laid on double bottom tank top plating, a coating that is not permeable to oil are to be applied first. The total thickness of the coating required is to depend on the construction of the tank and the composition of the coating used.

CHAPTER 4 TESTS

Section 1 PRESSURE TESTS

4.1.1 Pressure tests after completion of manufacturing

4.1.1.1 After completion of manufacturing components and parts exposed to the pressure of the refrigerants are to be subject to strength and leak tests as detailed in Table 4.1.1.1. Leak test is to be conducted after strength test.

Test Pressure

Table 4.1.1.1

Components or parts	Strength test (hydraulic)	Leak test (pneumatic)
Pressure vessels and plate freezer evaporating pipe sheets	1.5P	1.0P
Compressors		
Cast-in-block crankcases and cylinders	1.5P	1.0P
Separate cylinders or cylinder blocks or housings (screw type)	1.5P	1.0P
Crankcases separated from cylinders	1.2P	0.8P
Valves and fittings	2.0P	1.0P
Pressure piping, welded fabricated headers, air coolers, etc	1.5P	1.0P
Note 1: <i>P</i> is design pressure, as shown in Table 2.2.1.1.		
Note 2: Nitrogen or carbon dioxide or compressed air is generally used for leak test, but only nitrogen can be used for leak test for ammonia. The parts are to be submerged in water for inspection during the test. Alternative methods for leak test may be considered if practicable.		

4.1.1.2 The parts and components exposed to the pressure of brine or cooling water are to be hydraulically tested at 2.0P, but in no case less than 0.34MPa.

4.1.2 Pressure test after installation on board ship

4.1.2.1 For pressure piping welded in place, hydraulic tests of the welds are to be carried out at a pressure of 1.5P.

4.1.2.2 For pressure piping welded in place, the hydraulic tests required in 4.1.2.1 may be omitted provided non-destructive tests by ultrasonic or radiographic methods are carried out with satisfactory results on the entire circumferential butt welds. Where ultrasonic tests have been carried out, the manufacturer is to provide the Surveyor with a test report confirming that ultrasonic examination has been carried out and that there were no indications of defects which could be expected to have a prejudicial effect on the service performance of the piping.

4.1.2.3 After completing the test or inspection required by 4.1.2.1 or 4.1.2.2 in this PART, leak test is to be carried out at a pressure given in Table 4.1.1.1.

4.1.3 System drying

4.1.3.1 After tightness testing and before charging with refrigerant and oil, the complete plant is to be dried by a method of evacuation. The plant is to be evacuated until the vacuum degree is above 720mmHg as far as practicable, which is to be held constant until all water is evaporated. The plant is then to be refilled with air and the same procedure is to be repeated until no water is left in the plant.

Section 2 OPERATION TESTS

4.2.1 Preparations for tests

4.2.1.1 Before the operation test, all thermometers or temperature measuring equipment fitted in the refrigerated fish holds or on the refrigerating machinery are to be checked for accuracy, and a statement is to be given to the Surveyor. The Surveyor may require a random test if deemed necessary.

4.2.1.2 Pressure gauges and other measuring instruments are, before the operation test, also to be checked to the satisfaction of the Surveyor.

4.2.1.3 Before the operation test, it is required to check whether the safety valve opening lead seals of refrigeration compressors, condensers, reservoirs, intercoolers and evaporators are intact.

4.2.2 Fan test

4.2.2.1 After the installation of air cooling systems, working test is to be conducted for fans. During the test, it is required to record static air discharge pressure, air displacement, fan speed and power consumption, and check the ventilation in the fish holds in accordance with the requirements of 4.2.8.1 in this PART. After the test, test report is to be submitted to the surveyor.

4.2.3 Refrigeration tests

4.2.3.1 All refrigerating units of the refrigeration plant are to be subject to refrigeration tests under normal working conditions. The refrigeration test is to be carried out for a period of at least 12 h after the refrigerated fish hold temperatures have been lowered to the minimum temperature as required. However, the total time is not to be less than 24 h throughout the test.

The refrigeration test may be carried out with all refrigerated fish holds empty. The hatch covers, access plugs or doors and air refreshing arrangements are to be closed up and liquid sealed traps for scuppers are to be primed with brine.

4.2.3.2 At the beginning of the refrigeration test, all refrigerating units are to be put into action. After the refrigerated fish hold has been cooled down to the design temperature, the test may be carried on with one of the units out of action in turn in accordance with the requirements of 2.1.2, Chapter 2 in this PART, provided that the minimum required temperature in the refrigerated fish hold is maintained constant throughout the test. During the test, each unit is to operate for about the same time.

4.2.3.3 In the test for refrigerating plant, if the temperature is so low that there is no reasonable difference between the temperature inside the hold and the outer atmospheric temperature, the test conditions are to be submitted to CCS for special consideration.

4.2.4 Thermal balance tests

4.2.4.1 During the refrigeration test of newly designed refrigerating plant, a thermal balance test is to be carried out to the plant in the presence of the Surveyor.

4.2.4.2 When the refrigerated fish holds are cooled down to the minimum designed temperature, the thermal balance test is to be commenced after such a temperature has been maintained constant for a stabilizing period during which heat is removed from the insulation etc. The heat balance test is to last for at least 8 h. During this period, the ambient temperature is to be as stable as possible. This test is to be conducted without intense solar radiation.

During the test, the temperature of the refrigerated fish holds is to be maintained at the minimum designed temperature and is not to be reduced by more than 1 °C.

During thermal balance test, in order to keep the temperature in refrigerated fish hold stable, the number of refrigeration compressors that are running or their revolving speed can be changed, and compressors can also run intermittently. The time of such changes is to be carefully recorded. However, all such changes are not to be made with the aid of load regulation or automatic control system.

4.2.4.3 On completion of the thermal balance test, a thermal balance calculation is to be carried out and the calculations are to be submitted.

4.2.5 Data measurement record

4.2.5.1 Thermometers are to be provided outside refrigerated fish holds. During refrigeration test, the air temperature outside refrigerated fish hold is to be measured and recorded regularly.

4.2.5.2 The following items of refrigerating plant are to be recorded in detail during the whole test process from the beginning of refrigeration to the end of the test:

- .1 temperature in refrigerated fish hold;
- .2 atmospheric temperature outside refrigerated fish hold;
- .3 refrigerated seawater inlet/outlet temperature;
- .4 temperature and pressure of refrigerant system and brine system;
- .5 air inlet/outlet temperature of air cooler;
- .6 revolving speeds and power consumptions of refrigeration compressors and air coolers (in addition, running time of compressors are to be recorded in accordance with the provisions of 4.2.4.2 in this PART);
- .7 Power consumptions of seawater cooling pumps, brine pumps and refrigerant pumps.

The above items can be recorded every 2h during the cooling process at the initial stage of the test. The atmospheric temperature outside refrigerated fish hold is to be measured every hour within the last 18 hours of the

test. Other related temperature, pressure, revolving speed and power consumption of compressor and fan motor, and power consumption of brine pump, refrigerant pump and cooling water pump are to be measured and recorded every hour within the last 12 hours.

4.2.6 Test for temperature rise in the refrigerated fish hold

When the temperature in the refrigerated fish hold reaches the minimum designed temperature, a test for temperature rise in the refrigerated fish holds can be carried out. The temperature rises in the fish hold are to be logged hourly for a period of 6 h to check the heat insulation effectiveness of the heat-insulating layer.

According to the initial temperature difference between the temperature in the refrigerated fish hold and the outer atmospheric temperature at the beginning of the test for temperature rise in the refrigerated fish hold, the total rise values of the temperature in the refrigerated fish hold after 6 hours (average value of all measuring points) is not to be greater than that specified in Table 4.2.6.

Total Rise Values

Table 4.2.6

Initial temperature difference between the temperature in the refrigerated fish hold and the outer atmospheric temperature (°C)	60	55	50	46	40	35	30	25	20	15	10
Total rise value of temperature in the refrigerated fish hold (°C)	14.4	13.2	12	10.8	9.6	8.4	7.2	6	4.8	3.6	2.4

4.2.7 Test for quick-freezing installations (if any)

4.2.7.1 The operation test is to be conducted for quick-freezing installations of fishing vessels in accordance with the design requirements.

4.2.7.2 When quick-freezing installations are equipped with refrigerating systems independent of refrigerating installations, in addition to the independent test in accordance with the relevant provisions of this chapter, operation test mainly including freezing temperature and freezing capacity is also to be conducted.

4.2.8 Other tests

4.2.8.1 The required number of air changes and the uniform distribution of air volumes in refrigerated fish holds are to be verified.

4.2.8.2 Operation test is to be conducted for the control, alarm and safety devices of automatic control systems (if any). This test is generally to be conducted during the actual operation of refrigerating units. However, for the action effectiveness of alarm and safety protection, under the condition of ensuring equivalence, simulated fault test can be conducted.

4.2.8.3 Defrosting operation test is to be conducted for air coolers before or after refrigeration test.

4.2.8.4 Defrosting operation test is to be conducted for electric defrosting, hot exhaust defrosting and hot brine defrosting devices.



China Classification Society

RULES FOR CONSTRUCTION OF OCEAN-GOING STEEL FISHING VESSELS

2018

PART 6 LIFTING APPLIANCES

Effective from 1 December 2018

CHAPTER 1 GENERAL

Section 1 GENERAL PROVISIONS

1.1.1 Application

1.1.1.1 This PART applies to lifting appliances with a safe working load of not more than 98kN and their ancillary facilities.

1.1.1.2 The influence brought by the installation and arrangement of lifting appliances on the safety of crew is to be reduced to a minimum. The fishing appliances that also act as lifting appliances are to comply with the requirements for lifting appliances.

1.1.1.3 During maintenance and modification, lifting appliances of existing vessels are continue to comply with the requirements of original applicable rules, and are to comply with the requirements of this PART as far as possible.

1.1.1.4 Where lifting appliances as well as their fittings, loose gears and ropes not mentioned in this PART are used, the materials, construction procedures, testing methods and technical indexes of these appliances are to comply with the relevant provisions of the relevant standards accepted by CCS.

1.1.2 Definitions

1.1.2.1 *Lifting appliances* mean the appliances installed on a fishing vessel for the handling of fish catches and fishing supplies and for the auxiliary lifting and laying-down of fishing appliances, including derrick rigs (derrick posts, masts, gantries, and winches), air-space cable crane, etc.

1.1.2.2 *Winch* means a mechanical device that is drum or warping cone with one or more horizontally-mounted winding ropes.

1.1.2.3 *Derricks* means the derricks with a safe working load of not more than 98kN in this PART.

1.1.2.4 *Air-space cable crane* means cable hoisting appliances with a safe working load of not more than 9.8kN.

1.1.2.5 *Fittings* mean fitting which are permanently attached to the derrick booms, masts or derrick posts, decks, superstructures and other structural members of a fishing vessel such as eyeplates, derrick heel assemblies and gooseneck bearings (including gooseneck pipes, derrick bands and built-in sheaves, etc.).

1.1.2.6 *Loose gear* means the gear which is not permanently attached to the lifting appliances, such as chain, triangle eyeplates, hooks, blocks shackles, swivel, sockets, preventer guys with patent clips and rigging screws, etc.

1.1.2.7 *Safe working load (SWL) of a lifting appliances* means the maximum static load the appliance is certified to be capable of sustaining whilst correctly rigged under the design operation.

1.1.2.8 *Safe working load (SWL) of loose gear* means the maximum load for which the gear has been designed and tested. The load is not to be no less than the maximum load to which the gear will be subjected when the lifting appliance is operating at its SWL.

CHAPTER 2 DERRICK SYSTEMS

Section 1 CALCULATING CONDITIONS AND LOADS

2.1.1 Angles to the horizontal of derrick booms

2.1.1.1 For the purpose of determining the forces acting on the derrick systems, the boom angle to the horizontal is to be taken as 15°. Should the derricks not be operated at the foregoing angles, the boom angle to the horizontal may be increased so as the derrick can be operated in practice, however in no case, the boom angle to the horizontal is to be taken as more than 30°.

2.1.1.2 For determining the forces acting on the cargo blocks or built-in-sheaves (if fitted), the boom angle to the horizontal is to be taken as the maximum angle during the operation of the rig in practice and is not to be in general, less than 70°.

2.1.2 Basic load of derrick systems

2.1.2.1 The basic load for the calculation of force for the slewing derricks and derrick cranes is to be defined as the safe working load and the self-weights of derrick boom and the relevant tackle above the hook.

2.1.2.2 The basic load for the calculation of force for the union purchase rigs is to be taken as the safe working load.

2.1.3 Friction allowance

2.1.3.1 The allowance due to sheave friction and the stiffness of wire rope is to be taken as 5%, for blocks with plain or bushed bearing; 2%, for blocks with ball or roller bearing.

2.1.4 Safety factor of ropes

2.1.4.1 The safety factor of wire ropes is 5 where those used as running rigging (including cargo runners, span tackles, slewing guys, etc.) or mast stays, and that is 4 where those used as preventer guys.

2.1.4.2 The safety factor of fibre ropes is 8.

2.1.4.3 All the safety factors above-mentioned are relative to the breaking load of wire ropes and fibre ropes.

Section 2 SWINGING DERRICK AND UNION PURCHASE RIGS

2.2.1 Calculating conditions and loads

2.2.1.1 The conditions and loads for the calculation or analysis of forces acting on the derrick systems are to comply with the provisions of Section 1 in this Chapter.

2.2.2 Working load of slewing guy

2.2.2.1 The working load of slewing guy is to be determined in accordance with Table 2.2.2.1, and slewing guys are not be substituted by preventer guys.

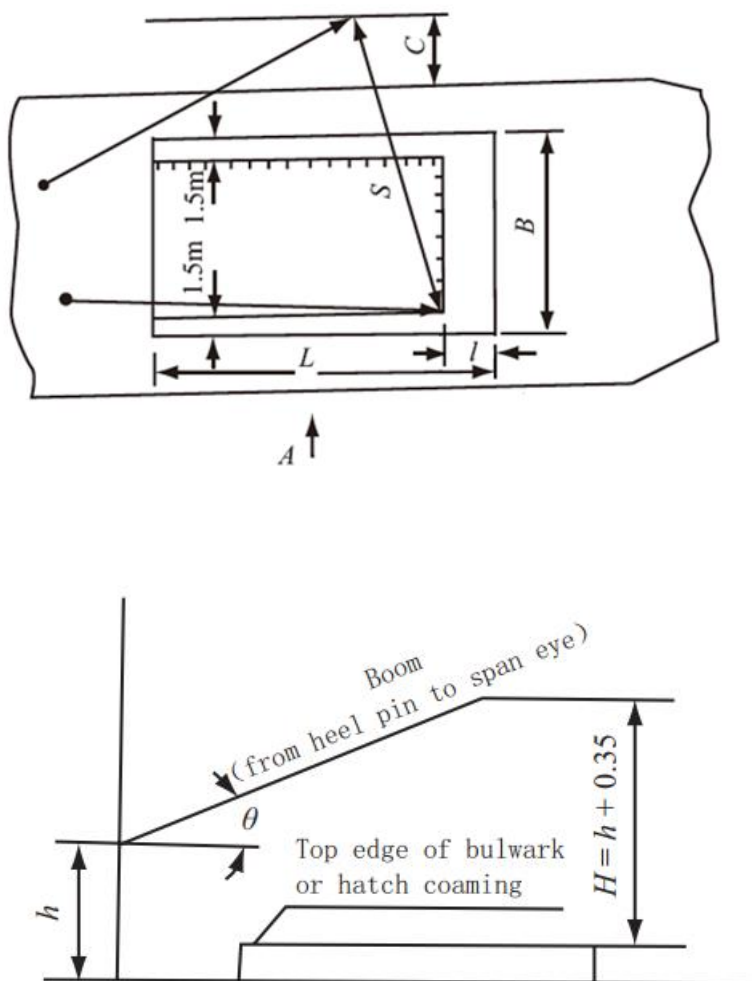
Working Load of Slewing Guys

Table 2.2.2.1

SWL of derrick rigs, in kN	Working load of slewing guys, in kN
SWL ≤ 49	0.5SWL + 4.9
SWL > 49	0.1SWL + 24.5

2.2.3 Working range requirements of the union purchase rig

2.2.3.1 When the derrick rigs are arranged for union purchase operation, the inboard and outboard booms are to be placed at the lowest angle to the horizontal for practical operation and the working range of the rig and the length of derrick booms are to comply with the requirements (see Figure 2.2.3.1):



θ - boom angles to the horizontal, both angles are equal; L - length of hatch, in m; B - breadth of hatch, in m; C - outreach, in m; S - the distance between two boom heads, in m, in horizontal plan; b - the vertical height from derrick heel pin, in m; l - see 2.2.4.2; h - see 2.2.4.3.

Figure 2.2.3.1 Operation Positions of union purchase rig

2.2.3.2 The outreach C beyond the midship breadth is not to be less than 3.5 m or that as required by the owner.

2.2.3.3 The inboard boom head in the projection plan within cargo hatch is to be located:

- .1 with a distance l not more than $L/5$ from the opposite side of the hatch for which only one pair of derricks;
- .2 with a distance l not more the $L/3$ from the opposite side of the hatch for which two pairs of derricks are fitted;
- .3 with a distance of 1.5 m from the side of hatch.

Where: L — length of hatch, as shown in Figure 2.2.3.1 in this Section.

2.2.3.4 Where the angle formed by the cargo runners is assumed to be equal to 120° , the minimum headroom “ h ” from the joint (triangle plate) of two cargo runners over the top edge of hatch coaming or bulwark is not to be less than:

5m when $SWL \leq 19.6\text{kN}$

6m when $SWL > 19.6\text{kN}$

Where: SWL -- safe working load of the union purchase rig, in kN.

Where the headroom “ h ” as stated above cannot meet the requirements for practical operation, it is to be suitably increased.

2.2.4 The force calculation for the union purchase rig

2.2.4.1 The force calculation for the union purchase rig is to be such that the thrust of derrick boom and the load of preventer guys will be obtained from the position of the rig which gives the maximum value within its practical working range. In general, the position of the rig as shown in Figure 2.2.4.1(a) may be used for such calculation, and in such case, the angle between the cargo runners is to be taken as 120° and the position of the triangle plate connecting two cargo runners is supposed at the lowest position as shown in Figure 2.2.4.1(b)..

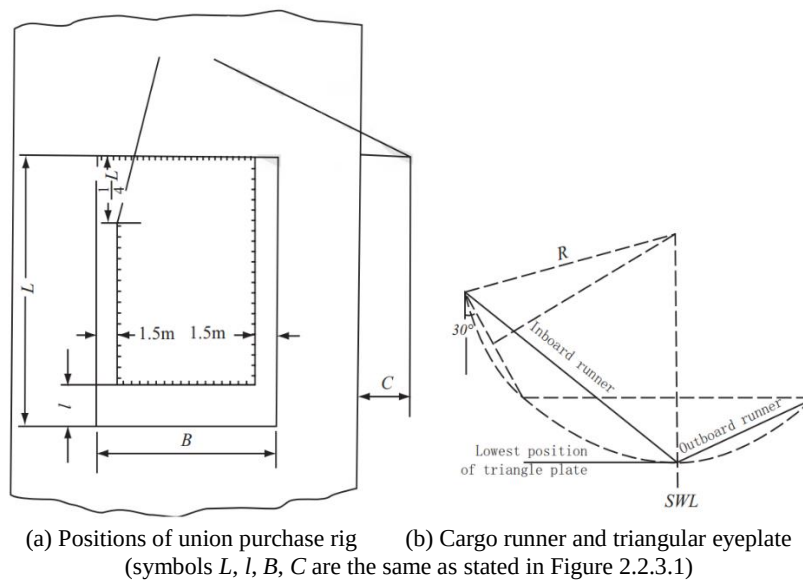


Figure 2.2.4.1

2.2.4.2 The arrangement of union purchase rigs is to be such that the jack-knifing will not occur within any working range of the rig. For this purpose, the resultant of the horizontal components of cargo runner and preventer guys in the direction of boom axis, which is named span relief “ f_h ” multiplied by $\tan \theta$ (θ – boom angle to the horizontal), is not to be greater than the sum of vertical components of cargo runner and preventer guys “ f_r ”, see Figure 2.2.4.2.

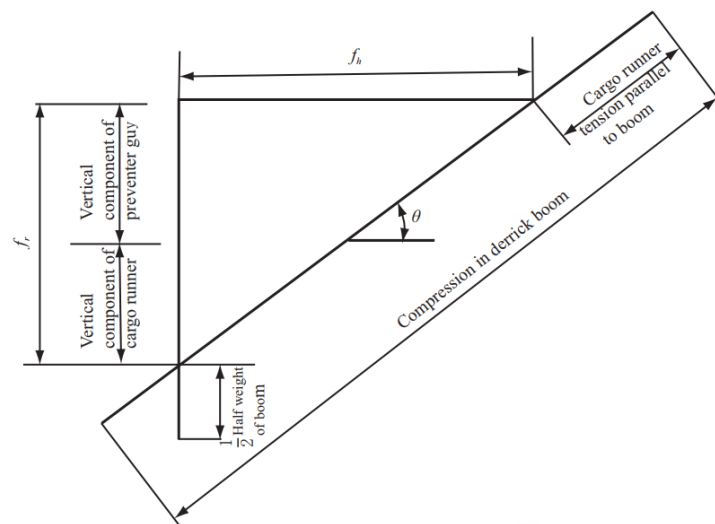


Figure 2.2.4.2 Force on Derrick, Cargo Runner and preventer Guy

2.2.4.3 The working load of the schooner guys in union purchase rig is to be taken as 20 per cent of the safe

working load of the rig, but not less than 9.8 kN.

Section 3 DERRICK BOOMS

2.3.1 Construction of derrick booms

2.3.1.1 The boom may be constructed as a member with uniform diameter and thickness over its full length or as a tapered component which has a mid-length with uniform diameter and thickness connected to the tapered ends.

2.3.1.2 The mid-length with uniform diameter of a tapered boom is to at least be maintained one third of the boom length and the end diameter of the tapered ends shall not be less than 70 percent of the mid-length diameter.

2.3.1.3 The wall thickness of boom is not to be less than 1/50 of the external diameter of the boom at its midlength and need not be greater than 1/30, but in no case be less than 4 mm

2.3.1.4 The slenderness ratio of the boom is to be obtained from the following formula, and the value obtained is to be no more than 145.

$$\lambda = \frac{L}{\sqrt{J_0/F}}$$

Where: L -- length of boom, in cm, to be measured from the centre of cargo block eyeplate to the hole centre of boom heel;

J_0 -- moment of inertia of mid-length section of boom, in cm^4 ;

F -- area of mid-length section of boom, in cm^2 .

2.3.1.5 The boom head is to be adequately strengthened or increase its thickness in way of the portion where the eyeplates for span tackle, cargo block or preventer guy are fitted.

2.3.2 Materials

2.3.2.1 The steel grade of the materials for derrick booms and their associated fittings are to be hull steels or to comply with a national standard accepted by CCS, which is appropriate to the intended purpose.

2.3.3 Axial compression

2.3.3.1 The permissible axial boom thrust compression P is to be no greater than the value obtained from the following formula:

$$P = \frac{mEJ_0}{nL^2} \times 10^{-5} \quad \text{kN}$$

Where: m -- a coefficient, to be taken in accordance with Table 2.3.3.1, intermediate values to be obtained by linear interpolation;

E -- modulus of elasticity steel, taken as $2.06 \times 10^5 \text{ N/mm}^2$;

L -- boom length, in m, to be measured from the centre of cargo block eyeplate to the hole centre of boom heel, as shown in Figure 2.3.3.1;

J_0 -- moment of inertia of mid-length section of boom, in cm^4 ;

n -- safety factor for the stability of boom, taken as 5.

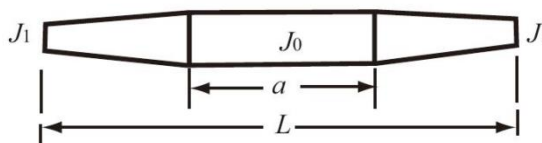


Figure 2.3.3.1 Derrick boom Diagram

		Factor m				Table 2.3.3.1
a/L	J_1/J_0	0	0.2	0.4	0.6	0.8
		Factor m				
0.01		2.55	3.65	5.42	7.99	9.63
0.1		5.01	6.32	7.84	9.14	9.77

0.2	6.14	7.31	8.49	9.39	9.81
0.4	7.52	8.38	9.10	9.62	9.84
0.6	8.50	9.02	9.46	9.74	9.85
0.8	9.23	9.50	9.69	9.81	9.86

Note: 1. a -- the mid-length of boom, in m;

Note: 2. J_1 -- the moment of inertia of the cross section of boom end, in cm^4 ;

2.3.3.2 If the yield strength R_{eH} of steel is greater than 70 per cent of its tensile strength R_m , the yield strength R_{eH} is to be modified, i.e. divided by a coefficient β which is to be taken in accordance with Table 2.3.5. Intermediate values are to be obtained by linear interpolation..

Coefficient

Table 2.3.3.2

Ratio of yield strength to tensile strength R_{eH}/R_m	≤ 0.7	0.75	0.8	0.85
Coefficient β	1.0	1.045	1.084	1.120

2.3.3.3 The end moment at boom head for a conventional derrick rig is to be taken as the algebraic sum of moments in the vertical plane of the derrick boom caused by the span tackle and cargo loads applied to their respective boom head fittings. The horizontal end moments at boom head due to the loads of slewing or preventer guys may, in general, be neglected.

Section 4 MASTS AND DERRICK POSTS

2.4.1 General requirements

2.4.1.1 Structural continuity is to be maintained for the structure of components and any abrupt change of section is to be avoided.

2.4.1.2 Mast and derrick post are to be supported by at least two firm supports and effectively connected to the main hull structure. Deck house may be considered as a deck support provided it has an adequate strength. The hull structure or such deck house in way of the supports shall be reinforced

2.4.1.3 Masts and derrick posts are to be welded to comply with the requirements of 4.2.5 in PART 8.

2.4.1.3 The mast or derrick post is to be adequately reinforced where concentrated loads take place, such as in way of gooseneck bearing, span eye fittings and the fittings for mast stay. The toes of brackets and the corners of fittings are not to be placed on the unstiffened panels of plating. Reinforcement is to be made by increasing plate thickness.

2.4.2 Outer diameter of mast or derrick post

2.4.2.1 The outer diameter D of the mast or derrick post is not to be greater than the value as given by the following formulas:

$$\text{When } t \leq 15\text{mm: } D = 1,000t/(25-t) \text{ mm}$$

$$\text{When } t > 15\text{mm: } D = 100 t \text{ mm}$$

Where: t -- wall thickness of mast or derrick post, in mm.

The minimum wall thickness of mast or derrick post is not to be less than 6 mm; where the mast or derrick is also used as a vent, the minimum thickness is not to be less than 7 mm.

2.4.2.2 It is recommended that the outside diameter of mast or derrick post in way of the span eye fitting should not be less than 85% of that in way of the level at supporting deck.

2.4.3 Strength calculation

2.4.3.1 The forces of span tackle, cargo runner and boom thrust applied to the mast or derrick post are to be calculated (also graphically) in accordance with the relevant requirements as specified in Section 1 and Section 2 of this Chapter, and by which the combined stresses in various sections of mast or derrick post are to be taken into account.

2.4.3.2 When calculating the strength of mast or derrick post, the least favourable combination of loading is, in general, to be considered as follows:

.1 For mast or derrick post with one derrick:

- (1) one derrick plumbing one hatch with lowest boom angle to the horizontal;
- (2) one derrick slewed outboard to its maximum working position.
- .2 For mast or derrick post with two or more derricks:
 - (1) two derrick plumbing one hatch with lowest boom angle to the horizontal;
 - (2) two derricks, the one for forward cargo hold and the other for the aft slewed outboard on one side of the ship to their respective maximum working position;
 - (3) Should it be possible that greater stress will occur at the position of mast or derrick (including stayed mast) other than above, such conditions are to be taken into account.
- 2.4.3.3 The combined stress at any particular section of a mast or derrick post are to be taken as:

$$\sigma_t = \sqrt{(\sigma_b + \sigma_c)^2 + 3\tau^2} \text{ N/mm}^2$$

Where: σ_b -- bending stress, in N/mm^2 ;

σ_c -- compression stress, in N/mm^2 , and in general, the compressive stress due to the self-weight of mast or derrick post can be ignored;

τ -- shear stress due to torque, in N/mm^2 .

2.4.3.4 The safety factor with respect to the yield strength R_{eH} of material for the mast and derrick post, including the crosstree and overhung structure is specified as follows:

- .1 no less than 2.20 for stayed mast;
- .2 no less than 2.0 for unstayed mast, crosstree and overhung structure.

2.4.3.5 The grade of steel used for the manufacture of mast, derrick post and its accessories is the same as that specified by 2.3.2.1 in this PART.

2.4.3.6 The arrangement of mast stays is not to obstruct the operation of derrick rig. Turnbuckles are to be fitted at the bottom of the stays and connected to the eyeplates attached to deck, bulwark or deckhouse.

The stays are to be set up to an initial tension and the prestress is to be approximately 30N/mm^2 .

The modulus of elasticity of wire ropes for the calculation of elongation of stays may be taken as $1.1 \times 10^5 \text{N/mm}^2$ and the sectional area of the rope may be taken as that of its nominal diameter. Greater value of the modulus of elasticity may be taken provided it is obtained from the actual test.

2.4.3.7 The requirements for gantry are the same as those for mast and derrick post. The uprights on the two sides of derrick post for portal frame or A frame gin pole are to be connected with the bottom or side structure after passing through the deck, and the hull structures at the joints are to be strengthened by doubling the plate and brackets. The plate thicknesses of door mast and bipod mast are to be no less than 7mm.

Section 5 AIR-SPACE CABLE CRANE

2.5.1 General requirements

2.5.1.1 The material and safety factor of uprights both ends of air-space cable crane are to comply with the relevant provisions of Section 4 in this Chapter.

2.5.1.2 The material of cable of air-space cable crane is to comply with the relevant provisions of 4.3 in this PART. The safety factor of cable of air-space cable crane is to comply with the provisions of 2.1.4 in this PART.

2.5.1.3 If one end of air-space cable crane is fixed on a superstructure or other hull members, the hull members at this position are to comply with the corresponding strength requirements and are to be strengthened, generally by means of increasing the plate thickness.

CHAPTER 3 MACHINERY, ELECTRICAL INSTALLATIONS AND CONTROL ENGINEERING SYSTEMS

Section 1 GENERAL PROVISIONS

3.1.1 General requirements

3.1.1.1 This Chapter applies to the machinery, electrical installations and control engineering systems for the derrick rigs.

3.1.1.2 The hoisting, luffing, slewing and travelling mechanisms of lifting appliances are to be designed to a recognized standard or in accordance with good engineering practices.

3.1.1.3 Consideration is to be given during design to the additional loads imposed by the static, dynamic loads and environmental effects. Brakes are to be capable of holding a static load of 1.5 times the rated load of the winch.

3.1.1.4 Electrical equipment is to comply with the relevant national or international standards, due consideration being given to the environmental conditions envisaged.

3.1.1.5 Electrical installations are to be designed in accordance with the recognized rules or standards.

3.1.1.6 Control engineering systems are to be provided to ensure the safe operation of lifting appliances and to meet the relevant requirements for the safeguard, alarm, interlocking and control.

3.1.1.7 The direction of movement of the control lever or wheel for the operation of the lifting appliances is to relate logically to the direction of motion controlled with the convention that, if there is a lever type controller, the movement towards the driver corresponds to the upward movement of the load or the jib and the movement towards the right of the driver corresponds to the crane slewing to the right; if there is a wheel type controller, the clockwise movement corresponds to the upward movement of the load or the jib or the crane slewing to the right, and so on.

On or near each control, the function of which is to be identified, there is to be affixed a written notice or symbols which clearly show the directions of movement of the lifting appliances and the neutral position of the controller.

3.1.1.8 The maximum maneuvering force of handle and other components of winches is not to exceed 157N. If pedals are used, it is not to exceed 314N.

3.1.1.9 Maneuvering handwheel or handle with automatic reset is to be provided with obvious grading.

3.1.1.10 Joysticks, handwheels or handles that are not automatic reset are to be provided with stop devices to prevent self-shifting.

3.1.1.11 The set pressure of overflow valve of hydraulic winch is not to exceed the maximum working pressure of hydraulic system, and is to be provided with a safety device to prevent the lifting object from falling down and the boom from losing control when the pressure is lost in the pipeline.

Section 2 CONTROLS AND SAFEGUARDS OF LIFTING APPLIANCES FOR CARGO HANDLING

3.2.1 General requirements

3.2.1.1 Lift appliances for cargo handling are to be provided with the control system to ensure safe and effective control of speed, direction and stopping of the lifting appliance.

3.2.1.2 The control stations are to be arranged such that the operator can observe the operating area of the lifting appliances and the load being lifted.

3.2.1.3 An emergency stop, independent of the controls as required by 4.3.1.1, is to be provided at each control station to stop the motion of the lifting appliances in an emergency. This emergency stop is to be clearly identified and suitably protected to prevent inadvertent operation.

3.2.1.4 An alarm is to operate in the event of failure of the operating power and means are to be provided to automatically hold the lifting appliances and load in position.

For the electric power control system, continuous running of the lift appliances after power failure can be realized only until the control lever return to its neutral position.

3.2.1.5 Indication of the operational status of running and standby machinery, if fitted, is to be provided at each control station.

CHAPTER 4 FITTINGS, LOOSE GEAR AND ROPES

Section 1 GENERAL PROVISIONS

4.1.1 General requirements

4.1.1.1 Fittings, loose gear, wires and ropes are, in general, to be manufactured in accordance with the recognized standards accepted by CCS.

4.1.1.2 The safe working load of Fittings, loose gear is not to be less than that required by the corresponding requirements in the PART for the item in question.

4.1.1.3 The grade of steel selected for the manufacture of the eyeplates, fabricated items and other components described in 4.2.1 in this PART is not to be less than Steel Grade A specified by CCS.

4.1.1.4 Loose gear such as hooks, lifting eyes, swivels and shackles described in 4.2.2 are not to be made of cast iron or cast steel.

4.1.1.5 Steel castings are to comply with the relevant provisions of Section 3, Chapter 5, PART 7; and steel forgings are to comply with the relevant provisions of Section 3, Chapter 4, PART 7.

Section 2 FITTINGS, LOOSE GEAR

4.2.1 Fittings

4.2.1.1 The double-ended eyeplate for attaching the derrick head cargo block at its lower end and the derrick head span block at its upper end as well as the eyeplate for attaching the preventer guy is to be fitted through the centreline of the boom and full-penetration welded on. Use of eyeplates of other construction is to be subject to agreement. The head fitting for slewing guy pendants of light-lift derricks need not be fitted through the boom and may be welded directly on the boom head.

4.2.1.2 Forked fitting at the boom heel may be of steel forging, fabricated item or steel casting, the derrick heel pin is to be fitted with nuts and split cotter pins.

4.2.1.3 Gooseneck bearing bracket may be of fabricated item or steel casting. The gooseneck is to be fitted with retaining ring, through pin and split cotter pin to prevent the gooseneck from being lifted out of the bearing.

4.2.1.4 Topping swivel bearing bracket may be of fabricated item or steel casting and is to be constructed to prevent the vertical locating pin from turning or being lifted out of the bracket.

4.2.1.4 Fixed eyeplates are to be so fitted that transverse bending moment will not occur during operating as far as possible. The type of eyeplates or brackets is to be appropriate to their attached parts. The locations on which the eyeplates are fitted are to have adequate strength and be strengthened if necessary.

4.2.1.6 Scantlings of the fittings for derrick rigs are to comply with the provisions of the relevant rules of or accepted by CCS.

4.2.2 Loose gear

4.2.2.1 Hooks are to be so designed as to prevent ropes from slipping out and prevent hook from catching on the ship's structure or other obstruction when hoisting by means of a hook shelter.

4.2.2.2 Swivels are to be provided between hooks and lifting cargo cables (or short link chains), or hooks with swivels are to be used. Swivels are to be able to rotate freely and prevent from getting loose.

4.2.2.3 The shackle pin end is to be screwed and provided with devices to prevent from getting loose. Shackles used for attaching the hooks are to be provided with countersunk pins.

4.2.2.4 Blocks are to be so constructed as to prevent the rope from jamming between the sheave and side or partition plates by minimizing the clearance or by fitting suitable guards in. Effective lubricating is to be maintained to the blocks during operation. Provision is to be made for lubricating all bearings and swivel head fittings without dismantling the block.

Sheaves for steel wire rope are to be made of steel, and the use of cast iron sheaves is to be specially review by CCS.

Snatch blocks are not to be used in the lifting appliance systems.

The ratio of sheave diameter measured at the bottom of rope groove to the diameter of rope is not to be less than that as given in Table 5.3.4 in Table 4.2.2.4

Ratio of Sheave Diameter to Rope Diameter

Table 4.2.2.4

Sheave use		Sheave diameter/rope diameter	
Wire rope	Derrick rigs, including derrick crane	Running rope	13
	Derrick rigs, including derrick crane	Static ropes	8
Fiber rope		6	

4.2.2.5 The thickness of triangle plates connecting short link chains and cargo runners is to be appropriate to the spacing of jaws of the associated shackle so as to minimize the clearance between them.

4.2.2.6 The construction of rigging screws is to be capable of preventing their end fittings from turning. The end fittings of the rigging screw are to be forged in one piece. The rigging screws of hook type end fittings are not to be used in the lifting appliance system.

4.2.2.7 Chains used as span chain or as part of preventer guy are to be of studless long link chains. Preventer guy with patent is to be fitted with stop device, the distance between the device and the end clip is to be as short as practical and, in general, not greater than one pitch of the clips.

Section 3 ROPES

4.3.1 Characteristics and splicing method of steel wires

4.3.1.1 The nominal breaking strength of the wire is not to be neither less than 1,420N/mm² nor greater than 2,200N/mm². Wire ropes are in general to be constructed of not less than six strands over a main core which may be of fibre or wire core.

4.3.1.2 Wire ropes for running rigging are to be adequately flexible, each strand is, in general, to consist of not less than 19 wires, the strand core may have a fibre or wire core.

The strand core for static ropes is generally of wire. Wire ropes used for air-space cable cranes are to adopt wire strand cores.

4.3.1.3 One of the following methods of splices for wire rope end forming eye or loop are acceptable:

- .1 not less than three tucks with each whole strand of the rope and then not less than two tucks with one half of wires cut from each strand, in all cases the strands to be tucked against the lay of rope;
- .2 four tucks with the whole strands of the rope and one tuck with each alternate strand of the rope, made over and under against the lay of the rope;
- .3 alternative methods of splices will be accepted provided they can be shown to be as efficient, from all aspects, as those described above.

4.3.1.4 As an alternative to splicing, approved clips, clamps, sockets or other type of terminal connections may be used.

4.3.1.5 The lengthening of wire ropes by splicing is not permitted.

4.3.2 Characteristics and splicing methods of fiber ropes

4.3.2.1 Fibre ropes may be made of natural or man-made fibre.

- .1 Man-made fibres are to be adequately stabilized against degradation by ultra-violet light.
- .2 Natural fibres may be manufactured from hemp, manila or sisal.
- .3 Ropes are generally to be three-strand but other constructions will be specially considered.

4.3.2.2 In a derrick system, fiber ropes are generally only allowed to be used for slewing guys tackle (but not pendant) or boom head guys in union purchase rigs.

4.3.2.3 Splicing and terminal connections are to comply with the following:

- .1 natural fibre ropes: eye splicing consisting of not less than three full tucks and two tucks in which half the fibres in each strand have been cut away;
- .2 man-made fibre ropes: eye splicing consisting of not less than four full tucks and two tucks in which half the fibres in each strand have been cut away. The ends of the strands are to be fused.

4.3.2.4 The lengthening of fibre ropes by splicing is not permitted.

CHAPTER 5 TESTING

Section 1 GENERAL PROVISIONS

5.1.1 General requirements

5.1.1.1 Lifting appliances are to be tested before being taken into use for the first time and periodically re-tested after being put into service.

5.1.1.2 Lifting appliances are to be re-tested in service in accordance with the requirements as detailed in 5.4.4 of this PART after any subsequent alteration or repair which may affect the strength of the appliance.

5.1.1.3 Every item of loose gear is to be proof tested in accordance with the requirements as detailed in Section 2 of this PART before being taken into use for the first time or after any subsequent repair or alteration which may affect the strength of the item.

5.1.1.4 Where testing machines are used to apply test loads they are to be calibrated biennially by a recognized unit and the accuracy is to be within ± 2 percent. Where test weights are used to apply test loads, the weights are to be certified as accurate to within ± 2 percent.

5.1.1.5 When serious accidents occur to lifting appliances, the captain or the user department of the fishing vessel is to report them in time for the inspection of the appliances.

5.1.1.6 Where, in testing, lifting appliances are found not meeting the requirements of this Chapter or not in a satisfactory technical condition, they are to be ceased in service or test.

Section 2 TEST FOR LOOSE GEARS

5.2.1 Testing requirements

5.2.1.1 Every item of loose gear is to be proof tested. The proof load applied to each item of loose gear is to be as required by Table 5.2.1.1 and associated notes. Proof load is to be applied to each item with a testing machine or test weight for a duration of not less than 5 min.

Proof Load for Loose Gear			Table 5.2.1.1
No.	Item	Proof load, in kN	
1	Single sheave blocks ¹	4 ×SWL	
2	Multi-sheave blocks ²	2 ×SWL	
3	Chains, hooks, rings, shackles, swivels, etc	2 ×SWL	
Note:			
1. The safe working load for single sheave blocks including single sheave blocks with becketts is to be taken as one half of the resultant load on the head fitting.			
2. The safe working load for a multi-sheave block is to be taken as the resultant load on the head fitting.			

5.2.1.2 After proof testing, each item of loose gear is to be thoroughly examined for deformation, cracks, flaws or other defects and to ensure that its rotating parts can rotate freely.

5.2.1.3 Short and long link chains are to be subjected to a breaking test in addition to the proof test as required in Table 5.2.1.1. In general, a sample of 5 links length is to be taken from each length of chain measuring 55 m and is to withstand a breaking load not less than 4 × SWL for the chain.

Section 3 BREAKING TESTS OF ROPES

5.3.1 Testing requirements

5.3.1.1 The breaking load of wire ropes is to be determined by one of the following methods:

.1 Testing to destruction a sample cut from the complete rope. Before a test sample is cut from the rope, it is to be securely seized or clamped so as to prevent any slacking of wire within the test length. The test sample is to have a length of 36 times the rope diameter. The load applied by the testing machine is to be such that up to 80 per cent of the nominal breaking load may be applied quickly and thereafter the load is to be applied slowly and steadily until the maximum load is attained. Tests in which a breakage occurs adjacent to the grips may be neglected, and a re-test is permitted.

.2 Testing the individual wires to destruction, summing the results by multiplying a coefficient which may be taken as specified in an international standard or other recognized standards.

5.3.1.2 The breaking load of fibre ropes is to be determined by testing to destruction a sample cut from the

complete rope. The minimum length of a test sample, the speed of loading applied by the test machine, and the initial load are to be as given in Table 5.3.1.2. Tests in which a breakage occurs within 150 mm of the grips may be neglected, and a re-test is permitted.

Parameters for Testing of Fibre Ropes**Table 5.3.1.2**

Material	Test length (mm)	Initial load (%)	Speed of loading (mm/min)
Natural fiber	1,800	2	150±50
Man-made fiber	900	1	75±25

Section 4 TESTS FOR LIFTING APPLIANCES

5.4.1 Testing of derricks

5.4.1.1 Each derrick in the system is to be tested with static and dynamic load, and the test procedure is to be subject to agreement. The derrick angle to the horizontal is to be placed in accordance with the approved plans. The test is to be carried out using certified weights suspended from the cargo hook or lifting attachment for a duration not less than 5 min after lifting up the test weights. The test load is to be obtained from the following formula:

$$T_{\text{static}} = SWL \times 1.25 \text{ kN}$$

$$T_{\text{dynamic}} = SWL \times 1.1 \text{ kN}$$

5.4.1.2 During the test, hoisting and slewing operations are to be carried out at slow speed, and simultaneously brake test and emergency brake test are also to be tested for the winch, to check whether the weight can be kept in the original position. The derrick boom is to be slewed as far as possible in both directions during the test.

5.4.1.3 Where derricks have been approved for operation in union purchase, they are to be rigged and tested with a test load in accordance with Table 5.4.1.1, after being tested in accordance with 5.4.1.1 to 5.4.1.2. The test is to be carried out for the headroom, runner angle and the guy positions which are to comply with the approved plans.

5.4.1.4 After completion of testing, the derricks are to be thoroughly examined for deformation or other defects.

5.4.2 Testing of air-space cable crane

5.4.2.1 The lifting test is to be implemented for air-space cable crane, and the hook is to be situated in the working position where the maximum force may appear. The test requirements are the same as those described by 5.4.1 in this PART. The test load is 1.25 times of the safe working load of appliances. At the end of the test, the cable and all the stressed parts are to be examined for deformation or other defects.

5.4.3 Testing of gantry

5.4.3.1 The test load and method are the same as those described by 5.4.1 of this Section.

5.4.3.2 After the test, the gantry and other stressed parts are to be examined for deformation or other defects.

5.4.4 Re-testing of lifting appliances

5.4.4.1 After derricks, air-space cable crane and gantry are put into use, repeated tests are to be provided that the circumstances as specified in 5.1.1.1 and 5.1.1.2 of this PART take place.

5.4.4.2 The test loads, the derrick angle to the horizontal or jib radius, as appropriate for the tests of derricks, air-space cable crane and gantry are to be in accordance with those as specified in 5.4.1.1, 5.4.2.1 and 5.4.3.1.

5.4.4.3 During the re-test of derricks, the test load is to be raised and lowered at slow speed and the brake is to be tested for its effectiveness.

5.4.4.4 Derricks may be re-tested using a spring or hydraulic weighing machine of which the accuracy is to comply with the requirements of 5.1.1.4 and the test load applied is to be at least for a duration of 5 min with the indicator remaining constant.

5.4.4.5 The re-test following any structural repair or alteration which affect the strength of the appliance may be carried out only to demonstrate the strength of the particular item at the discretion of the inspection organization.

5.4.4.6 After re-testing, the lifting appliances are to be examined for deformation or other defects.

5.4.5 Defects that are not allowed

5.4.5.1 The structural member and fittings have the maximum wastage over 10 per cent based on the material thickness, or cracks or permanent deformation, it is not allowed to continue using them.

5.4.5.2 The items of loose gear, such as eyes, links, shanks, straps and hooks, etc., have a wastage over 10 per cent of their original dimensions and a wastage of pins over 6 per cent of their original dimensions, or cracks or permanent deformation, and any breakage or cracks on the sheaves, it is not allowed to continue using them.

5.4.5.3 Excessive wear or corrosion or 5 per cent of broken wires in any length of ten times the rope diameter takes place, it is to be replaced.

5.4.5.4 The brake liner wears excessively and the fastenings securing the liner expose out in the friction surface, it is to be replaced.

5.4.5.5 The transmitting gear tooth is broken or its rim, sprocket or hub is cracked, it is not allowed to continue using them.



China Classification Society

RULES FOR CONSTRUCTION OF OCEAN-GOING STEEL FISHING VESSELS

2018

PART 7 MATERIALS

Effective from 1 December 2018

CHAPTER 1 GENERAL

Section 1 GENERAL PROVISIONS

1.1.1 Application

1.1.1.1 The chemical composition, mechanical properties and heat treatment procedures of hulls, machinery, boilers, pressure vessels and other parts of fishing vessels are to comply with the relevant provisions of this PART.

Section 2 TESTING AND SURVEY

1.2.1 Chemical composition

1.2.1.1 Manufacturers producing marine materials are to determine the chemical composition of test samples correctly.

1.2.1.2 The chemical analysis report of such a manufacturer may be accepted by CCS. Recheck may be requested if there is any doubt about the chemical composition of marine materials. The deviation between composition analysis of marine materials and sampling analysis of furnace pots is to comply with the accepted standards.

1.2.2 Mechanical tests

1.2.2.1 The dimensions, number as well as location and direction of the mechanical test specimens are to comply with the requirements of Chapter 2 and subsequent Chapters of this PART.

1.2.2.2 Where Charpy impact tests are required, a set of three test specimens is to be prepared and the average energy value is to comply with the relevant requirements of subsequent Chapters of this PART. One individual value may be less than the required average value provided that it is not less than 70% of that value.

1.2.3 Re-test procedures

1.2.3.1 For materials not required to be subjected to impact test, where the result of any mechanical test does not comply with the requirements, two additional tests of the same type may be carried out. For acceptance of the material, satisfactory results are to be obtained from both of these additional tests.

1.2.3.2 Where the results from a set of three impact test specimens do not comply with the requirements, an additional set of three impact test specimens may be taken provided that, of the original set tested, not more than two individual values are less than the required average value and, of these, not more than one is less than 70% of this average value. The results obtained are to be combined with the original results to form a new average which, for acceptance, is to be not less than the required average value. Additionally, for these combined results, not more than two individual values are to be less than the required average value and, of these, not more than one is to be less than 70% of this average value.

1.2.3.3 The additional tests detailed in 1.2.3.1 and 1.2.3.2 in this PART are to be made on material adjacent to the original samples. For castings, where insufficient material remains in the original test samples, the additional tests may be made on other test samples representative of the castings.

1.2.3.4 When unsatisfactory results are obtained from the additional tests detailed in 1.2.3.1 and 1.2.3.2 in this PART, the item or piece from which the specimens were taken is to be rejected. The remainder of the material in the batch may be accepted provided that two further items or pieces are selected and completely tested with satisfactory results. If the tests from one of these additional items or pieces give unsatisfactory results, the batch is to be rejected.

1.2.3.5 When a batch of material is rejected, the remaining items or pieces in the batch may be re-submitted individually for test, and those which give satisfactory results may be accepted. At the discretion of the manufacturer, the rejected batch may be re-submitted for complete re-tests after a heat treatment in accordance with the requirements of 1.3.1.2 in this PART and may then be accepted, provided that the test results are satisfactory. When unsatisfactory results are obtained from such tests, additional tests may be carried out in accordance with 1.2.3.1 and 1.2.3.2 in this PART. Where such re-tests again fail, the batch is not permitted to be re-submitted for acceptance.

1.2.4 Defect treatment

1.2.4.1 The material is to be free from harmful internal and external defects which will impair its future use.

The defects are to be determined in accordance with the accepted standards.

1.2.4.2 Small surface imperfections may be removed by mechanical means. Under appropriate conditions, repairs by welding may also be accepted provided that the relevant requirements in subsequent Chapters of this PART are complied with. In addition, the extent and method of repair are to be approved by CCS.

Section 3 HEAT TREATMENT

1.3.1 General requirements

1.3.1.1 Marine materials are to be supplied in the condition as specified in relevant Chapters of this PART. Important forgings or castings are to be subjected to heat treatment. The heat treatment procedures are to be developed by the manufacturers and submitted to CCS for information.

1.3.1.2 Heat treatment is to be carried out in properly constructed furnaces operating satisfactorily and having adequate means for the control and recording of temperature. The furnace dimensions are to be such as to allow the whole item to be uniformly heated to a specified temperature. In the case of very large components which require heat treatment, suitable alternative methods may be adopted. However, such methods are to be proved feasible.

CHAPTER 2 MECHANICAL TESTS AND TECHNOLOGICAL TESTS

Section 1 GENERAL PROVISIONS

2.1.1 Application

2.1.1.1 The provisions of this Chapter apply to the general mechanical tests (including tensile test, impact test, hardness test, creep test and other tests) and technological tests (including bend test, flattening test, expanding test, flanging test and other tests) of marine metallic materials. Tests other than those specified in this Chapter may be carried out in accordance with the relevant requirements of subsequent Chapters of this PART or relevant accepted standards.

2.1.2 Test material

2.1.2.1 Test material is the material used for the preparation of specimens for tests. Unless otherwise specified, all test materials are to be selected by CCS. The test material is to be so selected as to be representative of the quality of the item or batch as far as possible.

2.1.2.2 Where a certain treatment (for instance heat treatment) might affect the property of the material, the test material is to be subjected to the same treatment as the original material.

2.1.3 Preparation of test specimens

2.1.3.1 Test specimens are to be prepared in such a manner that the properties of the original material are not affected. During preparation of rolled metal specimens, the original rolled surfaces are to be retained as far as possible, or they are to be close to the original rolled surfaces as far as possible.

2.1.3.2 Where test material is cut from products by shearing or heat cutting, a reasonable margin is required to allow sufficient material to be removed from the cut edges during machining of the test specimens.

2.1.3.3 Test specimens are not to be subjected to any significant cold straining or heating during straightening or machining.

2.1.4 Testing machines

2.1.4.1 All tests are to be performed by qualified personnel on approved types of testing machines. Testing machines are to be maintained in a satisfactory and accurate condition and are to be calibrated as per the prescribed time intervals. Calibration is to be organized and conducted by a state-recognized measurement institution or any other standard organization. All calibration records are to be fully preserved in its laboratory for verification by CCS.

2.1.4.2 The measurement accuracy errors of tensile testing machine and impact testing machine are not to exceed $\pm 1\%$.

2.1.5 Discarding of test specimens

2.1.5.1 If a test specimen fails because of faulty preparation or incorrect operation of the testing machine, it may be discarded and replaced by a new test specimen prepared from material adjacent to the original test material.

2.1.5.2 A tensile test specimen may be discarded and a new specimen is to be prepared for re-test when the specified minimum elongation is not obtained and the distance between the fracture and the nearest gauge mark is less than 1/3 of the original gauge length.

2.1.6 Test temperature

2.1.6.1 Except for impact tests, the mechanical and technological tests are generally carried out at the room temperature (18 °C~25 °C), if it is not specified otherwise in the subsequent Chapters.

Section 2 TENSILE TESTS

2.2.1 General requirements

2.2.1.1 The mechanical properties of marine metallic materials such as tensile strength R_m , yield strength R_{eH} ,

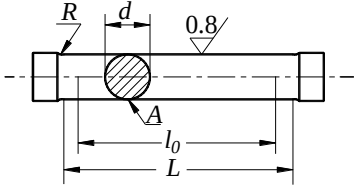
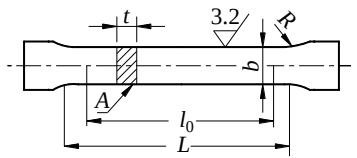
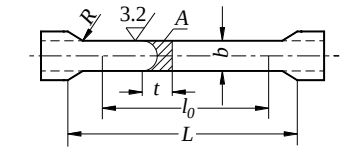
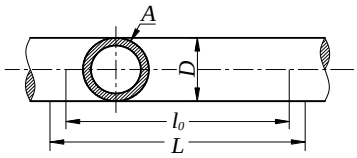
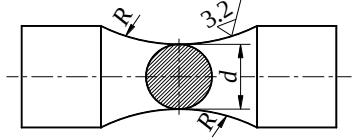
elongation A_5 and reduction in area Z are to be determined by a tensile test.

2.2.2 Specimens

2.2.2.1 Tensile specimens are to be of the type and dimensions as given in Table 2.2.2.1. Both ends of the test specimen may be machined to suit the grips of the testing machine used.

Type and Dimensions of Tensile Specimens

Table 2.2.2.1

Item	Type of specimen	Dimensions of specimen (mm)	Applicable materials
1		(1) $l_0 = 5d$, $d \geq 10$, $L = l_0 + 0.1l_0$, $R \geq 10$	Rollings, forgings, castings (except for grey cast iron) and pipes with wall thickness of more than 16mm
		(2) $l_0 = 70$, $d = 14$, $L \approx 85$, $R \geq 10$; for spheroidal or nodular graphite cast iron and materials with a specified elongation of less than 10%: $R \geq 20$	
		(3) $l_0 = 5d$ (d means diameter), $L = l_0 + d$, $R \geq 10$; for spheroidal or nodular graphite cast iron and materials with a specified elongation of less than 10%: $R \geq 1.5d$	
2		(1) $l_0 = 5.56\sqrt{A}$, t means plate thickness, $b = 25$, $L \approx l_0 + 2\sqrt{A}$, $R \geq 25$	Steel plates and profiles (Chapter 3 in this PART)
		(2) $l_0 = 200$, t is plate thickness, $b = 25$, $L \approx 225$, $R \geq 25$	—
		(3) $l_0 = 50$, t means plate thickness, $b = 12.5$, $L \approx 70$, $R \geq 25$	Aluminum plates and profiles with a thickness of not more than 12.5mm (Chapter 8 in this PART)
3		$l_0 = 5.65\sqrt{A}$, t means plate thickness, $b = 25$, $L = 2b$, $R \geq 25$ The test specimen is to be cut longitudinally. The parallel test length is not to be flattened, but the enlarged ends may be flattened for gripping in the testing machine.	Steel pipes and copper pipes
4		$l_0 = 5.65\sqrt{A}$ or 50, $L \approx l_0 + D$ Both ends of a pipe are to be blocked Where: L is the distance between the two ends	Steel pipes and copper pipes
5		$b = 20$, $R \geq 25$ Specimens are to be prepared from the components under test. Specimens with a diameter of 30mm can be separately casted with grey cast iron	Grey cast iron

Where: l_0 -- original gauge length, in mm;

L -- parallel length of the parallel segment of specimen, in mm;

A -- original cross-sectional area of the parallel segment of specimen, in mm².

Note: 1. Specimens of plates, flats and sections are to be processed into the dimensions as shown by serial number 2 in the table. For full-thickness specimens, where the testing machine capacity is insufficient, a rolled surface can be processed to reduce the thickness to 25mm.

2. In addition to the specimens specified in the table, other specimens approved by CCS can also be used.

2.2.2.2 After machining of tensile specimens, dimensional tolerances of tensile specimens are to comply with the requirements of the accepted standards.

2.2.3 Testing

2.2.3.1 Testing at room temperature:

- 1 When determining the upper yield strength or proof strength of steel products, the elastic stress rate is not to exceed 30N/mm² per second; for non-ferrous metals, it is not to exceed 10N/mm² per second. After reaching the yield load, when determining the tensile strength of plastic materials, the maximum strain rate is not to exceed 40% of the original gauge length per minute; for brittle materials, when determining the tensile strength of spheroidal or nodular graphite cast iron, the stress rate is not to exceed 10N/mm² per second;
- 2 The yield strength of steel products is specified as follows:

- For carbon, carbon-manganese and alloy steel products and welding consumables, either the upper yield strength or stress ($R_{p0.5}$) at the non-proportional elongation being 0.5% is to be determined;
- .3 For steel, the upper yield strength is to be calculated according to the following:
 - (1) the instantaneous load before the ranging rod of the testing machine falls down significantly;
 - (2) the instantaneous load before the pointer returns or the load when the pointer stops;
 - (3) the value of load measured either at the commencement of plastic deformation at yield or at the first peak obtained during yielding even when that peak is equal to or less than any subsequent peaks observed during plastic deformation at yield, as shown in a load/extension diagram;
 - .4 When the yield phenomenon of steel products is not obvious, 0.5% and/or 1.0% of the specified non-proportional elongation under the load are/is to be calculated by the load corresponding to the total elongation equal to 0.5% or 1.0% of the original gauge length. At this point, the elongation is to be measured by appropriate extensometer or divider;
 - .5 The non-proportional elongation is to be determined from an accurate load/extension diagram by drawing a line parallel to the straight elastic portion and distant from it an amount representing 0.2% or 1.0% of the extensometer gauge length. The point of intersection of this line with the plastic portion of the diagram represents the load for calculation of the proof strength (0.2% or 1.0%).
- 2.2.3.2 Testing at elevated temperatures ($\geq 50^\circ\text{C}$):
- .1 The test specimens used for determination of lower yield strength or the 0.2% proof strength at elevated temperatures are to have an gauge length l_0 of not less than 50 mm and a cross-sectional area A of not less than 65 mm^2 . Where this is precluded by the dimensions of the product or by the capacity of the test equipment available, the test specimen is to be of the largest practicable dimensions.
 - .2 The heating apparatus is to be such that the temperature of the specimen during testing does not deviate from that specified by more than $\pm 5^\circ\text{C}$.
 - .3 The straining rate when approaching the yield strength or proof strength is to be controlled within the range of 0.1% to 0.3% of the original gauge length per minute.
 - .4 The time intervals used for estimation of straining rate from measurements of strain are not to exceed 6s.

2.2.4 Equivalent elongation

2.2.4.1 Where the actual specimen gauge length is not $5.65\sqrt{A}$, in order to determine whether the elongation of material is in line with the minimum elongation when $l_0 = 5.65\sqrt{A}$ as specified by the sections/chapters in this PART, equivalent elongation of specimen $\delta_E(\%)$ corresponding to gauge length of $5.65\sqrt{A}$ is to be calculated according to the following formula:

$$\delta_E = 2[\delta]\left(\frac{\sqrt{A}}{l}\right)^{0.4}$$

Where: A -- original cross-sectional area of the parallel segment of specimen in mm^2 ;

$[\delta]$ -- minimum elongation value when $l_0 = 5.65\sqrt{A}$ as specified by the sections/chapters in this PART, in %;

l -- gauge length of specimen, in mm.

During testing, the elongation actually measured is not to be less than the specified minimum equivalent elongation.

2.2.4.2 The above conversion is applicable only to carbon, carbon-manganese and low alloy steels with a tensile strength not exceeding 700N/mm^2 in the hot rolled, annealed, normalized, or normalized and tempered conditions. For carbon, carbon-manganese and low alloy steels with a tensile strength exceeding 700N/mm^2 in other delivery conditions as well as for other materials, the minimum equivalent elongation is to be additionally calculated in accordance with recognized methods.

Section 3 BEND TESTS

2.3.1 General requirements

2.3.1.1 The bend test is normally used for the examination of the bend deformation property and metallurgical defects of metallic materials.

2.3.1.2 The bend test is to bend slowly a test specimen on a press machine at room temperature with an angle α using a former having a diameter D as required by the relevant Sections of this Chapter. After bending, the test specimens are to be examined by naked eye or by the aid of a five-fold magnifying glass for surface defects on the outside of the bend portion, such as cracks or laminations.

2.3.2 Test specimens

2.3.2.1 Bend test specimens are to be of the dimensions given in Table 2.3.2.1 in accordance with the type of materials.

Dimensions of Bend Test Specimens

Table 2.3.2.1

Item	Dimensions of test specimen (mm)	Applicable materials
1	Specimen thickness $t = t_m$, specimen width $b = 2t \pm 2$, specimen length $L = 5t + 150$, specimen fillet radius $r=1\sim 2$ Where, t_m means specimen thickness	Rolled material
2	Specimen thickness $t = t_m$, specimen width $b = 5t \pm 2$, specimen length $L = 5t + 150$, specimen fillet radius $r=1\sim 2$ Where, t_m means specimen thickness	
3	Specimen diameter $d = d_m$, specimen length $L = 5d + 150$ Where, d_m means specimen diameter	
4	Specimen thickness $t = 20$, specimen width $b = 25$, specimen length $L \geq 9t + D$, specimen fillet radius $r=1\sim 2$ Where, D pressure head diameter	Cast/forged steel material

2.3.2.2 The original surfaces of the bend test specimens are to be retained as far as possible. Where the capacity of the test machine is restricted, the thickness of plate specimens may be reduced to 25 mm by machining on the compression side while the side in tension is to be the original surface, and round bar specimens may be machined to a diameter of 35 mm.

Section 4 IMPACT TESTS

2.4.1 Impact test specimens

2.4.1.1 Impact test specimens are to be of the Charpy V-notch type or Charpy U- notch type, as shown in Figure 2.4.1.1. The dimensions and tolerances of the specimens are to comply with the requirements of Table 2.4.1.1.

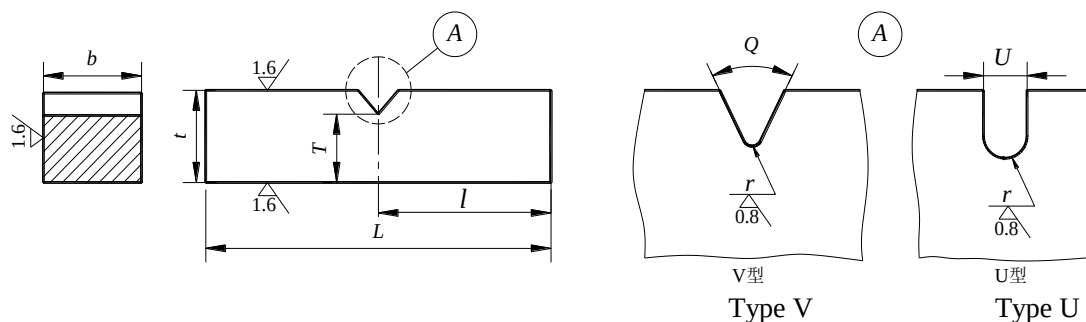


Figure 2.4.1.1 Impact Test Specimens

2.4.1.2 The position and direction of cutting of the impact test specimens are to comply with the relevant requirements of this PART. The specimens are generally to be near-surface specimens. The notch of the test specimen is generally to be perpendicular to the original surface of the piece, and the position of the notch is not to be nearer than 25 mm to a flame-cut or sheared edge.

2.4.1.3 For materials with a thickness of less than 10mm, a standard subsidiary test specimen is to be made as large as possible, and the notch direction is to be perpendicular to the rolled surface. The width of the standard subsidiary test specimen and the conversion relationship of the impact energy of the standard specimen are as shown in Table 2.4.1.3. For materials with a nominal thickness of less than 6mm, impact test is generally not to required..

Dimensions of Impact Test Specimens

Table 2.4.1.1

Item	Designation	Charpy V-notch specimen		Charpy U-notch specimen	
		Nominal dimension	Tolerance	Nominal dimension	Tolerance

Length (mm)		<i>L</i>	55	±0.6	55	±0.60
Width (mm)	Standard specimen	<i>b</i>	10	±0.11	10	±0.11
	Standard subsidiary test specimen	<i>b</i> <i>b</i>	7.5 5	±0.11 ±0.06	—	—
Thickness (mm)		<i>t</i>	10	±0.06	10	±0.11
Angle of notch (°)		<i>Q</i>	45	±2	—	—
Width of notch (mm)		<i>u</i>	—	—	2	±0.14
Depth below notch (mm)		<i>T</i>	8	±0.06	5	±0.09
Root radius of notch (mm)		<i>r</i>	0.25	±0.025	1	±0.07
Distance of notch from end of test specimen (mm)		<i>l</i>	27.5	±0.42	27.5	0.42
Angle between plane of symmetry of notch and longitudinal axis of test specimen (°)		—	90	±2	90	±2

Conversion

Table 2.4.1.3

Width of standard subsidiary specimen (mm)	Conversion ratio with impact energy of standard specimen
7.5	5/6
5	2/3

2.4.2 Testing

2.4.2.1 All the impact tests are to be carried out on pendulum-type impact testing machines approved by CCS, and the specifications of the testing machines are to comply with the requirements of Table 2.4.2.1.

Specifications of Testing Machines

Table 2.4.2.1

Maximum impact energy of testing machine (J)	≥150
Distance between supports (mm)	40 ^{+0.5} ₋₀
Radius of curvature of supports (mm)	1.0~1.5
Taper of supports	1:5
Angle of the tip of hammer (°)	30±1
Radius of curvature of the tip of hammer (mm)	1.0~2.5
Speed of hammer at the moment of striking (m/s)	4.5~7.0

2.4.2.2 Impact tests are to be carried out at specified test temperatures. Where the test temperature is not room temperature, the temperature of the test specimen is to be strictly controlled. Test specimens are to be kept at the specified test temperature for at least 5 min, and to be hammered within 5 s after being taken out so that the temperature of the test specimen at the moment of fracture is within the range of ±2°C of the specified test temperature.

Section 5 DUCTILITY TEST FOR PIPES AND TUBES**2.5.1 Flattening tests**

2.5.1.1 The test specimens are to be cut with the ends perpendicular to the axis of the pipe or tube; the lengths of specimens are to be equal to 1.5 times of the outer diameters of pipes, but not less than 10mm and not more than 100mm.

2.5.1.2 Testing is to be carried out at room temperature and is to consist of flattening the specimen in a direction perpendicular to the longitudinal axis of the pipe. Flattening is to be carried out between two parallel plain rigid platens which extend over both the full length and the full width after flattening of the test specimen. Flattening is to be continued until the distance between the platens, measured under load, is not greater than the value given by the formula:

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

Where: *H* -- distance between two parallel plates (mm);

t -- thickness of the pipe (mm);

D -- external diameter of the pipe (mm);

c –constant dependent on the steel type and detailed in the specific requirements (see Chapter 7 of this PART).

After flattening, the specimens are to be free from cracks or other flaws. Small cracks at the ends of the test specimens may be disregarded.

2.5.1.3 For welded pipes or tubes, the weld is to be placed at 90° to the direction of flattening.

2.5.2 Drift expanding tests

2.5.2.1 The test specimens are to be cut with the ends neat and perpendicular to the axis of the pipe or tube. The lengths of specimens are to be equal to 1.5 times of the outer diameters of pipes, but not less than 50mm; the edges of the end are to be rounded properly.

2.5.2.2 Testing is to be carried out at room temperature by forcing a hardened conical steel mandrel having a angle of 45° or 60° into the end in alignment with the axis of the tube (as shown in Figure 2.5.2.2), thus expanding the end of the tube to an external diameter as required in relevant Chapters of this PART. The mandrel is to be lubricated, but there is to be no rotation of the tube or mandrel during the test. The expanded portion of the tube is to be free from cracks or visible flaws after testing.

2.5.3 Flanging tests

2.5.3.1 The test specimens are to be cut with the ends perpendicular to the axis of the pipe or tube. The lengths of specimens are to be at least equal to the outer diameters of the pipe or tube. The edges of the end to be tested are to be rounded properly.

2.5.3.2 Testing is to be carried out at room temperature and is to consist of flanging the end of the tube by means of a hardened conical steel mandrel aligned to the center lines of pipes (See (1) and (2) in Figure 2.5.3.2). The percentage increase in the external diameter of the end of the specimens is to be as required in relevant Chapters of this PART. The cylindrical and flanged portion of the tube is to be free from cracks or visible flaws after testing.

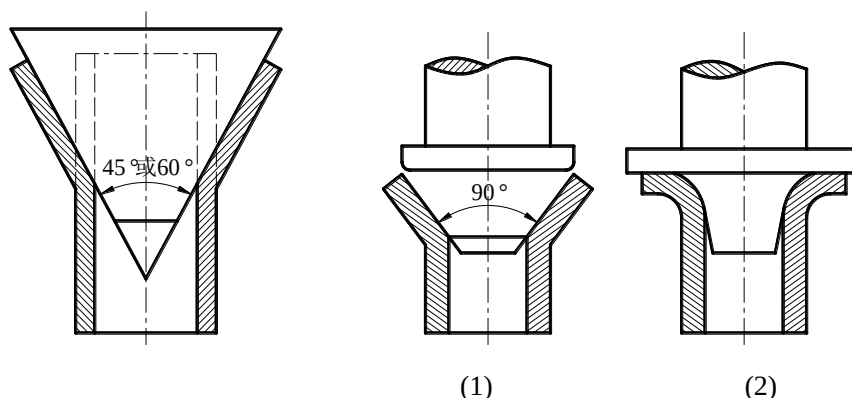


Figure 2.5.2.2 Drift Expanding Test of Tube Figure 2.5.3.2 Flanging Test

2.5.4 Bend tests

2.5.4.1 Steel pipe is to be cut lengthwise into a specimen. The specimen is to be capable of bending at the specified bending radius and angle.

2.5.4.2 For a steel pipe with an outer diameter of not less than 200mm, the test specimens are to be cut as circumferential strips of full wall thickness and with a width of not less than 40 mm when restricted by test conditions. For thick walled pipes, the thickness of the test specimens may be reduced to 20 mm by machining. The edges of the specimens may be rounded to a radius of 1.6 mm. During testing, the diameter of the former is to be selected in accordance with the provisions of Chapter 7 of this PART. The specimen is to be bent to an angle of 180° in the direction of the original curvature.

2.5.4.3 Testing is to be carried out at room temperature. After bending, the specimens are to be free from cracks or laminations.

Section 6 INTERGRANULAR CORROSION TESTS OF STAINLESS STEEL

2.6.1 General requirements

2.6.1.1 Intergranular corrosion tests of stainless steel are mainly used to evaluate basic corrosion-resisting properties of austenitic stainless steels and austenitic/ferritic duplex stainless steels.

2.6.2 Preparation of test specimens

2.6.2.1 The material for the intergranular corrosion test of stainless steel is to be taken adjacent to that for the tensile test.

2.6.2.2 The specimen for intergranular corrosion test is to be rectangular or circular section bending specimen with a thickness or diameter of not greater than 12mm. For small-diameter pipes or tubes, test pieces may be cut directly as the specimen for flattening test. The total surface area of specimen is to be within the range of 12~35cm².

2.6.3 Testing

2.6.3.1 The corroding media solution used for the test is to be prepared by placing 100g copper sulfate (CuSO₄•5H₂O) in 100ml sulfuric acid with a density of 1.84g/ml and then diluting it to 1L with distilled water.

2.6.3.2 Fine copper turnings are to be put into a test vessel to form a bed of copper turnings, and the ratio of the copper turnings to the solution is at least 50 g/L.

2.6.3.3 Cleaned specimens are to be heated to a temperature of $700 \pm 10^{\circ}\text{C}$ for 30min, followed by rapid cooling in water. They are then to be positioned on the bed of copper turnings in the test vessel, and soaked in boiling corroding media solution for 15h to 24h. Precautions are to be taken to prevent concentration of the solution by evaporation.

2.6.3.4 After immersion, each test specimen is to be bent 90° with 2 times of specimen diameter or thickness as the diameter of former at ambient temperature. Test specimens of small-diameter pipes/tubes may be subject to flattening tests as required by Section 5 of this Chapter.

2.6.3.5 After bending or flattening, the stretched surfaces of the test specimens are to be free from cracks (cracking at edges, and the appearance of deformation lines, wrinkles, or “orange peel” on the surface are all disregarded).

Section 7 CRACK TIP OPENING DISPLACEMENT (CTOD) TESTS FOR METALLIC MATERIALS

2.7.1 General requirements

2.7.1.1 This Section applies to the crack tip opening displacement (CTOD) tests for metallic materials and welding consumables.

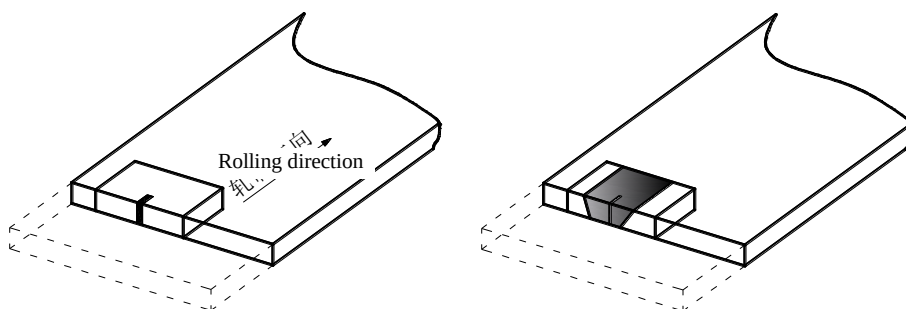
2.7.1.2 This Section applies to CTOD test using specimens in three point bending.

2.7.1.3 CTOD test is to use a testing machine with controllable loading rate and displacement-load synchronous recording device, and the data of test process are to be recorded automatically.

2.7.1.4 In addition to the provisions in this Section, other test methods may be used to determine CTOD values of metallic materials subject to prior agreement.

2.7.2 Specimen preparation

2.7.2.1 Unless specified in an agreement, the sampling direction for raw metal specimens is usually to be such that the notch is parallel to the rolling direction of the plate and perpendicular to the through-thickness direction of the plate (Figure 2.7.2.1 (1)); the sampling direction for deposited metal specimens is to be such that the notch is parallel to weld direction and perpendicular to the through-thickness direction (Figure 2.7.2.1 (2)).



(1) Sampling Direction of Plate

(2) Sampling Direction of Deposited Metal

Figure 2.7.2.1 Sampling Direction of Specimens

2.7.2.2 Unless agreed otherwise, tests are to be made on specimens of the full section thickness. Main dimensions of specimens are to comply with the provisions in Figure 2.7.2.2 and Table 2.7.2.2 and other dimensions are to comply with the requirements of recognized standards.

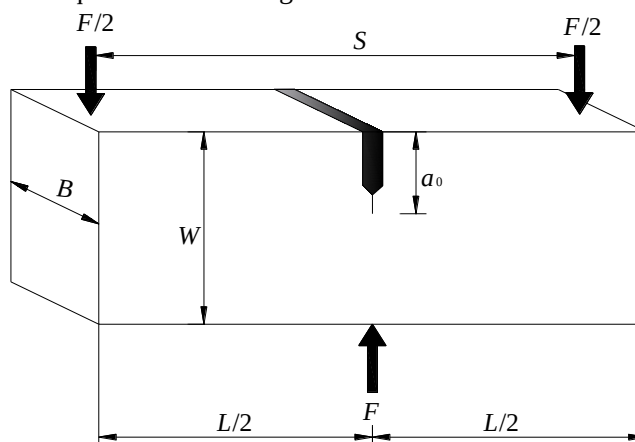


Figure 2.7.2.2 Dimensional Drawing of CTOD Specimens

Dimensions of CTOD Specimens

Table 2.7.2.2

Name	Symbol	Rectangular specimens	Square specimens	Deviation
Specimen width	B	B	B	$\pm 0.5\% B$
Specimen height	W	$2B$	B	$\pm 0.5\% W$
Fulcrum span	S	$4W$	$4W$	$\pm 0.5\% S$
Specimen length	L	$\geq 4.5W$	$\geq 4.5W$	—
Effective crack length	a	$0.45W \sim 0.55W$	$0.45W \sim 0.55W$	—

Note: For specimens of deposited metal test, the range of effective crack length may be $0.45W \sim 0.70W$.

2.7.2.3 Specimens are to be processed by means of machining. The length center of the specimen is to be machined (wire-cutting) with notch, and the radius of notch tip is not to be greater than 0.08 mm. Then fatigue cracks are to be prepared on a fatigue testing machine to specified effective crack length of the specimen. The difference between the two crack length measurements on the surfaces of the specimen, measured to ± 0.05 mm, is not to exceed 15% of the average of the two measurements. The minimum fatigue crack extension is not to be below $0.025W$, nor less than 1.3 mm. On preparing fatigue crack, circulating forces applied on the specimen are usually to comply with the following:

$$F_{\max} = kBW(R_{p0.2} + R_m) \quad \text{N}$$

Where: k -- loading coefficient, to be not more than 0.016 for steel and between 0.0117 and 0.0145 for weld;

B -- specimen width, in mm;

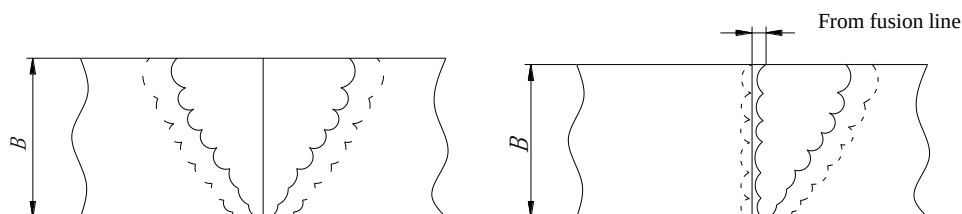
W -- specimen height, in mm;

$R_{p0.2}$ -- proof strength of test material, in N/mm^2 ;

R_m -- tensile strength of test material, in N/mm^2 .

2.7.2.4 When it is necessary to determine the fracture toughness in the heat affected zone of a weld, material of the maximum thickness applicable to the welding method used with K, single V or J type weld preparation is recommended.

2.7.2.5 The location and orientation of specimen notch may be selected based on test purpose and according to Figure 2.7.2.5.



(1) For evaluating deposited metal

(2) For evaluating heat affected zone of parent material

Figure 2.7.2.5 Location and Orientation of Specimen Notch

2.7.2.6 The specimen notch may be grooved or fitted with a knife-edge support according to Figure 2.7.2.6 to place a displacement gauge (clip-on extensometer). The distance between knife edge and upper surface of the

specimen is to be measured and recorded.

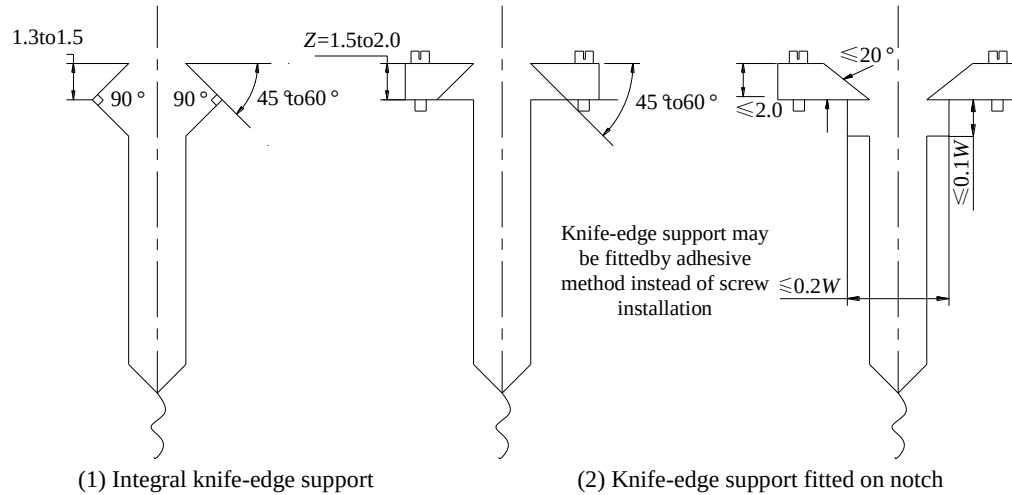


Figure 2.7.2.6 Specimen Slotting and Installation of Knife-Edge Support

2.7.3 Tests

2.7.3.1 CTOD tests are to be carried out in laboratories acceptable to CCS.

2.7.3.2 During test, specimen temperature is to be controlled to an accuracy of $\pm 2^\circ\text{C}$ of specified value, and the temperature is to be measured in a region not further than 2 mm from the crack tip.

2.7.3.3 Displacement gauges with good linearity and accuracy are to be used for test, and their full-scale ranges are to satisfy the need of expected crack opening displacement measurement and linear deviation is not to be more than $\pm 1\%$. The displacement gauge is to be calibrated once every day of testing before the test, and if multiple tests are to be carried out during the day, at intervals of no more than 10 tests. It is to be demonstrated that the calibration is satisfactory for the test conditions.

2.7.3.4 The displacement gauge is to be placed steadily at knife-edge support of the specimen and its design is to allow free rotation of the points of contact between the gauge and knife edges. When test is carried out in temperature medium, the effect of temperature medium on displacement measurement is to be minimized.

2.7.3.5 The test procedure and the evaluation of test results are to be in compliance with the accepted standards.

2.7.4 Test requirements

2.7.4.1 After test, the fracture surface of each specimen is to be examined and measured, and the effectiveness of the specimen is to be evaluated according to the requirements of 2.7.4.2 and 2.7.4.3 below. For each test, there are to be at least 3 effective specimens.

2.7.4.2 The specimen is to satisfy the following requirements; otherwise, the specimen is to be regarded as invalid:

- .1 the fatigue crack front is in a single plane;
- .2 any part of the fatigue crack surface lies in a plane whose angle with the plane of the notch does not exceed 10° ;
- .3 the length of any part of the fatigue crack is more than $0.025W$ or 1.3 mm, whichever is the greater;
- .4 as shown in Figure 2.7.4.2.4, the length of fatigue crack front is measured respectively at 9 locations in the through-thickness direction of the specimen and the weighted average length a_0 is calculated according to the following formula, with the difference between the maximum and minimum lengths of original fatigue crack not exceeding $0.1a_0$.

$$a_0 = \frac{1}{8} \left(\frac{a_{01} + a_{09}}{2} + \sum_{i=2}^8 a_{0i} \right)$$

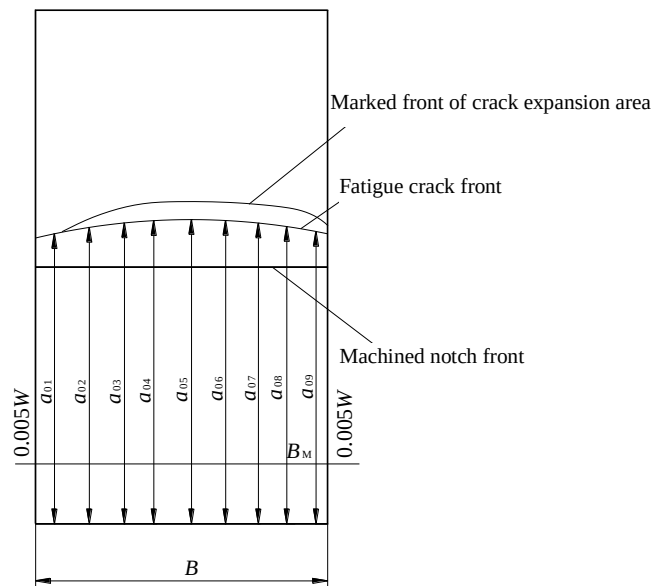


Figure 2.7.4.2.4 Length Measurement of Fatigue Crack Front

2.7.4.3 In addition to 2.7.4.2, tests on deposited metal and heat affected zones (HAZ) are to comply with the following requirements:

- .1 for specimens of grain coarsened HAZ, the front of fatigue crack is to be within 0.5 mm of the fusion line and all of the grain coarsened HAZ present is to be sampled. However, if fusion line irregularities prevent this, a sample including as much grain coarsened HAZ as possible may be accepted;
- .2 for test specimens of other structures of HAZ, the fatigue crack is to be in the expected region of the HAZ so far as practicable. However, if fusion line irregularities prevent this, a sample including as much relevant microstructure as possible may be accepted.

2.7.5 Test reports

2.7.5.1 CTOD test report is to include:

- .1 details of the material, its condition and size;
- .2 the thickness and width of the test specimen;
- .3 the fatigue pre-cracking conditions;
- .4 the test temperature and environment;
- .5 the test machine control system and rate of change of displacement or load;
- .6 crack length measurements;
- .7 force/displacement ($F \sim V$ curve) records, preferably in the form of an autographic record;
- .8 the critical crack opening displacement;
- .9 a photograph of the fracture;
- .10 any observation on the fracture surface.

Section 8 PITTING CORROSION TEST FOR DUPLEX STAINLESS STEELS

2.8.1 General requirements

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

2.8.2 Preparation of test specimens

2.8.2.1 An original surface of the specimen is to be kept as far as possible. For flat products, a specimen is recommended to be approximately 25 mm by 50 mm by (1.5 mm to 5.0 mm). Other product forms may be cut for test specimens convenient for testing. For weld joints, weld reinforcement is to be removed.

2.8.2.2 Specimens are generally taken by machining. After the specimens are cut, any material that may have been affected by high temperature or deformation associated with the cutting is to be removed by machining or grinding prior to testing.

2.8.2.3 All surfaces of the specimen are to be polished to a uniform finish. Polishing is to be performed

slowly to prevent overheating.

2.8.2.4 The dimensions of the specimen are measured, and the total exposed surface area is calculated.

2.8.2.5 The specimen is to be cleaned, dipped in alcohol or acetone, and air dried.

2.8.2.6 The specimen is to be weighed to the nearest 1 mg or better.

2.8.3 Test procedures

2.8.3.1 The test solution is prepared by dissolving 100 g of reagent-grade ferric chloride, $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$, in 900 ml of distilled water (approximately 6% FeCl_3 by weight). The pH of the test solution is to be adjusted to approximately 1.3 prior to beginning the test by the addition of HCl or NaOH, as required.

2.8.3.2 Fill the test container with the required volume of at least 0.2 ml/mm² of the specimen surface area, submerge the specimen, transfer it to the constant temperature bath, and allow it to come to equilibrium at the desired test temperature. Test temperatures for different materials are shown in Table 2.8.3.2.

Test Temperature for Different Duplex Stainless Steel Base Material and Weld Table 2.8.3.2

Grade	Uniform number	Condition	Test temperature (°C)
022Cr22Ni5Mo3N	S22253	Base metal	25
		Weld metal	22
022Cr23Ni5Mo3N	S22053	Base metal	25
		Weld metal	22
03Cr25Ni6Mo3Cu2N	S25554	Base metal/weld metal	40
022Cr25Ni7Mo4N	S25073	Base metal/weld metal	40

2.8.3.3 Place the specimen in the glass cradle and immerse it in the test solution for 24 h once the temperature has been established. Cover the test container with a watch glass during the test period. Maintain the test temperature with an accuracy of $\pm 1^\circ\text{C}$ throughout the test.

2.8.3.4 At the end of the test, remove the specimen from the solution, rinse with water, remove corrosion products, dry and weigh the specimen to 1 mg or better.

2.8.4 Test results

2.8.4.1 No pitting attack is to be visible on the test face(s).

2.8.4.2 Unless otherwise specified, the corrosion rate (i.e. weight loss per unit area after 24-hour immersion) is not to exceed 10 m dd. The corrosion rate is to be calculated as follows:

$$CR = \frac{W_1 - W_2}{S} \times 10^4$$

Where: CR -- corrosion rate, in m dd;

W_1 -- specimen weight prior to test, in mg;

W_2 -- specimen weight after test, in mg);

S -- total surface area, in mm².

CHAPTER 3 STEEL PLATES, FLAT BARS AND SECTIONS

Section 1 GENERAL PROVISIONS

3.1.1 Application

3.1.1.1 Steel plates, flats, sections and bar sin tended for use in the construction of hull, machinery, boilers and pressure vessels are to comply with the provisions of this Chapter.

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

3.1.2 Manufacture

3.1.2.1 The deoxidation method of the steels is to comply with the relevant requirements of subsequent Sections of this Chapter. The use of any other smelting method is to be approved by CCS.

3.1.2.2 The steels are to be cast in metal ingot moulds or made by a continuous casting process approved by CCS, and to comply with the following:

- .1 The size of the ingot, or of the continuous cast billet or slab, is to be of sufficient proportion to the dimensions of the final product, in order that the amount of mechanical work will be adequate to ensure a satisfactory property in the finished product.;
- .2 Where mould cast is employed, sufficient discard is to be taken from the top and bottom ends of each ingot to ensure that the finished product is free from internal defects.;
- .3 Where continuous casting is employed, a specified program of tests is to be carried out under the supervision of the Surveyor and the results are to be approved by CCS.

3.1.2.3 Steel may be manufactured by as rolled (AR), controlled rolling (CR) or thermo-mechanical controlled processing (TMCP), etc. The specified tests are to be conducted in the presence of the Surveyor, and the test results are to meet the test requirements.

3.1.3 Dimensional tolerance

3.1.3.1 With respect to steel plates and wide flats for all types of hull construction specified by Section 2 in this Chapter, the minus tolerances of thickness are not to exceed 0.3mm. The tolerance range of steel plates, wide flats and sections below 5mm is to be checked and accepted in accordance with the accepted standards.

3.1.3.2 For steel plates and wide flat sin tended for machinery as detailed in Section 6 of this Chapter, the minus tolerances of thickness are to comply with the requirements of Table 3.1.3.2.

Minus Tolerance of Thickness of Steel Plates and Wide Flats for Mechanical Construction Table 3.1.3.2

Nominal thickness t (mm)	Minus tolerance (mm)
$5 \leq t < 8$	<0.4
$8 \leq t < 15$	<0.5
$15 \leq t < 25$	<0.6
$25 \leq t < 40$	<0.8
$t \geq 40$	<1.0

3.1.3.3 For steels as detailed in Section 5 of this Chapter, where in the order specifications it is not specified that the nominal thickness is to be taken as the minimum thickness, the under thickness tolerance is not to exceed 0.3 mm for plate thickness not exceeding 10 mm, and 0.5 mm for plate thickness exceeding 10 mm.

3.1.3.4 The thicknesses of steel plates and wide flats are to be measured at the positions at least 10mm away from the edges.

3.1.4 Preparation of specimens

3.1.4.1 Depending on the type of product, steel may be presented for individual item testing or for batch testing as laid down in relevant Sections of this Chapter. Where the latter is permitted, all materials in a batch presented for acceptance tests are to be of the same product form (e.g. plates, flat bars, sections, etc.) from the same cast by the same rolling procedure, and in the same condition of supply.

3.1.4.2 The size of test material is to be dependent on the dimensions, number and direction of cutting of the test specimens. Test material is to be taken from the following positions (for smaller steels, the cutting positions are to be as close as possible to those specified):

- .1 for plates and flats equal to or greater than 600 mm wide, at approximately 1/4 of the width from an

edge, as shown in Figure 3.1.4.2.1;

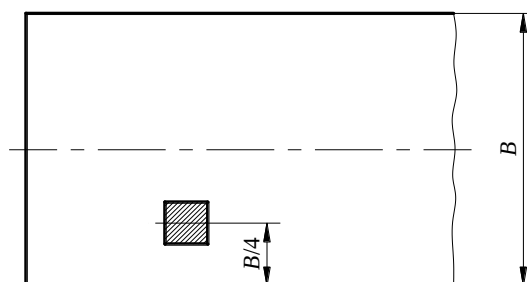


Figure 3.1.4.2.1 Interception of Test Materials for Steel Plates

- .2 for flats less than 600 mm in width, bulb flats, angles and other sections, at approximately 1/3 of the width from one edge, as shown in Figure 3.1.4.2.2. For channels and beams, at approximately 1/4 of the width from the web edge, as shown in Figure 3.1.4.2.2;

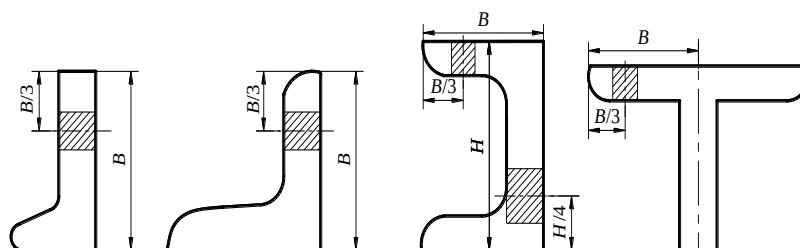


Figure 3.1.4.2.2 Interception of Test Materials for Sections

- .3 for bars or similar products as detailed in Sections 2&4 of this Chapter, at approximately 1/3 of the radius from the outer surface or 1/6 of the diagonal from the outer surface, as shown in Figure 3.1.4.2.3;

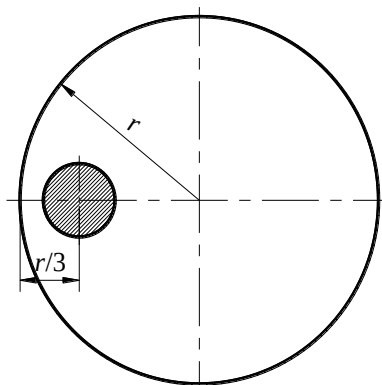


Figure 3.1.4.2.3 Interception of Test Materials for Round Bars

- .4 for bars or similar products as detailed in Sections 3 of this Chapter, at approximately 12.5 mm below the surface. For smaller bars, the test specimens may be machined coaxially;
 .5 for plates or flats with a thickness of more than 40mm, full-thickness specimen may be prepared; however, if a round specimen is used, the axis of the specimen is to be at 1/4 of the thickness.

3.1.4.3 When the specimens are cut from the test material, attention is to be paid to the relationship between the axes of specimens and the final direction of rolling:

- .1 For tensile specimens: steel plates and flats equal to or more than 600 mm in width: axes of specimens perpendicular to the final direction of rolling;
 other products: axes of specimens parallel to the final direction of rolling;
 .2 For impact specimens: longitudinal test: axes of specimens parallel to the final direction of rolling;
 transverse test: axes of specimens perpendicular to the final direction of rolling;

3.1.5 Testing

3.1.5.1 The material of marine steel is to be uniform, without defects such as delamination and crack; segregation and nonmetallic inclusions in steel are to be reduced or eliminated as far as possible.

3.1.6 Rectification of defects

3.1.6.1 For structural steels as detailed in Sections 2, 3, 4 and 6 of this Chapter, surface defects may be removed by local grinding provided all the conditions below are adhered to:

- .1 the thickness of any part after repair is to be not less than 93% of the nominal thickness, and the thinning amount is not to be more than 3mm;
- .2 The single polishing area is to be not greater than 0.25m², and the total polishing area is to be not greater than 2% of the total area of plate;
- .3 After repair, the surface is to be smooth.

Such repairs are to be made in the presence of the Surveyor. If necessary, the Surveyor may require appropriate non-destructive testing for the repaired area to prove that the defects have been completely eliminated.

3.1.6.2 Surface defects which cannot be dealt with as in 3.1.6.1 above may be repaired by chipping or grinding followed by welding, subject to agreement of and in the presence of the Surveyor, provided that:

- .1 After the elimination of defects and before welding repair, the thickness of any part of single steel piece is to be not greater than 20% of the nominal thickness of the steel piece;
- .2 Any one single welded area is not to exceed 0.125 m² and the total welded area is not to exceed 2% of the total area of the surface in question;
- .3 two defects are considered as one defect where the distance between them is less than their average width;
- .4 Appropriate non-destructive testing is to be conducted on the repaired area to prove that all defects have been eliminated;
- .5 The repair is to be carried out by qualified welders using an approved method and procedure; after welding, the repaired area is to be ground smooth for proving good welding quality;
- .6 If required by the Surveyor, the item is normalized or otherwise suitably heat-treated after welding and grinding.

3.1.6.3 For materials intended for the applications as detailed in Sections 5 and 7 of this Chapter, surface defects may be rectified in accordance with 3.1.6.1 and 3.1.6.2 of this Section, but the reduction in thickness will be subjected to special consideration. And after welding, suitable heat treatment and non-destructive testing of the repaired area is required.

Section 2 NORMAL STRENGTH HULL STRUCTURAL STEEL

3.2.1 Grades

3.2.1.1 Normal strength hull structural steel is subdivided into four grades as A, B, D and E. The requirements of this Section apply to steel plates and wide flats not more than 100 mm in thickness and sections and bars not more than 50 mm in thickness.

3.2.2 Deoxidation and chemical composition

3.2.2.1 The method of deoxidation and the chemical composition of ladle samples for normal strength hull structural steel are to comply with the requirements of Table 3.2.2.1.

Deoxidation and Chemical Composition of Normal Strength Hull Structural Steel **Table 3.2.2.1**

Grade		A	B	D	E
Deoxidation (Thickness <i>t</i> , mm)		For $t \leq 50$, any method except rimmed steel ^{Note 1} ; for $t > 50$, killed	For $t \leq 50$, any method except rimmed steel; for $t > 50$, killed	For $t \leq 5$, killed; for $t > 25$, killed and fine grain treated	Killed and fine grain treated
Chemical composition (%) ^{Note 7, 8, 9}	C ^{Note 2}	≤ 0.21 ^{Note 3}	≤ 0.21	≤ 0.21	≤ 0.18
	Mn ^{Note 2}	$\geq 2.5C$	≥ 0.80 ^{Note 4}	≥ 0.60	≥ 0.70
	Si	≤ 0.50	≤ 0.35	≤ 0.35	≤ 0.35
	S	≤ 0.035	≤ 0.035	≤ 0.035	≤ 0.035
	P	≤ 0.035	≤ 0.035	≤ 0.035	≤ 0.035
	Al (acid soluble)	—	—	≥ 0.015 ^{Note 5, 6}	≥ 0.015 ^{Note 6}

Note 1: Where agreed by CCS and the purchaser for grade A, rimmed steel may be accepted for sections up to 12.5 mm in thickness, provided that this is stated in the certificate.

Note 2: For all grades: $C\% + \frac{1}{6}Mn\% \leq 0.40\%$.

Note 3: For sections, the maximum carbon content may be 0.23%.

Note 4: Where Grade B steel is impact tested, the minimum manganese content may be reduced to 0.6%.

Note 5: For Grade D steel over 25 mm in thickness

Note 6: For Grade D steel over 25 mm in thickness and Grade E steel, the total aluminium content may be determined instead of the acid soluble content. In such cases the total aluminium content is to be not less than 0.02%. Other suitable grain refining elements

may be used with prior approval of CCS, but their contents should be submitted for approval.

Note 7: Where the steel is supplied in TMCP condition, the chemical composition may vary from the requirements in the Table with special approval of CCS.

Note 8: The residual content of copper in the steel is not to exceed 0.35% and that of chromium and nickel is not to exceed 0.30% respectively.

Note 9: Where any other element has been added as part of the steelmaking practice, the content is to be stated in the certificate.

3.2.3 Heat treatment

3.2.3.1 All materials are to be supplied in a condition complying with the requirements of Table 3.2.3.1.

Condition of Delivery for Normal Strength Hull Structural Steel

Table 3.2.3.1

Grade	Deoxidation	Product s	Condition of supply ^{Note 1, 2}				
			Thickness <i>t</i> (mm)				
			<i>t</i> ≤12.5	12.5< <i>t</i> ≤25	25< <i>t</i> ≤35	35< <i>t</i> ≤50	50< <i>t</i> ≤100
A	Rimmed steel	Sections	A(-)	Not applicable			
	For <i>t</i> ≤50mm, any method except rimmed steel; for <i>t</i> >50mm, killed	Plates	A(-)			N(-), TM(-) ^{Note 3} , CR(50)	
		Sections	A(-)			Not applicable	
B	For <i>t</i> ≤50mm, any method except rimmed steel; for <i>t</i> >50mm, killed	Plates	A(-)	A(50)		N(50), TM(50), CR(25)	
		Sections	A(-)	A(50)		Not applicable	
D	Killed	Plates, sections	A(50)	Not applicable			
	Killed and fine grain treated	Plates	A(50)	N(50), CR(50), TM(50)		N(50), TM(50), CR(25)	
		Sections	A(50)	N(50), CR(50), TM(50)		Not applicable	
E	Killed and fine grain treated	Plates	N (each piece), TM (each piece)				
		Sections	N(50), TM(25)			Not applicable	

Note 1: Condition of supply

A: any;

N: normalized;

CR: controlled;

TM (TMCP): thermo-mechanical controlled process.

Note 2: The number in parentheses denotes the batch weight for impact test (in t), (-) means impact tests are not required. One set of three Charpy V-notch impact test specimens is to be taken from each batch weight.

3.2.4 Mechanical properties

3.2.4.1 The tensile and impact tests for steel plates, flat bars and sections are to comply with the requirements of Chapter 2 of this PART, as well as the following requirements:

- .1 The flat proportional specimen given in Item 2 of Table 2.2.2.1 of Chapter 2 of this PART is to be used for tensile test; if the thickness of the material exceeds 40 mm, the round specimen given in Item 1 (1) may be accepted, in which case the axis of the specimen is to be at 1/4 of the thickness.
- .2 Where the thickness of the product does not exceed 40 mm, the impact test specimen is to be close to the surface, i.e. its edge is to be within 2 mm from the rolled surface; where the thickness exceeds 40 mm, the axis of the specimen is to be at 1/4 of the thickness. The notch of the impact test specimen is to be cut in a face of the test specimen which was originally perpendicular to the rolled surface.

3.2.4.2 The number of test specimens is to be as follows:

- .1 For each batch presented, one tensile test specimen is to be made from the thickest piece unless the weight of finished material is greater than 50 t, in which case one extra test specimen is to be made from a different piece from each 50 t or fraction thereof. Additional tests are to be made for every variation of 10 mm in thickness or diameter of products from the same cast. For sections, the thickness to be considered is the thickness of the product at the point where samples are taken for mechanical tests. A piece is to be regarded as the rolled product from a single ingot (or a single slab or billet).

.2 The number of impact test specimens is to comply with the requirements in Table 3.2.3.1.

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

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

Grade	Yield strength R_{eH} min. (N/mm ²)	Tensile strength R_m (N/mm ²)	Elongation A_5 min. (%)	Charpy V-notch impact test steel										
				Test temp.(°C)	Average impact energy min. (J)									
					Thickness t (mm)									
					$t \leq 50$		50< $t \leq 70$		70< $t \leq 100$					
					Long. ^{Note 2}	Trans. ^{Note 2}	Long.	Trans.	Long.	Trans.				
A	235	400~520 ^{Note 1}	22	20	—	—	34	24	41	27				
B				0	27 ^{Note 3}	20 ^{Note 3}								
D				-20										
E				-40										

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

Note 2: Generally for product thickness not exceeding 50 mm, impact tests need only be made in the longitudinal direction, except when required by the purchaser; however, satisfactory transverse test results for plates and wide flats are to be guaranteed by the manufacturer.

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

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

Note 5: Transverse impact tests are generally not required for sections.

3.2.4.4 For full-thickness flat test specimens with a width of 25 mm and a gauge length of 200 mm, the minimum elongation is to comply with Table 3.2.4.4.

Minimum Elongation of Full-thickness Flat Test Specimens**Table 3.2.4.4**

Thickness t (mm)	$t \leq 5$	$5 < t \leq 10$	$10 < t \leq 15$	$15 < t \leq 20$	$20 < t \leq 25$	$25 < t \leq 30$	$30 < t \leq 40$	$40 < t \leq 50$
Elongation A_5 (%)	14	16	17	18	19	20	21	22

Section 3 HIGHER STRENGTH HULL STRUCTURAL STEELS

3.3.1 Grades

3.3.1.1 Higher strength hull structural steels are to be subdivided into strength levels in accordance with the specified minimum yield strength, and each strength level is further subdivided into four grades as A, D, E and F in accordance with different levels of notch toughness. The requirements of this Section apply to Grades AH32, DH32, EH32, FH32, AH36, DH36, EH36, FH36, AH40, DH40, EH40 and FH40 steel plates and wide flats of thickness not exceeding 100 mm, as well as to sections and bars of the above-mentioned grades and of thickness not exceeding 50 mm.

3.3.2 Deoxidation and chemical composition

3.3.2.1 All grades of higher strength hull structural steels are to be killed and fine-grain treated, and the chemical composition of ladle samples is to comply with the requirements of Table 3.3.2.1.

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

Grade		AH32, AH36, AH40, DH32, DH36, DH40, EH32, EH36, EH40	FH32, FH36, FH40
Chemical composition ^{Note 5, 6} (%)	C	≤ 0.18	≤ 0.16
	Mn	$0.90 \sim 1.60$ ^{Note 1}	$0.90 \sim 1.60$
	Si	≤ 0.50	≤ 0.50
	S	≤ 0.035	≤ 0.025
	P	≤ 0.035	≤ 0.025
	Al (acid liquor)	> 0.015 ^{Note 2, 3}	≥ 0.015 ^{Note 2, 3}
	Nb ^{Note 4}	$0.02 \sim 0.05$ ^{Note 3}	$0.02 \sim 0.05$ ^{Note 3}
	V ^{Note 4}	$0.05 \sim 0.10$ ^{Note 3}	$0.05 \sim 0.10$ ^{Note 3}

	Ti ^{Note 4}	≤0.02	≤0.02
	Cu	≤0.35	≤0.35
	Cr	≤0.20	≤0.20
	Ni	≤0.40	≤0.80
	Mo	≤0.08	≤0.08
	N	—	≤0.009 (≤0.012 if Al is present)

Note 1: For steels up to 12.5 mm in thickness, the minimum manganese content may be reduced to 0.70%.

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

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

Note 4: The contents of Nb, V and Ti are, in addition, to comply with Nb%+V%+Ti%≤0.12%.

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

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

3.3.2.2 The carbon equivalent C_{eq} may be required, which is to be calculated from the ladle analysis using the following formula:

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

The maximum value of the carbon equivalent is not to exceed the agreed permissible value.

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

- 1 The carbon equivalent C_{eq} is to be calculated from the chemical composition of ladle samples using the formula given in 3.3.2.2 of this Section, and is to comply with Table 3.3.2.3.1.
- 2 If needed, the cold cracking susceptibility P_{CM} may be used instead of the carbon equivalent for evaluating weldability, in which case the following formula is to be used:

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

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

Carbon Equivalent C_{eq} of TMCP Higher Strength Steel up to 100 mm in Thickness **Table 3.3.2.3.1**

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

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

3.3.3 Heat treatment

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

Condition of Supply for Higher Strength Hull Structural Steel **Table 3.3.3.1**

Grade	Grain refining element	Product	Condition of supply (batch weight for impact test) ^{Note 1, 2}					
			Thickness t (mm)					
			$t \leq 12.5$	$12.5 < t \leq 20$	$20 < t \leq 25$	$25 < t \leq 35$	$35 < t \leq 50$	$50 < t \leq 100$
AH32 AH36	Nb and/or V	Plates	A(50)	N(50), CR(50), TM(50)				N(50), CR(25), TM(50)
		Sections	A(50)	N(50), CR(50), TM(50), AR*(25)				Not applicable
	Al or Al and	Plates	A(50)		AR*(25)		Not applicable	

	Ti				N(50), CR(50), TM(50)		N(50), CR(25), TM(50)
		Sections	A(50)	N(50), CR(50), TM(50), AR*(25)			Not applicable
AH40	Any	Plates	A(50)	N(50), CR(50), TM(50)			N(50), TM(50) QT (each length heat treated)
		Sections	A(50)	N(50), CR(50), TM(50)			Not applicable
DH32 DH36	Nb and/or V	Plates	A(50)	N(50), CR(50), TM(50)			N(50), CR(25), TM(50)
		Sections	A(50)	N(50), CR(50), TM(50), AR*(25)			Not applicable
	Al or Al and Ti	Plates	A(50)	AR*(25)	Not applicable		
				N(50), CR(50), TM(50)			N(50), CR(25), TM(50)
		Sections	A(50)	N(50), CR(50), TM(50), AR*(25)			Not applicable
DH40	Any	Plates	N(50), CR(50), TM(50)			N(50), TM(50) QT (each length heat treated)	
		Sections	N(50), CR(50), TM(50)			Not applicable	
EH32 EH36	Any	Plates	N (each piece), TM (each piece)				
		Sections	N(25), TM(25), AR*(15), CR*(15)			Not applicable	
EH40	Any	Plates	N (each piece), TM (each piece), QT (each length heat treated)				
		Sections	N(25), TM(25), QT(25)			Not applicable	
FH32 FH36	Any	Plates	N (each piece), TM (each piece), QT (each length heat treated)				
		Sections	N(25), TM(25), QT(25), CR*(15)			Not applicable	
FH40	Any	Plates	N (each piece), TM (each piece), QT (each length heat treated)				
		Sections	N(25), TM(25), QT(25)			Not applicable	

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

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

3.3.4 Mechanical properties

3.3.4.1 The tensile and impact tests for higher strength hull structural steel plates, flat bars and sections are to comply with the requirements of Chapter 2 of this PART as well as the following requirements:

- .1 The flat test specimen given in Item 2 of Table 2.2.2.1 of Chapter 2 of this PART is to be used for tensile testing; for products over 40 mm in thickness, round test specimens given in Item 1 may be accepted, in which case the axis of the specimen is to be at 1/4 of the thickness.
- .2 In case the thickness of products does not exceed 40 mm, the impact test specimen is to be close to the surface, i.e., its edge is to be within 2 mm from the rolled surface; where the thickness exceeds 40 mm, the axis of the specimen is to be at 1/4 of the thickness. The notch of the impact test specimen is to be cut in a face of the test specimen which was originally perpendicular to the rolled surface.

3.3.4.2 The number of test specimens is to comply with the following:

- .1 The number of tensile test specimens is to comply with the requirements of 3.2.4.2.1 of this Chapter.
- .2 The number of impact test specimens is to comply with Table 3.3.3.1.

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

Mechanical Properties of Higher Strength Hull Structural Steel**Table 3.3.4.3**

Mechanical Properties of Higher Strength Hull Structural Steel										
Grade	Yield strength R_{eH} min. (N/mm ²)	Tensile strength R_m (N/mm ²)	Elongation A_5 min. (%)	Charpy V-notch impact test ^{Note 1}						
				Test temp. (°C)	Average impact energy min. (J)					
					Thickness t (mm)					
					$t \leq 50$		$50 < t \leq 70$		$70 < t \leq 100$	
					Long.	Trans.	Long.	Trans.	Long.	Trans.
AH32	315	440~570	22	0	31 ^{Note 2}	22 ^{Note 2}	38	26	46	31
DH32				-20						
EH32				-40						
FH32				-60						
AH36	355	490~630	21	0	34 ^{Note 2}	24 ^{Note 2}	41	27	50	34
DH36				-20						
EH36				-40						
FH36				-60						
AH40	390	510~660	20	0	39	26	46	31	55	37
DH40				-20						
EH40				-40						
FH40				-60						

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

Note 2: For Grades AH32 and AH36 steels, a relaxation in the number of impact tests for acceptance purposes may be permitted by CCS provided that satisfactory results are obtained from occasional check tests.

3.3.4.4 For full-thickness flat test specimens with a width of 25 mm and a gauge length of 200 mm, the minimum elongation is to comply with Table 3.3.4.4.

Minimum Elongation of Full-thickness Flat Test Specimens**Table 3.3.4.4**

Thickness t (mm)	Grade	$t \leq 5$	$5 < t \leq 10$	$10 < t \leq 15$	$15 < t \leq 20$	$20 < t \leq 25$	$25 < t \leq 30$	$30 < t \leq 40$	$40 < t \leq 50$
Elongation A_5 (%)	AH32, DH32, EH32, FH32	14	16	17	18	19	20	21	22
	AH36, DH36, EH36, FH36	13	15	16	17	18	19	20	21
	AH40, DH40, EH40, FH40	12	14	15	16	17	18	19	20

Section 4 HIGH STRENGTH QUENCHED AND TEMPERED STEELS FOR WELDED STRUCTURES

3.4.1 Application

3.4.1.1 The provisions of this Section apply to high strength quenched and tempered steels for welded structures with a thickness of not more than 70mm. If the thickness of steel exceeds 70mm, it is to be approved by CCS. The provisions of this Section also apply to sections, steel pipes and other types of products.

3.4.1.2 High strength quenched and tempered steels for welded structures are divided into six strength grades as per minimum yield strength: 420N/mm², 460N/mm², 500N/mm², 550N/mm², 620N/mm² and 690N/mm². Each strength grade is subdivided into four grades as A, B, D and E.

3.4.2 Deoxidation and chemical composition

3.4.2.1 The high strength steel as specified in this Section are to be fully killed, and are to be fine grain treated.

Their chemical composition based on smelting analysis is to comply with Table 3.4.2.1.

Chemical Composition of High Strength Quenched and Tempered Steels for Welded Structures

Table 3.4.2.1

Strength grade (MPa)	Toughness grade	Chemical composition (%)					
		C	Si	Mn	P	S	N

420~690	A	≤0.21	≤0.55	≤0.17	≤0.035	≤0.035	≤0.020
	D, E	≤0.20	≤0.55	≤0.17	≤0.030	≤0.030	≤0.020
	F	≤0.18	≤0.55	≤0.16	≤0.025	≤0.025	≤0.020

Note: The elements used for alloying and grain refining are to comply with the accepted standards.

Cold cracking susceptibility P_{CM} is to be calculated as per the following formula according to the chemical composition based on smelting analysis, to measure the weldability of the steels:

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

The P_{CM} value calculated as per the above formula is to comply with the requirements for the accepted relevant standards.

3.4.3 Heat treatment

3.4.3.1 Steel is to be supplied in quenched and tempered condition. After approved by CCS, the steel with a thickness of not more than 50mm can also be supplied in TMCR condition.

3.4.4 Mechanical properties

3.4.4.1 For each heat-treated workpiece, at least 1 tensile specimen and 1 group of 3 Charpy V-notch impact specimens are to be taken for testing. For continuously heat-treated steel plates, the required specimen quantity and sampling location are to be taken by CCS into special consideration.

3.4.4.2 The axes of tensile specimens should be perpendicular to the final rolling directions, but longitudinal specimens may be taken for sections and rolled flats with a finished width of not more than 600mm. For other forms of products, CCS may require that the tensile specimens should be intercepted lengthwise or crosswise. The tensile specimens should be rectangular section proportional specimens specified in Table 2.2.2.1, Chapter 2 in this PART, and the original rolled surface should be retained at least on one side. If the nominal thickness exceeds 40mm, a circular section proportional specimens may be used, and the axes of the specimens should be situated in or close to 1/4 thickness away from the surface of the rolled material.

3.4.4.3 If there are no additional requirements by CCS, the axes of Charpy V-notch impact specimens of steel plates and flats with a width of more than 600mm should be perpendicular to the final rolling directions. For other types of products, they should be intercepted lengthwise. The impact specimens should be near-surface specimens, that is, the edges of the specimens should be less than 2mm away from the rolled surfaces. When the thickness of the products is more than 40mm, the axes of the specimens should be situated in the position of 1/4 thickness of the steel products. The notch directions of impact specimens should be perpendicular to the rolled surfaces.

3.4.4.4 The mechanical properties of high strength quenched and tempered steels for welded structures are to comply with Table 3.4.4.4.

Mechanical Properties of High Strength Quenched and Tempered Steels for Welded Structures

Table 3.4.4.4

Grade	Yield strength R_{eH} or $R_{p0.2}$ Note 1 min. (N/mm ²)	Tensile strength R_m (N/mm ²)	Elongation ^{Note 1} A_5 (trans.) min. (%)	Charpy V-notch impact test ^{Note 2}		
				Test temp. (°C)	Average impact energy min. (J)	
					Long.	Trans.
A420	420	530~680	18	0	42	28
D420				-20		
E420				-40		
F420				-60		
A460	460	570~720	17	0	46	31
D460				-20		
E460				-40		
F460				-60		
A500	500	610~770	16	0	50	33
D500				-20		

E500	550	670~830	16	-40	55	37
F500				-60		
A550				0		
D550				-20		
E550				-40		
F550				-60		
A620	620	720~890	15	0	62	41
D620				-20		
E620				-40		
F620				-60		
A690	690	770~940	14	0	69	46
D690				-20		
E690				-40		
F690				-60		

Note 1: When the yield stress R_{eH} is not obvious in the tensile test, the proof strength $R_{p0.2}$ is to be taken.

For longitudinal specimens, the elongation (longitudinal) is to be 2% higher than that specified in the table (transverse).

Note 2: If the manufacturer can ensure that the impact test spot check result is qualified, with the consent of CCS, impact test batch of A-grade high strength quenched and tempered steel can be relaxed in the acceptance.

3.4.4.5 For full-thickness flat test specimens with a width of 25 mm and a gauge length of 200 mm, the minimum elongation is to comply with Table 3.4.4.5.

Minimum Elongation of Full-thickness Flat Test Specimen

Table 3.4.4.5

Thickness t (mm)	Strength grade	$t \leq 10$	$10 < t \leq 15$	$15 < t \leq 20$	$20 < t \leq 25$	$25 < t \leq 40$	$40 < t \leq 50$	$50 < t \leq 70$
Elongation A_5 (%)	420	11	13	14	15	16	17	18
	460	11	12	13	14	15	16	17
	500	10	11	12	13	14	15	16
	550	10	11	12	13	14	15	16
	620	9	11	12	12	13	14	15
	690	9	10	11	11	12	13	14

Section 5 STEELS FOR BOILERS AND PRESSURE VESSELS

3.5.1 Application

3.5.1.1 This Section applies to the carbon, carbon-manganese and alloy steel plates, flat bars or sections intended for use in the construction of boilers and pressure vessels.

3.5.1.2 Where carbon steel, carbon manganese steel and alloy steel other than those specified in this Section are used, relevant information is to be submitted and approved by CCS. Carbon steel and carbon manganese steel with a tensile strength of greater than 490N/mm^2 but not greater than 520N/mm^2 and alloy steel with a tensile strength of not greater than 600N/mm^2 may be approved.

3.5.2 Deoxidation and chemical composition

3.5.2.1 The method of deoxidation and the chemical composition of ladle samples of the steel intended to be used for boilers and pressure vessels are to comply with the requirements given in Table 3.5.2.1.

Deoxidation and Chemical Composition of Steels Used for Boilers and Pressure Vessels

Table 3.5.2.1

Grade	Deoxidation	Chemical composition (%)							
		C	Si	Mn	P,S	Al	Cr	Mo	Other elements

360A	Killed	≤ 0.17	0.10 ~ 0.35	0.40 ~ 1.20	≤ 0.04	Note 2	—	—	Cr ≤ 0.25 Cu ≤ 0.30 Ni ≤ 0.30 Mo ≤ 0.1 Total ≤ 0.70
360B	Killed and fine grain treated	≤ 0.17	0.15 ~ 0.35	0.40 ~ 1.20	≤ 0.04	0.015 ~ 0.065	—	—	
410A	Killed	≤ 0.20	0.10 ~ 0.35	0.50 ~ 1.30	≤ 0.04	Note 2	—	—	
410B	Killed and fine grain treated	≤ 0.20	0.15 ~ 0.35	0.50 ~ 1.30	≤ 0.04	0.015 ~ 0.065	—	—	
460A	Killed	≤ 0.20 ^{Note 1}	0.10 ~ 0.40	0.80 ~ 1.40	≤ 0.04	Note 2	—	—	
460B	Killed and fine grain treated	≤ 0.20 ^{Note 1}	0.15 ~ 0.40	0.80 ~ 1.40	≤ 0.04	0.015 ~ 0.065	—	—	
490A	Killed	≤ 0.20 ^{Note 1}	0.15 ~ 0.50	0.90 ~ 1.60	≤ 0.04	Note 2	—	—	
490B	Killed and fine grain treated	≤ 0.20 ^{Note 1}	0.15~0.50	0.90~1.60	≤ 0.04	0.015~0.065	—	—	
1Cr0.5Mo	Killed	0.10~0.18	0.10~0.35	0.40~0.80	≤ 0.035	≤ 0.020	0.70~1.30	0.40~0.60	Cu ≤ 0.30 ; Ni ≤ 0.30
2.25Cr1Mo	Killed	0.08~0.18	0.10~0.50	0.40~0.80	≤ 0.035	≤ 0.020	2.0~2.50	0.90~1.10	Cu ≤ 0.30 ; Ni ≤ 0.30

Note 1: For thickness greater than 30 mm, the carbon content may be not higher than 0.22%.

Note 2: Steel may be deoxidized by aluminum.

3.5.3 Heat treatment

3.5.3.1 Carbon and carbon-manganese steels with a tensile strength of 360 ~ 490 N/mm² are to be supplied in normalized or controlled rolled condition, and alloy steels of 1Cr0.5Mo and 2.25Cr1Mo are to be supplied in normalized and tempered condition, except that, when agreed, material intended for hot forming may be supplied in the as rolled condition.

3.5.4 Mechanical properties

3.5.4.1 The number of test specimens is to be as follows:

- .1 For plates, a tensile specimen and a set of three impact test specimens are to be taken from one end of each piece when the mass does not exceed 5 t or the length does not exceed 15 m. When either of these limits is exceeded, one tensile and a set of three impact test specimens are to be taken from both ends of each piece. A piece denotes a rolled product from a single ingot (or billet, slab).
- .2 For strips, one tensile test specimen and a set of three impact specimens are to be taken from both ends of each coil.
- .3 Sections and bars may be presented for acceptance tests in batches containing not more than 50 lengths and with a mass not exceeding 10 t. The material in each batch is to be of the same section size, from the same cast and in the same condition of supply. One tensile test specimen and a set of three impact test specimens are to be taken from the material representative of each batch. When the mass of a batch exceeds 10 t, one extra tensile test specimen and one extra set of specimens are to be taken from each 10 t or fraction thereof.

3.5.4.2 The position of test specimens to be taken is to comply with the requirements of 3.1.4.2 of this PART. For rectangular hollow sections, the specimen is to be taken from the centre of any side as shown in Figure 3.5.4.2, and for circular hollow sections, at any position on the periphery.

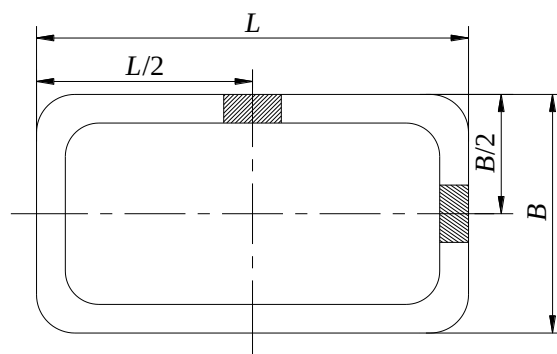


Figure 3.5.4.2 Sampling Diagram of Rectangular Hollow Sections

3.5.4.3 The mechanical properties of steels intended to be used for boilers and pressure vessels are to comply with the requirements in Table 3.5.4.3.

Mechanical Properties of Steels Used for Boilers and Pressure vessels**Table 3.5.4.3**

Grade		Tensile strength R_m (N/mm ²)	Yield strength R_{eH} min. (N/mm ²)			Elongation A_5 min. (%)		Charpy V-notch impact test	
			Thickness (mm)			Thickness (mm)		Test temp. (°C)	Average impact energy (J)
			≤16	16<≤40	40<≤60	≤40	40<≤60		
360	A	360~480	205	195	183	26	25	20	≥27
	B		235	215	195	26	25	0	
410	A	410~530	235	225	215	24	23	20	
	B		265	245	235	24	23	0	
460	A	460~580	285	255	245	22	21	20	
	B		295	285	275	22	21	0	
490	A	490~610	305	275	265	21	20	20	
	B		315	315	305	21	20	0	
1Cr0.5Mo		440~590	305	305	305	20	19	20	
2.25Cr1Mo		480~630	275	265	265	18	17	20	

3.5.5 Mechanical properties at elevated temperature

3.5.5.1 For steels intended for use at a working temperature of 50 °C or higher, the value of yield strength R_{eH}^T at the working temperature is to be verified through testing at elevated temperatures. Nominal values of yield strength R_{eH}^T at elevated temperatures are given in Table 3.5.5.1. These values are intended for design purposes only, and verification is not required for acceptance except that when the steel intended for boilers is listed in certain standards or when an initial approval is made to a new steel. If no such data are available or the working temperature is higher than specified in the Table, at least one tensile test specimen is to be taken from each cast (where materials of more than one thickness are supplied from one cast, the thickest material is to be tested) and the test is to be carried out at the design temperature or at any other agreed temperature.

Yield Strength R_{eH}^T at Elevated Temperature**Table 3.5.5.1**

Grade		Thickness t (mm)	Design temperature (°C)											
			50	100	150	200	250	300	350	400	450	500	550	600
			Yield strength R_{eH}^T min. (N/mm ²)											
360	A	$t \leq 16$	183	175	172	168	150	124	117	115	113			
		$16 < t \leq 40$	173	171	169	162	144	124	117	115	113			
		$40 < t \leq 60$	166	162	158	152	141	124	117	115	113			
	B	$t \leq 16$	214	204	185	165	145	127	116	110	106			
		$16 < t \leq 40$	200	196	183	164	145	127	116	110	106			
		$40 < t \leq 60$	183	179	172	159	145	127	116	110	106			
410	A	$t \leq 16$	220	211	208	201	180	150	142	138	136			
		$16 < t \leq 40$	204	201	198	191	171	150	142	138	136			
		$40 < t \leq 60$	196	192	188	181	168	150	142	138	136			
	B	$t \leq 16$	248	235	216	194	171	152	141	134	130			
		$16 < t \leq 40$	235	228	213	192	171	152	141	134	130			
		$40 < t \leq 60$	222	215	204	188	171	152	141	134	130			
460	A	$t \leq 16$	260	248	243	235	210	176	168	162	158			
		$16 < t \leq 40$	235	230	227	220	198	176	168	162	158			
		$40 < t \leq 60$	227	222	218	210	194	176	168	162	158			
	B	$t \leq 16$	276	262	247	223	198	177	167	158	153			
		$16 < t \leq 40$	271	260	242	220	198	177	167	158	153			
		$40 < t \leq 60$	262	251	236	217	198	177	167	158	153			
490	A	$t \leq 16$	280	270	264	255	228	192	183	177	172			
		$16 < t \leq 40$	255	248	245	237	214	192	183	177	172			
		$40 < t \leq 60$	245	240	236	227	210	192	183	177	172			
	B	$t \leq 16$	297	284	265	240	213	192	182	173	168			
		$16 < t \leq 40$	293	279	260	237	213	192	182	173	168			
		$40 < t \leq 60$	283	272	256	234	213	192	182	173	168			
1Cr0.5Mo	$t \leq 60$	284	270	265	248	236	216	205	199	194	188	181	174	

225Cr1Mo	t≤60	255	249	241	233	226	219	212	207	194	180	160	137

3.5.5.2 For steels intended for structural components subject to load at elevated temperatures, the rupture stress at elevated temperatures is to be verified in addition to the tensile strength. The rupture stress $R_{m100000}^T$ is the average breaking stress of materials at design temperature in 100,000 h. The values of rupture stress $R_{m100000}^T$ of materials are given in Table 3.5.5.2 and may be used for design purposes.

Average Rupture Stress at Elevated Temperature $R_{m100000}^T$

Table 3.5.5.2

Temperature (℃)	Grade		Temperature (℃)	Grade	
	360A	460A		1Cr0.5Mo	2.25Cr1Mo
	360B	460B			
	410A	490A			
	410B	490B			
	$R_{m100000}^T$ (N/mm²)			$R_{m100000}^T$ (N/mm²)	
380	171	227	480	210	170
390	155	203	490	177	153
400	141	179	500	146	137
410	127	157	510	121	122
420	114	136	520	99	107
430	102	117	530	81	93
440	90	100	540	67	79
450	78	85	550	54	69
460	67	73	560	43	59
470	57	63	570	35	51
—	—	—	580	—	44

Section 6 STEELS FOR MACHINERY STRUCTURES

3.6.1 General requirements

3.6.1.1 Rolled steels intended for use in the construction of welded machinery structures, such as engine frames, bedplates, reduction gear casings etc., are to be of killed steel having a carbon content not exceeding 0.23%.

3.6.1.2 Where it is intended to use any grade of normal or higher strength hull structural steel for the construction of machinery structures, such steels are to comply with the relevant requirements of Sections 2 or 3 of this Chapter.

3.6.1.3 Any grade of carbon or carbon-manganese steel for boilers and pressure vessels as detailed in Section 5 of this Chapter may be used for the construction of machinery structures. When such steels are used for machinery structures, they may be accepted in batches. The size of a batch and the number of tensile tests are to comply with the requirements of 3.2.4.2 of this PART.

3.6.1.4 For important machinery structures subject to a working temperature higher than 50℃, details of elevated temperature properties used for design purposes are to be submitted to CCS for reference.

Section 7 AUSTENITIC AND DUPLEX STAINLESS STEELS

3.7.1 Application

3.7.1.1 This Section applies to austenitic stainless steels and austenitic/ferritic duplex stainless steels (hereinafter referred to as duplex stainless steels) intended for use in the construction of LNG tanks or other components of fishing vessels.

3.7.2 General requirements

3.7.2.1 The austenitic stainless steels covered by this Section may also be used for the construction of pressure vessels where the design temperature is not lower than -165 °C.

3.7.2.2 The duplex stainless steels covered by this Section may generally be used for the construction of structural members where the design temperature is 0 °C to 300 °C.

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

3.7.3 Chemical composition

3.7.3.1 The chemical composition of ladle samples of austenitic stainless steels is to comply with the following requirements given in Table 3.7.3.1.

Chemical Composition of Austenitic Stainless Steels**Table 3.7.3.1**

Grade	Uniform number code	Chemical composition (%)									
		C	Si	Mn	P	S	Cr	Ni	Mo	N	Other elements
022Cr19Ni10	S30403	≤0.03	≤1.0	≤2.0	≤0.045	≤0.03	18.0~20.0	8.0~12.0	—	—	—
022Cr19Ni10N	S30453	≤0.03	≤1.0	≤2.0	≤0.045	≤0.03	18.0~20.0	8.0~11.0	—	0.10~0.16	—
022Cr17Ni12Mo2	S31603	≤0.03	≤1.0	≤2.0	≤0.045	≤0.03	16.0~18.0	10.0~14.0	2.0~3.0	—	—
022Cr17Ni12Mo2 N	S31653	≤0.03	≤1.0	≤2.0	≤0.045	≤0.03	16.0~18.0	10.0~13.0	2.0~3.0	0.10~0.16	—
022Cr19Ni13Mo3	S31703	≤0.03	≤1.0	≤2.0	≤0.045	≤0.03	18.0~20.0	11.0~15.0	3.0~4.0	—	—
022Cr19Ni13Mo4 N	S31753	≤0.03	≤1.0	≤2.0	≤0.045	≤0.03	18.0~20.0	11.0~15.0	3.0~4.0	0.10~0.22	—
06Cr18Ni11Nb	S34778	≤0.08	≤1.0	≤2.0	≤0.045	≤0.03	17.0~19.0	9.0~12.0	—	—	10C≤Nb≤1.10

3.7.3.2 The chemical composition of ladle samples of duplex stainless steels is to comply with the following requirements given in Table 3.7.3.2.

Chemical Composition of Duplex Stainless Steels**Table 3.7.3.2**

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

3.7.4 Heat treatment

All austenitic and duplex stainless steels are to be supplied in the solution treated condition.

3.7.5 Mechanical properties

3.7.5.1 The test specimens are to be taken in accordance with the requirements of 3.5.4.1 of this PART.

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

3.7.5.3 The mechanical properties of austenitic stainless steels are to comply with the following requirements given in Table 3.7.5.3.

Mechanical Properties of Austenitic Stainless Steels**Table 3.7.5.3**

Grade	Proof strength $R_{p0.2}$ ^{Note} min. (N/mm ²)	Proof strength $R_{p1.0}$ ^{Note} min. (N/mm ²)	Tensile strength R_m ^{Note} min. (N/mm ²)	Elongation A_{5min} . (%)
022Cr19Ni10	175	215	480	40
022Cr19Ni10N	245	285	550	40
022Cr17Ni12Mo2	175	215	480	40
022Cr17Ni12Mo2N	245	285	550	40
022Cr19Ni13Mo3	205	245	520	40
022Cr19Ni13Mo4N	275	315	570	40
06Cr18Ni11Nb	205	245	520	40

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

Note 2: The upper limit of tensile strength of austenitic stainless steels is not to exceed any value in the Table plus 200 N/mm².

3.7.5.4 The mechanical properties of duplex stainless steels are to comply with the following requirements given in Table 3.7.5.4.

Mechanical Properties of Duplex Stainless Steels**Table 3.7.5.4**

Grade	Proof strength $R_{p0.2min}$. (N/mm ²)	Tensile strength R_{min} . (N/mm ²)	Elongation A_{5min} . (%)	Charpy V-notch impact test		
				Test temp. (°C)	Impact (J)	
					Long.	Trans.
022Cr22Ni5Mo3N	450	620	25	-20	41	27
022Cr23Ni5Mo3N	450	620	25	-20	41	27
03Cr25Ni6Mo3Cu2N	490	690	25	-20	41	27
022Cr25Ni7Mo4N	550	790	20	-20	41	27

3.7.6 Intergranular corrosion test

3.7.6.1 When intergranular corrosion test is required for stainless steel, test specimens are to be taken and tested together with those for tensile tests according to the requirements in 3.5.4.1 of this Part for a set or batch of specimens.

3.7.6.2 The specimens are to be prepared and tested in compliance with Section 6, Chapter 2 of this PART.

CHAPTER 4 STEEL FORGINGS

Section 1 GENERAL PROVISIONS

4.1.1 Application

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

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

4.1.2 Chemical composition

4.1.2.1 The chemical composition of ladle samples of steel forgings is to comply with the requirements detailed in subsequent sections of this Chapter. The chemical composition selected is to be appropriate for the type of steel, dimensions and required mechanical properties of the forgings being manufactured.

4.1.2.2 Unless otherwise specified, suitable grain refining elements such as aluminum, niobium or vanadium may be used at the discretion of the manufacturer. The content of such elements is to be reported in the ladle analysis.

4.1.3 Forging requirements

4.1.3.1 All steel forgings are to be made from killed steel.

4.1.3.2 When forgings are made directly from ingots or from billets forged from ingots, the ingots are to be cast in chill moulds with the larger cross-section uppermost and with efficient feeder heads.

4.1.3.3 The forgings are to be gradually and uniformly heated and are to be formed as closely as possible to the finished shape and size with a reasonable machining allowance.

4.1.3.4 Adequate top and bottom discards are to be made to ensure freedom from piping and harmful segregations in the finished forgings.

4.1.3.5 The centre areas of all forgings are to have adequate plastic deformation. For steel forgings in which the fiber deformation is mainly longitudinal, the reduction ratio is not to be less than that shown in Table 4.1.3.5. Disc type forgings, such as gear wheels, are to be made by upsetting, and the thickness of any part of the disc is to be not more than half of the length of the billet from which it was formed, provided that this billet has received an initial forging reduction of not less than 1.5:1. Where the piece used has been cut directly from an ingot, or where the billet has received an initial reduction of less than 1.5:1, the thickness of any part of the disc is to be not more than one third of the length of the original piece.

Forging reduction ratio of Steel Forgings

Table 4.1.3.5

Method of forging	Total reduction ratio ^{Note 1, 2}
Made directly from ingots or from billets forged from ingots	3:1 for $L > D$; 1.5:1 for $L \leq D$
Made from rolled products ^{Note 3}	4:1 for $L > D$; 2:1 for $L \leq D$

Note 1: The reduction ratio means the ratio of the average cross-sectional area of an ingot to that of a forging (billet). Where an ingot is initially upset, this reference area may be taken as the average cross-sectional area after this operation.

Note 2: L and D are the length and diameter of the finished forging.

Note 3: Where rolled bars are used as a substitute for forgings, the total reduction ratio is to be not less than 6:1.

4.1.3.6 Rings and other types of hollow forgings are to be made from pieces cut from ingots or billets and which have been suitably punched, bored or trepanned prior to expanding or hollow forging. Alternatively, pieces from hollow cast ingots may be used. The wall thickness of the forging is to be not more than half of the thickness of the prepared hollow piece from which it was formed. Where this is impracticable, the forging procedure is to be such as to ensure that adequate work is given to the piece prior to punching, etc. This may be either longitudinal or upset working of not less than 2:1.

4.1.3.7 Where the operating loads imposed on certain components, e.g. crank shafts, necessitate a particular fiber flow, the method of manufacture is to be submitted to CCS for approval.

4.1.4 Heat treatment

4.1.4.1 At an appropriate stage of manufacture, after completion of all hot working operations, forgings are to be suitably heat treated to refine the grain structure and to obtain the required mechanical properties.

4.1.4.2 If for any reason a forging is subsequently heated for further hot working, the forging is to be reheated-treated.

4.1.4.3 The shaping of rolled slabs into steel forgings by flame cutting, or arc-air gouging is to be undertaken in accordance with recognized good practice and is to be carried out before the final heat treatment. Preheating is to be employed when necessitated by the composition and/or thickness of the steel.

4.1.4.4 Where a forging is subject to local heating and hot or cold straightening, after the final heat treatment, a subsequent stress relief heat treatment is to be considered.

4.1.4.5 Where it is intended to surface harden forgings, the proposed procedure is to be submitted to CCS for approval. For the purposes of this approval, the manufacturer is required to demonstrate by tests that the hardness and depth of the surface hardening layer of steel forgings can meet the quality requirements and that it does not impair the soundness and properties of the steel.

4.1.5 Test material and testing

4.1.5.1 The sectional dimensions of steel forging specimens are to be the same as that of the section of steel forging that they represent. The specimens are to be integral with each forging, and are to be subjected to the same heat treatment as the steel forging. Sampling is to be conducted at the riser ends equivalent to the ingots. When a steel forging is subsequently divided into several pieces after forging and all the pieces are put into the same furnace charge for heat treatment, these pieces can be regarded as one forging in the test, and the specified number of tests is to be related to the total length and mass of the original steel forging. The size of the specimen is to meet the need for the required test and possible retest.

4.1.5.2 Batch testing procedures may be adopted a number of small forgings of about the same shape and size are made from one cast and heat treated in the same furnace charge. Where the batch testing procedure is adopted, one of the forgings for test purposes, or alternatively, separately forged test samples may be used. These test samples are to have a forging reduction similar to that used for the forgings which they represent, and are to be properly identified and heat treated together with the forgings.

4.1.5.3 The preparation of specimens is to comply with the relevant requirements of Chapter 2 and each section of this Chapter. The longitudinal axis of tensile and impact test specimens is to be parallel (for longitudinal specimens) or tangential (for tangential specimens) to the axis of steel forgings.

4.1.5.4 In general, the specimens are to be taken in the position which is 1/3 radius or 1/2 thickness away from the surface. For some special steel forgings, the sampling locations may be specified on the drawings.

4.1.5.5 The tensile test specimens are to have a cross-sectional area of not less than 150 mm². Where this is precluded by the dimensions of the forging, the test specimen is to be of the largest practicable cross-sectional area, subject to agreement of CCS. Unless otherwise specified, manufacturer may select Charpy V-notch or U-notch impact specimens at its own discretion.

4.1.5.6 The procedures used for tensile and impact tests are to be in accordance with the requirements of Chapter 2 of this PART. Hardness tests are to be carried out whenever specified in subsequent sections of this Chapter.

4.1.6 Visual and non-destructive testing

4.1.6.1 All steel forgings are to be submitted to the Surveyor for visual inspection of their inner and outer surfaces.

4.1.6.2 Macrostructure examination is to be conducted on the billets or steel forgings in accordance with the relevant requirements of the sections in this Chapter and is to comply with the accepted relevant standards.

4.1.6.3 The surfaces of steel forgings are to be kept clean. In addition to steel forgings to be delivered in roughed condition, the surfaces of forgings may be treated by local grinding, shot or sand blasting, wire brushing, pickling or other chemical means as necessary.

4.1.6.4 After machining is completed, magnetic particle testing or dye penetrant testing is to be conducted on steel forgings in accordance with the relevant requirements of the sections in this Chapter. The test methods and criteria are to comply with the requirements of Appendix 7A, Chapter 7 in *Guidelines for Inspection of Hull Welds* issued by CCS.

4.1.6.5 After machining to the appropriate stage and final heat treatment, steel forgings are to be subjected to

radial and/or axial ultrasonic testing on their surfaces and are to comply with the accepted testing methods and criteria.

4.1.6.6 Except agreed by CCS, the above non-destructive testing is to be conducted in the presence of the Surveyor.

4.1.7 Rectification of defects

4.1.7.1 Small surface imperfections may be removed by grinding or by chipping and grinding. Small surface imperfections may be removed by grinding or by chipping and grinding. Complete removal of these imperfections may be proved by magnetic particle or dye penetrant testing, as appropriate.

4.1.7.2 It is generally not allowed to repair defects on the surface of steel forgings by welding. Except for crankshaft forgings, minor defects in the low stress areas can be repaired by welding with the consent of CCS, but the detailed welding and post-welding heat treatment information and inspection procedures are to be submitted to CCS for approval.

Section 2 FORGINGS FOR HULL STRUCTURES

4.2.1 Application

4.2.1.1 The provisions of this Section apply to carbon or carbon manganese steel forgings intended for use in hull structures such as rudder axles, rudder posts, rudder pintles, stems and stern frames.

Where carbon steel, carbon manganese steel or alloy steel with a tensile strength higher than that specified by 4.2.4.2 is used, the chemical composition, mechanical properties and heat treatment procedures are to be submitted to CCS for approval.

4.2.2 Chemical composition

4.2.2.1 For hull structural forgings either intended for welding or not intended for welding, the chemical composition of ladle samples is to comply with the requirements given in Table 4.2.2.1.

Chemical Composition of Forgings for Hull Structures

Table 4.2.2.1

Steel type	Chemical composition (%)									Total residuals
	C	Si	Mn	S	P	Cr	Mo	Ni	Cu	
Carbon and carbon manganese	≤ 0.23 ^{Note 1, 2}	≤ 0.45	0.30~1.50	≤ 0.035	≤ 0.035	≤ 0.30 ^{Note 3}	≤ 0.15 ^{Note 3}	≤ 0.40 ^{Note 3}	≤ 0.30 ^{Note 3}	≤ 0.85
Alloy	Note 4	≤ 0.45	Note 4	≤ 0.035	≤ 0.035	Note 4	Note 4	Note 4	≤ 0.30 ^{Note 3}	—

Note 1: The carbon content may be increased above this level provided that the carbon equivalent (C_{eq}) is not more than 0.41%, calculated using the following formula:

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

Note 2: The carbon content of carbon and carbon-manganese steel forgings not intended for welded construction may be 0.65% maximum.

Note 3: Elements are considered as residual elements.

Note 4: Specification is to be submitted for information.

Note 5: Rudder stocks and pintles are to be of weldable quality.

4.2.3 Heat treatment

4.2.3.1 Steel forgings are to be heat treated as follows:

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

4.2.4 Mechanical properties

4.2.4.1 Preparation of test specimens for forgings is specified as follows:

- .1 One tensile specimen is to be prepared from one end of each steel forging. If several steel forgings are made from one steel ingot and thermally treated in the same furnace, one of steel forgings is to be selected for preparation of 1 tensile specimen;
- .2 Where a forging exceeds both 4,000 kg in mass and 3 m in length, tensile test specimens are to be taken from each end.
- .3 Except agreed by CCS, tensile specimens are to be taken from each forging in a longitudinal direction.

4.2.4.2 The results of all tensile tests of steel forgings are to comply with the requirements given in Table 4.2.4.2.

4.2.4.2. For large forgings, where tensile tests are taken from each end, the variation in tensile strength is not to exceed 70 N/mm².

Mechanical Properties of Hull Steel Forgings**Table 4.2.4.2**

Tensile strength R_m min. (N/mm ²)	Yield strength R_{eH} min. (N/mm ²)	Elongation A_5 min. (%)	
		Long.	Tang.
430	215	24	18

4.2.5 Non-destructive testing

4.2.5.1 Hull structural forgings such as rudder stocks and axles, and flanges of cranes are to be ultrasonically examined. For the root of flange and taper, surface examination is to be carried out.

Section 3 FORGINGS FOR SHAFTING AND MACHINERY**4.3.1 Application**

4.3.1.1 The requirements of this Section apply to carbon and carbon-manganese steel forgings for shafting and other items of machinery which are not within the scope of Sections 4 and Sections 5 of this Chapter. For steel forgings for shafting used as main propulsion machinery, the tensile strength range is to be 400N/mm²~600N/mm².

4.3.1.2 Where alloy steel forgings are used, their chemical composition, mechanical properties and heat treatment procedures are to be submitted to CCS for approval, and are to comply with the following requirements:

- .1 When used as the main propulsion shafts, the tensile strength is generally not to exceed 800N/mm²;
- .2 When used as other machinery, the tensile strength is generally not to exceed 1,100N/mm².

4.3.2 Chemical composition

4.3.2.1 The chemical composition of ladle samples for forgings is to comply with the requirements of Table 4.3.2.1.

Chemical Composition of Forgings for Shafting and Machinery**Table 4.3.2.1**

Steel type	Chemical composition (%)									
	C	Si	Mn	S	P	Cr	Mo	Ni	Cu ^{Note 2}	Total residuals
Carbon and carbon-manganese	≤0.65 ^{Note 1}	≤0.45	0.30~1.50	≤0.035	≤0.035	≤0.3 ^{Note 2}	≤0.15 ^{Note 2}	≤0.40 ^{Note 2}	≤0.30	≤0.85
Alloy ^{Note 3}	≤0.45	≤0.45	0.30~1.00	≤0.035	≤0.035	≥0.40 ^{Note 4}	≥0.15 ^{Note 4}	≥0.40 ^{Note 4}	≤0.30	—

Note 1: The carbon content of carbon and carbon-manganese steel forgings intended for welded construction is to be 0.23 maximum. The carbon content may be increased above 0.23% provided that the carbon equivalent (C_{eq}) is not more than 0.41%, calculated using the following formula:

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

Note 2: Elements are considered as residual elements unless shown as a minimum.

Note 3: Where alloy steel forgings are intended for welded constructions, the proposed chemical composition is subject to approval by CCS.

Note 4: One or more of the elements is to comply with the minimum content.

4.3.3 Heat treatment

4.3.3.1 Carbon or carbon-manganese steel forgings are to be heat treated as follows:

- .1 fully annealed; or
- .2 normalized; or
- .3 normalized and tempered; or
- .4 quenched and tempered.

The tempering temperature is not to be less than 550 °C. Steel forgings with a tensile strength of greater than 700 N/mm² are to be quenched and tempered.

4.3.3.2 Alloy steel forgings are to be heat treated as follows:

- .1 quenched and tempered; or
- .2 normalized and tempered.

The tempering temperature is not to be less than 550 °C.

Where alloy steel forgings are supplied in the normalized and tempered condition, the mechanical properties are to be in compliance with the requirements of recognized international or national standards.

4.3.4 Tests and test specimens

4.3.4.1 At least one test sample sufficient for the preparation of various test specimens is to be made at one end (corresponding to the top end of the forged ingot) of each forging. For forgings made from one ingot and heat treated in the same furnace charge or small forgings in batches, at least one forging is to be taken as the test sample.

4.3.4.2 Where a forging exceeds both 4,000kg in mass and 3 m in length, one set of test specimens is to be taken from each end.

4.3.4.3 The tests and number of test specimens for forgings are to comply with the requirements of Table 4.3.4.3.

Tests and Number of Test Specimens of Forgings for Shafting and Machinery Table 4.3.4.3

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

4.3.4.4 The test specimens are in general to be taken in the longitudinal direction, and may also be selected as shown in Figures 4.3.4.4(1), (2) and (3).

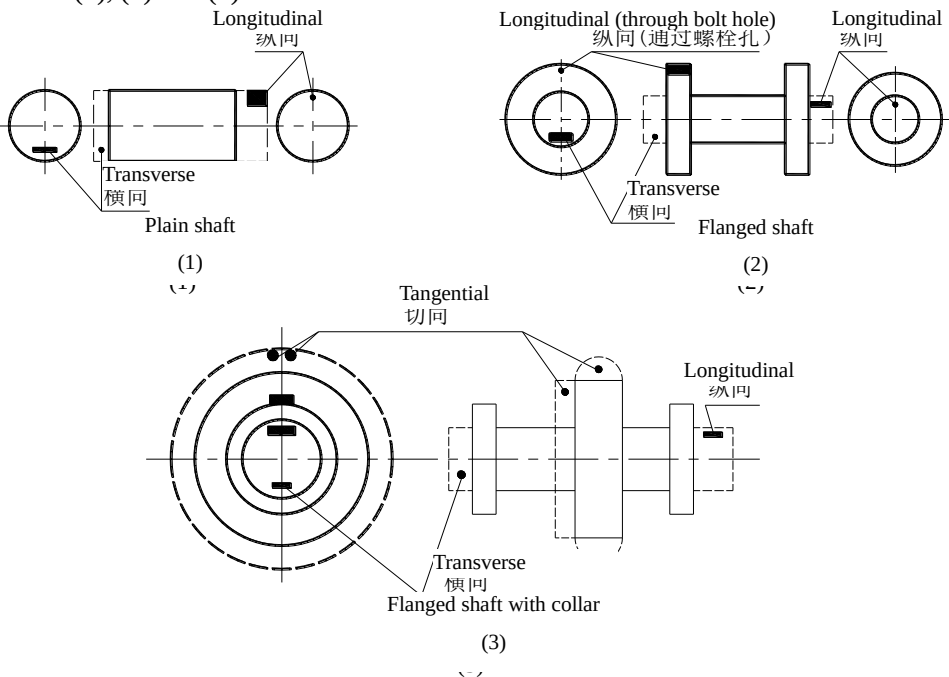


Figure 4.3.4.4 Preparation of Steel Forging Specimens

4.3.5 Mechanical properties

4.3.5.1 The mechanical properties of carbon and carbon-manganese steel forgings are to comply with the requirements of Table 4.3.5.1.

4.3.5.2 The mechanical properties of alloy steel forgings in the normalized and tempered or quenched and tempered condition are to comply with the requirements of Table 4.4.6.2.

4.3.5.3 Where tensile test specimens are taken from different positions of a forging, the variation in tensile strength is not to exceed the following:

If tensile strength is less than 600N/mm², the permissible difference is not to exceed 70N/mm²;

If tensile strength is not less than 600N/mm², the permissible difference is not to exceed 100N/mm².

Mechanical Properties of Carbon and Carbon-manganese Steel Forgings for Shafting and Machinery

Table 4.3.5.1

Tensile strength R_m min. ^{Note 2} (N/mm ²)	Yield strength R_{eH} min. ^{Note 1} (N/mm ²)	Elongation A_5 min. (%)			Hardness ^{Note 3} (HB)
		Long.	Tang.	Trans.	
360	180	28	23	20	95~125
400	200	26	22	19	110~150
440	220	24	21	18	125~160
480	240	22	19	16	135~175
520	260	21	18	15	150~185
560	280	20	17	14	160~200
600	300	18	15	13	175~215
640	320	17	14	12	185~230
680	340	16	14	12	200~240
720	360	15	13	11	210~250
760	380	14	12	10	225~265

Note 1: For an intermediate value of tensile strength in the table, R_{eH} and A_5 corresponding to it may be obtained by interpolation.

Note 2: For steel forgings at different strength grades and with a tensile strength of less than 600 N/mm², the tensile strength range is 120 N/mm²; for steel forgings at different strength grades and with a tensile strength of not less than 600 N/mm², the tensile strength range is 150 N/mm².

Note 3: Hardness values are given for information purposes only.

4.3.6 Non-destructive testing

4.3.6.1 The following steel forgings are to undergo magnetic particle testing in accordance with the requirements of 4.1.6 in this PART:

- .1 all steel forgings for connecting rods;
- .2 the following parts of diesel engine with a cylinder diameter of more than 400mm:
Cylinder cover; piston crown; piston rod;
Through bolt; camshaft drive gear;
Cylinder cover, crosshead, bolt and stud for main bearing and connecting rod bearing.

4.3.6.2 The following steel forgings are to be subjected to ultrasonic testing in accordance with the requirements of 4.1.6 in this PART:

- .1 tube shaft, propeller shaft, thrust shaft, intermediate shaft, and other shafts for important uses and with a finished diameter of equal to or more than 250mm;
- .2 all piston crowns and cylinder covers;
- .3 piston and connecting rod of diesel engine with a cylinder diameter of more than 400mm.

4.3.6.3 The non-destructive testing for other forgings may be carried out in accordance with the requirements given in the approved drawings.

Section 4 FORGINGS FOR CRANKSHAFTS

4.4.1 Application

4.4.1.1 The requirements of this Section apply to solid forged crankshafts and forgings for use in the construction of fully built and semi-built crankshafts, made of carbon or carbon-manganese steel.

4.4.1.2 Where it is proposed to use alloy steel forgings, particulars of the chemical composition, heat treatment and mechanical properties are to be submitted to CCS for approval. The minimum tensile strength of the alloy steel crankshaft forging is not to exceed 1,000 N/mm².

4.4.2 Manufacture

4.4.2.1 Solid forged crankshafts may be made by the closed die or continuous grain flow method. Full details of the proposed forging method are to be submitted to CCS for approval. When necessary, the manufacturer is required to carry out tests to demonstrate that a satisfactory structure and grain flow are obtained.

4.4.2.2 For semi-built crankshaft forgings, the proposed method of forging and fitting and the manufacturing procedure specification are to be submitted to CCS for approval.

4.4.2.3 Where crank webs are flame cut from forged or rolled slabs, the procedure used is to be in compliance with the requirements of 4.1.4.3 in this PART and additionally a depth of at least 7.5 mm is to be removed by machining from all flame-cut surfaces.

4.4.3 Chemical composition

4.4.3.1 For crankshaft steel forgings, the chemical composition of ladle samples is to comply with the requirements given in Table 4.3.2.1 in this PART.

4.4.4 Heat treatment

4.4.4.1 Forged steel crankshafts are to be heat treated as follows:

- .1 normalized and tempered; or
- .2 quenched and tempered.

The tempering temperature is not to be less than 550 °C.

4.4.4.2 Where it is proposed to surface harden crankshaft forgings by carburizing, nitriding or high frequency quenching, the requirements of 4.1.4.5 in this PART are to be complied with.

4.4.5 Tests and test specimens

4.4.5.1 The following tests are to be carried out on each crankshaft forging:

- .1 tensile test;
- .2 impact test;
- .3 hardness test;
- .4 macrostructure examination (only applicable to steel forgings made directly from ingots and not larger than 250mm in diameter)

4.4.5.2 The number of test specimens for crankshaft forgings is to comply with the following:

- .1 For solid open die-forged crankshafts, at least one set of longitudinal specimens is to be taken from the coupling end of each forging. Where the mass of a solid forged crankshaft exceeds 3 t (excluding the mass of the test material), one set of longitudinal specimens is to be taken from each end. Where the crank throws are formed by machining or flame cutting, the second set of test specimens is to be taken in a tangential direction from material removed from the crank throw at the end opposite the coupling, as shown in Figure 4.4.5.2.1.

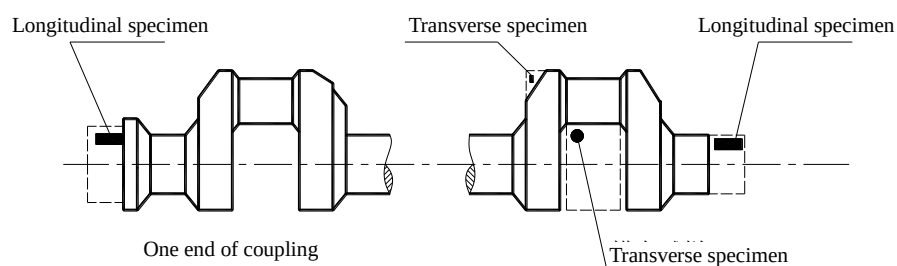


Figure 4.4.5.2.1 Preparation of Specimens of Forgings for Crankshafts

- .2 The number of specimens and sampling location of combined crankshafts are to be approved by CCS;
- .3 One set of specimens is to include:
 - One tensile specimen taken for carbon and carbon-manganese steel forgings for crankshafts;
 - One tensile specimen and one set of 3 impact specimens taken for alloy steel forgings for crankshafts.

4.4.6 Mechanical properties

4.4.6.1 For carbon and carbon-manganese steel forgings for crankshafts, the results of tensile tests are to comply with the requirements of Table 4.3.5.1 in this PART.

4.4.6.2 For alloy steel forgings for crankshafts, the mechanical properties are to comply with the requirements

of Table 4.4.6.2.

Mechanical Properties of Alloy Steel Forgings for Crankshafts**Table 4.4.6.2**

Tensile strength R_m min. (N/mm ²)	Yield strength R_{eH} min. (N/mm2)		Elongation A_5 min. (%)			Charpy V-notch test Average impact energy min. (J)						Charpy U-notch test Average impact energy min. (J)						Hardness (HB)
						Normalized and tempered			Quenched and tempered			Normalized and tempered			Quenched and tempered			
	Normalized and tempered	Quenched and tempered	Long.	Tang.	Trans.	Long.	Tang.	Trans.	Long.	Tang.	Trans.	Long.	Tang.	Trans.	Long.	Tang.	Trans.	
600	330	420	18	16	14	25	20	15	41	31	24	25	22	17	35	29	24	175~215
650	355	450	17	15	13	25	15	13	32	24	22	22	17	15	30	24	23	190~235
700	380	480	16	14	12	20	15	12	32	24	22	22	17	15	30	24	23	205~245
750	405	530	15	13	11	18	14	11	32	24	20	20	16	14	30	24	22	215~260
800	430	590	14	12	10	15	12	9	32	24	20	17	15	12	30	24	22	235~275
850	455	640	13	11	9	15	12	9	27	22	18	17	15	12	26	23	20	245~290
900	—	690	13	11	9	—	—	—	27	22	18	—	—	—	26	23	20	260~310
950	—	750	12	10	8	—	—	—	25	19	16	—	—	—	25	21	18	275~330
1,000	—	810	12	10	8	—	—	—	25	19	16	—	—	—	25	21	18	290~340
1,050	—	870	11	9	7	—	—	—	21	15	13	—	—	—	23	17	15	310~365

Note 1: The sampling direction is to comply with graphical representations of the sections in this Chapter.

Note 2: For an intermediate value of tensile strength, its corresponding R_{eH} , A_5 and average impact energy minimums may be obtained by interpolation.

Note 3: For steel forgings at different strength grades and with a tensile strength of less than 900 N/mm², the tensile strength range is 150 N/mm²; for steel forgings at different strength grades and with a tensile strength of not less than 900 N/mm², the tensile strength range is 200 N/mm²;

Note 4: Impact test is to be conducted at room temperature (18 °C to 25 °C). Average impact energy only applies to steel forgings with a diameter of not more than 250mm. For steel forgings with a greater diameter, its average impact energy is to comply with other standards approved by CCS.

4.4.6.3 Where two or more tensile tests are taken from a forging, the variation in tensile strength is to comply with the requirements given in Table 4.4.6.3.

Permissible Difference in Tensile Strength**Table 4.4.6.3**

Tensile strength R_m (N/mm ²)	Permissible difference in tensile strength max. (N/mm ²)
≥600 and <900	100
≥900	120

4.4.6.4 Hardness tests are to be carried out on each forging for small crankshaft forgings which have been batch tested, and the hardness values are generally to comply with the requirements of Table 4.3.5.1 and Table 4.4.6.2 in this PART.

4. 4. 7 Non-destructive testing

4.4.7.1 Magnetic particle testing is to be performed on all machined surfaces of steel forgings for crankshafts, and attention is to be especially paid to the following parts:

- .1 pins, journals and associated fillet radii of solid forged crankshafts;
- .2 pins and fillet radii of combined web and pin forgings.

4.4.7.2 Ultrasonic testing is to be performed on all steel forgings for crankshafts.

Section 5 FORGINGS FOR GEARING

4.5.1 Application

4.5.1.1 The requirements of this Section apply to forgings for gearing where the transmitted power exceeds 147 kW for main propulsion and 100 kW for auxiliary drives. For other forgings for gearing with less transmitted power, these requirements may be used as guidance.

4.5.1.2 Gear wheel and rim forgings with a minimum tensile strength not less than 400 N/mm² and not in excess of 760 N/mm² may be made in carbon or carbon-manganese steel. Gear wheel or rim forgings where the minimum tensile strength is in excess of 760 N/mm², and all pinion or pinion sleeve forgings, are to be made in a suitable alloy steel. Specifications for alloy steel are to be

submitted to CCS for approval.

4.5.1.3 Forgings for flexible couplings, quill shafts and gear wheel shafts are also to comply with the relevant requirements of Section 3 of this Chapter.

4.5.2 Manufacture

4.5.2.1 All forgings are to be made with sufficient material to allow an adequate machining allowance on all surfaces for the removal of unsound or decarburized material, taking into account any bending or distortion which may occur in heat treatment.

4.5.3 Chemical composition

4.5.3.1 For carbon and carbon-manganese steel forgings for gearing, the chemical composition of ladle samples is to comply with the requirements of Table 4.3.2.1 in this PART.

4.5.4 Heat treatment

4.5.4.1 Except as provided in 4.5.4.2 to 4.5.4.5 in this PART, the heat treatment of forgings for gearing is to be either:

- .1 normalized and tempered; or
- .2 quenched and tempered.

The tempering temperature is not to be less than 550 °C.

4.5.4.2 When the tensile strength exceeds 700 N/mm², the carbon and carbon-manganese steel forgings are to be heat treated only in the quenched and tempered condition.

4.5.4.3 When the teeth of a pinion or gear wheel are to be surface hardened by carburizing, nitriding or high frequency quenching, the proposed procedures and specifications are to be submitted to CCS for approval. For purposes of initial approval, the gear manufacturer is required to demonstrate by test that the surface hardening of the teeth is uniform and of the required depth and that it does not impair the soundness and quality of the steel.

4.5.4.4 Where high frequency quenching or nitriding is to be carried out after machining of the gear teeth, the forgings are to be heat treated at an appropriate stage to a condition suitable for this subsequent surface hardening.

4.5.4.5 For forgings that need to be carburized after final machining, they are first to be heat treated either by full annealing or by normalizing and tempering..

4.5.5 Test specimens

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

- .1 For pinion forgings where the finished diameter of the toothed portion exceeds 200 mm, test specimens are to be taken in a tangential direction and adjacent to the toothed portion (test position B in Figure 4.5.5.1.1). Where the dimensions preclude the preparation of test specimens from position B, specimens in a tangential direction are to be taken from the end of the journal. If, however, the journal diameter does not exceed 200 mm, test specimens are to be taken in a longitudinal direction. Where the finished length of the toothed portion exceeds 1.25 m, test specimens are to be taken from each end.

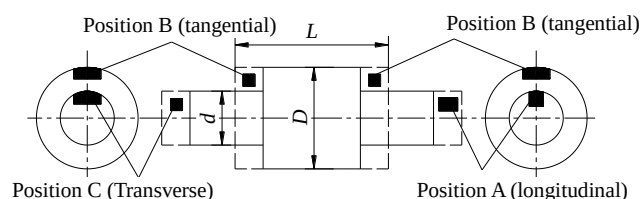


Figure 4.5.5.1.1 Preparation of Specimens of Forgings for Gearing

- .2 For small pinion forgings where the finished diameter of the toothed portion does not exceed 200 mm, test specimens are to be taken in a longitudinal direction from Position A as shown in Figure 4.5.5.1.1.
- .3 For gear wheel forgings, test specimens are to be taken in a tangential direction at either Position B as shown in Figure 4.5.5.1.3.

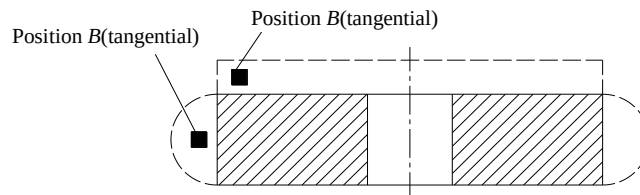


Figure 4.5.5.1.3 Preparation of Specimens of Gear Wheel Forgings

- .4 For gear wheel rim forgings, test specimens are to be taken in a circumferential (equivalent to tangential) direction at either Position B as shown in Figure 4.5.5.1.4. Where the finished diameter exceeds 2.5 m or the mass (as heat treated but excluding test material) exceeds 3 t, test specimens are to be taken from two diametrically opposite positions, i.e. two Position B, as shown in Figure 4.5.5.1.4.

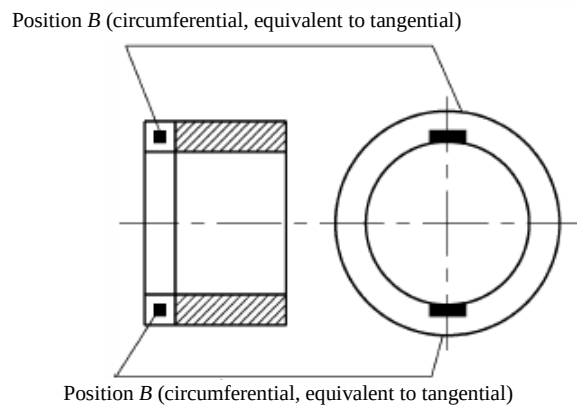


Figure 4.5.5.1.4 Preparation of Specimens of Gear Wheel Rim Forgings

- .5 For pinion sleeve forgings, test specimens are to be taken in a tangential direction at either Position C, as shown in Figure 4.5.5.1.5. Where the finished length exceeds 1.25 m, test specimens are to be taken from each end.

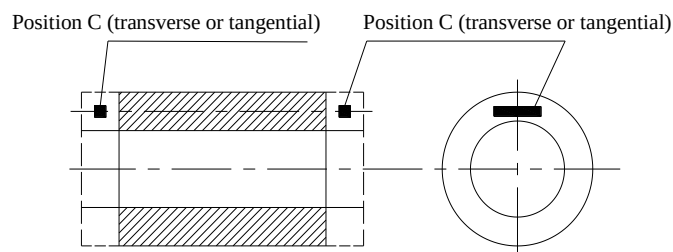


Figure 4.5.5.1.5 Preparation of Specimens of Pinion Sleeve Forgings

4.5.5.2 For forgings which are to be carburized, or for forgings where the ends are to be subsequently closed, sufficient test material may be cut from a forging prior to the final heat treatment. The test material so cut is to be heat treated together with the forging in the same furnace charge.

4.5.5.3 For forgings which are to be carburized, duplicate sets of test material are to be taken from one position as detailed in 4.5.5.1 irrespective of the dimensions or mass of the forgings. One specimen is to be used to simulate the subsequent heat treatment technology for pseudo-carburizing and heat treatment, and the other specimen is to be used for pseudo-carburizing and heat treatment together with the forging. In the case of forgings with integral journals, the test material is to be cut in a longitudinal direction. This test material is to be machined to a diameter of $D/4$ or 60 mm, whichever is less, where D is the finished diameter of the toothed portion. In addition, a test sample of about 30 mm in diameter is to be carburized together with the workpiece to determine the depth and hardness of the hardened zone. At the discretion of the forge master or gear manufacturer test samples of larger cross section may be either carburized or blank carburized, but these are to be machined to the required diameter prior to the final quenching and tempering heat treatment.

4.5.6 Mechanical properties

4.5.6.1 The mechanical properties for gear forgings made in carbon or carbon-manganese steel and alloy steel are to comply with the requirements of Table 4.3.5.1 and Table 4.4.6.2 in this PART respectively..

4.5.6.2 Where more than one tensile test specimen is taken from a forging, the variation in tensile strength is

not to exceed those given in Table 4.5.6.2.

Permissible Difference in Tensile Strength**Table 4.5.6.2**

Tensile strength R_m (N/mm ²)	Permissible difference in tensile strength max. (N/mm ²)
$R_m < 600$	70
$600 \leq R_m < 900$	100
$R_m \geq 900$	120

4.5.6.3 Upon approval, small gear forgings may be batch tested in accordance with the requirements of 4.1.5.2 in this PART, but at least one hardness test is to be carried out on each forging.

4.5.7 Surface hardening

4.5.7.1 Where the gear forgings are intended to be surface hardened by nitriding, or high frequency quenching, the tensile strength is not to be less than 800 N/mm².

Where it is intended to carburize a gear forging, details of carburizing procedure, preparation of test specimens and test procedures etc., are to be submitted to CCS for information. The tensile strength is not to be less than 750 N/mm². The results of all tensile and impact tests are to comply with the requirements for forgings in the quenched and tempered condition as given in Table 4.4.6.2. However, minimum yield strength and maximum tensile strength in the table do not apply.

4.5.7.2 Hardness tests are to be carried out on all forgings after completion of heat treatment and prior to machining the gear teeth. The hardness is to be determined at four positions equally spaced around the circumference of the surface where teeth will subsequently be cut. Where the finished diameter of the toothed portion exceeds 2.5 m, the number of test positions is to be increased to eight.

4.5.7.3 All the results of hardness tests are to comply with the requirements of Table 4.3.5.1 and Table 4.4.6.2 in this PART. After hardness test, the difference between the highest and lowest values on any one gear forging is to comply with the requirements of Table 4.5.7.3.

Permissible Difference in Hardness**Table 4.5.7.3**

Tensile strength R_m (N/mm ²)	Permissible difference in hardness max. (HB)
$R_m < 600$	25
$600 \leq R_m < 900$	35
$R_m \geq 900$	42

4.5.7.4 Nitrided and high-frequency quenched steel forgings are also to be subjected to hardness test on the gears after surface hardening and machining is completed. The test methods and results are to comply with the accepted standards.

4.5.7.5 For forgings which are to be carburized, the test samples which are to be carburized and heat treated together with the forgings are to be sectioned for determining hardness, shape and depth of the locally hardened zone. The results are to be in compliance with the approved specifications.

4.5.8 Non-destructive testing

4.5.8.1 Magnetic particle or dye penetrant testing is to be carried out on all gear forgings, including surface hardened (carburized, nitrided or high frequency quenched) forgings, and the results are to comply with the relevant recognized standards.

4.5.8.2 Ultrasonic examination is to be carried out on all forgings where the finished diameter of the surfaces, where teeth will be cut, is in excess of 200 mm, and the results are to comply with the relevant recognized standards.

4.5.8.3 Determination of the depth of the hardened zone may be required if deemed necessary by CCS.

Section 6 FORGINGS FOR BOILERS, PRESSURE VESSELS AND PIPING Systems

4.6.1 Application

4.6.1.1 This Section applies to carbon, carbon-manganese and low alloy steel forgings intended for use in the construction of boilers, pressure vessels and piping systems. Where carbon steel, carbon manganese steel or alloy steel other than those specified in this Section is used, the detailed technical information is to be submitted to CCS for approval.

4.6.1.2 Where forgings are joined by welding, details of the chemical composition, mechanical properties, heat treatment and welding procedure are to be submitted to CCS for approval.

4.6.2 Chemical composition

4.6.2.1 The chemical composition of ladle samples for carbon, carbon-manganese steel and alloy steel forgings is to comply with the requirements of Table 4.6.2.1.

Chemical Composition of Forgings for Boilers, Pressure Vessels and Piping Systems Table 4.6.2.1

Steel type	Tensile strength R_m min. (N/mm ²)	Chemical composition (%)						
		C	Si	Mn	S	P	Al	Residual elements
Carbon and carbon-manganese	410	≤0.20	0.10~0.40	0.50~1.20	≤0.04	≤0.04	Note 1	Ni≤0.40, Cu≤0.30 Mo≤0.10, Cr≤0.25 Total≤0.80
	460	≤0.23	0.10~0.40	0.60~1.40	≤0.04	≤0.04		
	490	≤0.25	0.10~0.40	0.90~1.70	≤0.04	≤0.04		
1Cr0.5Mo	410	≤0.20	0.10~0.40	0.40~0.70	≤0.04	≤0.04	≤0.02 ^{Note 2}	Cr 0.85~1.15
2.25Cr1Mo	490	≤0.15	0.10~0.40	0.40~0.70	≤0.04	≤0.04	≤0.02 ^{Note 2}	Mo 0.45~0.65
								2.0~2.50 0.90~1.20

Note 1: Fine grained steels are to contain: aluminium (acid soluble) 0.015% minimum, or aluminium (total) 0.018% minimum.

Note 2: For alloy steels, aluminum (acid soluble) 0.020% maximum. The determination of the aluminum (total) content is acceptable provided 0.020% is not exceeded.

4.6.3 Heat treatment

4.6.3.1 Carbon and carbon-manganese steel forgings are to be heat treated as follows:

- .1 normalized; or
- .2 normalized and tempered; or
- .3 quenched and tempered.

4.6.3.2 Alloy steel forgings are to be heat treated as follows:

- .1 normalized and tempered; or
- .2 quenched and tempered.

4.6.4 Test specimens

4.6.4.1 The test specimens for the forgings are to be taken as follows:

- .1 Except as provided in .4, at least one tensile test specimen is to be taken from each forging and, where the dimensions and shape allow, the test specimen is to be cut in the longitudinal direction.
- .2 On seamless drums and headers which are initially forged with open ends, test material is to be provided at each end of each forging. Where forged with one solid end, test material is to be provided at the open end only.
- .3 Where the ends are to be closed, rings of test material are to be cut off prior to the closing operation and are to be heat treated with the finished forging. Where the ends are to be subsequently closed by forging, the test material is not to be removed until heat treatment has been completed.
- .4 Small forgings may be batch tested in accordance with 4.1.5.2 in this PART provided that hardness tests are carried out on each forging. In such cases, the mass of each forging is not to exceed 1 t and that of the batch is not to exceed 10 t.
- .5 Unless otherwise agreed, tensile test specimens are to be taken with their axis at approximately 12.5 mm below the surface of the forgings.

4.6.5 Mechanical properties

4.6.5.1 The mechanical properties of carbon, carbon-manganese steel and alloy steel forgings are to comply with the appropriate requirements of Table 4.6.5.1.

Mechanical Properties of Forgings for Boilers, Pressure Vessels and Piping Systems Table 4.6.5.1

Steel type	Diameter or equivalent t (mm)	Tensile strength R_m min. (N/mm ²)	Yield strength R_{eH} min. (N/mm ²)	Elongation A5 min. (%)	Hardness (HB)

Carbon and carbon-manganese steel	$t \leq 63$	410	215	20	110 ~ 115
	$63 < t \leq 250$		205		
	$t \leq 63$	460	245	18	130 ~ 170
	$63 < t \leq 250$		235		
	$t \leq 63$	490	265	16	140 ~ 180
	$63 < t \leq 250$		255		
Fine grained carbon and carbon-manganese steel	$t \leq 63$	410	235	20	110 ~ 155
	$63 < t \leq 250$		220		
	$t \leq 63$	460	275	18	130 ~ 170
	$63 < t \leq 250$		255		
	$t \leq 63$	490	305	16	140 ~ 80
	$63 < t \leq 250$		280		
1Cr0.5Mo	$t \leq 100$	419	255	18	110 ~ 160
2.25Cr1Mo	$t \leq 100$	490	275	18	140 ~ 185

Note 1: For intermediate values of tensile strength, the minimum values for R_{eH} and A_5 may be obtained by interpolation.

Note 2: For all grades of carbon and carbon-manganese steel in the Table, the tensile strength range is 120 N/mm²; for alloy steel, the tensile strength range is 150 N/mm².

Note 3: Where test specimens are taken from each end of the forgings, the variation in tensile strength is not to exceed 70 N/mm².

Note 4: The hardness values are only applicable for each piece of small batch-tested forgings.

4.6.5.2 In case of forgings designed for use at temperatures of more than 200 °C, a tensile test at elevated temperatures is to be made on the forgings. The test specimen is to be taken from material adjacent to that used for tests at ambient temperature, and the test procedure and results are to be in accordance with the relevant recognized standards.

4.6.6 Non-destructive testing

4.6.6.1 Castings for shells and headers are to be subjected to ultrasonic test. On forgings for shells and drums with dish ends, the area of the dished ends is to be subjected to magnetic particle or dye penetrant testing.

4.6.6.2 For forgings with a wall thickness of less than 100mm, the above tests are not required.

4.6.7 Pressure tests

4.6.7.1 Hollow forgings are to be subjected to pressure tests.

CHAPTER 5 STEEL CASTINGS

Section 1 GENERAL PROVISIONS

5.1.1 Application

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

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

5.1.2 Manufacture

5.1.2.1 Flame cutting to remove surplus metal is to be undertaken in accordance with recognized good practice and is to be carried out before the final heat treatment. Preheating is to be employed when necessitated by the chemical composition and/or thickness of the casting. If necessary, the affected areas are to be either machined or ground smooth.

5.1.2.2 Where two or more castings are joined by welding to form a composite item, details of the proposed welding procedure specification are to be submitted to CCS for approval. Welding approval procedure tests may be required when necessary.

5.1.3 Quality

5.1.3.1 Castings are to be free from surface or internal defects such as cracks, shrinkage cavities, cold shuts and scabs, and free from other defects which would be prejudicial to their proper application in service, such as pores, etc.

5.1.3.2 Castings are to be surface finished in accordance with the specific requirements of the approved plan.

5.1.3.3 The surfaces of castings are not to be hammered, peened nor treated in any way which may obscure defects.

5.1.4 Chemical composition

5.1.4.1 All castings are to be made from killed steel. The chemical composition of the ladle sample is to be within the limits given in the relevant Sections of this Chapter.

5.1.4.2 The content of grain refining elements adopted by the manufacturer is to be reported in the ladle analysis.

5.1.5 Heat treatment

5.1.5.1 All castings are to be heat treated to refine the grain structure. The type of heat treatment is to be in accordance with the requirements of the relevant Sections of this Chapter.

5.1.5.2 If a casting is locally reheated, or any straightening operation is performed after the final heat treatment, a subsequent stress relieving heat treatment may be required in order to avoid the possibility of harmful residual stresses.

5.1.6 Test material and test specimens

5.1.6.1 Test material sufficient for the required tests and for possible re-test purposes is to be provided for each casting or batch of castings. The test samples are to be either integrally cast and are to have a thickness of not less than 30 mm. In the case of quenched and tempered thin-walled steel castings, the thickness of the test sample is to be at least 20 mm, and is to be appropriate to the thickness of the casting.

5.1.6.2 The test samples are not to be detached from the castings until heat treatment has been completed and they have been properly identified.

5.1.6.3 For a number of small castings submitted for batch testing, the test samples may be separately made from the same cast. Test samples are to be properly identified and heat treated together with the castings they represent.

5.1.6.4 All test specimens are to be prepared in accordance with the requirements of Chapter 2 of this PART. Tensile test specimens are to have a cross-sectional area of greater than 150 mm².

5.1.7 Mechanical properties

5.1.7.1 The mechanical properties of castings are to comply with the relevant requirements of the subsequent Sections in this Chapter.

5.1.8 Visual and non-destructive testing

5.1.8.1 All castings are to be cleaned and adequately prepared for inspection; suitable methods include pickling, wire brushing, local grinding, shot or sand blasting. The surfaces are not to be hammered, peened or treated in any way which may obscure defects.

5.1.8.2 All castings are to be presented to the Surveyor for visual examination. Where applicable, the internal surface examination is to be included.

5.1.8.3 Magnetic particle testing is to be performed on the surface of the finished steel castings in accordance with the requirements of the sections in this Chapter. The testing positions are specified as follows:

- .1 at positions indicated on the approved plan;
- .2 at all fillets and changes of section;
- .3 at positions where surplus metal has been removed by flame cutting, scarfing or arc-air gouging;
- .4 in way of fabrication weld preparations;
- .5 at areas which may be subjected to high stress in service.

For the above examinations, the dry powder method is not acceptable and the tests are to be made in the presence of the Surveyor.

5.1.8.4 For the above examinations, the dry powder method is not acceptable and the tests are to be made in the presence of the Surveyor.

- .1 at positions indicated on the approved plan;
- .2 in way of fabrication weld preparations;
- .3 at positions where experience shows that significant internal defects may occur.

The testing results are to comply with the requirements of the approved plan and the accepted relevant standards.

5.1.8.5 X-ray testing may be performed on steel castings according to the positions specified by 5.1.8.4 in this PART. Technical details of X-ray testing, all X-ray photos and acceptance criteria are to be approved by CCS.

5.1.9 Pressure testing

5.1.9.1 Steel castings are also to be subjected to pressure test in the presence of the Surveyor when required.

5.1.10 Rectification of defects

5.1.10.1 If there are any defects affecting the acceptance of steel castings, they should be removed by one of the following methods:

- .1 machining;
- .2 Chipping;
- .3 polishing;
- .4 flame-cutting or arc-air gouging

5.1.10.2 After removal of defects in steel castings, non-destructive testing is to be performed to verify that the defects have been completely eliminated. Where the shallow grooves or excavations caused by the removal of defects have no adverse effects on the use of steel castings, they can be grinded into smooth arc surfaces, but are to be inspected and accepted by CCS. Where the defective area is required to be repaired by welding, the excavations are to be suitably shaped to allow good access for welding.

5.1.10.3 Where defects are removed by flame cutting or arc-air gouging, the castings may be required to be preheated depending on their chemical composition, the dimensions and nature of defects.

5.1.10.4 Where the defects of steel castings are repaired by welding, the number, sizes and positions of the defects identified and welding procedure specification are to be submitted to CCS for approval.

5.1.10.5 Welding repairs are to be carried out in accordance with the approved procedure specification by qualified welders in the down hand position or a position in which a good welding quality is assured. Welding is to be done in positions free from adverse weather conditions.

5.1.10.6 The welding consumables used are to be of an approved low hydrogen type, giving a weld deposit with mechanical properties similar and in no way inferior to those of the parent castings. Before welding repair, a welding procedure approval test is to be conducted to prove that the welding technology used can guarantee the expected welding performance.

5.1.10.7 All alloy steel castings are to be suitably preheated prior to welding. Castings in carbon and

carbon-manganese steels may also be required to be preheated, depending on their chemical composition, the dimensions and positions of the defects. Where the repair of major defects is required, a grain refining heat treatment is to be given prior to carrying out weld repairs.

5.1.10.8 After completion of welding, the castings are to be given a stress relieving heat treatment at a temperature of not less than 550 °C in accordance with the relevant requirements of this Chapter. For steel castings with small welding area and machined to the final stage, local stress relieving heat treatment may be adopted.

5.1.10.9 On completion of post-weld heat treatment, the weld repairs and adjacent material are to be ground smooth and further examined by appropriate non-destructive method dependent on the dimensions, number and position of the defects as shown on a sketch so as to ensure that all defects have been eliminated.

5.1.10.10 Weld repair of defective steel castings for crankshafts is to comply with the requirements of Section 4 of this Chapter.

Section 2 CASTINGS FOR HULL STRUCTURES

5.2.1 Application

5.2.1.1 The requirements of this Section apply to carbon or carbon-manganese steel castings intended for use in the construction of hull structures. Where carbon steel or carbon manganese steel or alloy steel with a tensile strength of higher than that specified by 5.2.4.2 in this PART is used, the chemical composition, mechanical properties and heat treatment procedures are to be submitted to CCS for approval.

5.2.2 Chemical composition

5.2.2.1 The chemical composition of ladle samples of steel castings is to comply with the requirements of Table 5.2.2.1.

Chemical Composition of Ladle Samples of Castings for Hull Structures Table 5.2.2.1

Chemical composition (%)								
C	Si	Mn ^{Note 1}	P	S	Residual elements ^{Note 2}			
					Ni	Cr	Mo	Cu
≤0.23	≤0.60	≤1.60	≤0.04	≤0.04	≤0.40	≤0.30	≤0.15	≤0.30

Note 1: The manganese content is not to be less than 3 times the actual carbon content.

Note 2: The total content of residual elements is to be not more than 0.80%.

Note 3: If carbon equivalent C_{eq} calculated according to following formula is not more than 0.41%, the carbon content of castings may exceed the limit of 0.23%.

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

5.2.3 Heat treatment

5.2.3.1 Castings are to be heat treated as follows:

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

5.2.4 Mechanical properties

5.2.4.1 The test specimens for castings are to be prepared as follows:

- .1 The test samples are to be poured from the same cast as the castings. They are to be either integrally cast at locations as widely separated as possible or gated to the casting.
- .2 At least 1 tensile specimen is to be prepared for each casting or each batch of castings;
- .3 Where the casting is of complex design, or where the finished mass exceeds 10 t, two test specimens are to be provided. Where large castings are made from two or more casts which are not mixed in a ladle prior to pouring, two or more test samples are required corresponding to the number of casts involved. These are to be integrally cast at locations as widely separated as possible.

5.2.4.2 The mechanical properties of castings are to comply with the requirements of Table 5.2.4.2.

Mechanical Properties of Castings for Hull Structures

Table 5.2.4.2

Tensile strength $R_{m \min}$. (N/mm ²)	Yield strength $R_{eH \min}$. (N/mm ²)	Elongation $A_5 \min$. (%)	Reduction of cross section $Z \min$. (%)
400	200	25	40

5.2.5 Non-destructive testing

5.2.5.1 Castings which are to be used in the construction of the stern frame, rudder and propeller shaft supports are to be examined by ultrasonic and magnetic particle methods, and the results are to comply with the relevant recognized standards. For other steel castings the examination is to be carried out in accordance with the requirements indicated on the approved plans.

Section 3 CASTINGS FOR MECHANICAL CONSTRUCTION

5.3.1 Application

5.3.1.1 The requirements of this Section apply to carbon and carbon-manganese steel castings intended for use in machinery construction. Where carbon steel or carbon manganese steel or alloy steel with carbon content of higher than that specified by Table 5.3.2.1 is used, the chemical composition, mechanical properties and heat treatment procedures are to be submitted to CCS for approval.

5.3.2 Chemical composition

5.3.2.1 The chemical composition of ladle samples of steel castings is to comply with the requirements of Table 5.3.2.1.

Chemical Composition of Ladle Samples of Castings for Mechanical Construction Table 5.3.2.1

Application	Chemical composition (%)								
	C	Mn	Si	P	S	Residual elements ^{Note}			
						Cu	Cr	Ni	Mo
Used for welded structures	≤0.23	≤1.60	≤0.60	≤0.04	≤0.04	≤0.30	≤0.30	≤0.40	≤0.15
Used for non-welded structures	≤0.40	0.50~1.60	≤0.60	≤0.04	≤0.04	≤0.30	≤0.30	≤0.40	≤0.15

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

5.3.2.2 When two or more steel castings are welded together as a whole, the carbon content is not to exceed 0.23% and the whole is to have good weldability. Where carbon steel, carbon manganese steel or alloy steel with higher carbon content is used for welded structures, it is to be approved by CCS.

5.3.3 Heat treatment

5.3.3.1 Castings are to be heat treated as follows:

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

5.3.3.2 Engine bedplate castings and any other castings where dimensional stability and freedom from internal stresses are important are to be given a stress relief heat treatment as follows:

- .1 the casting is to be heated to a temperature not lower than 550 °C, followed by furnace cooling to 300 °C or lower; or
- .2 fully annealed, and followed by furnace cooling to 300 °C or lower.

5.3.4 Mechanical properties

5.3.4.1 At least one tensile test specimen is to be prepared for each casting or batch of castings from the same cast.

5.3.4.2 Where the casting is of complex design, or where the finished mass exceeds 10 t, two test specimens are to be provided. Where large castings are made from two or more casts which are not mixed in a ladle prior to pouring, two or more test samples are required corresponding to the number of casts involved. The test materials are to be integrally cast at locations as widely separated as possible.

5.3.4.3 For carbon or carbon-manganese steel castings, the mechanical properties are to comply with the requirements of Table 5.3.4.3.

Mechanical Properties of Castings for Mechanical Construction

Table 5.3.4.3

Tensile strength R_m min. ^{Note 2} (N/mm ²)	Yield strength R_{eH} min. ^{Note 1} (N/mm ²)	Elongation ^{Note 1} min. (%)	Reduction of cross section Z min. (%)
400	200	25	40
440	220	22	30
480	240	20	27
520	260	18	25
560	300	15	20
600	320	13	20

Note 1: For an intermediate value for tensile strength, its corresponding R_{eH} , A_5 and Z minimums maybe obtained by interpolation.

Note 2: For all grades of castings in the Table, the tensile strength range is 150 N/mm².

5.3.5 Non-destructive testing

5.3.5.1 Castings for important machinery constructions are to be subjected to non-destructive testing as follows:

- .1 Castings of engine bedplates, piston crowns and cylinder covers are to be examined by magnetic particle and ultrasonic testing.
- .2 Other castings are to be examined by non-destructive methods where indicated on the approved plan or specially required by CCS.

Section 4 CASTINGS FOR CRANKSHAFTS

5.4.1 Application

5.4.1.1 The requirements of this Section apply to carbon and carbon-manganese steel castings for semi-built and fully built crankshafts. Where carbon steel or alloy steel with carbon content of higher than that specified in this Section is used, the chemical composition, mechanical properties and heat treatment procedures are to be submitted to CCS for approval. For alloy steels, the tensile strength is not to exceed 700 N/mm².

5.4.2 Manufacture

5.4.2.1 The method of producing combined web and pin castings is to be approved by CCS. For this purpose, the manufacturer is required to carry out necessary procedure verification tests to demonstrate the soundness of the casting and the properties at important locations.

5.4.3 Chemical composition

5.4.3.1 The chemical composition of ladle samples of castings for crankshafts is to comply with the requirements of Table 5.3.2.1.

5.4.4 Heat treatment

5.4.4.1 Castings for crankshafts are to be heat treated as follows:

- .1 fully annealed and cooled in the furnace to a temperature of 300 °C or lower; or
- .2 normalized and tempered at a temperature of not less than 550 °C, and cooled in the furnace to a temperature of 300 °C or lower.

5.4.5 Mechanical properties

5.4.5.1 Test material for crankshaft castings is to be gated to the castings. Proposals for the number of tests and the location of test material on the casting are to be submitted by the manufacturer to CCS for approval.

5.4.5.2 The test material for each casting is to be sufficient for at least one group of test specimens and for possible re-test purposes. Each group of test specimens is to consist of one tensile specimen and one set of three impact specimens.

5.4.5.3 For carbon or carbon-manganese crankshaft castings, their mechanical properties are to comply with the requirements of Table 6.4.5.3.

Mechanical Properties of Castings for Crankshafts

Table 5.4.5.3

Tensile strength R_m min. ^{Note 2} (N/mm ²)	Yield strength ^{Note 1} min. (N/mm ²)	Elongation ^{Note 1} min. (%)	Reduction of area ^{Note 1} min. (%)	Charpy V-notch impact test Average impact energy min. (J)	Charpy U-notch impact test Average impact energy min. (J)
400	200	28	45	32	30
440	220	26	45	28	27
480	240	24	40	25	25
520	260	22	40	20	22
550	275	20	35	18	20

Note 1: For an intermediate value for tensile strength, its corresponding R_{eH} , A_5 and Z minimums maybe obtained by interpolation.

Note 2: For all grades of castings in the Table, the tensile strength range is 120 N/mm².

Note 3: Impact tests are to be carried out at an ambient temperature of 18 °C ~ 25 °C. Unless otherwise specified, manufacturer may select Charpy V-type or U-notch impact specimen at its own discretion.

5.4.6 Non-destructive testing

5.4.6.1 Each casting is to be examined by ultrasonic testing.

5.4.6.2 Magnetic particle examination is to be carried out over all surfaces of the crankshaft castings.

5.4.7 Rectification of defects

5.4.7.1 Where castings have shallow surface defects, consideration is first to be given to removing such defects by grinding and blending or by machining. Shadow grooves or depressions resulting from the removal of defects are not to exceed $0.0ld$ (d being the diameter of crankpin or pin hole). Shallow surface defects may be removed by machining the surface where there is excess metal.

5.4.7.2 Generally, approval for repairs by welding will be given to rectify areas only where accidental defects arise, subject to prior approval of CCS.

5.4.7.3 Approval for weld repairs will not be given in the following circumstances:

- .1 for the rectification of repetitive defects caused by improper foundry technique or practice;
- .2 for the building up by welding of surfaces or large shallow depressions;
- .3 where the carbon content of the steel exceeds 0.30%;
- .4 where the carbon equivalent of the steel exceeds 0.65%, given by:

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15} \quad \%$$

5.4.7.4 Where necessary and provided that agreement of CCS has been obtained, the surface defects of crankshaft castings may be repaired by welding:

.1 To the surfaces of crank webs:

(1) the volume of the largest groove which is to be welded is not to exceed $3.2t$ (cm³); the total volume of all grooves which are to be welded is not to exceed $9.6t$ (cm³ per crank web, where t is the web axial thickness, in cm (as shown in Figures 5.4.7.4.1-1 and 5.4.7.4.1-2);

(2) the welds do not extend within the cross-hatched zones marked on Figures 5.4.7.4.1-1 and 5.4.7.4.1-2 for fully built and semi-built crank throws, respectively;

(3) more weld repairs on balance weights may be permitted at the discretion of the Surveyor, provided that such repairs are wholly contained within the balance weight and do not affect the strength of the crank web.

.2 In the surface of the bore for the journal:

(1) the weld areas are not to be less than 125 mm apart;

(2) the welds are not to be located within circumferential bands of $t/5$ from the edges of the bores, nor at any position within the inner 120 ° arc of the bores, as show in Figures 5.4.7.4.1-1 and 5.4.7.4.1-2;

(3) the volume of the largest weld is to be not more than $1.1t$ (cm^3), where t is the web axial thickness at the bore, in cm, and not more than three welds are to be made in any one bore surface.

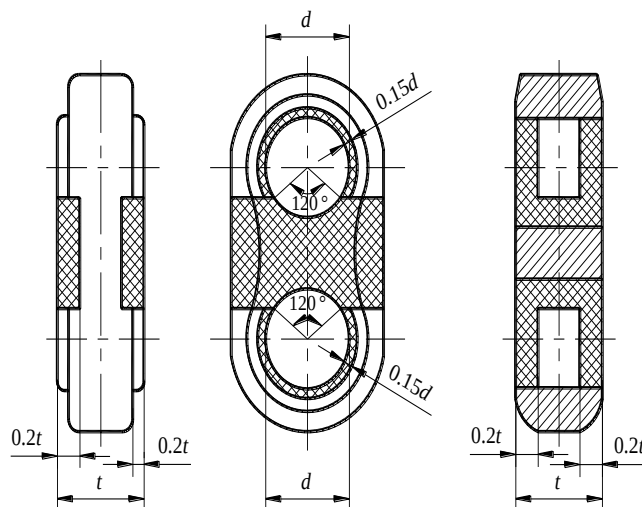


Figure 5.4.7.4.1-1 Fully Built Crankshaft Positions Not Allowed to Undergo Welding Repair

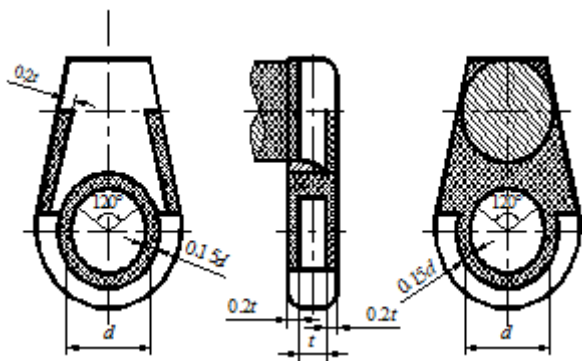


Figure 5.4.7.4.1-2 Semi-built Crankshaft Positions Not Allowed to Undergo Welding Repair

5.4.7.5 After all defective material has been removed from a region, this is to be proven by magnetic particle examination or other suitable method, and the excavation is to be suitably shaped to allow good access for welding.

5.4.7.6 Weld repairs are to be carried out by qualified welders. The welds are to be made in the down hand position using low hydrogen type consumables which will produce a deposited metal in no way inferior in properties to the parent metal.

5.4.7.7 All castings are to be given a preliminary refining heat treatment prior to the commencement of weld repairs. Before welding, the material is to be preheated to a temperature of not less than 200°C . It is recommended that this preheating be carried out in a furnace. The preheating temperature is to be maintained until welding repair and post-weld heat treatment are completed.

5.4.8 Post-weld heat treatment and inspection

5.4.8.1 On completion of the repairs, the casting is to be given a post-weld heat treatment, either:

- .1 fully annealed; or
- .2 normalized and tempered.

Where small isolated defects are revealed after completion of the above post-weld heat treatment, weld repairs followed by a stress relieving treatment at a temperature of not less than 550°C may be permitted.

5.4.8.2 Welds are to be dressed smooth by grinding, and proven by magnetic particle inspection. The surfaces of the welds and adjacent parent steel are to be free from harmful defects.

Section 5 CASTINGS FOR BOILERS, PRESSURE VESSELS AND PIPING SYSTEMS

5.5.1 Application

5.5.1.1 This Section applies to carbon, carbon-manganese and alloy steel castings for boilers, pressure vessels and piping systems. If carbon steel and carbon manganese steel with a tensile strength of higher than 490 N/mm² and lower than 520 N/mm² or alloy steel other than that specified by this Section is used, the chemical composition, mechanical properties and heat treatment procedures are to be submitted to CCS for approval.

5.5.2 Chemical composition

5.5.2.1 The chemical composition of ladle samples of castings is to comply with the limits specified in Table 5.5.2.1.

Chemical Composition of Ladle Samples of Castings for Boilers, Pressure Vessels and Piping Systems **Table 5.5.2.1**

Steel type	Chemical composition (%)									
	C	Si	Mn	S	P	Residual elements				
						Cr	Mo	Cu	Ni	Total content
Carbon and carbon-manganese steel	≤0.25	≤0.60	0.50~1.60	≤0.40	≤0.40	≤0.25	≤0.15	≤0.30	≤0.40	≤0.80
Alloy steel	C	Si	Mn	S	P	Cr	Mo	V	Residual elements	
									Cr	Cu Ni
0.5Mo	≤0.25	≤0.60	0.50~1.0	≤0.40	≤0.40	—	0.35~0.65	—	≤0.25	≤0.30 ≤0.40
1Cr0.5Mo	≤0.23	≤0.60	0.50~0.80	≤0.40	≤0.40	1.0~1.50	0.45~0.65	—	—	≤0.30 ≤0.40
2.25Cr1Mo	≤0.20	≤0.60	0.40~0.80	≤0.40	≤0.40	2.0~2.75	0.90~0.20	—	—	≤0.30 ≤0.40
0.5Cr0.5Mo0.25V	≤0.20	≤0.45	0.40~0.80	≤0.40	≤0.40	0.30~0.50	0.40~0.60	0.20~0.30	—	≤0.30 ≤0.40

5.5.3 Heat treatment

5.5.3.1 Castings are to be heat treated as follows:

- .1 fully annealed; or
- .2 normalized; or
- .3 normalized and tempered; or
- .4 quenched and tempered.

5.5.4 Mechanical properties

5.5.4.1 From each casting at least one test specimen is to be taken. Where a casting is of complex design, or where the finished mass exceeds 2.5t, at least two test specimens are to be provided. The test specimens are to be integrally cast at locations as widely separated as possible.

5.5.4.2 Small castings may be batch tested in accordance with the requirements of this Chapter subject to agreement of CCS.

5.5.4.3 The mechanical properties of the castings are to comply with the requirements of Table 5.5.4.3.

Mechanical Properties of Castings for Boilers, Pressure Vessels and Piping Systems **Table 5.5.4.3**

Steel type	Tensile strength R_m min. (N/mm ²)	Yield strength R_{eH} min. (N/mm ²)	Elongation A_5 min. (%)	Reduction of area Z min. (%)
Carbon and carbon-manganese steel	410	205	25	40
	460	230	22	30
	490	245	20	25
0.5Mo	440	245	21	30
1Cr0.5Mo	480	280	17	20
2.25Cr1Mo	480	280	17	20
0.5Cr0.5Mo0.25V	510	295	17	20

Note: For all grades of castings in the Table, the tensile strength range is 150 N/mm².

5.5.5 Non-destructive testing

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

5.5.6 Mechanical properties at elevated temperature

5.5.6.1 In the case of castings intended for use at elevated temperatures, details of the mechanical properties at elevated temperatures and relevant information are to be submitted to CCS for approval.

Section 6 STEEL CASTINGS FOR PROPELLERS

5.6.1 Application

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

5.6.2 Chemical composition

5.6.2.1 The chemical composition of ladle samples of carbon and carbon-manganese steel castings for propellers is to comply with the requirements of Table 5.3.2.1, but the carbon content is not to be higher than 0.25%.

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

Chemical Composition of Stainless Steel Castings for Propellers

Table 5.6.2.2

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

Note: M - martensite, F - ferrite, A - austenite.

5.6.3 Heat treatment

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

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

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

- .1 Martensitic castings are to be austenitized and tempered;
- .2 Austenitic castings are to be solution heated.

5.6.4 Mechanical properties

5.6.4.1 The test material is to be cast integral with the steel casting body of the propeller hub or blade flange.

5.6.4.2 At least one tensile specimen and one set of 3 Charpy V-notch impact specimens are to be intercepted for each steel casting.

5.6.4.3 The mechanical properties of steel castings for propellers are to comply with the requirements of Table 5.6.4.3.

Mechanical Properties of Steel Castings for Propellers**Table 5.6.4.3**

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

Note 1: The impact tests need not be required for austenitic stainless steel castings.

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

5.6.5 Non-destructive testing

5.6.5.1 For steel castings for propellers and blades, magnetic particle testing is to be performed on the surfaces at the roots of blades. Dye penetrant testing is to be conducted on austenitic stainless steel castings for blades.

CHAPTER 6 IRON CASTINGS

Section 1 GENERAL PROVISIONS

6.1.1 Application

6.1.1.1 This Chapter applies to both grey and spheroidal or nodular graphite iron castings or other higher tensile strength iron castings intended for use in the construction of ships, machinery, boilers, pressure vessels and piping systems. With the consent of CCS, all cast irons other than those specified in this Chapter may be inspected in accordance with the approved standards.

6.1.1.2 Iron castings are to be manufactured and tested in accordance with the relevant requirements of this Chapter and Chapters 1 and 2 of this PART.

6.1.2 Manufacture

6.1.2.1 Suitable mechanical methods are to be employed for the removal of runners and other surplus material from castings. Where it is proposed to use thermal cutting processes, machining is to be used so as to remove the cutting face that has been affected by heat.

6.1.3 Quality

6.1.3.1 Iron castings are to be free from defects such as cracks, pores, shrinkage cavities, porosities, sand and slag cavities and cold shuts, which would be prejudicial to their proper application in service and to subsequent machining.

6.1.3.2 The surface finish of iron castings is to be in accordance with the requirements indicated on the approved plans.

6.1.4 Chemical composition

6.1.4.1 Unless otherwise specified, the chemical composition of the iron used is left to the discretion of the manufacturer, who is to ensure that it is suitable to obtain the dimensions of the castings and their mechanical properties specified in the subsequent Sections of this Chapter.

6.1.5 Heat treatment

6.1.5.1 Unless otherwise specified, iron castings may be supplied in either the as cast or properly heat treated condition.

6.1.6 Test material

6.1.6.1 Sufficient test material is to be provided for each casting or batch of castings for the required tests and for possible re-test purposes. For large castings, where more than one ladle of metal is used, one test sample is to be provided, from each ladle used.

6.1.6.2 Where separately cast test samples are used, they are to be cast from the same ladle as the castings in moulds of the same type of material as the moulds for the castings. The test samples are not to be stripped from the moulds until the metal temperature is below 500 °C.

6.1.6.3 All test samples are to be suitably marked to identify them with the castings which they represent.

6.1.6.4 Where castings are supplied in the heat treated condition, the test samples are to be heat treated together with the castings which they represent.

6.1.6.5 Preparation of test specimens and methods of tests are to comply with the requirements of Chapter 2 of this PART.

6.1.7 Mechanical properties

6.1.7.1 The mechanical properties of iron castings are to comply with the relevant requirements of this Chapter.

6.1.8 Visual and non-destructive testing

6.1.8.1 All iron castings are to be cleaned and adequately prepared for visual examination of the internal and external surfaces. The surfaces are not to be hammered, peened or treated in any way which may obscure defects.

6.1.8.2 Unless otherwise stated in the approved plans or where there is reason to suspect the soundness of the casting, the non-destructive testing of iron castings is generally not required.

6.1.8.3 The manufacturer is to ensure an adequate accuracy of the dimensions of the castings.

6.1.8.4 Where necessary, pressure tests for iron castings may be required before the final acceptance.

6.1.9 Rectification of defects

6.1.9.1 Minor surface blemishes may be removed by a proper method.

6.1.9.2 Repairs of surface defects by welding are generally not permitted. If deemed necessary, full details of the proposed repair procedure are to be submitted for approval of CCS prior to the commencement of the proposed rectification.

6.1.9.3 Where an iron casting does not bear the internal pressure, the loosened portion can be filled with appropriate plastic filler with the consent of CCS.

Section 2 GREY IRON CASTINGS**6.2.1 Application**

6.2.1.1 The requirements of this Section apply to grey iron castings intended for use in the construction of machinery, pipe fittings and propellers.

6.2.2 Test material

6.2.2.1 The test samples are to be in the form of cylindrical bars 30 mm in diameter and of a suitable length. Where two or more test samples are cast simultaneously in a single mould, the bars are to be at least 50 mm apart.

6.2.2.2 Integral cast samples may be used when a casting is more than 20 mm in thickness and its mass exceeds 200 kg, subject to an agreement between the manufacturer and the purchaser. The type and location of the samples are to be such as to provide approximately the same cooling conditions as for the casting it represents and to be agreed by CCS.

6.2.2.3 Batch test can be performed on iron castings with a single piece weight of less than 1t after cleaning. The same batch of iron castings is to be of the same type and size and is to be cast in the same furnace. One specimen is to be taken per 2t for each batch of iron castings (after cleaning).

6.2.2.4 For the same type of iron castings that are continuously cast in large quantities, the mass of each batch can be increased to 2h casting output.

6.2.2.5 Where one grade of cast iron is melted continuously in large tonnages and production is carefully monitored by systematic checking of the melting process, such as chill testing, chemical analysis or thermal analysis, test samples may be taken at longer intervals as agreed by CCS.

6.2.2.6 Integral cast samples are to be heat treated together with the iron casting.

6.2.2.7 Each test piece is to be processed into a tensile specimen with a diameter of 20mm.

6.2.3 Heat treatment

6.2.3.1 For service at elevated temperatures or where geometrical and dimensional stability is required, the castings are to be given a suitable tempering or stress relieving heat treatment.

6.2.4 Mechanical properties

6.2.4.1 The mechanical properties of grey iron castings are to comply with the requirements of Table 6.2.4.1.

Mechanical Properties of Grey Iron Castings**Table 6.2.4.1**

Designation of grey cast iron	Tensile strength $R_{m,min.}$ ^{Note 1} (N/mm ²)	Brinell hardness ^{Note 2} (HB)
HT200	200	150~225
HT250	250	168~251
HT300	300	185~278

HT350	350	203~304

Note 1: In the table, the tensile strength ranges at various strength grades are 100 N/mm².

Note 2: Hardness test only applies to castings to which wear resistance is important, e.g. for propellers and cylinder blocks, cylinder liners, pistons, piston rings, guide plates of diesel engines.

Note 3: Where attached test samples are employed, the mechanical properties of grey iron castings may be accepted according to recognized national/international standards.

6.2.4.2 The minimum tensile strength of castings is not to be less than 200 N/mm². The fractured surfaces of all tensile test specimens are to be granular and entirely grey in appearance.

Section 3 SPHEROIDAL OR NODULAR GRAPHITE IRON CASTINGS

6.3.1 Application

6.3.1.1 The requirements of this Section apply to spheroidal or nodular graphite iron castings intended for use in the construction of machinery and pipe fittings.

6.3.1.2 This Section is applicable to spheroidal or nodular graphite iron castings for use at ambient temperatures. If the castings are intended for use at low or elevated temperatures, special approval of CCS is to be obtained.

6.3.2 Heat treatment

6.3.2.1 For service at elevated temperatures or where geometrical and dimensional stability is required, the castings are to be given a suitable stress relieving heat treatment before machining or after any refining heat treatment. Where special qualities with a tensile strength of 350 N/mm² or 400 N/mm² and impact tests are required, the castings are to be given a ferritizing heat treatment.

6.3.2.2 Where castings are to be surface hardened, details of the procedure are to be submitted to CCS for approval.

6.3.3 Test material

6.3.3.1 Specimens are generally divided into two types as per shape: U-type and Y-type, which are to be cast alone or in whole in accordance with the provisions of Figure 6.3.3.1(1) and 6.3.3.1(2) respectively, and may also be casted as per other shapes agreed by CCS.

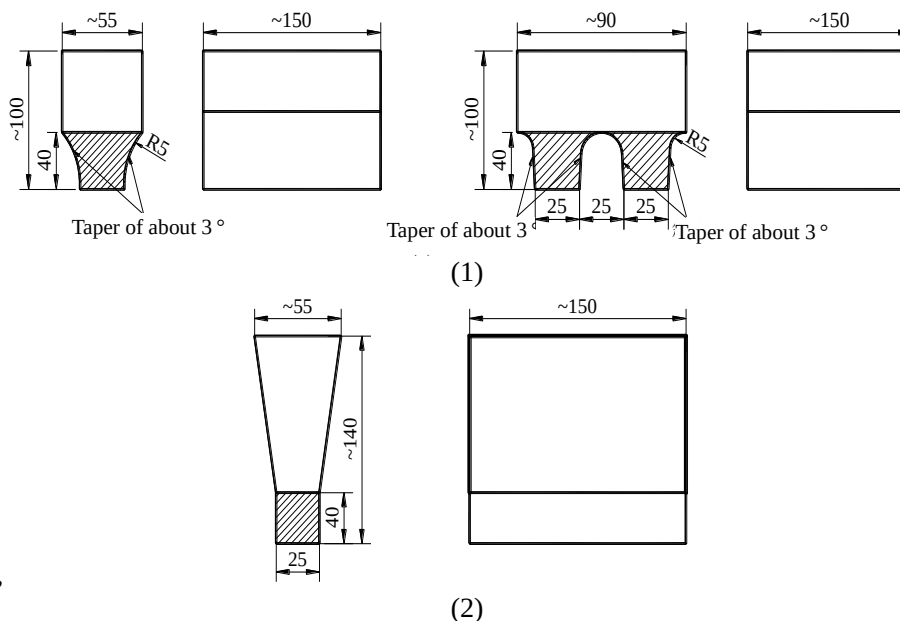


Figure 6.3.3.1 Shapes of Impact Test Pieces

6.3.3.2 Test samples are to be prepared as follows:

- 1 Monolithic cast test pieces: at least one test piece is to be provided for each iron casting or each batch of iron castings with a mass of 2t, and the test piece is to be taken near the sprue of the iron casting;
- 2 Separately cast test pieces: at least one test piece is to be provided for each iron casting or each batch of iron castings with a mass of not more than 1t; when the mass exceeds 1t, each 2t is to be cast

separately.

- .3 For large iron castings or bulk iron castings casted with more than one furnace of molten iron, specimens are to be provided for each furnace in accordance with the provisions of .1 or .2;
- .4 Where heat treatments are required for castings, the integrally cast samples are to be removed from the casting only after the heat treatment and the separately cast samples are to be heat treated together with the castings which they represent.

6.3.3.3 One tensile test specimen is to be prepared from each test sample.

6.3.4 Mechanical properties

6.3.4.1 The mechanical properties of spheroidal or nodular graphite iron castings are to comply with the requirements of Table 6.3.4.1.

Mechanical Properties of Spheroidal or Nodular Graphite Iron Castings

Table 6.3.4.1

Tensile strength R_m min. (N/mm ²)	Yield strength R_{eH} min. (N/mm ²)	Elongation A_5 min. (%)	Hardness (HB)	Typical structure of matrix
400	250	12	130~180	Ferrite
500	320	7	170~230	Ferrite + pearlite
600	370	3	190~270	Ferrite + pearlite
700	420	2	225~305	Pearlite
800	480	2	245~335	Pearlite or tempered structure
900	600	2	280~360	Bainite or tempered martensite

Note: Intermediate values may be obtained by interpolation. Generally, the tensile strength and elongation are used as the acceptance criteria. However, if required in the design plan, the yield strength and hardness are also to be used as the acceptance criteria. For integral cast samples, the elongation may be 2% less.

6.3.4.2 Where the result of any tensile test does not comply with the requirements, two additional specimens are to be taken from the same casting or batch of castings for re-tests. If both additional tests comply with the requirements, the said casting or batch of castings may be accepted. If one or both additional tests fail, the said casting or batch of castings is to be rejected.

6.3.4.3 Where necessary, impact tests may be required by CCS. One set of three Charpy V-notch impact test specimens is to be taken from each test sample, the dimension of the specimens and the test procedure are to comply with the relevant requirements of Chapter 2 of this PART.

6.3.5 Metallographic examination

6.3.5.1 Metallographic specimens are to be taken from each furnace of iron castings and may also be intercepted from tensile specimens.

6.3.5.2 Metallographic test is to show that at least 90% of graphite is dispersive globular or agglomerate flocculent. Typical metallographic structures are listed in Table 6.3.4.1.

Section 4 IRON CASTINGS FOR CRANKSHAFTS

6.4.1 Application

6.4.1.1 This Section gives additional requirements for cast iron crankshafts intended for diesel engines and compressors for refrigerants. Grey iron castings for crankshafts only apply to refrigerating compressors.

6.4.2 Heat treatment

6.4.2.1 The crankshaft castings other than those which are fully annealed, normalized or oil quenched and tempered, are to receive a suitable stress relief heat treatment before machining.

6.4.2.2 Where it is proposed to harden the surfaces of machined pins and/or journals of cast iron crankshafts, details of the process are to be submitted to CCS for approval. Before such a process is applied to a crankshaft, procedure tests are to be made to the satisfaction of CCS.

6.4.3 Test material

6.4.3.1 The dimensions of the test samples are to be such as to ensure that they have mechanical properties representative of those of the average section of the crankshaft casting.

6.4.3.2 For large crankshaft castings, the test samples are to be cast integral with, or gated from each casting.

6.4.3.3 For small crankshaft castings having a mass not exceeding 100 kg each and produced in batches, the test samples are to be cast in accordance with the requirements of 6.3.3 in this PART.

6.4.4 Mechanical properties

6.4.4.1 For crankshaft castings in grey iron, the tensile strength is to be not less than 300 N/mm². For crankshaft castings in spheroidal or nodular graphite iron, the tensile strength is to be not less than 490 N/mm² and the mechanical properties are to comply with the requirements given in Table 6.3.4.1 in this PART.

6.4.4.2 In addition to tensile tests, hardness tests are to be carried out on each casting. For spheroidal or nodular graphite iron castings, the hardness values are to comply with the requirements given in Table 6.3.4.1 in this PART and for grey iron castings, the hardness test results are to comply with the relevant recognized standards.

6.4.5 Rectification of defects

6.4.5.1 Cast iron crankshafts are not to be repaired by welding, and blemishes are not to be plugged with a filler.

6.4.6 Non-destructive testing

6.4.6.1 Cast crankshafts are to be subjected to a magnetic examination after final machining. The results of the magnetic particle examination are to be submitted to CCS for approval.

CHAPTER 7 STEEL PIPES AND TUBES

Section 1 GENERAL PROVISIONS

7.1.1 Application

7.1.1.1 The requirements of this Section apply to boiler tubes and superheater tubes, and pipes intended for use in the construction of boilers, pressure vessels, fishing vessels and machinery.

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

7.1.1.3 In addition to the requirements of Chapters 1 and 2 of this PART, all pipes and tubes (except Class III pipes) are to be manufactured and tested in accordance with the provisions of relevant Sections of this Chapter

7.1.1.4 For the classification of piping systems involved in this Chapter, please refer to the relevant requirements of Chapter 2, PART 3.

7.1.2 Manufacture

7.1.2.1 Unless otherwise agreed, pipes and tubes are to be made of killed steel manufactured by the basic oxygen, electric or open hearth processes, and the steel used is to be manufactured and cast in ingot moulds or by a continuous casting process approved by CCS.

7.1.2.2 Pipes and tubes may be manufactured by any one of the following methods:

- .1 Hot formed seamless;
- .2 Cold formed seamless;
- .3 electric resistance or induction welded;
- .4 electric fusion welded.

7.1.2.3 Care is to be taken during manufacture that the pipe or tube surfaces coming in contact with any non-ferrous metals or their compounds are not contaminated to such an extent as could prove harmful during subsequent fabrication and operation

7.1.3 Quality

7.1.3.1 The internal and external surfaces of the pipes and tubes are to be free from cracks, laps, laminations, scabs, pinches and hairlines. In case of the foregoing defects, they are to be removed, but the reduction in wall thickness resulting from the removal of defects is not to exceed the permissible minimum wall thickness.

7.1.3.2 The external and internal surfaces of welded pipes are to be free from cracks, scabs, dislocations, burrs, burnings, impressions and deep scratches, but small impressions having a depth not exceeding the minus tolerance in wall thickness, slight dislocations, roll marks and thin scales and traces resulting from grinding and removing of burrs may be accepted.

7.1.3.3 All pipes and tubes are to be reasonably straight and smooth. The ends are to be cut nominally square with the axis of the pipe or tube, and are to be free from excessive burrs.

7.1.3.4 The type and dimensional tolerances of steel pipes and tubes are to comply with relevant recognized standards.

7.1.4 Chemical composition

7.1.4.1 The chemical composition of ladle samples and methods of deoxidation of steel pipes and tubes are to comply with the corresponding requirements specified in relevant Sections of this Chapter.

7.1.5 Heat treatment

7.1.5.1 All pipes and tubes are to be heat treated and supplied in the appropriate conditions detailed in the relevant Sections of this Chapter.

7.1.6 Test and test specimens

7.1.6.1 Pipes and tubes may be presented for test and inspection in batches. Each batch is to consist of pipes or tubes of the same type of steel, the same size, from the same cast and heat treated in the same furnace charge.

7.1.6.2 For pipes for Class I pressure systems and boiler and superheater tubes, specimens are to be prepared from at least 2% of each batch of steel pipes.

7.1.6.3 For pipes for Class II pressure systems, the requirements of Table 7.1.6.3 are to be followed. Test

specimens are to be cut from at least one pipe selected at random from each batch or part thereof.

Number in Batch of Class II Steel Pipes**Table 7.1.6.3**

Outside diameter D of steep pipe (mm);	Number in batch (piece)
$D \leq 325$	200
$D > 325$	100

7.1.6.4 Pipes and tubes are to be tested and evaluated and with the test samples prepared in accordance with the relevant requirements given in this Chapter and Chapter 2 of this PART.

7.1.6.5 Normally, longitudinal test specimens are to be taken from the pipes. Where the diameter of pipes is 200 mm or more, test specimens may also be taken transverse to the pipe's axis.

7.1.7 Non-destructive testing

7.1.7.1 All the welds of welded pipes and tubes are to be examined by non-destructive methods on a continuous basis, and the results of testing are to comply with relevant recognized standards.

7.1.8 Hydraulic test

7.1.8.1 Each pipe or tube is to be subjected to a hydraulic test at the manufacturer's works. Subject to agreement of CCS, either an ultrasonic or eddy current test can be accepted in lieu of the hydraulic test, and technical documents which can demonstrate the efficiency of the method are to be submitted by the manufacturer.

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

- .1 The test pressure is to be twice the working pressure of the pipe, and is not to be less than 7.0 MPa. If required by the purchaser, the test pressure may be as specified in the contract, provided that the details are submitted to CCS for information.
- .2 The test pressure stated by .1 need not exceed the value calculated by the following formula:

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

Where: P -- test pressure (MPa);

D -- nominal outside diameter of the pipe, in mm;

t -- nominal wall thickness of the pipe, mm;

σ_t -- permissible stress, in N/mm^2 ; for carbon steel pipes, R is to be taken as 80% of the minimum yield strength (R_{eH} or $R_{p0.2}$); for austenitic steel pipes, 80% of the minimum proof strength ($R_{p0.2}$).

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

7.1.9 Rectification of defects

7.1.9.1 Surface imperfections may be removed by grinding provided that the thickness of the pipe or tube after dressing is not less than the required minimum thickness. The dressed area is to be blended into the contour of the tube.

7.1.9.2 Where it is proposed to repair minor surface defects by welding, details of the welding procedure specification, including preheating and post weld heat treatment, are to be submitted to CCS for approval. In all cases, the area is to be tested by magnetic particle examination, or, in the case of austenitic steels, by liquid penetrant examination on completion of welding, heat treatment and surface grinding.

Section 2 SEAMLESS PRESSURE PIPES

7.2.1 Application

7.2.1.1 The requirements of this Section apply to ferritic steel seamless pressure pipes in carbon, carbon-manganese and low alloy steels.

7.2.2 Manufacture and chemical composition

7.2.2.1 Seamless pressure pipes are to be manufactured by a seamless process and may be hot finished/formed or cold formed/finished.

7.2.2.2 The method of deoxidation and the chemical composition of ladle samples are to comply with the requirements of Table 7.2.2.2.

Deoxidation and Chemical Composition of Seamless Pressure Pipes**Table 7.2.2.2**

Steel type	Grade (N/mm ²)	Deoxidation	Chemical composition (%)											
			C	Si	Mn	S	P	Ni	Cr	Mo	Cu	Sn	V	Al
Carbon and Carbon manganese	320	Semi-killed or killed	≤0.16	—	0.4~0.7	≤0.04	≤0.04	Ni≤0.30 Cr≤0.25 Mo≤0.10 Cu≤0.30 Total residuals ≤ 0.7						
	360		≤0.17	≤0.35	0.4~0.8	≤0.04	≤0.04							
	410	Killed	≤0.21	≤0.35	0.4~1.2	≤0.04	≤0.04							
	460		≤0.22	≤0.35	0.8~1.4	≤0.04	≤0.04							
	490		≤0.23	≤0.35	0.8~1.5	≤0.04	≤0.04							
1Cr 0.5Mo	440	Killed	0.1~0.18	0.1~0.35	0.4~0.7	≤0.04	≤0.04	≤0.3	0.7~1.1	0.45~0.65	≤0.25	≤0.03	—	≤0.02
2.25Cr1Mo	410 490		0.08~0.15	0.1~0.35	0.4~0.7	≤0.04	≤0.04	≤0.3	2.0~2.5	0.9~1.2	≤0.25	≤0.03	—	≤0.02
0.5Cr0.5Mo0.25V	460		0.1~0.18	0.1~0.35	0.4~0.7	≤0.04	≤0.04	≤0.3	0.3~0.6	0.5~0.7	≤0.25	≤0.03	0.22~0.32	≤0.02

7.2.3 Heat treatment

7.2.3.1 Pipes are to be heat treated and are to comply with the following:

- 1 For carbon and carbon-manganese seamless steel pipes, they are to be normalized or normalized and tempered, but may be supplied in the hot finished condition provided that the finishing temperature is sufficiently high to soften the material.
- 2 For alloy steel pipes, they are to be heat treated in accordance with the requirements of Table 7.2.3.1.2.

Heat Treatment of Seamless Alloy Steel Pressure Pipes**Table 7.2.3.1.2**

Alloy steel		Method of heat treatment
1Cr0.5Mo		Normalized and tempered
2.25Cr1Mo	Grade 410	Fully annealed
	Grade 490	Normalized and tempered (tempered at 650 °C~780 °C or 650 °C~750 °C)
0.5Cr0.5Mo0.25V		Normalized and tempered

Mechanical and Technological Properties of Seamless Pressure Pipes**Table 7.2.4.1**

Steel type	Grade (N/mm ²)	Tensile strength R_m min. (N/mm ²)	Yield strength R_{eH} min. (N/mm ²)	Elongation A_5 min. (%)	Flattening test constant C	Bend test diameter of former (mm)
Carbon and carbon-manganese	320	320	195	25	0.10	4t (t is thickness)
	360	360	215	24	0.10	
	410	410	235	22	0.08	
	460	460	265	21	0.07	
	490	490	285	21	0.07	
1Cr0.5Mo	440	440	275	22	0.07	4t
2.25Cr1Mo	410	410	135	20	0.07	4t
	490	490	275	16		
0.5Cr0.5Mo0.25V	460	460	275	15	0.07	4t

Note 1: For carbon and carbon-manganese steels, the tensile strength range for all grades in the Table is 120 N/mm².

Note 2: For alloy steels, the tensile strength range for all grades in the Table is 150 N/mm².

7.2.4 Mechanical properties and technological properties

7.2.4.1 Pipes may be presented for acceptance in batches, and the number of test specimens are to be in accordance with the requirements of 7.1.6 of this Chapter. Each test pipe is to be subjected to tensile and flattening or bend testing. The results of the tests are to comply with the requirements of Table 7.2.4.1.

7.2.4.2 The mechanical properties of seamless pressure pipes at elevated temperatures are given for design purpose in Tables 7.2.4.2-1 and 7.2.4.2-2.

Mechanical Properties of Seamless Pressure Pipes at Elevated Temperature**Table 7.2.4.2-1**

Steel type	Grade	Yield Strength at Elevated Temperatures R_{eH}^T min. (N/mm ²)

	(N/mm ²)	Temperature (°C)											
		50	100	150	200	250	300	350	400	450	500	550	600
Carbon and carbon-manganese	320	172	168	158	147	125	100	91	88	87	—	—	—
	360	192	187	176	165	145	122	111	109	107	—	—	—
	410	217	210	199	188	170	149	137	134	132	—	—	—
	460	241	234	223	212	195	177	162	159	156	—	—	—
	490	256	249	237	226	210	193	177	174	171	—	—	—
1Cr0.5Mo	440	254	240	230	220	210	183	169	164	161	156	151	—
2.25Cr1Mo	410 ^{Note 1}	121	108	99	92	85	80	76	72	69	66	64	62
	490 ^{Note 2}	268	261	253	245	236	230	224	218	205	189	167	145
0.5Cr0.5Mo0.25V	460	266	259	248	235	218	192	184	177	168	155	148	—

Note 1: Annealed condition;

Note 2: Normalized and tempered condition;

Average Rupture Stress of Seamless Pressure Pipes at Elevated Temperatures

Table 7.2.4.2-2

Steel type	Grade (N/mm ²)	Estimated value of stress $R_{m100000}^T$ to rupture in 100,000h (N/mm ²)																					
		Temperature (°C)																					
		380	390	400	410	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	
Carbon and carbon-manganese	320	171	155	141	127	114	102	90	78	67	57	47	36	—	—	—	—	—	—	—	—	—	
	360	171	155	141	127	114	102	90	78	67	57	47	36	—	—	—	—	—	—	—	—	—	
	410	171	155	141	127	114	102	90	78	67	57	47	36	—	—	—	—	—	—	—	—	—	
	460	227	203	179	157	136	117	100	85	73	63	55	47	41	—	—	—	—	—	—	—	—	
	490	227	203	179	157	136	117	100	85	73	63	55	47	41	—	—	—	—	—	—	—	—	
1Cr0.5Mo	440	—	—	—	—	—	—	—	—	—	—	210	177	146	121	99	81	67	54	43	35	—	
2.25Cr1Mo	410	—	—	—	—	—	—	—	196	182	168	154	141	127	115	102	90	78	69	59	51	44	
	490 ^{Note 1}	—	—	—	—	—	—	—	221	204	186	170	153	137	122	107	93	79	69	59	51	44	
0.5Cr0.5Mo0.25V	460	—	—	—	—	—	—	—	—	—	—	218	191	170	150	131	116	100	85	72	59	46	

Note 1: Normalized and tempered. When the tempering temperature exceeds 750 °C, the values for Grade 410 N/mm² are to be used.

Section 3 WELDED PRESSURE PIPES

7.3.1 Application

7.3.1.1 The requirements of this Section apply to welded ferritic steel pressure pipes in carbon, carbon-manganese and low alloy steels.

7.3.1.2 Where it is proposed to use submerged arc longitudinally welded pipes, details of the specification are to be submitted to CCS for approval.

7.3.2 Manufacture and chemical composition

7.3.2.1 Pipes are to be manufactured by the electric resistance or induction welding process.

7.3.2.2 The method of deoxidation and the chemical composition of ladle samples of the pipes are to comply with the requirements of Table 7.2.2.2 in this PART, except Grade 490 N/mm² carbon and carbon-manganese steels and 2.25Cr1Mo and 0.5Cr0.5Mo0.25V alloy steels listed therein.

7.3.3 Heat treatment

7.3.3.1 Carbon steel and carbon manganese steel pipes are to be normalized. The manufacturer may also normalize and temper them at its own discretion; alloy steel pipes are to be normalized and tempered.

7.3.4 Mechanical and technological properties

7.3.4.1 All pipes are to be presented in batches as specified in 7.1.6 in this PART. Test specimens are to be taken from welded pipes in such a way that they are alternately with or without the weld in the middle of the specimens. Reinforcement welds situated within the gauge length of the specimen are to be machined off.

7.3.4.2 Each test pipe is to be subjected to tensile and flattening or bend testing. The test results of pipes are to

comply with the requirements given in Table 7.2.4.1 except Grade 490 N/mm² carbon and carbon-manganese steels and 2.25Cr1Mo and 0.5Cr0.5Mo0.25V alloy steels listed therein.

7.3.4.3 The mechanical properties at elevated temperatures for carbon and carbon-manganese steels Grade 320~460 N/mm² and 1Cr0.5Mo steel are to comply with the requirements given in Tables 7.2.4.2-1 and 7.2.4.2-2 of this Chapter.

Section 4 BOILER AND SUPERHEATER TUBES

7.4.1 Application

7.4.1.1 The requirements of this Section apply to boiler and superheater tubes made of carbon, carbon-manganese and alloy steels.

7.4.2 Manufacture and chemical composition

7.4.2.1 Boiler and superheater tubes are to be seamless or welded and are to comply with the relevant requirements of Sections 2 and 3 of this Chapter. The method of deoxidizing and the chemical composition of ladle samples are to comply with the requirements given in Table 7.2.2.2 in this PART, except Grade 490 N/mm² carbon and carbon-manganese steels and 0.5Cr0.5Mo0.25V alloy steel listed therein.

7.4.3 Heat treatment

7.4.3.1 Boiler and superheater tubes are to be heat treated and are to comply with the appropriate requirements of Table 7.4.3.1.

Heat Treatments of Boiler and Superheater Tubes

Table 7.4.3.1

Steel type		Heat treatment
Carbon and carbon-manganese		Normalized or normalized and tempered ^{Note 1}
1Cr0.5Mo		Normalized and tempered ^{Note 2}
2.25Cr1Mo	Strength grade: 410	Fully annealed
	Strength grade: 490	Normalized, and tempered at 650 °C~780 °C or 650 °C~750 °C

Note 1: Boiler and superheater tubes hot or cold finished seamless may be supplied in the hot finished condition provided that the finishing temperature is sufficiently high to soften the material.

Note 2: 1Cr0.5Mo steel may be supplied in the normalized condition when the carbon content exceeds 0.15%.

7.4.4 Mechanical and technological properties

7.4.4.1 Tubes are to be presented for testing in batches in accordance with the requirements of 7.1.6 in this PART. Each test pipe is to be subjected at least to tensile, flattening testing or bend, drift expanding testing or flanging testing. The results of the tests are to comply with the requirements given in Table 7.4.4.1.

Mechanical and Technological Properties of Boiler and Superheater Tubes Table

7.4.4.1

Steel type	Grade (N/mm ²)	Tensile strength R_m min. (N/mm ²) ^{Note 1}	Yield strength R_{eH} min. (N/mm ²) ^{Note 1}	Elongation A_5 min. (%)	Flattening test Constant C	Bend test diameter of former (mm)	Drift expanding or flanging test increase in outside diameter (%)		
							Inside/outside diameter		
							≤0.6	>0.6, ≤0.8	>0.8
Carbon and carbon-manganese	320	320	195	25	0.10	4t (t is thickness)	12	15	19
	360	360	215	24	0.10		12	15	19
	410	410	235	22	0.08		10	12	17
	460	460	265	21	0.07		8	10	15
1Cr0.5Mo	440	440	275	22	0.07	4t	8	10	15
2.25Cr1Mo	410	410	135	20	0.07	4t	8	10	15
	490	490	275	16					

Note 1: For carbon and carbon-manganese steels, the tensile strength range for all grades in the Table is 120 N/mm².

Note 2: For alloy steels, the tensile strength range for all grades in the Table is 150 N/mm².

7.4.4.2 The mechanical properties at elevated temperatures of carbon and carbon-manganese steels Grades

320~460 N/mm² and 1Cr0.5Mo and 2.25Cr1Mo alloy steels are to comply with the requirements given in Tables 7.2.4.2-1 and 7.2.4.2-2 in this PART.

CHAPTER 8 ALUMINIUM ALLOYS

Section 1 GENERAL PROVISIONS

8.1.1 Application

8.1.1.1 This Chapter applies to seawater corrosion resistant aluminum sheets, sections (including bars and pipes), aluminum alloy rivets and pistons intended for use in the construction of hull and equipment of fishing vessels..

8.1.1.2 Aluminum alloy castings and forgings may be accepted in accordance with the relevant recognized standards.

8.1.2 Manufacture

8.1.2.1 In addition to the requirements of this Chapter, the manufacture and acceptance of aluminum alloys are to comply with the relevant requirements of Chapters 1 and 2 of this PART

8.1.2.2 Aluminum alloys may be manufactured by an approved continuous or semi-continuous casting process. Plates and sheets are to be formed by hot or cold rolling according to the mechanical properties required. Sections may be formed by extrusion, and pipes may be formed by extrusion or drawing.

8.1.3 Chemical composition

8.1.3.1 The chemical composition of aluminum alloys is to comply with the relevant requirements of Sections of this Chapter. Special tests such as corrosion resistance test and weldability test or relative details may be required by CCS as deemed necessary. Other aluminum alloys or those not fully complying with the requirements of this Chapter cannot be used until the agreement of CCS is obtained.

8.1.4 Test

8.1.4.1 Products are to be presented for test individually or in batches according to the types of aluminum alloys and the relevant requirements of Sections of this Chapter. Where products are presented for test in one batch, they are to be from the same cast, having the same chemical composition, of the same type (e. g. plates, sections or bars), in the same condition of supply and of similar dimensions. Where the products are supplied in the heat treated condition, each batch is to be heat treated in the same furnace charge or subjected to the same finishing treatment when a continuous furnace is used.

8.1.5 Surface quality and dimensions

8.1.5.1 The surface of aluminum alloy products is to be free from harmful defects that will impair further processing and proposed applications, such as cracks, laminations, corrosion, oxide inclusions, oxide skins, blisters, nitrate spots and serious mechanical damages, etc. The defects are to be determined according to the relevant recognized specifications.

8.1.5.2 The edges of aluminum alloy products are to be flush, and free from burrs. The external dimensions and tolerances are to be in accordance with the relevant specifications acceptable to CCS.

8.1.6 Rectification of defects

8.1.6.1 Slight surface imperfections may be removed by mechanical means or grinding, provided that the prior approval of CCS is obtained. The depth of any rectification is not to exceed the allowable minus deviation from the thickness, and no unfavorable effects to the material are allowed. Unless otherwise agreed, all such rectifications are to be carried out in the presence of the Surveyor.

8.1.6.2 Defects which cannot be removed in accordance with 8.1.6.1 are generally not allowed to be repaired by welding unless it can be demonstrated that such repair will not impair the strength and application of the aluminum alloy products.

Section 2 ALUMINUM ALLOY PLATES AND SECTIONS

8.2.1 Application

8.2.1.1 The requirements of this Section apply to aluminum alloy plates and sections with a thickness of 3 mm to 50 mm and intended for use in the construction of hull structures and superstructures. However, the requirements of this Section are generally not applicable to the use of aluminum alloys for structures at a working temperature of below -100 °C.

8.2.1.2 Aluminum alloys other than those specified in this Section may be used for the construction of fishing vessels only when their chemical composition, delivery condition and mechanical properties are found satisfactory by CCS.

8.2.1 General requirements

8.2.2.1 Aluminium alloys used are to be of satisfactory seawater corrosion resistance and weldability.

8.2.2.2 AlSiMg series alloys (6000 series) are generally not allowed to be used in direct contact with seawater, unless effective protection measures (such as cathodic protection and/or being well coated) are taken.

8.2.3 Chemical composition

8.2.3.1 The chemical composition is to be determined by sampling from each batch of aluminum alloy products, and a certificate is to be submitted. The chemical composition of aluminum alloys is to comply with the requirements of Table 8.2.3.1.

Chemical Composition of Aluminum Alloys (%)

Table 8.2.3.1

Designatio n	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al	Other elements ^{Note 1}	
										Each type	Total amount
5A01	Si +Fe≤0.4		≤0.10	0.30~0.7 0	6.0~7. 0	0.10~0.2 0	≤0.20	≤0.1 5	Remainde r	≤0.05	≤0.15
5454	≤0.25	≤0.4 0	≤0.10	0.50~1.0	2.4~3. 0	0.05~0.2 0	≤0.25	≤0.2 0	Remainde r	≤0.05	≤0.15
5083	≤0.40	≤0.4 0	≤0.10	0.40~1.0	4.0~4. 9	0.05~0.2 5	≤0.25	≤0.1 5	Remainde r	≤0.05	≤0.15
5383	≤0.25	≤0.2 5	≤0.20	0.7~1.0	4.0~5. 2	≤0.25	≤0.40	≤0.1 5	Remainde r	≤0.05 ^{Nr e4}	≤0.15 ^{Nr e4}
5059	≤0.45	≤0.5 0	≤0.25	0.6~1.2	5.0~6. 0	≤0.25	0.40~0.9 0	≤0.2 0	Remainde r	≤0.05 ^{Nr e 5}	≤0.15 ^{Nr e5}
5086	≤0.40	≤0.5 0	≤0.10	0.20~0.7 0	3.5~4. 5	0.05~0.2 5	≤0.25	≤0.1 5	Remainde r	≤0.05	≤0.15
5456	≤0.25	≤0.4 0	≤0.10	0.50~1.0	4.7~5. 5	0.05~0.2 0	≤0.25	≤0.2 0	Remainde r	≤0.05	≤0.15
5754	≤0.40	≤0.4 0	≤0.10	≤0.50 ^{Note 2}	2.6~3. 6	≤0.30 ^{Note 2}	≤0.20	≤0.1 5	Remainde r	≤0.05	≤0.15
6005A	0.50~0.9 0	≤0.3 5	≤0.30	≤0.50 ^{Note 3}	0.4~0. 7	≤0.30 ^{Note 3}	≤0.20	≤0.1 0	Remainde r	≤0.05	≤0.15
6061	0.40~0.8 0	≤0.7	0.15~0.4 0	≤0.15	0.8~1. 2	0.04~0.3 5	≤0.25	≤0.1 5	Remainde r	≤0.05	≤0.15
6082	0.7~1.3	≤0.5 0	≤0.10	0.40~1.0	0.6~1. 2	≤0.25	≤0.20	≤0.1 0	Remainde r	≤0.05	≤0.15

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

Note 2: 0.10% ≤ Mn + Cr ≤ 0.60%.

Note 3: 0.12% ≤ Mn + Cr ≤ 0.50%.

Note 4: Zr ≤ 0.20. The total for other elements does not exclude zirconium (Zr).

Note 5: 0.05% ≤ Zr ≤ 0.25%. The total for other elements does not exclude zirconium (Zr).

8.2.3.2 Forges and foundries intending to supply semi-finished products are to issue to CCS a certificate indicating the cast number and chemical composition.

8.2.4 Conditions of supply

8.2.4.1 Aluminum alloy plates, bars, sections and pipes may be formed by rolling or extrusion.

8.2.4.2 Aluminium alloys are generally to be supplied in any of the following conditions:

O -- annealed;
H111 --annealed and slightly hardened (e.g. straightening)
H112 -- strain hardened from working at elevated temperatures
H116 -- with specified resistance to corrosion for aluminium alloys where the magnesium content not less than 4.0%
H32 -- stabilization to 1/4 hardness after work hardening
H321 -- stabilization to slightly below H32 hardness after work hardening
H34 -- stabilization to 1/2 hardness after work hardening
T5 -- hot worked and artificially aged
T6 -- solution heat treated and artificially aged

8.2.4.3 Rolled aluminium magnesium alloys are generally to be supplied in the condition of H111, H112, H116, H32, H321, H34 or O.

8.2.4.4 Extruded aluminium magnesium alloys are generally to be supplied in the condition of H111, H112 or O.

8.2.4.5 Extruded AlSiMg alloys are generally to be supplied in the condition of T5 or T6..

8.2.5 Testing and inspections

8.2.5.1 The manufacturer is to determine the chemical composition of each cast. The chemical composition of aluminium alloys is to be in accordance with the requirements given in 8.2.3.1 of in this PART.

8.2.5.2 All finished material is to have the specified surface roughness without internal or external defects which will interfere with the use. Slight surface imperfections may be removed by grinding or machining as long as the thickness of the material remains within the tolerances given in 8.2.5.3.

8.2.5.3 The manufacturer is to determine the dimensional tolerances of each batch of aluminium alloy products. The under thickness tolerances for rolled products are to be in accordance with the requirements of Table 8.2.5.3. The under thickness tolerances for extruded products are to be in accordance with the requirements of recognized national or international standards. The dimensional tolerances other than under thickness ones are to be in accordance with the requirements of recognized national or international standards.

Under thickness Tolerances for Rolled Products (mm)

Table 8.2.5.3

Nominal width B (mm) Nominal thickness t (mm)	$B \leq 1,500$	$1,500 < B \leq 2,000$	$2,000 < B \leq 3,500$
$3 \leq t < 4$	0.10	0.15	0.15
$4 \leq t < 8$	0.20	0.20	0.25
$8 \leq t < 12$	0.25	0.25	0.35
$12 \leq t < 20$	0.35	0.40	0.50

8.2.5.4 Mechanical test samples are to be taken from each batch of aluminium alloy products. Each batch is to be made up of products of the same alloy grade and from the same cast, of the same product form and similar dimensions (the same thickness for plates), manufactured by the same process. The number of test samples is to be in accordance with the requirements of 8.2.5.5 to 8.2.5.7 below.

8.2.5.5 The weight of each batch of rolled products is not to exceed 2,000kg. One specimen is to be prepared for each batch. Where the weight of a single piece (plate or coil) is greater than 2,000kg, only one specimen is to be prepared.

8.2.5.6 For extruded products, samples are to be taken for tests in accordance with Table 8.2.5.6.

Sampling Number of Extruded Products

Table 8.2.5.6

Nominal weight of products	Weight of each batch	Sampling number
<1kg/m	1,000 kg and fraction thereof	One sample
1~5 kg/m	2,000 kg and fraction thereof	One sample
>5 kg/m	3,000 kg and fraction thereof	One sample

8.2.5.7 In addition to 8.2.5.6 in this Section, for closed-type extruded sections fused by press welding, the factory should also prove by accepted methods that their welds are fused well.

8.2.5.8 Tests are to be carried out in accordance with the relevant requirements given in Chapter 2 of this PART. The test results are to be in accordance with the requirements given in 8.2.7 of this PART.

8.2.5.9 Where the results of any tensile test are not in accordance with the requirements, re-tests for acceptance may be carried out in accordance with the requirements given in 1.2.5 of Chapter 1 of this PART.

8.2.5.10 For aluminum-magnesium alloys delivered in H116 or H321 condition and used for hull panels or in long-term direct contact with seawater, one specimen is to be prepared for each batch for inspection or test related to the material's resistance to denudation and intergranular corrosion. The weight of each batch is to comply with the provisions of 8.2.5.5 in this Section.

8.2.5.11 The denudation and intergranular corrosion resistance of aluminum alloys is to be tested on the conditions specified in ASTM B928 accepted by CCS as well as the requirements of ASTM G66 and G67 standards.

8.2.5.12 When manufacturer has established the reference metallographic photo system which is approved by CCS and is related to the production process of aluminum alloys, the metallographic photo comparison method can be used to replace the corrosion test.

8.2.5.13 When a metallographic photograph comparison is used, the sampling and comparison are to be made in the presence of the Surveyor.

8.2.5.14 If the macrostructure examination shows any evidence of continuous aluminum-magnesium mesh precipitates at the grain boundary in excess of the reference metallographic photograph, this batch of materials are to be rejected, or the denudation test and intergranular corrosion test are to be conducted again with the consent of CCS. If the test results meet the acceptance criteria, this batch of materials can be accepted; otherwise, they should be rejected.

8.2.6 Test pieces and specimens

8.2.6.1 Tensile samples are to be taken at 1/3 width from a longitudinal edge of rolled products; tensile specimens are to be taken in the range 1/3 to 1/2 of the distance from the edge to the centre of the thickest part of extruded products.

8.2.6.2 Test samples are to be taken so that the orientation of test specimens is as follows:

- .1 Normally for rolled products, tests in the transverse direction are required. If the width is insufficient for obtaining transverse test specimens, or in the case of strain hardening alloys, tests in the longitudinal direction will be permitted.
- .2 The extruded products are normally to be tested in the longitudinal direction.

8.2.6.3 After removal of test samples, each test specimen is to be marked in order that its original identity, location and orientation is maintained.

8.2.6.4 Test specimens are to be cut from test samples in accordance with the following requirements:

- .1 For thicknesses up to and including 12.5 mm, flat tensile test specimens are to be used in accordance with the third non-proportional test specimen of item 2 in Table 2.2.2.1, Chapter 1 in this PART. The tensile test specimen is to be prepared so that both rolled surfaces are maintained.
- .2 For thicknesses exceeding 12.5 mm, round tensile test specimens are to be used in accordance with Item 1 of Table 2.2.2.1, Chapter 1 in this PART. For thicknesses up to and including 40 mm, the longitudinal axis of the round tensile test specimen is to be located at a distance from the surface equal to half the thickness. For thicknesses over 40 mm, the longitudinal axis of the round tensile test specimen is to be located at a distance from one of the surfaces equal to one quarter of the thickness.

8.2.6.5 For corrosion test or metallographic examination, a longitudinal section perpendicular to the rolled surface is to be prepared as follows:

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

8.2.7 Mechanical properties

8.2.7.1 The mechanical properties of rolled aluminum alloys in different conditions are to respectively comply with the requirements of Table 8.2.7.1.

8.2.7.2 The mechanical properties of extruded aluminum alloys in different conditions are to respectively comply with the requirements of Table 8.2.7.2.

Mechanical Properties of Rolled Aluminum Alloy Plates and Strips **Table 8.2.7.1**

Designation	Condition	Thickness t (mm)	Proof strength $R_{p0.2}$ (N/mm ²)	Tensile strength R_m (N/mm ²)	Minimum elongation after fracture $A^{\text{Note 1}}$ (%)	
					50mm	5d
5A01	O	$3 \leq t \leq 50$	≥ 165	≥ 325	10	
	H112	$3 \leq t \leq 50$	≥ 165	≥ 325	10	

	H32	$3 \leq t \leq 50$	≥ 245	≥ 365	8	
5454	O	$3 \leq t \leq 50$	≥ 85	215~285	17	16
	H112	$6 \leq t \leq 12.5$	≥ 125	≥ 220	8	—
		$12.5 < t \leq 50$	≥ 85	≥ 215	—	9
	H32	$3 \leq t \leq 6.3$	≥ 180	250~305	8	—
		$6.3 < t \leq 50$	≥ 180	250~305		10
5083	O	$3 \leq t \leq 50$	≥ 125	275~350	16	14
	H112	$3 \leq t \leq 50$	≥ 125	≥ 275	12	10
	H116	$3 \leq t \leq 50$	≥ 215	≥ 305	10	
	H321	$3 \leq t \leq 50$	215~295	305~385	12	10
5383	O	$3 \leq t \leq 50$	≥ 145	≥ 290	—	17
	H116	$3 \leq t \leq 50$	≥ 220	≥ 305	10	
	H321	$3 \leq t \leq 50$	≥ 220	≥ 305	10	
5059	O	$3 \leq t \leq 50$	≥ 160	≥ 330	—	24
	H116	$3 \leq t \leq 20$	≥ 270	≥ 370	10	
		$20 < t \leq 50$	≥ 260	≥ 360	10	
		$3 \leq t \leq 20$	≥ 270	≥ 370	10	
	H321	$20 < t \leq 50$	≥ 260	≥ 360	10	
5086	O	$3 \leq t \leq 50$	≥ 95	240~305	16	14
	H112	$3 \leq t \leq 12.5$	≥ 125	≥ 250	8	—
		$12.5 < t \leq 50$	≥ 105	≥ 240	—	9
	H116	$3 \leq t \leq 50$	≥ 195	≥ 275	10 ^{Note 2}	9
5456	O	$3 \leq t \leq 6.3$	130~205	290~365	16	—
		$6.3 < t \leq 50$	125~205	285~360	16	14
	H116	$3 \leq t \leq 30$	≥ 230	≥ 315	10	
		$30 < t \leq 40$	≥ 215	≥ 305	—	10
		$40 < t \leq 50$	≥ 200	≥ 285	—	10
	H321	$3 \leq t \leq 12.5$	230~315	315~405	12	—
		$12.5 < t \leq 40$	215~305	305~385	—	10
		$40 < t \leq 50$	200~295	285~370	—	10
5754	O	$3 \leq t \leq 50$	≥ 80	190~270	18	17

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

Note 2: 8 % for thicknesses up to and including 6.3 mm.

Mechanical Properties of Extruded Aluminum Alloys

Table 8.2.7.2

Designation	Condition	Thickness t (mm)	Proof strength $R_{p0.2}$ (N/mm ²)	Tensile strength R_m (N/mm ²)	Minimum elongation after fracture A ^{Note 1, 2} (%)	
					50mm	5d
5A01	H112	$3 \leq t \leq 50$	≥ 170	≥ 230	10	
5454	H112	$3 \leq t \leq 50$	≥ 100	—	10	
5083	O	$3 \leq t \leq 50$	≥ 110	270~350	14	12
	H111	$3 \leq t \leq 50$	≥ 165	≥ 275	12	10
	H112	$3 \leq t \leq 50$	≥ 110	≥ 270	12	10
5383	O	$3 \leq t \leq 50$	≥ 145	≥ 290	17	17
	H111	$3 \leq t \leq 50$	≥ 145	≥ 290	17	17
	H112	$3 \leq t \leq 50$	≥ 190	≥ 310	—	13
5059	H112	$3 \leq t \leq 50$	≥ 200	≥ 330	—	10
5086	O	$3 \leq t \leq 50$	≥ 95	240~315	14	12
	H111	$3 \leq t \leq 50$	≥ 145	≥ 250	12	10
	H112	$3 \leq t \leq 50$	≥ 95	≥ 240	12	10
5456	H112	$3 \leq t \leq 50$	≥ 130	≥ 300	10	
5754	H112	$3 \leq t \leq 50$	≥ 80	≥ 180	10	
6005A	T5	$3 \leq t \leq 50$	≥ 215	≥ 260	9	8
		$3 \leq t \leq 10$	≥ 215	≥ 260	8	6
	T6	$10 < t \leq 50$	≥ 200	≥ 250	8	6
6061	T6	$3 \leq t \leq 50$	≥ 240	≥ 260	10	8
6082	T5	$3 \leq t \leq 50$	≥ 230	≥ 270	8	6
		$3 \leq t \leq 5$	≥ 250	≥ 290	6	—
		$5 < t \leq 50$	≥ 260	≥ 310	10	8

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

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

Section 3 ALUMINIUM ALLOY RIVETS

8.3.1 Application

8.3.1.1 The requirements of this Section apply to aluminum alloy rivets used for the construction of marine structures.

8.3.2 Chemical composition

8.3.2.1 The chemical composition of bars used for the manufacture of rivets is to comply with the requirements in Table 8.3.2.1.

8.3.3 Heat treatment

8.3.3.1 Bars used for the manufacture of rivets or finished rivets are to be supplied for inspection in one of the following conditions:

- .1 annealed; or
- .2 solution heat treated and naturally aged.

Chemical Composition of Aluminum Alloy Rivets

Table 8.3.2.1

Designation	Original Designation	Chemical composition (%)										Miscellaneous ^{Note 1}
		Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti ^{Note 1}	Al	Other elements	
5052	AlMg2.5	≤0.25	≤0.40	≤0.10	≤0.10	2.2~2.8	0.15~0.35	≤0.10	—	Remainder	0.10≤Zr≤0.20	Each ≤ 0.05 Total ≤ 0.15
5754	AlMg3	≤0.40	≤0.40	≤0.10	≤0.50 ^{Note 2}	2.6~3.6	≤0.30 ^{Note 2}	≤0.20	≤0.15	Remainder	—	
5154A	AlMg3.5	≤0.50	≤0.50	≤0.10	≤0.50 ^{Note 3}	3.14~3.9	≤0.25 ^{Note 3}	≤0.20	≤0.20	Remainder	—	
5086	AlMg4	≤0.40	≤0.50	≤0.10	0.20~0.70	3.5~4.5	0.05~0.25	≤0.25	≤0.15	Remainder	—	
6082	AlSiMg	0.7~1.3	≤0.50	≤0.10	0.40~1.0	0.6~1.2	≤0.25	≤0.20	≤0.10	Remainder	—	

Note 1: Ti can be replaced totally or partially by other grain refining elements.

Note 2: 0.10%≤Mn+Cr≤0.60%

Note 3: 0.10%≤Mn+Cr≤0.50%

8.3.4 Test specimens and tests

8.3.4.1 Bars intended for the manufacture of rivets may be presented for test in batches. Where the weight of a batch exceeds 250 kg, one tensile test specimen and one dump test specimen are to be taken from each 250 kg or fraction thereof.

8.3.4.2 Where necessary, the shear test of bars used for the manufacture of rivets may be required by CCS. The results of the test are to comply with the relevant recognized standards.

8.3.4.3 Each batch of bars presented for test is to be from the same melt, having the same chemical composition and the same diameter, and each batch is to be heat treated in full cross section and in a manner simulating the heat treatment applied to the finished rivets in the same furnace charge.

8.3.4.4 The test specimens are to be taken in the direction and position specified in 8.2.6.2 of this Chapter. The preparation and dimensions of tensile test specimens are to comply with the appropriate requirements of Chapter 2 of this PART. The dump test specimen is to consist of a section cut from the bar with the ends perpendicular to the axis, and the length of this section is to be equal to the diameter of the bar.

8.3.5 Mechanical properties

8.3.5.1 The results of tensile tests are to comply with the requirements of Table 8.3.5.1.

Mechanical Properties of Aluminum Alloy Rivets

Table 8.3.5.1

Designation	Condition	Proof strength $R_{p0.2}$ min.	Tensile strength R_m min.	Elongation A_5 min.

		(N/mm ²)	(N/mm ²)	(%)
5052	O	70	170	16
5754	O	80	190	16
5154A	O	90	210	16
5086	O	100	230	16
6082	T6	115	200	16

Note: Values in the Table are applicable to all thicknesses or diameters.

8.3.5.2 The dump test is to be carried out at ambient temperature, and is to consist of compressing the specimen until the diameter is increased to 1.6 times the original diameter. After compression, the specimen is to be free from cracks.

8.3.6 Tests for finished rivets

8.3.6.1 For finished rivets, one dump test specimen is to be taken from every 100 kg or fraction thereof, and the test is to be carried out in accordance with the requirements in 8.3.5.2 of this Section. If the test fails, twice the number of rivets may be re-tested. If there is still an unsatisfactory result, the batch is to be rejected.

Section 4 ALUMINIUM ALLOY PISTONS

8.4.1 Manufacture

8.4.1.1 Aluminum alloy pistons for diesel engines may be made of aluminum alloy castings. The castings are to be manufactured and tested in accordance with the requirements of this Section and of Chapters 1 and 2 of this PART. Where it is proposed to use other types of aluminum alloys, their chemical composition and mechanical properties are to be in accordance with the design requirements and to be submitted to CCS for information.

8.4.2 Inspection items

8.4.2.1 Inspection items for aluminum alloy castings for pistons are to be as follows:

- .1 chemical composition: specimens from each cast;
- .2 tensile test: one tensile test specimen representative of each cast, the dimensions of the test specimens are to comply with the requirements in Table 2.2.2.1 of Chapter 2 of this PART;
- .3 hardness test;
- .4 macro-examination: to be carried out on each casting.

8.4.3 Chemical composition and mechanical properties

8.4.3.1 The chemical composition and mechanical properties of aluminum alloy pistons are to comply with the requirements of Table 8.4.3.1-1 and Table 8.4.3.1-2.

Chemical Composition of Aluminum Alloy Pistons

Table 8.4.3.1-1

Designation	Chemical composition (%)				
	Si	Cu	Mn	Mg	Al
ZL108	11~13	1~2	0.3~0.9	0.4~1.0	Remainder
ZL110	4~6	5~8	-	0.2~0.5	Remainder

Mechanical Properties of Aluminum Alloy Pistons

Table 8.4.3.1-2

Designation	Tensile strength R_m min. (N/mm ²)	Hardness min. (HB)	Heat treatment
ZL108	200	85	Artificial aging
	260	90	Quenching + full aging
ZL110	170	90	Artificial aging

8.4.4 Macro-examination

8.4.4.1 The surfaces of the piston castings are to be free from blow holes, cracks, etc.

Section 5 ALUMINIUM-STEEL TRANSITION JOINTS

8.5.1 Application

8.5.1.1 This Section applies to transition joints used for connecting aluminium alloy structures to steel plating.

8.5.1 General requirements

8.5.2.1 Aluminium/steel transition joints are composed of two or three layers of metal, with steel base being covered by aluminium alloy. For three-layer transition joints, the intermediate layer may be titanium or aluminium.

8.5.2.2 The base material is generally to be normal strength hull structural steels which comply with the relevant requirements of Section 2, Chapter 3 of this PART.

8.5.2.3 The cover material is generally to be marine aluminium alloys which comply with the relevant requirements of Section 2 of this Chapter.

8.5.2.4 The industrially pure titanium or aluminium used as the intermediate layer is to comply with recognized standards.

8.5.3 Manufacture

8.5.3.1 Composite plates are to be manufactured by explosion bonding.

8.5.3.2 Transition joints in the form of strips, blocks or in other shapes are made from such composite plates by machining.

8.5.4 Visual and ultrasonic testing

8.5.4.1 Each composite plate is to be subjected to 100 percent visual and ultrasonic testing to determine the extent of any unbonded areas. Unbonded areas plus 25 mm of surrounding sound material is to be discarded.

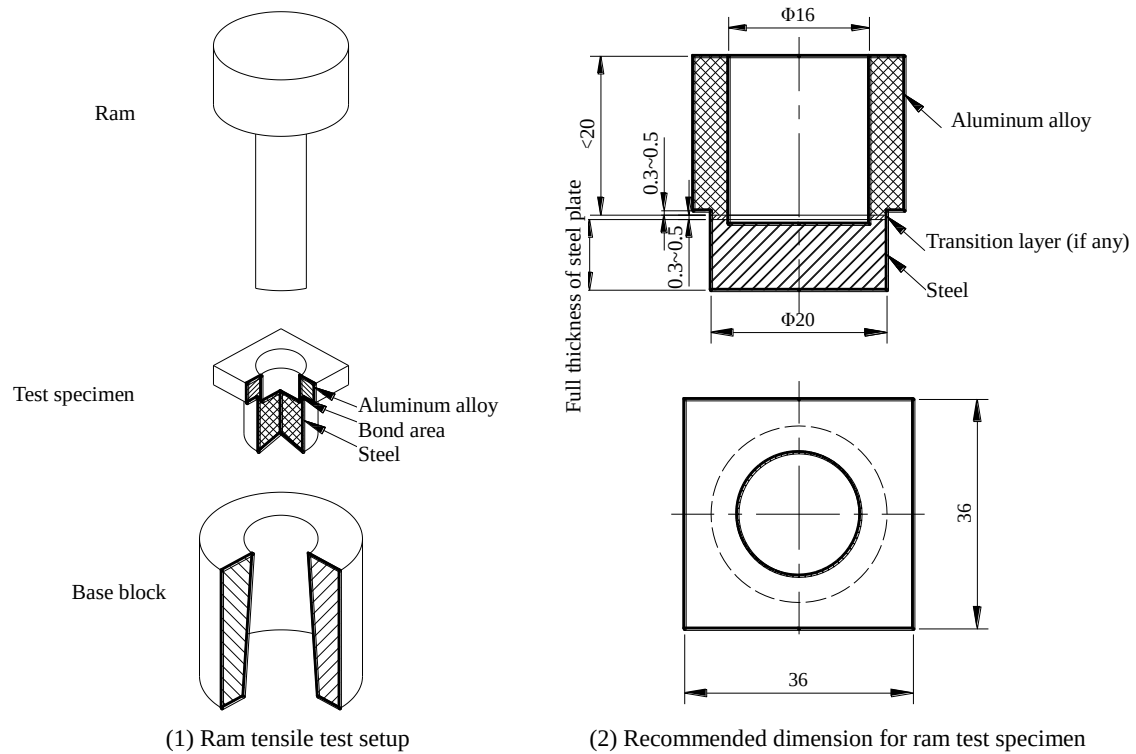
8.5.4.2 Ultrasonic testing is to comply with a recognized standard.

8.5.5 Mechanical tests

8.5.5.1 Each batch of composite plates is to be sampled for mechanical testing. A batch is to consist of three or less composite plates produced at one time and with same materials, dimension and explosion bonding technology. One set of test specimens is to be taken from each end of one of the composite plates.

8.5.5.2 The following specimens are included in each set:

- .1 two tensile test specimens: Tensile tests may be made across the interface by welding extension pieces to each surface or by the ram method shown in Figure 8.5.5.2. One specimen is to be tested at ambient temperature after heating to the maximum allowable interface temperature for 15 min;
- .2 two shear test specimens: Measuring shear strength of the interface. One specimen is to be tested at ambient temperature after heating to the maximum allowable interface temperature for 15 min. If the intermediate transition layer is titanium, two specimens are to be added to measure the shear strength at both interfaces under the above conditions;
- .3 one bend test specimen: The ram diameter is to $6t$ (t being the thickness of the specimen) and the specimen is to be bent to 90° .

**Figure 8.5.5.2 Ram Test in Thickness Direction**

8.5.5.3 Methods for the above tests are to comply with recognized standards.

8.5.5.4 Test results are to comply with the manufacturer's specifications.

8.5.5.5 Where the result of any mechanical test does not comply with the requirements, two additional specimens may be taken from the same plate for retests. If retest results comply with the requirements, the said batch may be accepted. If the retests fail, each composite plate of the batch is to be examined.

CHAPTER 9 OTHER NON-FERROUS METALS

Section 1 COPPER CASTINGS FOR PROPELLERS

9.1.1 Application

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

9.1.1.2 The castings are to be manufactured and inspected in accordance with the requirements of Chapter 1, Chapter 2 and this Section in this PART.

9.1.2 Manufacture

9.1.2.1 Generally, copper alloy castings are to be cast in sand molds, and the casting method is to ensure that there is no harmful stress in the castings.

9.1.3 Quality

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

9.1.4 Chemical composition

9.1.4.1 The chemical composition of ladle samples of the castings is generally to be as given in Table 9.1.4.1. For chemical composition of alloys other than those given in Table 9.1.4.1, the related information (including chemical composition, heat treatment procedure, mechanical properties and seawater corrosion resistance) is to be submitted, which may be accepted in accordance with relevant recognized standards subject to agreement of CCS.

Chemical Composition of Ladle Samples of Copper Castings for Propellers Table 9.1.4.1

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

9.1.4.2 The zinc equivalent of Cu1 and Cu2 copper alloys are to be determined as per the following formula, and is not to exceed 45%.

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

Where: A is algebraic sum of the following items: 1 × Sn%;

5 × Al%;

-0.5 × Mn%;

-0.1 × Fe%;

-2.3 × Ni%.

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

9.1.5 Heat treatment

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

9.1.6 Mechanical properties

9.1.6.1 Specimens are to be prepared for the castings in accordance with the following requirements:

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

9.1.6.2 The tensile test results are to comply with the provisions of Table 9.1.6.2.

Mechanical Properties of Copper Castings for Propellers

Table 9.1.6.2

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

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

9.1.7 Visual and non-destructive testing

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

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

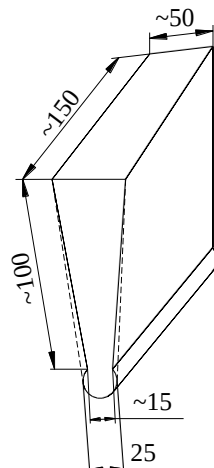


Figure 9.1.6.1.1 Keel Type Test Piece

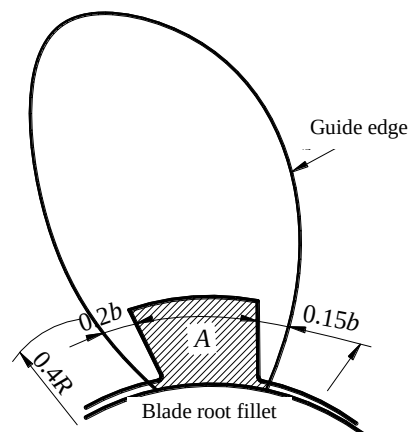


Figure 9.1.7.2 Schematic Diagram of Area A and Blade Root Fillet

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

9.1.8 Macrostructure examination

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

9.1.9 Rectification of defects

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

9.1.9.2 When excess defect is found in the castings, they can be removed mechanically and the pits generated

hereby are to be polished smooth. After the removal of the defect, dye penetrant testing is to be conducted to prove that the defect has been eliminated.

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

Section 2 CAST COPPER ALLOYS

9.2.1 Application

9.2.1.1 The requirements of this Section apply to cast copper alloys for the manufacture of valves, pump housings, shaft liners, bushes and other fittings.

9.2.1.2 Copper alloy castings are to be manufactured and tested in accordance with the requirements of this Section and of Chapters 1 and 2 of this PART.

9.2.2 Manufacture

9.2.2.1 Castings may be made by sand casting, chill casting, centrifugal casting or continuous casting, etc., depending on the shape of the casting.

9.2.3 Quality

9.2.3.1 All castings are to be supplied in a clean and fettled condition. They are to be free from shrinkage cavities, pores, blow holes, cracks, inclusions and other surface or internal defects which would be prejudicial to their proper application in service.

9.2.4 Chemical composition

9.2.4.1 The chemical composition of the cast copper alloys is to comply with the requirements of Table 9.2.4.1.

Chemical Composition of Cast Copper Alloys

Table 9.2.4.1

Designation	Chemical composition (%)								Recommended application
	Cu	Sn	Zn	Pb	Ni	Mn	P	Fe	
90/10 Cu-Sn phosphor bronze	Remainder	90~11.0	≤0.50	≤0.75	≤0.5	—	≤0.50	—	Shaft liners, bushes, valves, pump housings and fittings
88/10/2 gunmetal	Remainder	8.5~11.0	1.0~3.0	≤1.5	≤1.0	—	—	—	Shaft liners, valves, and fittings
83/7/4/6 gunmetal	Remainder	6.0~8.0	3.0~5.0	5.0~7.0	≤2.0	—	—	—	Shaft liners and bushes
85/5/5/5 Lead gunmetal	Remainder	4.0~6.0	4.0~6.0	4.0~6.0	≤2.0	—	—	—	Bushes, valves and fittings
90/10 Cu-Ni-Fe	Remainder	—	—	—	9.0~11.0	0.5~1.0	—	1.0~1.8	Valves, pump housings and fittings
70/30 Cu-Ni-Fe	Remainder	—	—	—	29.0~32.0	0.5~1.5	—	0.4~1.0	Shaft liners, valves, pump housings and fittings

Note: Manufacturer is to ensure that the content of other elements is within the limits approved by CCS.

9.2.4.2 The chemical analysis by the ingot maker is to comply with the requirements of 9.1.4.2 in this PART.

9.2.5 Heat treatment

9.2.5.1 Castings may be supplied in the as cast or properly heat treated condition.

9.2.6 Mechanical properties

9.2.6.1 Test pieces can be cast individually on a furnace-by-furnace basis, as shown in Figure 9.1.6.1.1 “Keel Type Test Piece” in this PART. Test pieces of shaft liners and bushes may also be intercepted from the end of the castings.

9.2.6.2 Where castings are supplied in a heat treated condition, the test samples are to be similarly heat

treated.

9.2.6.3 From each test sample, a tensile test specimen is to be prepared, the dimensions of which are to comply with those given in Table 2.2.2.1 of this PART.

9.2.6.4 Results of tensile tests are to comply with the requirements given in Table 9.2.6.4.

Mechanical Properties of Cast Copper Alloys

Table 9.2.6.4

Designation	Tensile strength R_m min. (N/mm ²)	Proof strength $R_{p0.2}$ min. (N/mm ²)	Elongation A_5 min. (%)
90/10 Cu-Sn phosphor bronze	250	120	15
88/10/2 gunmetal	270	130	13
83/7/4/6 gunmetal	270	130	16
85/5/5/5 Lead gunmetal	200	100	16
90/10Cu-Ni-Fe	320	160	20
70/30Copper-nickel-iron alloy	420	220	20

9.2.7 Appearance examination and rectification of defective castings

9.2.7.1 All castings are to be cleaned and presented to the Surveyor for visual examination of internal and external surfaces.

9.2.7.2 Subject to the prior approval of the Surveyor, castings containing local porosity may be rectified by impregnation with a suitable plastic filler provided that the extent of the porosity is such that it does not adversely affect the strength of the casting.

9.2.7.3 Proposals to repair a defective casting by welding are to be submitted to the Surveyor before this work is commenced. And the number, size, and position of the defects as well as the weld repair procedures are to be submitted to CCS for information. The welding of liners in copper alloys containing more than 0.5% lead is not permitted.

9.2.8 Pressure testing

9.2.8.1 Where pressure test is required for castings, the test is to be carried out in the presence of the Surveyor.

Section 3 COPPER TUBES

9.3.1 Application

9.3.1.1 The requirements of this Section apply to copper alloy tubes intended for use in condensers, heat exchangers and pressure piping systems. Where copper alloys other than those specified in this Section are used, with the consent of CCS, they may be checked and accepted in accordance with the relevant accepted standards.

9.3.2 Manufacture

9.3.2.1 Tubes are generally to be made by a seamless process. Where it is proposed to use welded tubes, details of the method of manufacture and the properties are to be submitted to CCS for approval.

9.3.3 Quality

9.3.3.1 The quality of tubes is to comply with the appropriate requirements of Chapter 7 of this PART.

9.3.4 Chemical composition

9.3.4.1 The chemical composition of tubes is to comply with the requirements of Table 9.3.4.1.

Chemical Composition of Copper Tubes

Table 9.3.4.1

Designation	Chemical composition (%)							
	Cu	As	Fe	Pb	Ni	Al	Mn	Zn

Aluminum brass	76.0~79.0	0.02~0.06	≤0.06	≤0.07	—	1.8~2.5	—	Remainder
90/10Cu-Ni-Fe	Remainder	—	1.0~2.0	—	9.0~11.0	—	0.5~1.0	—
70/30 Cu-Ni-Fe	Remainder	—	0.4~1.0	—	29.0~33.0	—	0.5~1.5	—

Note: In addition to the content of principal elements listed in the Table, the manufacturer is to ensure that the content of other elements is within acceptable limits approved by CCS.

9.3.5 Heat treatment

9.3.5.1 All tubes are to be supplied in the annealed condition. Aluminum brass tubes are required to be given a stress relieving heat treatment when subjected to a cold straightening operation after annealing.

9.3.6 Mechanical and technological properties

9.3.6.1 Tubes may be presented for test in batches of 300 lengths. Each batch is to consist of the tubes of the same size, manufactured from the same material grade and subjected to the same heat treatment process.

9.3.6.2 The tests and number of test specimens for each batch are to be as follows:

- .1 Tensile test: at least one specimen from each batch;
- .2 Flattening test: at least one specimen from each batch;
- .3 Drift expanding test: at least one specimen from each batch.

Where the tubes are supplied in reels, at least one reel is to be selected from each batch. One test sample is to be taken from every ten circles of tubes or fraction thereof.

9.3.6.3 The methods for mechanical tests and the dimensions of the test specimens are to be in accordance with Chapter 2 of this PART. The flattening test is to be continued until the interior surfaces of the tube meet. After flattening, the specimens are to be free from cracks and flaws. The drift expanding test is to be carried out with a mandrel having an included angle of 45°, and the outside diameter of the end of the test length is to be expanded by 30%. The expanded portion of the tube is to be free from cracks and flaws.

9.3.6.4 The mechanical properties of tubes are to comply with the requirements of Table 9.3.6.4.

Mechanical Properties of Copper Tubes

Table 9.3.6.4

Designation	Tensile strength R_m min. (N/mm ²)	Proof strength $R_{p0.2}$ min. (N/mm ²)	Elongation A_5 min. (%)
Aluminum brass	320	110	35
90/10Cu-Ni-Fe	270	100	30
70/30Cu-Ni-Fe	360	120	30

9.3.7 Stress corrosion cracking test

9.3.7.1 Stress corrosion cracking test is to be carried out on aluminum brass tubes in batches. The method of test is as follows:

- .1 one test specimen having a length of 150 mm is to be cut from one tube selected at random from each batch;
- .2 the specimen is to be immersed in a mercurous nitrate solution for a period of 2 h;
- .3 after being removed from the solution, the internal and external surfaces of the specimen are to be examined by the aid of a five to ten-fold magnifying glass, and no cracks are allowable;
- .4 should any specimen fail to meet the requirements of this test, then all tubes represented by that specimen are to be withdrawn. The tubes may be re-submitted after a stress relieving treatment for full testing.

9.3.8 Hydraulic test

9.3.8.1 Each tube is to be subjected to a hydraulic test, and the test pressure is to be 1.5 times the design pressure or 7.0MPa (the higher). An eddy current test may be accepted in lieu of the hydraulic test subject to agreement of CCS.

9.3.9 Visual examination and rectification of defects

9.3.9.1 All tubes are to be presented for visual examination of internal and external surfaces and for verification of dimensions. The surfaces of all tubes are to be smooth and clean and free from blow holes, cracks, blisters, laminations and verdigris.

9.3.9.2 The repair of surface defects by welding is not permitted. Surface defects may be removed by grinding provided that the dressed area is to be blended into the contour of the tube and that the dimensional tolerances are

not exceeded.

Section 4 BEARING METALS

9.4.1 Application

9.4.1.1 The bearings intended to be used for fishing vessel machinery may be made from tin-base bearing alloys, lead-base bearing alloy, aluminum-base bearing alloy or copper-lead alloy. Where any other bearing alloy is used, its chemical composition is to comply with the design requirements and is to be submitted to CCS for approval.

9.4.2 Inspection items and requirements

9.4.2.1 The inspection items and requirements of bearing metals are specified as follows:

- .1 Chemical analysis: samples from each cast in accordance with the requirements of Table 9.4.3.1;
- .2 Macro-examination: it is to be conducted on each piece, and the surface of each bearing alloy is to be smooth and clean without molten slags and non-metallic inclusions;
- .3 Adhesion examination: it is to be carried out on each piece, and the bearing alloy is to be firmly bonded to the bearing housing;
- .4 Microscopic examination and hardness test: the white metal used for the manufacture of main bearings, connecting rod top and bottom end bearings and thrust bearings of diesel engines, if necessary, is to be subjected to a microscopic examination ($\times 100$ magnification) and hardness test;
- .5 Metallographic examination: only applicable to copper-lead alloy. In a metallographic structure, lead is to be evenly distributed in the copper matrix with medium particle size, round granule or intermittent network, without block precipitation.

9.4.3 Chemical composition

9.4.3.1 The chemical composition of bearing metals is to comply with the requirements given in Table 9.4.3.1.

Chemical Composition of Bearing Metals

Table 9.4.3.1

Designation	Chemical composition (%)				
	Sn	Cu	Sb	Fb	Al
ChSnSb11-6	Remainder	5.5~6.5	10~12	—	—
ChSnSb7.5-3	Remainder	3~4	7~8	—	—
ChSnSb16-16-1.8	15~17	15~17	15~17	Remainder	—
ChSnSb15-5.5-2.8	5~6	2.5~3	14~16	Remainder	—
QPb30	—	Remainder	—	27~33	—
(210) SnCuAl-steel bimetal strip	20	1	—	—	Remainder

9.4.4 Miscellaneous

9.4.4.1 The surfaces of the bearing metal of each bearing are to be smooth and clean and free from slags and non-metallic inclusions.

9.4.4.2 The bearing metal is to be tightly adhered to bearing shells.

9.4.4.3 At the metallographic examination, it is required that lead in the copper-lead alloy is to be shown in medium size grains and in the form of globules or detached networks evenly distributed in the copper matrix, and no segregation of lead in blocks is allowable.

CHAPTER 10 PLASTIC PIPES AND FITTINGS

Section 1 GENERAL PROVISIONS

10.1.1 Application

10.1.1.1 The requirements of this Section apply to plastic pipes and fittings intended for use on fishing vessels.

10.1.1.2 This Chapter does not apply to plastic flexible pipes, hoses and their joints.

10.1.2 Definitions and terms

10.1.2.1 Plastics means both thermoplastic polymers and thermosetting resins with or without reinforcement.

10.1.2.2 Pipes/piping systems mean those made of plastics and include the pipes, fittings, system joints, method of joining and any internal or external liners, coverings and coatings required to comply with the performance criteria.

10.1.2.3 Fittings mean bends, elbows, telescoping pipelines, fabricated branch pieces etc., of plastic materials.

10.1.2.4 Joint means joining pipes by adhesive bonding, laminating, welding, etc.

10.1.2.5 Fire endurance means the capability of piping to maintain its strength and integrity (i.e. capable of performing its intended function) for some predetermined period of time while exposed to fire.

10.1.3 General requirements

10.1.3.1 The main material of which plastic pipes and fittings are made, construction and design strength of the pipe, manufacturing process, method of joining are to be approved by CCS.

10.1.3.2 Plastic pipes are to be selected according to their chemical composition, temperature limits, mechanical and physical properties, chemical properties and pressure rating of fluid being conveyed.

10.1.3.3 Except as validated by reliable data, plastic pipes and fittings are generally not used in a piping system with carried fluid temperature over 60 °C or below 0 °C.

10.1.3.4 The performance of fittings, joints and method of joining are to be equal to that of the plastic pipes to which they are attached.

10.1.3.5 Plastic pipes and fittings conveying fluids capable of generating electrostatic charge in the pipes or pass through a hazardous area are to be electrically conductive.

10.1.3.6 Fire endurance and low flame spread characteristics are required according to application and location of plastic pipes, and in addition to the requirements for design and construction in this Chapter, the fire resistance classes and low flame-spread characteristics as specified in the fire test procedures, adopted by IMO resolution A.753(18) and revised resolution A.653(16), are to be respectively required.

10.1.3.7 The material properties, sets and groups of pipe products, sampling, preparation of test specimens, test procedure, measuring method and evaluation of results covered by this Chapter are to be in accordance with recognized international or national standards.

Section 2 MATERIALS, DESIGN, MANUFACTURE AND STRENGTH TEST

10.2.1 Material

10.2.1.1 The main material of which plastic pipes and fittings are made are to be approved by CCS.

10.2.1.2 Where the main material is not approved, the manufacturer is, prior to using such material in fabricating pipes and fittings, to provide sufficient evidence for compliance of the properties and characteristics of the material with the specifications for piping.

10.2.1.3 Thermoplastic pipes are generally of polymers without reinforcement, e.g. polyvinyl chloride (PVC), polyethylene (PE), Polypropylene(PP) and acrylonitrile-butadiene-styrene (ABS). Fittings may be also of the above polymers reinforced with fiber glass. The manufacturer is to test the following items:

- .1 melting point;
- .2 melt flow index (MFI);
- .3 volume density or specific volume;

- .4 extruded body density;
- .5 filler or pigment content (if any);
- .6 thermal deformation temperature and hardness of extruded body;
- .7 tensile strength and elongation at break.

10.2.1.4 Thermosetting plastic pipes and fittings may be of unsaturated polyester resin, epoxy resin, phenolic resin, etc. The manufacturer is to test the following items:

- .1 unsaturated polyester resin (metaphenylene, phthalate, bisphenol A and vinyl ester)
 - (1) density;
 - (2) viscosity;
 - (3) gel time;
 - (4) epoxide number;
 - (5) solid body content;
 - (6) heat stability;
 - (7) thermal deformation temperature and hardness of casting body.
- .2 epoxy resin
 - (1) density;
 - (2) viscosity;
 - (3) gel time;
 - (4) epoxide number;
 - (5) organochlorine, inorganic chlorine;
 - (6) Thermal deformation temperature and hardness of casting body;
- .3 phenolic resin
 - (1) density;
 - (2) viscosity;
 - (3) free phenol content;
 - (4) free formaldehyde content;
 - (5) thermal deformation temperature and hardness of casting body;

10.2.1.5 Fiber glass reinforcing materials may be E glass fibers, alkali glass fibers high strength fibers and their fabrics or products, e.g. continuous rovings, surfacing mats, chopped strand mats and nets. The manufacturer is to test the following applicable items:

- .1 fiber type;
- .2 linear density of yarn or roving (Tex value);
- .3 type of weaving, fabric density (warp and weft);
- .4 tensile strength and elastic modulus of fiber, roving or fabric;
- .5 weight per unit area;
- .6 type and content of cementing agent;
- .7 type and content of surface treating agent;
- .8 thermal deformation temperature and hardness of finished plywood;
- .9 other necessary indicators.

10.2.1.6 Extruded, cast or laminated test specimens are to be prepared as far as practicable under conditions similar to those for the manufacture of products.

10.2.1.7 The values measured for properties of the above polymers, resins and reinforcing materials are to comply with the specifications for plastic pipes and fittings and the requirements for design approval.

10.2.2 Design

10.2.2.1 The design strength of plastic pipes is to be in accordance with the design criteria and specifications in recognized international or national standards, and in accordance with the requirements of this Section for strength evaluation.

10.2.2.2 The design strength of plastic pipes and fittings are to be examined by CCS. The submitted information is to contain a list of the materials used with confirmation that the properties and characteristics of the listed materials comply with the values used in the submitted design. This list is to include at least the following:

- .1 resin;
- .2 accelerator (type and concentration);
- .3 catalyst/curing agent (type and concentration);
- .4 cure/post-cure conditions (if applicable);
- .5 ratio of resin to reinforcement ;
- .6 reinforcement (specifications and varieties);
- .7 wind pattern (or lay-up sequence), wind angle and orientation;

.8 dimensions and tolerances.

10.2.2.3 If materials other than those covered by the application for approval are expected to be used, a list of such materials is to be submitted together with evidence showing that such materials will not adversely affect the properties of products.

10.2.2.4 Where any alteration to the materials used and manufacturing process is intended after approval, CCS is to be notified of this alteration and if necessary, a new approval is to be applied for.

10.2.2.5 The strength of the pipes is to be determined by a hydrostatic test failure pressure of a pipe specimen under the standard conditions: atmospheric pressure equal to 0.1 MPa, relative humidity 30%, environmental and carried fluid temperature 298 K (25 °C).

10.2.2.6 The hydrostatic test failure pressure and collapse pressure are to be verified by experiments and the testing methods are to be acceptable.

10.2.2.7 Where the circumferential strength of the pipes, as determined by the short-term hydrostatic test failure pressure, is the failure circumferential stress in respect to inner pressure, the safety factor is not to be less than 6.0.

10.2.2.8 Axial strength is to comply with the following:

- .1 The sum of the longitudinal stresses due to pressure, weight and other loads is not to exceed the allowable stress in the longitudinal direction.
- .2 In the case of fiber reinforced plastic pipes, the sum of the longitudinal stresses is not to exceed half of the nominal circumferential stress derived from the nominal internal pressure condition.

10.2.2.9 The information submitted for design approval is to include details and explanations for fittings and the method of connecting fittings to pipes, in addition to pipe structure (for thermosetting pipes) and strength calculations.

10.2.3 Manufacture

10.2.3.1 The manufacturer is to have the production, testing equipment and manufacturing capability necessary for production of plastic pipes as well as a perfect quality system to ensure that pipes and fittings are produced with consistent and uniform mechanical and physical properties.

10.2.3.2 Plastic pipes may be drawn by an extruder (for thermoplastic pipes) or wound by a filament winding machine (for thermosetting pipes). Fittings may be manufactured by mold pressing, filament winding, cutting/mitering and contact molding (for thermosetting fittings) or by injection, extrusion, etc. (for thermoplastic fittings).

10.2.3.3 The manufacturer is to submit the necessary technological process specifications, including the following:

- .1 Details of all components;
- .2 Manufacturing process and main parameters:
 - (1) at least cylinder heating temperature, each section temperature of head, extrusion speed and drawing speed for extrusion;
 - (2) liner lay-up sequence, structural layer winding procedure or winding angle, the filament tension, the ratio of curing agent to resin and of reinforcement to resin, the laminate thickness, mandrel dwell time (initial cure), cure/post-cure conditions for forming by filament winding (if applicable);
 - (3) repair procedure for slight surface defects

10.2.3.4 Sufficient quality control points are to be available during manufacturing to ensure at any time that the sequence of use of all raw materials, their amounts and proportions and other technological elements such as wind angle, gel time, laminate thickness and degree of cure remain within the limits set in the manufacturing specifications and design requirements.

10.2.4 Strength tests

10.2.4.1 When applying for approval, the actual strength of pipes is to be proved by the manufacturer through tests.

10.2.4.2 A strength test is to include the following items:

- .1 short-term hydraulic bursting test: Failure circumferential stress due to burst pressure is to be greater than such minimum stress specified in recognized standards;
- .2 axial tensile strength: Test specimens may be full-size, scaled-down or manually laminated ones and the axial tensile strength achieved during tests is to be greater than such minimum strength specified in recognized standards;
- .3 impact resistance: After going through an impact test procedure as specified in the accepted standard, the pipe specimen is to be subjected to hydrostatic pressure equal to 2.5 times the design pressure

for not less than 1 h and no delamination or leakage is allowed;

.4 external load test of parallel plates: The minimum rigidity of parallel plates under 5% radial deflection is to be greater than such minimum rigidity specified in recognized standards;

.5 external load test: A concentrated load of 100 kg is to be applied at midspan of the pipe having a diameter of 100 mm and no cracks are allowed. The test span is generally to be 6 m for at least 5 min.

10.2.4.3 The sampling, measuring and the evaluation of results for the above tests are to be in accordance with the procedures as specified in recognized international or national standards.

Section 3 QUALITY OF FINISHED PIPES AND REPAIRING OF DEFECTS

10.3.1 Surface

10.3.1.1 All pipes and fittings are to be visually examined and are to be free from surface defects and blemishes.

10.3.1.2 The inner surface of the pipe is to be smooth and free from cracks, delamination, pinholes, impurities, bubbles and unfilled parts affecting its performance.

10.3.1.3 The pipes are to be reasonably straight with neat bells and spigots and smooth grooves. The cut ends are to be square to the axis of the pipe.

10.3.2 Dimensions and tolerances

10.3.2.1 The dimensions and tolerances of pipes and fittings are to comply with the manufacturing specifications.

10.3.2.2 Each pipe is to be measured for diameter, length, wall thickness and liner thickness (if any).

10.3.2.3 The wall thickness of the pipes may be measured around the circumference of the pipe end square to the axis of the pipe. At least 7 measuring points are to be uniformly distributed and the mean value is to be taken. Where an electronic thickness gauge is used, measurements are to be made at intervals around the circumference square to the axis of the pipe and along the length, and the number and distribution of measuring points may be determined according to the accepted standard. The minimum thickness is to be more than 90% of the nominal thickness, and the mean thickness is to be not less than the nominal thickness. For fiber-reinforced pipes, the nominal thickness is the sum of inner lining thickness and the structural layer thickness.

10.3.3 Properties of pipes

10.3.3.1 Where electrical conductivity is to be ensured, the resistance of the pipes and fittings is not to exceed 0.1 MΩ/m.

10.3.3.2 The minimum temperature of deflection is to be more than 80 °C.

10.3.3.3 The degree of cure of fiber-reinforced thermosetting plastic pipes is to be over 40 barcol hardness. The recommended resin content and fiber glass content of the structural layer is to be controlled respectively at 30 ±5% and 70 ±5%.

10.3.4 Hydraulic tests

10.3.4.1 Each pipe is to be tested at a hydrostatic pressure 1.5 times the design pressure of the pipe. The test pressure is to be maintained for 5 min to permit proof and inspection.

10.3.4.2 The tested pipes are not to exhibit dripping, leakage, bulging or cracking.

10.3.5 Rectification of defects

10.3.5.1 Significant defects, such as fragmentation and deep scuffing are generally not allowed to be repaired. The procedure for intended repairs is to be submitted in advance. The quality of repairs is to be proved through appropriate tests.

10.3.5.2 Minor surface blemishes not affecting mechanical properties of the pipes are allowed to be repaired, provided that a repair procedure for such blemishes is included in the manufacturing specifications.

10.3.5.3 Minor surface blemishes may be removed by a grinding machine and/or repaired with same resin and thin glass fiber felt or fabric, provided that after repairs, the dimensions are acceptable and no structural defects are demonstrated so far.

CHAPTER 11 EQUIPMENT

Section 1 ANCHORS

11.1.1 Application

11.1.1.1 The requirements of this Section apply to steel forgings and castings for anchor heads, shanks and shackles as well as fabricated steel anchor heads.

11.1.2 Manufacture and mechanical properties

11.1.2.1 Cast anchor heads, anchor shanks and anchor shackles are to be manufactured and tested in accordance with the relevant requirements of Section 1 and 2, Chapter 5 I of this PART. Cast anchors can be made in one batch as per the same molten steel, the same specification and the same heat treatment procedures, and total mass not exceeding 3t. At least one specimen is to be taken from each batch for tensile test.

11.1.2.2 Forged anchor heads, anchor shanks and anchor shackles are to be manufactured and tested in accordance with the relevant requirements of Section 1 and 2, Chapter 4 of this PART. When the mass of a single forging exceeds 3t, heat treatments are to be conducted.

11.1.2.3 The steel plates used for fabricated steel anchor heads are to comply with the relevant requirements of Section 2 & 3, Chapter 3 of this PART.

11.1.3 Proof load tests of anchors

11.1.3.1 Anchors with nominal mass (including anchor shanks) of greater than or equal to 75kg and anchors with large holding force of greater than or equal to 56kg are to be subjected to tensile test. Tensile testing machines are to be calibrated and approved.

11.1.3.2 The anchors are to be proof-load tested as follows:

- .1 The proof load is to be applied to two points, one at the anchor shackle and the other at a point which, measured from the extremity of the bill, is $\frac{1}{3}$ of the distance between it and the center of the crown, as shown in Figure 11.1.3.2.1.

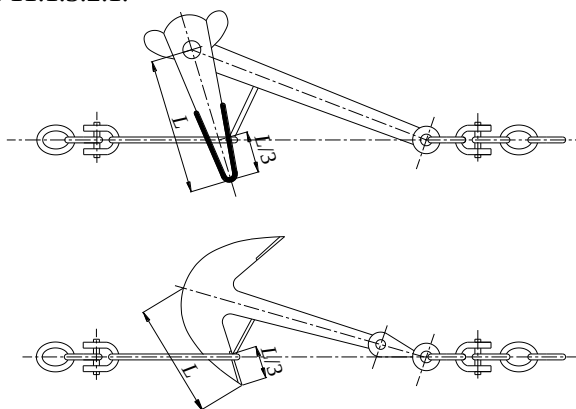


Figure 11.1.3.2.1 Application Point of Proof Load

- .2 For stockless anchors, both arms are to be tested at the same time, first on one side of the shank, then reversed and tested on the other.
- .3 For stocked anchors, each arm is to be tested individually.
- .4 Prior to the load test, a gauge mark (punched or cut, for measuring the gauge length) is to be made for each anchor respectively on the shank adjacent to the shackle and near each fluke tip. For one stockless anchor, the anchor is first to be subjected to 10% of the test load for a period of 5 min, and then the gauge length is to be measured and recorded. After that, the applied load is to be slowly increased to the test proof load and kept for 5 min, then the load is to be gradually decreased to 10% of the required load, then again the gauge length is to be measured. For one stocked anchor, the anchor is first to be subjected to the test load for a period of 5 min, and then, after the load is removed, the gauge length is to be measured and recorded.

11.1.3.3 The proof test loads for anchors are to comply with the requirements of Table 11.1.3.3. The mass of anchors given in the Table is to be taken as follows:

- .1 for stockless anchors, the actual total mass;
- .2 for stocked anchors, the actual mass of anchor excluding the stock;
- .3 for high holding power anchors, 1.33 times the actual mass is to be taken. Unless specifically agreed otherwise, the same applied to the mass of mooring anchors;

Proof Test Loads of Anchors**Table 11.1.3.3**

Mass of anchor m_a (kg)	Proof test load Q (kN)	Mass of anchor m_a (kg)	Proof test load Q (kN)	Mass of anchor m_a (kg)	Proof test load Q (kN)
50	23.2	500	116.0	1,800	335.0
55	25.2	550	125.0	2,000	349.0
60	27.1	600	132.0	2,100	362.0
65	28.9	650	140.0	2,200	376.0
70	30.7	700	149.0	2,300	388.0
75	32.4	750	158.0	2,400	401.0
80	33.9	800	166.0	2,500	414.0
90	36.3	850	175.0	2,600	427.0
100	39.1	900	182.0	2,700	438.0
120	44.3	950	191.0	2,800	450.0
140	49.0	1,000	199.0	2,900	462.0
160	53.3	1,000	199.0	3,000	474.0
180	57.4	1,050	208.0	3,100	484.0
200	61.3	1,100	216.0	3,200	495.0
225	65.8	1,150	224.0	3,300	506.0
250	70.4	1,200	231.0	3,400	517.0
275	79.5	1,250	239.0	3,500	528.0
300	84.1	1,300	247.0	3,600	537.0
350	88.8	1,350	255.0	3,700	547.0
375	93.4	1,400	262.0	3,800	557.0
400	97.9	1,450	270.0	3,900	567.0
425	103.0	1,500	278.0	4,000	577.0
450	107.0	1,600	292.0	4,100	586.0
475	112.0	1,700	307.0	4,200	595.0

Note: Proof loads for intermediate mass are to be determined by linear interpolation.

11.1.3.4 After the proof test, permanent set (i.e. variation in gauge length) is not to exceed 20mm, and the flexibility for the anchor claw to rotate to the maximum angle is to be checked. If the above rotation is not flexible or it cannot rotate to the maximum angle, the defect is to be eliminated and the proof test is to be conducted again. If it is still not qualified, the anchor cannot be accepted. For stocked anchor, there should be no permanent deformation after the tensile test.

11.1.4 Holding power tests

11.1.4.1 The newly designed anchor, if applied for approval as a high holding power anchor, is to be tested at sea to prove that the anchor's proof load is more than twice that of a stockless anchor with the same mass;

11.1.4.2 If high holding power anchor series is designed, at least two kinds of anchors are to be selected to for holding power test at sea.

11.1.4.3 The test is to be conducted on not less than three different types of seabed. Normally, seabed is soft mud or silt, sand or gravel and hard clay or similar compounded material.

11.1.4.4 For the test, tugging is generally to be completed by a tugboat, and the holding power is to be measured with a dynamometer. During the test, the anchor to be tested and the rod less anchor for comparison should adopt anchor chains with the same length. Anchor chain length is to be not less than 6 times of the vertical distance from hawse pipe opening to the seabed, but recommended anchor chain length is 10 times of the vertical distance from the hawse pipe opening to the seabed. Wire ropes can be used to replace anchor chains.

11.1.4.5 The design of high holding power anchor is to ensure: when the anchor is thrown from the common type of hawse pipe, regardless of its original angle or position on the seabed, the anchor claw can effectively hold the seabed in a short time, and the holding power can meet the requirements of 11.1.4.1 in this PART. If there is any doubt, verification may be required.

Section 2 ANCHOR CHAIN CABLES AND ACCESSORIES

11.2.1 Application

11.2.1.1 The requirements of this Section apply to stud link chain cables and their accessories made of rolled round, forged and cast steels. Where stud less short-link chains are used, it can be implemented in accordance with the relevant standards accepted by CCS.

11.2.1.2 According to tensile strength, anchor chain cables are subdivided into three grades: AM1, AM2 and AM3.

11.2.2 Manufacture

11.2.2.1 All materials used in the manufacture of anchor chain cables and their accessories are to be supplied by manufacturers approved by CCS.

11.2.2.2 The chain cables and accessories are to be designed and manufactured in accordance with recognized standards, and their typical designs are shown in Figures 11.2.2.2(1)~11.2.2.2(7). The numbers in the Figures represent multiples of the nominal diameter d . A length of chain cable is to comprise an odd number of links. Where accessories are of a construction and produced by a welding process other than those required in these Figures, the whole set of drawings giving details of dimensions, manufacturing process and heat treatment together with technological specifications are to be submitted to CCS for approval.

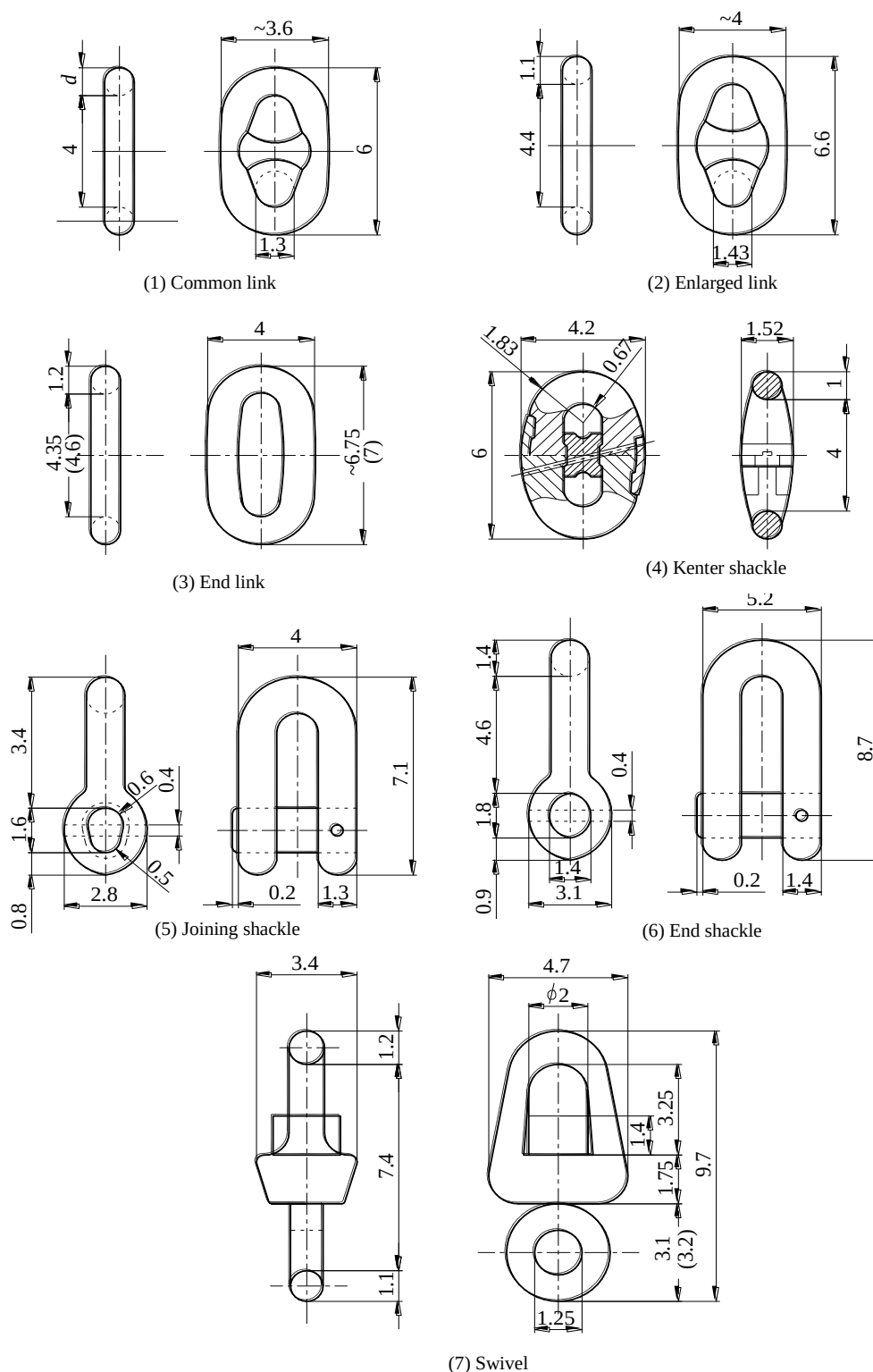


Figure 11.2.2.2 Chain Cables and Accessories

11.2.2.3 Stud link chain cables are preferably to be manufactured by flash butt welding, and may also be manufactured by drop forging or casting. Pressure butt welding may also be adopted for stud less chain cables provided that the nominal diameter of the chain cable does not exceed 26 mm.

11.2.2.4 Accessories such as shackles, swivels and swivel shackles are to be forged in steel of at least Grade AM2. The welded construction of these parts is subject to special approval by CCS.

11.2.2.5 The welding of studs is to comply with the requirements as follows:

- .1 The studs are to be welded at one end only, i.e., opposite to the weldment of the link. The stud ends are to fit the inside of the link without appreciable gap.
- .2 The welds, preferably in the horizontal position, are to be executed by qualified welders using

suitable welding consumables.

- .3 All welds are to be carried out before the final heat treatment of the chain cable.
- .4 The welds are to be free from defects liable to impair the proper use of the chain. Undercuts, end craters and similar defects are to be ground off.
- .5 A procedure test for the welding of chain studs may be required

11.2.3 Surface quality

11.2.3.1 All chain cables and accessories are to have a clean surface consistent with the method of manufacture and be free from cracks, notches, inclusions and other defects impairing the performance of the product. The flashes produced by drop forging or upsetting are to be properly removed.

11.2.3.2 Minor surface defects may be ground off so as to leave a gentle transition to the surrounding surface, provided that the diameter of ground links is not less than required by dimensional tolerances (see 11.2.4.2 of this PART). Remote from the crown, local grinding up to 5% of the nominal link diameter may be permitted.

11.2.3.3 Where the links are to be repaired by welding, the welding procedure specification is to be submitted to CCS for approval. Welding at the crown is not permitted.

11.2.4 Dimensions and tolerances

11.2.4.1 The dimensions of chain cables and accessories are to comply with the relevant recognized standards. The typical structural dimensions are as shown in Figure 11.2.2.2(1)~11.2.2.2(7) in this PART.

11.2.4.2 The following tolerances are applicable to links:

.1 dimensional tolerance of chain diameter (d is nominal anchor chain diameter):

$d \leq 40\text{mm}$:	-1mm
$40\text{mm} < d \leq 84\text{mm}$:	-2mm
$84\text{mm} < d \leq 122\text{mm}$:	-3mm
$d > 122\text{mm}$:	-4mm

The diameter of link is to be measured at the crown within the link plane and the positive tolerance of the chain diameter is to be no greater than 5% of the nominal chain diameter.

No minus tolerance is allowed in the cross-sectional area of the chain crown;

- .2 Manufacture tolerances of lengths consisting of every five links are 0%~+2.5% (measured after the tensile test for chain cables);
- .3 The allowable manufacturing tolerance of a length of 5 links is to be 0% to +2.5% (measured with the chain under tension after proof load test);
- .4 Studs are to be located in the links centrally and at right angles to the sides of the links. The following tolerances are acceptable provided that the stud fits snugly and its ends lie practically flush against the inside of the link (measured in accordance with Figure 11.2.4.2.4):
 - (1) maximum off-centre distance $X=(A-a)/2$ is 10% of the nominal diameter;
 - (2) maximum deviation from the 90° position is $\leq 4^\circ$.

The studs of enlarged links at each end of any length may be located off-centre so as to facilitate the insertion of the Kenter shackle.

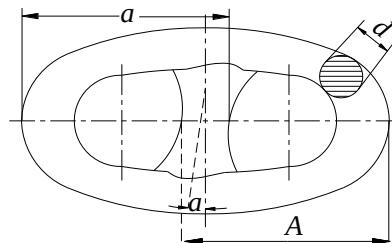


Figure 11.2.4.2.4 Anchor Chain Stud Location Plan

11.2.4.3 The dimensional tolerances of accessories are not to be greater than the following:

- Nominal diameter: (0~+5)%;
- Other diameters: $\pm 2.5\%$.

11.2.5 Material for welding chain cables

11.2.5.1 The round steel used for the manufacture of anchor chain is to comply with the relevant provisions of Section 1, Chapter 3 in this PART.

11.2.5.2 The deoxidation method and chemical composition of ladle samples of round steel are to comply with the provisions of Table 11.2.5.2.

Deoxidation and Chemical Composition of Round Steel for Chain Cables Table 11.2.5.2

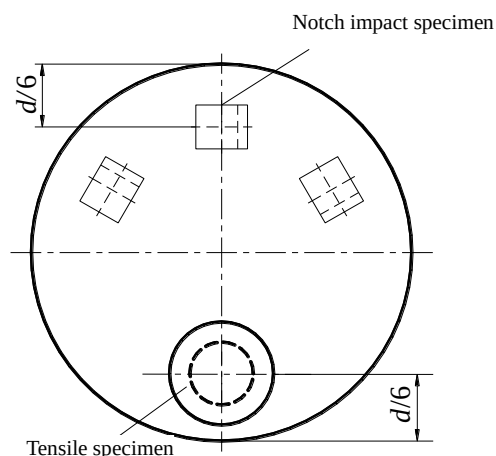
Grade of anchor chain	Grade of round steel for anchor chain cables	Deoxidation	Chemical composition (%)					
			C	Si	Mn	P	S	Al ^{Note 2}
AM1	Grade 1 anchor chain steel	Killed	≤0.20	0.15~0.35	≥0.40	≤0.040	≤0.040	—
AM2 ^{Note 1}	Grade 2 anchor chain steel	Killed and fine grain treated	≤0.24	0.15~0.55	≤1.6	≤0.035	≤0.035	≥0.020
AM3	Grade 3 anchor chain steel	Killed and fine grain treated	To comply with the standards accepted by CCS					

Note 1: Alloying elements may be added with the consent of CCS.

Note 2: It refers to total aluminum content. Aluminum may be partially replaced by other fine grain elements.

11.2.5.3 Round steel is to be submitted for test in batches with the same furnace number, diameter and mass of 40t or less. A section of appropriate length is intercepted from each batch of round steel at will as the specimen. Before sampling, the specimen is to be subjected to the same heat treatments as the finished anchor chain.

11.2.5.4 For anchor chain steel at all grade, a tensile specimen is to be intercepted from the selected test piece; for secondary anchor chain steel, a group of three Charpy V-notch impact specimens are to be intercepted from the same test piece. Specimens for tensile and impact tests are to be intercepted longitudinally along the round steel and located at 1/6 diameter away from the surface of the round steel. Round steel with a smaller diameter is to be placed as close as possible to this position, as shown in Figure 11.2.5.4.

**Figure 11.2.5.4 Tensile and Impact Test Specimens of Anchor Chain Steel**

11.2.5.5 The preparation and size of the specimens are to comply with the relevant requirements of Chapter 2 in this PART, and the results of tensile test and impact test are to comply with the requirements of Table 11.2.5.5.

Mechanical Properties of Chain Cables and Accessories Table 11.2.5.5

Anchor chain cable or accessory grade	Yield strength R_{eH} min. (N/mm ²)	Tensile strength R_m min. (N/mm ²)	Elongation A_5 min. (%)	Reduction of area Z min. (%)	Charpy V-notch impact test	
					Test temperature (°C)	Average impact energy (J)
AM1	—	370~490	≥25	—	—	—
AM2	≥295	490~690	≥22	—	0	≥27 ^{Note 1}
AM3	≥410	≥690	≥17	≥40	0 (-20) ^{Note 2}	≥60 (35)

Note 1: Where AM2 grade chain cables or accessories are delivered in heat-treated condition, the impact test may be exempted.

Note 2: AM3 grade anchor chain steel impact test temperature is usually 0 °C. When required by the ordering party, the delivery requirement can be -20 °C impact.

11.2.6 Forged anchor chain material

11.2.6.1 Except as otherwise provided in this Section, the forged steel materials used for forging chain cables and accessories are to comply with the relevant provisions of Section 1, Chapter 4 in this PART.

11.2.6.2 The chemical composition of forged steel is to comply with the technical conditions approved by CCS. The manufacturer is to determine the chemical composition of each furnace of steel and issue a corresponding certificate.

11.2.6.3 Forgings are to be normalized or quenched and tempered according to the grade of the corresponding chain cables and accessories.

11.2.6.4 Forgings with the same furnace (pot) number, the same heat treatment procedures and similar dimensions can be tested in batches. In batch test, one forging or that forged separately is to be taken as the test piece. At least one tensile specimen and a group of three Charpy V-notch impact specimens is to be taken from each batch of forgings for tensile and impact tests. The location of the specimen taken from the test piece is to comply with the provisions of Figure 11.2.5.4.

11.2.6.5 The tensile and impact test results of the forged steel are to comply with the requirements for chain cables or accessories in Table 11.2.5.5.

11.2.7 Material for casting chain cables

11.2.7.1 Except as otherwise provided in this Section, the manufacture and test of the cast steel for casting chain cables and accessories are to comply with the relevant provisions of Section 1, Chapter 5 in this PART.

11.2.7.2 The chemical composition of the cast steel is to comply with the conditions approved. The manufacturer is to determine the chemical composition of each furnace of steel and issue a corresponding certificate.

11.2.7.3 All steel castings are to be normalized or quenched and tempered according to the grade of the corresponding chain cables and accessories.

11.2.7.4 Castings with the same furnace (pot) number, the same heat treatment procedures and similar dimensions can be tested in batches. During the batch test, one of the castings can be used as a specimen or the casting can be cast with the same molding material at the same time. At least one tensile specimen and a group of three Charpy V-notch impact specimens are to be taken from each batch of castings for tensile and impact tests. The location of the specimen taken from the test piece is to comply with the provisions of Figure 11.2.5.4.

11.2.7.5 The tensile and impact test results of the cast steel are to comply with the requirements for AM2 chain cables or accessories in Table 11.2.5.5.

11.2.8 Stud material

11.2.8.1 Stud is to be made of a material equivalent to anchor chain steel (e.g. rolled, cast or forged steel with low carbon content). Materials such as gray cast iron and ductile iron are not allowed to be used.

11.2.9 Condition of supply of finished chain cables and accessories

11.2.9.1 According to the grade of steel, chain cables and accessories are to be supplied in one of the conditions specified in Table 11.2.9.1. The heat treatment is to be performed before the proof load test and breaking load test.

Condition of Supply of Chain Cables and Accessories**Table 11.2.9.1**

Grade	Chain cables	Accessories
AM1	As welded or normalized	Not applicable
AM2	As welded or normalized ^{Note}	Normalized
AM3	Normalized, normalized + tempered or quenched + tempered	Normalized, normalized + tempered or quenched + tempered

Note: Grade AM2 chain cables made by forging are to be supplied in the normalized condition.

11.2.10 Testing finished chain cables

11.2.10.1 Finished chain cables are to be subjected to the proof load test and the breaking load test in accordance with recognized standards in the presence of the Surveyor. Therefore, it is not allowed to apply paint or anticorrosive paint to anchor chains.

11.2.10.2 Proof load test: Each length of chain cable (27.5 m) is to be subjected to a proof load test at the proof load appropriate to the particular chain cables as shown in Table 11.2.10.2 using an approved testing machine. After unloading, each length of chain cable including the dimensions is to be examined. All links are to be free from significant defects, and the permanent stretch in a length of chain cable is not to exceed 5% of the original length.

Proof and Break Test Loads of Chain Cables**Table 11.2.10.2**

Test load	AM1	AM2	AM3
Proof load (kN)	$0.00686d^2(44-0.08d)$	$0.00981d^2(44-0.08d)$	$0.01373d^2(44-0.08d)$
Breaking load (kN)	$0.00981d^2(44-0.08d)$	$0.01373d^2(44-0.08d)$	$0.01961d^2(44-0.08d)$

11.2.10.3 For the breaking load test, one sample comprising of at least three links taken from every four lengths or fraction of chain cables is to be regarded as the specimen by the Surveyor and tested at the breaking loads given by Table 11.2.10.2. The breaking load is to be maintained for at least 30 s. The links concerned are to be made in a single manufacturing cycle together with the chain cable and welded and heat treated together with it. The test link is to be removed from the anchor chain in the presence of the Surveyor. Where the tensile loading capacity of the testing machine is insufficient to apply the breaking load for chain cables of large diameter, another equivalent testing method is to be agreed. Where the specimen is not broken after the specified load is applied, it is regarded that the specimen has passed the test.

11.2.10.4 Retest: Where a breaking load test fails to meet the requirements, an additional specimen may be taken from the same length of chain cable and tested. The test is to be considered successful if the requirements are then satisfied. Where the retest fails, the length of chain cable concerned is to be rejected. If the manufacturer so wishes, the remaining three lengths belonging to the batch test quantity may then be individually subjected to test at the breaking load. Where one such test fails to meet the requirements, the entire batch is to be rejected. Where a proof load test fails, the defective link(s) may be replaced by new links which have been locally heat treated and the proof load test repeated. In addition, an investigation is to be made to identify the cause of the failure.

11.2.10.5 For Grades 2 and 3 chain cables, mechanical test specimens are to be taken from every four lengths of welded chain cable. For forged chain cables where the batch size is less than four lengths, the sampling frequency is to be by heat and heat treatment charge. One tensile specimen and two sets of three Charpy V-notch impact test specimens are to be taken from each batch according to the requirements of 11.2.10.5-1. One tensile specimen and one set of three impact test specimens are to be taken from the side of the base material opposite the weld, and the other set of three impact test specimens is to be taken with the notch positioned at the centre of the weld. The specimen link is to be manufactured and heat treated together with this batch of chain cable.

Mechanical tests are to be conducted in the presence of the Surveyor. The mechanical properties of links are to comply with the requirements of Table 11.2.10.5-2 in this PART.

Number of Mechanical Specimens of Finished Chain Cables and Accessories Table 11.2.10.5-1

Grade of chain cable	Manufacture method	Condition of supply	Number of specimens		
			Tensile test for base metal	Charpy impact test	
				Base metal	Weld
AM1	Flash-butt welded	As welded, normalized	Not required	Not required	Not required
AM2	Flash-butt welded	As welded	1	3	3
		Normalized	Not required	Not required	Not required
	Forged or Cast	Normalized	1	3 ^{Note}	Not applicable
AM3	Flash-butt welded	Normalized, normalized + tempered, quenched + tempered	1	3	3
	Forged or Cast	Normalized, normalized + tempered, quenched + tempered	1	3	Not applicable

Note: This only applies to accessories

Mechanical Properties of Finished Chain Cables and Accessories**Table 11.2.10.5-2**

Anchor chain or accessory grade	Yield strength R_{eH} min. (N/mm ²)	Tensile strength R_m min. (N/mm ²)	Elongation A_5 min. (%)	Reduction of cross section Z min. (%)	Charpy V-notch impact test		
					Test temperature (°C)	Average impact energy (J)	
						Base metal	Weld

AM2	≥295	490~690	≥22	—	0	≥27	≥27
AM3	≥410	≥690	≥17	≥40	0 (-20) ^{Note 1}	≥60(35)	≥50(27)

Note 1: In general, the impact test temperature of grade 3 finished chain cables is 0 °C. Where it is required by the purchaser, -20 °C may be regarded as a supply condition.

If the mechanical properties of the link are disqualified, the link can be re-sampled after heat treatment. If the link is still disqualified after retest, the chain cable should be judged as disqualified.

11.2.11 Testing of for accessories

11.2.11.1 Proof load test: All the accessories are to be subjected to the proof load test at the proof load specified for the corresponding chain cable in Table 11.2.10.2 in this PART.

11.2.11.2 Breaking load test: From each manufacturing batch (the same cast, diameter and heat treatment) of 25 units or less of shackles, swivels, swivel shackles, enlarged links and end links and from each manufacturing batch of 50 units or less, one unit is to be subjected to the breaking load test at the break load specified in Table 11.2.10.2. Parts tested in this way may not be put to further use.

11.2.11.3 CCS may waive the breaking load test if:

.1 the breaking load has been demonstrated on the occasion of the approval testing of parts of the same design;

.2 the mechanical properties and impact energy of each manufacturing batch have been proved; and

.3 the accessories have been subjected to suitable non-destructive testing.

11.2.11.4 If the material used is of a tensile strength higher than the specified grade, or if the size of the accessory is sufficient to withstand a breaking load of 1.4 times of the breaking load during the test, the accessory may be approved for continued use.

Section 3 STEEL WIRE ROPES

11.3.1 Application

11.3.1.1 The requirements of this Section apply to steel wire ropes intended to be used as mooring lines, towlines and stream wires.

11.3.2 Manufacture

11.3.2.1 The construction of wire ropes are generally to comply with the requirements of Table 11.3.2.1, or other relevant recognized standards, or alternative types of wire ropes will be specially considered on the basis of an equivalent breaking load and the suitability of the construction for the purpose intended.

Construction of Steel Wire Ropes

Table 11.3.2.1

Purpose	Specification of rope			Construction of strands					
	Strands	Wires	Core	Core	Core wire	Inner layer	Middle layer	Outer layer	Hierarchical marker
Stream wires, towlines, mooring lines	6	24	Fiber	Fiber	0	—	9	15	6(0+9+15)
	6	37	Fiber	Wire	1	6	12	18	6(1+6+12+18)
	6	26	Fiber	Wire	1	5	(5+5)	10	6(1+5+ $\frac{5}{5}$ +10)
	6	31	Fiber	Wire	1	6	(6+6)	12	6(1+5+ $\frac{6}{6}$ +10)
	6	36	Fiber	Wire	1	7	(7+7)	14	6(1+5+ $\frac{7}{7}$ +10)
	6	41	Fiber	Wire	1	8	(8+8)	16	6(1+5+ $\frac{8}{8}$ +10)
	6	30	Fiber	Fiber	0	—	12	18	6(0+12+18)
Towlines and mooring lines used in association with mooring winches	6	31	Wire	Wire	1	6	6+6	12	6(1+6+ $\frac{6}{6}$ +12)
	6	36	Wire	Wire	1	7	7+7	14	6(1+7+ $\frac{7}{7}$ +14)
	6	41	Wire	Wire	1	8	8+8	16	6(1+8+ $\frac{8}{8}$ +16)

11.3.3 Steel wire

11.3.3.1 The wire used in the manufacture of the rope is to be made from high quality structural carbon steel, the content of sulphur and phosphorus of which is not to exceed 0.035% respectively and that of other elements is to comply with the relevant standards acceptable to CCS. The wire drawn from steel is to have a round cross section, and is to be of homogeneous quality, uniform strength and free from surface defects likely to impair the performance of the rope, such as cracks, corrugations, burrs, rust and scratches.

11.3.3.2 The tensile strength of wires is to be in the range of $1,420\text{N/mm}^2 \sim 1,570\text{N/mm}^2$ or $1,770\text{N/mm}^2 \sim 1,960\text{N/mm}^2$.

11.3.3.3 Steel wire ropes are in general to be manufactured from fully galvanized wires. The wire is to be galvanized by a hot dip or an electrolytic process to give a smooth, continuous and secure coating which may be any of the following grades:

Grade 1: heavy coating, drawn after galvanizing;

Grade 2: heavy coating, finally galvanized;

Grade 3: light coating, drawn after galvanizing.

11.3.4 Test samples and tests

11.3.4.1 Wire samples are to be taken from a suitable length of the completed rope. After unstranding and straightening, six wires are to be selected as specimens to conduct twisting and wrapping tests to test the adhesion degree of galvanized wire. In addition, the quality and uniformity of zinc are to be tested. A required number of wires are to be selected for the above tests before they are twisted into wire ropes.

11.3.4.2 Torsion test is to comply with the following requirements:

- .1 The length of the sample is to be such as to allow a length between the grips of 100 times the wire diameter or 300 mm, whichever is less.
- .2 The wire is to be twisted by causing one or both of the vices to be revolved until rupture. A tensile load not exceeding 2% of the nominal breaking load of the wire may be applied to keep the wire stretched.
- .3 The speed of the twisting and the number of complete twists are to meet the requirements of Table 11.3.4.2.3-1 and Table 11.3.4.2.3-2 respectively.

Maximum Twisting Speed of Torsion Test**Table 11.3.4.2.3-1**

Galvanized wire diameter d (mm)	Maximum twisting speed (times/min)
$d < 1.5$	90
$1.5 \leq d < 3.0$	60
$3.0 \leq d < 4.0$	30

Minimum Number of Twists of Torsion test**Table 11.3.4.2.3-2**

Galvanized wire diameter d (mm)	Minimum number of twists			
	Grade 2 zinc coating		Grade 1 or 3 zinc coating	
	Test before twisting	Test after twisting	Test before twisting	Test after twisting
$d < 1.3$	15	13	27	24
$1.3 \leq d < 2.3$	15	13	26	23
$2.3 \leq d < 3.0$	14	12	23	20
$3.0 \leq d < 4.0$	12	10	21	18

11.3.4.3 Coating test

Steel wire ropes are to be galvanized. Zinc coating is to be determined by the mass per unit area, and the minimum mass of unit area of zinc coating is not to be less than that given in Table 11.3.4.3. Determination of the mass of zinc coating is to be in accordance with a recognized standard. Generally, wires of various diameters are to be removed from the steel rope and tested individually. The zinc coating is to be removed by dipping the wire in a chemical solution. The loss of mass of the uncoated wire is measured and thus the mass of the zinc coating is determined. The uniformity of zinc coating is to be determined by liquid immersion test in accordance with the accepted standards.

Mass of Zinc Coating of Wire**Table 11.3.4.3**

Galvanized wire diameter d (mm)	Minimum mass of zinc coating per unit area (g/mm^2)	
	Grade 1 or 2	Grade 3

$0.4 \leq d < 0.5$	75	40
$0.5 \leq d < 0.6$	90	50
$0.6 \leq d < 0.8$	110	60
$0.8 \leq d < 1.0$	130	70
$1.0 \leq d < 1.2$	150	80
$1.2 \leq d < 1.5$	165	90
$1.5 \leq d < 1.9$	180	100
$1.9 \leq d < 2.5$	205	110
$2.5 \leq d < 3.2$	230	125
$3.2 \leq d < 4.0$	250	135

11.3.4.4 Wrapping test

The adhesion of the coating is to be tested by wrapping the wire round a cylindrical mandrel for 10 complete turns. After wrapping on the appropriate mandrel, the zinc coating is to have neither flaked nor cracked. At least 5 wires of each size are to be tested. The ratio between the diameter of the mandrel and that of the wire is to comply with the requirements given in Table 11.3.4.4.

Specifications for Wrapping test

Table 11.3.4.4

Zinc coating	Galvanized wire diameter (mm)	Ratio of mandrel to wire diameter
Grade 1 or 2	<1.5	1:4
	≥ 1.5	1:6
Grade 3	<1.5	1:2
	≥ 1.5	1:3

11.3.4.5 Breaking test of finished steel wire ropes

- .1 For ropes having a manufactured length less than 10,000 m, a section of test sample is to be cut from the end of each rope for breaking tests. The sample is to be of a sufficient length to provide a clear test length of at least 36 times the rope diameter between the grips. Where the manufactured length is more than 10,000 m, a second test sample is to be taken from the rope and tested.
- .2 During testing, the application of breaking load on the testing machine is to be well controlled. Not more than four-fifths of the nominal breaking load is to be applied quickly, and thereafter the load is to be applied slowly and steadily without any impact load on the rope. Tests in which a breakage occurs adjacent to the grips are to be rejected, and further samples may be taken for retests. If the applied breaking load is less than the minimum value given in the standards acceptable to CCS, the result will be considered to be unacceptable.
- .3 If facilities are not available for making a breaking test on completed ropes, the summation of actual test results of individual wires may be accepted. In such cases, the breaking strength of a single wire is to be multiplied by the total number of wires and the product so obtained is to be divided by a relevant conversion factor listed in Table 11.3.4.5.3 to determine the breaking load of the rope.

Conversion Coefficient of Single Wire Test

Table 11.3.4.5.3

Specification of wire rope	Conversion coefficient
6×24	0.87
6×37	0.825

Note: For the conversion coefficient of wire ropes of other specifications, please refer to the relevant provisions of other approved standards.

Section 4 FIBER ROPES

11.4.1 Application

11.4.1.1 The requirements of this Section apply to fiber ropes used as towlines and mooring lines made from natural or synthetic fibers.

11.4.2 Manufacture

11.4.2.1 Fiber ropes may be made of natural fibers (coir, hemp, manila or sisal) or may be composed of synthetic fibers (polyamide, polyester or polypropylene). Where it is intended to use other materials, it is to be approved by CCS.

11.4.2.2 The construction of marine fiber ropes is to comply with the accepted standards. Fiber ropes may be of a three-strand, four-strand, six-strand, eight-strand or twelve-strand construction appropriate to their respective materials and types, and other construction forms will be specially considered.

11.4.3 Materials

11.4.3.1 The material used for the manufacture of fiber ropes is to be of good and consistent quality and resistant to corrosion and in conformity with the approved standards. The ropes are not to be filled with any fillers or substances that increase their mass. The amount of any impregnating lubricant in vegetable fibers is to be reduced to a minimum and no preservatives or waterproofing measures used to cause damage to vegetable fibers. None of the above measures can increase the mass of the ropes, reduce their strength and shorten their service life.

11.4.4 Breaking test

11.4.4.1 The test length and initial load of the specimen intercepted from the finished fiber rope can be executed with the provisions of Table 11.4.4.2. After the initial load is applied, it is required to check whether the diameter of the specimen conforms to the nominal size and the rolling uniformity, and then increase the load evenly according to the strain rate specified in Table 11.4.4.2 until break. The actual breaking force is to be not less than the values specified by the accepted standards.

11.4.4.2 During the test, if the breaking position of the rope is within 150mm from the fixture, sampling can be conducted again for retest, but the breaking test of each coil of fiber rope is not to exceed two times. If the specimen breaks at the clamping or splicing part and the test result reaches more than 90% of the maximum breaking load specified for the fiber rope, the test result is considered qualified.

Fiber Breaking Test Parameters

Table 11.4.4.2

Material	Minimum free length of specimen between fixtures (mm)	Initial load/minimum breaking load (%)	Strain rate (mm/min)
Vegetable fiber	1,800	2	150±50
Synthetic fiber	900	1	75±25



CHINA CLASSIFICATION SOCIETY

RULES FOR CONSTRUCTION OF OCEAN-GOING STEEL FISHING VESSELS

2018

PART 8 WELDING

Effective from 1 December 2018

CHAPTER 1 GENERAL

Section 1 GENERAL PROVISIONS

1.1.1 Application

1.1.1.1 This PART applies to the welding of ship structures, boilers, pressure vessels, important machinery components and piping system, as well as to the approval of welding consumables specified in the Rules.

1.1.1.2 The requirements of this PART apply to manual arc welding, submerged arc welding, gas shielded arc welding and electro-slag welding process. Other welding processes are to be approved by CCS.

1.1.2 Welding consumables, facilities and operating environment

1.1.2.1 Welding consumables(including electrode, wires, fluxes and shielding gases) are to comply with the relevant requirements of Chapter 3 of this PART, and are to be approved by CCS.

1.1.2.2 The storage, transportation, preliminary treatment (including baking of electrodes and fluxes, rust-removing of wires, and dehumidification of shielding gases) and usage of welding consumables are to be in accordance with the instructions of manufacturers.

1.1.2.3 Welding plant and appliances are to be suitable for the intended purpose and are to be maintained in an efficient condition, And they are to be properly arranged so as to provide good conditions for welding operations.

1.1.3 Welders and welding procedures

1.1.3.1 In order to ensure welding quality, welders of engaged in fishing vessels or manufacturing marine products are to take part in qualification tests. Only the welders holding a *Qualification Certificate of Welder* issued or accepted by CCS are permitted to engage in welding operations appropriate to their qualified range of work.

1.1.3.2 The welding procedure specification is to be submitted to CCS for approval in accordance with Chapter 2 of this PART.

1.1.4 Control and non-destructive testing personnel

1.1.4.1 The works are to be provided with a perfect quality assurance department capable of operating efficiently. All important welds are to be made under the supervision of skilled supervisors so as to ensure the quality of welding.

1.1.4.2 Non-destructive testing personnel are to hold a *Qualification Certificate of NDT Personnel* issued or accepted by CCS, and can only engage in the non-destructive testing appropriate to their qualified category and level of work.

Section 2 TESTING

1.2.1 General requirements

1.2.1.1 Unless otherwise specified in this Section, the methods for mechanical tests of welds are to comply with the requirements of Chapter 2 of PART SEVEN of the Rules.

1.2.2 Preparation of test specimens

1.2.2.1 The dimensions of samples and the positions of specimens are to comply with the relevant requirements of this PART.

1.2.2.2 When test material is cut from products, allowance reasonable margin is required to allow sufficient material, which would affect test results, to be removed from the cut edges by machining of test specimens.

1.2.2.3 If any test specimen shows defects irrelevant to the welding, it may be discarded and another specimen substituted.

1.2.3 Shapes and dimensions of specimens

1.2.3.1 Deposited metal tensile test specimens (longitudinal) are to be machined to the shapes and dimensions

shown in Figure 1.2.3.1. The specimens may be heated to a temperature not exceeding 250°C for a period not exceeding 16 h for hydrogen removal, prior to testing..

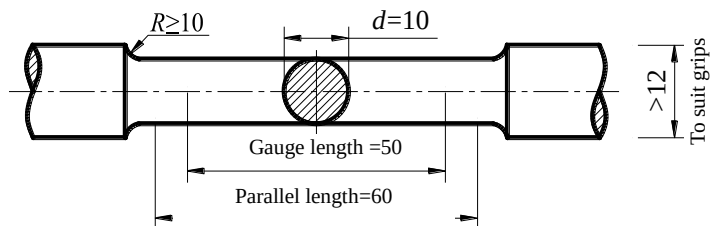
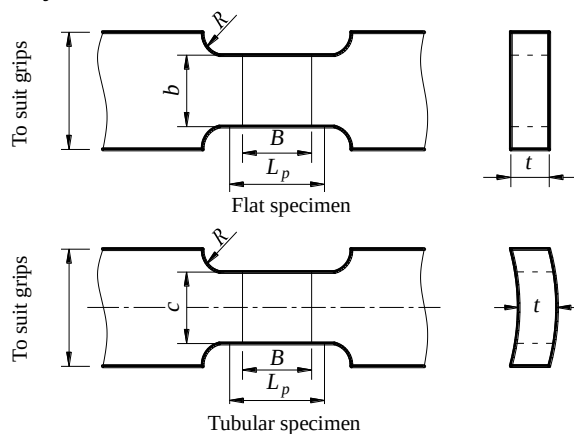


Figure 1.2.3.1 Deposited Metal Tensile Sample

1.2.3.2 Butt weld tensile test specimens (transverse) are to be machined to the dimensions shown in Figure 1.2.3.2-1. The upper and lower surfaces of the weld are to be filed, ground or machined flush with the surface of the plate.

When the breaking strength of a test specimen exceeds the capacity of the test machine, the test specimen may be divided into several portions in accordance with Figure 1.2.3.2-2, and the thickness of each portion is not to be less than 25 mm. The average value of the test results obtained from the portions is to be taken as the test result of the full thickness butt weld joint.



B —Width of weld, in mm; t —Thickness of specimen, in mm; b —Parallel breadth of flat specimen, to be taken as 25mm; c —Parallel breadth of tubular specimen, to be taken as 20mm for tube diameter equal to or greater than 76mm, and 12mm or full tube for tube diameter less than 76mm; L_p —Parallel length of specimen, to be taken as $3t$ or $B+60$ mm (subject to the bigger one); R —radius of curvature, taken as greater than 25mm.

Figure 1.2.3.2-1 Butt Weld Tensile Test Specimens

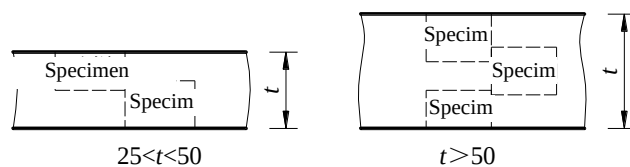


Figure 1.2.3.2-2 Transverse Tensile Specimen (when the breaking strength exceeds the capacity of the loading equipment)

1.2.3.3 Butt weld face and root bend test specimens are to be machined to the dimensions as shown in Figure 1.2.3.3. The upper and lower surfaces of the weld are to be filed, ground or machined flush with the surface of the plate. The edges on the tension side may be rounded to a radius of 1 mm to 2 mm. For tubular specimens, the compression side may be machined to a plane.

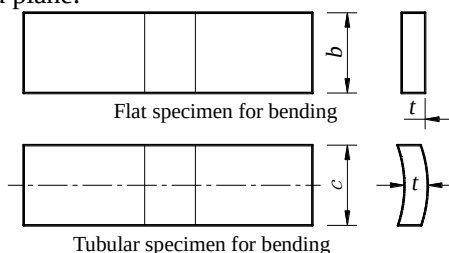


Figure 1.2.3.3 Butt Weld Face and Root Bend Test Specimens

t – Thickness of specimen, to be taken as the thickness of parent plate. Where the thickness exceeds 25 mm, the specimens may be machined on the compression side to reduce the thickness to 25 mm. For aluminum alloys, thickness reduction is not to be applied;

b – Breadth of flat specimen, to be taken as 30 mm;

c – Breadth of tubular specimen, taken as $t + 0.1d$, but neither less than 10 mm, nor more than 30 mm, where d is the outside diameter of tubular specimen, in mm.

1.2.3.4 Butt weld side bend test specimens are to be machined to the dimensions as shown in Figure 1.2.3.4. The upper and lower surfaces of the weld are to be machined flush with the surface of the plate. The edges on the tension side may be rounded to a radius of 1 to 2 mm.

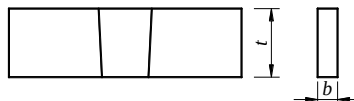


Figure 1.2.3.4 Butt Weld Side Bend Test Specimen

t—Thickness of the test plate, in mm. When t is greater than 40mm, the specimen may be divided into several portions with t equal to 20mm~40mm;

b—Thickness of specimen, to be taken as 10mm.

1.2.3.5 Charpy V-notch impact test specimens are to be machined to the dimensions as specified in PART SEVEN of the Rules, and the position of the V-notch is to comply with the relevant requirements of this PART. Unless otherwise specified, the notch is to be perpendicular to specimen surface and weld axis.

1.2.3.6 Macro specimens are to be taken by fracturing the test plate at the weld joint in a direction perpendicular to the weld, having a length including at least 10 mm unaffected base metal. The complete cross section of the fractured surface in way is to be ground, polished and acid-etched for examination.

1.2.3.7 Hardness test specimens may be taken using the method specified for macro specimens in 1.2.3.6 of this Section, and the complete cross section of the fractured surface in way is to be ground and polished.

1.2.4 Testing

1.2.4.1 The procedures used for tensile test and impact tests are to comply with the relevant requirements of Section 2 and 4 of Chapter 2 of PART SEVEN of the Rules.

1.2.4.2 Bend tests are generally to be carried out at ambient temperature. A former, having a specified diameter and with its axis perpendicular to the center of the weld, is to be used to push and bend the specimen. The face, root or side bend test is to be such that the bend test specimen is tested with the face, root or side of the weld in tension respectively. Unless otherwise specified, the diameter of the former and the bending angle are to be as follows:

.1 Bend tests of structural steels are to comply with the requirements of Table 1.2.4.2.1.

Requirements for Bend Tests of Structural Steels

Table 1.2.4.2.1

Purpose of test	Strength of Test Material (N/mm ²)	Diameter <i>d</i> of former	Bending angle α
For approval of welding consumables	$R_{eH} \leq 400$	3 <i>t</i>	120 °
	$400 < R_{eH} \leq 500$	4 <i>t</i>	
	$500 < R_{eH} \leq 690$	5 <i>t</i>	
For approval of welding procedures	$R_{eH} \leq 400$	4 <i>t</i>	180 °
	$400 < R_{eH} \leq 500$	5 <i>t</i>	
	$500 < R_{eH} \leq 690$	6 <i>t</i>	

Note: *t* is the thickness of the specimen.

For approval test of welding procedures for boilers and pressure vessels, the former diameter is to comply with 5.2.3.3 of this PART.

.2 The wrap around bend test method is recommended for bend tests of aluminum alloy welds and is to comply with the following requirements:

- (1) Tests for approval of welding consumables are to comply with the requirements of Table 3.9.3.7 of this PART.
- (2) The bending angle for approval tests of welding procedures is to be 180 °; and the diameter of the former is not to be greater than the value obtained from the following formula:

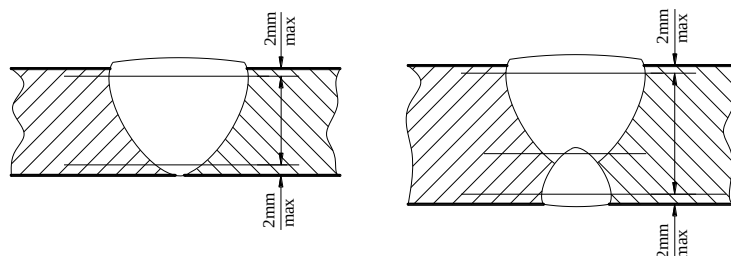
$$d = \frac{(100 \times t_s)}{A} - t_s$$

wherein: d — maximum former diameter, in mm;

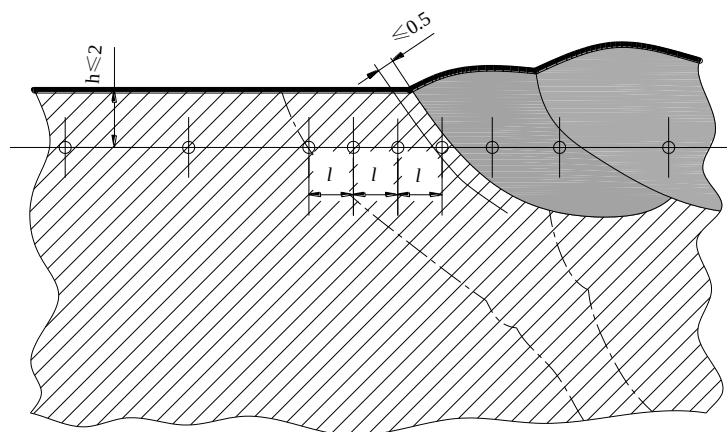
t_s — thickness of bend test specimens (including side bend specimens), in mm;

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

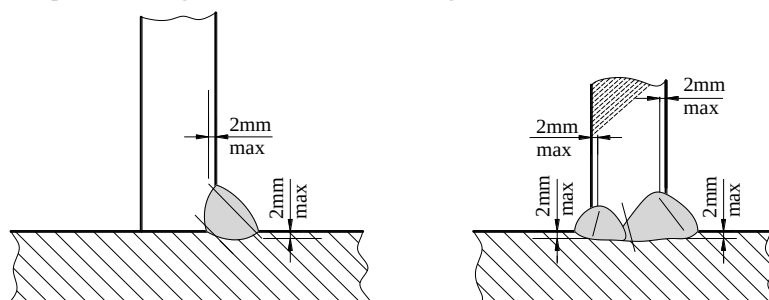
1.2.4.3 Hardness measurements are to be carried out by means of a Vickers hardness tester along the rows as shown in Figure 1.2.4.3, normally applying a force of 98 N. A minimum of 3 individual points in each area of the weld metal, the fusion line, the heat affected zone and the base metal are to be measured and the distance between measuring points is to be such that they will not interfere with each other.



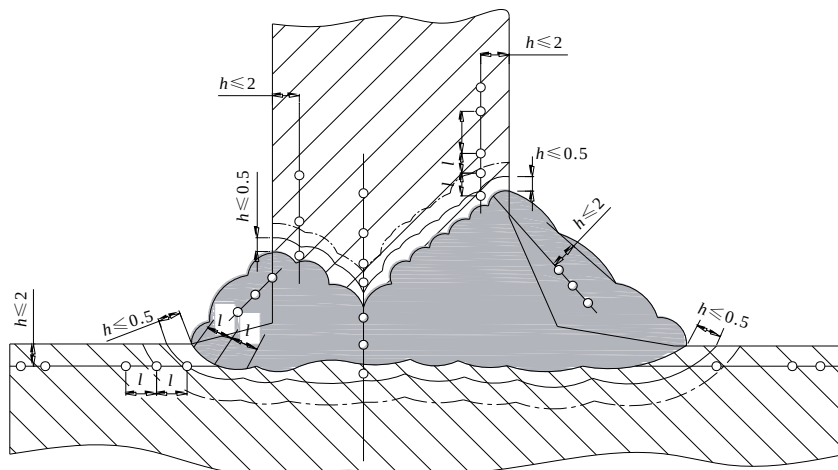
(1) Hardness Measuring Rows of Butt Weld



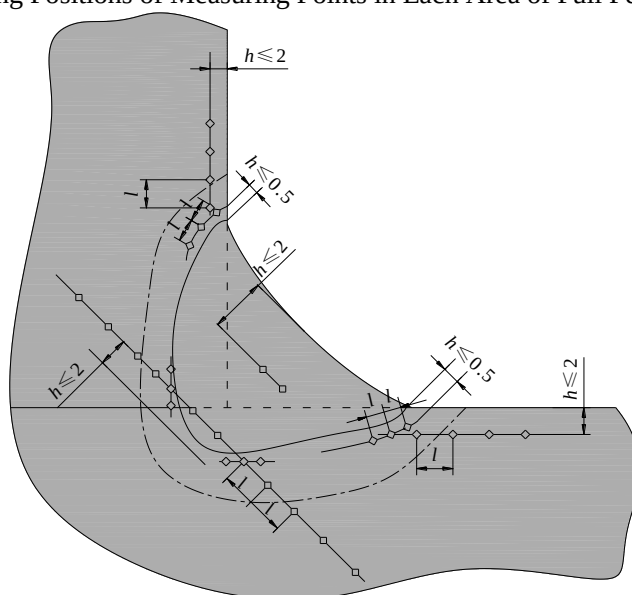
(2) Example Showing Positions of Measuring Points in Each Area of Butt Weld



(3) Hardness Measuring Rows of Fillet Weld



(4) Example Showing Positions of Measuring Points in Each Area of Full Penetration Fillet Weld



(5) Example Showing Positions of Measuring Point in Each Area of Fillet Weld

Figure 1.2.4.3 Weld Hardness Test

1.2.4.4 Fillet weld fracture tests are to be carried out as shown in Figure 1.2.4.4. A force is applied to the top of the abutting plate, with the root of the weld in tension and then fractured. If fracturing is unlikely, the surface of weld may be grooved to a depth not greater than 20% of the throat thickness.

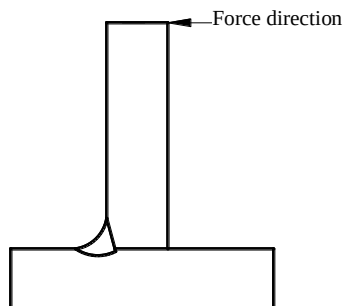


Figure 1.2.4.4 Fillet Weld Fracture Tests

1.2.5 Acceptance and re-tests

1.2.5.1 All results are to comply with the relevant requirements of this PART. For impact tests, the average energy value of the results from one set of 3 specimens is taken for acceptance purposes, in which one individual value may be less than the required average value provided that it is not less than 70% of this value.

1.2.5.2 Where the result of any specimen, except for impact tests, is unacceptable, duplicate test specimens of the same type may be prepared from the original welded assembly or from a new assembly rewelded with the same procedure and using welding consumables from the same batch, and the results of fall re-tests are to be satisfactory.

1.2.5.3 Where the results from a set of 3 impact test specimens do not comply with the requirements, an additional set of 3 impact test specimens may be taken provided that not more than two individual values are less than the required average value and, of these, not more than one is less than 70% of this average value. The results obtained are to be combined with the original results to form a new average value, which, for acceptance, is not to be less than the required value. Additionally for these combined results, not more than two individual values are to be less than the required average value and, of these, not more than one is to be less than 70% of the average value.

1.2.5.4 If there is a single hardness value above the maximum values allowed, additional hardness tests are to be carried out (on the reverse of the specimen or after sufficient grinding of the tested surface).

1.2.5.5 If the above re-tests again fail, further re-tests may be made, which are to be made on a new welded assembly and to include all tests required for the original assembly.

1.2.5.6 All test results are to be recorded in the test report.

CHAPTER 2 WELDING PROCEDURE APPROVAL TESTS

Section 1 GENERAL PROVISIONS

2.1.1 Application

2.1.1.1 This Chapter applies to the approval of welding procedures prior to the commencement of production welding at building yards of ships, and manufacturing works of marine products.

2.1.2 Approval

2.1.2.1 Prior to the commencement of construction, the shipbuilder or manufacturer is to prepare a summary table of welding procedures in combination with their own technical conditions and production experiences and submit it to the Surveyor for approval. The name and number of the welding procedure specification intended for use are to be indicated in the summary table according to different positions, types and sizes of welds at important structures and connections. For unapproved process, detailed procedure specification is to be prepared and submitted to CCS for approval. The welding procedure specification can be used only after it passes the procedure approval test

2.1.2.2 Prior to the tests for approval of welding procedures, the shipbuilder or manufacturer is to submit a detailed preliminary welding procedure specification, including the following:

- .1 type, grade, thickness and delivery status of the parent metal;
- .2 designation, grade and size of welding consumables (electrode, wire, flux and shielding gas)
- .3 type and main performance parameters of welding equipment;
- .4 design of and requirements for edge preparation;
- .5 number and order of welding metal disposition and welding sequence;
- .6 Welding positions (down hand, horizontal, vertical and overhead);
- .7 rule welding parameters (welding current, arc voltage, travel speed and shielding gas flow);
- .8 Pre-heating, inter pass temperature, post-weld heat treatment and post-weld stress-relieving;
- .9 Other special requirements.

2.1.2.3 If the welding procedures of the manufacturer have been approved by CCS, tests for approval of welding procedures can be exempted for the construction carried out according to the approved procedures. Any changes to the approved welding procedure specification are to be submitted to CCS for approval. CCS will decide whether a new welding procedure test is necessary depending on the nature and extent of such changes.

2.1.2.4 New processes and new materials require a procedure approval test so as to prove applicability of this welding procedure.

2.1.3 Application of Approved welding procedures

2.1.3.1 All the conditions of validity stated below are to be met independently of each other. Changes outside of the ranges specified are to require a new welding procedure test.

2.1.3.2 The approval is, in general, valid only for the welding process(es) used in the welding procedure test. It is not permitted to change from a multi-run to a single run and in respect to the welding of aluminum alloys, it is also not permitted to change from a single run to a multi-run. The approval of a multi-process procedure test is only valid for the process sequence carried out during the multi-process procedure test.

2.1.3.3 The application of a welding procedure specification to steels is specified as follows:

- .1 For each strength level, welding procedures are considered applicable to the same and lower toughness grades as that tested.
- .2 For each toughness grade where the minimum value of the specified yield strength of steel is not more than 390 N/mm^2 , welding procedures are considered applicable to the same and two lower strength levels as that tested. For high strength quenched and tempered steel, welding procedures are considered applicable to the same and one lower strength level as that tested.
- .3 For high heat input processes above 50 kJ/cm , the welding procedure is only applicable to that toughness grade tested and one strength level below.
- .4 For steel forgings and castings (carbon steel and carbon-manganese steel), welding procedures are considered applicable to the same or lower strength level as that tested.
- .5 For steels with delivery conditions other than those tested, CCS will put forward test requirements as appropriate. The approval of quenched and tempered steels does not qualify TMCP steels and vice versa.

2.1.3.4 The application of a welding procedure specification to aluminum alloys is to comply with the following requirements:

.1 Welding procedures to be approved for aluminum alloys may be grouped as follows according to the chemical composition of their parent metal:

Group A: aluminum-magnesium alloys with Mg content <4% (alloys 5754, 5454)

Group B: aluminum-magnesium alloys with $4\% \leq \text{Mg} \leq 7.0\%$ (alloys 5059, 5083, 5086, 5383, 5456, 5A01)

Group C: aluminum-magnesium-silicon alloys (alloys 6005A, 6061, 6082)

.2 The welding procedure qualified for one alloy is applicable to the other alloys with an equal or lower strength level in the same Group. The welding procedures qualified for Group B alloys are applicable to Group A alloys.

2.1.3.5 The application of welding procedures in respect to thickness is to comply with the following requirements:

.1 The application of the thickness of steels is to comply with the requirements of Table 2.1.3.5.1 respectively.

Application of Steel Thickness

Table 2.1.3.5.1

Thickness of test piece ^{Note 1} t (mm)	Range of approval	
	Butt and T-joint welds with single run or single run from both sides	Butt and T joint welds with multi-run and fillet welds ^{Note 2}
$t \leq 3$	$(0.7 \sim 1.1) t$	$(1 \sim 2) t$
$3 < t \leq 12$	$(0.7 \sim 1.1) t$	3mm $\sim 2t$
$12 < t \leq 100$	$(0.7 \sim 1.1) t$ ^{Note 3}	$(0.5 \sim 2) t$ (maximum 150mm)

Note 1: For multi-process procedures, the recorded thickness contribution of each process is to be used as a basis for the range of approval for the individual welding process.

Note 2: For fillet welds, the range of approval is to be applied to both base metals.

Note 3: For high heat input process over 50kJ/cm, the upper limit of the range of approval is to be 1.0 t .

.2 Application scope of aluminum alloy thickness is to conform to provisions of Table 2.1.3.5.2 respectively.

Application of Aluminum Alloy Thickness

Table 2.1.3.5.2

Thickness of test piece ^{Note 1 and Note 2} t (mm)	Range of approval ^{Note 3}
$t \leq 3$	$(0.5 \sim 2)t$
$3 < t \leq 20$	3 mm $\sim 2t$
$t > 20$	$\geq 0.8t$

Note 1: For multi-process procedures, the recorded thickness contribution of each process is to be used as a basis for the range of approval for the individual welding process.

Note 2: In the case of fillet joints between dissimilar thicknesses, t is the thickness of the thicker material.

Note 3: For automatic single-run procedure, the approved maximum penetration is the maximum penetration during test.

.3 In addition to the requirements of .1, the application of the throat thickness of fillet weld is to comply with the following requirements:

Steel: a value of 0.75 $\sim$ 1.5 times the throat thickness for test is to be required for single run fillet welds and that of 0.5 $\sim$ 2 times for multi-run fillet welds.

Aluminum alloy: a value of 0.75 $\sim$ 1.5 times the throat thickness for test is generally required, except that a tested throat thickness of 10 mm or more qualifies all throat thicknesses not less than 7.5 mm.

.4 For the vertical-down welding, the test piece thickness “ t ” is always taken as the upper limit of the range of application.

.5 For butt welds between plates having unequal thicknesses, the lesser thickness in Table 2.1.3.5.1 and Table 2.1.3.5.2 is the ruling dimension.

.6 Notwithstanding the above, the approval of maximum thickness of base metal for any technique is to be restricted to the thickness of the test assembly if three of the hardness values in the heat affected zone are found to be within 25 HV of the maximum permitted.

2.1.3.6 The application of welding procedures in respect to the external diameter of pipes is to comply with the requirements of Table 2.1.4.6.

Application of Welding Procedure in Respect to External Diameter of Pipes Table

2.1.3.6

External diameter of test pipe D (mm)	Application d (mm)
$D < 168$	$0.5D \leq d \leq 2D$
$D \geq 168$	$d \geq 0.5D$ (including the plate)

2.1.3.7 The application of welding consumables and auxiliary materials:

- .1 Steels: except high heat input processes over 50 kJ/cm, welding consumables cover other approved welding consumables having the same grade mark (including all suffixes) as the welding consumables tested.
- .2 Aluminums: approved welding consumables cover other approved welding consumables having the strength equal to or higher than that of the welding consumables tested.
- .3 Any variation of the composition of the shielding gas or the mixing ratio of mixed gases is to be restricted to the groups listed in Table 3.5.1.3 or Table 3.9.2.4 of this PART.

2.1.3.8 Approval for a test made in any position is restricted to that position. To qualify a range of positions, test assemblies are to be welded for the highest heat input position and the lowest heat input position, and all applicable tests are to be made on those assemblies. Butt weld joints of pipes with an external diameter not less than 168 mm apply to butt weld joints of plates at corresponding positions.

2.1.3.9 The upper limit of heat input approved is 25% greater than that used in the test or 55 kJ/cm, whichever is smaller. For high heat input processes over 50 kJ/cm, the upper limit is 10% greater than that used in the test.

2.1.3.10 Changes to the type (AC, DC, pulsed) and polarity (DCSP or DCRP) of the welding current normally require a new welding procedure qualification.

2.1.3.11 In production welding, the minimum preheating temperature is not to be less than that used in the qualification test. The maximum inter pass temperature is not to be higher than that used in the qualification test.

2.1.3.12 The post-weld heat treatment or aging used in the qualification test is to be maintained during manufacture. Artificial ageing for 6000 series alloys may substitute for prolonged natural ageing.

2.1.3.13 The range of approval for the type of welded joints is to be in accordance with Table 2.1.4.13. In general, qualified butt weld procedures are also applicable to fillet welds for corresponding thicknesses. For aluminum alloys and for steels with yield strength not less than 355 N/mm², however, the fillet weld test is to be carried out according to structural requirements.

Range of Approval for Type of Welded Joint

Table 2.1.3.13

Type of welded joint for test assembly			Range of application	
Welding process	Name	Code	Structural steel	Aluminum alloy
Butt weld	Both sides	With gouging	C	C
		Without gouging	D, C	D, C, A
	Both sides	With backing	A, C, D	A, C
		Without backing	B, A, C, D	B, A, C, D

2.1.3.14 Welding procedure qualification with shop primer qualifies welds without primer, but not vice versa.

2.1.3.15 The range of approval relating to other variables not covered above may be taken according to the relevant standards subject to agreement of CCS.

Section 2 WELDING PROCEDURE APPROVAL TESTS FOR BUTT WELDS

2.2.1 General requirements

2.2.1.1 This Section applies to welding procedure approval tests for butt welds of plates and pipes.

2.2.1.2 The welding procedure approval tests for butt welds are to be carried out for different welding processes and welding positions respectively.

2.2.2 Test assemblies

2.2.2.1 The base metals and welding consumables selected for test assemblies are to comply with the requirements of the preliminary welding procedure specification.

2.2.2.2 For aluminum alloys, the butt weld of the test piece is to be parallel to the rolling direction of the two plates. Dimensions of butt weld test plates are to comply with the following requirements:

Manual and semi-automatic welding: $L \geq 500\text{mm}$, $b = 150\text{mm}$;

Automatic welding: $L \geq 650\text{mm}$, $b = 200\text{mm}$.

Wherein, L is the length of the test plate, and b is the width of the test plate.

The test length L of pipes is not to be less than 150 mm. Where the diameter of a pipe is over 600 mm, a test plate may be substituted as the pipe for butt welding at the corresponding position.

Appropriate adjustment of the above dimensions of test plate maybe carried out according to the adopted method.

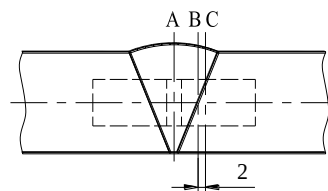
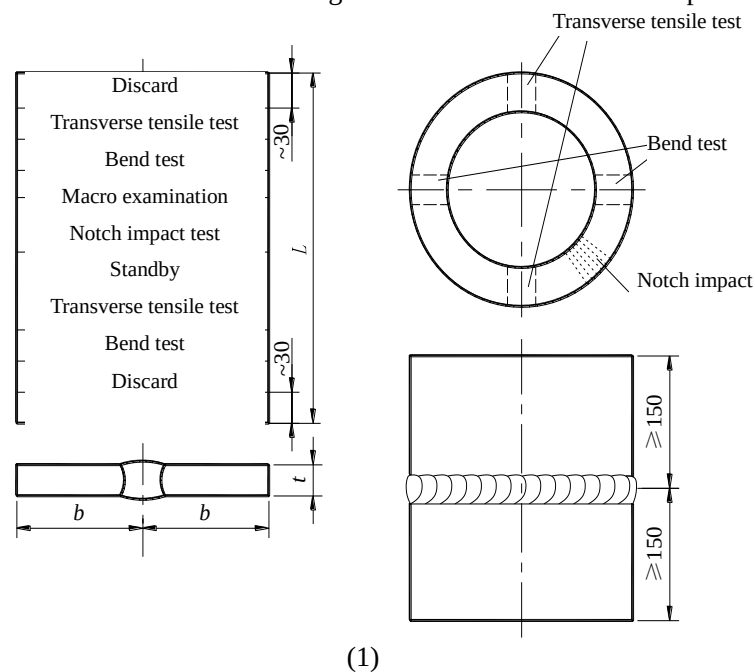
2.2.2.3 The beveling of plate edges, tacking, welding and heat treatment procedures are to comply with the preliminary welding procedure specification. The welding positions of test assemblies are to be the same as the actual welding positions.

2.2.3 Test items

2.2.3.1 After the test assemblies are welded, appearance inspection and non-destructive testing are to be conducted. The surface of weld sis to be well formed and uniform, showing a smooth transition from weld edges to the base metal and is to be free from injurious defects such as undercut, cracks and overlaps. There is to be no defects in the weld.

2.2.3.2 Unless otherwise specified, the following specimens are generally to be taken from the test assemblies as shown in Figure 2.2.3.2 (1):

- .1 two transverse tensile test specimens;
- .2 two bend specimens. They may be substituted by two side-bend specimens where the thickness of the test assembly is not less than 20 mm;
- .3 Where the thickness of the test assembly is greater than 6mm, three sets of impact specimens(three specimens for each set) are to be taken usually at the thickness center of specimen, as shown in Figure 2.2.3.2 (2), the notch positions of specimens are to beat the weld center, fusion line, and heat affected zone with a distance of 2mm from the fusion line. When a single-side welding and double-side forming process is adopted, two sets of impact specimens are to be taken from the surface near the back of specimens, and their notch position is to be at the weld center and the fusion line;
- .4 One specimen for hardness and one specimen for macroexamination(the specimens may be taken from the discard). Steels with the thickness not greater than 20mm can be exempted from hardness test.



(2)

Figure 2.2.3.2 Weld Specimens

2.2.3.3 The following examinations and test items may be required when deemed necessary by the Surveyor:

- .1 chemical analysis of deposited weld metal;
- .2 chemical analysis of parent plate;
- .3 metallographic structure of welded joints with an amplification factor of 100 times and 300 times;
- .4 longitudinal tensile test of deposited weld metal.

2.2.4 Test results

2.2.4.1 The tensile strength of butt welds is not to be less than the minimum specified for the base metal or the minimum considered in design.

2.2.4.2 The yield strength of deposited weld metal is not to be less than the minimum specified for the base metal or the minimum considered in design. Its tensile strength is not to be less than the minimum specified for the base metal. Its elongation is not to be less than 80% of the minimum specified for the base metal. When welds are made between steels of different grades, the tensile strength to be obtained on the welded assembly is to be in accordance with the requirements relating to the steel grade having lower strength..

2.2.4.3 After bending, the test specimens are not to reveal any defect in any direction exceeding 3mm in length on the outer surface.

2.2.4.4 The temperature for Charpy V-notch impact tests is to comply with Table 2.2.4.4-1, and the test results are to comply with Table 2.2.4.4-2.

Temperature for Impact Test

Table 2.2.4.4-1

Grade of steel	A, A32 A36, A40	B, D, D32, D36, D40	E, E32, E36, E40, D42, D46, D50, D55, D62, D69	F, F32, F36, F40, E42, E46, E50, E55, E62, E69	F42, F46, F50 F55, F62, F69
Test temperature (°C)	20	0	-20	-40	-60

Ductility for Impact Test^{Note 1}

Table 2.2.4.4-2

Grade of steel	A, B ^{Note 2} , D, E, F	A32, D32, E32, F32	A36, D36, E36, F36	A40, D40, E40, F40	D42, E42, F42	D46, E46, F46	D50, E50, F50	D55, E55, F55	D62, E62, F62	D69, E69, F69
Average energy (J)	47 ^{注3}			47 ^{注4}	47	47	50	55	62	69

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

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

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

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

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

2.2.4.5 The macro examination is to reveal full penetration and the absence of crack. If there is slag inclusion or pores in the welds, the quantity, size, position and density of such defects are to be reported to CCS for approval.

2.2.4.6 The results from the hardness test result usually are not to be greater than HV350. Otherwise, the results are to be submitted to CCS for approval.

Section 3 WELDING PROCEDURE APPROVAL TESTS OF FILLET WELDS

2.3.1 General requirements

2.3.1.1 This Section applies to welding procedure approval tests for plate-to-plate, pipe-to-pipe and pipe-to-plate fillet welds.

2.3.1.2 The welding procedure approval tests for fillet welds are to be carried out for different welding processes and welding positions respectively.

2.3.2 Test assemblies

2.3.2.1 The steels and welding materials selected for test assemblies are to be of the same grade as the steels and welding consumables used in actual construction.

2.3.2.2 The width of wing plate of the flat plate assemblies is to be 150mm, and the height of web is to be 75mm. For manual welding, the length of test assemblies is not to be less than 300mm; and not to be less than 500mm for semi-automatic welding and automatic welding, , and its thickness is to be within 15mm~20mm.

For pipe-to-plate assemblies, the length of sides of the plate is to be at least 50mm greater than outside diameter of the test pipe.

For pipe-to-plate assemblies, the length of the test pipe is to be more than 150mm.

2.3.2.3 The edge preparation, tacking welding of test plates are to comply with the requirements of the preliminary welding procedure specification.

2.3.2.4 The size of the welds of assemblies is to be determined according to the welding procedure and following requirements:

- .1 For single-run welding: the maximum size selected for the structure is to be taken as the size of the single-run re-melt deposit welding of test welds;
- .2 For multi-run welding: the minimum size selected for the structure is to be taken as the size of each weld bead to complete the weld tests of multi-run welding.

2.3.3 Test items

2.3.3.1 After welding, test assemblies are to be examined by visual testing. The weld surface is to be formed uniformly and free from defects such as crack, obvious overlap and undercut.

2.3.3.2 For fillet welds in plates, the specimens are to be taken as shown in Figure 2.3.3.2. Both ends of the test assembly are to be discarded for a length about 30 mm, then one section about 25 mm in length are to be taken at the mid-length of test assembly for the macro examination and hardness test of welds. Fracture tests are to be carried out on the longer part of the remainder of the test assembly.

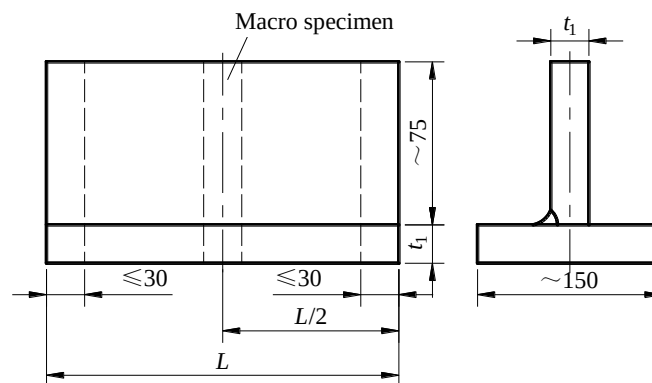
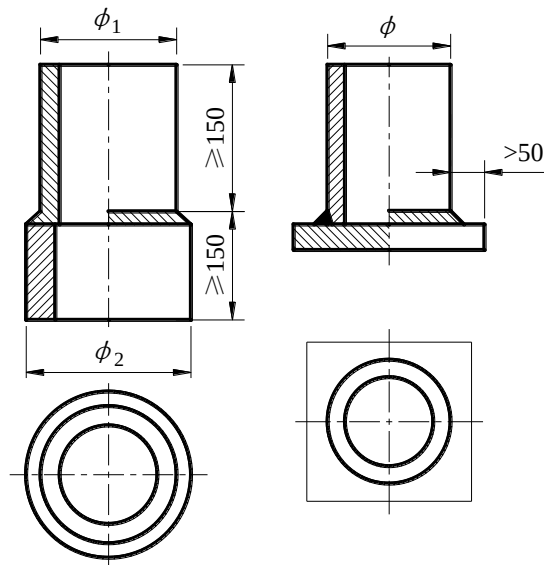


Figure 2.3.3.2 Pipe-to-pipe Fillet Weld Assemblies

2.3.3.3 Unless otherwise specified, the pipe-to-pipe and pipe-to-plate fillet weld assemblies are to be cut into four equal parts as shown in Figure 2.3.3.3 (1) or (2). Each weld is to be subjected to macro examination.



(1) Pipe to pipe fillet weld assembly (2) Pipe to plate fillet weld assembly

Figure 2.3.3.3 Pipe to Pipe Fillet Weld Assembly and Pipe to Plate Fillet Weld Assembly

2.3.4 Test results

2.3.4.1 The macro examination is to reveal a regular weld profile and full fusion. Meanwhile, the weld penetration on the web is to be measured on this specimen and recorded in the report.

2.3.4.2 The fractured surfaces of fracture test are to show welds without cracks and lack of fusion. For the slag inclusions or pores in the welds, if any, their quantity, sizes, positions and density are to be recorded in the report and this report is to be submitted to CCS for approval.

2.3.4.3 The results from the hardness test usually is not to be greater than HV350. Otherwise, the results are to be submitted to CCS for approval.

CHAPTER 3 WELDING CONSUMABLES

Section 1 GENERAL PROVISIONS

3.1.1 Application

3.1.1.1 This Chapter applies to welding consumables such as electrodes, wires and fluxes intended for use in the welding of metallic structures as specified in the Rules.

3.1.1.2 For welding consumables other than those specified in this Chapter, details of the technical specification are to be submitted to CCS and such welding consumables can only be used upon approval by CCS.

3.1.2 Approval tests

3.1.2.1 All types of welding consumables are to be subjected to approval tests in accordance with the requirements detailed in this Chapter. CCS may require, in any particular case, additional tests as may be necessary.

3.1.2.2 Unless otherwise specified in this Chapter, the specimens, test requirements and re-test conditions for the approval tests are to comply with the relevant requirements of Section 2 of Chapter 1 of this PART.

3.1.2.3 During approval tests, the preparation and testing of the test specimens are to be carried out in the presence of the Surveyor. It is recommended that the welded test assembly be examined by non-destructive testing to ascertain that no defect exists in the welds that will affect the accuracy of test results. Welded test assemblies and test specimens are not to be subjected to any heat treatment after welding, except longitudinal deposited metal tensile test specimens.

3.1.2.4 For all grades of welding consumables, the grade of steels used for the preparation of test assemblies may be selected from those listed in Table 3.1.2.4, and a toughness grade lower than that required in the Table may also be selected. For testing the deposited weld metal, any steel grade may be selected for welding consumables. Where general structural steels are used for deposited metal test of low-alloy steel containing nickel, it is recommended that one or two layers be built up using the welding consumables to be tested before the test assembly is fitted.

3.1.2.5 The plate edges of structural steels may be processed by machining or automatic cutting. If automatic gas cutting is applied, any remaining scale is to be removed from the beveled edges.

3.1.2.6 The welding current, arc voltage and travel speed, etc. are to be in accordance with the manufacturer's recommendations. Where a type of welding consumables is stated to be suitable for both alternating current (AC) and direct current (DC), AC is to be used for the preparation of the test assemblies.

Grade of Steels for Approval Test

Table 3.1.2.4

Grade of welding consumables	Grade of steel for test	Grade of welding consumables	Grade of steel for test
1	A	5Y50	F50
2	B、D	3Y55	D55
3	E	4Y55	E55
4	F	5Y55	F55
1Y	A32, A36	3Y62	D62
2Y	D32, D36	4Y62	E62
3Y	E32, E36	5Y62	F62
4Y	F32, F36	3Y69	D69
2Y40	D40	4Y69	E69
3Y40	E40	5Y69	F69
4Y40	F40	0.5Ni	0.5Ni
3Y42	D42	1.5Ni	1.5Ni
4Y42	E42	3.5Ni	3.5Ni
5Y42	F42	5Ni	5Ni
3Y46	D46	9Ni	9Ni
4Y46	E46	AS1—A	00Cr18Ni10
5Y46	F46	AS1—B	00Cr17Ni14Mo3
3Y50	D50	AS2—A	0Cr18Ni9Ti
4Y50	E50	AS2—B	1Cr18Ni11Nb

Section 2 MECHANICAL PROPERTIES OF WELDING CONSUMABLES

3.2.1 General requirements

3.2.1.1 In addition to the requirements of this Section, welding consumables are, depending on their usage, to be subjected to approval tests and annual tests in accordance with the relevant requirements of this Chapter.

3.2.2 Consumables for welding hull structural steels

3.2.2.1 Consumables for welding structural steels are graded into nine levels of yield stress, and each of which is further subdivided into several levels in respect of notch toughness. Designations of different grades are shown in Table 3.1.2.4. The notch toughness is indicated by the numerals 1 to 5, and the letter Y stands for high-strength welding consumables. Where the yield stress of welding consumables is greater than 400 N/mm^2 , Y is to be followed by a numeral from 40 to 69. Consumables for low-alloy steel containing nickel are divided into five levels of 0.5Ni, 1.5Ni, 3.5Ni, 5Ni and 9Ni in respect of the content of nickel in the base metal.

3.2.2.2 For each grade of consumables for welding structural steels, the consumables which have satisfied the requirements for a higher toughness grade are considered as complying with the requirements for a lower toughness grade.

3.2.2.3 The mechanical properties of consumables for welding structural steels are to comply with the requirements given in Table 3.2.2.3.

Mechanical Properties of Consumables for Welding Structural Steels

Table 3.2.2.3

Grade of welding consumables		1, 2, 3, 4	1Y, 2Y, 3Y, 4Y Note 1	2Y40, 3Y40, 4Y40 5Y40	3Y42 4Y42 5Y42	3Y46 4Y46 5Y46	3Y50 4Y50 5Y50	3Y55 4Y55 5Y55	3Y62 4Y62 5Y62	3Y69 4Y69 5Y69	0.5Ni	1.5Ni	3.5Ni	5Ni	9Ni
Deposited metal test	Yield strength Note 7 R_{eH} (N/mm ²)	≥305	≥375	≥400	≥420	≥460	≥500	≥550	≥620	≥690	≥375				

	Tensile strength Note 8 R_m (N/mm ²)		400~ 560	490~ 660	510~690	530~ 680	570~ 720	610~ 770	670~ 830	720~ 890	790~ 940	≥460		≥420	≥500	≥600	
	Elongation A_5 (%)		≥22			≥20		≥18				≥22		≥25			
	Charpy V-notch impact test	Test temperature (°C)	Note 2										—60	—80	—100	—120	—198
		Average impact energy Note 6 (J)	≥47 ^{Note 3}			≥47		≥50	≥55	≥62	≥69	≥34					
Butt weld test	Transverse tensile strength R_m , MPa		≥400	≥490	≥510	≥530	≥570	≥610	≥670	≥720	≥770	≥490		≥450	≥540	≥640	
	Charpy V-notch impact test	Test temperature (°C)	Note 2										—60	—80	—100	—120	—198
		Average impact energy Note 6 (J)	≥47 ^{Note 4}			≥47		≥50	≥55	≥62	≥69	≥34					
	Bending test		After testing, the test specimens are not to reveal any crack or other defects i greater than 3 mm. ^{Note 5}														

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

Note 2: a. The temperature of impact test for welding consumables of Grade1Y is to be 20°C;

b. The temperature of impact test for welding consumables of Grade2Y is to be 0°C;

c. The temperature of impact test for welding consumables of Grade3Y, 3Y40, 3Y42, 3Y46, 3Y50, 3Y55, 3Y62, 3Y69 is to be -20°C;

d. The temperature of impact test for welding consumables of Grade4Y, 4Y40, 4Y42, 4Y46, 4Y50, 4Y55, 4Y62, 4Y69 is to be -40°C;

e. The temperature of impact test for welding consumables of Grade5Y40, 5Y42, 5Y46, 5Y50, 5Y55, 5Y62, 5Y69 is to be -60°C.

Note 3: The average impact energy of deposited metal test of submerged arc automatic welding is not to be less than 34J for the welding consumables with $R_{eH} < 400 \text{ N/mm}^2$, and not to be less than 41J for those with $R_{eH} \geq 400 \text{ N/mm}^2$.

Note 4: The average impact energy of butt joints of vertical welding and submerged arc automatic welding is not to be less than 34J for the welding consumables with $R_{eH} < 400 \text{ N/mm}^2$, and not to be less than 41J for those with $R_{eH} \geq 400 \text{ N/mm}^2$.

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

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

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

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

3.2.2.4 Where the bend test results of welding consumables with the yield stress of 420 N/mm² or above do not comply with Table 3.2.2.3, except that the elongation within the gauge length L_0 of bend specimens complies with that required for the deposited metal test, the test may be considered satisfactory. The gauge length L_0 of the bend specimen is shown in Figure 3.2.2.4.

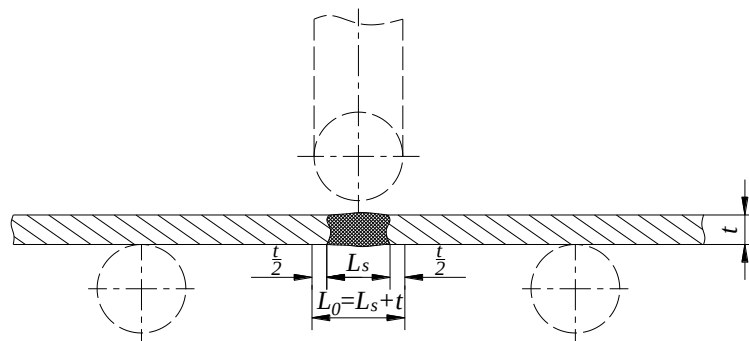


Figure 3.2.2.4 Gauge Length L_0 of Bend Specimen

Section 3 ELECTRODES FOR MANUAL ARC WELDING

3.3.1 General requirements

3.3.1.1 For electrodes which have satisfied the requirements for mechanical properties as given in Section 2 of this Chapter and passed the hydrogen test according to 3.3.6.6 of this Section, the suffix “H15”, “H10” or “H5” will be added after the grade mark to indicate compliance with the requirements for low hydrogen electrodes. The diffusible hydrogen content for electrodes of different grades is at least to comply with Table 3.3.1.1.

Required Hydrogen Content for Welding Consumables

Table 3.3.1.1

Grade of welding consumables	Diffusible hydrogen content
1, 2, 3	No mandatory
1Y, 2Y, 3Y	No mandatory
4, 4Y	H15
2Y40, 3Y40	H15
4Y40, 5Y40	H15
3Y42, 4Y42, 5Y42	H10
3Y46, 4Y46, 5Y46	H10
3Y50, 4Y50, 5Y50	H10
3Y55, 4Y55, 5Y55	H5
3Y62, 4Y62, 5Y62	H5
3Y69, 4Y69, 5Y69	H5

3.3.1.2 Where electrodes for welding structural steels have deep penetration properties, the suffix “DP” will be added after the appropriate grade mark for normal penetration welding. Only grade 1 electrodes can be approved as deep penetration electrodes.

3.3.1.3 Where an electrode is to be used in contact welding using automatic gravity or similar welding devices, tests similar to those for normal manual electrodes are to be carried out using the devices and processes for which the electrode is recommended by the manufacturer.

3.3.2 Test items

3.3.2.1 All electrodes are to be subjected to the deposited metal test.

3.3.2.2 Butt weld test assemblies are to be prepared for the welding positions for which the electrode is recommended by the manufacturer, e.g. down hand, horizontal, vertical (vertical-upward or vertical-downward) and overhead positions.

Electrodes satisfying the requirements for both down hand and vertical-upward positions will be considered as also complying with the requirements for the horizontal position. Where the electrode is recommended for welding in all positions, the test assemblies are to be prepared for the down hand, vertical and overhead positions.

3.3.2.3 In addition to the requirements of 2.3.2.1 and 2.3.2.2, for normal electrodes having fillet welding properties, one fillet weld test in the horizontal position is to be made.

Where an electrode is solely used for fillet welding, in addition to the deposited metal test, fillet weld tests are to be made in the welding positions as recommended by the manufacturer, such as down hand, vertical and overhead positions.

3.3.2.4 Electrodes requiring the control of diffusible hydrogen (e.g. low hydrogen or ultra-low hydrogen electrodes) are, in addition to compliance with the requirements of mechanical properties for the appropriate grade, to be subjected to a hydrogen test.

3.3.2.5 Where grade 1 electrodes are submitted for approval for deep penetration welding, in addition to compliance with the requirements for grade 1 electrodes, tests for deep penetration welding of down hand butt joints and horizontal-vertical fillets are to be carried out.

Where an electrode is submitted only for the deep penetration welding of down hand butt joints and horizontal-vertical fillets, in addition to the deposited metal test as required by 3.3.3, deep penetration welding tests are to be carried out in accordance with the requirements of 3.3.7 and 3.3.8 of this Section.

3.3.3 Deposited metal test

3.3.3.1 In general, two deposited metal test assemblies are to be prepared, one with 4 mm diameter electrodes

and the other with the largest size manufactured. If an electrode is available in one diameter only, one test assembly is sufficient.

3.3.3.2 Two test plates and one backing plate are to be prepared with each specimen. The dimension is to comply with the requirements of Table 3.3.3.2.

Dimension of test plate and backing plate

Table 3.3.3.2

Item	Thickness (mm)	Width (mm)	Length (mm)	Oblique angle
Test plate	20	100	300	10°
Backing plate	10	30	300	

3.3.3.3 The test assembly is to be fitted up as shown in Figure 3.3.3.4. The weld metal is to be deposited in down hand single-run or multi-run layers according to normal practice, and the direction of deposition of each layer is to alternate from each end of the plate, each run of weld metal being not less than 2 mm and not more than 4 mm thick. After completion of each run, the flux and welding slag are to be removed, and the assembly is to be left in still air until it has cooled to less than 250°C, but not below 100°C (the temperature being taken in the centre of the weld on the surface of the weld), then the next run is to start.

3.3.3.4 One longitudinal tensile test specimen and a set of three V-notch impact test specimens are to be taken from each test assembly as shown in Figure 3.3.3.4. The results of tensile and impact tests are to comply with the relevant requirements of Section 2 of this Chapter.

The axis of the tensile test specimen is to coincide with the centre of the weld and the mid-thickness of the plates as far as possible. The axes of the impact test specimens are to coincide with the mid-thickness of the plates, perpendicular to the centre of the weld. The V-notch is to be positioned in the centre of the weld and perpendicular to the surface of the plate.

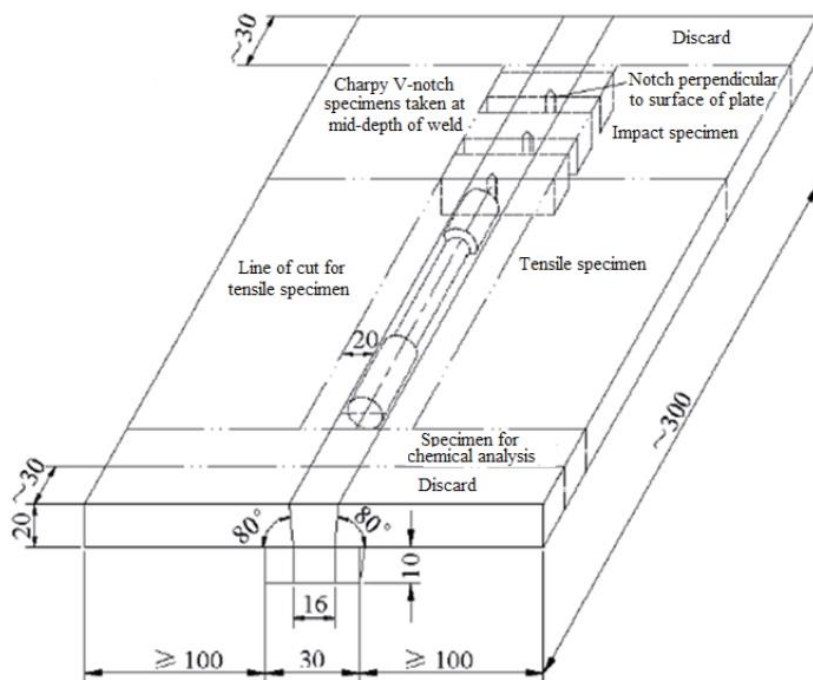


Figure 3.3.3.4 Sample Preparation Diagram

3.3.3.5 In addition to the requirements of 3.3.3.4, the chemical composition of the deposited metal is to be analyzed for each test assembly. The analysis report is to be submitted to CCS and the content of all significant alloying elements is to be included in the report.

3.3.4 Butt weld tests

3.3.4.1 One butt weld test assembly is to be prepared for each welding position, and the electrodes employed for different positions are to be as follows:

- .1 Down hand: the first run with 4 mm diameter electrode, middle runs with 5 mm diameter electrodes. The runs of the last two layers with the largest diameter of electrode manufactured for the same type

for which approval is requested;

.2 Horizontal-vertical: the first run with 4 mm or 5 mm diameter electrode, remaining runs with 5 mm diameter electrodes.

.3 Vertical-upward and overhead: the first run with 3.2 mm diameter electrode, remaining runs with 4 mm diameter electrodes or possibly with 5 mm if this is recommended by the manufacturer for the positions concerned;

.4 Vertical-downward: using electrode diameters as recommended by the manufacturer.

Where only one or two sizes are available for the same type of electrode, then in the welding positions mentioned above, the first run is to be applied with the small diameter electrode and the remaining runs with the larger.

3.3.4.2 Where the electrode is to be approved only for the down hand position, in addition to the test assembly as required by 2.3.4.1(1) of this Section, another test assembly is to be prepared in that position. The first run is to be made with 4 mm diameter electrode, next run with 5 mm or 6 mm diameter electrode, and remaining runs with the largest diameter of electrode manufactured for the same type for which approval is requested.

3.3.4.3 Each butt weld test assembly is to be made by welding together two plates of equal thickness (15mm to 20 mm), not less than 100 mm in width and of sufficient length to allow the cutting out of test specimens of the prescribed number and size. The plate edges are to be beveled to an angle of 30°.

3.3.4.4 The test plates are to be fitted and welded together as shown in Figure 3.3.4.4. The inter pass temperature is to be neither more than 250°C nor less than 100°C (the temperature being taken in the center of the weld on the surface of the seam). For all butt weld test assemblies, the back sealing runs are to be made with 4 mm diameter electrodes in the welding position appropriate to each test sample, after cutting out the root run to clean metal.

In order to keep the test assembly smooth and straight after welding, preset backward deformation may be applied prior to welding.

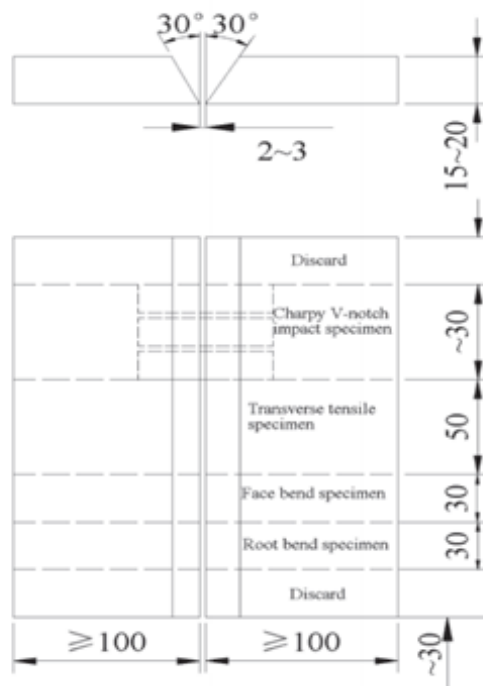


Figure 3.3.4.4 Specimen Preparation Diagram

3.3.4.5 One transverse tensile specimen, two bend specimens and a set of three impact test specimens (the specimens for overhead position can be exempted from impact test) are to be prepared from each test assembly as shown in Figure 3.3.4.4 for tensile, face and root bend and impact tests respectively. The results of all tests are to comply with the relevant requirements of Section 2 of this Chapter.

3.3.5 Fillet welding test

3.3.5.1 One fillet weld test assembly is to be prepared for each welding position. The first side is to be welded using the maximum diameter and the second side the minimum diameter of electrode manufactured. The fillet size will in general be determined by the electrode size and the welding current employed during testing.

3.3.5.2 Each fillet weld test assembly is to be made by welding together two plates of 20 mm in thickness, 150 mm in width and of a length sufficient to allow at least the deposition of the entire length of the largest diameter electrode being tested.

3.3.5.3 As shown in Figure 3.3.5.3(1), three macro-sections, each about 25 mm thick, are to be taken from the test assembly and examined for root penetration, satisfactory profile, freedom from cracking and reasonable freedom from porosity, and slag inclusions. The central macro-section is to be polished for hardness tests as shown in Figure 3.3.5.3(2), for the purpose of determining the hardness of the welded joint. One of the two remaining sections is to have the weld on the first side gouged or machined. On the other remaining section, the weld on the second side is to be gouged or machined. The two sections are then to be subjected to fracture tests in accordance with the requirements given in 1.2.4.4 of this PART. The fractured surfaces are to show satisfactory penetration, freedom from cracks and porosity.

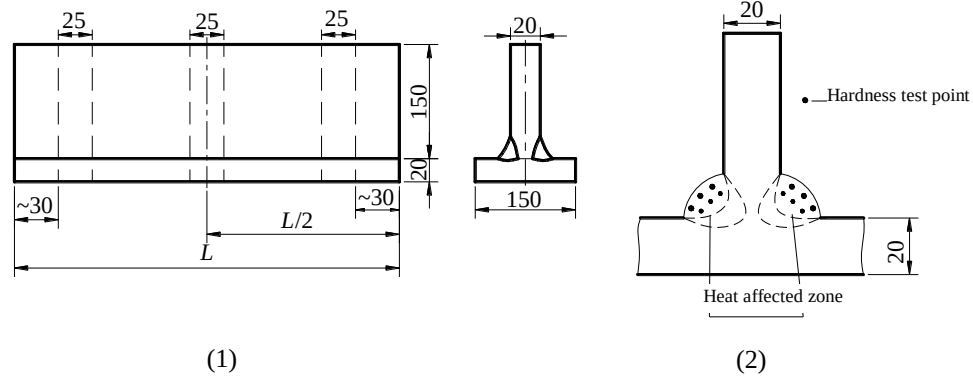


Figure 3.3.5.3 Specimen Preparation Diagram

3.3.6 Hydrogen test

3.3.6.1 Four plates of any grade of hull structural steel are to be prepared as hydrogen test specimens. The specimens are to be 12 mm in thickness, 25 mm in width and 125 mm in length.

3.3.6.2 Before welding, the specimens are to be cleaned and weighed to the nearest 0.1 g.

3.3.6.3 Prior to welding, the electrodes are to be baked according to the drying process recommended by the manufacturer, so as to fully dry the electrodes. On the 25 mm surface of each test specimen, a single bead of welding about 100 mm in length is to be deposited with a 4 mm electrode, using about 150 mm of the electrode. The welding is to be carried out with as short an arc as possible and with a current of about 150A.

3.3.6.4 Within 30 s of the completion of the welding of each specimen, the slag is to be removed and the specimen quenched in water having a temperature of approximately 20°C. After a further 30 s, the specimens are to be cleaned and placed in an apparatus suitable for the collection of hydrogen by displacement of glycerin. All four specimens are to be welded and placed in the hydrogen collecting apparatus within 30 min by a single operator.

3.3.6.5 The specimens are to be kept immersed in the glycerin having a temperature of 45°C for a period of 48h and, after removal, are to be cleaned in water and spirit, dried and weighed to the nearest 0.1 g to determine the amount of weld deposited. The amount of gas evolved is to be measured to the nearest 0.05 cm³ and corrected for temperature and pressure to 0°C and 101.325 kPa. The determination method of hydrogen content can be replaced by the mercury determination method specified in ISO-3690.

3.3.6.6 The average value of diffusible hydrogen per 100g deposited metal of four specimens is to comply with the requirements of Table 3.3.6.6:

Average value of diffusible hydrogen (cm³)

Table 3.3.6.6

Mark	Mercury method	Glycerin method
H15	15	10
H10	10	5
H5	5	

3.3.7 Deep penetration butt weld tests

3.3.7.1 Two test plates are to be prepared for each deep penetration butt weld test assembly.

- .1 The test plates are to have a thickness equal to twice the diameter of the core of the electrode plus 2 mm, a width of not less than 100 mm and a length appropriate to the size and number of specimens.
- .2 The joint edges are to be prepared square and smooth without being beveled;
- .3 The test plates are to fit well and, after tacking, the gap is not to exceed 0.25 mm. The test plates are to be butt welded together with one down hand run of welding from each side, using the largest diameter electrode manufactured, and the welding current and the procedure employed are to be as

recommended by the manufacturer for the electrodes. Between runs, root gouging is not needed.

3.3.7.2 Two transverse tensile specimens, two bend specimens and a set of three impact test specimens (with the notch positioned at the centre of the weld) are to be prepared from each test assembly as shown in Figure 3.3.7.2 for tensile, bend and impact tests respectively. The results of all tests are to comply with the relevant requirements of Section 2 of this Chapter.

3.3.7.3 During the preparation of test specimens, the weld is to be examined for root penetration. The discards at the end of the welded assemblies, which are to be about 30 mm wide, are to be prepared as macro-section test specimens in accordance with the requirements of 1.2.3.6 of this PART. The cross sections of these specimens are to show complete fusion and interpenetration of the weld beads.

3.3.8 Deep penetration fillet weld tests

3.3.8.1 Two test plates are to be prepared for each deep penetration fillet weld test assembly.

.1 The test plates are to have a thickness of about 12.5 mm, a width of about 100 mm and a length of about 180 mm. The joint edge of the abutting plate is to be prepared square.

.2 The test plates are to be joined to form a T-connection with a gap between the plates of not more than 0.25 mm, as shown in Figure 3.3.8.1.2. The welding on one side is to be carried out with a 4 mm diameter electrode, and that on the other side with the maximum diameter electrode manufactured. The welding current used is to be within the range recommended by the manufacturer. The length of the fillet on each side is not to be less than 160 mm.

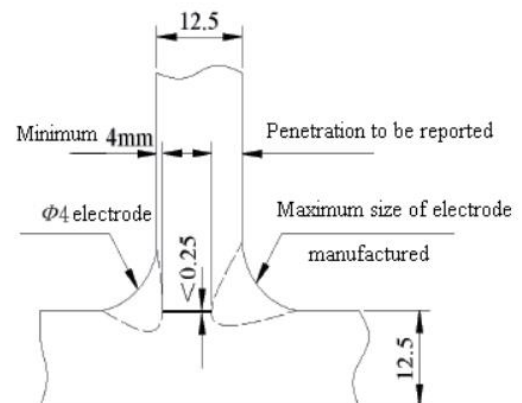
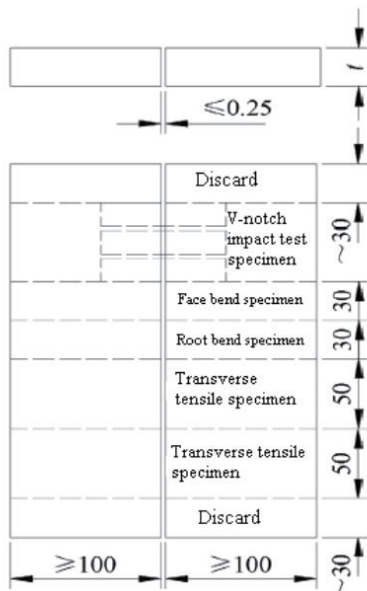


Figure 3.3.7.2 Specimen Preparation Diagram

Figure 3.3.8.1.2 Deep Penetration Fillet Weld Specimen

3.3.8.2 Macro specimens are to be taken from the welded assembly by cutting within 35 mm of the ends of the fillet welds and examined for root penetration. The welding of the fillet made with a 4 mm diameter electrode is to show a penetration of not less than 4 mm and the corresponding penetration of the fillet made with the maximum diameter electrode manufactured is to be reported.

3.3.9 Annual inspections

3.3.9.1 For normal penetration electrodes, two deposited metal test assemblies are to be prepared and tested in accordance with 3.3.3 of this Section. If electrodes are available in one diameter only one test assembly is sufficient.

3.3.9.2 Where an electrode is approved solely for deep penetration welding, one butt welded test assembly is to be prepared and tested in accordance with 3.3.7 of this Section.

3.3.9.3 Where an electrode is approved for both normal and deep penetration welding, the test assemblies are to be prepared and tested as detailed in .1 and .2 above.

3.3.9.4 Where an electrode is approved for gravity welding, one deposited metal test assembly is to be prepared and tested using the device as recommended by the manufacturer.

Section 4 WIRE-FLUX CONSUMABLES FOR SUBMERGED ARC AUTOMATIC WELDING

3.4.1 General requirements

3.4.1.1 For wire-flux combinations used with the two-run technique, the suffix “T” is to be added after the grade mark.

3.4.1.2 For wire-flux combinations used with the multi-run technique, the suffix “M” is to be added after the grade mark.

3.4.1.3 For wire-flux combinations used with both two-run and multi-run techniques, the suffix “TM” is to be added after the grade mark.

3.4.2 Test items

3.4.2.1 Where wire-flux combinations are intended for use with the multi-run technique, deposited metal butt weld tests are to be carried out.

3.4.2.2 Where wire-flux combinations are intended for use with the two-run technique, butt weld tests for the two-run technique are to be carried out.

3.4.2.3 Where particular wire-flux combinations are intended for use with both techniques, tests are to be carried out for each technique.

3.4.2.4 Where wire-flux combinations are intended for use with multiple electrode submerged-arc welding, separate approval tests are to be carried out, normally in accordance with the requirements of this Section.

3.4.2.5 Where welding consumables are intended to be used for high strength steel used for welding structures with a yield strength of 420 N/mm² and above, a hydrogen test is to be carried out in accordance with the method approved by CCS, and the test results are to comply with the requirements of Table 3.3.1.1.

3.4.3 Deposited metal tests for multi-run technique

3.4.3.1 Two test plates and one backing plate are to be prepared for a deposited metal test assembly for the multi-run technique. The test plates are to be 20 mm in thickness, about 200 mm in width and of sufficient length to allow the cutting out of test specimens of the prescribed number and size. The plate edges are to be beveled to an angle of 10°. The backing plate is to be 12 mm in thickness, 50 mm in width and of a length equal to that of the test plates.

3.4.3.2 The test assembly is to be as shown in Figure 3.4.3.3 and welded in the down hand position using the maximum diameter of wire for which approval is requested. The direction of deposition of each run is to alternate from each end of the plate. After completion of each run, the flux and welding slag are to be removed, and the assembly is to be left in still air until it has cooled to less than 250°C, but need not be below 100°C (the temperature being taken in the centre of the weld on the surface of the seam), and then the next run is to start. The thickness of the layer is to be not less than the diameter of the wire not less than 4 mm.

3.4.3.3 Two longitudinal tensile specimens and a set of three impact test specimens are to be taken from each test assembly as shown in Figure 3.4.3.3 for tensile and impact tests respectively. The test results are to comply with the relevant requirements of Section 2 of this Chapter. Particulars for cutting the specimens are to be the same as specified in 3.3.3.4 of this Chapter. The chemical composition of the deposited weld metal in each test assembly, including the content of all significant alloying elements, is to be submitted to CCS for examination.

3.4.4 Butt weld tests for multi-run technique

3.4.4.1 Two test plates are to be prepared for a butt weld test assembly for the multi-run technique. The test plates are to be 20 to 25 mm in thickness, not less than 150 mm in width and not less than 400 mm in length. The plate edges are to be beveled to an angle of 30°, with the root face being 4 mm.

3.4.4.2 The test plates are to be butt welded by the multi-run technique in the down hand position. The welding conditions are to be the same as those described in 3.4.2.2 of this Section. On completion of welding the first side, the back sealing run is to be applied in the down hand position after cutting out the root run to clean metal.

3.4.4.3 As shown in Figure 3.4.4.3, two transverse tensile specimens, four bend specimens and a set of three impact test specimens (with the notch positioned at the centre of the weld) are to be taken from the test assembly (the axis of specimen being at the middle of plate thickness) for tensile, face and root bend, and impact tests respectively. The results of all tests are to comply with the relevant requirements of Section 2 of this Chapter.

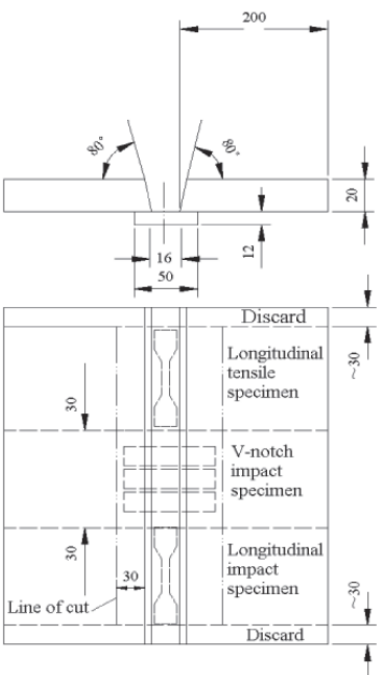


Figure 3.4.3.3 Specimen Preparation Diagram

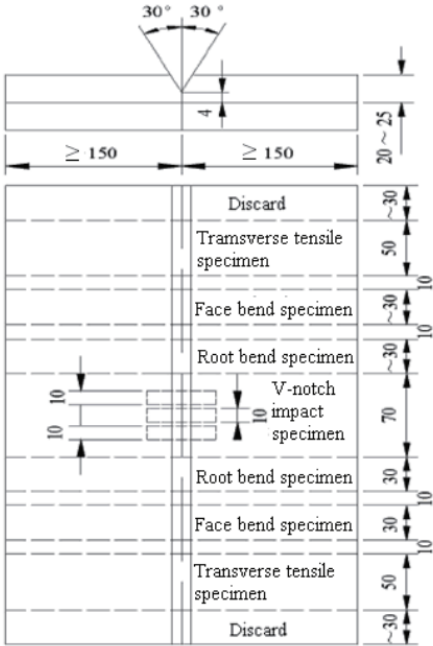


Figure 3.4.4.3 Specimen Preparation Diagram

3.4.5 Butt weld tests fortwo-run technique

3.4.5.1 Two butt weld test assemblies for the two-run technique are to be made respectively from a pair of plates of different thicknesses and having an appropriate strength level according to the grades of wire-flux combinations for which approval is required. The thickness of one pair of test plates is to be applicable maximum thickness, and that of the other pair 2/3 of the thickness of the former pair. Each test plate is not to be less than 150 mm in width and of sufficient length to allow the cutting out of test specimens of the prescribed number and size.

3.4.5.2 The maximum diameter of wire and the edge preparation that may be used to prepare test assemblies of different thicknesses are to comply with Table 3.4.5.2. Small deviations in the edge preparation may be allowed.

Thickness and Edge Preparation of Butt Weld Test Plates for Two-Run Technique Table 3.4.5.2

Plate thickness (mm)	12～15	20～25	30～35
Maximum diameter of wire (mm)	5	6	7
Forms and dimensions of edge preparation (mm)			

3.4.5.3 Each butt weld is to be welded in two runs, one from each side. After completion of the first run, the flux and welding slag are to be removed and the assembly is to be left in still air until it has cooled to less than 100℃, the temperature being taken in the centre of the weld on the surface of the seam and then the second run is applied.

3.4.5.4 As shown in Figure 3.4.5.4-1, two transverse tensile specimens, two bend specimens and a set of three impact test specimens are to be cut from each assembly, and one longitudinal tensile specimen cut from the thicker assembly. The impact test specimens are to be cut in positions as shown in Figure 3.4.5.4-2. The above test specimens are to be subjected to tensile, bend and impact tests respectively. The results of all tests are to comply with the relevant requirements of Section 2 of this Chapter. The edges of the discards are to be polished and etched for macro-section examination.

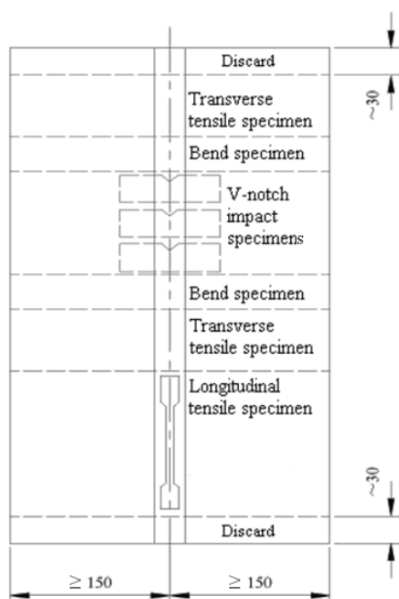


Figure 3.4.5.4-1 Specimen Preparation Diagram

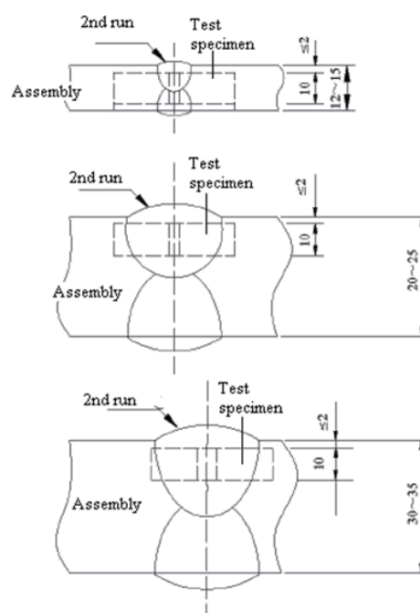


Figure 3.4.5.4-2 Impact Specimen Preparation Diagram

3.4.5.5 Where the combination is to be approved for the two-run technique only, in addition to the specimens required by 3.4.5.4, the chemical composition analysis and tensile test of the deposited metal is to be carried out for the thicker assembly. The axis of the longitudinal tensile specimen is to coincide with the center line of the weld, and to be positioned about 7mm below the surface of the weld on the second side. The chemical analysis report is to include the content of all significant alloying elements.

3.4.6 Annual inspections

3.4.6.1 The annual test of the wire –flux combinations are to consist of the following:

- .1 for fluxes for use with the multi-run technique, one deposited metal test assembly is to be prepared;
- .2 for wire-flux combinations for use with the two-run technique, one butt weld test assembly is to be prepared, using plate material at least 20 mm in thickness.

3.4.6.2 The deposited metal test assemblies are to be prepared and tested in accordance with the requirements of 3.4.3 of this Section, except that only one longitudinal tensile specimen and a set of three V-notch impact test specimens are required.

3.4.6.3 One butt weld test assembly with a thickness of not less than 20 mm is to be prepared in accordance with 3.4.5 of this Section, from which only one transverse tensile specimen, two bend specimens and a set of three V-notch impact test specimens are to be cut. One longitudinal tensile test specimen is additionally to be taken where the wire-flux combination is approved solely for the two-run technique.

3.4.6.4 Where a wire-flux combination is used for welding both normal strength and higher strength steels, the latter steel is to be used for the preparation of the butt weld assembly required by 3.4.6.1.2 of this Section.

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

3.5.1 General requirements

3.5.1.1 Wires and wire-gas combinations may be divided into the following categories according to the process used:

- .1 for wires and wire-gas combinations used in semi-automatic multi-run welding, the suffix “S” is to be added after the grade mark;
- .2 for wires and wire-gas combinations used in single electrode automatic multi-run welding, the suffix “M” is to be added after the grade mark;
- .3 for wires and wire-gas combinations used in single electrode automatic multi-run welding, the suffix

“M” is to be added after the grade mark;

.4 for wires and wire-gas combinations used in both two-run and multi-run welding, the suffix “TM” is to be added after the grade mark;

.5 for wires and wire-gas combinations used in both semi-automatic and automatic welding, the suffix “SM” is to be added after the grade mark.

3.5.1.2 Solid-core or flux-cored wires are to be subjected to the deposited metal hydrogen test with the method approved by CCS, and the test results are to satisfy the requirements of Table 3.3.6.3 of this Chapter. An appropriate low hydrogen suffix will be added after the grade mark of welding consumables which have satisfied low hydrogen requirements. The low hydrogen requirements for different grades of welding consumables are given in Table 3.3.1.1 of this Chapter.

3.5.1.3 The composition of the shielding gas used in the approval test is to be reported, and the group and composition limits of shield gas are given in Table 3.5.1.3. When a wire is used in composition with grouped shielding gases, they are to be subjected to an approval test respectively.

Composition of Shielding Gases

Table 3.5.1.3

Group	Gas composition (vol. %)			
	Argon (Ar)	Carbon dioxide (CO ₂)	Oxygen (O ₂)	Hydrogen (H ₂)
M11	Residual ^{Note 1, 2}	0~5	—	0~5
M12	Residual ^{Note 1, 2}	0~5	—	—
M13	Residual ^{Note 1, 2}	—	0~3	—
M14	Residual ^{Note 1, 2}	0~5	0~3	—
M21	Residual ^{Note 1, 2}	5~25	—	—
M22	Residual ^{Note 1, 2}	—	3~10	—
M23	Residual ^{Note 1, 2}	5~25	0~8	—
M31	Residual ^{Note 1, 2}	25~50	—	—
M32	Residual ^{Note 1, 2}	—	10~15	—
M33	Residual ^{Note 1, 2}	5~50	8~15	—
C1	—	100	—	—
C2	—	Residual	0~30	—

Note 1: 95% of the content of argon gas can be substituted by helium gas.

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

3.5.1.4 Wires and wire-gas combinations for multiple electrode automatic welding are, in general, to be approval tested in accordance with the relevant requirements of this Section.

3.5.2 Tests for wires and wire-gas combinations

3.5.2.1 Deposited metal, butt weld and fillet weld tests are to be carried out for the wires and wire-gas combinations for use in semi-automatic multi-run welding.

3.5.2.2 Deposited metal and butt weld tests are to be carried out for the wires and wire-gas combinations for use in multi-run automatic welding.

3.5.2.3 Butt weld tests are to be carried out for the wires and wire-gas combinations for use in automatic two-run welding

3.5.3 Deposited metal tests for semi-automatic multi-run technique

3.5.3.1 The deposited metal tests for the semi-automatic multi-run technique are to be carried out in accordance with the requirements of 3.3.3 of this Chapter, except that two test assemblies are to be prepared in accordance with the requirements of 3.5.3.2 of this Section.

3.5.3.2 One deposited metal test assembly is to be prepared using wires of the smallest diameter manufactured, and the other using wires of the largest diameter manufactured. Where only one diameter is manufactured, only one deposited metal test assembly is to be prepared. During welding, the thickness of each layer of weld metal is to be between 2 mm and 6 mm.

3.5.4 Butt weld tests for semi-automatic multi-run technique

3.5.4.1 For approval of wires and wire-gas combinations for the semi-automatic multi-run technique, one butt weld test assembly is to be prepared for each welding position (down hand, horizontal, vertical and overhead) for which the wire is recommended by the manufacturer. The butt weld tests are to be carried out in accordance with

the requirements of 3.3.4 of this Chapter, except that the assemblies are to be welded according to the requirements of 3.5.4.2 of this Section.

3.5.4.2 The down hand assembly is to be welded using, for the first run, wires of the smallest diameter manufactured and, for the remaining runs, wires of the largest diameter manufactured. Where approval is requested only in the down hand position, an additional butt weld assembly is to be prepared in that position using wires of a different diameter from those required above.

The butt weld assemblies, in positions other than down hand, are to be welded using, for the first run, wires of the smallest diameter manufactured, and for the remaining runs, wires of the largest diameter recommended by the manufacturer for the position concerned.

3.5.5 Fillet weld tests for semi-automatic multi-run technique

3.5.5.1 Fillet weld tests for the semi-automatic multi-run technique are to be carried out in accordance with the requirements of 3.3.5 of this Chapter, except that both sides are to be welded using respectively wires of the smallest and the largest diameters manufactured.

3.5.6 Deposited metal and butt weld tests for automatic multi-run technique

3.5.6.1 Deposited metal tests for automatic multi-run welding are to be carried out in accordance with the requirements of 3.4.3 of this Chapter, except that the thickness of each layer is not to be less than 3 mm. Butt weld tests for automatic multi-run welding are to be carried out in accordance with the requirements of 3.4.4 of this Chapter.

3.5.7 Butt weld tests for automatic two-run technique

3.5.7.1 Butt weld tests for the automatic two-run technique are to be carried out in accordance with the requirements of 3.4.5 of this Chapter, except that two test assemblies are to be prepared in accordance with the requirements of 3.5.7.2 to 3.5.7.4 of this Section.

3.5.7.2 Two butt weld test assemblies are in general to be prepared, using plates 12 mm to 15 mm and 20 mm to 25 mm in thickness respectively. Each assembly consists of two plates. Where the welding consumables are suitable for welding plates thicker than 25 mm, one assembly is to be prepared using plates of 20 mm in thickness and the other using plates of the maximum thickness for which the consumables are suitable.

3.5.7.3 The edge preparation of the test assemblies is to be as shown in Figure 3.5.7.3. Small deviations in the edge preparation may be allowed, if requested by the manufacturer. Where plates over 25 mm in thickness are used, dimensions of the edge preparation are to be stated in the test report.

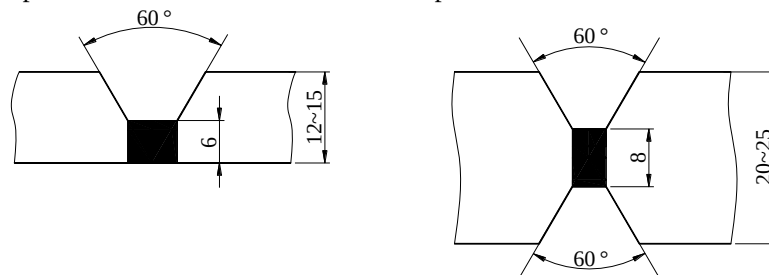


Figure 3.5.7.3 Edge Preparation of Specimen

3.5.7.4 Wire diameters recommended by the manufacturer may be used and are to be reported.

3.5.8 Annual inspections

3.5.8.1 For wires and wire-gas combinations approved for semi-automatic or for both semi-automatic and automatic multi-run welding, one deposited metal test assembly is to be prepared in accordance with the requirements of 3.5.3 of this Chapter for deposited metal tests using wires of a diameter within the range approved;

3.5.8.2 For wires and wire-gas combinations approved solely for automatic multi-run welding, one deposited metal test assembly is to be prepared in accordance with the requirements of 3.5.6 of this Section for deposited metal tests, except that only one longitudinal tensile test specimen is required;

3.5.8.3 For wires and wire-gas combinations approved for two-run automatic welding, one butt weld test assembly is to be prepared in accordance with the requirements of 3.5.7 of this Section for butt weld tests, using plates 20 mm to 25 mm in thickness, except that only one transverse tensile test specimen is required.

Section 6 CONSUMABLES FOR USE IN ELECTRO-SLAG OR ELECTRO-GAS VERTICAL WELDING

3.6.1 General requirements

3.6.1.1 Unless otherwise specified in this Section, the requirements for the two-run technique in Section 4 of this Chapter are also applicable to consumables used for electro-slag or electro-gas vertical welding with or without consumable nozzles.

3.6.1.2 For welding consumables of Grades 1Y, 2Y, 3Y, 4Y, 2Y40, 3Y40 and 4Y40 used for electro-slag or electro-gas vertical welding, the approval may be restricted for use only with specific types of higher strength steel. This is in respect of the content of grain refining elements and if general approval is required, a niobium treated steel is to be used for approval tests.

3.6.1.3 For technical reasons, the special high-ductility welding consumables as mentioned in this Section may not be entirely suitable to the welding of low-ductility steels. Where approval is requested for the welding of both normal strength and higher strength steels, two test assemblies are in general to be prepared using higher strength steel. Where deemed necessary by CCS, two additional assemblies prepared using normal strength steel may be required.

3.6.2 Butt weld tests

3.6.2.1 Two butt weld test assemblies are to be prepared, one with plates 20 mm to 25 mm in thickness and the other with plates 35 mm to 40 mm in thickness. Each plate is not to be less than 250 mm in width and of sufficient length to allow the cutting out of test specimens of the number and size as specified in 3.6.2.3 of this Section.

3.6.2.2 The welding conditions and the edge preparation for the test assemblies are to be those recommended by the manufacturer and reported.

3.6.2.3 Two longitudinal tensile, two transverse tensile, two bend, two macro specimens and two sets of three Charpy V-notch impact test specimens are to be cut from each assembly for tensile, bend and impact tests respectively, as shown in Figure 3.6.2.3(1). The results of all tests are to comply with the relevant requirements of Section 2 of this Chapter. The positions of the two sets of Charpy V-notch impact test specimens are to be as shown in Figure 3.6.2.3(2).

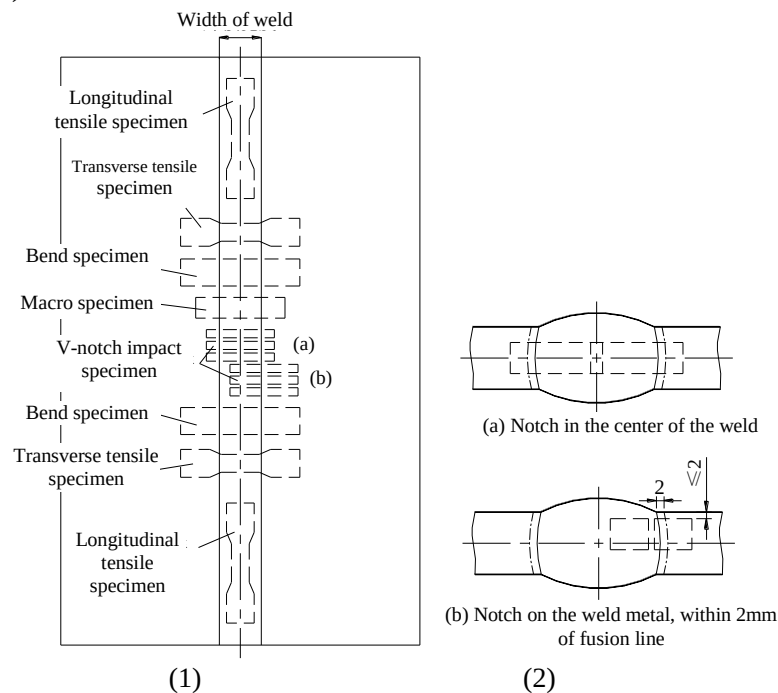


Figure 3.6.2.3 Specimen Preparation Diagram

3.6.3 Annual inspections

3.6.3.1 The annual tests are to consist of at least one butt weld test assembly prepared using plates of 20mm to 25 mm in thickness according to the requirements of 3.6.2 of this Section. And one longitudinal tensile, one transverse tensile, two bend specimens, two sets of impact test specimens (the notch of impact specimens

positioned in the centre the weld and at 2 mm from the fusion line of the weld respectively) and one macro specimen are to be taken from the assembly for tensile, bend, impact tests and macro examination respectively.

Section 7 CONSUMABLES FOR USE IN ONE-SIDE WELDING WITH TEMPORATR BACKING MATERIALS

3.7.1 General requirements

3.7.1.1 The tests for approval of wire-flux (or wire-gas) combinations for use in automatic one-side welding with temporary backing materials are generally to be carried out in accordance with the requirements of Sections 4 and 5 of this Chapter and this Section.

3.7.1.2 The requirements for approval of electrodes or wire-flux combinations for use in manual or semi-automatic one-side welding with temporary backing materials will be specially considered by CCS.

3.7.2 Butt weld tests

3.7.2.1 For the consumables for use in one-side welding with temporary backing materials, two butt weld test assemblies are to be prepared, one with plates 25 mm to 30 mm in thickness and the other with plates 35 mm to 40 mm in thickness. Each plate is not to be less than 150 mm in width and of sufficient length to allow the cutting out of test specimens of the prescribed number and size.

3.7.2.2 Two longitudinal tensile, two transverse tensile and two bend specimens, one macro specimen and the Charpy V-notch impact test specimens specified in 3.7.2.3 of this Section are to be cut from each assembly for tensile, bend and impact tests respectively. The results of all tests are to comply with the relevant requirements of Section 2 of this Chapter.

3.7.2.3 As shown in Figure 3.7.2.3, two sets of three impact test specimens are to be taken from the assembly prepared using plates 25 mm to 30 mm thick, and three sets of three Charpy V-notch impact test specimens are to be taken from the assembly prepared using plates 35 mm to 40 mm thick.

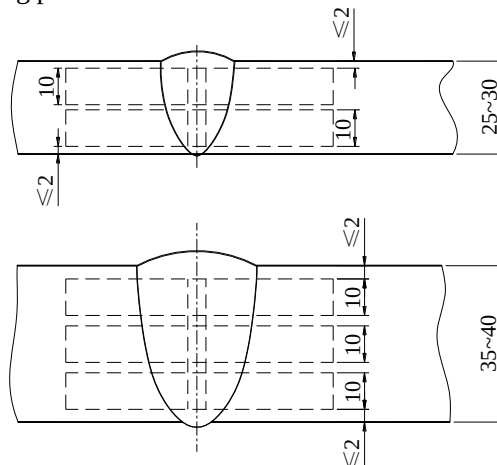


Figure 3.7.2.3 Specimen Preparation Diagram

3.7.3 Annual inspections

3.7.3.1 The annual tests are to consist of at least one butt weld test assembly prepared using plates of 25mm to 30 mm in thickness according to the requirements of 3.7.2 of this Section. And one longitudinal tensile, one transverse tensile, two bend specimens and one set of three Charpy V-notch impact test specimens (cut from the root of the weld) are to be taken from the assembly, as shown in Figure 3.7.2.3, for tensile, bend and impact tests respectively.

Section 8 WELDING CONSUMABLES FOR STAINLESS STEEL

3.8.1 Application

3.8.1.1 This Section applies to welding consumables for austenitic and austenitic/ferritic duplex stainless

steels (unless expressly indicated otherwise, hereinafter referred to as stainless steel(s)) specified in Section 7 of Chapter 3, PART SEVEN of the Rules.

3.8.2 General requirements

3.8.2.1 Welding consumables for stainless steels are graded according to applicable parent stainless steel. Detailed grades are shown in Table 3.8.2.1.

Grading of Welding Consumables for Stainless Steel and Materials Adopted in Approval Test Table 3.8.2.1

Grade of welding consumables	Parent metal used in approval	Grade of welding consumables	Parent metal used in approval
304L	022Cr19Ni10 (S30403)	347	06Cr18Ni11Nb (S34778)
304LN	022Cr19Ni10N (S30453)	309L	06Cr23Ni13 (S30908)
316L	022Cr17Ni12Mo2 (S31603)	2205	022Cr23Ni5Mo3N (S22053)
316LN	022Cr17Ni12Mo2N (S31653)	2550	03Cr25Ni6Mo3Cu2N (S25554)
317L	022Cr19Ni13Mo3 (S31703)	2750	022Cr25Ni7Mo4N (S25073)
317LN	022Cr19Ni13Mo4N (S31753)		

3.8.2.2 For welding consumables suitable to different welding procedures, a suffix showing technological applicability is to be added after the grade mark according to 3.4.1 or 3.5.1 of this Chapter.

3.8.2.3 Unless expressly provided otherwise in this Section, approval tests for welding consumables are to be carried out based on the type of welding consumables and according to the applicable requirements in Sections 3, 4 and 5 of this Chapter.

3.8.3 Deposited metal tests

3.8.3.1 Plates used in the test assembly for deposited weld metal tests may be of stainless steel compatible with welding consumables, or of normal strength carbon steel or carbon-manganese steel provided that the prepared edges are built up by means of low heat input with two layers of insulation from welding consumables to be tested. The thickness of insulation is not to be less than 3 mm after processing.

3.8.3.2 The deposited weld metal is to be subjected to chemical analysis, mechanical test and metallographic examination.

3.8.3.3 The chemical composition of the deposited weld metal, including all significant elements, is to be reported. The analysis results are to comply with recognized standards or the manufacturer's specifications.

3.8.3.4 The mechanical properties of the deposited weld metal are to comply with the relevant requirements in Table 3.8.3.4.

3.8.3.5 Specimens are to be taken at the center of the deposited metal, and the ferrite content of the deposited metal is to be measured by metallographic or magnetic means. For welding consumables for austenitic stainless steels, the ferrite content is to comply with the manufacturer's specifications. For welding consumables for austenitic/ferritic duplex stainless steels, the ferrite content is to be within the range of 35% to 65%.

Mechanical Properties of Deposited Metal of Welding Consumables for Stainless Steel Table 3.8.3.4

Grade of welding consumables		Austenitic stainless steel		Austenitic/ferritic duplex stainless steel		
		304L	304L	2205	2550	2750
		316L	316L			
		317L	317L			
		309L	347			
Proof strength (N/mm ²)	$R_{p0.2}$	≥270	≥290	≥450	≥550	≥550
	$R_{p1.0}$ ^{注 1}	≥310	≥330	≥490	≥590	≥590
Tensile strength (N/mm ²)		≥500	≥550	≥620	≥690	≥790
Elongation A ₅ (%)		≥25	≥22	≥25	≥15	≥15
Charpy V-notch impact test	Test temperature, °C	-20/-196 ^{注 2}		-20		
	Average impact energy, J	≥29				

Note 1: Unless otherwise agreed, the value of proof strength $R_{p1.0}$ is generally not to be used as a criterion for acceptance;

Note 2: Austenitic stainless steel is to be subjected to impact test at -20°C. When used in deep cold condition, austenitic stainless steel is to be subjected to impact test at -196°C. If required by an agreement, impact test may also be carried out as agreed.

3.8.4 Butt weld tests

3.8.4.1 Test plates for butt weld tests are to be of stainless steel compatible with welding consumables.

3.8.4.2 Butt joints are to be subjected to mechanical and intergranular corrosion tests.

3.8.4.3 The mechanical properties of butt joints are to comply with the relevant requirements in Table 3.8.4.3 of this PART.

3.8.4.4 Stainless steel butt joints are to be sampled for intergranular corrosion test according to Section 7, Chapter 2, PART SEVEN of the Rules.

3.8.5 Annual inspections

3.8.5.1 Annual tests of welding consumables for stainless steels are to be carried out based on the type of welding consumables and according to the requirements of 3.3.9, 3.4.6 or 3.5.8 of this Chapter.

3.8.5.2 All test results are to comply with the relevant requirements of Table 3.8.3.4 and Table 3.8.4.3.

Mechanical Properties of Butt Joint of Welding Consumables for Stainless Steel Table 3.8.4.3

Grade of welding consumables		Austenitic stainless steel		Austenitic/ferritic duplex stainless steel		
		304L 316L 317L 309L	304LN 316LN 317LN 347	2205	2550	2750
Tensile strength of joint (R_m (N/mm ²))		≥480	≥550	≥620	≥690	≥790
Charpy V-notch impact test	Test temperature, °C	-20/-196 ^注		-20		
	Average impact energy, J	≥27				
Bend test	Former diameter	3t			6t	
	Bending angle	120 °				
	Requirement	After test, length of crack or other defects on specimen surface is not to be more than 3 mm.				

Note: Austenitic stainless steel is to be subjected to impact test at -20°C. When used in deep cold condition, austenitic stainless steel is to be subjected to impact test at -196°C. If required by an agreement, impact test may also be carried out as agreed.

Section 9 WELDING CONSUMABLES FOR ALUMINUM ALLOYS

3.9.1 Application

3.9.1.1 This Section applies to welding consumables intended for welding aluminum alloys to be used for hull construction according to Chapter 8, PART SEVEN of the Rules.

3.9.1.2 Unless otherwise specified in this Section, welding consumables for aluminum alloys are to be subjected to approval and test based on types of welding consumables and according to approval procedures and test methods in Sections 1 and 5 of this Chapter.

3.9.2 General requirements

3.9.2.1 The welding consumables for aluminum alloys are graded as A, B, C and D in accordance with the alloy type and strength level of the base materials used for the approval tests.

3.9.2.2 For wires and wire-gas combinations used in metal-arc inert gas welding (MIG), tungsten inert gas arc welding (TIG) and/or plasma arc welding, the letter “W” is to be added before the grade mark, e.g. “WC”.

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

3.9.2.4 Approval of a wire or a rod will be granted in conjunction with a specific shielding gas according to Table 3.9.2.4 or defined in terms of composition and purity of “special” gas to be designated with group sign “S”.

The composition of the shielding gas is to be reported. The approval of a wire or rod with any particular gas can be applied or transferred to any combination of the same wire or rod and any gas in the same numbered group as defined in Table 3.9.2.4, subject to agreement of CCS.

3.9.2.5 Approval on higher strength AlMg base materials covers also the lower strength AlMg grades and their combination with AlSi grades.

Groups and Composition of Shielding Gases

Table 3.9.2.4

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

3.9.3 Test requirements

3.9.3.1 For approval of welding consumables for aluminum alloys, deposited metal tests and butt weld tests are in general to be carried out.

3.9.3.2 One deposited weld metal test assembly may be prepared according to Figure 3.9.3.2. The base metal used is to be compatible with the weld metal in respect of chemical composition. The size depends on the type of the welding consumables and on the welding process and is to give a sufficient amount of pure weld metal for chemical analysis.

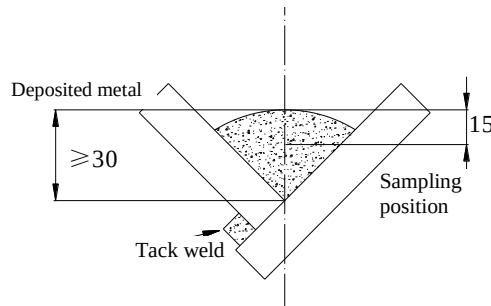
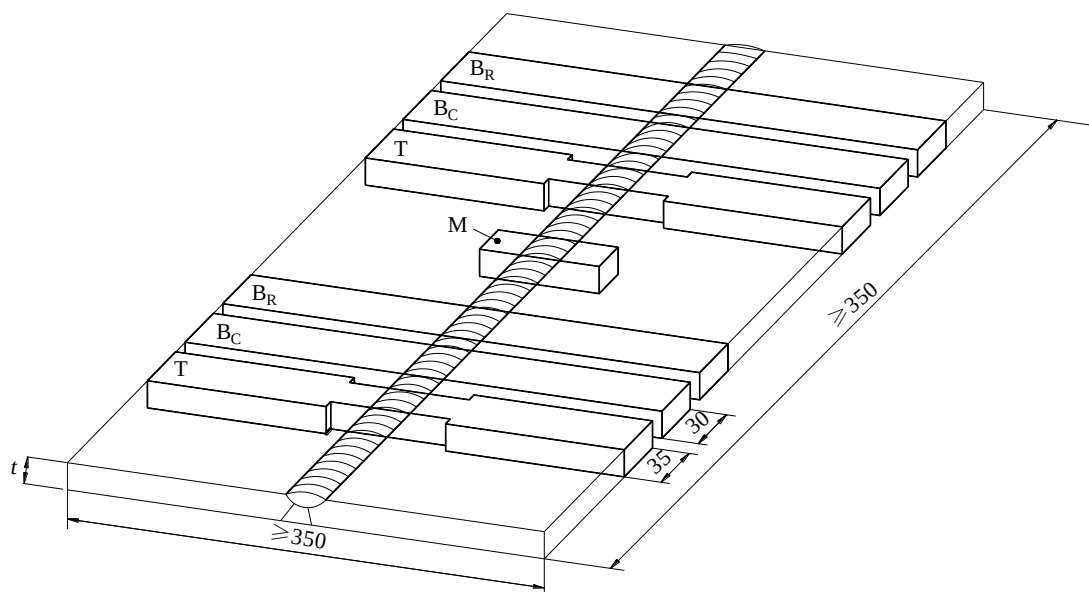


Figure 3.9.3.2 Preparation of Deposited Weld Metal Test Assembly

3.9.3.3 A report of chemical analysis of the deposited weld metal, including contents of all significant elements, is to be submitted. The test results are not to exceed the limit values specified by the manufacturer.



T—Flat tensile test specimen; Bc—Face bend test specimen; BR—Root bend test specimen;
M—Macroscopic section; $t=10\sim12\text{mm}$, or $20\sim25\text{mm}$

Note: 1. Edge preparation is to be single V or double V with 70° angle; 2. Back sealing runs are allowed in single V weld assemblies. 3 In case of double V assembly, both sides are to be welded in the same welding position.

Figure 3.9.3.4 Positions of Weld Test

3.9.3.4 Butt weld test assemblies according to Figure 3.9.3.4 with a thickness of 10 mm to 12 mm are to be prepared for each welding position (down hand, horizontal-vertical, vertical-upward and overhead) for which the consumable is recommended by the manufacturer. Consumables satisfying the requirements for down hand and vertical-upward positions may be exempted from testing for the horizontal-vertical position, subject to agreement of CCS. Additionally, one test assembly according to Figure 3.9.3.4 with a thickness of 20 mm to 25 mm is to be welded in the down hand position only.

3.9.3.5 Welding may be carried out according to the requirements of 3.5.4 or 3.5.6 of this Chapter. On completion of welding, assemblies are to be allowed to cool naturally to ambient temperature. Welded test assemblies and test specimens are not to be subjected to any heat treatment. Grade D assemblies are to be allowed to naturally ageing for a minimum period of 72 h from the completion of welding before testing is carried out.

3.9.3.6 As shown in Figure 3.9.3.4, two flat tensile test specimens, four bend test specimens (two face bend ones and two root bend ones) and one macrographic section are to be taken from each butt weld test assembly for tests.

3.9.3.7 The results of tensile tests and bend tests are to comply with the relevant requirements of Table 3.9.3.7. The position of the fractures of tensile specimens is to be stated in the report. The macrographic specimen is to be examined for imperfections such as visible flaws, lack of fusion, pores and inclusions.

Mechanical Properties of Welding Materials Consumables for Aluminum Alloys

Table 3.9.3.7

Grade of welding consumables		A		B	C				D
Brand of base material used for test		5754	5454	5086	5083	5383 5456	5A01	5059	6061 6005A 6082
Tensile test	Tensile strength (N/mm ²)	190	215	240	275	290	325	330	170
Bend test	Former diameter	3t	4t	6t					
	Minimum bending angle	180 °							
	Test requirements	During testing, the test specimen is not to reveal any one single flaw greater than 3 mm in any direction. Flaws appearing at the corners of a test specimen are to be ignored in the evaluation, unless there is evidence that they result from lack of fusion.							

3.9.4 Annual inspections

3.9.4.1 For annual inspections of welding consumables for aluminum alloys, one deposited metal test assembly and one down hand butt weld test assembly for chemical analysis of the deposited metal and for mechanical tests of butt joints are to be prepared according to the type of welding consumables.

3.9.4.2 All test results are to comply with the relevant requirements of 3.9.3.3 and Table 3.9.3.7.

CHAPTER 4 WELDING OF HULL STRUCTURE

Section 1 GENERAL PROVISIONS

4.1.1 Application

4.1.1.1 This Chapter applies to the welding and inspection of hull structural members made of steels. The design of welds for hull structure is to comply with the relevant requirements of Chapter 1 of PART TWO of the Rules.

4.1.2 Procedure specification and inspection standards

4.1.1.2 Before the commencement of construction, the proposed procedure specification and inspection standards are to be submitted to CCS for approval, and a welding procedure test, where necessary, will be carried out on this account, according to the requirements of Chapter 2 of this PART. Welding construction and inspection are to be carried out in accordance with the plans, procedure specification and inspection standards approved by CCS.

4.1.3 Preparation before welding

4.1.3.1 The sequence of assembling, gaps between structural members, alignment of joints and preparation of plate edges are to comply with the requirements of the approved procedure specification. Improper assembling is to be avoided so as to reduce internal stresses of structural members. Where excessive gap exists between surfaces or edges to be joined, the corrective measures adopted are to be agreed by the Surveyor.

4.1.3.2 The surfaces of all parts to be welded are to be clean and dry, and free from rust, scale, grease and other impurities.

Where a primer is used to coat steel and not removed prior to welding, the composition of the primer is to be shown as having no significant deleterious effect on the finished weld, and relevant information is to be submitted to CCS for reference.

4.1.3.3 Where welding is required to be carried out in exposed positions in wet, windy or cold weather, adequate cover and protection is to be provided.

For the purpose of preventing the development of excessive stresses or undesirable micro-structures in weldments, suitable measures are to be taken for preheating and/or slow-cooling in the following cases.

- .1 where the ambient temperature is lower than 0°C;
- .2 where the carbon equivalent C_{eq} of the base material is greater than 0.41%,

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15} ;$$

- .3 where excessively rigid structures, thick plates or short beads are employed.

When the carbon equivalent C_{eq} is greater than 0.45%, in addition to preheating, post weld heat treatment is to be considered.

4.1.4 Welding procedures

4.1.4.1 The welds in hull structures are to be made in accordance with the approved welding procedure specification. For long welds, welding is to be started from a point midway between both ends as far as possible so as to reduce the deformation and internal stress of the structure.

4.1.4.2 Tack welding is to be kept to a minimum. The tack welds are to have a sufficient throat thickness. The length of tack welds is not to be less than 30 mm for normal strength steels. Tack welds are to be of the same quality as the finished welds. Any defective tack welds are to be cut out before completing the finished welds.

4.1.4.3 Craters at the ends of welds are to be filled to prevent crater cracks. Where automatic welding is employed, run-on and run-off tabs are generally to be used.

Where multi-run welding is employed, slag from the previous run is to be removed before the next run is applied.

4.1.4.4 Design of welds is to comply with the requirements of 1.4.1.3 and 1.4.1.4 of PART TWO of the Rules. For welds where full penetration is required, a back sealing run is to be applied after the root run is cut out to clean metal and suitably gouged, unless otherwise specially agreed by CCS.

4.1.4.5 When removing temporary fittings used for assembly, tack welds, defective welds, arc scars and root welds, care is to be taken to ensure that the parent material of the structure is not damaged.

Section 2 WELDING OF HULL STRUCTURAL MEMBERS

4.2.1 General requirements

4.2.1.1 Unless full penetration is entirely ensured, the edges of plates for butt joints are to be beveled on one or both sides to provide an included angle of 50° to 60° in general. The adoption of other forms of edge preparation is subject to agreement of CCS.

4.2.1.2 Where it is impracticable to apply the back sealing run to full penetration butt joints for structural reasons, backing strips may be used as agreed by the Surveyor. The type of bevel and the root gap are to ensure complete fusion between the joints and the backing strips.

4.2.1.3 Where structural members are attached by continuous fillet welds and cross completely finished butt welds of the plates:

- .1 the finished butt welds in way of the laying surface are to be made flush; or alternatively, a scallop is to be arranged in the web of the abutting member so as to cross over the butt welds and ensure tight fitting and satisfactory welding;
- .2 where the abutting member to be attached by continuous fillet welds is to have butt welds on itself, the butt welds are to be applied first and then made flush prior to the application of fillet welds.

4.2.2 Fillet weld at small included angles

4.2.2.1 Care is to be taken in structure design to avoid the arrangement of fillet welds at a small included angle so as to prevent complicated weldments. In particular cases where the included angle is smaller than 50° , the welding may be carried out as follows:

- .1 For the fillet welds of the connection of inner bottom plating to side shell, the edge is to be beveled to not less than 45° , as shown in Figure 4.2.2.1(1). If the included angle is less than 45° , the edge of inner bottom plating may be beveled. Multi-run continuous fillet welds are to be completed at the beveled edge, and the small diameter electrode is to be employed in the bottom run;
- .2 If the included angle is as small as mentioned above for a bracket, the fillet weld may be applied on the side having the obtuse angle provided that welding is carried round the toe end of the bracket to the other side to an adequate length.

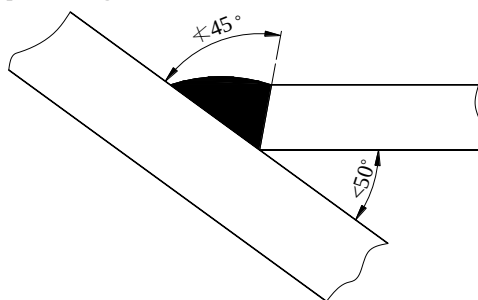


Figure 4.2.2.1.1 Fillet Welds of Connection of Inner Bottom Plating to and Side Shell

4.2.3 Welding of hull structural members made from steel castings and forgings

4.2.3.1 Where the hull structural members such as stems, stem frames, rudder stocks and propeller shaft bracket are made from steel castings or forgings, the welding is to comply with the following:

- .1 Where the members to be welded have a carbon content not exceeding 0.23% or are highly rigid, due measures are to be taken for preheating and temperature keeping prior to and after the welding;
- .2 Where manual arc welding is employed, stems, stern frames, rudder stocks and propeller shaft brackets are to be subjected to tempering on completion of welding. Where electro-slag welding is employed, stems, stern frames and rudder stocks are to be subjected to normalizing and tempering on completion of welding

Where stems, stern frames, rudder stocks and propeller shaft brackets are of such dimensions that the whole body cannot be heat-treated at the same time, an efficient local heat treatment process may be accepted.

4.2.4 Welding of sheer strakes to strength deck stringers

4.2.4.1 Where strength deck stringers are fillet welded to sheer strakes, within 0.4L amidships, the edges of the strength deck plates are to be beveled and fully penetrated in general. The form of edge preparation may depend on the construction situation.

4.2.4.2 Where rounded sheer strakes are butt welded to strength deck stringers, the edges of plates are to be beveled in way of the butt connection to ensure full penetration. Where T-connection is adopted to connect rounded sheer strakes to deck stringers near fore and aft ends of the ship, an adequate length of transition is to be provided. In the transition region, the butt welds for the connection of rounded sheer strakes to deck stringers are to be fully penetrated.

4.2.5 Welding of goalposts and derrick masts (posts)

4.2.5.1 The welding of goalposts and derrick masts (posts) supporting the derricks with the maximum safe working loads not greater than 10t are to comply with the following requirements:

- .1 For goalposts and derrick masts (posts) made of steel plates, the circumferential and longitudinal seams of the mast (post) body are to be butt welded on single side with full penetration.
- .2 If Where the mast (post) root is directly welded onto the strength deck instead of passing through it, the lower end of the mast is to be fully beveled on one side and the small diameter electrode is to be employed in the first run so as to ensure full penetration.
- .3 Where the mast (post) passes through the strength deck, the edges of the deck plates connected to it are to be beveled on both sides and continuous fillet weld is to be used on double sides. The root of the mast is to be fully beveled on one side and continuous fillet weld is to be used on single side. All above welds are to be fully penetrated.

4.2.6 Welding of main engine seatings

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

4.2.6.2 For the fillet welds of other structural members (such as bottom plating, floors, tripping brackets, transverse webs etc.) attached to the main engine seating, the throat thickness is to comply with the relevant requirements of Section 4, Chapter 1, PART TWO of the Rules.

Section 3 INSPECTION AND REPAIRING OF WELD**4.3.1 General requirements**

4.3.1.1 This Section applies to the inspection and repairing of welds in hull structures of steel ships.

4.3.2 Inspection

4.3.2.1 On completion of welding of hull structures, visual inspection is to be carried out on all the finished welds. The weld defects generated in hull sectional construction are to be repaired before joining.

4.3.2.2 The surface of welds is to be uniform and compact, with a smooth transition to the base metal and free from excessive reinforcements and defects such as cracks, undercut, pore, slag inclusion, overlap and arc crater. The above defects, if any, are to finish repairing prior to internal quality inspection and tightness test of welds.

4.3.2.3 The internal quality of welds may be examined by non-destructive testing such as radio graphic examination, ultrasonic inspection or other suitable methods. Non-destructive testing processes and evaluation standards are generally to meet the requirements of Chapter 7 of *CCS Guidelines for Inspection of Hull Welds* or recognized methods of examination and acceptance criteria.

4.3.2.4 The location and extent of welds to be examined by non-destructive testing are to be agreed between the shipbuilder and CCS according to practical situation.

4.3.2.5 The number n of radiographs for the welds in the strength deck and shell within 0.4L amidships in general may be calculated by the following formula:

$$n = 0.25(i + 0.1W_T + 0.1W_L)$$

Wherein: i —Amount of intersections of butt welds within 0.4L amidships;

W_T ——whole length of transverse welds within 0.4L amidships, in m;

W_L ——whole length of longitudinal welds joining the blocks within 0.4L amidships, in m;

The distribution density of radiographs of radiographic testing is to decrease in number with the decrease of material grades of steels, and the material grades of steels can be seen in Chapter 1 of PART TWO of the Rules. Where non-destructive testing is carried out at an intersection, the distribution direction of radiographs is to be paralleled to the direction of the transverse welds.

Where the vessel length is not less than 60m, the above range is to extend to 0.6L.

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

4.3.2.7 Where non-destructive examination reveals unacceptable defects in the welds and there is the possibility for such defects to develop, additional examinations are to be made along the direction of possible extension of the defective welded seam (one end or both ends) until a sound weld is obtained.

4.3.2.8 The positions and results of non-destructive testing are to be recorded in the reports, which are to be submitted to CCS for confirmation.

4.3.3 Repair of defects

4.3.3.1 Where the examination reveals that the defects in welds are unacceptable, such defective sections are to be cut out and re-welded. The repair methods of welds are to be approved by CCS.

4.3.3.2 Prior to re-welding, all defects necessitating repairs are to be thoroughly cut out, and non-destructive testing may be necessary to verify that all defects have been thoroughly removed.

4.3.3.3 On completion of repairing, visual inspection and corresponding non-destructive testing are to be carried out on the re-welded portion of welds. The results are to comply with the requirements of the acceptance criteria.

Section 4 WELDING OF STAINLESS STEELS AND STAINLESS STEEL-CLAD PLATES

4.4.1 General requirements

4.4.1.1 This Section applies to the welding of austenitic stainless steels, austenitic/ferritic duplex stainless steels (both hereinafter referred to as “stainless steel(s)”, unless expressly designated otherwise) and their clad plates. The welding of steel plates with other metallic clad materials will be specially considered by CCS.

4.4.1.2 Unless otherwise specified in this Section, the welding of stainless steels and stainless steel-clad plates is to comply with the requirements of Section 1 of this Chapter.

4.4.2 Welding consumables

4.4.2.1 Welding consumables basically equivalent to the base material in the chemical composition of their deposited metal are usually to be used for austenitic stainless steel.

4.4.2.2 Welding consumables having more austenitic elements than ferritic ones in the metallurgical structure of their deposited metal are preferably to be used for austenitic/ferritic duplex stainless steel, or austenitic welding consumables appropriate for the duplex stainless steel are to be used.

4.4.2.3 Welding consumables for steel plates clad with stainless steel are to be appropriate to the base and cladding materials respectively.

4.4.2.4 For the welding of stainless steel plates containing nitrogen, the use of inert shielding gas containing a right amount of nitrogen may be considered.

4.4.3 Preparation before welding

4.4.3.1 The joints of austenitic stainless steel and austenitic stainless steel-clad plates are to be so designed and the welding procedure so prepared as to minimize the stress produced by welding. The side of plates facing the corrosive medium is generally to be welded finally.

4.4.3.2 Surfaces of plates are to be thoroughly cleaned to remove oil, paint, dirt and impurities before welding.

4.4.3.3 Surfaces of stainless steel or stainless steel-clad plates adjacent to the weld are to be suitably protected to prevent them from being stained or damaged by spatters or other objects.

4.4.3.4 The edges of stainless steel and stainless steel-clad plates are to be beveled by machining or grinding. Flame cutting is to be avoided.

The form of beveled edges of clad plates is to be specially considered. After beveling, the groove surfaces(including root face) are to be inspected and no cracks and loosened cladding are allowed.

4.4.3.5 Butt welded clad plates are to be aligned using the cladding metal as a datum plane. Tack welds are to be applied to the base material.

4.4.4 Welding

4.4.4.1 Welding of stainless steel plates is preferably to be carried out by means of energy concentration(e.g. metal inert-gas welding, tungsten inert-gas welding, plasma arc welding).

4.4.4.2 For welding of stainless steel, inter pass temperatures are to be kept as low as practicable and preferably below 100°C and as a maximum not to exceed 150°C. Welding parameters are to be in accordance with an approved welding procedure. Welding is generally to be carried out by means of low heat input and short arc. The arc is to be straightly moved in a steady and quick way so as to prevent it from waving.

4.4.4.3 It is recommended that one or two transitional layers be deposited between the weld of the base material and that of the cladding metal, using the consumables made of austenitic stainless steel having an alloy element content higher than that of the cladding metal. The beads of the base material close to the transitional layers are to be deposited with low hydrogen or ultra-low hydrogen welding consumables.

4.4.4.4 In order to keep weld dilution to a minimum, the transitional layers and the subsequent layer are to be deposited for clad plates using electrodes of a small diameter and low welding current.

4.4.4.5 The plate surface facing the corrosive medium is not to be struck for arc and not to be randomly welded with temporary fittings.

4.4.5 Post-weld treatment

4.4.5.1 The surface of both sides of stainless steel and stainless steel-clad plates is not to be straightened by hammering.

4.4.5.2 The post-weld treatment (pickling or passivating) may be carried out according to the instructions of the material manufacturer to achieve sound corrosion resistance in welded areas, if deemed necessary.

4.4.6 Inspection of finished welds

4.4.6.1 All welds are to be visually inspected. The surface of welds is to be uniform with a smooth transition to the parent metal, and is to be free from cracks, pores, unfilled cavities, overlaps, undercuts and other defects.

4.4.6.2 The internal quality of the welds is to be examined by non-destructive testing. The extent and number of non-destructive testing and the procedures and acceptance criteria used are to be in compliance with the standards acceptable to CCS.

4.4.7 Repairing

4.4.7.1 It is recommended that the defects in welds be removed by machining. The repairing processes are to be agreed by CCS.

Section 5 WELDING OF ALUMINUM ALLOYS

4.5.1 General requirements

4.5.1.1 This Section applies to the welding of weldable aluminum alloys complying with the requirements of Chapter 8, PART SEVEN of the Rules.

4.5.1.2 The welding procedure specification for aluminum alloys is to be submitted to CCS for approval. The procedure specification is to include the measures for preventing and rectifying welding deformation.

4.5.1.3 The welding procedure tests for aluminum alloys are to be carried out according to the relevant requirement of Chapter 2 of this PART.

4.5.1.4 Welders engaged in the welding of aluminum alloys are to have been trained in the operational skill and certified accordingly upon qualification tests.

4.5.2 Preparations before welding

4.5.2.1 Protective means against moisture, dust, cold and wind are to be provided at the welding site. The wind speed is to be less than 1.5 m/s during the welding operation.

4.5.2.2 Aluminum alloys may be cut by machining or plasma technique. Edge preparation may be performed by machining such as planning or grinding. Any other proposed method is to be agreed by CCS Surveyor.

4.5.2.3 Wires, welding grooves and adjacent areas are to be thoroughly cleaned, by chemical means where necessary, and kept dry. After cleaning, the welding is to be applied as soon as possible. Usually, the cleaned parts are to be welded within 24 h, otherwise they are to be effectively protected or cleaned again.

4.5.2.4 Preheating is to be considered for the areas to be welded in any one of the following cases:

- .1 aluminum alloys with thickness over 8 mm;
- .2 ambient temperature below 0°C; or
- .3 ambient humidity over 80%.

Oxy-acetylene FLAME is unacceptable for preheating of aluminum alloys.

The preheating temperature of aluminum-magnesium alloys is generally to be $50^{\circ}\text{C} \pm 10^{\circ}\text{C}$.

4.5.2.5 Where inert gas-shielded arc welding is employed, the purity of the shielding gas is to be checked for compliance with the welding procedure specification, prior to welding.

4.5.3 Welding

4.5.3.1 It is recommended that tungsten inert gas arc welding (TIG) or metal inert gas arc welding (MIG) be adopted for aluminum alloy structures. Both ends of important welds are to be provided with temporary run-on and run-off tabs.

4.5.3.2 Main butt welds are to be down hand butt welded with an angle of inclination less than 20° as far as possible.

4.5.3.3 To minimize the deformation, the following are to be complied with while welding:

- .1 starting at the center of the seam and welding outward symmetrically or welding with back step sequence for a single long weld;
- .2 starting at the center weld and welding outward symmetrically for long and close-spaced welds;
- .3 the dimensions of the welds are not to be enlarged as far as possible so long as the design requirements are met.

4.5.3.4 The continuity of welding is to be kept; where for any reason the welding is interrupted, the location of stopping is to be cleaned before striking the arc; and the succeeding weld is to be overlapped on the previous one for an adequate length. Where the multi-run welding technique is employed, care is to be taken to the cleaning and the inter pass temperature between two runs.

4.5.3.5 Root runs are to be cut out to clean metal and weld defects removed by machining such as planning or grinding.

4.5.3.6 For full penetration butt welds, back chipping is required to eliminate all defects after the frontside is welded.

4.5.3.7 Where multi-run welding is used, the surface of each run of the deposit is to be thoroughly cleaned before the next run is deposited, and the inter pass temperature is to be controlled at 60°C or lower as far as possible.

4.5.3.8 If spatters are visibly attached to the nozzle during MIG welding, the nozzle is to be renewed or cleaned. If the tungsten electrode is found oxidized or defective in shape during TIG welding, it is to be renewed or repaired by grinding. If the tungsten electrode touches the molten bath or the wire, the welding is to be stopped immediately, and the welds having tungsten inclusions are to be thoroughly cleaned. The wire and tungsten electrode stained are also to be cleaned.

4.5.3.9 Where steel-aluminum transition joints are welded, heat input is to be strictly controlled in order to prevent harmful effects to the joints.

4.5.3.10 For intersections of major structures at a small angle, beveling and welding are generally to be performed at the back side, and the leg length of the fillet weld is to comply with the design. The deformation of aluminum alloy structures resulted from the welding is preferably not to be rectified by hammering. Heating for rectification, where employed, is to be carried out in accordance with instructions of the aluminum alloy manufacturer.

4.5.4 Inspection and repairing of welds

4.5.4.1 Final welds are to be subjected to visual inspection and non-destructive testing. The methods of examination and acceptance criteria are to be agreed by CCS.

4.5.4.2 Final welds are to be subjected to visual inspection and non-destructive testing. The methods of

examination and acceptance criteria are to be agreed by CCS.

4.5.4.3 The surface of welds is to be free from defects such as cracks, tungsten inclusions, unfilled cavities, pores, burning damages and overlaps. Undercuts are not permitted for plates of 3 mm or less in thickness. For plates over 3 mm in thickness, the depth of undercuts is not to be greater than 0.5 mm, their total length is not to be greater than 10% of the length of a single weld and not to exceed 100 mm.

4.5.4.4 The weld repairs for aluminum alloys are generally not to be performed more than twice unless approved by CCS.

4.5.4.5 Weld repairs are to be carried out using the same welding consumables and procedures as those adopted for the original welds. After repairing, the welds are to be inspected again.

CHAPTER 5 WELDING OF BOILERS AND PRESSURE VESSELS

Section 1 GENERAL PROVISIONS

5.1.1 Application

5.1.1.1 This Chapter applies to the welding of boilers and pressure vessels of structural type specified in Chapter 8 of PART THREE of the Rules.

5.1.1.2 This Chapter applies to welded joints of manual, automatic or semi-automatic electrical arc welding process. Where it is proposed to use other welding processes, details are to be submitted to CCS for approval.

5.1.2 Consumables

5.1.2.1 Welding consumables used for boilers and pressure vessels of welded construction are to be appropriate to the parent metal and approved by CCS.

5.1.3 Approval

5.1.3.1 When a product is to be manufactured for the first time or when a new welding procedure is to be adopted, the manufacturer is required to submit the welding procedure for the appropriate structural type to CCS for approval in accordance with the requirements of Chapter 2 of this PART. In the approval tests, the diameter of the bend former used for specimens of boilers and pressure vessels is to comply with the requirements given in Table 5.2.3.3 of this Chapter.

5.1.3.2 For the welding procedure approval test of Class III pressure vessels, only face and root bend, butt weld tensile and nick bend tests are required.

5.1.3.3 The nick bend test specimen is to be as shown in Figure 5.1.3.3. The specimen is to have a slot cut into each side along the centerline of the weld and perpendicular to the plate surface. During testing, the specimen is to be bent along the weld centerline until fracture occurs, or to be fractured by a drop hammer, and the fracture faces are to be examined visually or using a magnifying glass of not more than 10-fold magnification. The fracture is to reveal a sound weld, substantially free from slag inclusions, porosity, and coarse crystallinity.

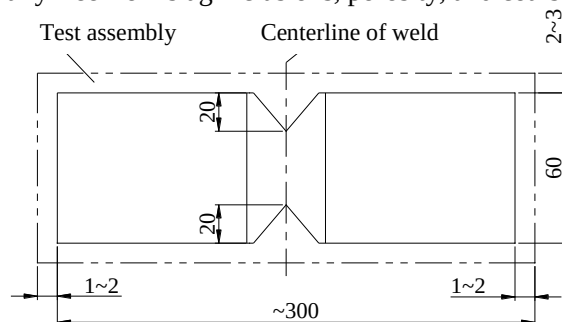


Figure 5.1.3.3 Specimen for Fracture Microstructure Uniformity Inspection

Section 2 PRODUCTION WELDING TESTS OF BOILERS AND PRESSURE VESSELS

5.2.1 General requirements

5.2.1.1 During production of any class of welded pressure shells (except for pressure vessels of Class III), production welding tests are to be carried out according to the requirements of this Section. For grading of boilers and pressure vessels, see the relevant requirements of Chapter 8 of PART THREE of the Rules.

5.2.2 Test assemblies

5.2.2.1 Two test assemblies are generally to be prepared for each boiler and pressure vessel, and their

materials are to be of the same thickness and the same steel grade as used in the construction of the shell. The test assemblies are to have a length not less than 150mm, and a length sufficient for providing one complete set of specimens specified by Table 5.2.3.1 of this PART.

5.2.2.2 Where it is impracticable to prepare two test assemblies, subject to agreement of CCS, one test assembly may be prepared, provided that its length is sufficient to provide one complete set of specimens required by Table 5.2.3.1 of this PART, and for cutting out additional re-test pieces. Test plates are to be tack welded to the shell plate in such a manner that the edges to be welded are a continuation and simulation of the corresponding edges of the longitudinal joint.

5.2.2.3 Generally, test assemblies need not be prepared for the circumferential seams, except where the shell has circumferential seams only or where the welding procedure for the circumferential joints is significantly different from that used for the longitudinal joints, one test assembly is to be prepared. This test assembly is to provide one complete set of specimens required by Table 5.2.3.1 of this Section and specimens for re-test purposes. For the manufacture of boilers and pressure vessels of the same type, one test assembly may be welded for each 30 m of circumferential seams.

5.2.2.4 Proper measures are to be taken to minimize the warping resulted from welding. The test assemblies are to be straightened before being subjected to heat treatment.

5.2.2.5 The process, procedure and heat treatment for welding test assemblies are to be the same as those for the shell. The test assemblies are to be heat treated together with the shell. Before being cut out, the test assemblies are to be stamped with CCS stamp by CCS Surveyor or his deputy.

5.2.3 Specimens and testing

5.2.3.1 The test specimens for boilers and pressure vessels are to be taken as required by Figure 5.2.3.1 and Table 5.2.3.1.

Specimens for Classes of Boilers and Pressure Vessels

Table 5.2.3.1

No.	Sample name	Name of boiler and pressure vessel	
		ClassI	ClassII
1	Deposited metal tensile sample	Required	Required
2	Face bend ^{Note}	Required	Required
3	Root bend ^{Note}	Required	Required
4	Butt weld transverse tensile	Required	Required
5	Macro examination	Required	Required
6, 7, 8	Impact test	Required	

Note: Where a test plate is greater than 20 mm in thickness, a side bend test specimen may be substituted for the face or root bend specimen.

5.2.3.2 Where the test plate is greater than 70 mm in thickness, two deposited metal tensile test specimens are to be taken as shown in Figure 5.2.3.2. If a specimen of 10 mm diameter cannot be taken, the largest practicable diameter is to be used, and the gauge length of the test specimen is to be 5 times the diameter.

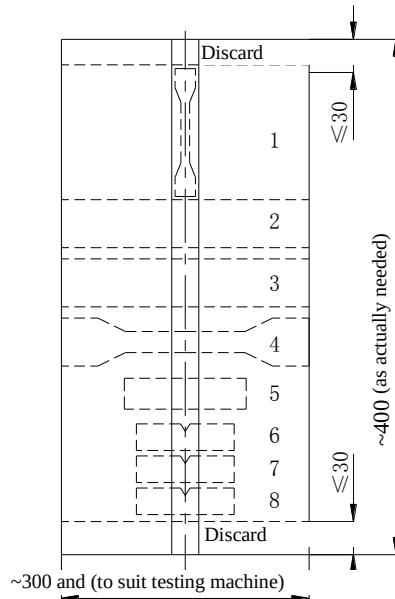


Figure 5.2.3.1 Specimen Preparation Diagram

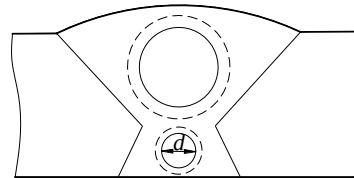


Figure 5.2.3.2 Tensile Test Specimen

5.2.3.3 For bend tests, the diameter of the former and the clear space between the supports are to comply with the requirements given in Table 5.2.3.3.

Former Diameter and Space between Supports, in mm

Table 5.2.3.3

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

Note: t being the plate thickness, in mm.

5.2.3.4 In addition to the requirements of 5.2.3.2 and 5.2.3.3 of this PART, preparation and testing of test specimens are to comply with the relevant requirements of Section 2, Chapter 1 of this PART.

5.2.4 Acceptance and re-tests

5.2.4.1 The results of various tests are to comply with the requirements given in Table 5.2.4.1.

5.2.4.2 If any of the tests fail, the reason for the failure is to be investigated and additional specimens are to be prepared from the original specimen for re-tests.

5.2.4.3 Where two test assemblies have been prepared, the re-test specimens are to be cut from the second test assembly.

5.2.4.4 If it can be shown that the failure of the initial test resulted from a local or accidental defect and the re-test results are satisfactory, the re-test results may be accepted.

Requirements for Product Welding Test

Table 5.2.4.1

Test	Boilers and pressure vessels	
	Class I	Class II
Deposited metal tensile	(1) Tensile strength R_m : not less than the minimum specified tensile strength of the parent metal, and not greater than the minimum specified tensile strength of the parent metal plus 145 N/mm ² ; (2) Elongation A_5 : $A_5 \geq (980 - R_m) / 21.6$, and not less than 80% of the minimum specified elongation of the parent metal.	
Bend	The diameter of the former and the clear space between supports are to be in accordance with Table 5.2.3.3. A former with its axis perpendicular to the specimen is to bend the specimen by pushing it through the clear space between the supports. After bending, there is to be no crack or other defects exceeding 3 mm in dimension on the outer surface of the bent portion	
Butt weld transverse	Butt weld tensile strength is to be not less than the minimum specified tensile strength of	

tensile	the parent metal.	
Macro examination	No incomplete penetration, lack of fusion and significant slag inclusions or other defects are allowed	
Impact	The average energy obtained in room temperature impact test is not to be less than 27J.	Not required.

Section 3 MANUFACTURE AND WORKMANSHIP OF BOILERS AND PRESSURE VESSELS

5.3.1 General requirements

5.3.1.1 Unless otherwise specified, all major seams in the boiler and pressure vessel shells are to be butt welded.

5.3.2 Edge preparation

5.3.2.1 Where plate edges of boilers and pressure vessels are to be joined by welding, they are to be well beveled. Edges may be prepared by gas cutting, machining, chipping or grinding. Where gas cutting is employed, any remaining slag and scale are to be removed by machining or grinding from the beveled edges.

5.3.3 Alignment of butt welds

5.3.3.1 For boilers and pressure shells, the surfaces of two butt welded plates are not to be out of alignment with each other at any point by more than 10% of the plate thickness. But in no case is the misalignment to exceed 3 mm for longitudinal seams or 4 mm for circumferential seams.

5.3.3.2 Where a shell is constructed of plates of different thicknesses (tube plate and wrapper plate), the plates are to be so arranged that their centerlines form a continuous circle, and the following requirements are to be complied with:

- .1 For the longitudinal seam, the thicker plate is to be equally chamfered inside and outside by machining over a circumferential distance not less than twice the difference in the thickness, so that the two plates are of equal thickness at the longitudinal weld seam. For the circumferential seam, the thicker plate is to be similarly prepared over the same distance longitudinally.
- .2 For the circumferential seam, where the difference in the thickness is the same throughout the circumference, the thicker plate is to be reduced in thickness by machining to a taper for a distance not less than 4 times the offset, so that the two plates are of equal thickness at the weld point.

5.3.4 Welding

5.3.4.1 Before welding, all surfaces of the pieces to be welded are to be thoroughly cleaned of scale, moisture, grease or other dirt which would be detrimental to the quality of welding for a distance of at least 25 mm from the weld. All tack welds and edge imperfections which would be detrimental to the quality of welding are to be removed prior to welding.

5.3.4.2 Unless otherwise approved, low hydrogen or ultra-low hydrogen welding consumables are to be used for the welding of boilers and pressure vessels.

5.3.4.3 In general, butt welding is to be carried out from both sides for shells of boilers and pressure vessels. The back sealing run is to be applied after cutting out the root run to clean metal. Where it is impracticable to apply the back sealing run for special structures, welding may be allowed by installing the backing strips. If steel backing strips are used, they are to be of the same nominal composition as the plates to be welded.

5.3.4.4 Where a butt joint is welded from one side of the plate only, suitable measures are to be taken to ensure that the root is properly fused and that distortion due to the contraction of the weld metal is minimized.

5.3.4.5 Welding is to be carried out in the down hand position as far as practicable. In the case of circumferential seams, means are to be adopted to ensure compliance with this requirement.

5.3.4.6 Where the multi-run welding technique is employed, care is to be taken to the cleaning between two runs. Where for any reason the welding is interrupted, care is to be taken in restarting to ensure that the previously deposited weld metal is thoroughly cleaned of slag and debris, and that there is proper penetration into the plate and the previously deposited weld metal.

5.3.4.7 Preheating and maintenance of minimum inter pass temperature are to be employed where

necessitated by the joint restraint, thickness of the plate or composition of the material to be welded.

5.3.4.8 The outer surface of the weld may be flush with the surfaces of the plates joined, but no objection will be raised if the total thickness at the center of the weld is greater than the thickness of the plates, provided that the change of the reinforced cross section is gradual.

5.3.4.9 Spool pieces, flanges and pads are in general to be attached to the boiler and pressure vessel by double continuous fillet welding, and all welds are to be completed prior to heat treatment.

5.3.4.10 All lugs, brackets, branches, manhole frames, reinforcements around openings and other fittings are to have a close fit to the surface of the shell plate to which they are attached, and all welds are to be completed prior to heat treatment. If such fittings have to be welded after heat treatment for structural reasons, prior approval of CCS is to be obtained.

5.3.4.11 The procedure for the welding of the above-mentioned fittings, together with other attachments used for supporting internal and external components, to the pressure shell is to be the same as that required for the shell, and the material used is to be of compatible composition.

Section 4 HEAT TREATMENT

5.4.1 General requirements

5.4.1.1 Boilers and pressure vessels and their test assemblies are to be heat treated on completion of the welding and prior to the hydraulic test.

5.4.1.2 Post-weld heat treatment may be exempted for the following boilers and pressure vessels:

.1 Class-I boilers and pressure vessels made of carbon or carbon-manganese steel and having a plate thickness less than 20 mm for their welded components;

.2 Class II boilers and pressure vessels made of carbon steel, having a plate thickness less than 30 mm for their welded components and the working temperature not greater than 150°C; or made of carbon-manganese steel, having a plate thickness less than 20 mm for their welded components and the working temperature not greater than 150°C;

.3 all Class III pressure vessels.

5.4.2 Furnaces for heat treatment

5.4.2.1 The furnaces used for heat treatment are to be provided with:

- .1 adequate means of temperature control;
- .2 pyrometers capable of measuring and recording temperature changes within the furnace.

5.4.3 Heat treatment

5.4.3.1 The boilers and pressure vessels are generally to be subjected to heat treatment as a whole. Where it is impracticable to do so, the shells may be heated in sections, provided that sufficient overlap is allowed to ensure the heat treatment of the entire length of the longitudinal seam.

5.4.3.2 The heat treatment is to heat the boilers and pressure vessels slowly and uniformly to a suitable stress relieving temperature, soak it at this temperature for a suitable time, then cool it slowly and uniformly in the furnace to a temperature not exceeding 400°C and subsequently cool it in a still atmosphere.

5.4.3.3 The heat treatment temperatures, soaking times, heating and cooling rates are to be so selected as to relieve residual stress and improve the properties of the material, without undue deterioration of its properties.

5.4.3.4 For boilers and pressure vessels made of carbon and carbon-manganese steels, it is recommended that the stress relieving temperatures and soaking times be in accordance with the requirements given in Table 5.4.3.4. The heat treatment of alloy steels is to be based on the material used and agreed by CCS.

Stress Relieving Temperature and Soaking Time

Table 5.4.3.4

Grade of steel	Temperature (°C)	Soaking time (h)
360, 410, 460, 490	580~620	1h per 25mm of thickness, but at least 1h

Section 5 INSPECTIONS AND REPAIRING

5.5.1 General requirements

5.5.1.1 The inspection of boilers and pressure vessels is to include measuring the amount of out-of-roundness, visual examination and non-destructive testing of welds, and hydraulic testing.

5.5.1.2 The hydraulic tests of boiler and pressure vessels are to be carried out according to the requirements of Section 7, Chapter 8, PART THREE of the Rules.

5.5.2 Measuring of a mount of out-of-roundness

5.5.2.1 The out-of-roundness and overall dimensions of boilers and pressure vessels are to be examined before and after the final heat treatment. The out-of-roundness is defined as the difference between the maximum and minimum internal diameters measured at one cross-section.

5.5.2.2 The cylindrical shell is to be measured for the amount of out-of-roundness either when laid flat outside or when set up on end. When the shell is lying on side, the diameter is to be measured twice for each 60° and the mean value of the two measurements taken while turning the shell around its longitudinal axis, thereby obtaining the out-of-roundness value of the shell. The amount of out-of-roundness of cylindrical shell is to comply with Table 5.5.2.2.

Out-of-Roundness Deviation of Cylindrical Shells

Table 5.5.2.2

Nominal inside diameter of boiler and pressure vessel D_i (mm)	Allowable out-of-roundness $\Delta\phi$ of (mm)	Maximum deviation from designed form x (mm)
$D_i \leq 300$	$\leq 0.01 D_i$	1.2
$300 < D_i \leq 460$		1.6
$460 < D_i \leq 600$		2.4
$600 < D_i \leq 900$		3.2
$900 < D_i \leq 1220$		4.0
$1220 < D_i \leq 1520$		4.8
$1520 < D_i \leq 1900$		5.6
$1900 < D_i \leq 2300$	≤ 19	6.4
$2300 < D_i \leq 2670$		7.2
$2670 < D_i \leq 3950$		8.0
$3950 < D_i \leq 4650$	≤ 19	$0.002 D_i$
> 4650	$\leq 0.004 D_i$	$0.002 D_i$

5.5.2.3 The deviation of the profile of the shell from the designed form is the difference between the actual profile and the theoretical profile measured by a “gauge of the designed form” of the shell. The chord length of the “gauge of the designed form” is 1/4 nominal inside diameter of the shell. Measurements are to be carried out on the inside (Figure 5.5.2.3(1)) or outside (Figure 5.5.2.3(2)) of the shell, for determining the deviation X from the actual profile. This difference is to comply with the requirements of Table 5.5.2.2.

5.5.2.4 There is to be no flat or acute-angled shape on the weld of the shell. Any local out-of-roundness is to show uniform transition.

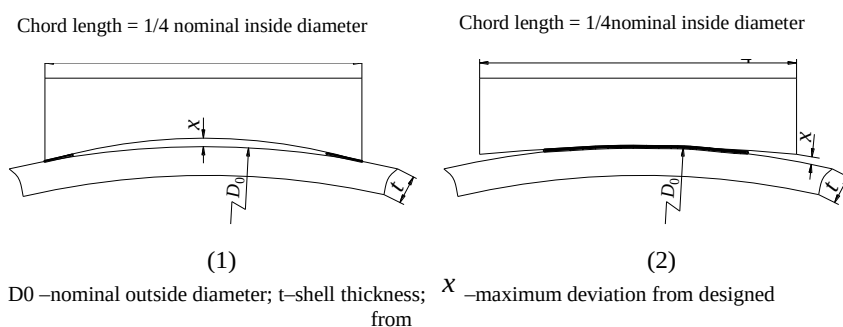


Figure 5.5.2.3 Diagram of Gauge of Designed Form

5.5.2.5 The external circumference of the completed shell of boilers and pressure vessels is not to deviate from the calculated circumference (based upon the nominal inside diameter and actual plate thickness of the shell)

by more than the values given in Table 5.5.2.5.

Deviation of External Circumference

Table 5.5.2.5

Outside diameter (nominal inside diameter plus twice plate thickness) (mm)	Deviation value of cylinder perimeter (mm)
300~600	$\leq \pm 5$
>600	$\leq \pm 0.25\%$ circumference

5.5.3 Appearance examination

5.5.3.1 All finished welds in the shell are to be uniform and sound, and free from cracks, overlaps, undercuts, pores, slag inclusions, craters and unfilled cavities. In case of occurrence of the above defects, they are to be completely removed prior to the non-destructive testing

5.5.3.2 Shell surfaces are to be free from mechanical damages. Tacking lugs on the shell are to be removed by chipping, or to be flame cut at 3 mm to 5 mm from the surface of the shell, then to be ground smooth.

5.5.4 Non-destructive testing of welds

5.5.4.1 The welds in Class I and II boilers and pressure vessels are to be subjected to non-destructive testing. The requirements for the non-destructive testing are to comply with the requirements of Table 5.5.4.1. The procedures of the non-destructive testing are to be agreed by CCS.

Testing Requirements for Boilers and Pressure Vessels

Table 5.5.4.1

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

Note: headers, connecting pipes and other cylindrical parts of 170 mm or less in outside diameter, 25% of circumferential butt welds in the die-forged connectors.

5.5.4.2 Where the accuracy of non-destructive testing may be influenced by the surface roughness of welds and adjacent areas, the surfaces of such portions are to be ground to the required surface smoothness.

5.5.4.3 The sensitivity of radiographic testing is to comply with the following requirements:

- .1 For the use of image quality indicators of the hole type, the minimum diameter of the hole that can be seen on the radiogram, is not to be greater than 3% of the thickness for the welds having the thickness not exceeding 50mm, and is not to be greater than 2.5% of the thickness for the welds having the thickness exceeding 50mm;
- .2 For the use of image quality indicators of metal wire type, the minimum diameter of the metal wire that can be seen on the radiogram, is not to be greater than 1.5% of the thickness for the welds having the thickness within 10mm~50mm, and is not to be greater than 1.25% of the thickness for the welds having the thickness within 50mm~200mm.

5.5.4.4 Image quality indicators are to be placed at both ends of each radiograph and are to be put at the weld surface facing the radioactive source as far as practicable.

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

5.5.4.6 The quality of welds subjected to non-destructive testing is to be evaluated according to the criteria

acceptable to CCS.

5.5.5 Repairs of defects

5.5.5.1 Where non-destructive tests show unacceptable defects in the welds, the extent of the defects is to be determined. Unacceptable defects are to be removed and re-welded.

5.5.5.2 When unacceptable defects are revealed in a spot examination of welds, two further randomly selected spots are to be examined in the weld length represented by the first spot examination. If these reveal no further unacceptable defects, the defects revealed by the first spot examination are to be removed and repair welding is to be carried out. If the further spot examinations reveal unacceptable defects, the neither:

- .1 the whole weld length represented is to be cut out and re-welded, then subjected to spot examination as if it were a new weld, and the original test plates associated with the weld are to be similarly treated; or
- .2 the whole weld length represented is to be examined. Unacceptable defects are to be repaired and the repaired portions are to be subjected to re-examination.

5.5.5.3 The repairing procedures for pressure shells are to be agreed by CCS. The removing of defects and rewelding are to be completed prior to post-weld heat treatment. The results of the re-examination after repairing are to be to the satisfaction of CCS Surveyor.

CHAPTER 6 WELDING OF IMPORTANT MACHINERY COMPONENTS

Section 1 GENERAL PROVISIONS

6.1.1 Application

6.1.1.1 This Chapter applies to the welding of important components and bedplates of diesel engines, reduction gear boxes, exhaust gas turbochargers.

6.1.2 Consumables

6.1.2.1 The welding consumables employed are to be approved according to the relevant requirements specified in Chapter 3 of this PART.

6.1.3 Approval of welding procedures

6.1.3.1 Prior to the commencement of welding of important welding components, the information specified in 2.1.2 of this PART is to be submitted to CCS for approval.

6.1.3.2 If welding approval procedure tests are required, manufacturers are to carry out the tests in accordance with the relevant requirements of Sections 2 and 3 of this Chapter and for this purpose, representative welds are to be made by simulating the actual welding conditions.

6.1.4 Construction

6.1.4.1 Major components which will be subjected to alternating or impact loads are usually to be butt welded with edge preparation to ensure full penetration.

6.1.4.2 The butt welding of two plates with different thickness is to comply with the relevant requirements of 1.4.3.1 of PART 2 of the Rules.

6.1.4.3 Where a combination of casting and welding is used for components of complex design, care is to be taken to avoid the intersection of welded seams at a acute angle and any abrupt change in cross sections.

6.1.5 Preheating

6.1.5.1 Suitable preheating is to be considered in the following cases:

.1 where heavy components, complex components, and important components specially indicated on plans are welded;

.2 where welding is carried out at an ambient temperature below 0°C and/or high ambient humidity;

.3 where either the carbon content of the weldment or workpiece is greater than 0.23% or the carbon equivalent C_{eq} obtained by is greater than 0.41%,

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15}$$

Section 2 WELDING OF ROTOR SHAFTS

6.2.1 General requirements

6.2.1.1 This Section applies to the welding of rotor shafts of exhaust gas turbochargers.

6.2.1.2 Before the commencement of welding, rotor shafts are to be uniformly preheated and the temperature is to be strictly maintained during welding. The preheating temperature may be dependent on the materials used.

6.2.2 Welding procedure approval test

6.2.2.1 Prior to the commencement of welding, test assemblies are to be prepared in accordance with the welding procedure specification approved by CCS, and deposited metal tensile test, transverse tensile test, face

bend and root bend tests, and macro examination are to be carried out.

6.2.3 Post-weld heat treatment

6.2.3.1 Rotor shafts are to be properly heat treated on completion of welding. The requirements for heat treatment are to be dependent on the materials and welding processes used, subject to agreement of CCS.

6.2.3.2 All superficial and internal defects in the welds are to be completely removed and repaired prior to the post-weld heat treatment.

6.2.4 Non-destructive testing

6.2.4.1 Prior to finish machining, welded rotors are to be subjected to surface inspection by magnetic particle testing or other effective means. Any cracks and other defects thus revealed are to be thoroughly cut out and repaired by welding and then the components are to be heat treated for stress relieving.

Section 3 WELDING OF BEDPLATES, ENGINE FRAMES, CYLINDERS AND CASINGS

6.3.1 General requirements

6.3.1.1 This Section applies to the welding of the machinery components such as the bedplates, engine frames, crankcases and cylinder bodies of diesel engines, and the casings of exhaust gas turbochargers and reduction gearboxes.

6.3.2 Welding procedure approval test

6.3.2.1 For the bedplates and engine frames of diesel engines, test specimens representative of the welded joints are to be prepared for tensile, bend, impact tests and macro examination, and the results are to comply with the following requirements:

Tensile test—not less than the specified minimum tensile strength of the parent metal;

Impact test—not less than the specified minimum average energy of the parent metal;

Bend test—in accordance with the requirements of Table 5.2.4.1 of this PART;

Macroscopic inspection—no cracks, incomplete penetration and lack of fusion, and no unacceptable under cuts, slag inclusions etc.

6.3.3 Preparation before welding

6.3.3.1 The beveling of plate edges is to be performed by gas cutting or machining to the required shape and surface roughness.

6.3.3.2 The component parts to be welded are to be accurately assembled and aligned, and the form of edge preparation and the root gap are to comply with the relevant requirements.

6.3.3.3 Prior to welding, the plate edges to be welded are to be cleaned and free from scale, slag and grease which may affect the welding quality

6.3.3.4 Prior to welding, the plate edges to be welded are to be cleaned and free from scale, slag and grease which may affect the welding quality

6.3.4 Post-weld heat treatment

6.3.4.1 For bedplates made of carbon steel or carbon-manganese steel, the post-weld heat treatment is to be carried out in accordance with the requirements for temperature and soaking time as specified in Table 5.4.3.4 of this PART.

6.3.4.2 Details for the heat treatment of alloy steels are to be submitted to CCS for approval.

6.3.5 Non-destructive testing

6.3.5.1 Examinations of welds by non-destructive methods are to be made on completion of heat treatment as follows:

- .1 Welds in combined beams of diesel engines are to be examined by non-destructive methods agreed by CCS
- .2 Joints of other important machinery components, if deemed necessary by CCS Surveyor, are also to be subjected to non-destructive testing.

CHAPTER 7 WELDING OF PRESSURE PIPES

Section 1 GENERAL PROVISIONS

7.1.1 Application

7.1.1.1 This Chapter applies to manual, automatic, semi-automatic arc welding or other processes approved by CCS, for butt joints in pipes and for joints in the attachment of branch pieces and flanges. Oxy-acetylene welding is to be used only for butt joints in pipes not exceeding 100 mm in diameter or 9.5 mm in wall thickness.

7.1.2 Approval of welding procedures

7.1.2.1 Where any of the following joints is to be welded for the first time or when a new welding procedure is proposed to the following joints, details of the welding procedure specification are to be submitted to CCS for approval, in accordance with the relevant requirements in 2.1.2 of this Chapter:

- .1 attachment of flanges and pipes;
- .2 attachment of valve chests and pipes;
- .3 attachment of fittings and pipes;
- .4 butt joints of pipes to pipes;
- .5 fabrication of branch pieces.

7.1.2.2 The manufacturer is to prepare test specimens with representative joints by simulating the actual welding conditions, for carrying out the welding procedure approval test.

7.1.2.3 Test welds are to be examined for defects in accordance with the requirements given in Section 3 of this Chapter, and then to be sectioned at positions selected by CCS, with one surface of each section being prepared, etched and examined for defects in the weld and heat affected zones.

7.1.2.4 For joints of pipes and branches made of alloy steels, destructive tests and as specified in Section 2, Chapter 1 of this PART, mechanical tests are also required. And for joints of pipes and branches made of carbon and carbon-manganese steels, where deemed necessary by CCS, the mechanical tests may also be required to demonstrate that the joints are of adequate strength.

Section 2 WELDING OF PIPE JOINTS

7.2.1 General requirements

7.2.1.1 All welds are to be away from the bends and expansion compensation portions of pipes and so arranged that the effects of bending moments or alternating loads are minimized.

7.2.1.2 Pipes are to be welded in workshops as far as practicable. Where welding on board is intended, consideration is to be given to an ample space necessary for preheating, welding, heat treatment and inspection.

7.2.1.3 Prior to welding, the surfaces to be welded are to be free from scale, grease, dirt and moisture. The edge preparation and root gap are to comply with the requirements of the welding procedure specification.

7.2.2 Welding

7.2.2.1 During assembling, the axes of pipes are to be properly aligned so as to minimize the offset as far as practicable. The tolerances on the alignment for Class I and II piping systems are not to be greater than those required as follows:

- .1 For pipes welded with fixed backing rings: 0.5mm;
- .2 For pipes welded without fixed backing rings:
 - (1) 1 mm or $t/4$, whichever is the lesser, for internal diameters less than 150 mm and thicknesses up to 6mm;
 - (2) 1.5 mm or $t/4$, whichever is the lesser, for internal diameters less than 300 mm and thicknesses up to 9.5 mm;
 - (3) 2.0 mm or $t/4$, whichever is the lesser, for internal diameters of 300 mm or over, or thicknesses over 9.5 mm.

7.2.2.2 The preheating temperature of pipe joints is to be determined according to the chemical composition of the pipe material and the wall thickness of pipes. The temperature is, in general, to comply with the

requirements in Table 7.2.2.2.

Preheating Temperature of Pipe Joints

Table 7.2.2.2

Type of steel	Thickness of thicker part (mm)	Minimum temperature (°C)
Carbon and carbon-manganese steels ($C + Mn/6 \leq 0.4$)	≥ 20 ^{note 2}	50
Carbon and carbon-manganese steels ($C + Mn/6 > 0.4$)	≥ 20 ^{Note 2}	100
0.3Mo	> 13 ^{Note 2}	100
1Cr0.5Mo	< 13	100
	≥ 13	150
2.25CrMo and 0.5Cr0.5Mo0.25V ^{Note1}	< 13	150
	≥ 13	200

Note 1: For these materials, preheating may be omitted for thicknesses up to 6 mm if hardness tests results for welding procedure approval are accepted by CCS.

Note 2: For welding at ambient temperatures below 0°C, preheating is to be carried out at the minimum preheating temperature regardless of the thickness. Special consideration will be given by CCS to special cases.

Note 3: The values in the Table are based on using low hydrogen processes. When low hydrogen processes are not used, higher preheating temperatures are to be considered.

7.2.2.3 The surface of butt welds is to be uniform with a smooth transition to the base metal.

Section 3 INSPECTION OF WELDING QUALITY

7.3.1 General requirements

7.3.1 Visual inspection, non-destructive testing and hydraulic pressure test are to be carried out after the welding of pipes. The hydraulic tests are to be carried out according to the requirements of Chapter 2, PART 3 of the Rules.

7.3.2 Visual inspection

7.3.2.1 The surface of welds is to be free from cracks, overlaps, pores, undercuts, unfilled cavities and depressions. In case of the above defects, repairs by welding are to be performed.

7.3.3 Non-destructive testing

7.3.3.1 For butt joints of Class I pressure pipes, radiographic testing is to be carried out according to the requirements of Table 7.3.3.1; for butt joints of Class II pressure pipes in positions specified by CCS, radiographic testing is to be carried out. The sensitivity of radiographic testing is to comply with the requirements of 5.5.4.3 of this PART.

Range of Radiographic Testing for Butt Welds of Class I Pressure Pips Table 7.3.3.1

External diameter of pipes (mm)	Range of testing
≤ 76	Random inspection for the positions specified by CCS
> 76	Examination 100% for welds

7.3.3.2 Where radiographic testing is substituted by ultrasonic testing or other equivalent examination, it is to be approved by CCS.

7.3.3.3 For fillet welds of Class I pressure pipes, magnetic particle testing is to be carried out according to Table 7.3.3.3. For fillet welds of Class II pressure pipes in the positions specified by CCS, magnetic particle testing is to be carried out.

Range of Magnetic Particle Testing for Fillet Welds of Class II Pressure Pipes Table 7.3.3.3

External diameter of pipes (mm)	Range of testing
≤ 76	Random inspection for the positions specified by CCS

>76	Examination 100% for welds

Section 4 POST-WELD HEAT TREATMENT

7.4.1 General requirements

7.4.1.1 Carbon and carbon-manganese steel pipes and fabricated branch pieces are to be subjected to stress relieving heat treatment in the following cases:

- .1 The carbon content of steel pipes and fabricated branch pieces exceeds 0.23%;
- .2 The carbon content of steel pipes and fabricated branch pieces does not exceed 0.23%, but the wall thickness exceeds 20mm for Class I pressure pipes, or for 30 mm for Class II pressure pipes.,.

7.4.1.2 All alloy steel pipes and fabricated branch pieces are subjected to suitable heat treatment in the following cases:

- .1 The pipes are connected by electrical arc welding;
- .2 The pipes are formed by heating or processed by bending;
- .3 The pipes are formed by cold bending and have the radius of bending center less than three times of the external diameter of pipes (the radius of bending center is to be measured from the inside edge of elbow).

7.4.1.3 The pipes welded by oxy-acetylene gas are to be subjected to a heat treatment of normalizing and tempering after welding. For the pipes made of carbon or carbon-manganese steels, normalizing treatment may be applied.

7.4.1.4 The temperature of stress relieving heat treatment for carbon and carbon-manganese steels is to be 580℃~620℃, with the soaking time taken as one hour per 25mm of thickness. The temperature of stress relieving heat treatment for alloy steels is to be determined by material composition, and is to be approved by CCS.