



China Classification Society

RULES FOR CONSTRUCTION OF OCEAN-GOING STEEL FISHING VESSELS

2021

Effective From 1 July 2021

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China Classification Society

RULES FOR CONSTRUCTION OF OCEAN-GOING STEEL FISHING VESSELS

2021

GENERAL

GENERAL

1 Application

1.1 Unless expressly provided otherwise, Rules for Construction of Ocean-going Steel Fishing Vessels (hereinafter referred to as the Rules) of China Classification Society (hereinafter referred to as CCS) apply to ocean-going steel fishing vessels of 24 m and over in length (hereinafter referred to as fishing vessels).

1.2 Fishing vessels of less than 24 m in length, reference may be made to the requirements of the Rules.

1.3 Any fishing vessel to be classed with CCS or maintain such class assigned shall also comply with the relevant provisions of PART ONE and CHAPTER 5, PART EIGHT of CCS Rules for Classification of Sea-going Steel Ships.

1.4 The surveys and certifications of marine products shall also comply with the relevant provisions of CCS.

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

1.6 Fishing vessels in polar waters, reference may be made to the relevant applicable requirements of International Code for Ships Operating in Polar Waters.

1.7 MATERIALS and welding of Ocean-going fishing vessels are to comply with the relevant provisions of CCS Rules for Materials and Welding.

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, the rules (including their amendments) will generally come into force in 3 months after being published. The effective date will be indicated on the first page of the corresponding PART or 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 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_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).
- (9) 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.

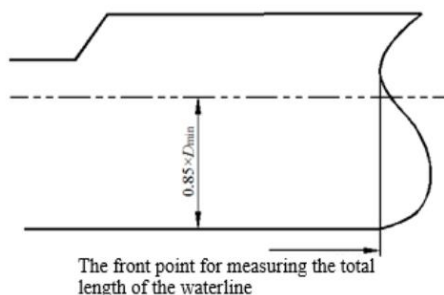


Fig. 6.1 (8)-1 The foremost end of the total length of measurement waterline of a fishing vessel with a concaved stem

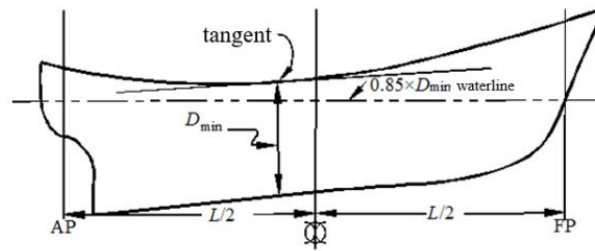


Fig. 6.1 (8)-2 Length of a fishing vessel designed with a tilting keel



China Classification Society

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PART ONE HULL

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

1.1.1.3 Unless expressly provided otherwise, Chapter 1, 2, and 3 of this PART apply to fishing vessels of less than 90 m in length.

1.1.2 Definitions

1.1.2.1 *Length of vessel L* (in m), i.e. the Rule length, means the distance on the waterline at the scantling draught 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 extreme length on the waterline at the scantling draught.

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 waterline at the scantling draught.

1.1.2.2 *Breadth of vessel B* (in m) means the horizontal distance measured over the main frames at the widest part of the ship

1.1.2.3 *Moulded depth D* (in m) means the vertical distance measured at the middle of the length L from keel line to top of the deck beam at side on the uppermost continuous deck. 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), i.e. the scantling draught, means the vertical distance measured at the middle of the length L from keel line to the waterline at the scantling draught. Scantling draught means at which the strength requirements for the scantlings of the ship are met and represents the full load condition. The scantling draught is to be not less than that corresponding to the assigned freeboard.

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

1.1.2.8 *Strength deck* means

(1) the uppermost continuous deck;

(2) the superstructure deck extending within $0.5 L$ amidships, and having a length not less than $0.15 L$, and the uppermost continuous deck extending outside the region of such a superstructure.

1.1.2.9 *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.

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

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

1.1.2.12 *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.

1.1.2.13 *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.

1.1.2.14 *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.

1.1.2.15 *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.

1.1.2.16 *Secondary members*: The stiffeners of the hull plate are generally regarded as secondary members, i.e. frames, beams, longitudinals, bulkhead stiffeners and members of bracket floors, etc.

1.1.2.17 *Block coefficient* C_b is the moulded block coefficient corresponding to the waterline at the scantling draught, and to be determined by the following formula:

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

Where, ∇ — moulded displacement corresponding to the scantling draught, in m³

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

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

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

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

1.1.2.21 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.

1.1.4 List of Plans for submission

1.1.4.1 Plans and documents covering the following items are to be submitted to CCS for approval. In the case of special constructions and arrangements, additional plans and documents may be required if considered necessary by CCS:

- (1) General arrangement;
- (2) Principal transverse sections;
- (3) Construction profile, longitudinal sections, decks, inner bottom, superstructures and deckhouses;
- (4) Shell expansion;
- (5) Aft part structures, including stem;
- (6) Fore part structures, including stern frame;
- (7) Oiltight and watertight bulkheads;
- (8) Machinery space structures
- (9) Main engine seating and thrust bearing seating;
- (10) Propeller shaft bracket;
- (11) Hatch coamings and fish-holds hatch covers
- (12) Longitudinal strength calculations (where applicable);
- (13) Rudder system arrangement
- (14) Rudder, rudder blade, rudder stock and pintles;
- (15) Arrangement of anchoring and mooring equipment;
- (16) Duct structures (where applicable);
- (17) Ice strengthening with calculations;
- (18) Welding type;
- (19) Additional plans and documents if considered necessary by CCS.

1.1.4.2 The following plans and documents are to be submitted to CCS for information:

- (1) Specifications for hull and equipment;
- (2) Lines or offsets;
- (3) Capacity plan of fish-holds;
- (4) Body plan (frame lines);
- (5) Rule calculations of hull structures;
- (6) Rudder system calculations;
- (7) Arrangement and calculations of fishing machinery equipment and lifting appliances;
- (8) Arrangement of movable bulkhead in bulk fish tank (where applicable).

Section 2 HULL STRUCTURE MEMBERS

1.2.1 General Requirements

1.2.1.1 Except where otherwise stated, the Rule section modulus or moment of inertia in this PART is the minimum required value of the section in association with attached plating, and the attached plating is assumed as being normal to the web. When the attached plating is not normal to the web and the angle between them is less

than 75°, the sectional characteristics (moment of inertia, section modulus and shear area) are to be calculated in respect to the axis parallel to the attached plating. When a structural member is of rolled section(s), its actual section modulus may be approximately determined by the following formula:

$$W = W' \sin \alpha \quad \text{cm}^3$$

where: W' — actual section modulus with the attached plating assumed as being normal to the web, in cm^3 ;

α — angel between web and attached plating, in degrees.

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 Geometrical characteristics of members may be calculated in accordance with Appendix I of this PART.

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:

$$A = 10fbt_p \quad \text{cm}^2$$

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

$$A = 10at \quad \text{cm}^2$$

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

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

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, m;

t_p — the mean thickness, in mm, of the attached plating, mm;

l — the overall length, in m, of the primary member;

a — the width, in m, of corrugated plating flange, m;

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):

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

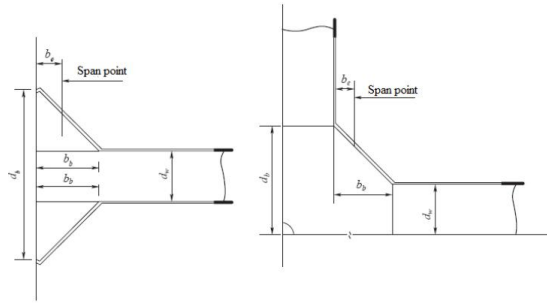


Fig. 1.2.3.2 Span points of primary members

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)).

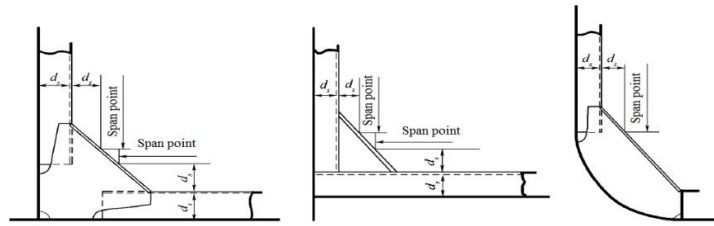


Fig. 1.2.3.3(1) Span points of primary members

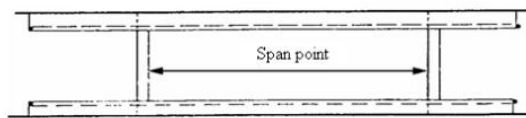


Fig. 1.2.3.3(2) Measuring points of secondary member span

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 the effective continuity of the 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. If the fish-holds are of liquid storage type, the primary members in tank 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 fish-holds 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 $d_w t_w / 150 (\text{cm}^2)$, (where d_w is depth of primary member web, in mm, t_w is 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 $0.06t_b$, the tripping brackets are to have face plate or flange, and the sectional area A (in cm^2) of which is generally not to be less than $10l_b$.

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 $0.4L$ amidships, where the web height of strength deck girders is greater than $65t\sqrt{K}$ (t being web thickness, while K being material factor), an additional horizontal stiffener is to be fitted parallel to and at a distance of $1/4$ web depth from the face plate.

1.2.5 Secondary member end connections

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

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

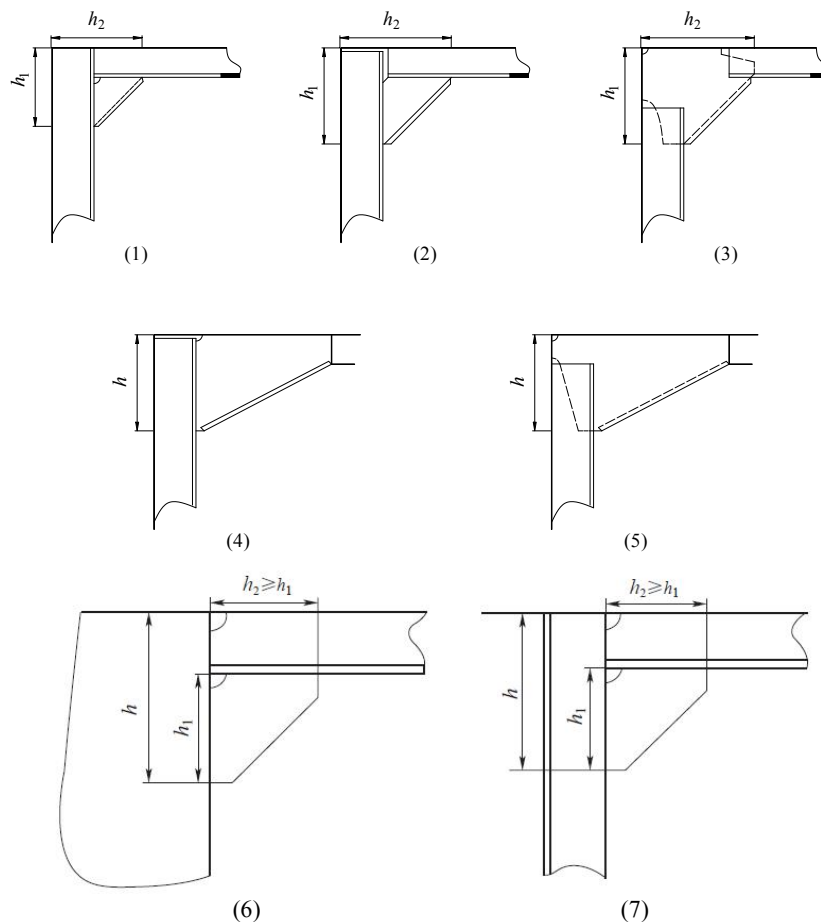


Fig. 1.2.5.2 Secondary member end connections

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 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:

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

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, the end connections of primary members are to be in compliance with the requirements of this article.

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. The distance from the stiffeners near the face plate to the face plate is not to be greater than 30 times the thickness of the bracket. The spacing of other stiffeners may not be greater than 45 times the thickness of bracket plating.

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.

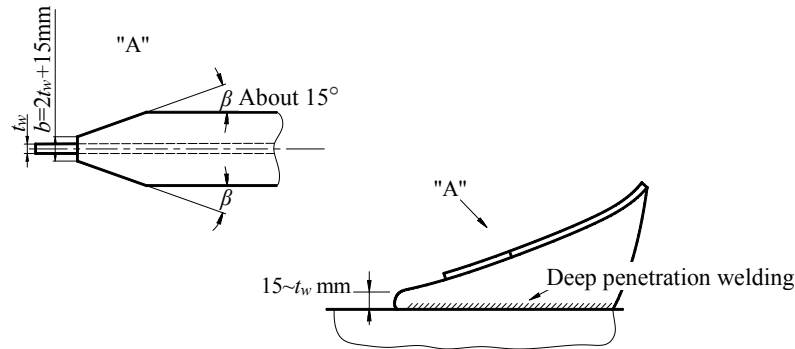


Fig. 1.2.6.6 Structure form at the bracket toe

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.

$$s_b = 0.0016L + 0.5 \quad \text{m}$$

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 1 of CCS Rules for Materials and Welding.

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 1 of CCS Rules for Materials and Welding.

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 Chapter 5 and Chapter 6 of PART 1 of CCS Rules for Materials and Welding.

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

Notes: ① Austenitic stainless steel may generally be used.

② Grade FH may generally be used.

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 -10 °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 . The design temperature t_D is to be taken as defined in 1.3.5.6.

1.3.5.2 Materials in the various strength members above the lowest ballast waterline (BWL) exposed to low air temperatures (including the plating covered by note ① of Table 1.3.5.2) are not to be lower than those as given in Table 1.3.5.2. For non-exposed hull structural steel above BWL (except for ① as indicated in Table 1.3.5.2) and hull structural steel below BWL, the requirements in 1.3.2 of this Section apply.

Material Classes at Low Temperatures

Table 1.3.5.2

Structural member category	Structural member	Material class	
		Within 0.4L amidships	Outside 0.4L amidships
Secondary	Deck plating exposed to weather in general, side plating above BWL, transverse bulkheads above BWL ^①	I	I
Primary	Strength deck plating ^② Continuous longitudinal members above strength deck (excluding longitudinal hatch coamings) Longitudinal bulkhead above BWL ^① Top wing tank bulkhead above BWL ^①	II	I
Special	Sheer strake at strength deck, including rounded gunwale Stringer plate in strength deck Deck strake at longitudinal bulkhead	III	II

Notes: ① Applicable to plating attached to hull envelope plating exposed to low air temperature. At least one strake is to be considered in the same way as exposed plating and the strake width is to be at least 600 mm.

② Class III or grade E/EH to be applied in positions where high local stresses may occur.

1.3.5.3 Grades of steel for hull structural members are to be selected according to Table 1.3.5.3 depending on plate thickness and design temperature. Where the design temperature t_D is below -55 °C, the grades of steel are to be subject to special consideration by CCS.

1.3.5.4 Single strakes required to be of class III or of grade E/EH or FH are to have breadths not less than 800 + 5L mm (L being length of the ship, in m), but need not be greater than 1,800 mm.

1.3.5.5 Plating materials for stern frames, rudders, rudder horns and shaft brackets are not to be of lower grades than those required in 1.3.2 of this Section.

1.3.5.6 The design temperature t_D is to be taken as the lowest mean daily average air temperature in the area of operation, where:

mean: statistical mean over observation period;

daily average: average during one day and night;

lowest: lowest during year.

The temperature definition see Figure 1.3.5.6

For seasonally restricted service the lowest value within the period of operation applies. For the purpose of issuing a Polar Ship Certificate in accordance with the Polar Code, the design temperature t_D is to be no more than 13°C higher than the Polar Service Temperature (PST) of the ship. In the Polar Regions, the statistical mean over observation period is to be determined for a period of at least 10 years.

Material Grade Requirements at Low Temperatures

Table 1.3.5.3

Class I										
Plate thickness, in mm	-11~-15°C		-16~-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	Mild steel	Higher tensile steel
$t \leq 10$	A	AH	A	AH	B	AH	D	DH	D	DH
$10 < t \leq 15$	A	AH	B	AH	D	DH	D	DH	D	DH
$15 < t \leq 20$	A	AH	B	AH	D	DH	D	DH	E	EH
Class II										
Plate thickness, in mm	-11~-15°C		-16~-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	Mild steel	Higher tensile steel
$t \leq 10$	A	AH	B	AH	D	DH	D	DH	E	EH
$10 < t \leq 20$	B	AH	D	DH	D	DH	E	EH	E	EH
Class III										
Plate thickness, in mm	-11~-15°C		-16~-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	Mild steel	Higher tensile steel
$t \leq 10$	B	AH	D	DH	D	DH	E	EH	E	EH
$10 < t \leq 20$	D	DH	D	DH	E	EH	E	EH	—	FH

Note: “—” in the Table is Not applicable.

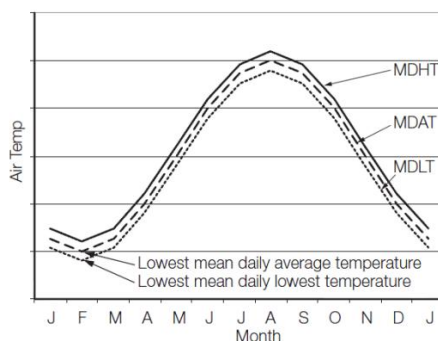


Figure 1.3.5.6 General Temperature Definitions

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 1 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: $t_a = t_s \sqrt{K_a}$ mm

For section modulus: $W_a = W_s K_a$ 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 $K_a = \frac{235}{R'_{lim}}$;

R'_{lim} — the minimum yield stress $R'_{p0.2}$ of parent material which could be guaranteed under welding condition, in N/mm², to be taken not greater than 70% minimum tensile strength R'_m of parent material which could be guaranteed under welding condition:

$$R'_{p0.2} = \eta_1 R'_{p0.2}$$

$$R'_m = \eta_2 R'_m$$

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

R'_m — the minimum tensile strength of parent material which could be guaranteed under delivery condition, in N/mm²; η_1 and η_2 are given in Table 1.3.6.3 (1) .

Aluminium Alloy used for Welded Structures

Table 1.3.6.3(1)

Aluminium alloy	η_1	η_2
Not treated by hardening (5000 series under annealed condition O or annealing leveling condition H111)	1	1
Treated by hardening (5000 series other than O or H111)	$R'_{p0.2} / R'_{p0.2}$	R'_m / R'_m
Heat treated and hardened (6000 series) ¹	$R'_{p0.2} / R'_{p0.2}$	0.6

Note ①: If information is not provided, the factor η_1 is to be taken as metallographic efficiency coefficient β defined in Table 1.3.6.3(2);

$R'_{p0.2}$ — the minimum yield stress of material which could be guaranteed under welding condition, in N/mm²;

R'_m — the minimum tensile strength of material which could be guaranteed under welding condition, in N/mm².

Aluminum Alloy — Metallographic Efficiency Coefficient β

Table 1.3.6.3(2)

Aluminium alloy	Tempering condition	Total thickness (mm)	β
6005A (opening section)	T5 or T6	$t \leq 6$	0.45
		$t > 6$	0.40
6005A (closed section)	T5 or T6	All	0.50
6061 (section)	T6	All	0.53
6082 (section)	T6	All	0.45

1.3.6.4 The welding procedures for aluminium alloy are to be subject to approval. The methods used for connecting aluminium alloy with steel members and the information for measures to be taken for corrosion control are to be submitted to CCS for examination.

1.3.7 Use of stainless steel

1.3.7.1 Stainless steel may be used for fish hatch to equivalently substitute the hull structure steels required in the Rules.

1.3.7.2 Except where otherwise stated, the elastic modulus of stainless steel may be taken as 2.06×10^5 N/mm².

1.3.7.3 The material factor K_l is to be calculated by the following formula:

$$K_l = \frac{235}{R_{eHT}}$$

Where: R_{eHT} — the minimum yield strength or non-proportional extension strength of stainless steel under the designed allowable maximum catch temperature, N/mm², to be calculated by the following formulae:

for no nitrogen austenitic stainless steel:

$$R_{eHT} = -40 \ln(T) + 127 + R_{p0.2}$$

for nitrogen austenitic stainless steel:

$$R_{eHT} = -48 \ln(T) + 142 + R_{p0.2}$$

for duplex stainless steel:

$$R_{eHT} = -65 \ln(T) + 200 + R_{p0.2}$$

T — the designed allowable maximum catch temperature, in °C;

$R_{p0.2}$ — the minimum yield strength or non-proportional extension strength of stainless steel, in N/mm² at room temperature, in accordance with the relevant requirements of Section 8, Chapter 3, PART ONE of CCS Rules for Materials and Welding.

1.3.7.4 The scantlings of stainless steel structure may be obtained from the following formula:

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

For section modulus: $W_a = W_s K_I$ 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_I — see 1.3.7.3 of this Section;

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).

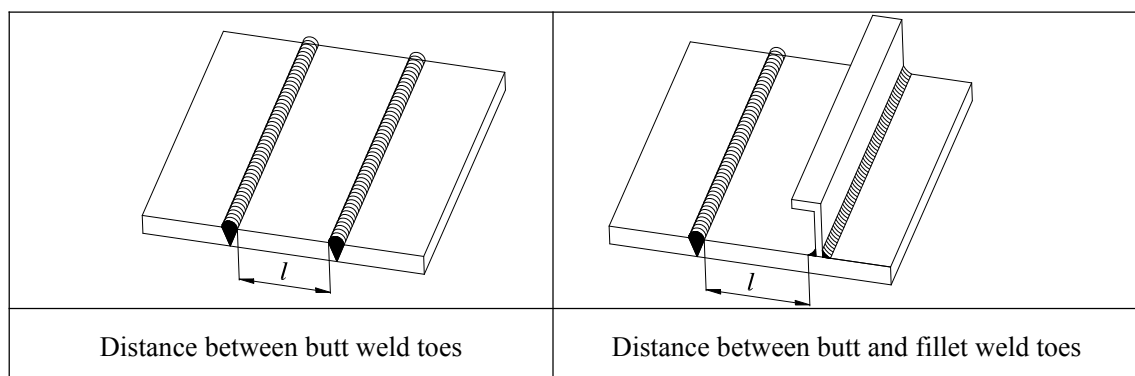


Fig. 1.4.1.4 Weld spacing measurement position

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, laundry rooms, bathrooms, toilets, pantries 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 Where higher tensile steel is used, double continuous fillet welds are normally to be adopted.

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 2 of PART THREE of CCS Rules 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

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

Note: “×” means applicable;

① When joining structural steels of normal strength, it is not recommended to use a much higher grade of welding consumable.

② When using Grade 1Y welding consumables, the material thickness should not exceed 25 mm.

1.4.2.2 For the joining of steels of different strength levels, the welding consumables in general may be of a type suitable for the lower strength level except at structural discontinuities or areas of stress concentration. For the joining of steels of the same strength level but of different toughness grades, the welding consumables in general may be of a type suitable for the lower toughness grade except for the structural members subjected to complicated forces or severe construction conditions.

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) End and side joints of the shell of ships with ice strengthening;
- (3) Masts, derricks, boat davits, portal frame, bollards and other outfits subjected to heavy loads and all other highly stressed fittings;
- (4) 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;

(5) Main engine seatings and the associated structural members, winches seatings of fish vessels and the associated structural members.

1.4.2.4 It is recommended that low hydrogen welding consumables be used for the joining of higher strength structural steel or of steel with carbon equivalent over 0.41%.

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 3 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 Overlaps are generally not to be used to connect plates which may be subjected to high tensile stress or compressive loading. 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.

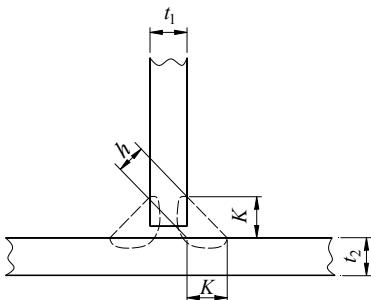
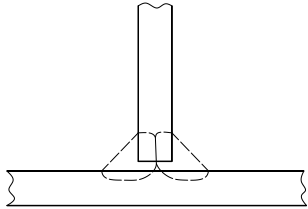
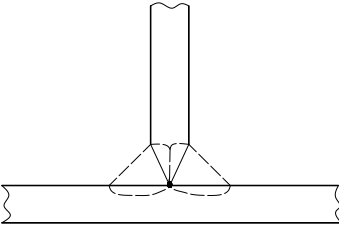
1.4.3.4 Connection of rudder side plating to vertical and horizontal webs, where internal access for fillet welding is not practicable, is to be by means of slot welds on to flat bars on the webs. The slots are to have a minimum length of 75 mm and, in general, a minimum width of twice the side plating 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.

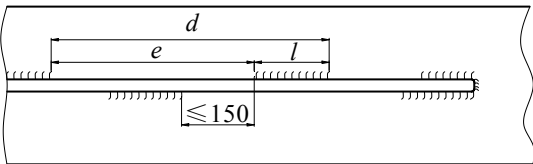
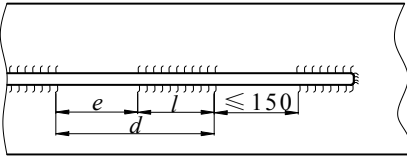
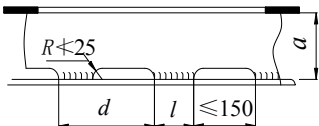
1.4.4 Fillet welds

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:

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

Where: w_{τ} — weld factor. The weld factors used for hull structures are as specified in Table 1.4.4.2(1) 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:

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

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 factor	Remark
1 General application (except as required below):		
(1) Watertight or oiltight plate boundaries	0.34	
(2) Non-tight plate boundaries	0.13	
(3) Longitudinals, frames, beams, and other secondary members to shell, deck or bulkhead plating	0.10	
	0.13	In tanks
	0.21	In way of end connections
(4) Panel stiffeners (i.e. small stiffeners)	0.1	
(5) Overlap welds	0.27	
(6) Longitudinals of the flat-bar type to plating	0.21	Double continuous

2 Bottom structure of fish holds area		
(1) Tight centre girder: to keep	0.44	Deep penetration welding
to inner bottom	0.44	
(2) Non-tight centre girder (or centre keelson):to keel	0.27	
to inner bottom (or face plate of centre keelson)	0.21	No scallops
(3) Tight boundaries of floors, girders	0.39	
(4) Non-tight boundaries of floors, girders (or side keelson) and	0.21	In way of $0.2 \times \text{span}$ at ends
brackets	0.27	In way of brackets at lower end of main frame
(5) Inner bottom longitudinals or reverse frames to inner bottom	0.13	
(6) Floors supporting plane bulkhead, corrugated bulkhead to inner bottom	0.44	Double continuous
3 Hull framing		
(1) Web frames to shell or stringers to shell	0.16	Main webs to shell plating 0.16
(2) Webs of stringers to face plate or webs of web frames to face plate	0.13	
(3) Tank side brackets to shell and inner bottom	0.34	End bracket of frame to shell plating 0.34
4. Decks and supporting structure		
(1) Strength deck plating to shell	0.44	See 5.2.5 of PART THREE of CCS Rules for Materials and Welding
(2) Other decks to shell and bulkheads (except where forming tank boundaries)	0.21	Generally double continuous
(3) Webs of cantilevers to deck and to shell in way of root bracket	0.44	
(4) Webs of cantilevers to face plate	0.21	
(5) Pillars: end connections	0.34	
end connections (tubular)	0.44	Deep penetration $t > 10\text{mm}$ turn on groove
(6) Girder web connections and brackets in way of pillar heads and heels	0.21	
(7) Web plates of hatch girders and deck web beams to deck, their face plates	0.16	
5 Bulkhead and liquid tank structure		
(1) watertight plane bulkheads boundaries	0.39	
(2) Stiffeners on watertight bulkheads where acting as pillars	0.13	
(3) watertight corrugated bulkheads boundaries	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 (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	0.27	
(3) Non-tight floors and girders (or side keelsons) to shell and inner bottom	0.21	
(4) Main engine foundation girders to top plate	0.44	Deep penetration, edge to be prepared with maximum root $\leq t/3$.
Main engine foundation girders to hull structure	0.44	
Main engine foundation girders to floors	0.27	
Main engine foundation girders to brackets	0.21	
(5) Transverse and longitudinal framing to shell	0.13	
7. Construction in 0.25L forward		
(1) Floors and girders (or centre keelson, etc.) to shell and inner bottom	0.21	
(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) All internal structure in fore peak	0.13	Unless a greater weld factor is required
8 Aft peak construction: All internal structure including stiffeners on aft peak bulkhead	0.21	Unless a greater weld factor is required
9. Superstructure and deckhouses		
(1) Connection of external bulkheads to deck	0.34	1st and 2nd tier erections
	0.21	Elsewhere
(2) Internal bulkheads to deck	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	0.13	
to deck	0.21	
(3) Hatch cover rest bar	0.16	
(4) Cleats and fittings	0.44	Increased welding may be required
(5) Primary and secondary stiffening of hatch covers	0.10	0.13 for tank covers and where covers strengthened for loads over
11. Steering control systems		
(1) Rudder		
① Fabricated main piece and main piece to side plates and webs	0.44	Increased welding may be required
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	Positions 1 and 2 specified by Load Line assignment
(2) Frames of shell and weathertight bulkhead doors	0.34	
(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) Bracket of portal frame, mast(posts), derrick posts (trawl beam) to deck	0.44	PART THREE of CCS Rules for Materials and Welding
(8) Seats of web winder, winches, windlass to deck	0.44	Special equipment subject to design
(9) Deck machinery seats to deck	0.21	Increased or full penetration welding maybe required
(10) Mooring equipment (bollards, etc.) seats to deck	0.21	
(11) Bulwark stays to deck	0.21	
(12) Bulwark attachment and guard rails, stanchions, etc., to deck	0.34	
(13) Bilge keel backing bars to shell	0.34	
(14) Bilge keels to backing bars	0.21	

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:

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

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

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.

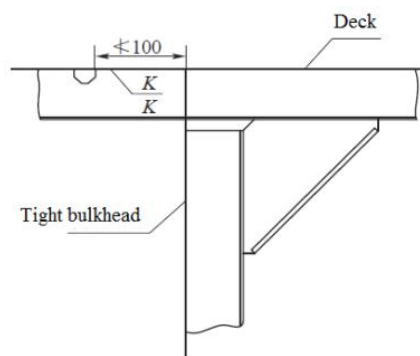


Fig. 1.4.4.7 Position of double-sided continuous round-the-end weld

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_s , in cm^2	Position ^①	In tanks		In dry spaces	
		To face plate	To plating	To face plate	To plating
		w_t	w_t	w_t	w_t
$A \leq 30$	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 ^②	0.21	0.27
	Remainder	0.27	0.34	0.16	0.21
$95 < A \leq 130$	End	0.34	0.44 ^②	0.27	0.34
	Remainder	0.27	0.34	0.21	0.27
$130 < A$	At ends	0.44	0.44 ^②	0.34	0.44 ^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 $0.44t_p$ or $0.34t_c$, 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_t 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_t 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_t
1 Stiffener welded direct to deck, shell, bulkhead plating etc.	$0.25A_s$ or 6.5	0.34
2 Stiffener to bracket or bracket lapped to stiffener		0.27 0.34 0.34
(1) in dry space		
(2) in tank		
(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) $\times$ weld throat thickness (cm).

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.

1.4.4.13 Partial or full penetration welds

In areas with high stresses or areas considered critical (e.g. areas where fatigue cracks may easily initiate), full or partial penetration welds are to be used.

In case of full penetration welding, there is no requirement for root face.

For partial penetration welds, the requirements for root face are referred to in 5.2.5.1 of Chapter 5, PART THREE of Rules for Materials and Welding.

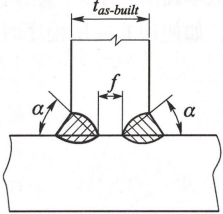
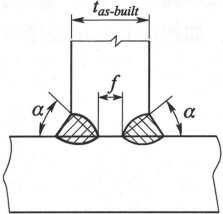
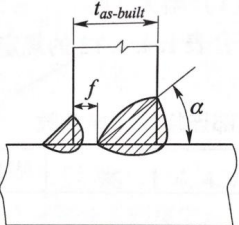
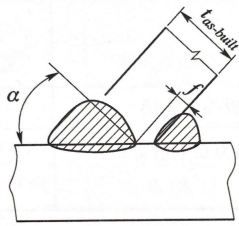
The groove angle made to ensure welding bead penetrating up to the root of the groove, α , is usually from 40° to 60° .

The welding bead of the full/partial penetration welds is to cover root of the groove.

The effective length of weld throat is to be the sum of height of weld throats at both ends of the groove.

Partial and full penetration welds

Table 1.4.4.13

No.	Name of weld	Type	Remarks
1	Full penetration welding		One of the double continuous fillet welds, which is used in areas with high tensile stresses or areas considered critical $t_{as-built}$ —as-built thickness of weldment f —root face to be taken as 0 α —groove angle
2	Double symmetrical groove partial penetration welding		One of the double continuous fillet welds, which is used in areas with high tensile stresses or areas considered critical $t_{as-built}$ —as-built thickness of weldment f —root face α —groove angle
3	Double asymmetrical groove partial penetration welding		One of the double continuous fillet welds, which is used in areas with high tensile stresses or areas considered critical $t_{as-built}$ —as-built thickness of weldment f —root face α —groove angle
4	Double asymmetrical groove partial penetration welding		One of the double continuous fillet welds, which is used in areas with high tensile stresses or areas considered critical $t_{as-built}$ —as-built thickness of weldment f —root face α —groove angle

Section 5 USE OF HIGHER TENSILE STEEL

1.5.1 General Requirements

1.5.1.1 Steels having a yield point not less than 265 N/mm^2 are regarded as higher tensile steels. The chemical compositions and mechanical properties of higher tensile steel are to comply with the relevant requirements of SECTION 3, CHAPTER 3, PART ONE of CCS Rules for Materials and Welding.

1.5.1.2 Where higher tensile steel is used for hull structures, its category, grade, location and extent are to be marked on the structural drawings so as to facilitate 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 Where higher tensile steel is used in the construction of hull structure amidships, the minimum midship section modulus W_{h0} and moment of inertial I_h are not to be less than the values given by the following formulae respectively:

$$W_{h0} = K W_0 \quad \text{cm}^3$$

$$I_h = 3 W_0 L \quad \text{cm}^4$$

Where: W_{h0} — minimum midship section modulus, in cm^3 ; to be calculated in accordance with 2.1.5.1 of CHAPTER 2 of this PART;

K — material factor as specified in 1.5.1.3 of this Section.

1.5.2.2 Where higher tensile steel is used in some portions of hull, the vertical extent of application of the higher tensile steel is not to be less than:

Where higher tensile steel is applied to the strength deck, the region $y_1(1-K)$ below the deck line is to be made of higher tensile steel; where applied to the bottom, the region $y_2(1-K)$ above the keel is to be made of higher tensile steel. y_1 and y_2 are the vertical distances from the neutral axis to the deck line at side and to the plate keel respectively, in m, as shown in Figure 1.5.2.2. K is material factor, F_d and F_b are as defined in 2.2.5.7 of this PART.

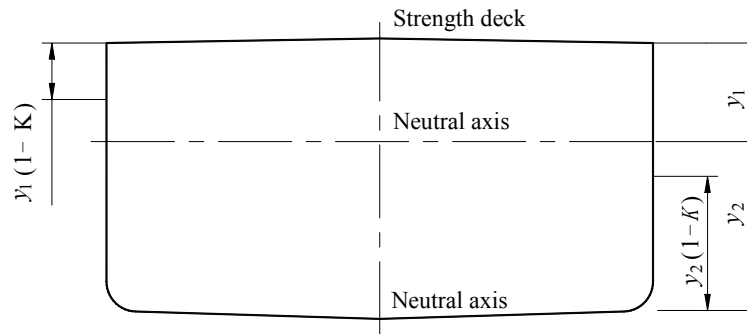


Fig. 1.5.2.2 Vertical arrangement range of higher tensile steel

1.5.2.3 Where higher tensile steel is used amidships and low carbon steel at the ends of the ship, the region in which higher tensile steel is used is to be extended to the points where the thickness required for the low carbon steel is equal to that of the higher tensile steel (See Figure 1.5.2.3).

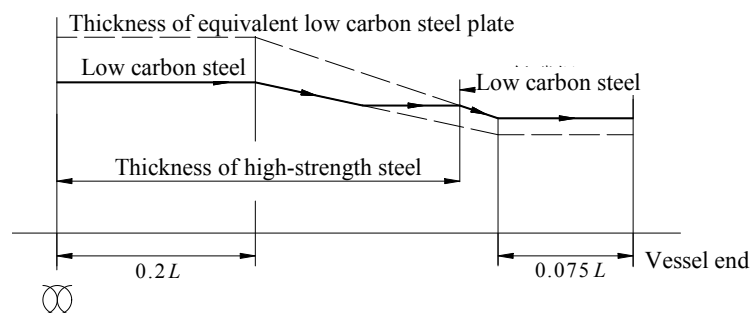


Fig. 1.5.2.3 Longitudinal arrangement range of higher tensile steel

1.5.2.4 Where higher tensile steel is applied to strength deck structure, corresponding higher tensile steel is usually to be applied to the continuous members (e.g. stiffening members of hatch coamings and deck openings) welded to strength deck.

1.5.3 Local strength

1.5.3.1 Where higher tensile steel is applied to shell plating or strength deck within $0.4L$ amidships, the thickness t_h of shell plating or strength deck is not to be less than the values given by the following formulae:

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

Where: t — the thickness of mild steel used for shell plating and strength deck respectively, in mm;

K — Material factor, see 1.5.1.3 of this PART;

s — Length of the shorter side of a single plate field for mild steel, in m;

s_h — Length of the shorter side of a single plate field for higher tensile steel, in m;

1.5.3.2 With the exception of 1.5.3.1 and Section 9 of CHAPTER 2 in this PART, the plating thickness t_h ,

section modulus W_h and moment of inertia I_h of all other structural members using higher tensile steel are not to be less than the values obtained from the following formulae:

$$\begin{aligned}t_h &= t\sqrt{K} && \text{mm} \\W_h &= WK && \text{cm}^3 \\A_h &= AK && \text{cm}^2 \\I_h &= I && \text{cm}^4\end{aligned}$$

Where: t — Rule thickness for mild steel structural members, in mm;

W — Rule section modulus for mild steel structural members, in cm³

A — Rule sectional areas for mild steel structural members, in cm²;

I — Rule moment of inertia for mild steel structural members, in cm⁴;

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, 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 catch spaces, inner surface of hatch coamings and fish-holds hatch covers, side shell plating transverse bulkheads as well as their stiffeners and end brackets exposed to the catch 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 or an impressed current cathodic protection system are to be provided on the hull plating, rudder blades and subsea valve box. Where anodes are fitted, the material, type, quantity, and distribution of the anodes are to comply with industry standards currently in effect.

1.6.1.7 Where a primer is used to coat steel during construction, the primer is to be applied right after surface preparation. The composition of the primer is to be such that it will have no significant deleterious effect on subsequent welding work and that it is compatible with the paints or other coatings subsequently applied in association with an approved system of corrosion control for structures. Primers are subject to approval in accordance with the relevant CCS requirements.

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.

1.6.2.4 For fish vessels subject to in-water survey instead of drydocking survey, the underwater portion of the hull is to be coated with a high resistant paint. Details of the high resistant paint are to be submitted to CCS for information.

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 These test procedures are to confirm the watertightness of tanks and watertight boundaries and the structural adequacy of tanks which consist of the watertight subdivisions of ships. These procedures may also be applied to verify the weathertightness of structures and shipboard outfitting. The tightness of all tanks and watertight boundaries of ships during new construction and those relevant to major conversions or major repairs¹ is to be confirmed by these test procedures prior to the delivery of the ship.

1.7.2 Application

1.7.2.1 All gravity tanks² and other boundaries requiring watertight or weathertight verification are to be tested in accordance with this procedure and proven to be tight and structurally adequate as follows:

- (1) gravity tanks for their tightness and structural adequacy;
- (2) watertight boundaries other than tank boundaries for their watertightness; and;
- (3) weathertight boundaries for their weathertightness.

1.7.2.2 The testing of structures not listed in Table 1.7.2.2 are to be specially considered.

Test requirements for tanks and boundaries **Table 1.7.2.2**

No.	tanks or boundaries to be tested	Test type	Test head or pressure	Remark
1	Double bottom tanks	Leak and structural ^{note①}	The greater of: • top of the overflow • to 2.4m above top of tank ^{note②} , or • to bulkhead deck	
2	Double bottom voids ^{note③}	Leak	See 1.7.4.4 (4) through 1.7.4.4 (6), as applicable	including pump room double bottom and bunker tank protection double hull required by MARPOL Annex I
3	Double side tanks	Leak and structural ^{note①}	The greater of - top of the overflow, - to 2.4 m above top of tank ^{note②} , or - to bulkhead deck	
4	Double side voids	Leak	See 1.7.4.4 (4) through 1.7.4.4 (6), as applicable	
5	Deep tanks other than those listed elsewhere in this Table	Leak and structural ^{note①}	The greater of - top of the overflow, - to 2.4 m above top of tank ^{note②} ,	

¹ Major repair means a repair affecting structural integrity.

² Gravity tank means a tank that is subject to vapor pressure not more than 70 kPa.

6	Peak tanks	Leak and structural ^{note①}	The greater of - top of the overflow, - to 2.4 m above top of tank ^{note②}	After peak to be tested after installation of stern tube
7	(1) Forepeak space with equipment	Leak	See 1.7.4.4 (3) through 1.7.4.4 (6), as applicable	
	(2) Forepeak voids	Leak	See 1.7.4.4 (4) through 1.7.4.4 (6), as applicable	
	(3) Afterpeak space with equipment	Leak	See 1.7.4.4 (3) through 1.7.4.4 (6), as applicable	
	(4) Afterpeak voids	Leak	See 1.7.4.4 (4) through 1.7.4.4 (6), as applicable	After peak to be tested after installation of stern tube
8	Cofferdams	Leak	See 1.7.4.4 (4) through 1.7.4.4 (6), as applicable	
9	(1) Watertight bulkheads	Leak	See 1.7.4.4 (3) through 1.7.4.4 (6), as applicable ^{note ⑥}	
	(2) Superstructure end bulkheads	Leak	See 1.7.4.4 (3) through 1.7.4.4 (6), as applicable	
10	Watertight doors below working deck	Leak ^{note⑤} and ^⑥	See 1.7.4.4 (3) through 1.7.4.4 (6), as applicable	
11	Double plate rudder blades	Leak	See 1.7.4.4 (4) through 1.7.4.4 (6), as applicable	
12	Shaft tunnels clear of deep tanks	Leak ^{note③}	See 1.7.4.4 (3) through 1.7.4.4 (6), as applicable	
13	Shell doors	Leak ^{note③}	See 1.7.4.4 (3) through 1.7.4.4 (6), as applicable	
14	Weathertight hatch covers and closing appliances	Leak ^{note③} and ^⑥	See 1.7.4.4 (3) through 1.7.4.4 (6), as applicable	Hatch covers closed by tarpaulins and battens excluded
15	Dual purpose tanks/dry cargo hatch covers	Leak ^{note③} and ^⑥	See 1.7.4.4 (3) through 1.7.4.4 (6), as applicable	Hatch covers closed by tarpaulins and battens excluded
16	Chain lockers	Leak and structural ^{note①}	Top of chain pipe	
17	L.O. sump. tanks and other similar tanks/spaces under main engines	Leak ^{note⑦}	See 1.7.4.4 (3) through 1.7.4.4 (6), as applicable	
18	Ballast ducts	Leak and structural ^{note①}	The greater of: ● Ballast pump maximum pressure, or ● Setting of any pressure relief valve	
19	Fuel Oil tanks	Leak and structural ^{note①}	The greater of: ● Top of the overflow; ● to 2.4m above the top of tank ^{note②} , or ● to top of tank ^{note②} plus setting of any pressure relief valve, or ● to bulkhead deck	

Note ①: Refer to 1.7.4.2 (2).

Note ②: The top of a tank is the deck forming the top of the tank, excluding any hatchways.

Note ③: Hose Test may also be considered as a medium of the test. See 1.7.3.2.

Note ④: Including duct keels and dry compartments, and/or oil fuel tank protection and pump room bottom protection arranged in accordance with the provisions of MARPOL Annex I, Chapter 3, Part A regulation 12A and Chapter 4, Part A, regulation 22 respectively.

Note ⑤: 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 II-1/16.2 and Notification MSC / Circ.1176).

Note ⑥: As an alternative to the hose testing, other testing methods listed in 1.7.4.4 (7) through 1.7.4.4 (9) may be applicable subject to adequacy of such testing methods being verified. (See SOLAS II-1/11.1). An alternative to the hose testing may only be used where a hose test is not practicable.

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

1.7.3 Test types and definitions

1.7.3.1 The following two types of tests are specified in this requirement:

(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 a hydrostatic/hydropneumatic test or an air test. A hose test may be considered an acceptable form of leak test for certain boundaries, as indicated by Footnote 3 of Table 1.7.2.2.

1.7.3.2 The definition of each test type is shown in Table 1.7.3.2.

Test Type

Table 1.7.3.2

Hydrostatic test (Leak and structural)	A test wherein a space is filled with a liquid to a specified head.
Hydropneumatic test: (Leak and structural)	A test combining a hydrostatic test and an air test, where in a space is partially filled with a liquid and pressurized with air.
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.
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.
Compressed Air Fillet Weld test (Leak)	An air test of fillet welded tee joints wherein leak indicating solution is applied on fillet welds.
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.
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.
Penetration 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 tension liquids (i.e. dye penetrant test)..

1.7.4 Test procedures

1.7.4.1 General

(1) Tests are to be carried out in the presence of a Surveyor at a stage sufficiently 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 1.7.4.4 and Table 1.7.2.2. For the timing of the application of coating and the provision of safe access to joints, see 1.7.4.5, 1.7.4.6 and Table 1.7.4.1 (1).

Provisions for application of the safety access, coating and penetration test of different types of welded joints Application of Leak Test, Coating and Provision of Safe Access for Type of Welded Joints

Table 1.7.4.1 (1)

Type of welded joints		Leak test	Coating ^{Note①}		Safe access ^{Note②}	
			Before leak test	After leak test & structural tests	Leak test	Structural test
Butt	Automatic	Not required	Allowed ^{Note③}	N/A	Not required	Not required
	Manual or Semi-automatic ^{Note④}	Required	Not allowed	Allowed	Required	Not required
Fillet	Boundary including penetrating	Required	Not allowed	Allowed	Required	Not required

Note ①: Coating refers to internal (tank 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.

Note ③: The condition applies provided that the welds have been carefully inspected visually to the satisfaction of the Surveyor.

Note ④: Flux Core Arc Welding (FCAW) semiautomatic butt welds need not be tested provided that careful visual inspections show continuous uniform weld profile shape, free from repairs, and the results of NDT testing show no significant defects.

1.7.4.2 Structural test procedures

(1) Type and time of test

① Where a structural tests is specified in Table 1.7.2.2. a hydrostatic test in accordance with 1.7.4.4 (1) will

be acceptable. Where practical limitations (strength of building berth, liquid density of liquid, etc) prevent the performance of a hydrostatic test, a hydropneumatic test in accordance with 1.7.4.4(2) 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 that the results of a leak test are confirmed to be satisfactory before the vessel is afloat.

(2) Testing schedule for new construction or major structural conversion

① Tanks which are intended to hold liquids, and which form part of the watertight subdivision of the ship, shall be tested for tightness and structural strength as indicated in Table 1.7.2.2.

② The tank boundaries are to be tested from at least one side. The tanks for structural test are to be selected so that all representative structural members are tested for expected tension and compression.

③ Structural test are to be carried out for at least one tank of a group of tanks having structural similarity (i.e. same design conditions, alike structural configurations with only minor local differences determined to be acceptable by the attending Surveyor) on each vessel provided all other tanks are tested for leaks by an air test. The acceptance of leak testing using an air test instead of a structural test does not apply to the boundaries of tanks for catch or pollutant cargoes.

④ Additional tanks may require structural testing if found necessary after the structural testing of the first tank.

⑤ Where the structural adequacy of the tank of a vessel were verified by the structural testing required in Table 1.7.2.2, subsequent vessels in the series (i.e. sister ships built from the same plans at the same shipyard) may be exempted from structural testing of tanks, provided that:

a water-tightness of boundaries of all tanks is verified by leak tests and thorough inspections are carried out;

b structural testing is carried out for at least one tank of each type among all tanks of each sister vessel;

c additional tanks may require structural testing if found necessary after the structural testing of the first tank or if deemed necessary by the attending Surveyor.

⑥ Sister ships built (i.e. keel laid) two years or more after the delivery of the last ship of the series, may be tested in accordance with 1.7.4.2 (2) ⑤ of this Section at the discretion of CCS, provided that:

a general workmanship has been maintained (i.e. there has been no discontinuity of shipbuilding or significant changes in the construction methodology or technology at the yard, shipyard personnel are appropriately qualified and demonstrate an adequate level of workmanship as determined by CCS); and;

b an NDT plan is implement and evaluated by CCS for the tanks not subject to structural tests. Shipbuilding quality Standards for of the hull structure during new constructed are to be reviewed and agreed during the kick-off meeting. Structural fabrication is to be carried out in accordance with Appendix 2 to CHAPTER 4, PART ONE, VOLUME ONE of Rules for Classification of Sea-going Steel Ships, or a recognized fabrication standard which has been accepted by CCS prior to the commencement of fabrication/construction. The work is to be carried out in accordance with the Rules and under survey by CCS.

⑦ The watertight boundaries of spaces (except chain lockers) other than tanks for structural testing may be exempted, provided that the water-tightness of boundaries of exempted spaces is verified by leak tests and inspections.

⑧ Tanks which do not form part of the watertight subdivision of the ship, may be exempted from structural testing provided that the watertightness of boundaries of exempted spaces is verified by leak test and inspections.

1.7.4.3 Leak test procedures

(1) For the leak tests specified in Table 1.7.2.2, tank air tests, compressed air fillet weld tests, vacuum box tests in accordance with 1.7.4.4(4) through 1.7.4.4(6), or their combination, will be acceptable. Hydrostatic or hydropneumatic tests may also be accepted as leak tests provided that 1.7.4.5, 1.7.4.6 and 1.7.4.7 are complied with. Hose tests will also be acceptable for such locations as specified in Table 1.7.2.2, Footnote ③, in accordance with 1.7.4.4 (3)

(2) The application of the leak test for each type of welded joint is specified in Table 1.7.4.1 (1).

(3) 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 1.7.4.5(1) (for the application of final coatings)、1.7.4.6 (for the safe access to joints) and the summary in Table 1.7.4.1 (1).

1.7.4.4 Test methods

(1) Hydrostatic 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 (4) will also apply to hydropneumatic tests. See also 1.7.4.7

② All external surfaces of the tested space are to be examined for structural distortion, bulging and

buckling, other related damage and leaks.

(2) Hydropneumatic 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 1.7.4.4 (4). See also 1.7.4.7.

② All external surfaces of the tested space are to be examined for structural distortion, bulging and buckling, other related damage and leaks.

(3) Hose test

① Hose tests are to be carried out with the pressure in the hose nozzle maintained at least at 2×10^5 Pa 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. The water jet is to impinge directly upon the weld.

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.

(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 above atmospheric pressure not less than 0.15×10^5 Pa, with a leak indicating solution such as soapy water/detergent or a proprietary brand applied.

② 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 not to be less than that of the pipe supplying air to the tank.

③ Arrangements involving the use of two calibrated pressure gauges to verify the required test pressure may be accepted.

④ A double inspection is to be made of tested welds. The first is to be immediately upon applying the leak indication solution; the second is to be after approximately four or five minutes in order to detect those smaller leaks which may take time to appear.

(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 0.15×10^5 Pa can be verified at each end of all passages within the portion being tested.

Note: 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.

(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 $0.20 \times 10^5 \sim 0.26 \times 10^5$ Pa inside the box.

(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. A location where sound is detectable by the receiver indicates a leakage in the sealing of the compartment.

(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. In certain cases, a developer solution may be painted or sprayed on the other side of the weld to aid leak detection.

(9) Other tests

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

1.7.4.5 Application of coating

(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, provided that the welds have been carefully inspected visually to the satisfaction of the Surveyor.

② Surveyors reserve the right to require a leak test prior to the application of final coating over automatic erection butt welds.

③ For all other joints, the final coating is to be applied after the completion of the leak test of the joint. See

also Table 1.7.4.1 (1)

(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 (see 1.7.4.5 (1)). This requirement does not apply to shop primer.

1.7.4.6 Safe access to joints

For leak tests, safe access to all joints under examination is to be provided. See also Table 1.7.4.1 (1)

1.7.4.7 Hydrostatic or hydropneumatic tightness test

In cases where the hydrostatic or hydropneumatic tests are applied instead of a specific leak test, examined boundaries must be dew-free, otherwise small leaks are not visible.

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 fishing vessels are to comply with the following requirements:

$$L/B > 5$$

$$B/D < 2.5$$

2.1.1.3 Fishing vessels that do not comply with the conditions specified in 2.1.1.2 of this section 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) departure to fishing (departure for the fishing grounds with full fuel, food, fishing gear, ice, fresh water, stores, etc);
- (2) return with full load (departure for the fishing grounds with full catches, fuel, food, fresh water and 30% stores);
- (3) arrival with full load (arrive at home port with full catches and 10% stores, fuel, etc);
- (4) arrival with empty load (arrive at home port with 10% stores, fuel, etc. and the minimum catches, usually 20% of the fully catches; For ice fresh ship, the amount of ice carried is calculated at 50%);
- (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.

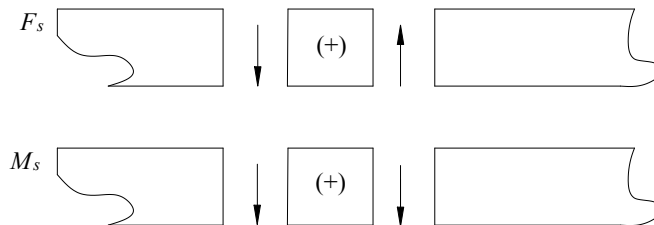


Fig. 2.1.2.2 Still water bending moments and shear forces (+, -)

2.1.3 Wave bending moment and wave shear force

2.1.3.1 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:

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

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

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, $C=0.0412L+4$.

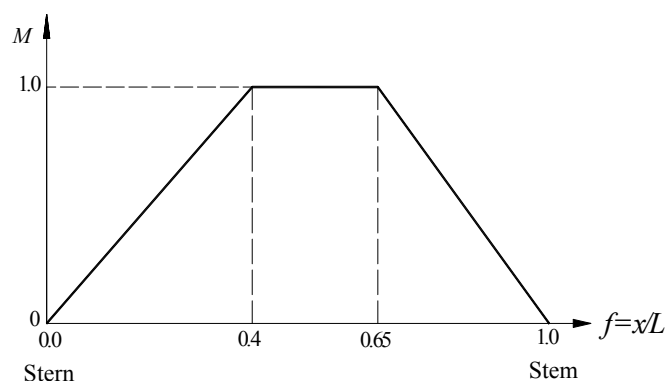


Fig. 2.1.3.1 Moment distribution coefficient

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.

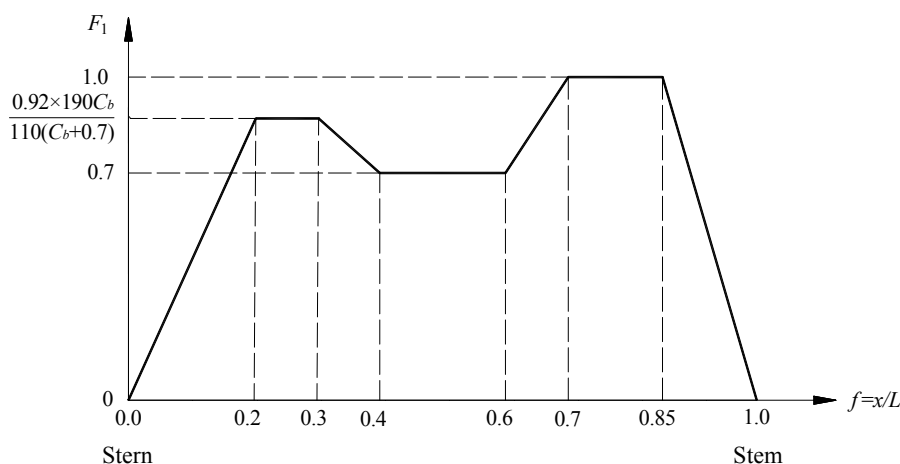


Figure 2.1.3.2(1) Shear force distribution coefficient F_1

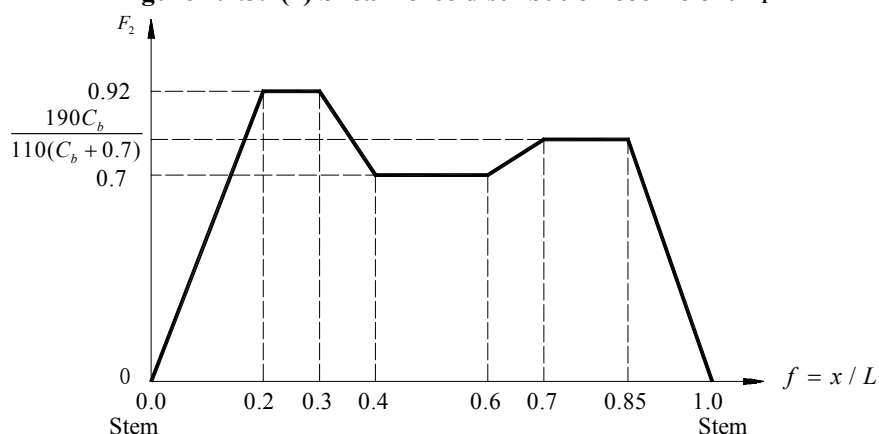


Figure 2.1.3.2(2) Shear force distribution coefficient F_2

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

2.1.4.3 For the cases in 2.1.4.2 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_t 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 .

2.1.4.4 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.

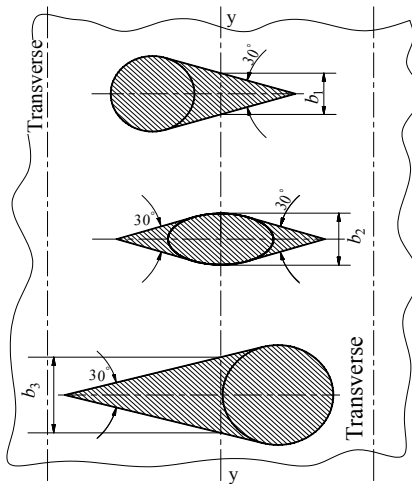
2.1.4.5 Deck openings having a length in the fore-and-aft direction exceeding 2.5 m or a breadth exceeding 1.2 m or $0.04B$ (whichever is the lesser) are to be deducted from the sectional areas used in the calculation of the hull girder section modulus.

2.1.4.6 Smaller openings (including manholes, lightening holes, single scallops in way of seams, etc.) smaller than those stated in 2.1.4.5 above need not be deducted from the sectional areas used in the calculation of the hull girder section modulus, provided that the sum of their breadths or shadow area breadths (The shadow area will be obtained by drawing two tangent lines with an opening angle of 30° , as shown in Figure 2.1.4.6) in one transverse section complies with the following or that the section modulus at deck or bottom is not reduced by more than 3%:

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

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 2.1.4.6 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

2.1.4.7 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 at deck and keel is not to be less than that obtained from the following formulae:

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

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

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

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:

$$I = 3W_0L \quad \text{cm}^4$$

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

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 fish 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.

⑤ in way of the afterword end of the last fish-hold of a fishing vessel fitted fish-hold behind the superstructure (deckhouse) or engine room, as well as the profile in the afterword end of deckhouse or engine room.

(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.

2.1.5.5 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:

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

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:

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

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:

$$\begin{aligned} [\sigma] &= 175/K & \text{N/mm}^2, \text{ for } 0.4L \text{ amidships} \\ [\sigma] &= 125/K & \text{N/mm}^2, \text{ for } 0.1L \text{ from the vessel's ends} \end{aligned}$$

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

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

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

Where: $\overline{M}_s$ — permissible still water bending moment, in $\text{kN} \cdot \text{m}$, see 2.1.5.5 of this Section;

M_w —wave bending moment, in $\text{kN} \cdot \text{m}$, calculated in accordance with 2.1.3.1 of this section;

W_c —hull girder section modulus at the point considered, in cm^3 .

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 2.1.6.2, 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 2.1.6.1. The values N_k and N_m of shear force correction are to be calculated in accordance with the following formulae respectively:

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

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

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:

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

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;

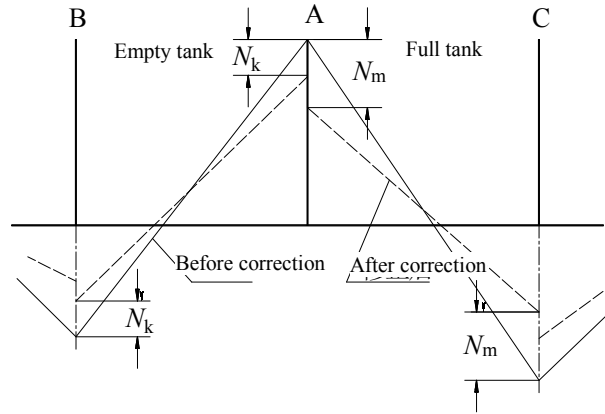


Figure 2.1.6.1 Shear force correction diagram

2.1.6.2 The designer is to provide permissible still water shear forces $\bar{F}_s(+)$ and $\bar{F}_s(-)$ 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:

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

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

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:

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

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

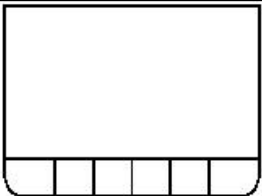
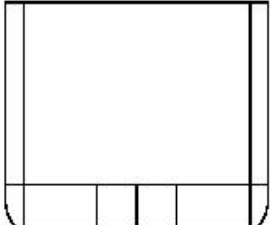
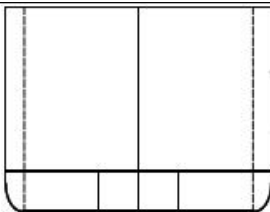
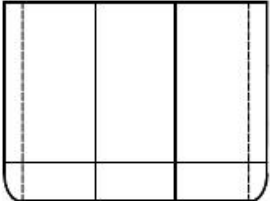
t_1 —thickness (the total thickness of inner and outer plating for double hull-skin vessel) of side shell at the horizontal neutral axis of the section under consideration, in mm;

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		$f_1 = 0.261 + 0.058 A_1 / A_2$ $f_2 = 0.478 - 0.116 A_1 / A_2$	$m_1 = 0.5 m_2$ $m_2 = 0.5(0.1 + \gamma)$
4		$f_1 = 0.154 + 0.08 A_1 / A_2$ $f_2 = 0.346 - 0.08 A_1 / A_2$	$m_1 = m_2$ $m_2 = (0.1 + \gamma) \frac{b}{B}$

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 2.1.6.2, 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:

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

Where: $\overline{F_s}$ — 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 , δ_1 — see 2.1.6.2.

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

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

Where: $\overline{F_s}$, S — see 2.1.6.4(1);

F_w , I , δ_2 — see 2.1.6.2.

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.

2.2.1.2 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:

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

Where: s — spacing of frames, in m

2.2.1.3 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:

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

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 Where $24\text{m} \leq L < 30\text{m}$, the thickness of bottom shell plating within $0.4L$ amidships is to be equal to that of the bottom shell plating amidships.

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:

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

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:

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

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 $\frac{\gamma}{165K}$ (γ 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 within $0.4L$ amidships 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 $L < 65$ 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 $L \geq 65$ 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:

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

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

- 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:

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

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

Where: s — spacing of longitudinals, in m, to be taken as not less than the standard spacing of longitudinals;
 $h_2 = 0.5C$, to be taken as not greater than $0.36d$;
 h_1 , and C — see 2.2.1.3;

- 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 section.

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

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, and 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 $0.5L$ amidships or in way of breaks of superstructures.

Where a rounded sheer strake is adopted, the radius is not to be less than 15 times the thickness of the plate. The thickness of rounded sheer strake is to be at least equal to that of deck plating. Effective measures are to be taken to maintain the required properties of material after shaping. Deck fittings welded directly to the rounded sheer strake within $0.5L$ amidships are to be avoided, wherever possible.

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 Oblique half-round bar rubbing strakes are to be provided from the top edge of the bulwark wall to the outer side of trawler fishing 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 thickness of shell plates connected to the stern frame or fitted in way of the shaft bossing in single screw ships and in way of the palms of propeller struts in multi-screw ships, is neither to be less than 1.5 times the thickness of shell plating at ends, nor to be less than the thickness of the shell plating amidships.

2.2.6.4 The shell plating in way of hawse pipe and one plate below are to be increased in thickness or to be fitted with doubler plates. The outlet of hawse pipe is to have adequate corner radius. It is recommended that the corner radius of chafing lips made of steel plate or cast steel be not less than 12 times the diameter of anchor chain.

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 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:

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

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:

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

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:

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

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

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:

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

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 CHAPTER.

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.

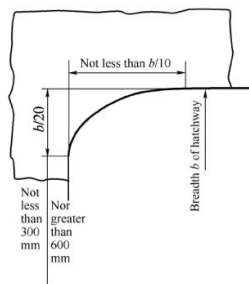


Figure 2.3.4.1 Schematic diagram of corner line

2.3.4.2 When the corners of the engine room or fish hold 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 are to comply with the requirements of Figure 2.3.4.2.

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.

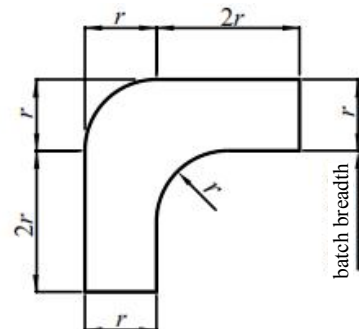
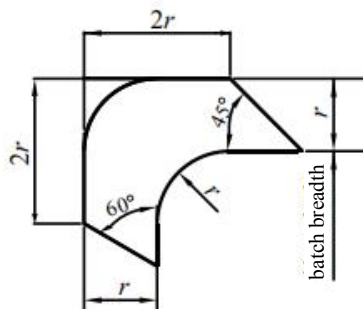


Fig. 2.3.4.2(1) Schematic diagram of the thickened area of the corner Fig. 2.3.4.2 (2) Schematic diagram of the thickened area of the corner

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.

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

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

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.

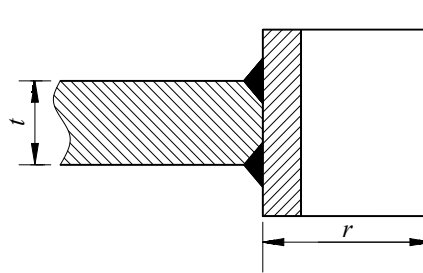


Figure 2.3.4.4 Ring form stiffening

2.3.4.5 In the area within $0.4L$ 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 $0.4L$ amidships.

2.3.5 Lower deck and platform deck

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

$$t = 0.02L + 4.5 \quad \text{mm}$$

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

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

2.3.6 Raised quarter decks

2.3.6.1 The raised quarter decks are to comply with the relevant requirements of 2.15.6 of this CHAPTER.

2.3.7 Superstructure ends

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

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 effective coating according to corresponding covering.

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 $0.4L$ amidships:

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

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

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 $0.4L$ 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).

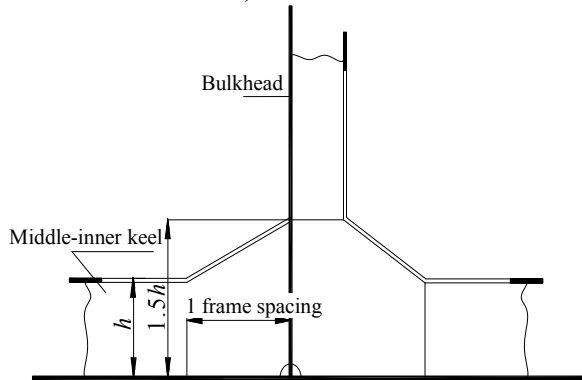


Figure 2.4.2.2(1) Type of web rise connection

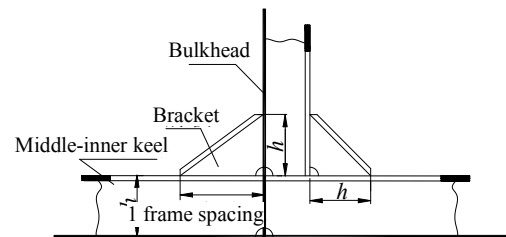


Figure 2.4.2.2(2) Type of bracket connection

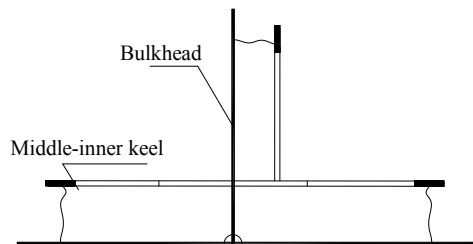


Figure 2.4.2.2(3) Panel widening connection type

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.

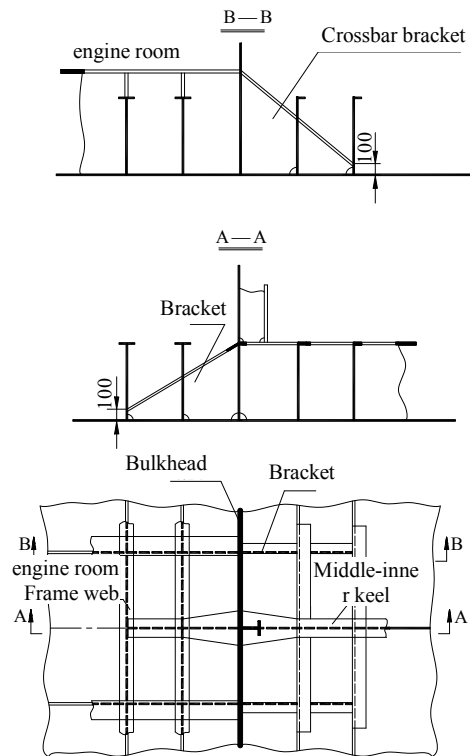


Figure 2.4.2.3 Transition bracket connection type

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:

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

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

In the machinery space, the web thickness of side keelsons is not to be less than that of the center keelson as required in 2.4.2.1 of this section.

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 2.4.2.2 of this section).

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:

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

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

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

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 section.

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 keel line within amidship 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

2.4.6.1 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:

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

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-hold region, the plate floors are to comply with the requirements for plate floors specified in 2.5.3.4 of this section.

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

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

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

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 fish-hold 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:

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

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

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 2.5.3.4 (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.

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 $(1/1.6C_2-1)A$. 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 fish-hold 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 fish-hold region 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:

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

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

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 For fishing vessels, 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 Cofferdams are to be provided between oil compartments in the double bottom and compartments intended for drinking water, boiler water.

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 bottom framing is transitioned from double bottom to single bottom, there structures should comply with the following requirements:

(1) Where the double bottom is interrupted, the continuity of bottom longitudinal members is to be maintained.

(2) 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.

(3) 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.

(4) 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.

(5) Where the structure is duct keels and centerline girder in way of the break, the duct keels is also to extend not less than three frame spaces beyond the break of the double bottom, and the width of the margin plate may be reduced gradually.

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:

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

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

(1) For $0.4L$ amidships:

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

(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.

(3) The thickness of centre girders in boiler spaces is to be increased by 2.5 mm above that required for centre girders within $0.4L$ amidships.

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:

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

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.

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

Where: s — spacing of frames, in m

The thickness of plate floors in boiler rooms and in way of the bilge wells 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:

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

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.

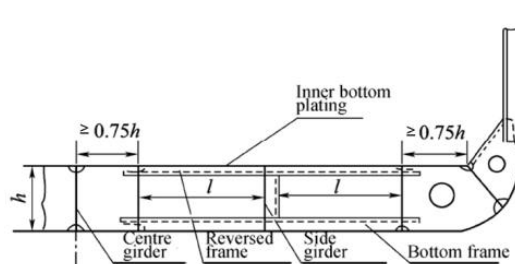


Figure 2.6.7.1 Structural type of double bottom bracket floors

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:

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

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:

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

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

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.

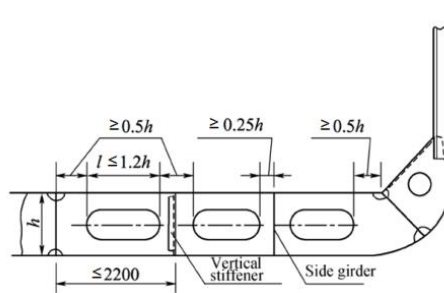


Figure 2.6.8.1 Structural type of double bottom lightened floors

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:

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

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

Where: s —spacing of frames, in m

For $0.075L$ from the vessel's ends, the thickness is to be 0.9 times that required for $0.4L$ 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.

Where the margin plate is inclined downwards, the thickness of the margin plate throughout the fish hold is to be 1.5 mm greater than that required for the inner bottom plating. In engine rooms, the thickness of the margin

plate is not to be less than that required for the inner bottom plating within such spaces respectively.

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 Section. 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:

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

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 Chapter.

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:

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

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

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 Section.

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.

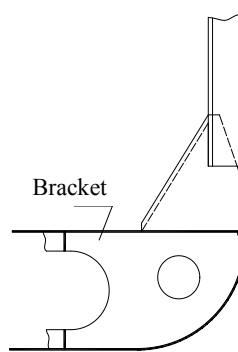


Figure 2.6.13.3 Type of brackets at every frame

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.

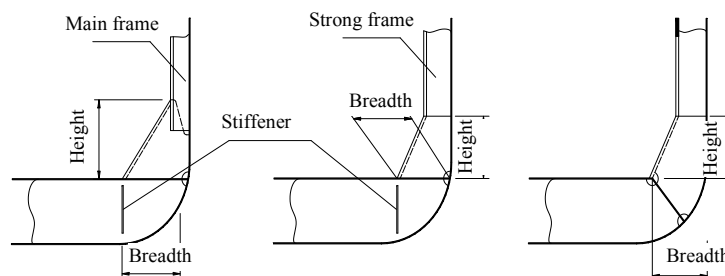


Figure 2.6.14.3 Double plate floors

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 Chapter.

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:

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

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:

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

Where: c —coefficient, $c = \frac{(2 + \frac{0.65d}{D})}{(1.45 - \frac{\sqrt{D}}{l})}$;

s —spacing of frames, in m;

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

If side girders complying with the requirements of 2.7.5 of this Section 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 Section.

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

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

Where: W —see 2.7.2.2 of this Section;

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:

$$\begin{aligned} W &= 2.3sdDl & \text{cm}^3 \\ I &= 3.5Wl & \text{cm}^4 \end{aligned}$$

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 10cm³):

$$W = cc_1 s d l \sqrt{D} \quad \text{cm}^3$$

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:

$$\begin{aligned} W &= 7.8 h b l^2 & \text{cm}^3 \\ I &= 2.5 W l & \text{cm}^4 \end{aligned}$$

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 Section. 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 Section 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:

$$\begin{aligned} t &= 0.023L + 6 & \text{mm} \\ A &= 0.14L + 1 & \text{cm}^2 \end{aligned}$$

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:

$$W' = 0.2 n c W \quad \text{cm}^3$$

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 Section;

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 Section, 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 93.2N/mm² and the allowable shear stress as 83.4N/mm².

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:

$$W = \frac{8.5}{f} h s l^2 \quad \text{cm}^3$$

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:

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

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

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 Section;

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 Section and also in accordance with 2.7.7.4 of this Section.

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 Section and in addition, not less than 0.8 times that obtained from the formula in 2.7.7.5 of this Section.

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:

$$W = 7.5 s h l^2 \quad \text{cm}^3$$

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:

$$W = 8.5 s l^2 (h + 0.167D) \quad \text{cm}^3$$

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:

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

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.

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

$$\text{below the lowest deck: } W=10Shl^2 \quad \text{cm}^3$$

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

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.

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:

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

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

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:

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

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 frames under hatch end beams in 'tween deck spaces is not to be less than 1.67 times that of normal 'tween deck frames, as required in this Section. 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:

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

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 $L \leq 30$ m, the design head of the deck h is to be taken as: 1.0 m for strong deck; 0.6 m 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, superstructure and deckhouse 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 $d/D=0.7$, 80% of h_0
Decks above the superstructure deck or above the first deck of deckhouse	Take 60%, 40%, etc. of the value h_0 when $d/D = 0.7$ respectively, 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 fish holds. 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:

$$W = 4.6 c s h l^2 \quad \text{cm}^3$$

Where: c —coefficient, $c=1.2$; for fishing vessels with multi-deck and $L < 30$ 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 Section;

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 The deck beam of the watertight bulkhead step is to meet the requirements of 2.10.6 of this Chapter.

2.8.2.3 The connection between the beam and frame is to comply with the requirements of 1.2.5 of this PART.

2.8.2.4 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.

2.8.2.5 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, or calculated according to 2.8.3.3 and 2.8.3.4 of this section. Web frames are to be provided under transverses. If no transverses are provided, they can be strengthened by other methods.

2.8.2.6 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 (1.2 times in the superstructure) 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 0.075 L 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:

$$W=4.75bhl^2 \quad \text{cm}^3$$

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 Section;

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:

$$W=0.102cPl \quad \text{cm}^3$$

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:

$$I=2Wl \quad \text{cm}^4$$

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) The face plate of the deck stringers is, within one frame spacing, to be gradually widened to twice its original width.

(4) 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 cm³, 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:

$$W = 1.1 c_1 s h l^2 \quad \text{cm}^3$$

$$W = 1.1 (c_2 s h + c_3 s l^2 L^2 \times 10^{-4}) \quad \text{cm}^3$$

Where: s —spacing of longitudinals, in m;

h —design head of deck, in m, see 2.8.1.1 of this Section, 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 、 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:

$$W = 5.5 s h l^2 \quad \text{cm}^3$$

Where: s 、 h 、 l —see 2.8.5.1 of this Section.

2.8.5.3 The section modulus W of accommodation and superstructure deck longitudinals is not to be less than the following:

$$W = 4.4 s h l^2 \quad \text{cm}^3$$

Where: s 、 h 、 l —see 2.8.5.1 of this Section.

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/mm².

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:

$$I=2Wl \quad \text{cm}^4$$

Where: W —section modulus of deck girders, in cm³, 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:

$$W=5Shl^2 \quad \text{cm}^3$$

Where: S —spacing of deck transverses, in m;

h —design head of deck, in m, see 2.8.1.1 of this Section;

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 Section.

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:

$$I=2Wl \quad \text{cm}^4$$

Where: W —section modulus of deck transverses, in m³, 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:

$$\begin{aligned} W &= 7hbl^2 & \text{cm}^3 \\ I &= 2.6Wl & \text{cm}^4 \end{aligned}$$

Where: h — design head of deck, in m, see 2.8.1.1 of this Section;

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:

$$\begin{aligned} W &= 5.2hbl^2 & \text{cm}^3 \\ I &= 2Wl & \text{cm}^4 \end{aligned}$$

Where: h — design head of deck, in m, see 2.8.1.1 of this Section;

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 Chapter.

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 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:

$$\begin{aligned} W &= 4.6chAl & \text{cm}^3 \\ I &= 3Wl & \text{cm}^4 \end{aligned}$$

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 Section;

A — load area, in m^2 , $A=F_1+F_2$, selected according to Fig. 2.8.9.1. Where no additional girders are provided, see Figure 2.8.9.1(1), where additional girders are provided, see Figure 2.8.9.1(2).

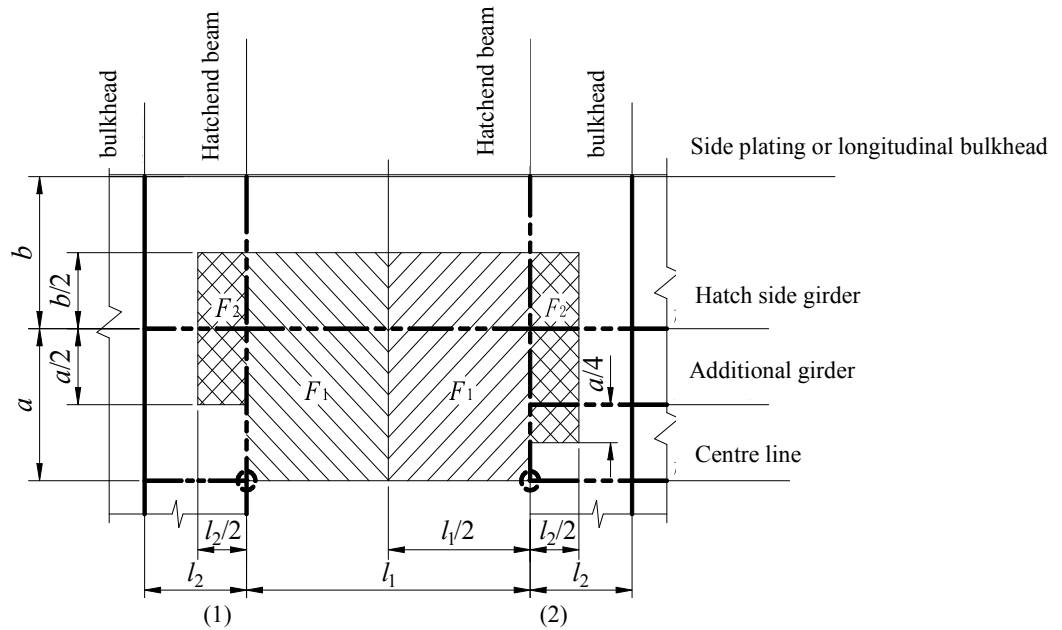


Figure 2.8.9.1 Area supported by the hatch end beam

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 Section.

Section 9 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:

$$P = 7.06abh + P_0 \quad \text{kN}$$

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 Chapter;

P_0 —load transmitted from the pillar above, in kN.

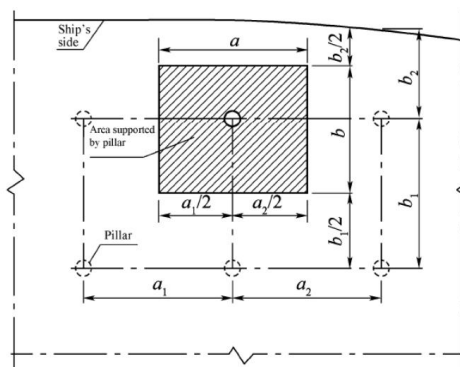


Figure 2.9.1.1 Schematic diagram of support area of pillar

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:

$$P = 7.06abh + cP_0 \quad \text{kN}$$

Where: a , b , h —the same as 2.9.1.1 of this section;

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:

$$A = \frac{P}{12.26 - 5.1l/r} \quad \text{cm}^2$$

Where: P —load applied on the pillars, in KN, to be calculated according to 2.9.1 of this Section;
 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 cm⁴;
 A —cross-sectional area of the pillar, in cm²;

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 The thickness t of face plate of I-shaped pillars and channel-section pillars are comply with the following regulations:

(1) The thickness t of face plate of I-shaped pillars is not to be less than the lesser of the following:

$$t = \frac{br}{40l} \quad \text{mm}$$

$$t = \frac{b}{36} \quad \text{mm}$$

Where: b —breadth of face plate of I-shaped pillars, in mm

r , l —same as defined in 2.9.2.1 of this Section.

(2) The thickness t of face plate of channel-section pillars are not to be less than the lesser of the following:

$$t = \frac{br}{20l} \quad \text{mm}$$

$$t = \frac{b}{18} \quad \text{mm}$$

Where: b —breadth of face plate of I-shaped pillars, in mm

r , l —same as defined in 2.9.2.1 of this Section.

2.9.3.3 Thick wall pillars are preferred in fish-holds.

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:

$$t = 3.2s\sqrt{h} + 2.3 \quad \text{mm}$$

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 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:

$$W = cshl^2 \quad \text{cm}^3$$

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, $c=6$;

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 $L < 30\text{m}$, 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.

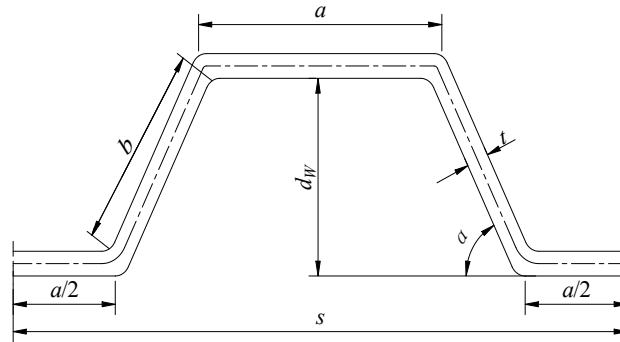


Figure 2.10.4.1 Dimensional diagram of corrugation bulkhead

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:

$$W = cshl^2 \quad \text{cm}^3$$

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(1)	See Figure 2.10.4.2(2)
c value	5.04	3.84

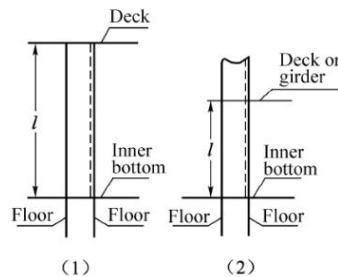


Figure 2.10.4.2 Schematic diagram of end fixity of corrugation bulkhead

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:

$$t \geq \frac{a}{70} \quad \text{mm}$$

Where: a — see Figure 2.10.4.1 of this Section.

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:

$$W = 6.6bhl^2 \quad \text{cm}^3$$

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:

$$W = 4.2shl^2 \quad \text{cm}^3$$

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 holds and fresh water tanks; if the spaces between the fish holds 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:

$$t = 4s\sqrt{h} + 2.5 \quad \text{mm}$$

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 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:

$$W = 8.2shl^2 \quad \text{cm}^3$$

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 section moment of inertia I of stiffeners is not to be less than that obtained from the following formula:

$$I = 2.3Wl \quad \text{cm}^4$$

Where: W , l — same as defined above.

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 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:

$$W=12bhl^2 \quad \text{cm}^3$$

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:

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

Where: W , l are the same as 2.11.2.4(1) of this Section;

2.11.2.5 The height of girder web is to comply with the requirements of 2.10.5.2 of this Chapter.

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 Chapter.

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:

$$W=cshl^2 \quad \text{cm}^3$$

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 Chapter;

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(1) in this Chapter	See Figure 2.10.4.2(2) in this Chapter
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 Section. 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 Chapter.

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 Chapter, and is not to be less than the value W calculated in 2.7.4 of this Chapter;

(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:

$$W=7shl^2 \quad \text{cm}^3$$

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

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

Where: See W , l in 2.11.4.1(2) of this Section;

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:

$$W=9shl^2 \quad \text{cm}^3$$

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 2.7.7.7. 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:

$$W=12shl^2 \quad \text{cm}^3$$

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 inertia I of web frames section is not to be less than that obtained from the following formula:

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

Where: W , l are the same as 2.11.5.2 of this Section.

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:

$$t = 4s\sqrt{h} + 3.5 \text{ mm}$$

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 $L < 60$ m; and is not be less than 7 mm for fishing vessel's length $L \geq 60$ 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:

$$W=9shl^2 \quad \text{cm}^3$$

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.

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

$$I=2.3Wl \quad \text{cm}^4$$

Where: W , l , K — same as defined above.

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:

$$W=12shl^2 \quad \text{cm}^3$$

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:

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

Where: W , l — same as defined above.

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.

2.11.8 Bottom framing

2.11.8.1 The transversely framed single bottom in deep tanks forward of $0.2L$ from F.P. is to comply with the following requirements:

(1) Plate floors are to be fitted at every frame space, and the scantlings of floors are not to be less than those required in 2.13.1.1 of this Chapter. In way of web frames, the depth of floors and scantlings of face plates are not to be less than those of web frames.

(2) The section modulus W of the centerline girder is not to be less than the greater of those obtained from the following formulae:

$$\begin{aligned} W &= 9sh_1l^2 & \text{cm}^3 \\ W &= 10.05sh_2l^2 & \text{cm}^3 \end{aligned}$$

Where: s — mean spacing supported by centerline girder, in m;

l — span of centerline girder, in m;

h_1 — vertical distance, in m, measured from the mid-span to upper deck at side; for the region forward of $0.15L$ from F.P., to 3 m above the deck for measuring minimum bow height;

h_2 — vertical distance, in m, measured from the mid-span to the top of the deep tank, or half the vertical distance to the top of overflow, whichever is the greater;

The section moment of inertia I is not to be less than that obtained by the following formula:

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

Where: W , l , K — same as defined above.

(3) Intercoastal side girders are to be fitted and spaced not more than three frame spaces apart. The scantlings of intercoastal side girders are to be the same as those of floors.

2.11.8.2 For longitudinally framed single bottom in deep tanks forward of $0.2L$ from F.P., the spacing of plate floors supporting longitudinals is to be the same as that of the web frames as provided in 2.11.5.4 of this Section. The plate floors are to be supported by a continuous centreline girder or a longitudinal bulkhead. The scantlings of plate floors and centreline girders are to comply with the relevant requirements of Section 5 of this PART.

Section 12 STEMS, STERN FRAMES, RUDDER POST, BULBOUS BOWS, PROPELLER SHAFT BRACKETS AND PROPELLER DUCT

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:

$$A=1.2L \quad \text{cm}^2$$

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:

$$t=0.1L+5 \quad \text{mm}$$

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:

$$\text{Length of stern frame} \quad a = 46\sqrt{L} \quad \text{mm}$$

$$\text{Thickness of stern frame} \quad t = 2.3\sqrt{L} + 3 \quad \text{mm}$$

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:

$$\text{Length of stern frame} \quad a = 41\sqrt{L} \quad \text{mm}$$

$$\text{Thickness of stern frame} \quad t_1 = 3\sqrt{L} \quad \text{mm}$$

$$t_2 = 4\sqrt{L} \quad \text{mm}$$

$$\text{Radius of fillet} \quad R = 0.4L + 16 \quad \text{mm}$$

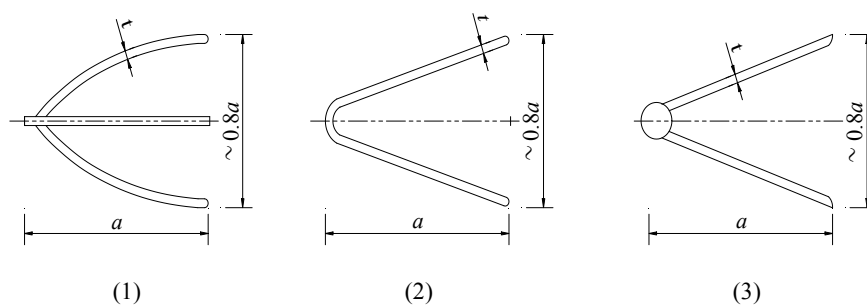


Figure 2.12.2.2 Propeller post welded with steel plates

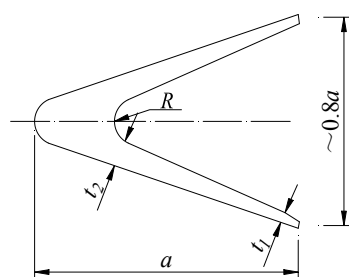


Figure 2.12.2.3 Cast steel propeller post

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 2.12.2.6) about the vertical neutral axis (z-axis) at any considered section, is not to be less than that obtained from the following formula:

$$W_z = 1.2AxV^2 \quad \text{cm}^3$$

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.

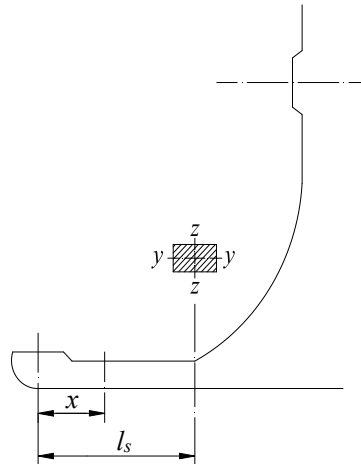


Figure 2.12.2.6 Sole piece type

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, either by welding, watertight bolted joints or epoxy pouring joints, 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: $b = 33\sqrt{L}$ mm

Thickness of section: $t_1 = 3.3\sqrt{L}$ mm

$t_2 = 3.7\sqrt{L}$ mm

$t_3 = 4.5\sqrt{L}$ mm

Radius of fillet: $R = 4.4\sqrt{L}$ mm

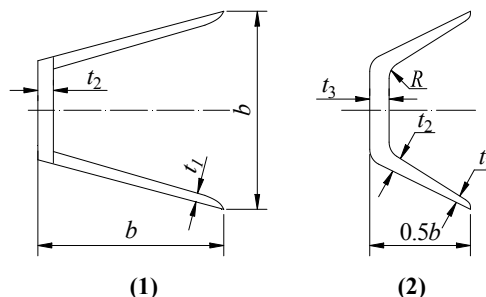


Figure 2.12.3.1 Rudder post of twin screw vessels

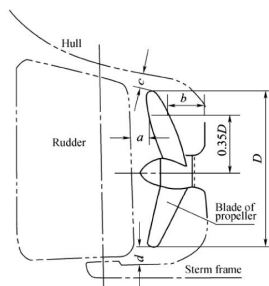


Figure 2.12.4.1 Clearance between the propeller and the stern frame or between the propeller and the rudder

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:

$$\begin{aligned} a &= 0.12D & \text{mm} \\ b &= 0.20D & \text{mm} \\ c &= 0.14D & \text{mm} \\ d &= 0.04D & \text{mm} \end{aligned}$$

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:

$$\begin{aligned} \text{Thickness of arm:} & \quad t = 0.45d & \text{mm} \\ \text{Cross sectional area of arm:} & \quad A = 0.45d^2 & \text{mm}^2 \\ \text{Thickness of shaft bossing:} & \quad t = 0.35d & \text{mm} \\ \text{Length of shaft bossing:} & \quad l = 3d & \text{mm} \end{aligned}$$

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:

$$P_d = cP_{d0} \quad \text{kPa}$$

Where: $P_{do} = \varepsilon \frac{N}{A_p}$ kPa;

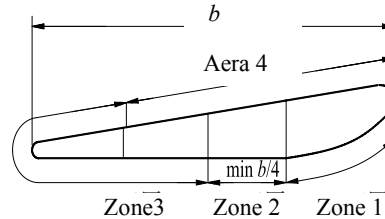
N —Maximum shaft power, in kW;

A_p —Propeller disk area, in m^2 ; $A_p = \frac{\pi D^2}{4}$

Where: D —diameter of propeller, in m;

ε —Coefficient, $\varepsilon = 0.21 - 2 \times 10^{-4} \frac{N}{A_p}$, but not less than 0.10;

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.

$$t = 5a\sqrt{P_d} + 2 \quad \text{mm}$$

Where: a —spacing of duct stiffening ring, in m;

P_d —Calculated value according to 2.12.7.2 of this Section.

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 shown in Figure 2.12.7.2 to the horizontal neutral axis of the duct, shall not to be less than that obtained from the following formula:

$$W = nd^2bV_0^2 \quad \text{cm}^3$$

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 $V \leq 10\text{kn}$, $V_0 = (V+20)/3$;

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.

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:

$$h = 85D + 140 \quad \text{mm}$$

$$t = 0.03L + 6 \quad \text{mm}$$

$$A = 0.85B \quad \text{cm}^2$$

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 2.13.1.1 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:

$$\begin{aligned} A &= 0.27L + 8 && \text{cm}^2 \\ I &= ceh_i l^2 && \text{cm}^4 \end{aligned}$$

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 $0.5B$, 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 Chapter.

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:

$$\begin{aligned} h &= 5.6L + 166 && \text{mm} \\ t &= 0.023L + 6 && \text{mm} \end{aligned}$$

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.

$$t = 0.023L + 5 \quad \text{mm}$$

(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:

$$A = 0.13L + 4 \quad \text{cm}^2$$

(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 0.15L 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 Section);

(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:

$$A = 0.14L + 1 \quad \text{cm}^2, \text{ and not to be less than } 6 \text{ cm}^2;$$

(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 Chapter.

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 $0.04L$, the flat portion of bottom from 0.15L 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:

$$t = 0.1L + 5 \quad \text{mm}$$

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 where the span is not greater than 2.5 m. Where 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:

$$W = 3.5Sdh\sqrt{D} \quad \text{cm}^3, \text{ and not to be less than } 10\text{cm}^3;$$

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:

$$W = 4.4Sdh\sqrt{D} \quad \text{cm}^3$$

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:

$$t = 1.44\sqrt[3]{P} + 10s \quad \text{mm}$$

$$t_1 = 0.7t \quad \text{mm}$$

$$t_2 = 0.8t_1 \quad \text{mm}$$

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 Section.

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 Chapter. 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:

$$W = 6shl^2 \quad \text{cm}^3$$

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 Chapter).

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:

$$t = 0.05L + 4 \quad \text{mm}$$

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:

$$t = 0.05L + 3 \quad \text{mm}$$

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:

$$t = 0.035L + 3.5 \quad \text{mm}$$

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:

$$W = 3.5shl^2 \quad \text{cm}^3$$

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 $0.4L$	$0.001L(0.07L+25)$
Superstructure rear end bulkhead	$0.0178L$
Note: L is to be taken as 40m for $L > 40$ m.	

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:

Forecastle and short bridge $t=0.045L+4$ mm

Poop $t=0.04L+4$ 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 of this CHAPTER.

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:

Forecastle and short bridge $t=0.023L+5$ mm

Poop $t=0.018L+5$ 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 65 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 CHAPTER

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 $0.4L$ 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 $0.25L$, the thickness of the extension plating is to be increased by 25%;

(2) For forecastle and poop with a length no greater than $0.2L$, 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 $0.4L$ 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 $0.2L$ 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 $0.2L \sim 0.25L$ 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

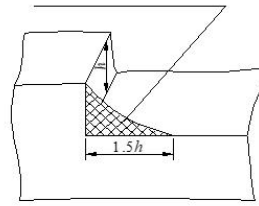
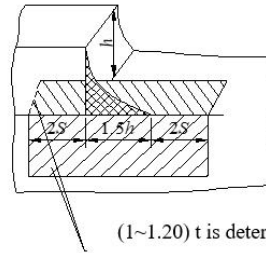


Figure 2.15.5.2 Transitional type of superstructure side shell plating



(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 thickness of the raised quarter deck sheer strake is to be determined according to the requirements of Section 2 of this CHAPTER.

2.15.6.3 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.

2.15.6.4 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.

2.15.6.5 Strengthening at the break within 0.4 L amidships

(1) For $L < 65$ 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 $L \geq 65$ 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.

2.15.6.6 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.

2.15.6.7 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:

$$t=0.03L+4.2 \quad \text{mm}$$

(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:

$$t=0.03L+3.5 \quad \text{mm}$$

(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), (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:

$$\text{Lowest layer front end bulkhead stiffener} \quad h=0.06L+0.8 \quad \text{m}$$

$$\text{Stiffeners of boundary bulkhead at other positions} \quad h=0.0045L+1.1 \quad \text{m}$$

(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 .

$$W=4shl^2 \quad \text{cm}^3$$

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 10 cm^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:

$$t=0.025L+4 \quad \text{mm}$$

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, but the design pressure head is to be as specified in 2.16.3.3 of this Section.

2.16.3.3 The section modulus W of the deck longitudinals of deckhouse or beams are not to be less than:

$$W=5shl^2 \quad \text{cm}^3, \text{ and not less than } 25s$$

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 $0.4L$ amidships, the thickness of the deck plating of the long deckhouse and frame sizes are to increase. When the length of vessel is less than 65 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:

$$W=8sl \quad \text{cm}^3$$

Where: s —spacing of stiffeners, in m;

l —span of stiffener, in m.

For vessels of 60 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 $0.4L$ 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 60 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 any openings near the breaks of superstructures.

2.17.1.5 The thickness of bulwark plating in way of trawl gallows and purse winch seat is to be 2 mm greater than that requirements in 2.17.1.1 of this Section.

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:

$$W = (30 + 0.45L) sh^2 \quad \text{cm}^3$$

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 Chapter on each beam.

Section 18 HATCH

2.18.1 Hatch coamings

2.18.1.1 The thickness t of exposed hatch coamings shall not to be less than the minimum thickness of the deck calculated according to rule requirements.

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;

(4) When the deck plating extends into the hatch coaming and the deck opening meets the requirements of 2.3.4 of this Chapter at the corner, the corners of the hatch coaming may be right-angled.

Section 19 OTHERS SPECIAL CONSTRUCTION

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_l meeting the following requirements:

$$B_l \geq B - 2 \quad \text{m}$$

Where: B_l —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 Article (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 Chapter.

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 Chapter. The design pressure head h used is to be 2 m. The deck fitted with heavy machinery or equipment should be specially strengthened by means of fitted with doubler plates or increased in thickness.

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 of this Chapter.

2.19.3 Live fish holds

2.19.3.1 For fishing vessels equipped with live fish holds, the sea openings on the bottom and side plates of live fish holds 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 2.1.4.6 of this Chapter.

2.19.4 Transom counter

2.19.4.1 The thickness of transom plating is to comply with the requirements in 2.2.4.4 of this CHAPTER.

2.19.4.2 The scantlings of framing in way of the transom counter are to be equal to those of peak framing. Where necessary, web frames are to be adopted for strengthening.

CHAPTER 3 OUTFITS

Section 1 RUDDERS

3.1.1 General requirements

3.1.1.1 Application

(1) The Section applies to ordinary profile rudders, and to some enhanced profile rudders with special arrangements for increasing the rudder force. Rudders not conforming to the profile types included in this Section will be subject to special consideration.

(2) This section applies to rudders made of steel. Rudders made of material different from steel will be subject to special consideration.

3.1.1.2 Design considerations

(1) Effective means are to be provided for supporting the weight of the rudder without excessive bearing pressure, e.g. by a rudder carrier attached to the upper part of the rudder stock. The hull structure in way of the rudder carrier is to be suitably strengthened.

(2) Suitable arrangements are to be provided to prevent the rudder from lifting.

(3) In rudder trunks which are open to the sea, a seal or stuffing box is to be fitted above the deepest load waterline, to prevent water from entering the steering gear compartment and the lubricant from being washed away from the rudder carrier. If the top of the rudder trunk is below the deepest waterline, two separate stuffing boxes are to be provided.

3.1.1.3 Materials

(1) Welded parts of rudders are to be made of materials complying with relevant requirements for hull structural steel in CCS Rules for Materials and Welding.

(2) Material factor k for normal and high tensile steel plating may be taken into account when specified in each individual rule requirement. The material factor k is to be taken as defined in Section 3, Chapter 1 of this PART, unless otherwise specified.

(3) Steel grade of plating materials for rudders and rudder horns are to be in accordance with Section 3, Chapter 1 of this PART.

(4) Rudder stocks, pintles, coupling bolts, keys and cast parts of rudders are to be made of rolled, forged or cast carbon manganese steel in accordance with CCS Rules for Materials and Welding.

(5) For rudder stocks, pintles, keys and bolts the minimum yield stress is not to be less than 200 N/mm². The requirements of this Section are based on a material's yield stress of 235 N/mm². If material is used having a yield stress differing from 235 N/mm² the material factor K is to be determined as follows:

$$K = \left(\frac{235}{R_{eH}} \right)^e$$

where: $e = 0.75$ for $R_{eH} > 235 \text{ N/mm}^2$;

$e = 1.00$ for $R_{eH} \leq 235 \text{ N/mm}^2$;

R_{eH} —specified minimum yield stress (N/mm²) of material used, and is not to be taken greater than $0.7R_m$ or 450 N/mm², whichever is the smaller value;

R_m —tensile strength (N/mm²) of material used.

3.1.1.4 Welding and design details

(1) Slot-welding is to be limited as far as possible. Slot welding is not to be used in areas with large in-plane stresses transversely to the slots or in way of cut-out areas of semi-spade rudders.

When slot welding is applied, the length of slots is to be minimum 75 mm with breadth of $2t$, where t is the rudder plate thickness, in mm. The distance between ends of slots is not to be more than 125 mm. The slots are to be fillet welded around the edges and filled with a suitable compound, e.g. epoxy putty. Slots are not to be filled with weld.

Continuous slot welds are to be used in lieu of slot welds. When continuous slot welding is applied, the root gap is to be between 6-10 mm. The bevel angle is to be at least 15°.

(2) In way of the rudder horn recess of semi-spade rudders, the radii in the rudder plating except in way of solid part in cast steel are not to be less than 5 times the plate thickness, but in no case less than 100 mm. Welding

in side plate is to be avoided in or at the end of the radii. Edges of side plate and weld adjacent to radii are to be ground smooth.

(3) Welds between plates and heavy pieces (solid parts in forged or cast steel or very thick plating) are to be made as full penetration welds. In way of highly stressed areas e.g. cut-out of semi-spade rudder and upper part of spade rudder, cast or welding on ribs is to be arranged. Two sided full penetration welding is normally to be arranged. Where back welding is impossible welding is to be performed against ceramic backing bars or equivalent. Steel backing bars may be used and are to be continuously welded on one side to the heavy piece.

(4) Requirements for welding and design details of rudder trunks are described in 3.1.9.2 of this Section.

(5) Requirements for welding and design details when the rudder stock is connected to the rudder by horizontal flange coupling are described in 3.1.6.1(4) of this Section.

(6) Requirements for welding and design details of rudder horns are described in 3.1.9.1(3).

3.1.1.5 Equivalence

(1) CCS may accept alternatives to requirements given in this Section, provided they are deemed to be equivalent.

(2) Direct analyses adopted to justify an alternative design are to take into consideration all relevant modes of failure, on a case by case basis. These failure modes may include, amongst others: yielding, fatigue, buckling and fracture. Possible damages caused by cavitation are also to be considered

(3) Where deemed necessary by CCS, lab tests, or full scale tests may be requested to validate the alternative design approach.

3.1.2 Rudder force and rudder torque

3.1.2.1 Rudder blades without cut-outs

(1) The rudder force C_R upon which the rudder scantlings are to be based is to be determined from the following formula:

$$C_R = 132K_1K_2K_3AV^2 \quad \text{in N}$$

Where: C_R —rudder force, in N;

A —area of rudder blade, in m^2 ;

V —maximum service speed, in kn. When the speed is less than 10 kn, V is to be replaced by the following:

$$V_{\min} = (V + 20) / 3$$

For astern condition the maximum astern speed V_{astern} is to be used, however, in no case less than:

$$V_{\text{astern}} = 0.5 V$$

K_1 —factor depending on the aspect ratio λ of the rudder area;

$K_1 = (\lambda + 2) / 3$, with λ not to be taken greater than 2;

$$\lambda = b^2 / A_t;$$

b —mean height of rudder area, in m. The mean rudder breadth and mean height of rudder are calculated according to the coordinate system in Figure 3.1.2.1;

A_t —sum of rudder blade area A and area of rudder post or rudder horn, if any, within the height b , in m^2 ;

K_2 —coefficient depending on the type of the rudder and the rudder profile according to Table 3.1.2.1; data may be provided by tests with approval of CCS;

K_3 —factor, taken as follows:

= 0.8 for rudders outside the propeller jet

= 1.15 for rudders behind a fixed propeller nozzle

= 1.0 otherwise.

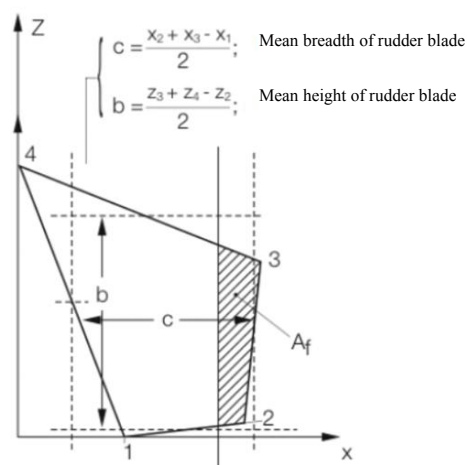


Figure 3.1.2.4 Coordinate system of rudder dimension

Factor K_2

Table 3.1.2.1

Profile Type		K_2	
		Ahead condition	Astern condition
NACA-00 series Göttingen		1.1	0.80
Flat side		1.1	0.90
Hollow		1.35	0.90
Lift rudders		1.7	To be specially considered; if not known: 1.30
Fish tail		1.4	0.8
Single plate		1.0	1.0
Mixed profiles (e.g.HSVA)	—	1.21	0.9

(2) The rudder torque Q_R is to be calculated for both the ahead and astern condition as follows:

$$Q_R = C_R r^2 \quad \text{N} \cdot \text{m}$$

Where: r —levers, $r = c (\alpha - k)$, in m ;

c —mean breadth of rudder area, in m , as shown in Figure 3.1.2.1;

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

k —factor, $k = A_f / A$;

A_f —portion of the rudder blade area situated ahead of the centre line of the rudder stock, in m^2 ;

For the ahead conditions, $r_{min} = 0.1c$, in m .

3.1.2.2 Rudder blades with cut-outs (semi-spade rudders)

The total rudder force C_R is to be calculated according to 3.1.2.1(1) of this Section. The pressure distribution

over the rudder area, upon which the determination of rudder torque and rudder blade strength is to be based, is to be derived as follows:

The rudder area may be divided into two rectangular or trapezoidal parts with areas A_1 and A_2 , so that $A = A_1 + A_2$ (see Figure 3.1.2.2).

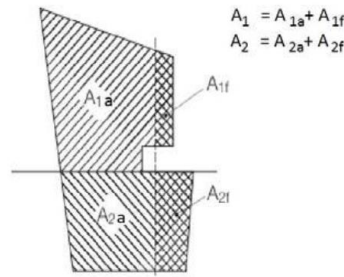


Figure 3.1.2.2 Areas A_1 and A_2

The levers r_1 and r_2 are to be determined as follows:

$$r_1 = c_1 (\alpha - k_1), \text{ m};$$

$$r_2 = c_2 (\alpha - k_2), \text{ m};$$

Where: c_1, c_2 — mean breadth of partial areas A_1, A_2 determined, where applicable, in accordance with Figure 3.1.2.1;

$$k_1 = A_{1f}/A_1;$$

$$k_2 = A_{2f}/A_2;$$

A_{1a} —portion of A_1 situated aft of the centre line of the rudder stock, in m^2 ;

A_{1f} —portion of A_1 situated ahead of the centre line of the rudder stock, in m^2 ;

A_{2a} —portion of A_2 situated aft of the centre line of the rudder stock, in m^2 ;

A_{2f} —portion of A_2 situated ahead of the centre line of the rudder stock, in m^2 ;

α —coefficient, to be taken as:

$\alpha = 0.33$, for ahead condition;

$\alpha = 0.66$, 0.66 for astern condition;

For parts of a rudder behind a fixed structure such as the rudder horn:

$\alpha = 0.25$, for ahead condition;

$\alpha = 0.55$, for astern condition;

The resulting force of each part may be taken as:

$$C_{R1} = C_R A_1 / A \quad \text{N}$$

$$C_{R2} = C_R A_2 / A \quad \text{N}$$

The resulting torque of each part may be taken as:

$$Q_{R1} = C_{R1} r_1 \quad \text{N} \cdot \text{m}$$

$$Q_{R2} = C_{R2} r_2 \quad \text{N} \cdot \text{m}$$

The total rudder torque is to be calculated for both the ahead and astern condition as follows:

$$Q_R = Q_{R1} + Q_{R2} \quad \text{N} \cdot \text{m}$$

For ahead condition Q_R is not to be taken less than:

$$Q_{R\min} = 0.1 C_R (A_1 C_1 + A_2 C_2) / A \quad \text{N} \cdot \text{m}$$

3.1.3 Rudder strength calculation

3.1.3.1 The rudder force and resulting rudder torque as given in 3.1.2 of this Section causes bending moments and shear forces in the rudder body, bending moments and torques in the rudder stock, supporting forces in pintle bearings and rudder stock bearings and bending moments, shear forces and torques in rudder horns and heel pieces. The rudder body is to be stiffened by horizontal and vertical webs enabling it to act as a bending girder.

3.1.3.2 The bending moments, shear forces and torques as well as the reaction forces are to be determined by a direct calculation or by an approximate simplified method considered appropriate by CCS. For rudders supported by sole pieces or rudder horns these structures are to be included in the calculation model in order to account for the elastic support of the rudder body. Guidelines for calculation of bending moment and shear force distribution are given in Appendix III to this PART.

3.1.4 Rudder stock scantlings

3.1.4.1 The rudder stock diameter required for the transmission of the rudder torque is to be dimensioned such that the torsional stress τ_t is not exceeding the following value:

$$\tau_t = 68 / \text{KN/mm}^2$$

The rudder stock diameter for the transmission of the rudder torque d_t is therefore not to be less than:

$$d_t = 4.2 \sqrt[3]{Q_R K} \text{ mm}$$

Where: Q_R —total rudder torque [N•m] as calculated in 3.1.2.1(2) and 3.1.2.2 of this Section;

K —material factor for the rudder stock as given in 3.1.1.3(5) of this Section.

3.1.4.2 Rudder stock scantlings due to combined loads

If the rudder stock is subjected to combined torque and bending, the equivalent stress in the rudder stock is not to exceed $118 / K$, N/mm². K is material factor for the rudder stock as given in 3.1.1.3(5).

The equivalent stress σ_c is to be determined by the formula:

$$\sigma_c = \sqrt{\sigma_b^2 + 3\tau_t^2} \quad \text{N/mm}^2$$

Where: bending stress $\sigma_b = 10.2M/d_c^3 \times 10^3$, in N/mm²

torsional stress: $\tau_t = 5.1Q_R/d_c^3 \times 10^3$, in N/mm².

The rudder stock diameter D_p is not to be less than that obtained from the following formula:

$$d_c = d_t \sqrt[6]{1 + (M / Q_R)^2 \cdot 4 / 3} \quad \text{mm}$$

Where: M —bending moment, in N•m, at the station of the rudder stock considered.

3.1.4.3 Before significant reductions in rudder stock diameter due to the application of steels with specified minimum yield stresses exceeding 235 N/mm² are granted, CCS may require the evaluation of the rudder stock deformations. Large deformations of the rudder stock are to be avoided in order to avoid excessive edge pressures in way of bearings.

3.1.5 Rudder stock

3.1.5.1 Permissible stresses

The section modulus and the web area of a horizontal section of the rudder blade are to be such that the following stresses will not be exceeded:

(1) In general

① bending stress $\sigma_b \leq 110/K$, N/mm²

② shear stress $\tau \leq 50/K$, N/mm²

③ equivalent stress $\sigma_e = \sqrt{\sigma^2 + 3\tau^2} \leq 120/K$, N/mm²

K —material factor for rudder plating, see 3.1.1.3 (2) of this Section.

(2) In way of the recess for the rudder horn pintle on semi-spade rudders

① bending stress: $\sigma_b \leq 75$, N/mm² (in way of rudder recess sections)

② shear stress $\tau \leq 50$, N/mm²

③ equivalent stress $\sigma_e = \sqrt{\sigma^2 + 3\tau^2} \leq 100$, N/mm²

Note: The stresses in (2) apply equally to high tensile and ordinary steels.

3.1.5.2 Rudder plating

The thickness t of the rudder side, top and bottom plating are not to be less than the values obtained from the following formula:

$$t = 5.5s\beta \sqrt{K} \sqrt{d + C_R 10^{-4} / A + 2.5} \quad \text{mm}$$

Where: d —summer load waterline draught, in m;

C_R —rudder force, in N, see 3.1.2.1 in this Section;

A —area of rudder blade, in m²;

$\beta = \sqrt{1.1 - 0.5(s/b)^2}$, if $b/s \geq 2.5$, maximum value for β is taken as 1;

s —smallest unsupported width of plating, in m;

b —greatest unsupported width of plating, in m;

K —material factor of rudder blade, see 3.1.1.3 (2) of this Section.

The thickness of the nose plate of rudder blades is not to be less than 1.2 times that of rudder side plating, but

need not be greater than 22 mm. The thickness of web plates is not to be less than the greater of 70% of the rudder side plating thickness and 6 mm.

The rudder plating in way of the solid part is to be of increased thickness per 3.1.5.3 (4).

3.1.5.3 Connections of rudder blade structure with solid parts

(1) Solid parts in forged or cast steel, which house the rudder stock or the pintle, are to be provided with protrusions.

These protrusions are not required when the web plate thickness is less than:

-10 mm for web plates welded to the solid part on which the lower pintle of a semi-spade rudder is housed and for vertical web plates welded to the solid part of the rudder stock coupling of spade rudders;

-20 mm for other web plates.

(2) The solid parts are in general to be connected to the rudder structure by means of two horizontal web plates and two vertical web plates.

(3) Minimum section modulus of the connection with the rudder stock housing.

The section modulus of the cross-section of the structure of the rudder blade W_s , in cm^3 , formed by vertical web plates and rudder plating, which is connected with the solid part where the rudder stock is housed is to be not less than:

$$W_s = c_s d_c^3 \left(\frac{H_E - H_X}{H_E} \right) \frac{K}{K_s} 10^{-4} \quad \text{cm}^3$$

where: c_s —coefficient, to be taken equal to:

$c_s = 1.0$, if there is no opening in the rudder plating or if such openings are closed by a full penetration welded plate;

$c_s = 1.5$, if there is an opening in the considered cross-section of the rudder;

d_c —diameter of rudder stock in way of lower bearing, in mm, calculated according to 3.1.4 of this Section;

H_E —vertical distance between the lower edge of the rudder blade and the upper edge of the solid part, in m;

H_X —vertical distance between the considered cross-section and the upper edge of the solid part, in m;

K —material factor for the rudder blade plating as given in 3.1.1.3(2);

K_s —material factor for the rudder stock as given in 3.1.1.3(5).

The actual section modulus of the cross-section of the structure of the rudder blade is to be calculated with respect to the symmetrical axis of the rudder. The breadth of the rudder plating, in m, to be considered for the calculation of section modulus is to be not greater than:

$$b = s_v + 2H_X/3 \quad \text{m}$$

Where: s_v —spacing between the two vertical webs, in m (see Figure 3.1.5.3).

Where openings for access to the rudder stock nut are not closed by a full penetration welded plate, they are to be deducted.

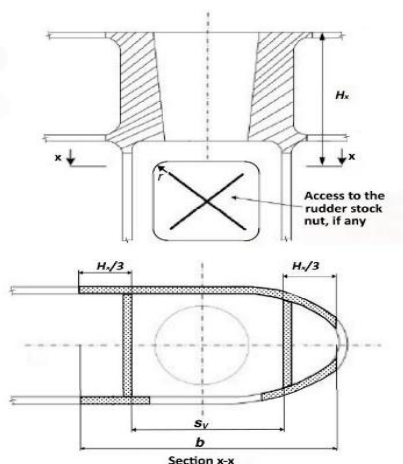


Figure 3.1.5.3 Cross-section of the connection between rudder blade structure and rudder stock housing, example with opening in only one side shown

(4) The thickness of the horizontal web plates connected to the solid parts, in mm, as well as that of the rudder blade plating between these webs, is to be not less than the greater of the following values:

$$t_H = 1.2t \quad \text{mm}$$

$$t_H = 0.045 d_s^2 / S_H \quad \text{mm}$$

Where: t —defined in 3.1.5.2 of this Section;

d_s —diameter, in mm, to be taken equal to:

$d_s = d_c$, as per 3.1.4.2 of this Section, for the solid part housing the rudder stock;

$d_s = d_p$, as per 3.1.7.1 of this Section, for the solid part housing the pintle;

S_H —spacing between the two horizontal web plates, in mm.

The increased thickness of the horizontal webs is to extend fore and aft of the solid part at least to the next vertical web.

(5) The thickness of the vertical web plates welded to the solid part where the rudder stock is housed as well as the thickness of the rudder side plating under this solid part is to be not less than the values obtained, in mm, from Table 3.1.5.3.

Thickness of side plating and vertical web plates

**Table 3.1.5.
3**

Type of rudder	Thickness of vertical web plates, in mm		Thickness of rudder plating, in mm	
	Rudder blade without opening	Rudder blade with opening	Rudder blade without opening	Rudder blade with opening
Rudder supported by sole piece	1.2t	1.6t	1.2t	1.4t
Semi-spade and spade rudders	1.4t	2.0t	1.3t	1.6t

where: t = thickness of the rudder plating, in mm, as defined in 3.1.5.2 of this Section.

The vertical web plates and rudder plating the thickness of which has been increased are to extend below the solid piece at least to the next horizontal web.

3.1.5.5 Single plate rudders

(1) Mainpiece diameter

The mainpiece diameter is calculated according to 3.1.4.1 and 3.1.4.2 of this Section respectively. For spade rudders the lower third may taper down to 0.75 times stock diameter.

(2) rudder blade thickness

The rudder blade thickness t is not to be less than that obtained from the following formula:

$$t = 1.5sV\sqrt{K} + 2.5 \quad \text{mm}$$

Where: s —spacing of stiffeners, in m, and is not to exceed 1 m;

V —speed, in knots, see 3.1.2.1 (1) of this Section;

K —material factor of rudder blade, see 3.1.1.3 (2) of this Section.

(3) Stiffeners

The thickness t_a of stiffeners is not to be less than that of rudder blade:

$$t_a = t_b \quad \text{mm}$$

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

$$W = 0.5sC_1^2V^2K \quad \text{cm}^3$$

Where: C_1 —horizontal distance from the aft edge of the rudder to the centreline of rudder stock, in m;

K —Material factor, as given in 3.1.1.3(2) or 3.1.1.3 (5) of this Section respectively.

3.1.6 Rudder stock couplings

3.1.6.1 Horizontal flange couplings

(1) The diameter d_b of coupling bolts is not to be less than that obtained from the following formula:

$$d_b = 0.62\sqrt{d_s^3 K_b / ne_m K_s} \quad \text{mm}$$

Where: d_s —rudder stock diameter, taken equal to the greater of the diameters d_t or d_c according to 3.1.4.1 and 3.1.4.2, in mm;

n — total number of bolts, which is not to be less than 6;

e_m —mean distance of the bolt axes from the centre of the bolt system, in mm;

K_s —material factor for the stock as given in 3.1.1.3(5) of this Section;

K_b —material factor for the bolts as given in 3.1.1.3(5) of this Section;

(2) The thickness of the coupling flanges t_f , in mm, is not to be less than the greater of the following formulae:

$$t_f = d_b\sqrt{K_f/K_b} \quad \text{mm}$$

$$t_f = 0.9d_b \quad \text{mm}$$

Where: K_f —material factor for flange as given in 3.1.1.3(5) of this Section;

K_b —material factor for the bolts as given in 3.1.1.3(5) of this Section;

d_b —bolt diameter calculated for a number of bolts not exceeding 8, in mm;

(3) The width of material between the perimeter of the bolt holes and the perimeter of the flange is not to be less than $0.67d_b$;

(4) The welded joint between the rudder stock and the flange is to be made in accordance with Figure 3.1.6.1 or equivalent;

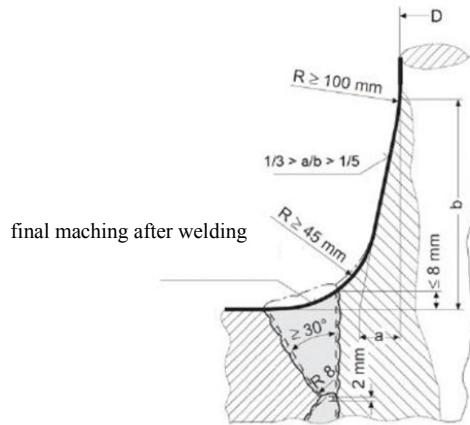


Figure 3.1.6.1 Welded joint between rudder stock and coupling flange

(5) Coupling bolts are to be fitted bolts and their nuts are to be locked effectively.

3.1.6.2 Vertical flange couplings of rudder stock and rudder blades

The diameter d_b of coupling bolt is not to be less than that obtained from the following formula:

$$d_b = 0.81 d_s / \sqrt{n} \times \sqrt{K_b / K_s} \quad \text{mm}$$

Where: d_s —rudder stock diameter in way of coupling flange, in mm;

n —total number of bolts, which is not to be less than 8;

K_b —material factor for bolts as given in 3.1.1.3(5) of this Section;

K_s —material factor for stock as given in 3.1.1.3(5) of this Section.

(2) The first moment of area of the bolts about the centre of the coupling, m , is to be not less than:

$$m = 0.00043 d_s^3 \quad \text{cm}^3$$

(3) The thickness of the coupling flanges is to be not less than the bolt diameter, and the width of the flange material between the perimeter of the bolt holes and the perimeter of the flange is to be not less than $0.67d_b$;

(4) Coupling bolts are to be fitted bolts and their nuts are to be locked effectively.

3.1.6.3 Cone couplings with key

(1) Tapering and coupling length

Cone couplings without hydraulic arrangements for mounting and dismounting the coupling are to have a taper c on diameter of 1:8 – 1:12.

Where, $c = (d_0 - d_u) / l_c$, see Figure 3.1.6.3(a) and Figure 3.1.6.3(c). The diameters d_0 and d_u are shown in Figure 3.1.6.3(a) and the cone length l_c is defined in Figure 3.1.6.3(c).

The cone coupling is to be secured by a slugging nut. The nut is to be secured, e.g. by a securing plate as shown in Figure 3.1.6.3(a).

The cone shapes are to fit exactly. The coupling length l is to be, in general, not less than $1.5d_0$.

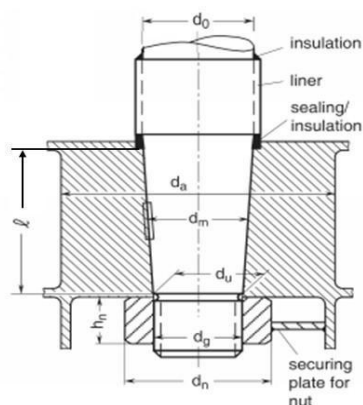


Figure 3.1.6.3(a) Cone coupling with key

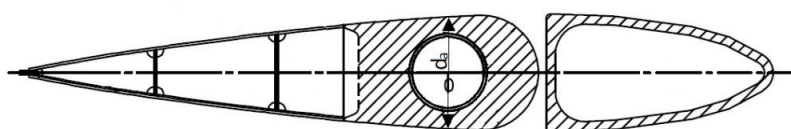


Figure 3.1.6.3(b) Gudgeon outer diameter d_a

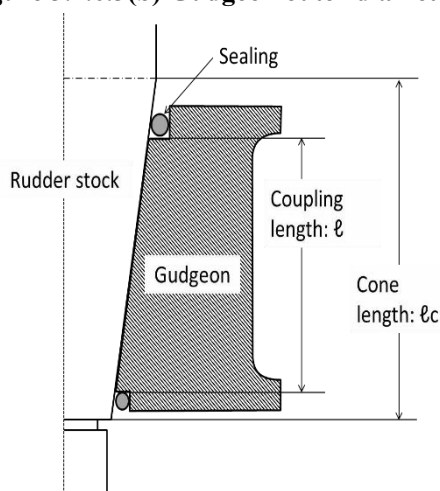


Figure 3.1.6.3(c) Cone length and coupling length

(2) Dimensions of key

For couplings between stock and rudder a key is to be provided, the shear area as of which, in cm^2 , is not to be less than:

$$a_s = \frac{17.55 Q_F}{d_k R_{eH1}} \quad \text{cm}^2$$

where: Q_F —design yield moment of rudder stock, in $\text{N}\cdot\text{m}$;

$$Q_F = 0.02664 d_r^3 / K \quad \text{N}\cdot\text{m}$$

Where the actual diameter d_{ta} is greater than the calculated diameter d_t , the diameter d_{ta} is to be used. However, d_{ta} applied to the above formula need not be taken greater than $1.145 d_t$.

d_r —stock diameter, in mm, according to 3.1.4.1 of this Section;

K —material factor for stock as given in 3.1.1.3(5) of this Section;

d_k —mean diameter of the conical part of the rudder stock, in mm, at the key;

R_{eH1} —specified minimum yield stress of the key material, in N/mm^2 .

The effective surface area a_{k_s} , in cm^2 , of the key (without rounded edges) between key and rudder stock or cone coupling is not to be less than:

$$a_k = \frac{5Q_F}{d_k R_{eH2}} \quad \text{cm}^2$$

where: R_{eH2} —specified minimum yield stress of the key, stock or coupling material, in N/mm².

(3) The dimensions of the slugging nut are to be as follows (see Figure 3.1.6.3(a)):

external thread diameter: $d_g \geq 0.65d_o$

height: $h_n \geq 0.6d_g$;

outer diameter: $d_n \geq 1.2d_u$ or $1.5d_g$, whichever is the greater.

(4) It is to be proved that 50% of the design yield moment is solely transmitted by friction in the cone couplings. This can be done by calculating the required push-up pressure and push-up length according to 3.1.6.4(2) for a torsional moment $Q'_F = 0.5Q_F$;

(5) Notwithstanding the requirements of 3.1.6.3(2) and 3.1.6.3(4), where a key is fitted to the coupling between stock and rudder and it is considered that the entire rudder torque is transmitted by the key at the couplings, the scantlings of the key as well as the push-up force and push-up length are to be subject to special consideration.

3.1.6.4 Cone couplings with special arrangements for mounting and dismounting the couplings

(1) Where the stock diameter exceeds 200 mm, the press fit is recommended to be effected by a hydraulic pressure connection. In such cases the cone is to be more slender, $c \approx 1:12$ to $\approx 1:20$.

In case of hydraulic pressure connections the nut is to be effectively secured against the rudder stock or the pintle.

For the safe transmission of the torsional moment by the coupling between rudder stock and rudder body the push-up pressure and the push-up length are to be determined according to 3.1.6.4(2) and 3.1.6.4(3) respectively.

(2) Push-up pressure

The push-up pressure is not to be less than the greater of the two following values:

$$p_{req1} = \frac{2Q_F \times 10^3}{d_m^2 l \pi \mu_0} \quad \text{N/mm}^2$$

$$p_{req2} = \frac{6M_b \times 10^3}{l^2 d_m} \quad \text{N/mm}^2$$

where: Q_F —design yield moment of rudder stock, as defined in 3.6.3.2 of this Section, in N·m;

d_m —mean cone diameter, in mm, see Figure 3.1.6.3(a);

l —coupling length, in mm;

μ_0 —frictional coefficient, equal to 0.15;

M_b —bending moment in the cone coupling (e.g. in case of spade rudders), in N·m.

It has to be proved by the designer that the push-up pressure does not exceed the permissible surface pressure in the cone. The permissible surface pressure, in N/mm², is to be determined by the following formula:

$$p_{perm} = \frac{0.8R_{eH}(1-\alpha^2)}{\sqrt{3+\alpha^4}} \quad \text{N/mm}^2$$

where: R_{eH} —specified minimum yield stress of the material of the gudgeon, in N/mm²;

$\alpha = d_m / d_a$;

d_m —diameter, in mm, see Figure 3.1.6.3(a);

d_a —outer diameter of the gudgeon to be not less than $1.25 d_0$, in mm, see Figure 3.1.6.3 (a) and 3.1.6.3(b). (The least diameter is to be considered).

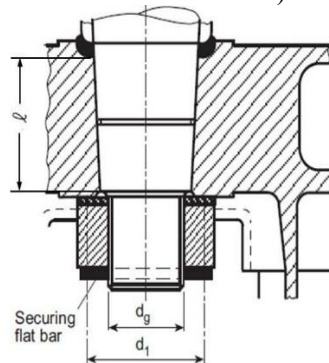


Figure 3.1.6.4 Cone couplings without key

(3) Push-up length

Push-up length l , in mm , is to comply with the following formula:

$$\Delta l_1 \leq \Delta l \leq \Delta l_2$$

Where:

$$\Delta l_1 = \frac{p_{req} d_m}{E \left(\frac{1 - \alpha^2}{2} \right) c} + \frac{0.8 R_{tm}}{c}, \text{ in mm};$$

$$\Delta l_2 = \frac{1.6 R_{et} d_m}{Ec \sqrt{3 + \alpha^4}} + \frac{0.8 R_{tm}}{c}, \text{ in mm};$$

R_{tm} —mean roughness, in mm , taken equal 1 to 0.01;

c —taper of diameter according to 3.1.6.4 (1) of this section, in mm .

In any case, the push -up length is not to be less than 2 mm .

Note: Where hydraulic connections the required push-up force P_e for the cone may be determined by the following formula:

$$P_e = p_{req} d_m \pi l \left(\frac{c}{2} + 0.02 \right) N$$

The value 0.02 is a reference for the friction coefficient using oil pressure. It varies and depends on the mechanical treatment and roughness of the details to be fixed. Where due to the fitting procedure a partial push-up effect caused by the rudder weight is given, this may be taken into account when fixing the required push-up length, subject to approval by CCS.

3.1.7 Pintles

3.1.7.1 Scantlings

The pintle diameter d_p is not to be less than:

$$d_p = 0.35 \sqrt{BK_p} \text{ in mm}$$

Where: B —relevant bearing force, in N ;

K_p —material factor for pintle as given in 1.1.3.5 of this Section.

3.1.7.2 Couplings

(1) Tapering

Pintles are to have a conical attachment to the gudgeons with a taper on diameter not greater than:

1:8 to 1:12 for keyed and other manually assembled pintles applying locking by slugging nut;

1:12 to 1:20 on diameter for pintles mounted with oil injection and hydraulic nut.

(2) Push-up pressure for pintle

The required push-up pressure for pintle p_{req} , in N/mm^2 , is to be determined by the following formula:

$$p_{req} = 0.4 \frac{B_1 d_0}{d_m^2 l} \quad N/mm^2$$

where: B_1 —Supporting force in the pintle, in N ;

d_0 —Pintle diameter, in mm , see Figure 3.1.6.3(a).

The push up length is to be calculated similarly as in 3.1.6.4(3) of this Section, using required push-up pressure and properties for the pintle.

3.1.7.3 The minimum dimensions of threads and nuts are to be determined according to 3.1.6.3(3).

3.1.7.4 Pintle housing

The length of the pintle housing in the gudgeon is not to be less than the pintle diameter d_p , d_p is to be measured on the outside of liners.

The thickness of the pintle housing is not to be less than $0.25d_p$.

3.1.8 Rudder stock bearing, rudder shaft bearing and pintle bearing

3.1.8.1 Liners and bushes

(1) Rudder stock bearing

Liners and bushes are to be fitted in way of bearings. The minimum thickness of liners and bushes t_{min} is to be equal to:

t_{min} = 8mm for metallic materials and synthetic material;

$t_{\min}=22\text{mm}$ for lignum material.

(2) Pintle bearing

The thickness of any liner or bush t , in mm, is not to be less than the minimum thickness defined in 3.1.8.1(1) and the following value:

$$t = 0.01\sqrt{B} \quad \text{mm}$$

where: B —relevant bearing force, in N.

3.1.8.2 Minimum bearing surface

An adequate lubrication is to be provided.

The bearing surface A_b (defined as the projected area: length $\times$ outer diameter of liner) is not to be less than:

$$A_b = P/q_a \quad \text{mm}^2$$

where: P —reaction force, in N, in bearing as determined in 3.1.3.2 of this Section;

q_a —allowable surface pressure according to Table 3.1.8.2.

The allowable surface pressure q_a for the various combinations is to be taken as reported in the table below. Higher values than given in Table 3.1.8.2 may be taken in accordance with makers' specifications if they are verified by tests:

Allowable surface pressure q_a

Table 3.1.8.2

Bearing material	q_a (N/mm ²)
Lignum vitae	2.5
White metal, oil lubricated	4.5
Synthetic material with hardness greater than 60 Shore D ^①	5.5 ^②
Steel ^③ and bronze and hot-pressed bronze-graphite materials	7.0

Notes:

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 Surface pressures exceeding 5.5 N/mm² may be accepted in accordance with bearing manufacturer's specification and tests, but in no case more than 10 N/mm².

③ Stainless and wear-resistant steel in an approved combination with stock liner.

3.1.8.3 Bearing dimensions

The length/diameter ratio of the bearing surface is not to be greater than 1.2.

The bearing length L_p of the pintle is to be such that $D_p \leq L_p \leq 1.2D_p$.

Where, D_p —Actual pintle diameter measured on the outside of liners, in mm.

3.1.8.4 Bearing clearances

With metal bearings, clearances should not be less than $d_b / 1000 + 1.0$ mm on the diameter. 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.

3.1.9 Strength of rudder horns and rudder trunk

3.1.9.1 Rudder horns

The bending moments and shear forces are to be determined by a direct calculation or in line with the guidelines given in 2.4 and 2.5 of Appendix III of this Part for semi spade rudder with one elastic support and semi spade rudder with 2-conjugate elastic support respectively.

The section modulus around the horizontal x-axis W is not to be less than:

$$W = M_b K / 67 \quad \text{cm}^3$$

Where: M_b —bending moment at the section considered, in N·m.

Shear stress τ is not to be greater than:

$$\tau = 48/K \quad \text{N/mm}^2$$

K —material factor as given in 3.1.1.3(2) or 3.1.1.3(5) of this Section.

(1) Equivalent stress

At no section within the height of the rudder horn is the equivalent stress to exceed $120/K$, in N/mm². The equivalent stress σ_v is to be calculated by the following formula:

$$\sigma_v = \sqrt{\sigma_b^2 + 3(\tau^2 + \tau_T^2)} \quad \text{N/mm}^2$$

Where: $\sigma_b = M_b/W_x$, in N/mm²;

$\tau = B_1/A_h$, N/mm²;

W_x —section modulus of rudder horn around x -axis, in cm³;

B_1 —supporting force in the pintle bearing, in N;

A_h —effective shear area of rudder horn in y direction, in mm²;

$\tau_T = M_T 10^3 / (2A_T t_h)$, in N/mm²;

M_T —torsional moment, in N·m;

A_T —area in the horizontal section enclosed by the rudder horn, in mm²;

t_h —plate thickness of rudder horn, in mm;

K —Material factor, see 3.1.1.3 (2) or 3.1.1.3 (5) respectively in this Section.

(2) Rudder horn plating

The thickness t of the rudder horn side plating is not to be less than:

$$t = 2.4\sqrt{LK} \quad \text{mm}$$

Where: L —length of ship, in m;

K —material factor, see 3.1.1.3 (2) of this Section.

(3) Welding and connection to hull structure

The rudder horn plating is to be effectively connected to the aft ship structure, e.g. by connecting the plating to side shell and transverse/ longitudinal girders, in order to achieve a proper transmission of forces, see Figure 3.1.9.1.

Brackets or stringer are to be fitted internally in horn, in line with outside shell plate, as shown in Figure 3.1.9.1.

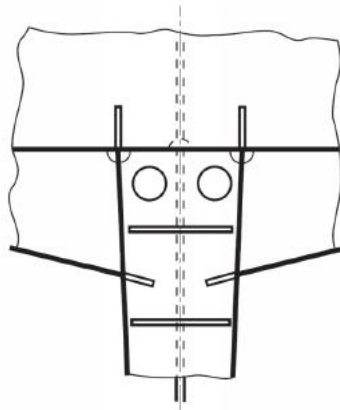


Figure 3.1.9.1 Connection of rudder horn to aft ship structure

Transverse webs of the rudder horn are to be led into the hull up to the next platform deck in a sufficient number.

Strengthened plate floors are to be fitted in line with the transverse webs in order to achieve a sufficient connection with the hull.

The centre line bulkhead (wash-bulkhead) in the after peak is to be connected to the rudder horn. Scallops are to be avoided in way of the connection between transverse webs and shell plating. The weld at the connection between the rudder horn plating and the side shell is to be full penetration. The welding radius is to be as large as practicable and may be obtained by grinding.

3.1.9.2 Rudder trunk

The requirements in this paragraph apply to trunk configurations which are extended below stern frame and arranged in such a way that the trunk is stressed by forces due to rudder action.

(1) Materials, welding and connection to hull

The steel used for the rudder trunk is to be of weldable quality, with a carbon content not exceeding 0.23% on ladle analysis or a carbon equivalent C_{EQ} not exceeding 0.41%.

Plating materials for rudder trunks are in general to meet the requirements in 1.3.2 of this PART.

The weld at the connection between the rudder trunk and the shell or the bottom of the skeg is to be full penetration.

The fillet shoulder radius r , in mm (see Figure 3.1.9.2) is to be as large as practicable and to comply with the following formulae:

$r=0.1d_c$, without being less than:

$r=60$ mm, when $\sigma \geq 40/K$, N/mm²

30 mm when $\sigma < 40/K$, N/mm²

where: d_c —rudder stock diameter axis as defined in 3.1.4.2;

σ —bending stress in the rudder trunk, in N/mm²;

K —material factor as given in 3.1.1.3(2) or 3.1.1.3(5) of this Section.

The radius may be obtained by grinding. If disk grinding is carried out, score marks are to be avoided in the direction of the weld. The radius is to be checked with a template for accuracy.

Four profiles at least are to be checked. A report is to be submitted to the Surveyor.

Rudder trunks comprising of materials other than steel are to be specially considered by CCS.

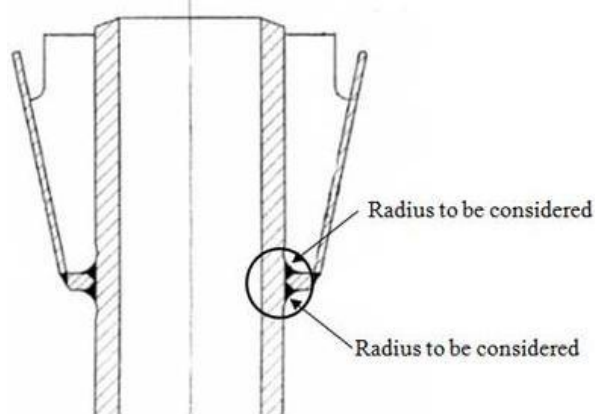


Figure 3.1.9.2

(2) Scantlings

The scantlings of the trunk are to be such that: the equivalent stress due to bending and shear does not exceed $0.35 R_{eH}$.

The bending stress on welded rudder trunk σ is to be in compliance with the following formula:

$$\sigma \leq 80/K \quad \text{N/mm}^2$$

Where: σ —bending stress in the rudder trunk, as defined in 3.1.9.2(1);

K —material factor for the rudder trunk as given in 3.1.1.3(2) or 3.1.1.3(5) of this Section, not to be taken as less than 0.7;

R_{eH} —specified minimum yield stress, in N/mm², of the material used.

For calculation of bending stress, the span to be considered is the distance between the mid-height of the lower rudder stock bearing and the point where the trunk is clamped into the shell or the bottom of the skeg.

3.1.10 Others

3.1.10.1 Quadrants and tillers

(1) The section modulus W of the tiller at any section from the centre of the rudder stock about the vertical axis is not to be less than that obtained from the following formula:

$$W = 0.14(1 - D_s / R)D_t^3 \quad \text{mm}^3$$

Where: D_s —distance from the section under consideration to the centerline of the stock on the tiller, not greater than the bore diameter of the pin, in mm, see Figure 3.1.10.1;

d_t —stock diameter, in mm, at the tiller, calculated according to 3.1.4.1 of this Section;

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;

(2) Depth of boss of the quadrant or tiller $h \geq 1.0D_t$, and its outside diameter $D_o \geq 1.8D_t$. See Figure 3.1.10.1.

Where the depth of boss of the tiller h is greater than D_t , the required outer diameter D_o may be reduced accordingly. It is to ensure that $hD_o^2 \geq 1.8D_t^3$, and D_o is not to be less than $1.6D_t$ in any case.

The definition of D_t is the same as that specified in 3.1.10.1 (1);

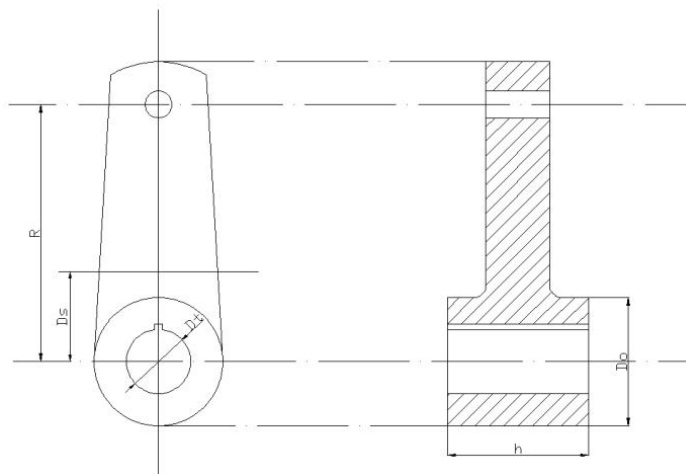


Fig. 3.1.10.1

(3) Where the boss of a tiller (quadrant) is composed of two half pieces, at least one key is to be fitted and each end of the key is to be secured by at least 2 bolts. The bolts are to be pretightened and the prestressing force on each bolt is to correspond to 70% of the permissible stress of bolt material. Where double keys are used, the prestressing force may be reduced appropriately. The total cross-sectional area A_b of all bolts is not to be less than that obtained by the following formula:

$$A_b = 0.2D_t^3/b \quad \text{mm}^2$$

Where: D_t —diameter of the rudder stock, in mm, at the tiller, calculated according to 3.1.4.1 of this Section;

b —distance between centerlines of bolt at both ends, in mm.

(4) The cross-sectional area A_x and moment of inertia I_x of the rod connecting the tiller (quadrant) to the tiller are not to be less than those obtained from the following formulas:

$$A_x = 0.12D_t^3/R \quad \text{mm}^2$$

$$I_x = 10^{-6} \times 6.6D_t^3 l^2 / R \quad \text{mm}^4$$

Where: D_t —diameter of the rudder stock, in mm, at the tiller of a passive rudder, calculated according to 3.1.4.1 of this Section;

l —length of connecting rod, in mm;

R —length of the tiller of the passive rudder, in mm.

(5) For a rotary vane type steering gear, the rotor and blades of the gear are to comply with the requirements of 3.1.10.1(1) and 3.1.10.1(2) for boss of the tiller and the tiller.

3.1.10.2 Connection of rudder tiller to stock

(1) The connection of the rudder tiller to stock is to be such that mechanical forces are transmitted from the steering gear to the rudder stock in any operational condition. The torque T_d transmitted by such connection is not to be less than twice the design torque of the steering gear, but need not be greater than the design yield torque Q_F of the stock calculated according to 3.1.6.3(2) of this Section. The design torque of the steering gear is corresponding to the design pressure in 13.1.6.5 of Chapter 9, PART 3 of the Rules.

(2) For torque transmission by friction, the average surface pressure p_r for the connection of tiller to stock is not to be less than that obtained from the following formula:

$$p_r \geq \frac{2T_{fr}}{\pi D_m^2 l f} \times 10^3 \quad \text{N/mm}^2$$

Where: T_{fr} —torque transmitted by friction, in N·m;

$= T_d$, for keyless connection;

$= 0.5T_d$, key connection;

T_d —torque transmitted through connection of tiller to stock, in N·m, determined according to 3.1.10.2(1) of this Section;

D_m —diameter of the rudder stock or mean diameter of the taper, in mm;

l —length of the effectively connected portion of the tiller, in mm;

f —coefficient of friction, taken as 0.15 for hydraulic fit or 0.18 for dry fit.

(3) For conical connection, nuts are to be used for securing against axial displacement. It is to be ensured that the size of nuts is to sustain the weight of rudder and rudder stock without considering the force of friction between rudder tiller and rudder stock, and reference may be made to the requirements of 3.1.6.3(3) of this Section.

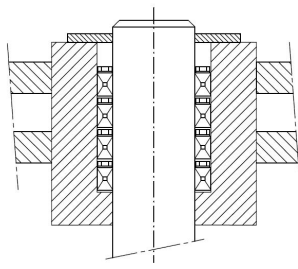
(4) Where the tiller is connected to the stock by means of several expansion sleeves or conical sleeves, as indicated in Figure 3.1.10.2, the influence of axial forces is also to be taken into account. In this case, the torque T_{d1} transmitted by the connection of tiller to stock is not to be less than that obtained from the following formula:

$$T_{d1} = \sqrt{T_d^2 + (2WD_m)^2} \times 10^{-4} \quad \text{N} \cdot \text{m}$$

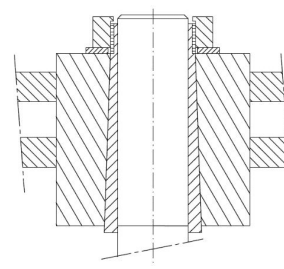
Where: T_d —torque, in N·m, determined according to 3.1.10.2 (1) of this Section;

W —weight of rudder and rudder stock, in kg;

D_m —diameter of the rudder stock, in mm;



(a) expansion sleeve



(b) conical sleeve

Fig. 3.1.10.2

(5) The taper of cone on diameter is to be not greater than 1:15 for keyless conical connection and not greater than 1:10 for keyed conical connection.

(6) For keyed connection, the shear area A_s of the key is not to be less than that obtained from the following formula:

$$A_s = \frac{70(T_d - k_{key}T_{fr})}{D_k R_{eH}} \quad \text{cm}^2$$

Where: T_d —torque transmitted through connection of tiller to stock, in N·m, calculated according to 3.1.10.2 of this Section.

k_{key} —coefficient, determined as follows:

= 0.7, where boss of tiller is composed of two half pieces and secured by bolts;

= 0.9, for hydraulic fitting of tiller to stock;

= 1.0, in other cases.

T_{fr} —torque transmitted by friction, in N·m, calculated according to the following formula:

$$T_{fr} = 0.5\pi p_r D_m^2 l f \times 10^{-3}$$

Where: p_r —average surface pressure for the connection of tiller to stock, in N/mm², determined according to 3.1.10.2(2) of this Section. Where hydraulic fitting or shrinkage fit is adopted for the conical connection, the average push-up surface pressure is to be taken;

D_m, l, f —same as in 3.1.10.2(2) of this Section;

d_k —mean diameter, in mm, of rudder stock cone in way of the position where the key is fitted;

R_{eH} —yield stress of key material, in N/mm².

(7) For keyed connections, the compressed area A_k of keys (round edge portion not included) is not to be less than that obtained from the following formula:

$$A_k = \frac{22(T_d - k_{key}T_{fr})}{D_k R_{eH}} \quad \text{cm}^2$$

Where: T_d , k_{key} , T_{fr} , D_k —the same as in 3.1.10.2 (6);

R_{eff} —yield stress of key material, in N/mm².

(8) Where two keys are fitted, the shear area A_s and compressed area A_k of each key may be taken as 2/3 of the value obtained for one key;

(9) The keyway is to have an adequately rounded end. The radius of curvature is usually not to be less than 5% of the thickness of the key. The compressive stress on the stock/tiller keyway is not to exceed 90% of the yield stress of the material used.

(10) Where the hydraulic fitting or shrinkage fit is adopted for the conical connection, the push-up length and the average push-up surface pressure are to be determined in accordance with the following requirements:

①The push-up length S is to meet the following:

$$S_1 \leq S \leq S_2$$

The minimum push-up length S_1 : $S_1 = \frac{1}{k_1} \left[\frac{2p_r D_m k_2^2}{E(k_2^2 - 1)} + 0.02 \right]$ mm

The maximum push-up length S_2 : $S_2 = \frac{1}{k_1} \left[1.6 R_{eff} D_m \frac{k_2^2}{E \sqrt{3k_2^4 + 1}} + 0.02 \right]$ mm

Where: p_r —average surface pressure for the connection of tiller to stock, in N/mm², determined according to 3.1.10.2(2) of this Section;

k_1 —taper of cone on diameter;

$k_2 = (D_m + t_a) / D_m$;

D_m —mean diameter of cone, in mm;

t_a —mean thickness of boss of tiller, in mm;

R_{eff} —yield stress of material of boss of tiller or rudder stock, whichever is less, in N/mm²;

E —elastic modulus, to be taken as 2.06×10^5 , in N/mm².

②The average push-up surface pressure P is to be calculated by the following formula:

$$P = \frac{SE(k_2^2 - 1)k_1}{2D_m k_2^2} \quad \text{N/mm}^2$$

Where: k_1 , k_2 , D_m and E —same as (1) above;

S —the push-up length to be determined in accordance with (1) above, in mm.

3.1.11 Accessories of hand steering gear

3.1.11.1 The diameter of steering chains d is not to be less than that obtained from the following formula:

$$d = 0.32 \sqrt{\frac{D_t^3}{R}} + 5 \quad \text{mm}$$

Where: D_t —diameter of the rudder stock at the tiller, in mm;

R —radius of quadrant or length of tiller, in mm.

Steering chains with a diameter of not more than 15 mm can be replaced by flexible galvanized wire ropes of equivalent breaking strength.

3.1.11.2 The diameter of steering rods is to be 1.2 times that of steering chains.

3.1.11.3 The diameter of leading block sheaves for steering chains, measured at the centre of the chains, is not to be less than 12 times that of steering chains; and the diameter of the sheave pins is not to be less than twice that of steering chains.

3.1.11.4 The turnbuckle screw with a effective locking devices are to be fitted to the leads of steering chain on each side of the ship.

3.1.11.5 The spring buffer are to be fitted to the leads of steering chain on each side of the ship, and the dimensions of spring buffer 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 m^2 , 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 $B/4$.

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 -3% ~ +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 mooring rope 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
					CCS 1	CCS 2	CCS 3			
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 of Section 1, Chapter 10 of PART ONE of CCS Rules for Materials and Welding.

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 CCS 1 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 Chapter). 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 ≤ 1.1 1

1.1 < A/N ≤ 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 wire rope 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 replacement

3.2.5.1 Anchor chains can be replaced by wire rope. Among them, anchor chains with a diameter of not more than 17.5 mm can also be replaced by fiber ropes.

The length of the 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 Where the anchor chains is replaced by wire rope or fiber ropes, the mass of the anchor is not to be less than 1.25 times the mass of the anchor specified in 3.2.2 of this Section.

3.2.5.3 A short anchor chain is to be fitted between the anchor and the wire rope. 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 wire rope 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 wire rope from being worn by deckhouses, superstructures, deck boards and equipment on deck. When the diameter of wire rope is not less than 18 mm, its guide roller is to be installed permanently.

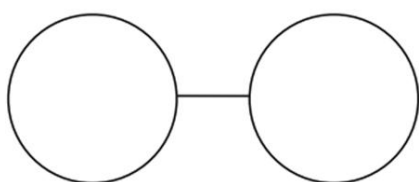
3.2.6 Arrangement of chain lockers

3.2.6.1 Spurling pipes and cable lockers are to be watertight up to the deck exposed to weather. However, the bulkhead between separate chain lockers (Figure 3.2.6.1(1)) or the common bulkhead between adjacent lockers (Figure 3.2.6.1(2)) need not be watertight.

3.2.6.2 Where means of access are provided, they are to be closed by a substantial cover and secured by closely spaced bolts.

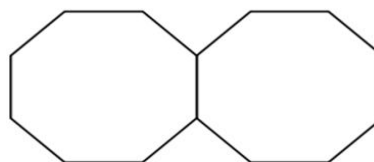
3.2.6.3 Where a means of access to spurling pipes or cable lockers is located below the weather deck, the manhole covers and securing appliances are to be in consistence with recognized standards (e.g., i) ISO 5894-1999; ii) China: GB 11628-1989 Ship Manhole Cover; iii) India: IS 15876-2009 “Ship and Marine Technology manholes with bolted covers”; iv) Japan: JIS F2304, “Ship’s Manholes” and JIS F2329, “Marine Small Size Manhole”; v) Korea: KSV 2339:2006 and KS VISO5994; vi) Norway: NS 6260:1985 to NS 6266:1985; vii) Russia: GOST 2021-90 “Ship’s steel manholes, Specifications”), or equivalent to the watertight manhole covers. The use of butterfly nuts and/or hinged bolts as the securing appliances of manhole covers is prohibited.

3.2.6.4 Spurling pipes through which anchor cables are led are to be provided with permanently attached closing appliances (e.g. steel plates in halves hooked over the spurling pipe tops, or canvas covers lashed) to minimize water ingress.



chain locker A chain locker B

figure 3.2.6.1(1)



chain locker A chain locker B

figure 3.2.6.1(2)

Section 3 OTHERS

3.3.1 Fish holds bottom planks

3.3.1.1 If planks are laid in the fish holds, the thickness is to be selected according to the length of ship L by the following requirements:

Where $L \leq 60\text{m}$, the thickness of plank is not to be less than 50 mm;

Where $L > 60\text{ m}$, the thickness of plank is not to be less than 55 mm;

Where insulation material is used in the fish holds, the thickness of plank shall be in accordance with standard SC/T 8074.

3.3.1.2 If the other side of the fish hold 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 hold and the fish hold. 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 hold 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 Section.

3.3.1.5 The outer surface of the double bottom bilge roofs or shaft tunnel roofs with planks are to be painted effective coatings according to whether laying planks.

3.3.2 Movable bulkhead in bulk fish hold

3.3.2.1 The arrangement of movable bulkheads in fish holds 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 holds 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 holds reaches 3m, at least one longitudinal partition is to be provided.

3.3.2.3 Movable bulkheads for fish holds 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.

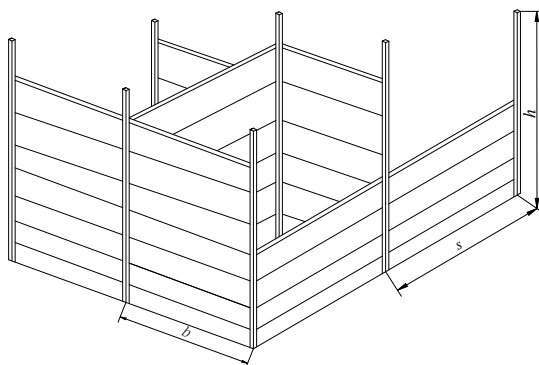


Figure 3.3.2.3 Movable bulkhead of fish holds

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:

$$W = ch^3(b+s) \quad \text{cm}^3$$

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 、 h — the same as 3.3.2.4 of this Section.

The minimum thickness of horizontal plank is not be to 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 this 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 ADDITIONAL PROVISION FOR STRUCTURE

Section 1 GENERAL PROVISIONS

4.1.1 General requirements

4.1.1 The provisions of this chapter apply to ocean-going fishing vessels of 90 m and over in length. For transoceanic fishing vessels only through the ocean of 90 m and over in length, a reduction base on service may be made in accordance with the provisions of PART TEN of Rules for Classification of Sea-going Steel Ships (hereinafter referred to as CCS Steel Rules).

4.1.2 If not covered in this Section, the requirements of Chapters 1 to 3 of CCS Steel Rules are to be complied with.

4.1.1.3 Hull structures directly evaluated by finite element calculation based on actual loads may not be thickened according to the relevant requirements in Section 2 of this chapter after CCS evaluation and approval.

Section 2 HULL STRUCTURE

4.2.1 Shell and inner bottom plating

4.2.1.1 The thicknesses of bottom shell plating and the thickness of bilge plating, within $0.4L$ amidships are to be 0.5 mm greater respectively than that required in Section 3, Chapter 2, PART TWO of CCS Steel Rules.

4.2.1.2 The thicknesses of bottom shell plating within $0.075L$ from ends is to be 0.5 mm greater than that required in Section 3, Chapter 2, PART TWO of CCS Steel Rules.

4.2.1.3 The thicknesses of bottom shell plating adjacent to plate keel within $0.25L$ from the forward perpendicular is not to be less than that required in 4.2.1.1 of this Section.

4.2.1.4 The thicknesses of side shell plating and sheer strakes within $0.4L$ amidships is to be 0.5 mm greater than that required in Section 3, Chapter 2, PART TWO of CCS Steel Rules.

4.2.1.5 The thicknesses of side shell plating within $0.075L$ from ends is to be equal to that required in 4.2.1.2 of this Section.

4.2.1.6 For seine boats, the thickness of shell plating in way of purse winch seat is to be increased by 1 mm over a suitable extent.

4.2.2 Decks and bulkhead plating

4.2.2.1 The thicknesses of strength deck is to be 0.5 mm greater than that required in Section 4, Chapter 2, PART TWO of CCS Steel Rules.

4.2.2.2 The thickness of deck under turn table is to be increased by 1 mm.

4.2.2.3 The thickness of deck under trawl winch, seine winch, trawl gallows, purse winch seat, windlass, etc. is to be 2 mm greater than that required in Section 4, Chapter 2, PART TWO of CCS Steel Rules.

4.2.2.4 The thicknesses of bulkhead plating in the area of fish holds is to be 1 mm greater than that required in Section 12, Chapter 2, PART TWO of CCS Steel Rules.

4.2.3 Bottom, side, deck and bulkhead framing

4.2.3.1 For trawlers, inclined half-round steel or equivalent chafing bars are to be arranged at the side plating and the external side of bulwark from the top of bulwark to 0.3 m below the designed load waterline over an extent at least 1 m forward and 2m aft of the trawl gallows, spaced not more than 400 mm apart. If the inward indentation below the work deck is great, the chafing bars can only be arranged at the sites with an indentation of 400 mm compared to working deck.

4.2.3.2 Side stringers are to be fitted in accordance with the relevant requirements of Section 15, CHAPTER 2, PART TWO of CCS Steel Rules from the collision bulkhead to $0.25L$ from the forward perpendicular. Where the side stringers are not fitted, the section modulus of main frames is to be 25% more than that required in Section 7, CHAPTER 2, PART TWO of CCS Steel Rules.

4.2.3.3 The deck framing under trawl winch, seine winch, trawl gallows, purse winch seat and windlass is to be adequately strengthened.

4.2.3.4 The deck framing may be calculated according to the relevant requirements of Section 8, CHAPTER 2, PART TWO of CCS Steel Rules, but the span l of deck beam is not to be less than $B/3$ when calculating the section

modulus of deck beam, with B being breadth of the vessel.

4.2.4 Stern ramp and transom counter

4.2.4.1 The thickness t of stern ramp plating and the section modulus W of stiffeners of stern trawlers are not to be less than those obtained respectively as follows:

$$t = 8 + 0.1L \quad \text{mm}$$

$$W = 16sl^2 \quad \text{cm}^3$$

Where: L —length of vessel, in m;

s —spacing of stiffeners, in m;

l —stiffeners of span, in m.

The thickness of side plating of the stern ramp is to be 1 mm greater than that required in 4.2.1.2 of this Section. It is recommended that chafing bars or plates of increased thickness be fitted to the ramp and ramp sides liable to excessive wear.

4.2.4.2 The thickness of transom plating is to comply with 4.2.1.5 of this Section.

4.2.4.3 The scantlings of framing in way of the transom counter are to be equal to those of the peak framing. Where necessary, web frames are to be adopted for strengthening.

4.2.5 Fish hatch

4.2.5.1 The thickness of the coamings on the exposed is not to be less than the minimum thickness as required in this rules for the deck for that position, or 11 mm, whichever is the lesser.

4.2.5.2 The structures of the coamings on the exposed are to comply with the requirements of 2.18.1.2 of this PART.

4.2.6 Bulwarks

4.2.6.1 The thickness of bulwark plating in way of working deck is not to be less than that obtained from the following formula, but not greater than 8mm:

$$t = 0.067L + 2 \quad \text{mm}$$

Where: L —length of vessel, in m.

4.2.6.2 The thickness of bulwark plating in way of trawl gallows and purse winch seat is to be 2 mm greater than that required in 4.2.6.1 of this Section.

4.2.6.3 The spacing of bulwark stays is, in general, not to be more than 2 frame spaces apart. The bulwark stays are to be fitted at every frame in way of trawl gallows, purse winch seat, forward bulwarks and raised bulwarks at stern.

4.2.7 Other special construction

4.2.7.1 Side reinforcement of fishing vessels moored at sea

Fishing vessels frequently moored at sea should be carried out side reinforcement in accordance with the following requirements.

(1) Side reinforcement area are to comply with the requirements in 2.19.1.2 of this PART;

(2) Side frame of reinforced area
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 1.2.6 of PART TWO of CCS Steel Rules;

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 Section 7 of PART TWO of CCS Steel Rules;

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.

Above work deck

Both ends of the frames at the 'tween decks are to be welded to the deck and meet the relevant requirements about the side frame of below work deck.

(3) The thickness of side shell plating in reinforcement areas is to be 1 mm thicker than that required in 2.3.4 of PART TWO of CCS Steel Rules

(4) 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.

(5) 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.

4.2.7.2 Fish product processing compartment

(1) Unless expressly provided otherwise, fish product processing compartment are to comply with the requirements in 2.19.2.1、2.19.2.2 and 2.19.2.3 of this PART.

(2) The deck in catch processing area fitted with heavy machinery or equipment should be specially strengthened by means of fitted with doubler plates or increased in thickness.

(3) When concentrated loads are applied to the deck, the strong beams and deck girders below the deck are to comply with the requirements in 2.8.3.2 of PART TWO of CCS Steel Rules.

4.2.7.3 Live fish holds

(1) Unless expressly provided otherwise, fishing vessels equipped with live fish holds are to comply with the requirements in 2.19.3.13 and 2.19.3.2 of this PART;

(2) 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 2.2.4.7 of PART TWO of CCS Steel Rules.

4.2.7.4 Fish holds bottom planks

(1) If planks are laid in the fish holds, the thickness should not be less than 55mm

(2) If the other side of the fish hold 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) A clearance layer not less than 50 mm is to be provided between the top of the fuel hold and the fish hold. 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.

(4) If the common bulkheads or decks of fish hold and non-edible oil tanks are increased by 2 mm from the plate thickness required by the relevant regulations in CHAPTER 2 of t PART TWO of CCS Steel Rules, and the welds comply with the requirements of 1.4.4 of PART TWO of CCS Steel Rules, they can replace the requirements of (2) and (3) above.

(5) The outer surface of the double bottom bilge roofs or shaft tunnel roofs with planks are to be painted effective coatings according to whether laying planks.

4.2.7.5 Movable bulkhead in bulk fish holds are to comply with the requirements in 3.3.2 of this PART.

4.2.7.6 Isolation layer are to comply with the requirements in 3.3.3 of this PART.

4.2.7.7 Chain lockers are to comply with the requirements in 3.2.6 of this PART.

CHAPTER 5 STRENGTHENING FOR NAVIGATION IN ICE

Section 1 GENERAL PROVISIONS

5.1.1 General Requirements

5.1.1.1 The provisions of this chapter apply to ocean-going fishing vessels navigating in ice of 90 m and over in length.

5.1.1.2 Fishing vessels intending to navigate/operate in ice should adopt appropriate structural reinforcement measures against ice

5.1.1.3 The structural reinforcement measures navigating in ice shall be based on the ice class chosen by the ship owners. The ice class and its relevant provisions are to comply with the provisions of CHAPTERT FOUR, PART TWO of Rules for Classification of Sea-going Steel Ships

5.1.1.4 Low air temperature environments may affect hull structure, function of equipment and systems, human performance and safety of the ships' operation. To remove or mitigate adverse impacts of low air temperatures and take anti-cold climate measures reasonably and effectively, the following risks, but not limited to, are to be taken into account:

- (1) loss of material properties;
- (2) reduced efficiency or failure of machinery/equipment;
- (3) freezing of cargo;
- (4) freezing of ballast water;
- (5) reduced habitability;
- (6) reduced human performance;
- (7) frostbite;
- (8) ice accretion of the ship above the waterline.

5.1.1.5 For fishing vessels intended to operate in areas with low air temperatures should adopt appropriate anti-icing and/or de-icing measures, the arrangements of anti-icing and/or de-icing measures may be referred to the relevant provision of SECTION 11, CHAPTER 23, PART 8 of Rules for Classification of Sea-going Steel Ships.

APPENDIX I GEOMETRICAL CHARACTERISTICS OF MEMBERS

1 Calculation methods of section modulus and W moment of inertia I of composite sections

1.1 Section area A_z , moment of inertia I and section modulus W of rolled sections (including bulb flats, unequal angle steel and unequal angle bars of unequal thickness) (see attached Figure 1) together with attached plating are to be calculated by the following formulae:

$$A_z = A_1 + A \text{ cm}^2$$

$$I = I_{x1} + (y_1 - y)^2 A_1 + \frac{At^2}{12} \times 10^{-2} + (0.05t + y)^2 A \text{ cm}^4$$

$$W = \frac{I}{0.1h - y} \text{ cm}^3$$

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 ;

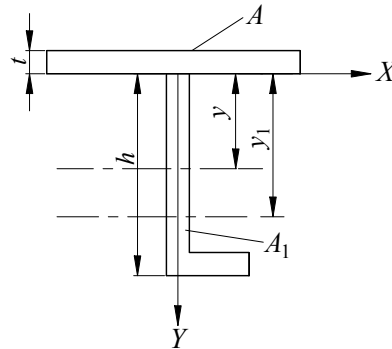
y_1 —neutral axis of the sections, in cm;

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:

$$y = \frac{A_1 y_1 - 0.05 A t}{A_z} \text{ cm}$$



Attached Figure 1 Schematic diagram of rolled sections with attached plates

1.2 Sectional modulus W and moment of inertia I of T sections with attached plates (Attached Figure 2):

$$W = \frac{d_w}{10} \left[a + \frac{f_s}{6} \left(1 + \frac{2(A - a)}{2A + f_s} \right) \right] \text{ cm}^3$$

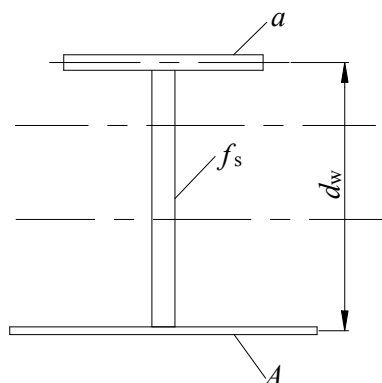
$$I = \left(\frac{d_w}{10} \right)^2 \left[\frac{1}{3} f_s + \frac{Aa - 0.25 f_s^2}{A + a + f_s} \right] \text{ cm}^4$$

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

1.3 Sectional modulus W and moment of inertia I of a corrugation breadth s for corrugated stiffened bulkheads (see attached Figure 3):

$$W = t d_w \left(a + \frac{b}{3} \right) \text{ cm}^3$$

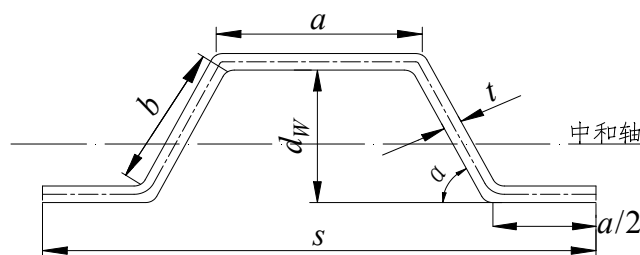
$$I = \frac{t d_w^2}{20} (a + 3b) \text{ cm}^4$$

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

1.4 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 1.4 (1) and 1.4 (2).

Section elements of triangular stiffened plates

Table 1.4 (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 1.4 (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	

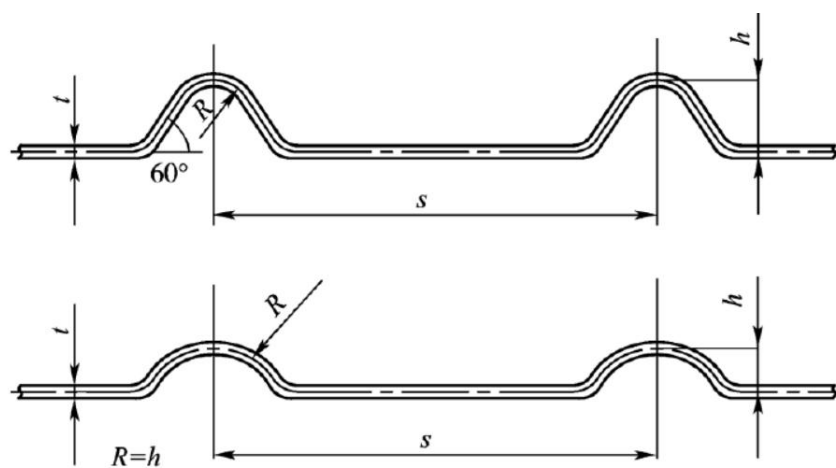


Figure 4 Schematic diagram of triangular and semi-circular stiffeners

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
	15	5	9	4	8	6	9	9	9
	16	5	10	4	9	6	10	9	10
0.13	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	5	8	8	8
	13	5	8	4	7	5	8	8	8
	14	5	9	4	7	5	9	9	9
	15	5	9	4	8	6	9	9	9
	16	5	10	4	9	6	10	10	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
	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
	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		$d/l=2.00$		$d/l=4.00$	
		Minimum	Maximum	Minimum	Maximum	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

APPENDIX III GUIDELINES FOR CALCULATION OF BENDING MOMENT AND SHEAR FORCE DISTRIBUTION

1 Application:

1.1 The evaluation of bending moments, shear force and support forces for the system rudder-rudder stock may be carried out for some basic rudder types as outlined in 2.1 to 2.5 of this Appendix.

2 The force on rudder-rudder stock

2.1 Spade rudder

Data for the analysis

$l_{10} \sim l_{30}$ —length of the individual girders of the system, in m;

$I_{10} \sim I_{30}$ —moment of inertia of these girders, in cm^4 .

Load of rudder body

$$P_R = C_R / (l_{10} 10^3) \quad \text{kN/m}$$

Moments and forces

The moments and forces may be determined by the following formula

$$M_b = C_R (l_{20} + (l_{10} (2c_1 + c_2) / 3 (c_1 + c_2))) \quad \text{N} \cdot \text{m}$$

$$B_3 = M_b / l_{30} \quad \text{N}$$

$$B_2 = C_R + B_3 \quad \text{N}$$

Where: C_R —rudder force, in N.

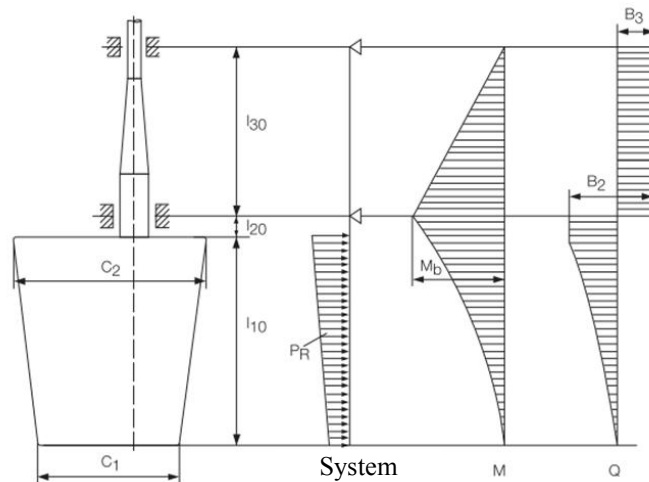


Figure 2.1 Spade rudder

2.2 Spade rudder with trunk

Data for the analysis

$l_{10} \sim l_{30}$ —length of the individual girders of the system, in m;

$I_{10} \sim I_{30}$ —moment of inertia of these girders, in cm^4 .

Load of rudder body

$$P_R = C_R / ((l_{10} + l_{20}) 10^3) \quad \text{kN/m}$$

Moments and forces

For spade rudders with rudders trunks the moments, and forces may be determined by the following formula:

M_R is the greatest of the following values:

$$M_{CR1} = C_{R1} (C_{G1} - l_{10}) \quad \text{N} \cdot \text{m}$$

$$M_{CR2} = C_{R2} (l_{10} - C_{G2}) \quad \text{N} \cdot \text{m}$$

Where: C_{R1} —rudder force over the rudder blade area A_1 , in N;

C_{R2} —rudder force over the rudder blade area A_2 , in N;

C_{G1} —Vertical position of the gravity of rudder blade area A_1 , in m;

C_{G2} —Vertical position of the gravity of rudder blade area A_2 , in m;

$$C_R = C_{R1} + C_{R2} \quad \text{N}$$

$$B_3 = (M_{CR2} - M_{CR1}) / (l_{20} + l_{30}) \quad \text{N}$$

$$B_2 = C_R + B_3 \quad \text{N}$$

Where: C_R —rudder force, in N.

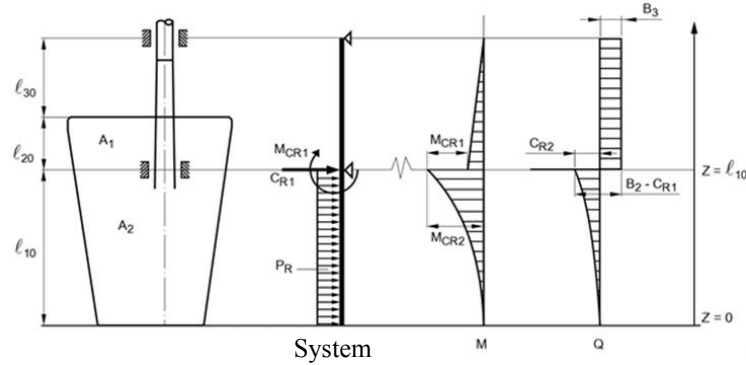


Figure 2.2 Spade rudder with trunk

2.3 Rudder supported by tail frame

Data for the analysis

$l_{10} \sim l_{50}$ —length of the individual girders of the system, in m;

$I_{10} \sim I_{50}$ —moments of inertia of these girders, in cm^4 .

The rudder supported by a sole piece the length, l_{20} is the distance between lower edge of rudder body and centre of sole piece and I_{20} is the moment of inertia of the pintle in the sole piece..

I_{50} —moment of inertia of sole piece around the z-axis, in cm^4 ;

l_{50} —effective length of sole piece, in m.

Load of rudder body

$$P_R = C_R / (l_{10} 10^3) \quad \text{kN/m}$$

Where: C_R —rudder force, in N;

Z —spring constant of support in the sole piece;

$$Z = 6.18 I_{50} / l_{50}^3 \quad \text{kN/m}$$

Moments and forces

Moments and shear forces are indicated in Figure 2.3.

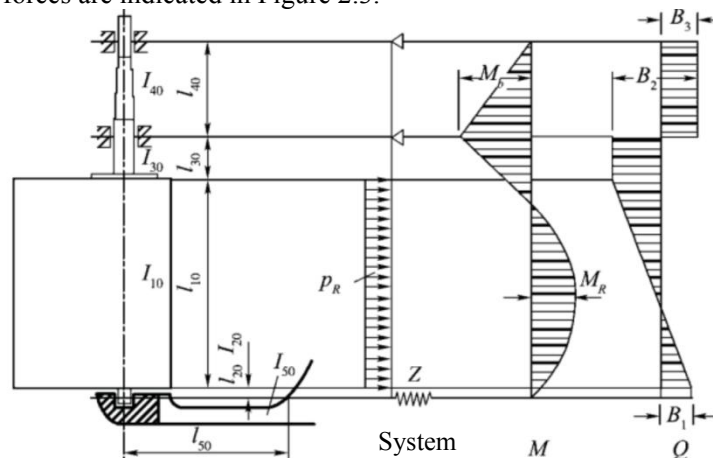


Figure 2.3 Rudder supported by sole piece

2.4 Semi spade rudder with one elastic support

Data for the analysis

$l_{10} \sim l_{50}$ —length of the individual girders of the system, in m;

$I_{10} \sim I_{50}$ —moment of inertia of these girders, in cm^4 .

Z —spring constant of support in the rudder horn;

$Z = 1 / (f_b + f_t)$, kN/m , for the support in the rudder horn. See Figure 2.4.1.

f_b —unit displacement of rudder horn due to a unit force of 1 kN acting in the centre of support, in m/kN ;

$f_b = 1.3h^3 / (6.18I_n)$ m/kN (guidance value)

I_n —moment of inertia of horizontal section of rudder horn around the x-axis, in cm^4 ;

f_t —unit displacement due to torsion, in m/kN ;

$f_t = he^2 \sum (u_i/t_i) / (3.14 \times 10^8 F_T^2)$ m/kN

F_T —mean section area of rudder horn, in m^2 .

u_i —breadth of the individual plates forming the mean horn sectional area, in mm ;

t_i —thickness within the individual breadth u_i , in mm ;

h —height of the rudder horn, in m , defined in Figure 2.4.1. This value is measured downwards from the upper rudder horn end, at the point of curvature transition, to the mid-line of the lower rudder horn pintle;

e —distance as defined in Figure 2.4.2, in m , measured to $h/2$ of the height of the rudder horn.

Load of rudder body

$$P_{R10} = C_{R2} / (l_{10} 10^3) \quad \text{kN/m}$$

$$P_{R20} = C_{R1} / (l_{20} 10^3) \quad \text{kN/m}$$

Where: C_{R1} , C_{R2} —see 2.2 of this Appendix.

Moments and forces

Moments and shear forces are indicated in Figure 2.4.1.

Rudder horn

The loads on the rudder horn are as follows:

M_H —bending moment, in $\text{N} \cdot \text{m}$, $M_H = B_1 z$;

$$M_{H\max} = B_1 h \quad \text{N} \cdot \text{m}$$

Q_H —shear force, in N , $Q_H = B_1$;

M_T —torsional moment, in $\text{N} \cdot \text{m}$, $M_T = B_1 e$ (z);

An estimate for B_1 is:

$$B_1 = C_R b / (l_{20} + l_{30}) \quad \text{N}$$

b —distance between the centre point of the force over rudder blade and lower bearing along z-axis in m .

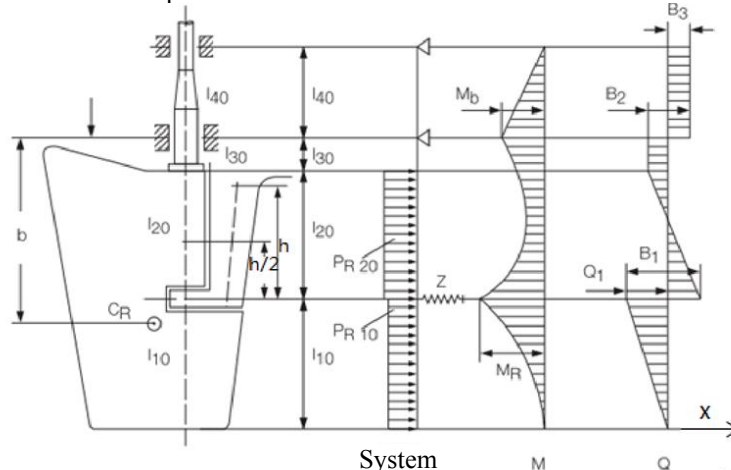


Figure 2.4.1 Semi spade rudder with one elastic support

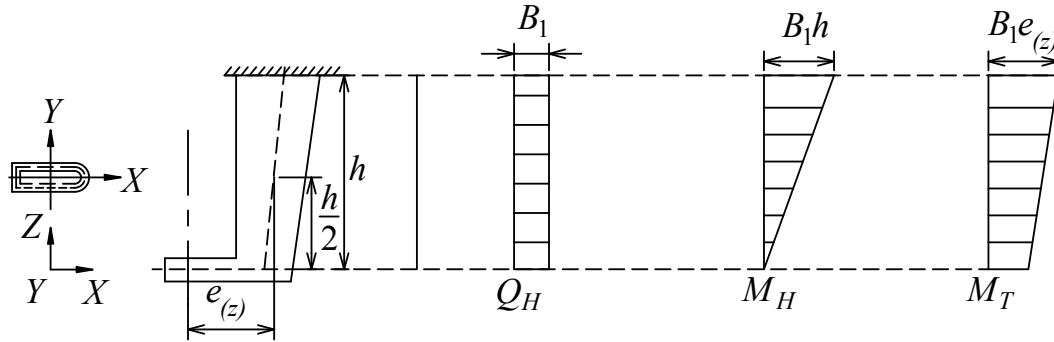


Figure 2.4.2 Rudder horn of semi spade rudder with one elastic support

2.5 Semi spade rudder with 2-conjugate elastic support

Data for the analysis

K_{11} , K_{22} , K_{12} —rudder horn compliance constants calculated for rudder horn with 2-conjugate elastic supports.

See Figure 2.5.1. The 2-conjugate elastic supports are defined in terms of horizontal displacements, y_i by the following equations:

at the lower rudder horn bearing:

$$y_1 = -K_{12}B_2 - K_{22}B_1$$

at the upper the rudder horn bearing:

$$y_2 = -K_{11}B_2 - K_{12}B_1$$

Where: y_1 , y_2 —horizontal displacements at the upper and lower rudder horn bearings, respectively, in m;

B_1 , B_2 — horizontal support forces at the upper and lower rudder horn bearings, respectively, in kN;

K_{11} , K_{22} , K_{12} —obtained from the following formula, in m/kN:

$$K_{11} = 1.3 \times \frac{\lambda^3}{3EJ_{1h}} + \frac{e^2 \lambda}{GJ_{th}}$$

$$K_{22} = 1.3 \times \left[\frac{\lambda^3}{3EJ_{1h}} + \frac{\lambda^2(h-\lambda)}{2EJ_{1h}} \right] + \frac{e^2 \lambda}{GJ_{th}}$$

$$K_{12} = 1.3 \times \left[\frac{\lambda^3}{3EJ_{1h}} + \frac{\lambda^2(d-\lambda)}{EJ_{1h}} + \frac{\lambda(h-\lambda)^2}{EJ_{1h}} + \frac{(h-\lambda)^3}{3EJ_{2h}} \right] + \frac{e^2 \lambda}{GJ_{th}}$$

Where: h —height of the rudder horn, in m, as defined in Figure 2.5.1. This value is measured downwards from the upper rudder horn end, at the point of curvature transition, to the mid-line of the lower rudder horn pintle;

λ —length, in m, as defined in Figure 2.5.2. This length is measured downwards from the upper rudder horn end, at the point of curvature transition, to the mid-line of the upper rudder horn bearing. For $\lambda = 0$, the above formula converges to those of spring constant Z for a rudder horn with 1-elastic support, and assuming a hollow cross section for this part ;

e —rudder horn torsion lever, in m, as defined in Figure 2.5.1, value taken at $z = h / 2$;

J_{1h} —moment of inertia of rudder horn about x-axis, in m^4 .for the region above the upper rudder horn bearings. Note that J_{1h} is an average value over the length λ . See Figure 2.5.1;

J_{2h} —moment of inertia of rudder horn about x-axis, in m^4 .for the region between the upper and lower rudder horn bearings. Noted that J_{2h} is an average value over the length $h-\lambda$, see Figure 2.5.1;

J_{th} —torsional stiffness factor of rudder horn, in m^4 , for any thin wall closed sections:

$$J_{th} = 4F_T^2 / \sum_i \frac{u_i}{t_i} \quad m^4$$

F_T —mean of areas enclosed by the inner and outer boundaries of the thin-walled sections of rudder horn, in m^2 ;

u_i —length of the individual plates forming the mean horn sectional area, in mm;

t_i —thickness of the individual plates mentioned above, in mm.

Noted that the J_{th} value is taken as an average value, valid over the rudder horn height.

Load of rudder body

$$P_{R10}=C_{R20}/(I_{10}10^3) \text{ kN/m}$$

$$P_{R20}=C_{R10}/(I_{20}10^3) \text{ kN/m}$$

Where: C_{R1} , C_{R2} —see 2.2 of this Appendix.

Moments and forces

Moments and shear forces are indicated in Figure 2.5.1.

Rudder horn bending moment

The bending moment acting on the generic section of the rudder horn is to be obtained from the following formula, in N·m

Between the lower and upper supports provided by the rudder horn:

$$M_H=F_{A1}z \text{ N·m}$$

Above the rudder horn upper support :

$$M_H=F_{A1}z+F_{A2}(z-d_{lu}) \text{ N·m}$$

Where: F_{A1} —support force at the rudder horn lower support, in N, to be obtained according to Figure 2.5.1 and taken equal to B_1 ;

F_{A2} —support force at the rudder horn upper support, in N, to be obtained according to Figure 2.5.1 and taken equal to B_2 ;

z —distance, in m, defined in Figure 2.5.2, to be taken less than the distance h , in m, defined in the same figure;

d_{lu} —distance, in m, between the rudder horn upper and lower bearings according to Figure 2.5.1, $d_{lu}=h-\lambda$.

Rudder horn shear force

The shear force Q_H acting on the generic section of the rudder horn, is to be obtained, in N, from the following formula:

between the lower and the upper rudder horn bearings:

$$Q_H=F_{A1} \text{ N}$$

Above the rudder horn upper bearings :

$$Q_H=F_{A1}+F_{A2} \text{ N}$$

The torque M_T acting on the generic section of the rudder horn is to be obtained from the following formula Between the lower end and the upper rudder horn bearings:

$$M_T=F_{A1}e_{(z)} \text{ N·m}$$

Above the upper rudder horn upper bearings:

$$M_T=F_{A1}e_{(z)}+F_{A2}e_{(z)} \text{ N·m}$$

Where: F_{A1} , F_{A2} —support forces, in N

$e_{(z)}$ —torsion lever, in m, as defined in Figure 2.5.2.

Rudder horn shear stress calculation

For a generic section of the rudder horn, located between its upper and lower bearings, the following stresses are to be calculated:

τ_s —shear stress, to be obtained from the following formula:

$$\tau_s=F_{A1}/A_H \text{ N/mm}^2$$

τ_T —torsional stress, to be obtained for hollow rudder horn from the following formula:

$$\tau_T=M_T10^3/(2F_{TH}) \text{ N/mm}^2$$

For solid rudder horns, τ_T is to be considered by CCS on a case by case basis.

For a generic section of the rudder horn, located in the region above its upper bearing, the following stresses are to be calculated:

τ_s —shear stress, to be obtained from the following formula:

$$\tau_s=(F_{A1}+F_{A2})/A_H \text{ N/mm}^2$$

τ_T —torsional stress, to be obtained for hollow rudder horn from the following formula:

$$\tau_T=M_T10^3/(2F_{TH}) \text{ N/mm}^2$$

For solid rudder horns, τ_T is to be considered by CCS on a case by case basis..

Where: F_{A1} , F_{A2} —support forces, in N;

A_H —effective shear sectional area of the rudder horn in y direction, in mm^2 ;

M_T —torque, in $\text{N}\cdot\text{m}$;

F_T —mean of areas enclosed by the inner and outer boundaries of the thin walled section of rudder horn, in m^2 ;

t_H —plate thickness of rudder horn, in mm; For a generic section of the rudder horn the maximum value of τ_T is obtained at the minimum value of t_H .

Rudder horn bending stress calculation

For a generic section of the rudder horn within the length h , the following stresses are to be calculated:

σ_B —bending stress, to be obtained from the following formula:

$$\sigma_B = M_H / W \quad \text{N/mm}^2$$

Where: M_H —bending moment at the section considered, in $\text{N}\cdot\text{m}$;

W —section modulus around the x-axis, in cm^3 , see Figure 2.5.2.

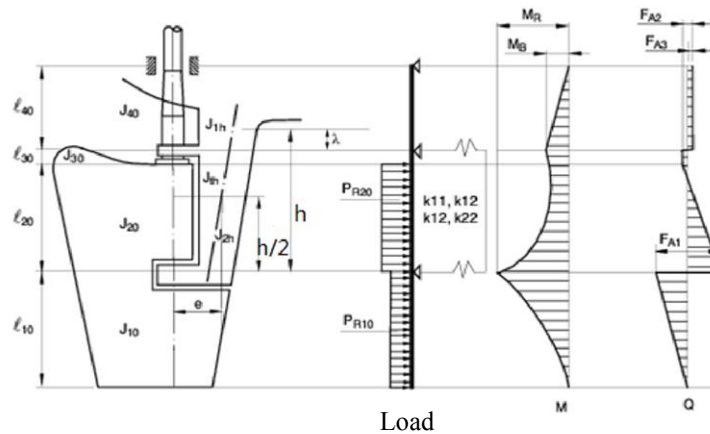


Figure 2.5.1 Semi spade rudder with 2- elastic supports

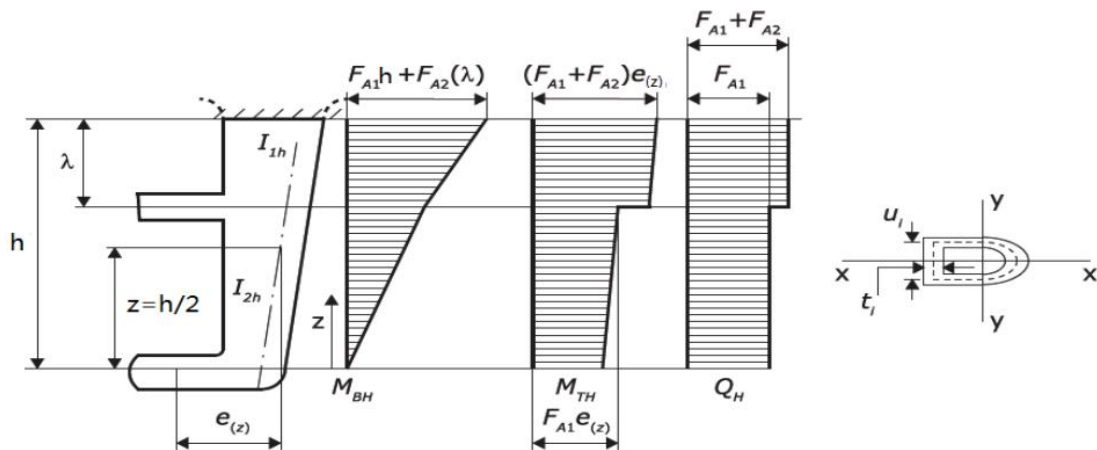


Figure 2.5.2 Rudder horn of semi spade rudder with 2-elastic supports



China Classification Society

RULES FOR CONSTRUCTION OF OCEAN-GOING FISHING STEEL VESSELS

2021

**PART TWO ENGINE AND FISHING MACHINERY
EQUIPMENT**

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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 Plans and documents

1.1.2.1 Prior to the commencement of ship construction, plans and documents as listed in the respective Chapters of this PART are to be submitted for approval. Other plans and documents may be required to be submitted as deemed necessary for individual cases.

1.1.2.2 Any major alterations to basic design, materials or other aspects of the approved plans are to be re-submitted to CCS for approval.

1.1.2.3 For products approved by CCS, the submission of such plans and detailed information are not necessary.

1.1.3 Ambient conditions

1.1.3.1 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 1.1.3.1 (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 1.1.3.1**

Installations and equipment	Angle of inclination			
	Athwartships		Athwartships	
	Static	Static	Static	Static
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°

1.1.3.2 The fishing vessel machinery is to be so designed and arranged as to ensure normal operation under the ambient temperature conditions as shown in Table 1.1.3.2. For fishing vessels in specific waters, the ambient temperature can be selected according to actual conditions of the navigation area.

Ambient temperature**Table 1.1.3.2**

Environment	Location	Temperature (°C)
Air	fishing vessel	0 to 45
	Within specific space or on machinery installations	According to the actual temperatures of specific sites or equipment
	On the open deck	-25 to 45
Seawater	All positions	32

1.1.3.3 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.

1.1.3.4 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.

1.1.4 Vibration

1.1.4.1 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.

1.1.5 Propulsion device

1.1.5.1 The fishing vessels are to be provided with a propulsion clutch device suitable for the operation requirements.

1.1.5.2 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.

1.1.6 Astern power

1.1.6.1 In order to maintain sufficient manoeuvrability and secure control of the vessel in all normal circumstances, the main propulsion machinery is to be capable of reversing the direction of thrust so as to bring the ship to rest from the maximum service speed. The main propulsion machinery is to be capable of maintaining in free route astern at least 70% of the ahead revolution.

1.1.6.2 For the main propulsion systems with reversing gears, controllable pitch propellers or electric propeller drive, running astern is not to lead to the overload of propulsion machinery.

1.1.6.3 Main propulsion systems are to undergo tests to demonstrate the astern response characteristics.

The tests are to be carried out at least over the manoeuvring range of the propulsion system and from all control positions. A test plan is to be provided by the yard and accepted by the surveyor. If specific operational characteristics have been defined by the manufacturer these are to be included in the test plan

1.1.6.4 The reversing characteristics of the propulsion plant, including the blade pitch control system of controllable pitch propellers, are to be demonstrated and recorded during trials

1.1.7 Protection against pollution and noise

1.1.7.1 The machinery space is to be provided with collection facilities to prevent oil from leaking into the bilge.

1.1.7.2 The machinery space is to be provided with effective facilities to prevent water pollution from oil.

1.1.7.3 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.

1.1.8 Materials

1.1.8.1 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 CCS Specification for materials and welding.

1.1.8.2 Materials not specified in CCS Specification for materials and welding are to be approved by CCS before being used.

1.1.8.3 All fishing vessels are to be prohibited from newly installation of materials containing asbestos.

1.1.9 Dead ship starting

1.1.9.1 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 propulsion plant, boilers and auxiliaries are not in operation and in restoring the propulsion, no stored energy for starting and operating the propulsion plant, the main source of electrical power and other essential auxiliaries is assumed to be available. Where the emergency source of power is an emergency generator which complies with 5.5.6 of this PART and 2.5.1.3 of PART THREE of the Rules, this generator may be used for restoring operation of the main propulsion plant, boilers and auxiliaries where any power supplies necessary for engine operation are also protected to a

similar level as the starting arrangements.

Where there is no emergency generator installed or an emergency generator does not comply with the above-mentioned requirements, the arrangements for bringing main and auxiliary machinery into operation are to be such that the initial charge of starting air or initial electrical power and any power supplies for engine operation can be developed on board ship without external aid. If for this purpose an emergency air compressor or an electric generator is required, these units are to be powered by a hand-starting oil engine or a hand-operated compressor.

The arrangements for bringing main and auxiliary machinery into operation are to have capacity such that the starting energy and any power supplies for engine operation are available within 30 min of a dead ship condition.

1.1.10 Emissions treatment

1.1.10.1 Vessels installed with selective catalytic reduction systems for reduction of NO_x emission from diesel engines are, in addition to the relevant provisions of this PART, to comply with the requirements of CCS *Guidelines for Approval and Survey of Selective Catalytic Reduction (SCR) systems* and *Guidelines for Application of Selective Catalytic Reduction (SCR) Systems Onboard Ships*.

1.1.10.2 Vessels installed with exhaust gas cleaning systems for reduction of SO_x emission from fuel oil combustion units are, in addition to the relevant provisions of this PART, to comply with the requirements of CCS *Guidelines for Testing and Inspection of Vessel Waste Gas Cleaning Systems* and *Guidelines for Design and Installation of Exhaust Gas Cleaning Systems*.

1.1.11 Ice strengthening

1.1.11.1 The propulsion and auxiliary equipments of fishing vessels sailing/operating in ice areas are to meet the requirements of the corresponding ice class in Chapter 14, PART 3 of CCS RULES FOR CLASSIFICATION OF SEA-GOING STEEL SHIPS.

1.1.12 Polar navigation

1.1.12.1 The design and manufacture of propulsion, steering gear, auxiliary equipment and fishing machinery for vessels navigating/operating in polar waters, are to also take into account the expected environmental conditions of the polar waters through which they pass, and adopt appropriate anti-icing and/or de-icing measures.

1.1.13 Tests

1.1.13.1 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.

1.1.14 Products

1.1.14.1 All propulsion, auxiliary machinery and important equipment of fishing machinery are to be inspected and approved by CCS.

Section 2 ARRANGEMENT

1.2.1 Boiler arrangement

1.2.1.1 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.

1.2.1.2 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.

1.2.1.3 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.

1.2.2 Communication

1.2.2.1 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 THREE.

1.2.2.2 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.

1.2.3 Ventilation and lighting

1.2.3.1 Machinery spaces and control rooms are to be adequately ventilated.

1.2.3.2 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.

1.2.3.3 Machinery spaces and control rooms are to be adequately illuminated.

1.2.4 Protective facilities

1.2.4.1 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.

1.2.4.2 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.

1.2.4.3 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.

1.2.4.4 In order to avoid misoperation of mechanical equipment and systems, safety operation signs are to be provided at appropriate locations when necessary.

1.2.4.5 Evacuation and excretion facilities shall be able to ensure safe discharge of excrements.

1.2.5 Anti-corrosion

1.2.5.1 Parts exposed to corrosive environment are to be made of anti-corrosive materials or provide effective anti-corrosion protection.

1.2.6 Accessibility

1.2.6.1 Accessibility, for the purposes of maintenance, inspection and repair of various machinery and equipment, is to be provided in machinery and boiler spaces.

1.2.6.2 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.

1.2.7 Maintenance access

1.2.7.1 The machinery spaces are to be provided with access to facilitate the operation, maintenance and repair of various mechanical equipment.

1.2.8 Stuffing boxes for shafting

1.2.8.1 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.

1.2.9 Fixing of lifting equipment and spare parts

1.2.9.1 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.

1.2.9.2 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 Plans and documents

2.1.1.1 The following plans and documents are to be submitted for approval:

- (1) arrangement of machinery and boiler spaces;
- (2) bilge piping and ballast piping;
- (3) arrangement of air pipes, sounding pipes and overflow pipes;
- (4) fuel oil feeding system for main and auxiliary engines and boilers;
- (5) fuel oil transfer system;
- (6) lubricating oil piping for main and auxiliary engines;
- (7) cooling water piping system for main and auxiliary engines;
- (8) compressed air piping system;
- (9) steam piping (if any) ;
- (10) boiler feed and blow-off piping (if any) ;
- (11) oil fuel heating piping (if any) ;
- (12) purgative system for fuel oil and lubricating oil;
- (13) exhaust gas piping for main and auxiliary engines;
- (14) arrangement of ventilation pipes for engine room;
- (15) hydraulic systems;
- (16) arrangement of drain pipes;
- (17) additional plans and documents as may be deemed necessary by CCS.

2.1.1.2 The following plans and documents are to be submitted for information (if relevant information is reflected in the submitted plans, submission of following plans and documents is not necessary):

- (1) specifications of machinery installations;
- (2) particulars of machinery equipment;
- (3) calculations of machinery equipment.

2.1.1.3 The materials, sizes, types, design pressures and design temperatures of pipes, valves and fittings, and the set pressure of safety valves are to be clearly marked on plans. Where separate calculations are not submitted, necessary rule calculations are to be affixed to the plans.

2.1.2 Design pressure

2.1.2.1 The design pressure for piping is the maximum permissible working pressure and it is not to be less than the highest set pressure of any safety valve or relief valve.

2.1.2.2 For pipes containing fuel oil, the design pressure is to be taken as given in Table 2.1.2.2.

Design pressure for pipes containing fuel oil		Table 2.1.2.2
Working temperature Working pressure	$T \leq 60^{\circ}\text{C}$	$T > 60^{\circ}\text{C}$
$P \leq 0.7\text{MPa}$	0.3MPa or highest working pressure, whichever is greater	0.3MPa or highest working pressure, whichever is greater
$P > 0.7\text{MPa}$	Highest working pressure	1.4MPa or highest working pressure, whichever is greater

2.1.2.3 For special cases, the design pressure is to be specially considered.

2.1.3 Design temperature

2.1.3.1 The design temperature is to be taken as the maximum temperature of the internal fluid.

In the case of pipes for superheated steam, the temperature is to be taken as the designed operating steam temperature for the pipeline, provided that the temperature at the superheater outlet is closely controlled. Where

temperature fluctuations exceeding 15 °C above the designed temperature are expected in normal service, the steam temperature to be used for determining the allowable stress is to be increased by the amount of this excess. For special cases, the design temperature is to be specially considered.

2.1.4 Classes of pipes

2.1.4.1 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 2.1.4.1.

Piping system class

Table 2.1.4.1

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. ④ Toxic or corrosive media, flammable media heated above flash point or with flash point below 60 °C media and liquefied gas belong to class I. If means of special safeguards for preventing leakage and its consequences are provided, they may also belong to class II, but except toxic media.						

2.1.5 Piping arrangement and liquid tank separation

2.1.5.1 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.

2.1.5.2 Penetration pieces or steel pads are to be provided for pipes passing through watertight or gastight structures. If pipes are fixed on watertight bulkhead by bolts, bolt holes are not to pass through bulkhead. For pipes pass through deck or bulkhead with fire division, their arrangement is not to damage fire division of deck or bulkhead.

2.1.5.3 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.

2.1.5.4 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.

2.1.5.5 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.

2.1.5.6 For vessels required for damage stability, the arrangement is to ensure that the continuing flooding will not extend to the compartments other than those with assumption of flooding, provided the piping system is fitted in the assumed flooding compartments.

2.1.6 Corrosion protection and coloring

2.1.6.1 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.

2.1.6.2 Piping systems for different media are to be painted with identification paint in accordance with relevant standards.

2.1.7 Fire protection

2.1.7.1 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.

2.1.7.2 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.

2.1.8 Protection

2.1.8.1 Pipes in positions where they are liable to mechanical damage are to be efficiently protected by removable casings.

2.1.8.2 All pipes, fittings, pumps, filters and other equipment of piping systems are to be provided with drain valves or cocks where necessary.

2.1.8.3 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.

2.1.8.4 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.

2.1.9 Insulation

2.1.9.1 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.

2.1.9.2 Pipes of non-refrigerated devices passing through refrigerated fish hold, are to be well insulated to prevent freezing and from the steel structure.

2.1.10 Compensation for expansion and heat treatment

2.1.10.1 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.

2.1.10.2 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.

2.1.10.3 In general, slip type expansion joints are only used for pipes in spaces accessible to operators for inspection during normal navigation. Slip type expansion joints are not to be used for pipes in spaces such as dry cargo tank and deep tank which are not easy to inspect. Slip type expansion joints may be used for pipes in tanks carrying the same liquid as that in the pipes.

Slip type expansion joints are not to be used in the systems listed below:

- (1) class I Piping system;
- (2) oil (such as fuel oil, lubricating oil, hydraulic oil, thermal oil) pipes of Class II piping system;
- (3) steering gear hydraulic system;
- (4) starting air and control air system;

- (5) boiler feed water system;
- (6) fixed gas fire extinguishing system;
- (7) bilge pipelines located in cargo hold, deep tanks and double bottom tanks;
- (8) oil pipes, such as fuel oil, lubricating oil, hydraulic oil and thermal oil, of Class III systems located in machinery spaces of category A, accommodation spaces or non-mechanically ventilated pipe duct keels;
- (9) pipes passing through other tanks;
- (10) exhaust system.

2.1.10.4 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.

2.1.10.5 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.

2.1.10.6 The post-weld heat treatment of pressure pipes are to meet the relevant requirements of Section 4, CHAPTER 9, PART THREE of CCS Rules for Materials and Welding.

2.1.11 Nondestructive inspection

2.1.11.1 Nondestructive inspection of piping systems are to comply with the relevant requirements of Section 3, CHAPTER 9, PART THREE of CCS Rules for Materials and Welding.

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.

2.2.1.2 In general, carbon and carbon-manganese steel pipes, valves and fittings are not to be used for medium temperatures above 400 °C. Nevertheless, they may be used for higher temperatures if their metallurgical behavior and time dependent strength (UTS after 100,000 h) are in compliance with national or international codes or standards and if such values are guaranteed by the steel manufacturer.

Special alloy steel pipes, valve and fittings are to be employed according to the relevant provisions of Rules for Materials and Welding.

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. The value for this allowance is to be chosen in such a way that the calculated stress in the bend, due to the internal pressure only, does not exceed the permissible stress. When this allowance is not determined by a more accurate procedure, it is to be taken according to 2.2.2.3 of this Section;

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/mm², 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:

$$[\sigma] = \frac{R_m}{2.7} \quad \text{N/mm}^2$$

$$[\sigma] = \frac{R_{eH}^T}{1.6} \quad \text{N/mm}^2$$

$$[\sigma] = \frac{R_{100000D}^T}{1.6} \quad \text{N/mm}^2$$

Where: R_m —minimum tensile strength of material at ambient temperature, in N/mm²;

R_{eH}^T —yield stress or 0.2% proof stress ($R_{p0.2}$) of material at design temperature, in N/mm²;

$R_{100000D}^T$ —average stress of material to produce rupture in 100,000 h at design temperature, in N/mm²;

R_m , R_{eH}^T and $R_{100000D}^T$ are to comply with the relevant requirements of Section 2, CHAPTER 4, PART ONE of Rules for Materials and Welding

2.2.2.5 The minimum wall thickness δ 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 13.5~17.2 20	1.6 1.8 2.0			
21.3~25 26.9~33.7 38~44.5	2.0 2.0 2.0	4.5	3.2 3.2 3.6	6.3
48.3 51~63.5 70	2.3 2.3 2.6	4.5 4.5 4.5	3.6 4.0 4.0	6.3 6.3 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.

②: When the diameter of the pipe is large, the wall thickness is to be considered separately.

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 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.

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 Materials of copper and copper alloys for Class III piping systems are to be manufactured and tested in accordance with the approved standards.

2.3.1.3 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. The value for this allowance is to be chosen in such a way that the calculated stress in the bend, due to the internal pressure only, does not exceed the permissible stress. When this allowance is not determined by a more accurate procedure, it is to be taken according to 2.3.2.3 of this Section;

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/mm², 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 temperature											
		N/mm ²	50	75	100	125	150	175	200	225	250	275	300	
		Tensile strength Lower limitN/mm ²												
Copper	Annealing	15	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 submit 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 δ mentioned in 2.3.2.1 of this PART 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 gray cast iron.

2.4.2.2 Ferritic nodular graphite iron pipes, valves and fittings may be accepted for bilge and ballast piping.

2.4.2.3 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.

2.4.2.4 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 7, PART 1 of Rules for Materials and Welding.

2.4.2.5 Where the elongation is less than the minimum required in 2.4.2.1 of this Section, the material is to be subject to the same limitations as grey cast iron.

2.4.3 Plastic pipes

2.4.3.1 The ranges and locations of plastic pipes used in ships are to comply with the provisions in Table 1 of Appendix 1, and the plastic pipes are to comply with the fire endurance requirements in the Table.

2.4.3.2 Plastic pipes used on ships are to be selected in relation to their chemical composition, physical and mechanical properties, and temperature limits.

2.4.3.3 Plastic pipes are in general not to be used for media with a temperature above 60°C or below 0°C.

2.4.3.4 Plastic pipes used on ships are to be designed, manufactured, used and test in accordance with the relevant requirements in Appendix 1 of this Chapter.

2.4.4 Flexible hoses

2.4.4.1 Flexible hoses mean short length of metallic or non-metallic hoses normally with prefabricated end fittings ready for installation.

2.4.4.2 Flexible hoses may be used for a permanent connection between a fixed piping system and items of machinery, as well as temporary connection between portable equipment and pipes.

2.4.4.3 Flexible hoses are to be designed, manufactured, used and tested in accordance with the relevant requirements of CCS. Flexible hoses with end pieces made of fire-resistant materials shall withstand a high temperature fire test at 800°C for 30 minutes. At this time, the water in the pipe is circulated at the maximum working pressure. The water temperature at the outlet is not to be lower than 80°C. There shall be no records of leakage during or after the test. Alternatively, the flexible hoses may be subjected to a fire test under a flowing water pressure condition of at least 0.5 MPa in the pipe, and a subsequent pressure test at twice the design pressure.

Section 5 CONNECTION OF PIPE LENGTHS

2.5.1 Connection of pipe lengths

2.5.1.1 Direct connection of pipe lengths may be obtained by:

(1) welded butt-joints between pipes or between pipes and valve chests or other fittings, the welded butt-joints are to be of full penetration type with or without special provisions for the quality of root side¹.

(2) slip-on sleeve welded joints, the slip-on sleeve welded joints are to have sleeves and relative welding of adequate dimensions conforming to the recognized standard;

(3) threaded sleeve joints of approved type;

(4) mechanical joints.

2.5.1.2 The application of the aforesaid types of connection is as follows:

(1) Welded butt-joints and slip-on sleeve welded joints are to comply with the requirements specified in Table 2.5.1.2(1).

¹ Special requirements for root quality mean that the butt welding is completed by double-sided welding, or the first welding process is completed by pad welding or single-sided welding filled with inert gas, or other similar methods accepted by CCS.

Connection of pipe length**Table 2.5.1.2 (1)**

Type of connection	Allowed for classes	Allowed for outside diameter
Butt welded joints with special provision for a high quality of root side	I, II, III	No restriction
Butt welded joints without special provision for a high quality of root side	II, III	
Slip-on sleeve welded joints	III	
	I, II, except for piping systems conveying toxic media where fatigue, severe erosion is expected to occur	$D \leq 88.9$ mm

(2) Slip-on threaded joints are to comply with requirements of a recognized standard. Slip-on threaded joints may be used for outside diameters as stated below except for piping systems conveying toxic or flammable media or services where fatigue, severe erosion or crevice is expected to occur. Threaded joints in CO₂ systems are to be allowed only inside protected spaces and in CO₂ cylinder rooms.

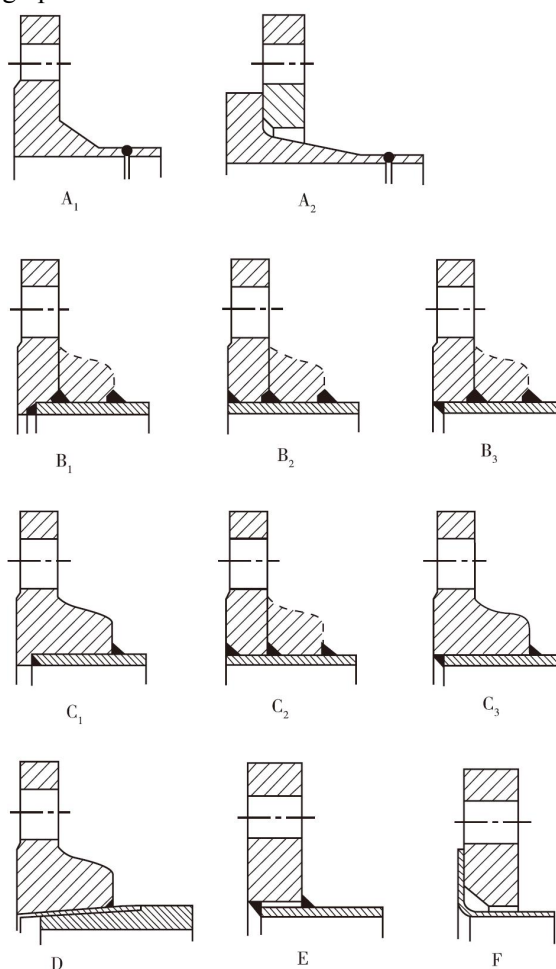
① Threaded joints for direct connectors of pipe lengths with tapered thread may be allowed for Class I, outside diameter not more than 33.7 mm as well as Class II and Class III, outside diameter not more than 60.3 mm.

② Threaded joints for parallel thread may be allowed for Class III, outside diameter not more than 60.3 mm.

③ In particular cases, sizes in excess of those mentioned above may be accepted if they satisfy the requirements of recognized international or national standards.

2.5.2 Flange connections

2.5.2.1 Typical flange connections are indicated in Figure 2.5.2.1. Slip-on joints, sleeve threaded joints and other types of direct connection of pipe lengths (e.g. bell and spigot joints) may be allowed in each particular case for small diameter and depending upon the service conditions.

**Figure 2.5.2.1 Typical flange connections**

Notes: ① For type D, 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.

② The leg length of the fillet weld and the penetration of the flange edge, as shown in the Figure, are in general to be 1.5 times the wall thickness of the pipe, but not less than 5 mm.

2.5.2.2 The above-mentioned types of flange connections are to be selected in accordance with the requirements specified in Table 2.5.2.2.

Application of typical flange connections

Table 2.5.2.2

Piping class	Toxic or corrosive media ^④ , flammable media ^④ , liquefied gas	Lubricating oil and fuel oil	Steam ^③ and hot oil	Other media ^{①②③}
I	A, B ^⑥	A, B	A, B ^⑥	A, B
II	A, B, C	A, B, C, E ^⑦	A, B, C, D ^⑤ , E ^⑤	
III		A, B, C, E	A, B, C, D, E	A, B, C, D, E, F ^②

Notes: ① Include water, air, other gases and hydraulic oil;

② Type F is only applicable to water pipes and open pipes;

③ When the design temperature exceeds 400°C, only type A is applicable;

④ When the design pressure exceeds 1 MPa, only type A is applicable;

⑤ When the design temperature exceeds 250°C, type D and type E are not applicable;

⑥ Type B is only applicable to pipes with an outer diameter less than 150 mm;

⑦ Type E is only applicable to oil pipes with design temperature less than 150 °C and design pressure less than 1.6 MPa.

2.5.2.3 The dimensions of flanges and relative bolts are to be chosen in accordance with the national standards or acceptable standards. For special application, the dimensions of flanges and relative bolts are to be subject to special consideration¹.

Gaskets are to be suitable for the media being conveyed under design pressure and temperature conditions and their dimensions and configuration are to be in accordance with national or acceptable standards.

Flange connections are to be in accordance with national or international standards that are applicable to the piping system and are to recognize the boundary fluids, design pressure and temperature conditions, external or cyclic loading and location.

2.5.3 Mechanical joints

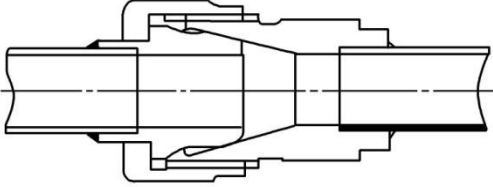
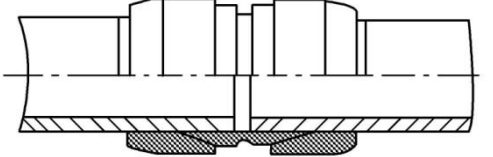
2.5.3.1 The different mechanical joints applicable to this paragraph are indicated in Table 2.5.3.1(1). The mechanical joints are to be subject to type approval based on different usage and location in accordance with the requirements of Appendix 3 of the CCS Rules for Classification of Sea-going Steel Ships.

2.5.3.2 Where appropriate, mechanical joints are to be of fire resistant type as required by Table 2.5.3.1(2).

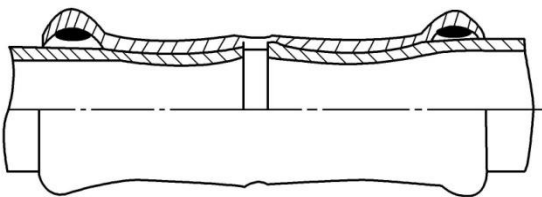
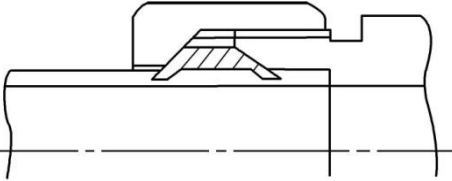
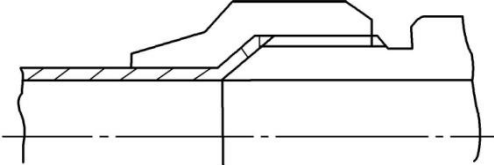
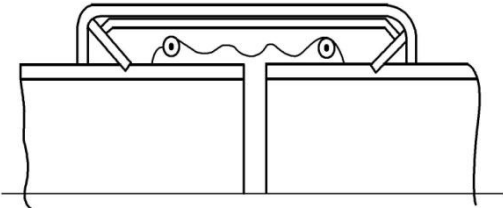
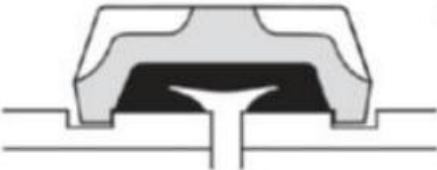
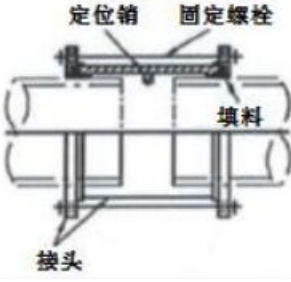
2.5.3.3 Material of mechanical joints is to be compatible with the piping material and internal and external media.

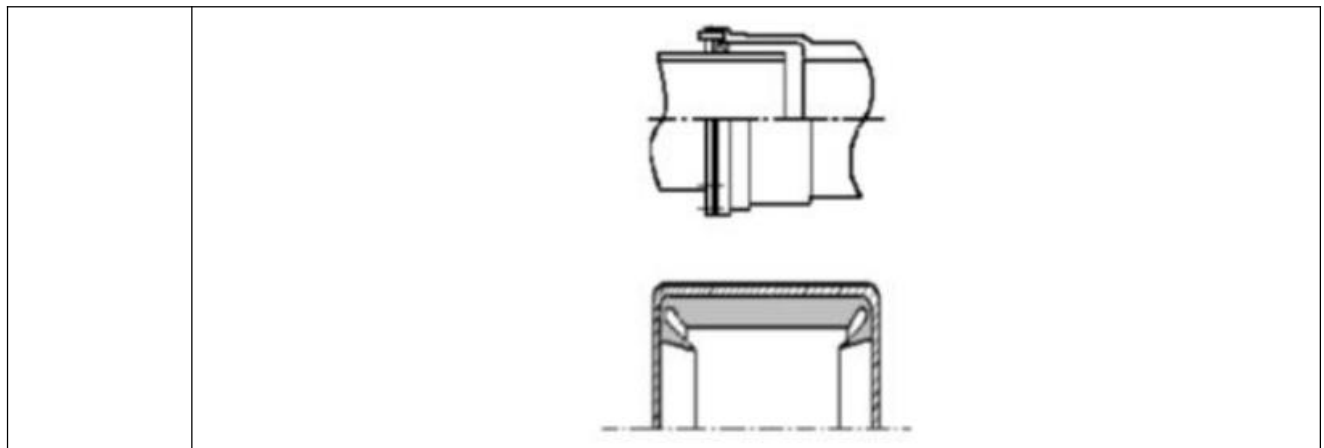
Examples of mechanical joints

Table 2.5.3.1 (1)

Pipe unions	
Welded and brazed types	
Compression	
Swage type	

¹ For special applications where the fitting temperature, pressure and size of the flange exceed reliable limits, a complete calculation is to be carried out for bolts and flanges.

Press type	
Bite type	
Flared type	
Slip-on joints	
Grip type	
Machine grooved type	 轧槽  切槽
Slip type	 定位销 固定螺栓 填料 接头



Application of mechanical joints

Table 2.5.3.1 (2)

Systems		Kind of connections		
		Pipe unions	Compression couplings	Slip-on joints
Flammable fluids (flash point > 60°C)				
1	Fuel oil lines ^{③②}	×	×	×
2	Lubricating oil lines ^{②③}	×	×	×
3	Hydraulic oil ^{②③}	×	×	×
4	Thermal oil ^{②③}	×	×	×
Sea water				
5	Bilge lines ^①	×	×	×
6	Fire main (not permanently filled) ^⑥	×	×	×
7	Ballast system ^①	×	×	×
8	Cooling water system ^①	×	×	×
9	Tank cleaning services	×	×	×
10	Non-essential systems	×	×	×
Fresh water				
11	Cooling water system ^①	×	×	×
12	Condensate return ^①	×	×	×
13	Non-essential systems	×	×	×
Sanitation/drains /scuppers				
14	Deck drains (inboard) ^⑥	×	×	×
15	Sanitary drains	×	×	×
16	Scuppers and discharge (overboard)	×	×	-

Sounding / vent				
17	Water tanks/dry spaces	×	×	×
18	Oil tank ^{②③}	×	×	×
Miscellaneous				
19	Starting/control air ^①	×	×	-
20	Service air (non-essential)	×	×	×
21	Brine	×	×	×
22	CO ₂ system ^①	×	×	-
23	Steam	×	×	× ^⑤

Notes:

× —Application is allowed.

- —Application is not allowed.

* Fire resistance capability:

If mechanical joints include any components which readily deteriorate in case of fire, they are to be of an approved fire resistant type under consideration of the following footnotes:

① Inside machinery spaces of category A, only approved fire resistant types.

② Sliding joints cannot be accepted in machinery spaces of category A or living spaces. If the joints are located in an easily visible and accessible location, they can be accepted in other machinery spaces.

③ Approved fire resistant types except in cases where such mechanical joints are installed on exposed open decks and not used for fuel oil lines.

* General:

④ Slip type slip-on joints as shown in Table 2.5.3.1(1) may be used for pipes on deck with a design pressure of 10 bar or less. 1.02 MPa (10 bar).

⑤ Only above working deck.

Application of mechanical joints depending upon the class of piping

Table 2.5.3.1 (3)

Types of joints	Classes of piping system		
	Class I	Class II	Class III
Pipe unions			
Welded and brazed type	× ($D_0 \leq 60.3$ mm)	× ($D_0 \leq 60.3$ mm)	×
Compression couplings			
Swage type	×	×	×
Bite type	× ($D_0 \leq 60.3$ mm)	× ($D_0 \leq 60.3$ mm)	×
Flared type	× ($D_0 \leq 60.3$ mm)	× ($D_0 \leq 60.3$ mm)	×
Press type	-	-	×
Slip-on joints			
Machine grooved type	×	×	×

Clip type	-	×	×
Slip type	-	×	×

Notes:

× — Application is allowed.

- — Application is not allowed.

D_0 — outside diameter of the pipe.

2.5.3.4 Application of mechanical joints and their acceptable use for each service is indicated in Table 2.5.3.1(2); dependence upon the Class of piping and pipe dimensions is indicated in Table 2.5.3.1(3).

In particular cases, sizes in excess of those mentioned above may be accepted if in compliance with a recognized national and/or international standard.

2.5.3.5 Where the application of mechanical joints results in reduction in pipe wall thickness due to the use of bite type rings or other structural elements, this is to be taken into account in determining the minimum wall thickness of the pipe to withstand the design pressure.

2.5.3.6 Mechanical joints, which in the event of damage could cause flooding or fire, are not to be used in piping sections directly connected to the ship's side below the working deck of passenger vessels (or freeboard deck of cargo vessels) or tanks containing flammable fluids. The number of mechanical joints in flammable fluid systems is to be kept to a minimum. In general, flanged joints conforming to recognized standards are to be used.

2.5.3.7 Mechanical joints in bilge systems of machinery space are to be of fire resistant type. For the required fire resistant mechanical joints, see Table 2.5.3.1(2).

2.5.3.8 Mechanical joints are to be tested where applicable, to a burst pressure of 4 times the design pressure.

2.5.3.9 Piping in which a mechanical joint is fitted is to be adequately adjusted, aligned and supported. Supports or hangers are not to be used to force alignment of piping at the point of connection.

2.5.3.10 Slip-on joints are not to be used in pipelines in cargo holds, tanks and other spaces which are not easily accessible. Application of these joints inside tanks may be permitted only for the same media that is in the tanks.

Usage of slip type slip-on joints as the main means of pipe connection is not permitted except for cases where compensation of axial pipe deformation is necessary.

2.5.3.11 Mechanical joints are not to be used in the following cases:

- (1) bilge piping through ballast tanks and fuel tanks;
- (2) sea water and ballast piping (including air and overflow pipes) through cargo holds and fuel tanks;
- (3) fuel and oil piping (including air and overflow pipes) through machinery spaces, cargo holds and ballast tanks.

2.5.3.12 The installation of mechanical joints is to be in accordance with the manufacturer's assembly instructions. Where special tools and gauges are required for installation of the joints, these are to be supplied by the manufacturer.

Section 6 PUMPS, VALVES AND FITTINGS

2.6.1 Pumps

2.6.1.1 Pumps are to be designed and manufactured according to accepted standards.

2.6.1.2 Hydraulic tests

(1) All components of pumps subject to pressure are to be subject to hydraulic tests in workshop prior to assembly. The hydraulic test pressure is to be 1.5 times the design pressure, but need not exceed the design pressure plus 7 MPa.

(2) For centrifugal pumps, the design pressure is to be taken as the maximum pressure head on the performance curve. For displacement pumps, the design pressure is to be taken as the relief valve setting pressure.

(3) For steam driven pumps, the test pressure at the steam side is to be 1.5 times the steam working pressure.

2.6.1.3 Capacity tests

(1) Pump capacities are to be checked with the pump operating at design conditions (rated speed and pressure head). For centrifugal pumps, the pump characteristic (head-capacity) design curve is to be verified to the satisfaction of the Surveyor.

(2) Capacity tests may be waived if previous satisfactory tests have been carried out on similar pumps.

2.6.1.4 Relief valve capacity test

(1) For positive displacement pumps with an integrated relief valve, the valve's setting and full flow capacity corresponding to the pump maximum rating is to be verified.

(2) The operational test for relief valve capacity may be waived if previous satisfactory tests have been carried out on similar pumps.

2.6.2 Valves and fittings

2.6.2.1 Valves are to be designed and manufactured according to accepted standards. For other structurally new-type valves or non-standard valves, detailed drawings and information are to be submitted.

2.6.2.2 The strength of valves and fittings in piping system is to be appropriate to the strength required by the connected pipes and is to be able to work efficiently under the maximum working pressure. Valves are to be made of steel, cast iron, copper, copper alloy or other materials suitable for the intended service.

2.6.2.3 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. Screwed-on valve bonnets are not to be used for valves with nominal diameter exceeding 40 mm in Class I and Class II piping systems, sea valves, ship-side valves and valves in flammable liquid system.

2.6.2.4 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.

2.6.2.5 Indicators are to be provided to show the open and closing condition of the valves, unless this can be observed in some other way.

2.6.2.6 Valves and cocks are to be fitted with nameplates to indicate their purposes. The casing of non-return valves is to be permanently marked with flow direction.

2.6.2.7 The welded necks on the valve bodies are to be long enough to ensure that the valves will not deform due to welding and subsequent heat treatment of the joints.

2.6.2.8 All valves are to be subject to hydraulic tests in workshop. The hydraulic test pressure is to be 1.5 times the design pressure.

Section 7 HYDRAULIC TEST AND TIGHTNESS TEST

2.7.1 Hydraulic tests for piping prior to installation on board

2.7.1.1 All Classes I and II pipes and their associated fittings and, all steam pipes, feed pipes, compressed air 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 be less than 1.5 times the design pressure p .

2.7.1.2 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 —design pressure, in MPa

$[\sigma]_{100}$ —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. In no case is the membrane stress to exceed 90% of the yield stress at the testing temperature.

2.7.1.3 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.

2.7.1.4 For pipes with an internal diameter less than 15 mm, the hydraulic test may be waived.

2.7.1.5 When, for technical reasons, it is not possible to carry out complete hydraulic test for all sections piping, prior to assembly on board, applications are to be submitted to CCS for approval for testing the closing lengths of piping, particularly in respect to closing seams.

2.7.2 Hydraulic tests for valves and fittings prior to installation on board

2.7.2.1 Valves and fittings non-integral with the piping system, intended for Classes I and II, are to be hydraulically tested in accordance with recognized standards, but the test pressure is not to be less than 1.5 times the design pressure.

Valves, cocks and distance pieces intended to be fitted on the ship side below the load waterline are to be tested by hydraulic pressure not less than 0.5 MPa.

2.7.3 Testing after assembly on board

2.7.3.1 All piping systems are to be checked for leakage under working conditions.

2.7.3.2 Fuel (oil or gas) 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 2.7.3.2.

Hydraulic tests after assembly on board

Table 2.7.3.2

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 piping	1.25 times design pressure, but no need to exceed design pressure plus 7 MPa

2.7.3.3 Where Classes I and II pipes are butt welded together during assembly on board, they are to be tested by hydraulic pressure in accordance with the requirements of 2.7.1.1 to 2.7.1.3 after welding. During installation and before the hydraulic test is carried out, the pipe lengths may be insulated, except in way of the joints. The hydraulic test required in 2.7.3.3 of this Section 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.

Appendix 1 PRODUCTION AND APPLICATION OF PLASTIC PIPING SYSTEMS ON SHIPS¹

1.1 Terms and Definitions

1.1.1 “Plastic(s)” means both thermoplastic and thermosetting plastic materials with or without reinforcement, such as PVC and fiber reinforced plastics – FRP. Plastic(s) includes synthetic rubber and materials of similar thermos/mechanical properties.

1.1.2 “Pipes/piping systems” means 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.

1.1.3 “Joint” means the location at which two pieces of pipe or a pipe and a fitting are connected together. The joint may be made by adhesive bonding, laminating, welding, flanges, etc.

1.1.4 “Fittings” means bends, elbows, fabricated branch pieces etc. of plastic materials.

1.1.5 “Nominal pressure” means the maximum permissible working pressure which should be determined in accordance with the requirements in 1.3.1 of this Appendix.

1.1.6 “Design pressure” means the maximum working pressure which is expected under operation conditions or the highest set pressure of any safety valve or pressure relief device on the system, if fitted.

1.1.7 “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.

1.2 Scope

1.2.1 This Appendix is applicable to piping systems on ships, including pipe joints and fittings, made predominately of other material than metal.

1.2.2 Use of mechanical and flexible couplings which are accepted for use in metallic piping systems is not addressed in this Appendix.

1.2.3 Piping systems intended for non-essential services are to meet only the requirements of recognized standards and 1.5 and 1.6 of this Appendix.

1.3 General Requirements

The specification of piping is to be in accordance with a recognized national or international standard acceptable to CCS. In addition, the following requirements apply:

1.3.1 Strength

(1) 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).

(2) The strength of fittings and joints is not to be less than that of the pipes.

(3) The nominal pressure is to be determined from the following conditions:

① Internal Pressure

For an internal pressure, the following is to be taken whichever is smaller:

$$P_{n\ int} \leq P_{sth}/4 \text{ 或 } P_{n\ int} \leq P_{lth}/2.5$$

where: P_{sth} — short-term hydrostatic test pipe failure pressure, in MPa;

P_{lth} — long-term hydrostatic test pipe failure pressure (> 100,000 h), in MPa.

② External Pressure

For an external pressure:

$$P_{n\ ext} \leq P_{col}/3$$

where: P_{col} — pipe collapse pressure, in MPa.

(4) In no case is the pipe collapse pressure to be less than 0.3 MPa.

¹ *Production and Application of Plastic Piping Systems on Ships* is addressed by IACS according to the provisions of IMO Resolution. A.753(18)

(5) The maximum working external pressure is a sum of the vacuum inside the pipe and a head of liquid acting on the outside of the pipe.

(6) The maximum permissible working pressure is to be specified with due regard for maximum possible working temperatures in accordance with manufacturer's recommendations.

1.3.2 Axial Strength

(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 (see 1.3.1 of this Appendix).

1.3.3 Axial Strength

(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 (see 1.3.1 of this Appendix).

1.3.4 Temperature

(1) The permissible working temperature depending on the working pressure is to be in accordance with manufacturer's recommendations, but in each case it is to be at least 20°C lower than the minimum heat distortion temperature of the pipe material, determined according to ISO 75 method A, or equivalent.

(2) The minimum heat distortion/deflection temperature is not to be less than 80°C.

1.4 Requirements for Pipes/Piping Systems Depending on Service and/or Locations

1.4.1 Fire Endurance

(1) Pipes and their associated fittings whose integrity is essential to the safety of fishing ships, are required to meet the minimum fire endurance requirements of Appendix 1 or 2, as applicable, of IMO resolution A.753 (18).

(2) Depending on the capability of a piping system to maintain its strength and integrity, there exist five different levels of fire endurance for piping systems.

① Level 1: Piping having passed the fire endurance test specified in Appendix 1 of IMO resolution A.753(18) for duration of a minimum of one hour without loss of integrity in the dry condition is considered to meet level 1 fire endurance standard (L1).

② IW 级: Level 1W: Piping systems similar to level 1 systems except these systems do not carry flammable fluid or any gas and a maximum 5% flow loss in the system after exposure is acceptable¹, which is considered to meet level 1W fire endurance standard (L1W).

③ Level 2: Piping having passed the fire endurance test specified in Appendix 1 of IMO resolution A.753(18) for a duration of a minimum of 30 min in the dry condition is considered to meet level 2 fire endurance standard(L2).

④ Level 2W: Piping systems similar to level 2 systems except a maximum 5% flow loss in the system after exposure is acceptable¹, which is considered to meet level 2W fire endurance standard(L2W).

⑤ Level 3: Piping having passed the fire endurance test specified in Appendix 2 of IMO resolution A.753(18) for a duration of a minimum of 30 min in the wet condition is considered to meet level 3 fire endurance standard (L3).

(3) Permitted use of piping depending on fire endurance, location and piping system is given in Table 1.4.1.

Fire-resistance Requirements

Table 1.4.1

N piping system	Parts						
	A	B	C	D	E	F	G

¹ The flow loss must be taken into account when dimensioning the system.

	Machinery space of category A	Other machinery space	Fuel oil tank	Ballast tank	cofferdam, void, tunnel and duct	Accommodation and service spaces, control room	Open deck
Flammable liquid (flash point > 60)							
1 fuel oil pipe	×	×	O	O	O	L1	L1
2 lubricating oil pipe	×	×	NA	NA	O	L1	L1
3 hydraulic oil pipe	×	×	O	O	O	L1	L1
Sea water ^①							
4 bilge main and branch pipes	L1	L1	O	O	O	NA	L1
5 fire main pipe and water mist pipe	L1	L1	NA	O	O	×	L1
6 foam system	L1W	L1W	NA	NA	O	L1W	L1W
7 automatic water spray system	L1W	L1W	NA	O	O	L3	L3
8 ballast system	L3	L3	O	O	O	L2W	L2W
9 ballast system	L3	L3	NA	O	O	NA	L2W
10 fixed machinery system for cleaning tank	NA	NA	NA	O	O	NA	L3 ^②
11 non-essential system	O	O	O	O	O	O	O
Fresh water							
12 essential services of cooling water	L3	L3	O	O	O	L3	L3
13 condensate back water	L3	L3	NA	NA	O	O	O
14 non-essential system	O	O	O	O	O	O	O
Sanitary/drainage/discharge							
15 deck drainage (inside)	L1W ^②	L1W ^②	O	O	O	O	O
16 sanitary drainage (inside)	O	O	O	O	O	O	O
17 scupper and discharge (overboard)	O ^{①③}	O ^{①③}	O	O	O	O ^{①③}	O
Sounding/air							
18 water tank / dry space	O	O	O	O	O	O	O
19 oil tank (flash point > 60°C)	×	×	O	O ^④	O	×	×
Miscellaneous							
20 air pipe for control	L1 ^④	L1 ^④	O	O	O	L1 ^④	L1 ^④
21 service air pipe (non-essential service)	O	O	O	O	O	O	O
22 salt water pipe	O	O	NA	NA	O	O	O
23 auxiliary low pressure steam pipe (≤0.7MPa)	L2W	L2W	O	O	O	O ^⑤	O ^⑤

Notes:

L1—Fire endurance test (Annex 1 of IMO resolution A.753(18)) in dry conditions, 60 min;

L2—Fire endurance test (Annex 1 of IMO resolution A.753(18)) in dry conditions, 30 min;

L3—Fire endurance test (Annex 2 of IMO resolution A.753(18)) in wet conditions, 30 min;

L1W—Fire endurance test (appendix 1 of IMO Resolution A.753(18), in dry conditions, 60 min, a maximum 5% flow loss in the system;

L2W—Fire endurance test (appendix 1 of IMO Resolution A.753(18), in dry conditions, 30 min, a maximum 5% flow loss in the system;

O — No fire endurance test required;

NA—Not applicable;

× — Metallic materials having a melting point greater than 925°C.

① Where non-metallic piping is used, remotely controlled valves to be provided at ship's side (valve is to be controlled from outside space).

② For drains serving only the space concerned, "O" may replace "L1W".

③ Scuppers serving open decks in positions 1 and 2, as defined in regulation 13 of the International Convention on Load Lines, 1966, should be "×" throughout unless fitted at the upper end with the means of closing capable of being operated from a position above the freeboard deck in order to prevent down-flooding.

④ When controlling functions are not required in statutory requirements or guidelines, "O" may replace "L1".

⑤For essential services, such as fuel oil tank heating and ship's whistle, "×" is to replace "O".

Location Definition:

A—Machinery spaces of category A

Machinery spaces of category A as defined in regulation 1.2.14 of PART NINE of Technical rules for statutory inspection of ocean-going fishing vessels (2019) .

B—Other machinery spaces

Spaces, Sother than category A machinery spaces and cargo pump rooms, containing propulsion machinery, boilers, fuel oil units, steam and internal combustion engines, generators and major electrical machinery, pumps, oil filling stations, refrigerating, stabilizing, ventilation and air-conditioning machinery, and similar spaces, and trunks to such spaces.

C—Fuel oil tanks

All spaces used for fuel oil and trunks to such spaces.

D—Ballast water tanks

All spaces used for ballast water and trunks to such spaces.

E—Cofferdams, voids, etc.

Cofferdams and voids are those empty spaces between two bulkheads separating two adjacent compartments.

F—Accommodation and service spaces

Accommodation spaces, service spaces and control stations as defined in regulation 1.2.10, 1.2.12, 1.2.13 in PART NINE of Technical rules for statutory inspection of ocean-going fishing vessels (2019) .

G—Open decks

Open deck spaces as defined in regulation 2.5 in PART NINE of Technical rules for statutory inspection of ocean-going fishing vessels (2019) .

1.4.2 Flame Spread

(1) All pipes, except those fitted on open decks and within tanks, cofferdams, pipe tunnels and ducts, if separated from accommodation, permanent manned areas and escape ways by means of an A class bulkhead, are to have low surface flame spread characteristics not exceeding average values listed in Appendix 3 of IMO resolution A.753(18).

(2) Surface flame spread characteristics are to be determined in Appendix 3 of IMO Resolution A.753(18), with regard to the modifications due to the curvilinear pipe surfaces as listed in Appendix 3 of IMO Resolution A.753(18).

(3) Surface flame spread characteristics may also be determined using the test procedures given in ASTM D635, or in other national equivalent standards.

1.4.3 Fire Protection Coatings

Where a fire protective coating of pipes and fittings is necessary for achieving the fire endurance level required, it is to meet the following requirements:

(1) The pipes are generally to be delivered from the manufacturer with the protective coating on.

(2) The fire protection properties of the coating are not to be diminished when exposed to salt water, oil or bilge slops. It is to be demonstrated that the coating is resistant to products likely to come into contact with the piping.

(3) In considering fire protection coatings, such characteristics as thermal expansion, resistance against vibrations, and elasticity are to be taken into account.

(4) The fire protection coatings are to have sufficient resistance to impact to retain their integrity.

1.4.4 Electrical Conductivity

Where electrical conductivity is to be ensured, the resistance of the pipes and fittings is not to exceed $1 \times 10^5 \Omega/\text{m}$.

1.5 Material Approval and Quality Control During Manufacture

1.5.1 Except as required in 1.2.3 of this Appendix, Prototypes of pipes and fittings are to be tested to determine short-term and long-term design strength, fire endurance and low surface flame spread characteristics (if applicable), electrical resistance (for electrically conductive pipes), impact resistance in accordance with this Appendix.

1.5.2 For prototype testing, representative samples of pipes and fittings are to be selected to the satisfaction of CCS.

1.5.3 The manufacturer is to have quality system that meets ISO 9000 series standards or equivalent. The quality system is to consist of elements necessary to ensure that pipes and fittings are produced with consistent and

uniform mechanical and physical properties.

1.5.4 Each pipe and fitting is to be tested by the manufacturer at a hydrostatic pressure not less than 1.5 times the nominal pressure. Alternatively, for pipes and fittings not employing hand lay-up techniques, the hydrostatic pressure test may be carried out in accordance with the hydrostatic testing requirements stipulated in the recognized national or international standard accepted by CCS to which the pipe or fittings are manufactured, provided that there is an effective quality system in place.

1.5.5 Pipes and fittings are to be permanently marked with identification. Identification is to include pressure ratings, the design standards that the pipe or fitting is manufactured in accordance with, and the material of which the pipe or fitting is made.

1.5.6 In case the manufacturer does not have an approved quality system complying with ISO 9000 series or equivalent, pipes and fittings are to be tested in accordance with this Appendix to the satisfaction of the Surveyors for every batch of pipes.

1.5.7 Depending upon the intended application, CCS may require the pressure testing of each pipe and/or fitting.

1.6 Installation

1.6.1 Supports

(1) Selection and spacing of pipe supports in shipboard systems are to be determined as a function of allowable stresses and maximum deflection criteria. Support spacing is not to be greater than the pipe manufacturer's recommended spacing. The selection and spacing of pipe supports are to take into account pipe dimensions, pipe length, mechanical and physical properties of the pipe material, mass of pipe and contained fluid, external pressure, operating temperature, thermal expansion effects, loads due to external forces, thrust forces, water hammer, vibrations, maximum accelerations to which the system may be subjected. Combination of loads is to be considered.

(2) Each support is to evenly distribute the load of the pipe and its contents over the full width of the support. Measures are to be taken to minimize wear of the pipes where they contact the supports.

(3) Heavy components in the piping system such as valves and expansion joints are to be independently supported.

1.6.2 Expansion

(1) Suitable provision is to be made in each pipeline to allow for relative movement between pipes made of plastic and the steel structure, having due regard to:

- ① the difference in the coefficients of thermal expansion;
- ② deformations of the ship's hull and its structure.

(2) When calculating the thermal expansions, account is to be taken of the system working temperature and the temperature at which assembly is performed.

1.6.3 External Loads

(1) When installing the piping, allowance is to be made for temporary point loads, where applicable. Such allowances are to include at least the force exerted by a load (person) of 100 kg at mid-span on any pipe of more than 100 mm nominal outside diameter.

(2) Besides for providing adequate robustness for all piping including open-ended piping a minimum wall thickness, complying with 1.3.1 of this Appendix, may be increased taking into account the conditions encountered during service on board ships.

(3) Pipes are to be protected from mechanical damage where necessary.

1.6.4 Strength of Connections

(1) The strength of connections is not to be less than that of the piping system in which they are installed.

(2) Pipes may be assembled using adhesive-bonded, welded, flanged or other joints.

(3) Adhesives, when used for joint assembly, are to be suitable for providing a permanent seal between the

pipes and fittings throughout the temperature and pressure range of the intended application.

(4) Tightening of joints is to be performed in accordance with manufacturer's instructions.

1.6.5 Installation of Conductive Pipes

(1) In piping systems for fluids with conductivity less than 1,000 pS/m, such as refined products and distillates use is to be made of conductive pipes.

(2) Regardless of the fluid being conveyed, plastic piping is to be electrically conductive if the piping passes through a hazardous area. The resistance to earth from any point in the piping system is not to exceed $1 \times 10^6 \Omega/\text{m}$. It is preferred that pipes and fittings be homogeneously conductive. Pipes and fittings having conductive layers are to be protected against a possibility of spark damage to the pipe wall. Satisfactory earthing is to be provided.

(3) After completion of the installation, the resistance to earth is to be verified. Earthing wires are to be accessible for inspection.

1.6.6 Application of Fire Protection Coatings

(1) Fire protection coatings are to be applied on the joints, where necessary for meeting the required fire endurance as for 1.4.3 of this Appendix, after performing hydrostatic pressure tests of the piping system.

(2) The fire protection coatings are to be applied in accordance with manufacturer's recommendations, using a procedure approved in each particular case.

1.6.7 Penetration of Divisions

(1) Where plastic pipes pass through "A", "B" or "F" class divisions, arrangements are to be made to ensure that the fire endurance is not impaired. These arrangements are to be tested in accordance with Recommendations for fire test procedures for "A", "B" and "F" bulkheads specified in revised Resolution A.754(18).

(2) When plastic pipes pass through watertight bulkheads or decks, the watertight integrity of the bulkhead or deck is to be maintained. If the bulkhead or deck is also a fire division and destruction by fire of plastic pipes may cause the inflow of liquid from tanks, a metallic shut-off valve operable from above the freeboard deck should be fitted at the bulkhead or deck.

1.6.8 Control during Installation

(1) Installation is to be in accordance with the manufacturer's guidelines.

(2) Prior to commencing the work, joining techniques are to be approved.

(3) The tests and examinations specified in this Appendix are to be completed before shipboard piping installation commences.

(4) The personnel performing this work are to be properly qualified and certified to the satisfaction of CCS.

(5) The procedure of making bonds is to include:

- ① materials used;
- ② tools and fixtures;
- ③ joint preparation requirements;
- ④ cure temperature;
- ⑤ dimensional requirements and tolerances;
- ⑥ tests acceptance criteria upon completion of the assembly.

(6) Any change in the bonding procedure which will affect the physical and mechanical properties of the joint is to require the procedure to be re-qualified.

1.6.9 Bonding Procedure Quality Testing

(1) A test assembly is to be fabricated in accordance with the procedure to be qualified and it is to consist of at least one pipe-to-pipe joint and one pipe-to-fitting joint.

(2) When the test assembly has been cured, it is to be tested to a hydraulic pressure equal to 2.5 times the design pressure for at least 1 h. No leakage or separation of joints is allowed. The test is to be conducted so that the joint is loaded in both longitudinal and circumferential directions.

(3) Selection of the pipes used for test assembly, is to be in accordance with the following:

- ① When the largest size to be joined is 200 mm nominal outside diameter, or smaller, the test assembly is to

be the largest piping size to be joined.

② When the largest size to be joined is greater than 200 mm nominal outside diameter, the size of the test assembly is to be either 200 mm or 25% of the largest piping size to be joined, whichever is greater.

(4) When conducting performance qualifications, each bonder and each bonding operator are to make up test assemblies, the size and number of which are to be as required above.

1.7 Test specification for plastic pipes

1.7.1 General requirements

1.7 contains requirements for the type approval of plastic pipes. It is applicable to piping systems, including pipe joints and fittings, made predominately of other material than metal.

1.7.2 Documentation

The following information for the plastic pipes, fittings and joints is to be submitted for consideration and approval:

(1) General information:

- ① Pipe and fitting dimensions;
- ② Maximum internal and external working pressure;
- ③ Working temperature range;
- ④ Intended services and installation locations;
- ⑤ The level of fire endurance;
- ⑥ Electrically conductive;
- ⑦ Intended fluids;
- ⑧ Limits on flow rates;
- ⑨ Serviceable life;
- ⑩ Installation instructions;
- ⑪ Details of marking.

(2) Drawings and supporting documentation:

- ① Certificates and reports for relevant tests previously carried out;
- ② Details of relevant standards;
- ③ All relevant design drawings, catalogues, data sheets, calculations and functional descriptions;
- ④ Fully detailed sectional assembly drawings showing pipe, fittings and pipe connections.

(3) Materials(as applicable):

- ① The resin type;
- ② Catalyst and accelerator types, and concentration employed in the case of reinforced polyester resin pipes or hardeners where epoxide resins are employed;

③ A statement of all reinforcements employed where the reference number does not identify the mass per unit area or the tex number of a roving used in a filament winding process, these are to be detailed;

④ Full information regarding the type of gel-coat or thermoplastic liner employed during construction, as appropriate;

⑤ Cure / post-cure conditions. The cure and post-cure temperatures and times employ resin /reinforcement ratio;

⑥ Winding angle and orientation.

1.7.3 Testing

Testing is to demonstrate compliance of the pipes, fittings and joints for which type approval is sought with the requirement of this Appendix.

Pipes, joints and fittings are to be tested for compliance with the requirements of standards¹ acceptable to CCS

¹For the list of standards refer to IACS Recommendation No.86.

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 Plans and documents

3.1.2.1 The plans and documents to be submitted as required in this Chapter are referred to in 2.1.1 of this PART.

3.1.3 Valves

3.1.3.1 All valves are to be so constructed as to prevent the possibility of valvebonnets or glands being slackened back or loosened when the valves are operated.

3.1.3.2 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.

3.1.3.3 Valves and cocks not easily identifiable are to be fitted with nameplates to indicate their purposes.

3.1.3.4 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.

3.1.3.5 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.

3.1.4 Installation of ship-side valves and fittings (other than those on scuppers and sanitary discharges)

3.1.4.1 All sea inlet and overboard discharge pipes are to be fitted with valves or cocks secured direct to the shell plating, or to the plating of fabricated steel sea chests attached to the shell plating. The installation of the valves or cocks is to comply with the following requirements in (1) or (2):

(1) The valves or cocks are to be secured by means of studs screwed into but not penetrating through the pads welded on the shell plating or sea chests.

(2) The valves or cocks may be secured to the distance piece welded on the shell plating or sea chests. The wall thickness of the distance piece is to comply with the requirements in following table, or may be same as that of the shell plating in way of its penetration into the distance piece. The distance piece is to be adequately strengthened as to ensure its rigidity.

Nominal diameter and wall thickness of the distance piece

Table 3.1.4.1

Nominal diameter of pipe ^① (in mm)	Pipe wall thickness (in mm)
50	6.3
100	8.6
125	9.5
150	11.0
200 and above	12.5

Notes: ①The wall thickness of pipes with nominal diameters between the columns can be calculated by insertion method.

3.1.4.2 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.

3.1.4.3 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.

3.1.4.4 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.

3.1.4.5 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.

3.1.4.6 Ship-side valves and fittings as well as sea chests, if made of steel, are to be suitably protected against wastage.

3.1.4.7 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.

3.1.4.8 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°.

3.2.1.3 For small particular compartments, if the survival capability and the safety of the ship are not impaired by flooding of the compartments, bilge pumping arrangements may be dispensed with.

3.2.2 Refrigerated Fish Holds

3.2.2.1 Generally, two bilge suctions are to be provided in each refrigerated fish hold, locating at the longitudinal section in center plane at the front and rear ends respectively, or one on each side. In any case, they should be able to continuously drain water at each site in the refrigerated fish hold to the bilge suction. Sewage bilges are to be set when necessary. If the length of refrigerated fish hold 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 refrigerated fish hold.

3.2.2.3 Refrigerated fish holds are not to be provided with drainage facilities specified in 3.2.3.4 of this PART. However, when the bottom of the refrigerated fish hold is stacked with a pre-cooled seawater hold, water can be discharged to the pre-cooled seawater hold by a drain pipe, and a self-closing cock or stop valve is to be installed at a place where it is easy to check and operate.

3.2.2.4 Refrigerated fish holds 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.

3.2.2.5 Each bilge suction in the refrigerated fish holds are to be connected to the bilge main pipe through closing check valve boxes.

3.2.2.6 Appropriate drainage devices such as drain holes or portable pumps are to be provided in refrigerated fish holds above the working deck to remove stagnant water from any part of the holds.

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 suction. 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 suction when the ship is on an even keel, and is either upright or has a list of not more than 5°. One of these suction 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 suction and direct bilge suction arranged appropriate to the conditions of machinery space with single bottom 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°, suction 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 suction, one of which is a direct bilge suction. The arrangement is to ensure continuous drainage.

3.3.3 Emergency bilge suction

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. Where the pump to which the emergency bilge suction is connected is of the self-priming type, the direct bilge suction on the same side of the ship may be omitted.

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 suction, 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: $Q = 5.66d_1^2 \times 10^{-3}$ m³/h;

When the length of vessel is less than 30 m: $Q = 4.24d_1^2 \times 10^{-3}$ m³/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 pipe systems

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 as defined in GENERAL PART of this RULES, in m;

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.

The actual internal diameter of the bilge main may be rounded off to the acceptable nearest standard size, but not less than the calculated value by 5 mm.

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.

The actual internal diameter of branch bilge suction pipes may be rounded off to the acceptable nearest standard size, but not less than the calculated value by 5 mm.

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 0.1m³ in capacity. When the length of vessel is less than 45 m, it can be appropriately reduced but not to be less than 0.05m³. 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 suction 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 suction or between pumps and overboard discharges.

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 0.5m³, 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 0.5m³, 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). When an overflow pipe serves several tanks, the sectional area of the overflow pipe is to be at least the combined area of the largest overflow pipes for two tanks."

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 suction 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.

3.7.2 Ventilator cowls

3.7.2.1 Ventilator cowls are to be placed on the exposed deck and located as far from exhaust outlets, sky-lights and companionways as possible.

3.7.3 Sparkless fan

3.7.3.1 For fans that require a non-sparking fan, it means that the fan does not generate sparks under any circumstances, that is, it is considered to be non-sparking.

3.7.3.2 Design requirements:

(1) The gap between the impeller and the fan casing is not to be less than 0.1 times the shaft diameter at the impeller bearing, 2 mm as the minimum and 13 mm as the maximum;

(2) The ventilation inlet and outlet of the open deck are to be provided with a protective mesh with a square grid width of not more than 13 mm to prevent objects from entering the fan casing.

3.7.3.3 Materials:

(1) Both the impeller and its housing are to pass appropriate tests and be made of alloy materials believed as not producing produce sparks;

(2) Antistatic materials are to be used to prevent electrostatic charges on the rotating body and the casing. In addition, when installing ventilation equipment on board, make sure that the equipment itself is safely grounded;

(3) For the following combinations, the spark test is not required for fans:

① The impeller and / or housing are made of non-metallic materials, and the elimination of static electricity is to be taken into consideration;

② Impeller and housing are made of non-ferrous metal;

③ The impeller is made of aluminum alloy or magnesium alloy, and the housing is made of ferrous metal (including austenitic stainless steel).

A ring of non-ferrous metal material of appropriate thickness is to be applied on the housing;

④ The impellers and housings are made of any combination of ferrous metals (including austenitic stainless steel), but the design gap of the impeller end is not to be less than 13 mm.

(4) The following impellers and housings will generate sparks and should not use:

① The impellers are made of aluminum alloy or magnesium alloy, and the housings are made of ferrous metal, regardless of the end gap;

② The housings are made of aluminum alloy or magnesium alloy, and the impellers are made of ferrous metal, regardless of the end gap;

③ The impellers and housings are made of any ferrous metal combinations, but the design gap of the impeller end is less than 13mm.

(5) The type test after fan production is to meet the requirements of international standards or other standards accepted by CCS.

3.7.4 Ventilation of emergency generator rooms

3.7.4.1 Emergency generator rooms are to be provided with ventilation openings for the admission of combustion air to engines and the removal of heat. These openings are usually provided with louvers which can be closed from the outside of the emergency generator rooms (when fire breaks out in emergency generator rooms). The louvers may be hand-operated or power-operated. Alternatively, the louvers may be of fixed type with a closing door which may be hand-operated or automatic.

3.7.4.2 The following requirements apply to ventilation louvers for emergency generator rooms and to closing appliances where fitted to ventilators serving emergency generator rooms:

(1) Ventilation louvers and closing appliances may either be hand-operated or power-operated (hydraulic / pneumatic / electric) and are to be operable under a fire condition.

(2) Hand-operated ventilation louvers and closing appliances are to be kept open during normal operation of the vessel. Corresponding instruction plates are to be provided at the location where hand-operation is provided.

(3) Power-operated ventilation louvers and closing appliances are to be of a fail-to-open type. Closed ventilation louvers and closing appliances are acceptable during normal operation of the vessel. Power-operated ventilation louvers and closing appliances are to open automatically whenever the emergency generator is starting / in operation.

(4) It is to be possible to close ventilation openings by a manual operation from a clearly marked safe position outside the space where the closing operation can be easily confirmed. The louver status (open /closed) is to be indicated at this position. Such closing is not to be possible from any other remote position.

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.

4.1.2 Plans and documents

4.1.2.1 The plans and documents to be submitted as required in this Chapter are referred to in 2.1.1 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 below 10°C below the flash point of the fuel, 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 or other reliable means of isolation are to be fitted to the drain pipes to prevent sea water entering tank through drain pipes after double bottom tank is damaged.

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 PART 5 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 of sufficient capacity is to be

provided for the main engine at its maximum continuous output and one standby pump of sufficient capacity is to be provided for normal navigation of the ship. Such a standby pump is to be independently power driven and capable of being ready for immediate use. Where two or more main engines are fitted, each with its own booster pump, 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 Every oil fuel pipe, which, if damaged, would allow oil to escape from a storage, settling or daily service tank situated above the double bottom are to be fitted with a cock or valve directly on the tank or short pipe welded to the oil tank bulkhead with a length not exceeding the value obtained from the following formula. 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. In the case of tanks having a capacity of less than 0.5m³, remotely controlled closing devices may be omitted.

$$L = 0.8D + 80 \quad \text{mm}$$

where: L — length of short pipe, in mm;

D — outside diameter of steel pipe, in mm.

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 2.1.7.2 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 fore peak tank or other flammable liquids.

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 2.2.2.7 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 Fueloil (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 Fueloil (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. For diesel engines with open cooling, the cooling water is to be led to the outboard through the discharge valve or upright return pipe which is higher than the highest cooling water chamber of the diesel engine, and an observation device is to be set on the discharge pipe.

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 2.1.7.2 and 4.2.5.2 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 or other equivalent noise reduction measures, 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 is 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 Turbochargers

5.1.11.1 The turbochargers are to be designed to operate under conditions given in 1.1.2, Chapter 1 of this PART. The component lifetime and the alarm level for speed are to be based on 45°C air inlet temperature.

5.1.11.2 Turbochargers are categorized in three groups depending on served power by cylinder groups (e.g. for a V-engine with one turbocharger for each bank, the categorization is based on half of the total engine rated power) with:

- (1) Category A: $\leq 1,000$ kW;
- (2) Category B: $> 1,000$ kW and $\leq 2,500$ kW;
- (3) Category C: $> 2,500$ kW.

5.1.11.3 The requirements for turbochargers with regard to design, approval, type testing and certification escalate with the size of the turbochargers. For details, see Section 6 of this Chapter.

5.1.11.4 Turbochargers are to be type approved, either separately or as a part of an engine.

5.1.11.5 The requirements relating to turbochargers in this Chapter are written for exhaust gas driven turbochargers, but apply in principle also for engine driven chargers.

5.1.12 Test

5.1.12.1 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.

5.1.12.2 Bench trials of diesel engines are to be carried out in accordance with relevant national standards or the test programs approved by CCS.

5.1.13 Plans and documents

5.1.13.1 The following engine plans and documents are to be submitted for approval:

Submit the approved drawings and plans**Table 5.1.13.1**

No.	Item
(1)	Bedplate and crankcase of welded design, with welding details and welding instructions ^{①,②}
(2)	Thrust bearing bedplate of welded design, with welding details and welding instructions ^①
(3)	Bedplate/oil sump welding drawings ^①
(4)	Frame/framebox/gearbox of welded design, with welding details and instructions ^{①,②}
(5)	Frame/framebox/gearbox, with welding drawings ^{①,②}
(6)	Crankshaft, details, each cylinder No.
(7)	Crankshaft, assembly, each cylinder No.
(8)	Crankshaft calculations
(9)	Thrust shaft or intermediate shaft (if integral with engine)
(10)	Shaft coupling bolts (Sectional crankshaft)
(11)	Material specifications of main parts with information on non-destructive material tests and pressure tests ^③
(12)	Schematic layout or other equivalent documents on the engine of starting air system, fuel oil system, lubricating oil system, cooling water system, hydraulic system (including hydraulic system for valve lift), control and safety system
(13)	Shielding of high pressure fuel pipes, assembly ^④
(14)	Construction and strength of accumulators (for electronically controlled engine)
(15)	Arrangement and details of the crankcase explosion relief valve ^⑤
(16)	Calculation results for crankcase explosion relief valves
(17)	Details of the type test program and the type test report ^⑦
(18)	High pressure parts for fuel oil injection system ^⑥
(19)	Oil mist detection and/or alternative alarm arrangements
(20)	Details of mechanical joints of piping systems
(21)	Documentation verifying compliance with inclination limits

Notes:

①. For approval of materials and weld procedure specifications. The weld procedure specification is to include details of pre and post weld heat treatment, weld consumables and fit-up conditions.

②. For each cylinder for which dimensions and details differ.

③. For comparison with rules requirements for material, NDT and pressure testing as applicable.

④. All engines.

⑤. Only for engines of a cylinder diameter of 200 mm or more or a crankcase volume of 0.6 m³ or more.

⑥. The documentation to contain specifications for pressures, pipe dimensions and materials.

⑦. The type test program is to be submitted before the type test, and the type test report may be submitted after the conclusion of the type test.

5.1.13.2 The following engine plans and documents are to be submitted for information:

Submit the drawings for future reference

Table 5.1.13.2

No.	Item
(1)	Engine particulars (e.g. Data sheet with general engine information, Project Guide, Marine Installation Manual)
(2)	Engine cross section
(3)	Engine longitudinal section
(4)	Bedplate and crankcase of cast design
(5)	Thrust bearing assembly ^①
(6)	Frame/framebox/gearbox of cast design ^②
(7)	Tie rod
(8)	Connecting rod
(9)	Connecting rod, assembly ^③
(10)	Crosshead, assembly ^③
(11)	Piston rod, assembly ^③
(12)	Piston, assembly ^③
(13)	Cylinder jacket/ block of cast design ^②
(14)	Cylinder cover, assembly ^③
(15)	Cylinder liner
(16)	Counterweights (if not integral with crankshaft), including fastening
(17)	Camshaft drive, assembly ^③
(18)	Flywheel
(19)	Fuel oil injection pump
(20)	Shielding and insulation of exhaust pipes and other parts of high temperature which may be impinged as a result of a fuel system failure, assembly
(21)	For electronically controlled engines, construction and arrangement of control valves, high-pressure pumps and drive for high pressure pumps
(22)	Operation and service manuals ^④
(23)	FMEA (for engine control system) ^⑤
(24)	Production specifications for castings and welding (sequence)
(25)	Evidence of quality control system for engine design and in service maintenance
(26)	Quality requirements for engine production
(27)	Type approval certification for environmental tests, control components of electrical system ^⑥
(28)	Fatigue analysis of high pressure fuel oil piping and hydraulic oil piping (where applicable)
(29)	Other plans and documents as deemed necessary by CCS

Notes:

①. If integral with engine and not integrated in the bedplate.

②. Only for one cylinder or one cylinder configuration.

③. Including identification (e.g. drawing number) of components.

④. Operation and service manuals are to contain maintenance requirements (servicing and repair) including details of any special tools and gauges that are to be used with their fitting/settings together with any test requirements on completion of maintenance.

⑤. Where engines rely on hydraulic, pneumatic or electronic control of fuel injection and/or valves, a failure mode and effects analysis (FMEA) is to be submitted to demonstrate that failure of the control system will not result in the operation of the engine being degraded beyond acceptable performance criteria for the engine.

⑥. Tests are to demonstrate the ability of the control, protection and safety equipment to function as intended under the specified testing conditions per CCS Guidelines for Type Approval Test of Electric and Electronic Products.

5.1.13.3 For turbochargers, the following plans and documents are to be submitted for approval:

(1) Category A:

① Containment test report;

② Cross sectional drawing with principal dimensions and names of components;

③ Test program.

(2) Category B and C:

① Cross sectional drawing with principal dimensions and materials of housing components for containment evaluation;

② Documentation of containment in the event of disc fracture;

③ Operational data and limitations, including maximum permissible operating speed (rpm), alarm level for over speed, maximum permissible exhaust gas temperature before turbine, alarm level for exhaust gas temperature before turbine, minimum lubrication oil inlet pressure, lubrication oil inlet pressure low alarm set point, maximum lubrication oil outlet temperature, lubrication oil outlet temperature high alarm set point, maximum permissible

vibration levels (i.e. self- and externally generated vibration);

Note: Alarm levels may be equal to permissible limits but are not to be reached when operating the engine at 110% power or at any approved intermittent overload beyond the 110%.

- ④ Arrangement of lubrication system, all variants within a range;
- ⑤ Type test reports;
- ⑥ Test program.

(3) In addition to the provisions of (2) above, the following plans and documents for category C turbochargers are to be submitted:

- ① Drawings of the housing and rotating parts including details of blade fixing;
- ② Material specifications (chemical composition and mechanical properties) of all parts mentioned above;
- ③ Welding details and welding procedure of above mentioned parts, if applicable;
- ④ Documentation* of safe torque transmission when the disc is connected to the shaft by an interference fit;
- ⑤ Information on expected lifespan, considering creep, low cycle fatigue and high cycle fatigue;
- ⑥ Operation and maintenance manuals*.

Note: * Applicable to two sizes in a generic range of turbochargers.

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 CCS the Materials and Welding Code.

- (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:

$$d = \sqrt[3]{\frac{D^2 [A\alpha_B p_Z (L - L_p) + C\alpha_T p_i S]}{59 \left(0.3 + \frac{0.7 R_m}{490} \right)}} \quad \text{mm}$$

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)、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_B 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, $0 \leq \delta \leq 0.65$.

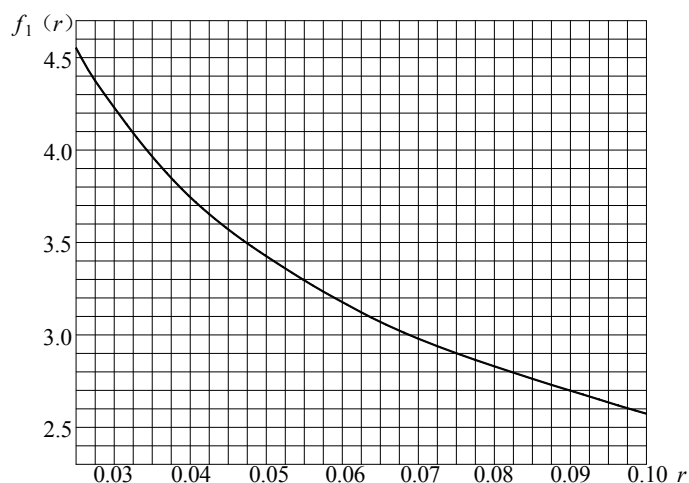


Figure 5.2.3.1(1) Coefficient

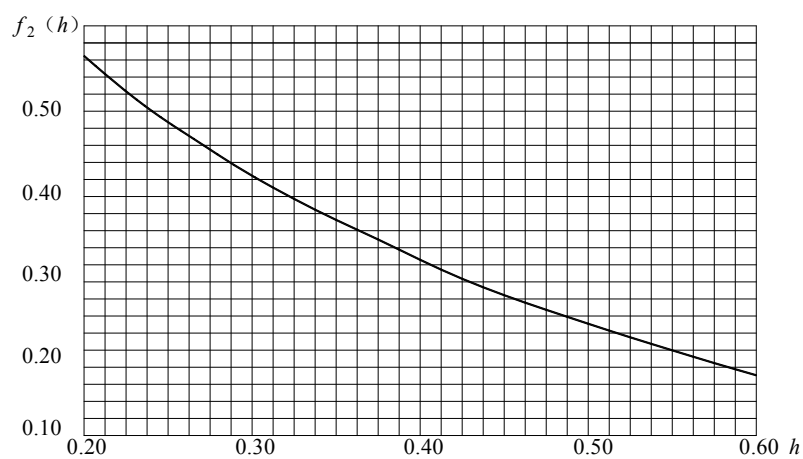


Figure 5.2.3.1(2) Coefficient

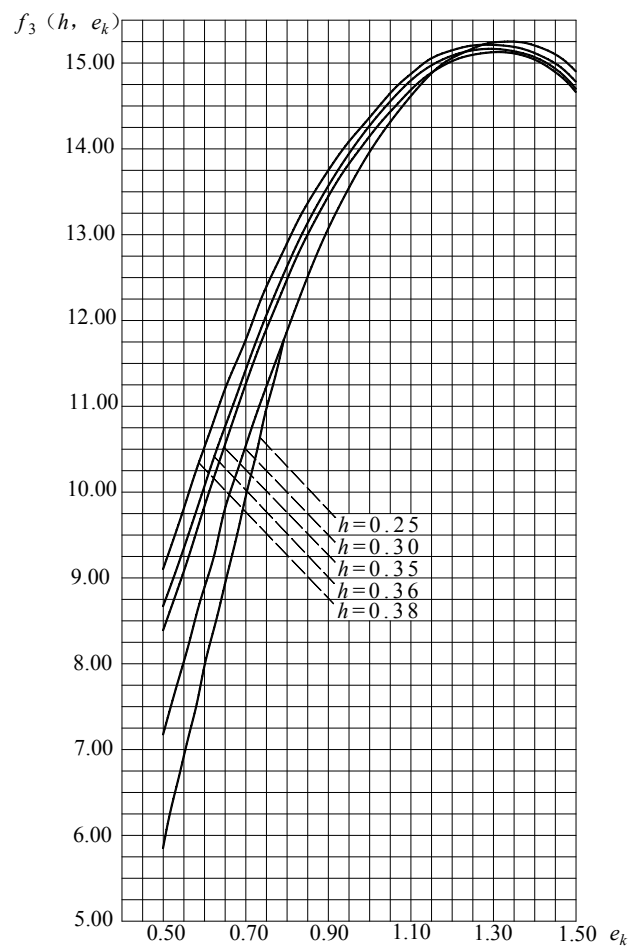


Figure 5.2.3.1(3) Coefficient

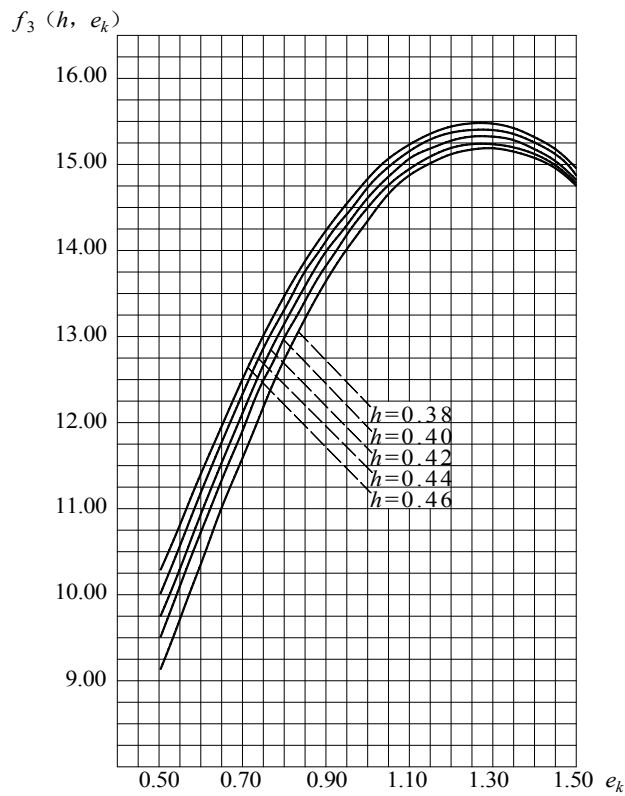


Figure 5.2.3.1(4) Coefficient

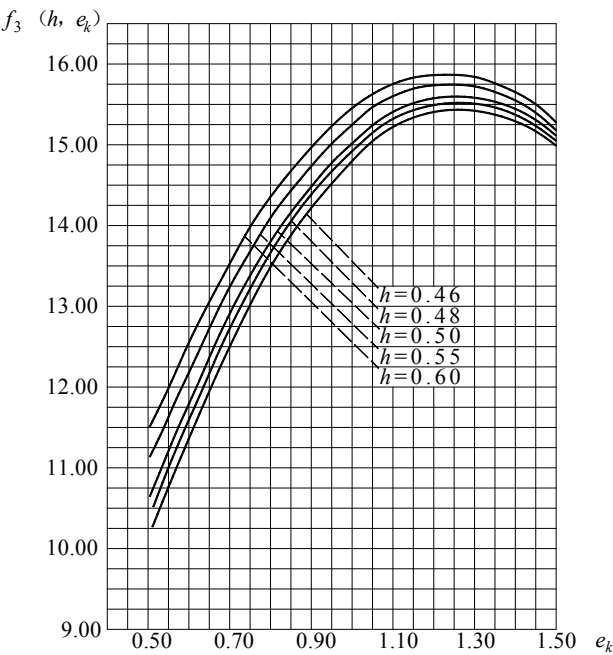


Figure 5.2.3.1(5) Coefficient

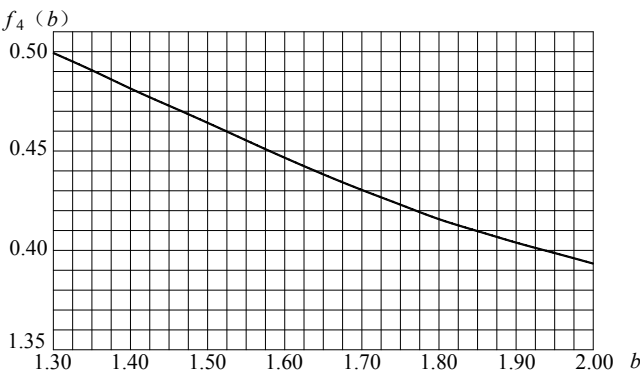


Figure 5.2.3.1(6) Coefficient

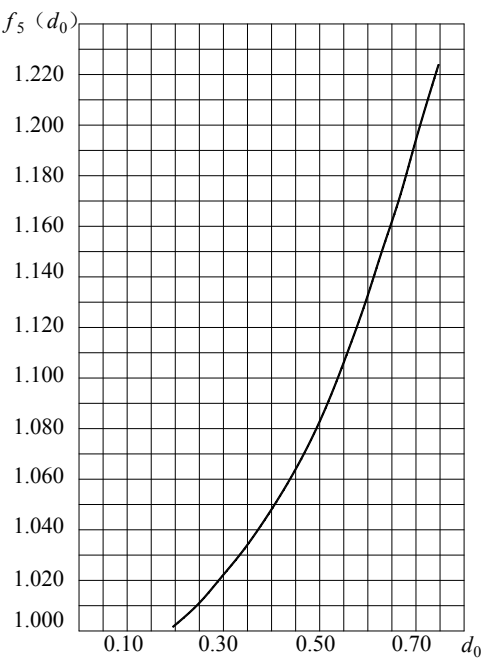


Figure 5.2.3.1(7)

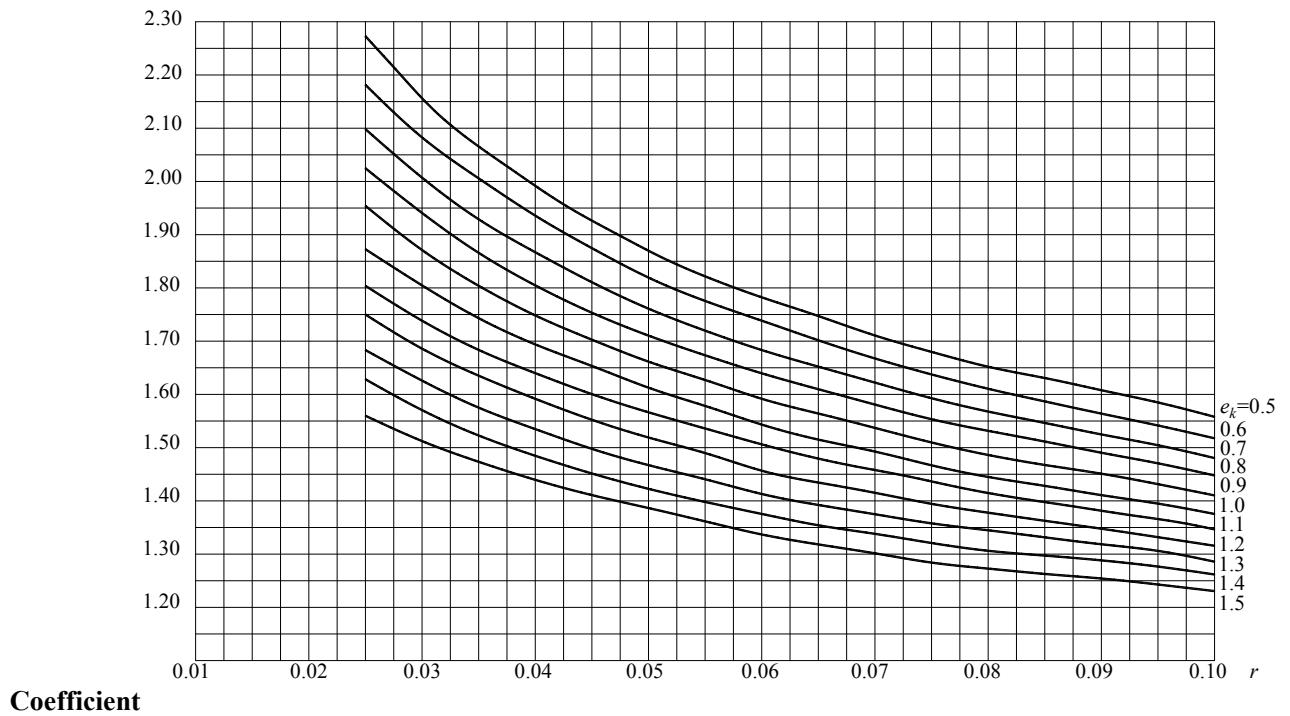


Figure 5.2.3.1(8) Coefficient

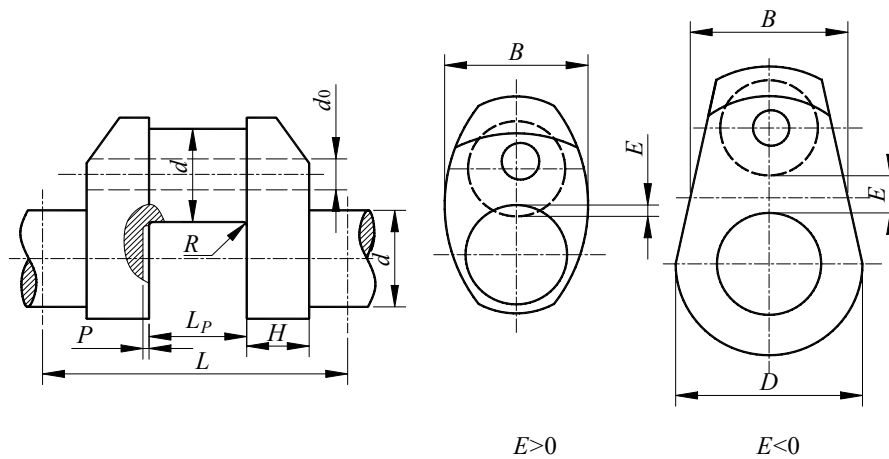


Figure 5.2.3.1(9) Overall Dimensions of Crankshaft

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/mm²;

M_{max} —maximum instantaneous impact torque of engine, in N·mm; calculated according to the following formula:

$$M_{max} = T_{max} R \quad \text{N·mm}$$

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 8 Part 3 of CCS Materials and Welding Code.

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 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 In diesel engines having cylinders not exceeding 200 mm bore or having a crankcase gross volume not exceeding 0.6 m³, relief valves may be dispensed.

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, where crank throws exceed eight.

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 in way of each main crank throw.

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.

5.3.4.3 The structural design of crankcase relief valves are to comply with following requirements:

(1) Crankcase explosion relief valves are to be provided with lightweight spring-loaded valve discs or other quick-acting and self-closing devices to relieve a crankcase of pressure in the event of an internal explosion and to prevent the inrush of air thereafter;

(2) The valve discs in crankcase explosion relief valves are to be made of ductile material capable of withstanding the shock of contact with stoppers at the full open position;

(3) Crankcase explosion relief valves are to be designed and constructed to open quickly and be fully open at a pressure not greater than 0.02 MPa;

(4) Crankcase explosion relief valves are to be provided with a flame arrester that permits flow for crankcase pressure relief and prevents passage of flame following a crankcase explosion;

(5) Where crankcase relief valves are provided with arrangements for shielding emissions from the valve following an explosion, the valve is to be type tested to demonstrate that the shielding does not adversely affect the operational effectiveness of the valves;

(6) Crankcase explosion relief valves are to be provided with a copy of manufacturer's installation and maintenance manual that is pertinent to the size and type of valve being supplied for installation on a particular engine. The manual is to contain the following information:

① description of valve with details of function and design limits;

② copy of type test certification;

③ installation instructions;

④ maintenance in service instructions to include testing and renewal of any sealing arrangements;

⑤ actions required after a crankcase explosion.

(7) A copy of the installation and maintenance manual required by 5.3.4.3(6) of this Section is to be provided on board.

(8) Valves are to be provided with suitable markings that include the following information:

① name and address of manufacturer;

② designation and size;

③ month/Year of manufacture;

④ approved installation orientation.

(9) Crankcase explosion relief valves are to be type tested in a configuration that represents the installation arrangements that will be actually used on an engine.

5.3.4.4 The total volume of the stationary parts within the crankcase may be discounted in estimating the crankcase gross volume (rotating and reciprocating components are to be included in the gross volume).

5.3.4.5 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 external 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 Crankcase oil mist detection and alarm devices

5.3.6.1 In engine having cylinders with an output greater than or equal to 250 mm or cylinder bore exceeding 300 mm, approved crankcase oil mist detection and alarm devices (or diesel engine bearing temperature monitors or equivalent devices) are to be fitted.

For low-speed engines, an alarm is to be given and speed is to be reduced when high level of oil mist is detected.

For medium and high-speed diesel engines, an alarm is to be given and engines are to be automatically

stopped when high level of oil mist is detected.

5.3.6.2 The oil mist detection/monitoring system and arrangements are to be installed in accordance with the engine designer's and oil mist manufacturer's instructions/recommendations. The following particulars are to be included in the instructions:

- (1) Schematic layout of engine oil mist detection/monitoring and alarm system showing location of engine crankcase sample points and piping or electrical cable arrangements together with dimensions of pipes connected to detector/monitor;
- (2) Evidence of study to justify the selected location of sample points and sample extraction rate (if applicable) in consideration of the crankcase arrangements and geometry and the predicted crankcase atmosphere where oil mist can accumulate;
- (3) The manufacturer's maintenance and test manual;
- (4) Information relating to type or in-service testing of the engine with engine protection system test arrangements having approved types of oil mist monitoring equipment.

5.3.6.3 A copy of the oil mist detection/monitoring equipment maintenance and test manual is to be provided on board.

5.3.6.4 Oil mist monitoring and alarm information is to be capable of being read from a safe location away from the engine.

5.3.6.5 Each engine is to be provided with its own independent oil mist detection arrangement and a dedicated alarm if multiple diesel engines need to be fitted with oil mist detection and alarm devices.

5.3.6.6 Oil mist detection/monitoring and alarm systems are to be subject to the simulated functional test on the test bench and on board at stop state and normal operating conditions of diesel engines in accordance with test procedures accepted by CCS.

5.3.6.7 The alarms and shutoff of oil mist detection devices are to comply with relevant requirements of Chapter 12 in this PART.

5.3.6.8 The oil mist detection/monitoring arrangements are to provide an alarm indication in the event of a foreseeable functional failure in the equipment and installation arrangements.

5.3.6.9 The oil mist detection/monitoring system is to provide an indication that any lenses fitted in the equipment and used in determination of the oil mist level have been partially obscured to a degree that will affect the reliability of the information and alarm indication.

5.3.6.10 Where oil mist detection/monitoring equipment includes the use of programmable electronic systems, the arrangements are to be in accordance with relevant requirements of Chapter 12 in this PART.

5.3.6.11 The equipment together with detectors/monitors is to be tested when installed on the test bench and on board to demonstrate that the detection/monitoring and alarm system functionally operates. The testing arrangements are to be submitted to CCS for approval.

5.3.6.12 Where sequential oil mist detection/monitoring arrangements are provided, the sampling frequency and time is to be as short as reasonably practicable.

5.3.6.13 Where alternative methods are provided for the prevention of the build-up of oil mist that may lead to a potentially explosive condition within the crankcase, the following information is to be included in the details to be submitted for approval:

- (1) Engine particulars, including type, power, speed, stroke, bore and crankcase volume;
- (2) Details of arrangements preventing the build-up of potentially explosive conditions within the crankcase, e.g. bearing temperature monitoring, oil splash temperature, crankcase pressure monitoring and recirculation arrangements;
- (3) Evidence to demonstrate that the arrangements are effective in preventing the build-up of potentially explosive conditions together with details of in-service experience;
- (4) Operating instructions and the maintenance and test instructions.

5.3.6.14 Where it is proposed to use the introduction of inert gas into the crankcase to minimize a potential crankcase explosion, details of the arrangements are to be submitted for approval.

5.3.7 Warning notice

5.3.7.1 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 Lubricating oil drain pipes from the engine sump to the drain tank are to be submerged at their outlet ends.

5.4.1.5 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.

5.4.1.6 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.

5.4.1.7 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.

5.4.1.8 Fuel filters and lubricating oil filters directly mounted on the diesel engines are not to be installed near hot parts.

5.4.1.9 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.

5.4.1.10 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 Where main engines are started by compressed air, at least two starting air receivers, available for operating separately, with equivalent capacity are to be fitted. The total capacity of air receivers is to be sufficient to provide, without their being replenished, not less than 12 consecutive starts of each main engine of the reversible type at the cold condition (the test is to be carried out alternating between ahead and astern); and not less than 6 starts of each main non-reversible type engine at the cold condition. Where main engines are at hot running state, starting times are to be added during the test. Where there are more than two main engines, the total capacity of air receivers is to be sufficient to provide 3 starts for each main engine and totally no less 12 starts but no more than 18 starts preferably. 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 compressors are to be installed, including at least one set driven independently of the main engine and with the capacity no less than 50% of total required capacity, where main engines are arranged to be started by compressed air.

The total capacity of these air compressors is to be such that the atmospheric pressure will increase to the pressure required for consecutive start as specified in 5.5.1.2 of this PART, excluding emergency air compressors which may be fitted to comply with requirements of 5.5.2.2 in this Section. The total capacity is to be evenly distributed to each compressor in general.

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 and are not to be connected in parallel. Each storage battery is to start main engines at cold condition and ready-to-start state. The combined capacity of the batteries is to be sufficient without recharging to provide starts of main engines required for air starting as specified in 5.5.1.2 of this Section.

5.5.5.2 The electric starting device of auxiliary engine is to be fitted with two sets of independent storage battery, or the power may be also supplied by storage battery of main engine by means of independent circuit where the starting storage battery for main engine is fitted. Only 1 set of storage battery may be fitted in case of only single auxiliary engine. The combined capacity of the batteries is to be sufficient to provide no less 3 starts of each auxiliary engine.

5.5.5.3 The starting batteries are to be used for starting and the engines own monitoring purposes only. Provisions are to be made to maintain continuously the stored energy at all times.

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 shall comply with the provisions of Chapter 1,1.1.9.1 of this article.

5.5.6.6 If the emergency generator set is equipped with an electronic governor (or other auxiliary facilities requiring power supply to start), two independent power supply sets shall be provided.

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 Alarm and monitoring

5.6.2.1 For all turbochargers of Categories B and C, indications and alarms as listed in Table 5.6.2.1 are required.

Requirements for alarm and indication of turbochargers of categories B and C**Table 5.6.2.1**

SN	Monitored Parameters	Category of Turbochargers				Remark
		B		C		
		Alarm	Indication	Alarm	Indication	
1	Speed	High ^④	X ^④	High ^④	X ^④	
2	Temperature of exhaust gas at each turbocharger inlet	High ^①	X ^①	High	X	High temperature alarms for each cylinder at engine is acceptable ^②
3	Temperature of Lub. Oil at turbocharger outlet			High	X	If not forced system, oil temperature near bearings
4	Pressure of lub. Oil at turbocharger inlet	Low	X	Low	X	Only for forced lubrication systems ^③

Notes:

① For Category B turbochargers, the exhaust gas temperature may be alternatively monitored at the turbocharger outlet, provided that the alarm level is set to a safe level for the turbine and that correlation between inlet and outlet temperatures is substantiated.

② Alarm and indication of the exhaust gas temperature at turbocharger inlet may be waived if alarm and indication for individual exhaust gas temperature is provided for each cylinder and the alarm level is set to a value safe for the turbocharger.

③ Separate sensors are to be provided if the lubrication oil system of the turbocharger is not integrated with the lubrication oil system of the diesel engine or if it is separated by a throttle or pressure reduction valve from the diesel engine lubrication oil system.

④ On turbocharging systems where turbochargers are activated sequentially, speed monitoring is not required for the turbocharger(s) being activated last in the sequence, provided all turbochargers share the same intake air filter and they are not fitted with waste gates.

5.6.2.2 Monitoring parameters indicators may be fitted at the local control station or remote control position.

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.

5.6.6.2 For turbochargers of category C, in cases where the disc is connected to the shaft with interference fit, calculations is to substantiate safe torque transmission during all relevant operating conditions such as maximum speed, maximum torque and maximum temperature gradient combined with minimum shrinkage amount.

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.

5.6.9.2 Crosshead type engine scavenge spaces in open connection with cylinders are to be provided with independent fire extinguishing arrangements which are to be independent of the fire extinguishing system of the engine room.

5.6.10 Containment of turbochargers

5.6.10.1 Turbochargers are to fulfill containment in the event of a rotor burst. This means that at a rotor burst no part may penetrate the casing of the turbocharger or escape through the air intake. For documentation purposes (test/calculation), it is to be assumed that the discs disintegrate in the worst possible way.

5.6.10.2 For category B and C, containment is to be documented by testing. Fulfillment of this requirement can be awarded to a generic range of turbochargers based on testing of one specific unit. Testing of a large unit is preferred as this is considered conservative for all smaller units in the generic range. In any case, it must be documented (e.g. by calculation) that the selected test unit really is representative for the whole generic range.

5.6.10.3 The minimum test speeds, relative to the maximum permissible operating speed, are:

- for the compressor: 120%;
- for the turbine: 140% or the natural burst speed, whichever is lower.

5.6.10.4 Containment tests are to be performed at working temperature.

5.6.10.5 A numerical analysis (simulation) of sufficient containment integrity of the casing based on calculations by means of a simulation model may be accepted in lieu of the practical containment test, provided that:

(1) the numerical simulation model has been tested and its suitability/accuracy has been proven by direct comparison between calculation results and the practical containment test for a reference application (reference containment test). This test is to be performed at least once by the manufacturer for acceptance of the numerical simulation method in lieu of tests;

(2) the corresponding numerical simulation for the containment is performed for the same speeds as specified for the containment test;

(3) material properties for high-speed deformations are to be applied in the numeric simulation. The correlation between normal properties and the properties at the pertinent deformation speed are to be substantiated;

(4) the design of the turbocharger regarding geometry and kinematics is similar to the turbocharger that was used for the reference containment test. In general, totally new designs will call for a new reference containment test.

Note: Series means a set of turbocharger with dimensions scaled proportionally in the same design.

5.6.11 Type testing

5.6.11.1 Type testing is applicable to categories B and C. The type test for a generic range of turbochargers may be carried out either on an engine (for which the turbocharger is foreseen) or in a test rig.

5.6.11.2 Turbochargers are to be subjected to at least 500 load cycles at the limits of operation. This test may be waived if the turbocharger together with the engine is subjected to this kind of low cycle testing, see Appendix 4 of this Chapter.

5.6.11.3 The suitability of the turbocharger for such kind of operation is to be preliminarily stated by the manufacturer.

5.6.11.4 The rotor vibration characteristics are to be measured and recorded in order to identify possible sub-synchronous vibrations and resonances.

5.6.11.5 The type test is to be completed by a hot running test at maximum permissible speed combined with maximum permissible temperature for at least one hour. After this test, the turbocharger is to be opened for examination, with focus on possible rubbing and the bearing conditions.

5.6.11.6 The extent of the surveyor's presence during the various parts of the type tests is left to the discretion of each Society.

5.6.12 Certification

5.6.12.1 The manufacturer is to adhere to a quality system designed to ensure that the designer's specifications are met, and that manufacturing is in accordance with the approved drawings.

5.6.12.2 For category C, this is to be verified by means of periodic product audits of CCS Type approval A.

5.6.12.3 These audits are to focus on:

- (1) chemical composition of material for the rotating parts;
- (2) mechanical properties of the material of a representative specimen for the rotating parts and the casing;
- (3) UT and crack detection of rotating parts;
- (4) dimensional inspection of rotating parts;
- (5) rotor balancing;
- (6) hydraulic testing of cooling spaces to 4 bars or 1.5 times the maximum working pressure, whichever is higher;

(7) The overspeed test of all compressor wheels is to be carried out for a duration of 3 min. at least. The test may be carried out in one of the following conditions:

- ① 120% of alarm level speed at room temperature;
- ② 110% of alarm level speed at 45°C inlet temperature and corresponding pressure ratio.

The overspeed test may be waived for forged wheels that are individually controlled by an approved non-destructive method.

5.6.12.4 The certification requirements for turbochargers are to be in compliance with relevant requirements of the Rules.

5.6.12.5 The requirements of 5.6.12.1 to 5.6.12.3 also apply to replacement of rotating parts and casing.

5.6.12.6 Alternatively to the above periodic product audits, individual certification of a turbocharger and its parts may be made. However, such individual certification of category C turbocharger and its parts are to be based on test requirements specified in 5.6.12.4.

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 speed does not exceed 115% of the rated speed.

5.7.1.2 Where electronic speed governors of main engines form part of a remote control system, they are to comply with the following conditions:

(1) If lack of power to the governor may cause major and sudden changes in the present speed and direction of thrust of the propeller, back-up power supply is to be provided.

(2) Local control of the engines is always to be possible even in the case of failure in any part of the automatic or remote control systems, and to this purpose, from the local control position it is to be possible to disconnect the remote signal. In addition, independent governors may be fitted to comply with the speed control requirements as specified in 5.7.1.1.

(3) Electronic governors and their actuators are to be subject to the type test in accordance with CCS Guidelines for Type Approval Test of Electric and Electronic Products.

5.7.2 Overspeed protective devices

5.7.2.1 In addition to speed governors as described in 5.7.1 of this PART, main engines, with rated output more than 220kW and capable of disconnecting transmission shafting or driving controllable-pitch propeller, are to be also fitted with overspeed protection devices, to prevent the speed of main engines from exceeding 120% of the nominal speed. Equivalent arrangements are also accepted provided that special considerations are given. Such overspeed protection devices, including their driving mechanisms, are to be separated from required governors.

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:

They will prevent transient frequency variations in the electrical network in excess of 10% of the rated frequency with a recovery time to steady state conditions not exceeding 5 s, when the maximum electrical step load is switched on or off. When the rated load is suddenly taken off, a transient speed variation in excess of 10%

of the rated speed may be acceptable, provided this does not cause the intervention of the overspeed device as required by 5.7.3.2 of this Section. The permanent speed variation is not to exceed 5% of the rated 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 rated speed, and permanent variation in speed is not to exceed 5% of the rated 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. When a four-stroke diesel engine with high supercharge is used as the prime mover for driving generator, application of electrical load in more than 2 load steps can be permitted in its governing characteristics tests (see Figure 5.7.3.1). Thus, the power necessary electrical installations being automatically switched on after block-out and the sequence in which it is connected are to be sufficiently considered in designing the load of vessel's electric power station. This also applies analogously for generators to be operated in parallel and where the power has to be transferred from one generator to another in the event of any one generator has to be switched off.

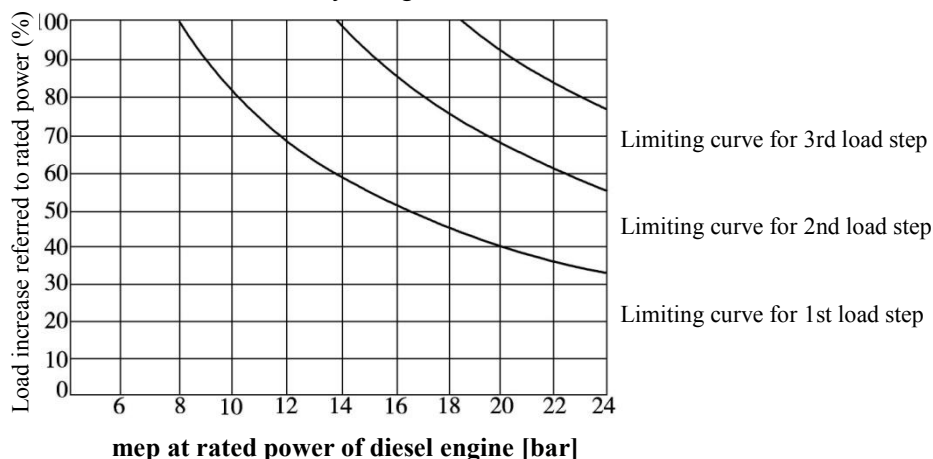


Figure 5.7.3.1

Emergency generator sets are to be subject to a sudden or stepped rated load application test and comply with the governor conditions aforesaid. Where the load is suddenly applied, the following requirements are to be complied with:

- (1) emergency generator sets are to be started and supply power to the 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 ALARMS AND SAFEGUARDS FOR EMERGENCY DIESEL ENGINES

5.8.1 General requirements

5.8.1.1 Emergency diesel engines mainly include:

- (1) a diesel engine generator used as the emergency source of electrical power;
- (2) a diesel engine used to power the emergency fire pump (except for portable type);
- (3) a diesel engine generator used as the independent source of power required for steering gear;
- (4) other diesel engines used in an emergency.

5.8.1.2 This Section applies to diesel engines required to be immediately available in an emergency and capable of being controlled remotely or automatically operated.

5.8.2 Alarms and safeguards

5.8.2.1 The safety and alarm systems are to be designed to “fail safe” and satisfy the requirements of Chapter 12 in this PART.

5.8.2.2 Regardless of the engine output, shutdowns (if provided) other than the overspeed shutdown specified in Table 5.8.2.5 are to be automatically overridden when the engine is in automatic or remote control mode during navigation of fishing vessels.

5.8.2.3 The alarm system (including the indication) is to function in accordance with the relevant requirements of PART SEVEN of the Rules, with additional requirements that grouped alarms are to be arranged in the bridge.

5.8.2.4 In addition to the fuel oil control from outside the space, a local means of engine shutdown is to be provided.

5.8.2.5 Emergency diesel engines are to be fitted with alarms and safeguards in accordance with the requirements of Table 5.8.2.5. Local indications of at least those parameters listed in Table 9.9.2.5 are to be provided within the same space as the diesel engines and are to remain operational in the event of failure of the alarm and safety systems.

Alarms and Safeguards for Emergency Diesel Engines

Table 5.8.2.5

Parameter	≥220kW	<220kW
Lubricating oil inlet pressure	Low	Low
Lubricating oil inlet temperature	High	
Temperature of cooling water or cooling air	High	High
Pressure or flow of cooling water	Low	
Overspeed activated	Alarm and shutdown for overspeed	
Fuel oil leakage from high pressure pipes	Oil leakage	Oil leakage
Oil mist concentration in crankcase ^①	High	

Note: ① only for engines having a power of not less than 2250kW or a cylinder bore of more than 300mm.”

Section 9 HYDRAULIC TESTING

5.9.1 Testing pressure

5.9.1.1 Spaces of diesel engine parts bearing pressure are to be subject to the hydraulic testing in accordance with Table 5.9.1.1.

5.9.1.2 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 5.9.1.1

SN	Item	Testing pressure ^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	1.5P, but no less than 0.4MPa
4	Cooling chamber of vent valve	1.5P, 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	1.5 P or P+30MPa, whichever is smaller 1.5 P or P+30MPa, whichever is smaller 1.5 P or P+30MPa, whichever is smaller

7	Hydraulic high-pressure pipeline of hydraulic system for driving the vent valve	1.5 <i>P</i>
8	Cylinder of scavenging pump	0.4MPa
9	Cooling chamber of turbosupercharger	1.5 <i>P</i> , but no less than 0.4MPa
10	Cooling chamber of exhaust pipe	1.5 <i>P</i> , 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 <i>P</i> 1.5 <i>P</i> , but no less than 0.4MPa
12	Each side of cooler ^{note 2}	1.5 <i>P</i> , but no less than 0.4MPa
13	Engine driven pumps (oil, water, fuel and sewage)	1.5 <i>P</i> , but no less than 0.4MPa

①: *P* means the maximum operating pressure of tested part.

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.

6.1.3 Plans and documents

6.1.3.1 Following plans and documents are to be submitted for approval:

- (1) General arrangement (longitudinal and transverse sections);
- (2) Details of pinions and wheels, including ring gear, where applicable, and parameters necessary for calculation of load capacity;
- (3) Gear shafts;
- (4) Bosses, if any;
- (5) Clutches and/or couplings;
- (6) Other power transmitting parts;
- (7) Gear casing, incl. propeller thrust bearing housing, if any;
- (8) Basic sizes of the tooth profile of the tools;
- (9) Calculations of the load capacity of gears;
- (10) Strength calculations of shafts;
- (11) Strength calculations of clutches and/or couplings;
- (12) Calculation of combined dynamic reaction forces and its acting direction of sliding bearings for gearboxes;
- (13) Details of heat treatment of gears;
- (14) Details of gear materials;
- (15) Details of weld procedures for gears or gearbox, if any;
- (16) Plans and documents for gear box lubricating and cooling systems.

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 5 Part 1 of CCS Materials and Welding Code.

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, T_1 and T_2 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 $b = b_B$;

$$K_{H\alpha} \text{ — Transverse load distribution factor, } K_{H\alpha} = 1 + \frac{10 b f_{pb}}{F_t K_A K_v K_{H\beta}},$$

Where of, 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:

$$\sigma_{Hp} = \frac{\sigma_{Hlim}}{S_H} Z_L Z_R Z_V Z_W \quad \text{N/mm}^2$$

Where, σ_{Hlim} — endurance limit for contact stress, N/mm²; 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:

$$Z_L = 0.83 + 0.68v_f \quad (\text{for through-hardened steel});$$

$$Z_L = 0.91 + 0.36v_f \quad (\text{for surface-hardened steel});$$

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;

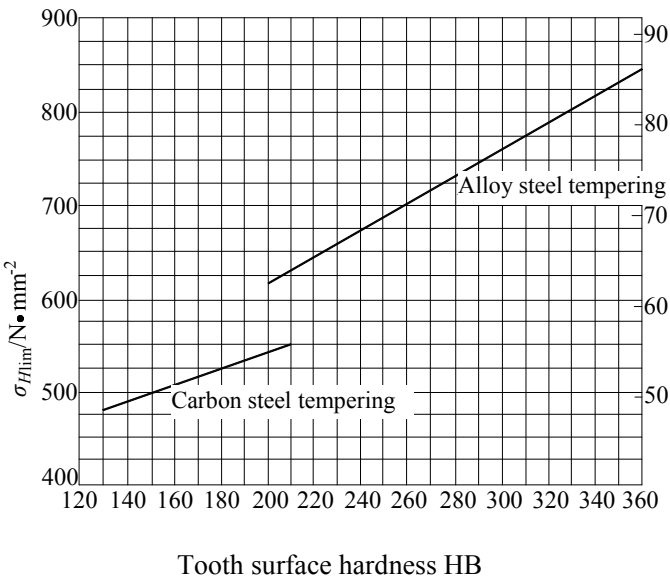


Figure6.3.2.3(1) Contact Fatigue Limiting Stress

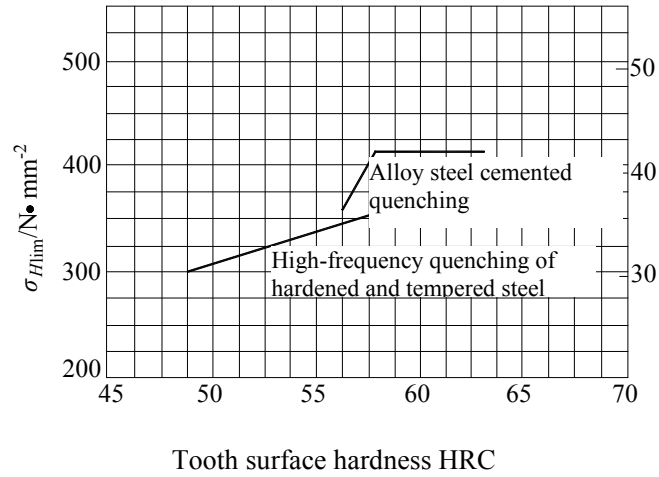
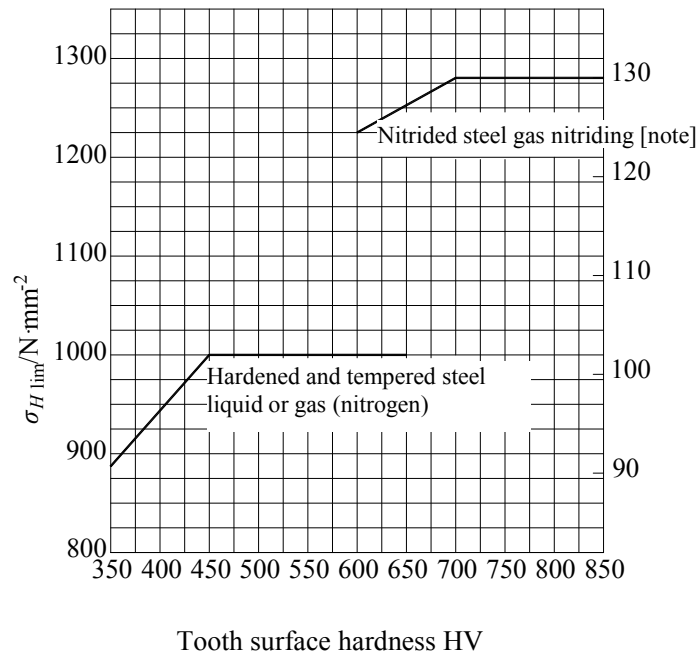


Figure 6.3.2.3(2) Contact Fatigue Limiting Stress



Note: including aluminum steel gas nitriding HV ≤ 750

Figure 6.3.2.3(3) Contact Fatigue Limiting Stress

$$Z_R \text{ —roughness factor, } Z_R = \left(\frac{3}{R_{zm}}\right)^c, \text{ where } R_{zm} = \frac{R_{Z1} + R_{Z2}}{2} \cdot \sqrt[3]{\frac{100}{a}}, \mu m;$$

Where, R_{Z1} and R_{Z2} 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:

$$Z_V = 0.93 + 0.14V_p \quad (\text{for surface-hardened steel});$$

$$Z_V = 0.85 + 0.3V_p \quad (\text{for through-hardened steel});$$

$$\text{Where, } V_p = \frac{1}{\sqrt{0.8 + \frac{32}{V}}};$$

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

6.3.3.1 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):

$$\sigma_F = \frac{F_t}{bm_n} Y_{FS} Y_\varepsilon Y_\beta K_A K_V K_{F\beta} K_{F\alpha} \quad \text{N/mm}^2$$

Where: Y_{FS} — composite tooth form factor, $Y_{FS} = Y_{Fa} Y_{sa}$

$$\text{Tooth form factor: } Y_{Fa} = \frac{6\left(\frac{h_{Fa}}{m_n}\right) \cos \alpha_{Fan}}{\left(\frac{S_{Fn}}{m_n}\right)^2 \cos \alpha_n};$$

$$E = \frac{\pi}{4} m_n - h_{ao} \operatorname{tg} \alpha_n + h_k (\operatorname{tg} \alpha_n - \operatorname{tg} \alpha_{pro}) - (1 - \sin \alpha_{pro}) \frac{\rho_{ao}}{\cos \alpha_{pro}} \quad \text{mm}$$

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;

$$\frac{S_{Fn}}{m_n} = Z_n \sin\left(\frac{\pi}{3} - \theta\right) + \sqrt{3} \left(\frac{G}{\cos \theta} - \frac{\rho_{ao}}{m_n} \right);$$

$$d_n = \frac{d}{\cos^2 \beta_b} \quad \text{mm};$$

$$d_{bn} = d_n \cos \alpha_n \quad \text{mm};$$

$$d_{an} = d_n + d_a - d \quad \text{mm};$$

$$\alpha_{an} = \arccos\left(\frac{d_{bn}}{d_{an}}\right) \quad \text{rad};$$

$$\operatorname{inv} \alpha_n = \tan \alpha_n - \alpha_n \quad \text{rad};$$

$$\operatorname{inv} \alpha_{an} = \tan \alpha_{an} - \alpha_{an} \quad \text{rad};$$

Where, α_n , α_{an} are in the unit of rad.

$$\gamma_a = \frac{1}{Z_n} \left(\frac{\pi}{2} + 2X \tan \alpha_n \right) + \operatorname{inv} \alpha_n - \operatorname{inv} \alpha_{an} \quad \text{rad};$$

$$\alpha_{Fan} = \alpha_{an} - \gamma_a \quad \text{rad};$$

$$\frac{h_{Fn}}{m_n} = \frac{1}{2} \left[(\cos \gamma_a - \sin \gamma_a \tan \alpha_{Fan}) \frac{d_{an}}{m_n} - Z_n \cos\left(\frac{\pi}{3} - \theta\right) - \frac{G}{\cos \theta} \right] + \frac{\rho_{ao}}{m_n};$$

For internal meshing gear:

$$\frac{S_{Fn2}}{m_n} = 2 \left(\frac{\pi}{4} + \tan \alpha_n \frac{h_{f2} - \rho_{ao2}}{m_n} + \frac{\rho_{ao2} - P_{ro}}{m_n \cos \alpha_n} - \frac{\sqrt{3} \rho_{ao2}}{2m_n} \right);$$

$$\frac{h_{Fn2}}{m_n} = \frac{d_{a2} - d_{f2}}{2m_n} - \left[\frac{\pi}{4} + \left(\frac{h_{f2}}{m_n} + \frac{d_{a2} - d_{f2}}{2m_n} \right) \tan \alpha_n \right] \tan \alpha_n - \frac{\rho_{a02}}{2m_n};$$

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} .

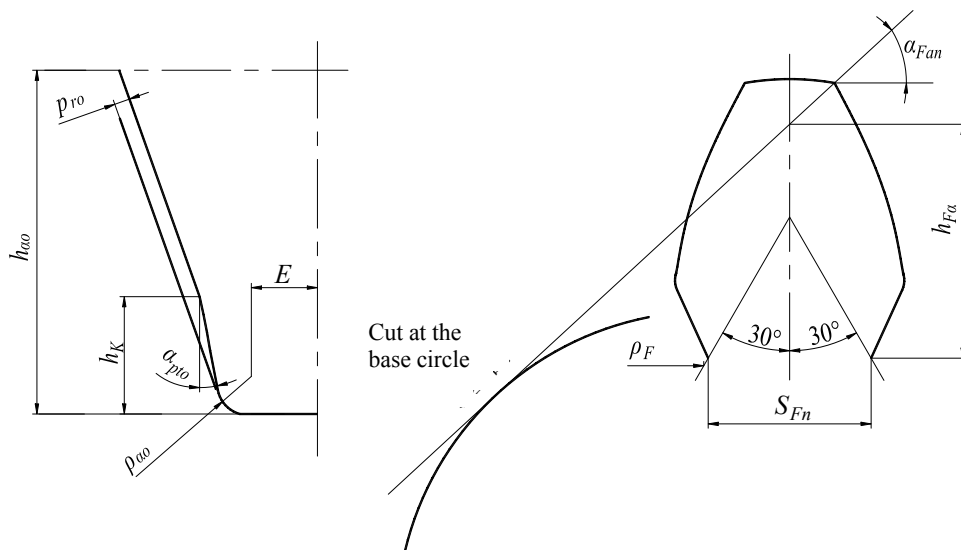


Figure 6.3.3.2 Cutter Basic Tooth Profile Size, Tooth Root Chordal Tooth Thickness S_{Fn} and Bending Moment Arm h_F

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/mm² 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/mm²;

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:

$$Y_X = 1.03 - 0.006 m_n \quad (\text{for through-hardened gears}), \text{ but } 0.85 \leq Y_X \leq 1;$$

$$Y_X = 1.05 - 0.01 m_n \quad (\text{for surface-hardened gears}), \text{ but } 0.75 \leq Y_X \leq 1.$$

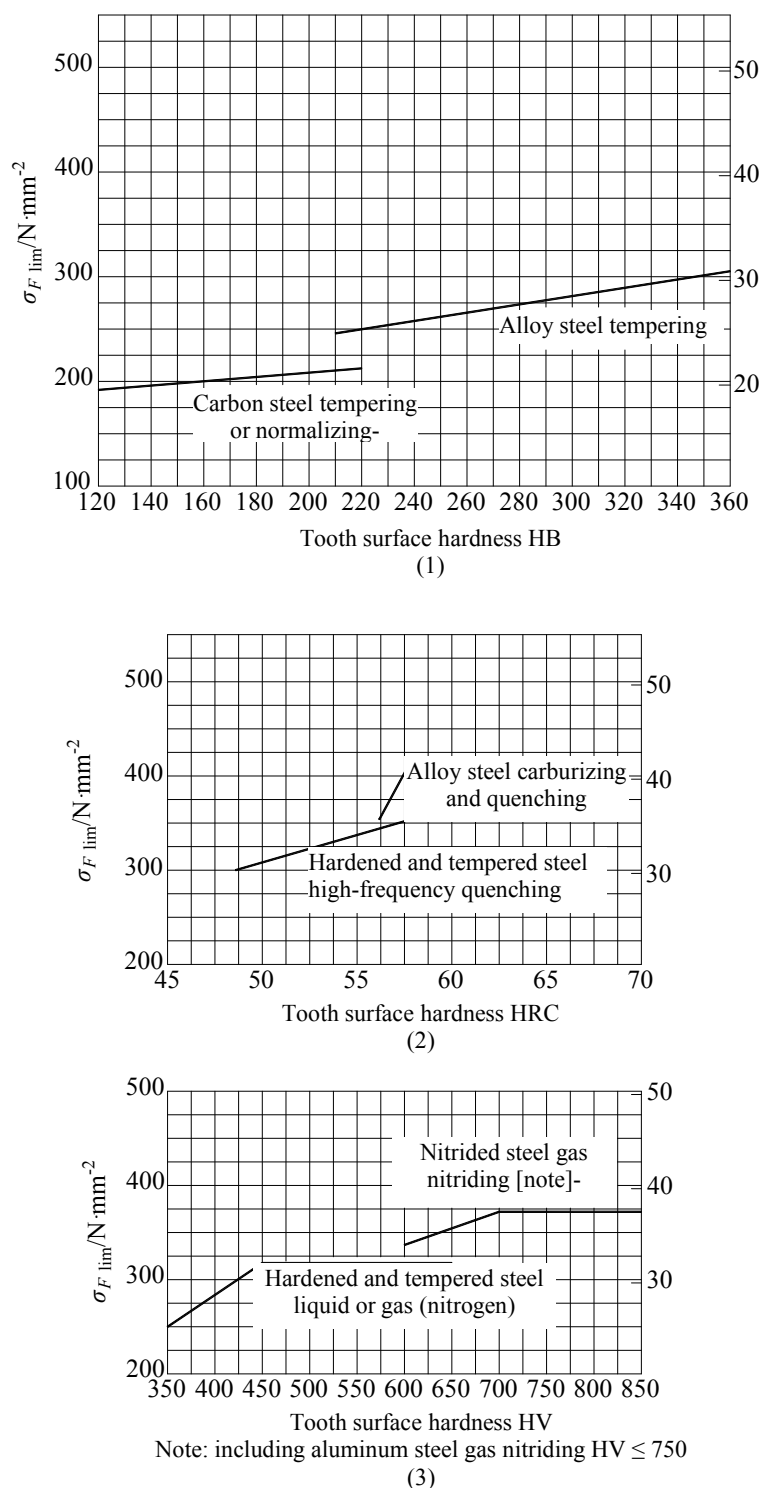


Figure 6.3.3.3 Materials, Thermal Treatment and Surface Hardness of Gear

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 $0.38m_n$.

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 $0.25m_n$ 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 $0.15m_n$.

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:

$$d = 100 \sqrt[3]{\frac{400N_e}{n_e R_m}} \quad \text{mm}$$

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 CCS Materials and Welding Code.

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 600 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 The propulsion shaft system with the actual diameter of the propeller shaft at the rear bearing of the tail pipe (the propeller shaft diameter) exceeding 250mm shall be reasonably calculated and the calculation book (including the instructions in the shaft) shall be submitted for CCS review. The shaft system calibration shall enable the shaft system to meet the following requirements under static conditions:

- (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 be 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.

7.1.3.3 For the shaft alignment calculated in the shaft alignment calibration, the actual load error of the bearing shall generally not exceed $\pm 20\%$ of the calculated value.

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.

7.1.5 Plans and documents

7.1.5.1 The following plans and documents of shafting and propellers are to be submitted for approval:

- (1) Arrangement of Shafting;
- (2) Thrust shaft, intermediate shaft, tube shaft (where applicable), and screwshaft;
- (3) General arrangement of stern tube, including oil sealing gland and tube shaft bearings;
- (4) Strength calculations for shafting, including calculations for the connection of couplings and strength calculations of bolts;
- (5) Strength calculations for propellers;
- (6) Propeller (including the clearances between the propeller and hull etc.);
- (7) Oil shrink fitting of key or keyless propeller together with calculations (where applicable).

7.1.5.2 Detailed sizes and necessary parameters for verifying the calculations are to be indicated in plans.

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/mm² for $R_m > 760$ N/mm²; when alloy steel is used, it is to be taken as 800 N/mm² for $R_m > 800$ N/mm². For screwshaft and tube shaft, it is to be taken as 600 N/mm² for $R_m > 600$ N/mm².

C —factor for the particular shaft design features, selected according to Table 7.2.2.1;

Factor C for different design features[®]

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 length equal to the thrust shaft diameter, the remainder maybe 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 0.25d [®] ; 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 tubeshaft lubricated with grease in the stern tube

1.0 ①	1.0	1.10 ②、⑤	1.10 ③、⑥	1.20 ④、⑦	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 $0.08d$.
 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 $0.0125d$.
 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 $0.3d$.
 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 $0.2d$.
 ⑤: For shaft having several design features, the factor is to be the product of several factors.
 ⑥: Where, d is calculated with $C=1.0$.
 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 $C=1.0$.

7.2.2.3 The diameter d_l 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 $0.75t$.

7.2.4.4 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 in the stern bush next to and supporting the propellers is to be as follows:

(1) For water lubricated bearings which are lined with lignum vitae, synthetic materials (such as synthetic rubber or staves of approved plastic material), the length of the bearing is not to be less than 4 times the rule calculated diameter for the screwshaft. For water lubricated synthetic materials, if the bearing design and materials are proven as complying with the requirements of CCS, the length of the bearings may be appropriately reduced, but not less than 2 times the rule diameter of the shaft in way of the bearing. The synthetic materials of water lubricated bearings are to be subject to type approval;

(2) For bearings which are white-metal lined and oil lubricated, the length of the bearing is not to be less than twice the rule calculated diameter for the screwshaft. If the normal bearing pressure is less than 0.8 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;

(3) For bearings of synthetic rubber, reinforced resin or plastics materials which are approved for use as oil lubricated stern bush bearings, the length of the bearing is to be not less than twice the rule diameter of the shaft in way of the bearing. 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. Synthetic materials for application as oil lubricated stern tube bearings are to be Type Approved.

Where the material has proven satisfactory testing and operating experience, consideration may be given to an increased bearing pressure.

(4) The length of a grease lubricated bearing is to be not less than 4.0 times the rule diameter of the shaft in way of the bearing.

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. Fillets are to have a smooth finish and not to be recessed in way of nuts

and bolt heads. The fillet may be formed of multi-radii in such a way that the stress concentration factor is not to be greater than that for a circular fillet with radius 0.08 times the actual shaft diameter.

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:

$$S_1 \leq S \leq S_2 \quad \text{mm};$$

$$\delta_1 \leq \delta \leq \delta_2 \quad \text{mm};$$

$$S_1 = \frac{\delta_1}{K} = \frac{1}{K} \left[1672 \frac{N_e}{An_e} (c_1 + c_2) + 0.03 \right] \quad \text{mm};$$

$$S_2 = \frac{\delta_2}{K} = \frac{0.034 \times 10^{-4}}{K} R_{eH} d_1 (c_1 + c_2) \frac{K_2^2 - 1}{\sqrt{3K_2^4 + 1}} \quad \text{mm};$$

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 —intermediate shaft 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 type 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 3.

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 The following items shall have single instructions or alarm instructions in the bridge.

- (1) overload of prime mover and servo unit;
- (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 PART 5.

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.

7.4.2 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; 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 propulsion diesel engine crankshafts are not to exceed the values given by the following formulae:

Continuous running ($0 < r \leq 1.0$):

$$[\tau_c] = \pm [(52 - 0.031d) - (33.8 - 0.02d)r^2] \quad \text{N/mm}^2$$

$$(1.0 < r \leq 1.15):$$

$$[\tau_c] = \pm [(18.1 - 0.0113d) + (87.6 - 0.052d)\sqrt{r-1}] \quad \text{N/mm}^2$$

Transient running ($0 < r < 0.8$):

$$[\tau_t] = \pm 2.0[\tau_c] \quad \text{N/mm}^2$$

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/mm²;

$[\tau_t]$ — allowable torsional vibration stress for transient running, in N/mm²;

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 and screwshafts are not to exceed the values given by the following formulae:

Continuous running ($0 < r < 0.9$),

$$[\tau_c] = \pm C_w C_K C_D (3 - 2r^2) \quad \text{N/mm}^2;$$

$$(0.9 \leq r \leq 1.05):$$

$$[\tau_c] = \pm 1.38 C_w C_K C_D \quad \text{N/mm}^2;$$

Transient running ($0 < r \leq 0.8$),

$$[\tau_t] = 1.7[\tau_c] / \sqrt{C_K} \quad \text{N/mm}^2;$$

Where: C_w — material factor: $C_K = (R_m + 160) / 18$;

R_m — tensile strength of shaft, it is to be taken as 600 N/mm² for $R_m > 600$ N/mm²;

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 7.4.3.3

Intermediate shafts						Thrust shafts		Propeller shafts and tube shafts		
Integral coupling flange	Shrink fit coupling	Keyway (tapered connection)	Keyway (Cylindrical connection)	Radial hole	Longitudinal slot	On both sides of thrust collar	In way of axial bearings where roller bearing is used as thrust bearing	Flange mounted or keyless taper fitted propeller shafts	Key fitted propeller shafts	The portion of the screwshaft and tube shaft forward of the length of screwshaft required by 7.2.2.4 till it reaches the aft peak bulkhead
1.0 ^①	1.0 ^①	0.6	0.45	0.50	0.30 ^②	0.85	0.85	0.55	0.55	0.8

Notes: ①For multiple-arc transition intermediate shaft, if C_k is greater than 1, the testing basis or service experience is to be provided and approved by CCS.

② $C_k = 0.3$ is a safe approximation within the limitations in note 4 of Table 7.2.2.1. More accurate estimate of the shape coefficient C_k may be determined by direct application of FE calculation or the following formula.

$$C_k = \frac{1.45}{scf}$$

where: scf — stress concentration factor, which is defined as the ratio between the maximum local principal stress and $\sqrt{3}$ times the nominal torsional stress (determined for the bored shaft without slots), to be calculated according to following formula:

$$scf = 2.3 + 0.8 \times \frac{(l - e) / d}{\sqrt{(1 - d_0 / d) \times e / d}}$$

l — length of slot, in mm;

e — width of slot, in mm;

d — basic diameter of shaft, in mm;

d_0 — actual bore of shaft, in mm.

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 ($0 < r < 0.95$):

$$[\tau_t] = \pm 5.5 [\tau_c] \quad \text{N/mm}^2$$

7.4.3.5 Where data from experience or detailed calculations are furnished by manufacturers, allowable torsional vibration stresses (or torques) as supplied by the manufacturers may be adopted.

7.4.3.6 Except the shafting material is of nodular graphite cast iron, the tensile strength of intermediate shaft material specified in 7.4.3.2 and 7.4.3.4 is greater than 430 N/mm², the allowable stress τ' may be calculated by the following formula:

$$\tau' = \frac{R_m + 184}{614} \tau \quad \text{N/mm}^2$$

where: R_m — tensile strength of shaft material, in N/mm², to be taken as 600 N/mm² for $R_m > 600$ N/mm²;

τ — allowable torsional vibration stress determined by 7.4.3.2 and 7.4.3.4 of this Section, in N/mm².

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 ± 2.5 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 $r < 0.95$.

7.4.4.3 The generating set shall show torsional vibration levels which are compatible with the allowable limits for the alternator, shafts, coupling and damper. The coupling selection for the generating set shall take into account the stresses and torques imposed on it by the torsional vibration of the system. The torsional vibration calculations are to be submitted to CCS for approval when the engine power is 110 kW or above (except for those sets consisting of a propulsion engine which also drives power take off generators).

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 $[\tau_c]$ 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:

$$Y = \frac{1.36 A_1 N_e}{Z b n_e}$$

$$\text{Where: } A_1 = \frac{D}{P} (K_1 - K_2 \frac{D}{P_{0.7}}) + K_3 \frac{D}{P_{0.7}} - K_4 ;$$

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 (MPa)	Material density G (g/c m ³)	Material coefficient K
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
Cu4manganese-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.

②: The performance of the material shall comply with the requirements of CCS Materials and Welding Code.

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:

$$X = \frac{A_2 G A_d n_e^2 D^3}{10^{10} Z b}$$

$$\text{Where: } A_2 = \frac{D}{P} (K_5 + K_6 \varepsilon) + K_7 \varepsilon + K_8$$

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, 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.

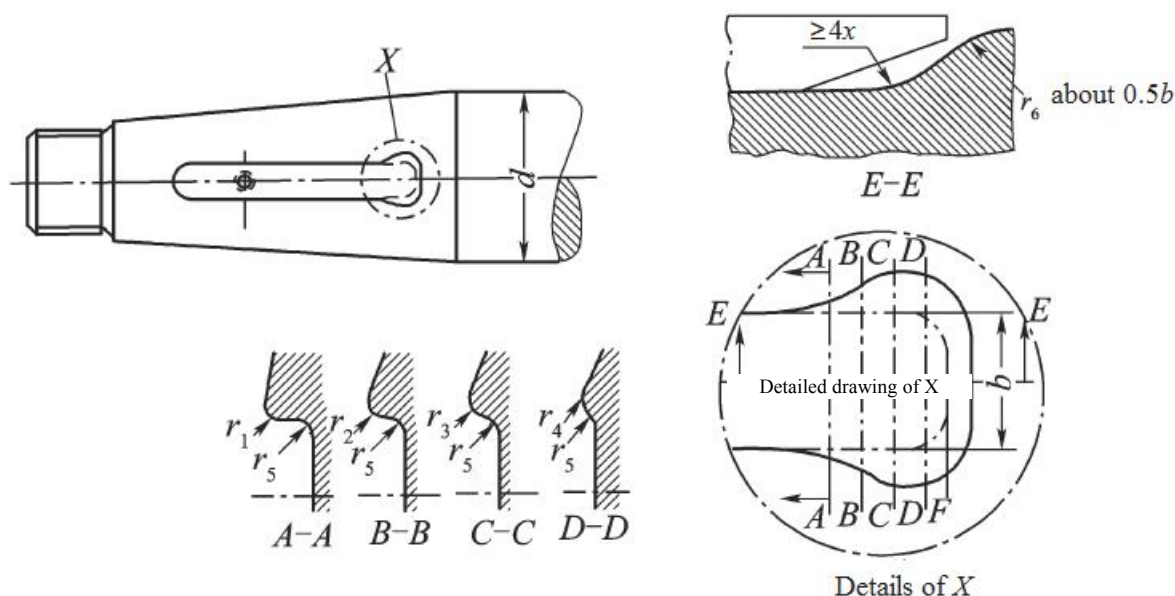


Figure 7.5.3.2 Keyway Shape on Propeller Shaft

Values of r_5

Table 7.5.3.2

$d(\text{mm})$	$r_5(\text{mm})$	$d(\text{mm})$	$r_5(\text{mm})$
$d \leq 150$	3	$250 < d \leq 400$	5
$150 < d \leq 250$	4	$d > 400$	6

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:

$$S_{35} = P_{35} \frac{d_1}{K} \left[\frac{1}{E_2} \left(\frac{K_2^2 + 1}{K_2^2 - 1} + \mu_2 \right) + \frac{1}{E_1} (1 - \mu_1) \right] \quad \text{mm}$$

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 :

$$W_t = AP_t \left(\mu + \frac{K}{2} \right) \quad \text{N}$$

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 — normal rated thrust, in N;

V — Ship speed at rated output N_e , 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 ——Tangential force on the binding surface, in N;

M_e ——The rated torque of corresponding to N_e and n_e , in N·m

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.

C value is to be increased correspondingly in case of large pulsatory torque at the fitted position.

N_e ——Rated power transmitted to the propeller shaft, kW

n_e ——speed at rated output N_e , in r/min;

A ——100% theoretical contact area of propeller boss and propeller shaft, in mm²; referring to drawings, oil groove not deducted;

$$K_2 = \frac{d_2}{d_1};$$

d_1 ——mean diameter of the propeller shaft at the axial taper center point, in mm;

d_2 ——mean outside diameter of the propeller boss corresponding to the axial position of d_1 shaft, in mm;

u_1 ——Poisson's ratio of shaft material, refer to Table 7.5.4.1;

u_2 ——Poisson's ratio of propeller material, refer to Table 7.5.4.1;

E_1 ——modulus of elasticity of propeller shaft material, refer to Table 7.5.4.1;

E_2 ——modulus of elasticity of propeller material, refer to Table 7.5.4.1;

t ——the temperature of the propeller sleeve when closing, °C

a_1 ——coefficient of linear expansion of propeller shaft material, refer to Table 7.5.4.1;

a_2 ——coefficient of linear expansion of propeller material, refer to Table 7.5.4.1;

R_{eH} ——specified yield stress of propeller material or 0.2% of non-proportional elongation stress in N/mm².

Material coefficient

Table 7.5.4.1

Material	Poisson's ratio	Modulus of elasticity E_1, E_2 (N/mm ²)	Coefficient of linear expansion a_1, a_2 (1/°C)
Cast and forged steel	0.29	2.1×10^5	12.0×10^{-6}
Cast steel	0.26	1.0×10^5	12.0×10^{-6}
Copper base alloy	0.33	Cu 1 and Cu 2: 1.1×10^5 Cu 3 and Cu 4: 1.2×10^5	17.5×10^{-6}

7.5.4.2 Prior to the pull-up of propeller and propeller shaft, the actual contact area of the propeller boss and conical portion of the shaft is to be inspected and such contact area is not to be less than 70% of the theoretical contact area (100%). Non-contact bands extending circumferentially around the boss or over the full length of the boss are not acceptable. After final pull-up, the propeller is to be secured by a nut on the propeller shaft.

7.5.4.3 The calculation formula of this article 7.5.4.1 is applicable to the normal vehicle working condition, and can also provide sufficient safety for the reversing state. The formula is applicable only for the solid shafts.

7.5.4.4 Make the temperature-related installation curve and the corresponding load data, and should be kept on the ship, while the necessary special disassembly tools should be provided.

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/mm²;

R_{eH} —specified yield stress of material at room temperature, in N/mm²;

R_{eH}^T —specified yield stress or proof stress of material at metal temperature, in N/mm²;

$R_{m100000}^T$ —average stress to produce rupture in 10⁵h of material at metal temperature, in N/mm².

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 CCS Materials and Welding code.	To be done		To be done, See CCS Materials and Welding code.
Class II	0.85	To be done, See CCS Materials and Welding code.	To be done		To be done, See CCS Materials and Welding code.
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 the relevant provisions of CCS Rules for Materials and Welding. 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 7 PART 3 of CCS Rules for Materials and Welding.

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 Plans and documents

8.1.9.1 The following plans and documents of boilers are to be submitted for approval:

- (1) General arrangement (the highest part of heating surfaces of the boiler is to be clearly indicated in the submitted drawing);
- (2) Body construction (including details of welded connections, attachments and supports);
- (3) Construction of pressure parts (cylindrical shell, steam and water drums, headers, combustion chamber, furnace, superheater, desuperheater, economizer, etc.);
- (4) Arrangement of mountings and fittings;
- (5) Safety valves with diameter calculation;
- (6) Strength calculations;
- (7) Heat treatment procedures of welded connections;
- (8) Test pressure.

8.1.9.2 The following plans and documents of pressure vessels are to be submitted for approval:

- (1) General arrangement;
- (2) Body construction (including details of welded connections, attachments and supports);
- (3) Construction of pressure parts (cylindrical shell, end plate, etc.);

- (4) Arrangement of mountings and fittings;
- (5) Strength calculations;
- (6) Test pressure.

8.1.9.3 For thermal oil heaters, the following plans and information are to be submitted for approval or reference, in addition to those as required for boilers:

- (1) Plan of monitoring and alarm system;
- (2) Plan of fire-extinguishing system and relevant calculations (if applicable);
- (3) Design temperature and pressure of the system, physical and chemical properties (e.g. viscosity, flash point, ignition temperature, decomposition temperature, self-ignition temperature) of thermal oil (for reference);
- (4) Operation and maintenance instructions (for reference).

8.1.10 Miscellaneous

8.1.10.1 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.

8.1.10.2 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.

8.1.10.3 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;

$$m = \frac{t_1}{t_2}; \varphi_k = \frac{t_k - d}{t_k}.$$

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.

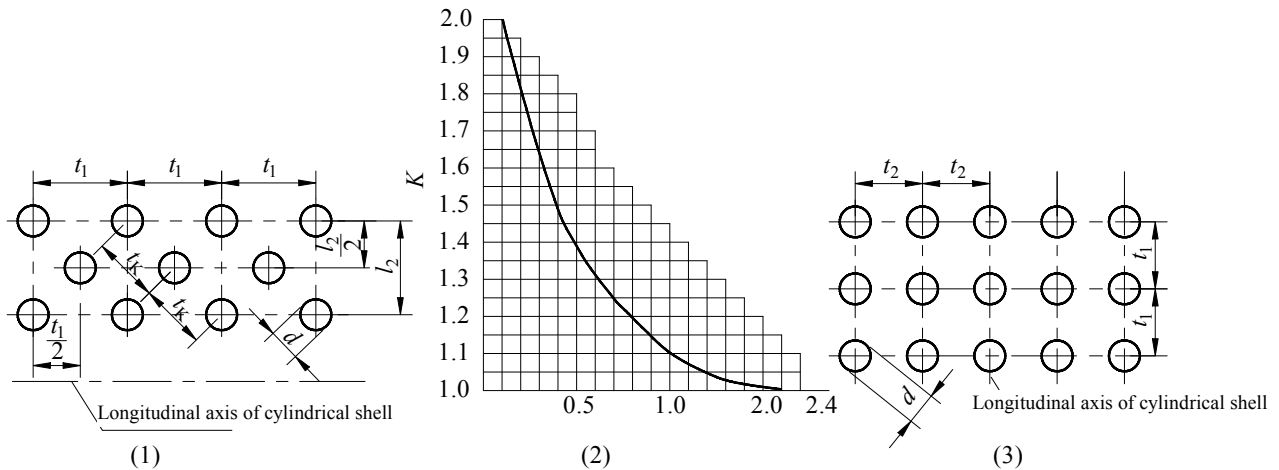


Figure 8.2.3.1(2) Cylindrical Shell Unweakened by Tube Holes

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 $2t_1$.

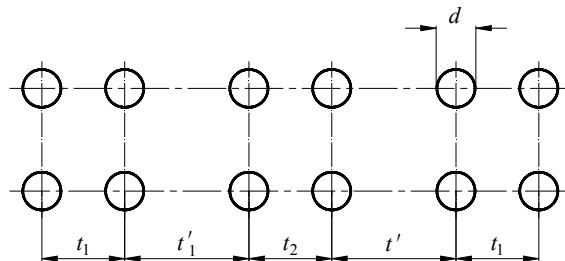


Figure 8.2.3.2 Pipe Hole Diameter Arrangement

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) ①~③, is to be determined by the following formula:

$$\delta = \frac{pD_1 Y}{2[\sigma]} + 0.75 \quad \text{mm}$$

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.

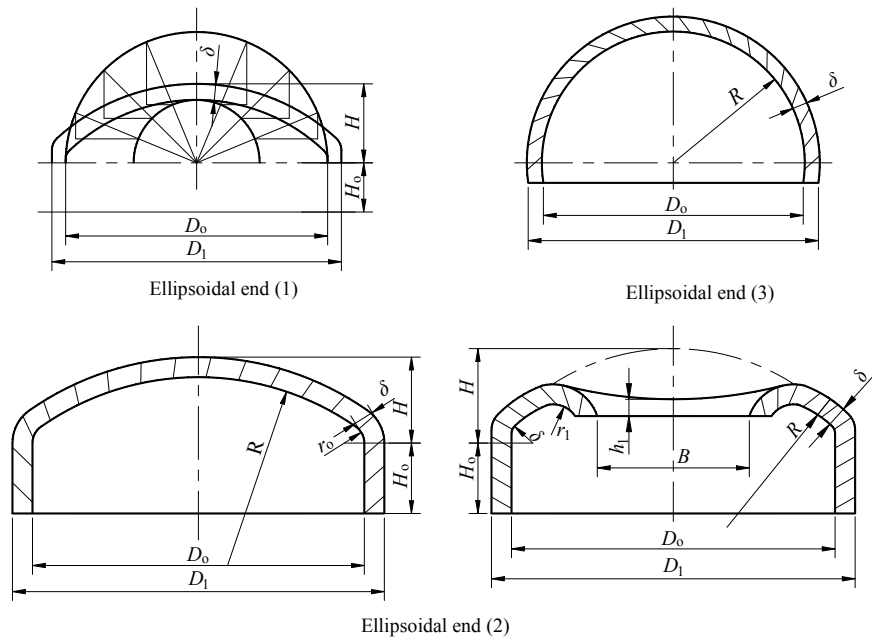


Figure 8.2.4.1(1) Dish Ends Subject to Pressure on Concave Surface

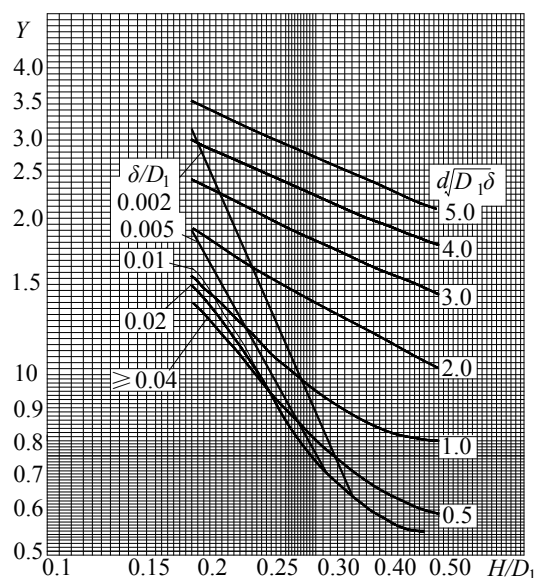


Figure 8.2.4.1(2) Y—Shape Factor

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.

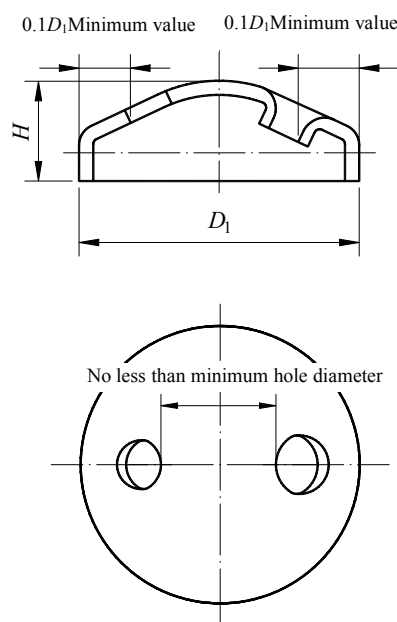


Figure 8.2.4.2 Openings in Ellipsoidal and Torispherical Ends

8.2.4.3 The construction of dished ends is to comply with the following requirements:

(1) For torispherical ends, see Figure 8.2.4.1 (2):

$r_b \geq 0.1D_1$ or $r_b \geq 3\delta$, whichever is the greater;

$R \leq D_1$; $H \geq 0.18D_1$ and $H_0 \geq 2\delta$;

(2) For ellipsoidal ends, see Figure 8.2.4.1. $H \geq 0.20D_1$ and $H_0 \geq 2\delta$;

(3) For manhole flanges in ellipsoidal, torispherical and hemispherical ends, see Figure 8.2.4.1 (2);

$h_1 = \sqrt{B\delta}$ B 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.

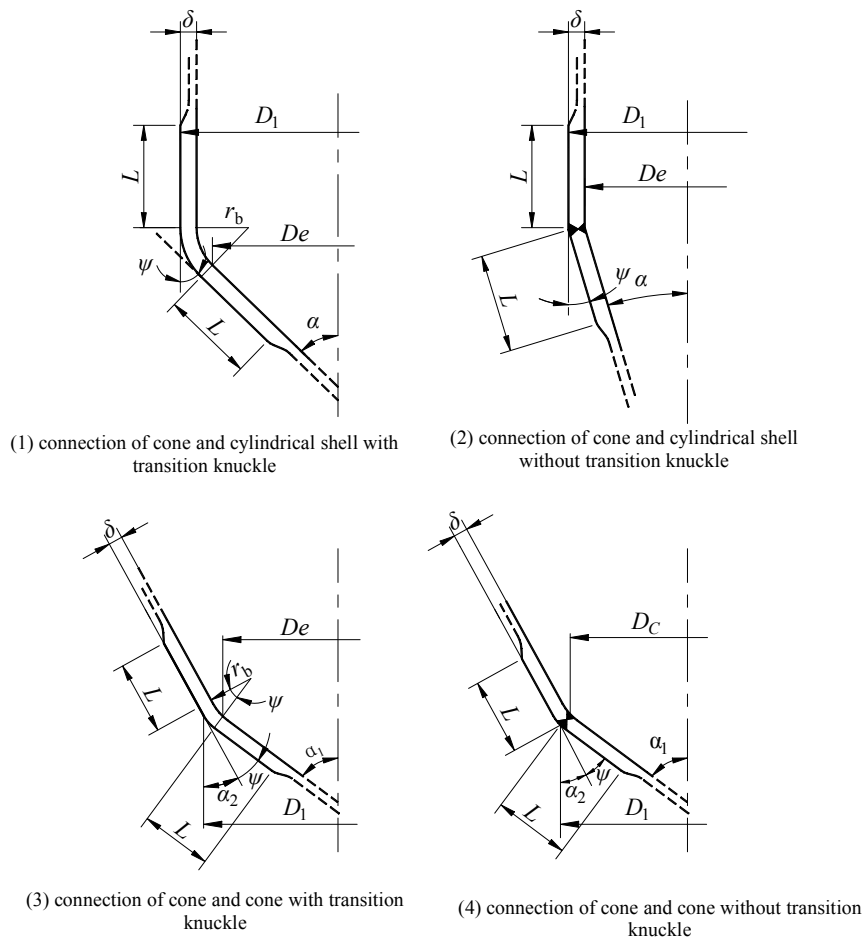


Figure 8.2.5.1 Connections of Cones

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:

$$\delta = \frac{pD_c}{2[\sigma]\phi' - p} \cdot \frac{1}{\cos \alpha} + 0.75 \text{ mm}$$

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:

$$\delta = \frac{pD_1K}{2[\sigma]\phi'} + 0.75 \text{ mm}$$

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/mm².

The distance L mentioned in this paragraph, as shown in Figure 8.2.5.1, is to be determined by the following formula:

$$L = 0.5 \sqrt{\frac{D_1 \delta}{\cos \psi}} \text{ mm}$$

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 ψ	r_0/D_1	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:

$$\delta = CD \sqrt{\frac{p}{[\sigma]}} + 0.75 \text{ mm}$$

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/mm²;

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:

$$D = a \sqrt{\frac{2}{1 + \left(\frac{a}{b}\right)^2}} \text{ mm}$$

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		Figure 8.2.6.1 (1)	Figure 8.2.6.1 (6) L/D specific value			Figure 8.2.6.1 (2)	Figure 8.2.6.1 (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

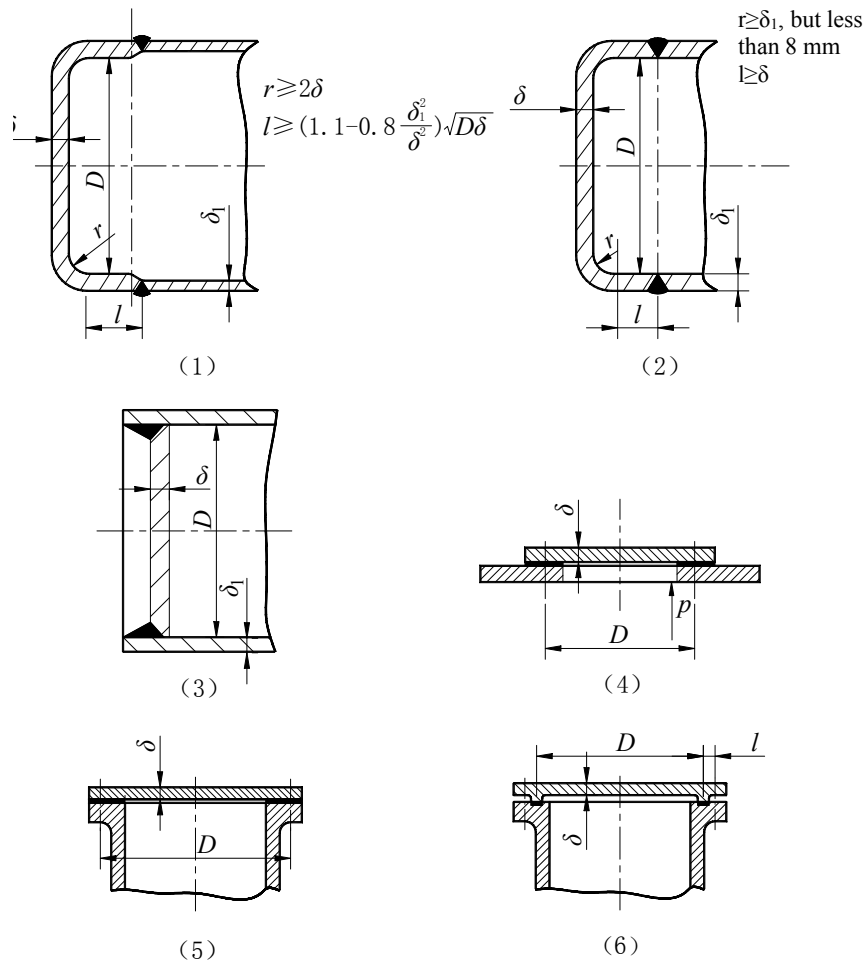


Figure 8.2.6.1 Type of End Plate

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/mm²;

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).

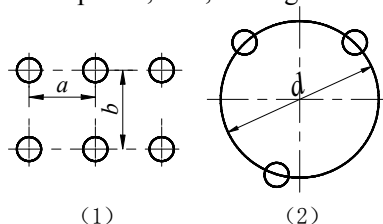


Figure 8.2.7.1 Stays Arrangement

Factor C

Table 8.2.7.1

Serial No.	Method of support	Factor ^②	
		Not exposed to flame	Exposed to flame
1	Flange or fillet welding ^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.

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:

$$t = 1.125d + 12.5 \text{ mm}$$

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:

$$\delta = \frac{2pDt}{R_{eH}(t-d)} + 0.75 \text{ mm}$$

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:

$$\delta = \frac{pd_1}{69} + 2 \text{ mm}$$

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.

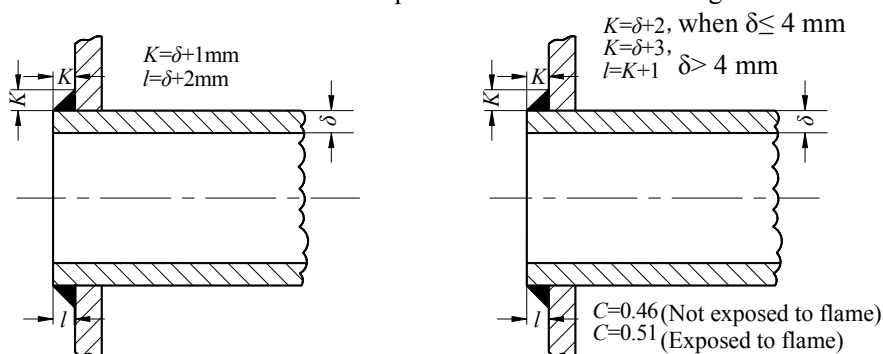


Figure 8.2.9.2 Smoke Tube Welded to Tube Plate Figure 8.2.10.2 Stray Tube Welded to Tube Plate

8.2.11 Strays

8.2.11.1 The minimum cross-sectional area F of welded-in stays 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).

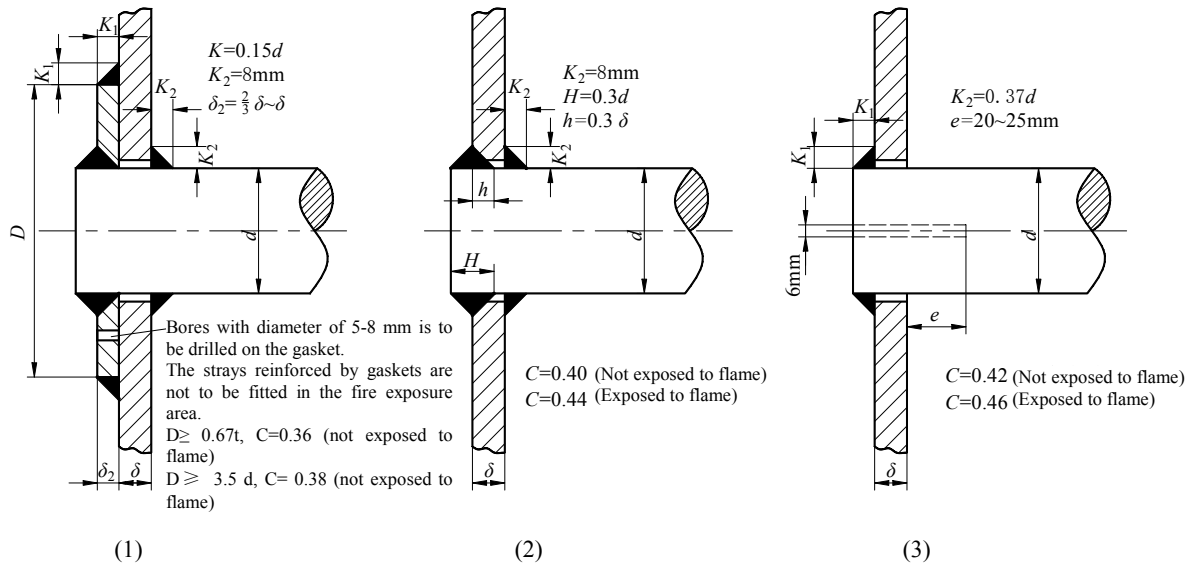


Figure 8.2.11.2 Structural Type of Welded Strays

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:

$$\delta = \frac{2 p D_1}{2[\sigma] + p} + 0.75 \quad \text{mm}$$

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:

$$K = \frac{10.2 A D p}{t}$$

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:

1 gusset, 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;

$C = 2\text{mm}$ for furnace;

$C = 4\text{mm}$ 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

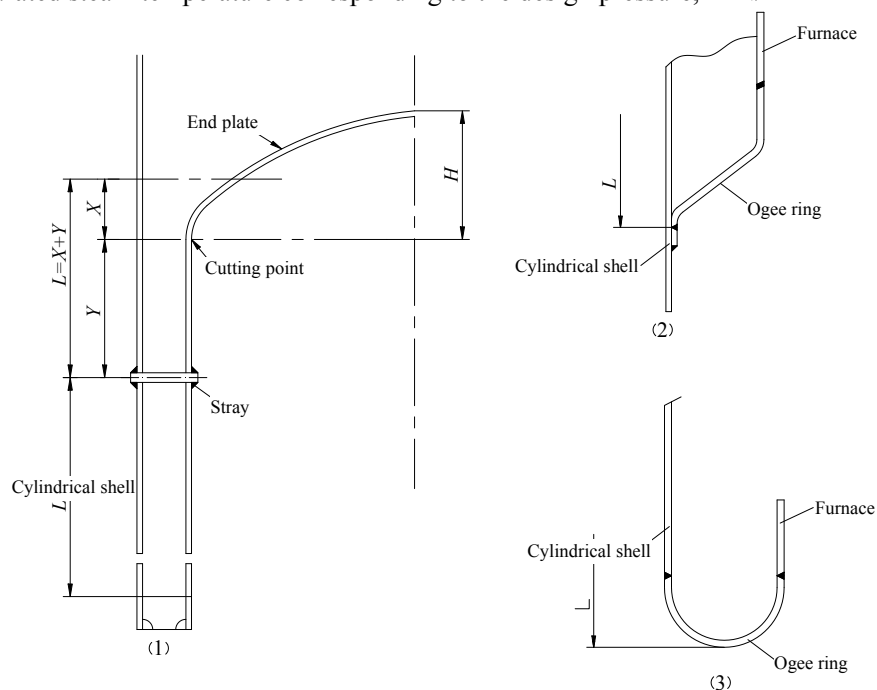


Figure 8.2.14 Calculated Length of Cylindrical Furnace or Internal Intake

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:

$$\delta = \frac{KpR}{61} + 0.75 \quad \text{mm}$$

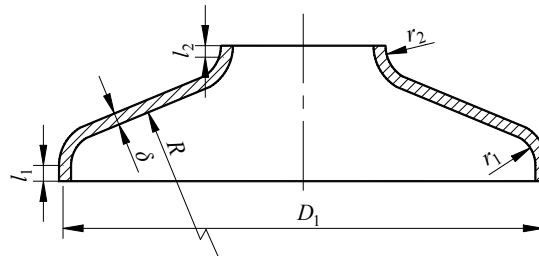
Where: p — design pressure, as specified in 8.1.3 of this Chapter, in MPa;
 R — outside radius of curvature of the furnace, in mm;
 K — as defined in 8.2.14 of this PART.

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:

$$\delta = \frac{pR}{[\sigma]} + 0.75 \quad \text{mm}$$

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/mm².



$$R < D_1;$$

$$r_1 > 4\delta, \text{ and } > 50 \text{ mm}$$

$$r_2 > 2\delta, \text{ and } > 25 \text{ mm}$$

$$l_1 \text{ and } l_2, \text{ butt welding structure } > 2\delta$$

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 is in no case to be less than the thickness determined by 8.2.14 of this PART:

$$\delta = \frac{KpR}{66} + 0.75 \quad \text{mm}$$

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;
 K — as defined in 8.2.14 of this Chapter.

8.2.17 Ogee rings

8.2.17.1 The minimum thickness δ of the ogee ring which connects the bottom of the furnace to the boiler shell and sustains the whole vertical load on the furnace (see Figure 8.2.17.1) is to be determined by the following formula:

$$\delta = \sqrt{\frac{pD(D-d)}{990}} + 0.75 \quad \text{mm}$$

Where: p — design pressure, MPa, as specified in 8.1.3 of this PART;
 D — internal diameter of boiler shell, in mm;
 d — outside diameter of the furnace where it connects the ogee ring, in mm.

8.2.17.2 The minimum thickness of the U-shaped ring as shown in Figure 8.2.17.2 is to be 10% thicker than that obtained from the formula as specified 8.2.17.1 of this PART.

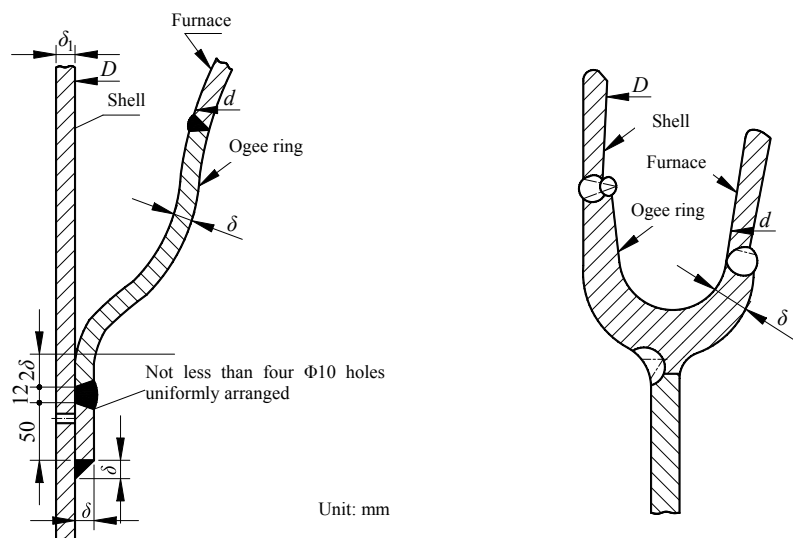


Figure 8.2.17.1 Ogee ring connecting furnace bottom to boiler shell Figure 8.2.17.2 U-shaped ring

Section 3 BOILER MOUNTINGS AND FITTINGS

8.3.1 General requirements

8.3.1.1 Valves over 25 mm in diameter and the covers are to be secured by flange connections and valves having a diameter up to 25 mm and the covers may be secured by screw connections with stoppers.

8.3.1.2 Boiler mountings are to be connected to pads or stand-pipes with flanges. Mountings under 20 mm in diameter may be fitted with screws on pads or stand-pipes.

8.3.1.3 Valve bodies for boilers are to be made of steel or other equivalent material. For boilers having a design pressure not exceeding 0.98 MPa and steam temperature not exceeding 220 °C, the valve bodies may be made of cast iron with the exception of blow-off valves.

8.3.1.4 Boiler mountings are to be located in positions easily accessible for maintenance and operation.

8.3.2 Feed check valves

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.

8.3.11 Fittings of shell type exhaust gas heated economizer

8.3.11.1 All shell type exhaust gas heated economizers that may be isolated from the steam plant system in a flooded condition are to comply with the following requirements.

8.3.11.2 Where a shell type economizer is capable of being isolated from the steam plant system, it is to be provided with at least one safety valve, and when it has a total heating surface of 50 m² or more, it is to be provided with at least two safety valves.

8.3.11.3 To avoid the accumulation of condensate water on the outlet side of safety valves, the discharge pipes and/or safety valve housings are to be fitted with drainage arrangements from the lowest part, directed with continuous fall to a position clear of the economizer where it will not pose threats to either personnel or machinery. No valves or cocks are to be fitted in the drainage arrangements.

8.3.11.4 Every shell type economizer is to be provided with a means of indicating the internal pressure. A means of indicating the internal pressure is to be located so that the pressure can be easily read from any position from which the pressure may be controlled.

8.3.11.5 Every economizer is to be provided with arrangements for pre-heating and de-aeration, addition of water treatment or combination thereof to control the quality of feed water to within the manufacturer's recommendations.

8.3.11.6 Every shell type economizer is to be provided with removable lagging at the circumference of the tube end plates to enable ultrasonic examination of the tube plate to shell connection.

8.3.11.7 For design and construction of shell type economizers, particular attention is to be paid to the welding, heat treatment and inspection arrangements at the tube plate connection to the shell.

8.3.11.8 The manufacturer is to provide operating instructions for each economizer which is to include reference to:

- (1) feed water treatment and sampling arrangements;
- (2) operating temperatures –exhaust gas and feed water temperatures;

- (3) operating pressure;
- (4) inspection and cleaning procedures;
- (5) records of maintenance and inspection;
- (6) the need to maintain adequate water flow through the economizer under all operating conditions;
- (7) periodical operational checks of the safety devices to be carried out by the operating personnel and to be documented accordingly;
- (8) procedures for using the exhaust gas economizer in the dry condition;
- (9) procedures for maintenance and overhaul of safety valves.

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		Low or shutoff	×	

ventilation ^①				
Oil fuel pressure ^①	×	Low		Standby pumps to start automatically
Heavy oil fuel temperature or viscosity ^①	×	Low and great		For heavy oil fuel only
Uptake temperature ^①	×	High	×	
Burner flame or ignition ^①		Flameout/ Failure	×	Each burner to be monitored
Exhaust temperature ^②	×	High		
Note : ×——functional requirement. ①: Applicable for oil-fired heaters. 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:

$$\delta = 0.04D + 0.25 \quad \text{mm}$$

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:

$$\delta = 0.8ab \sqrt{\frac{p}{(a^2 + b^2)[\sigma]}} + 0.75 \quad \text{mm}$$

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.

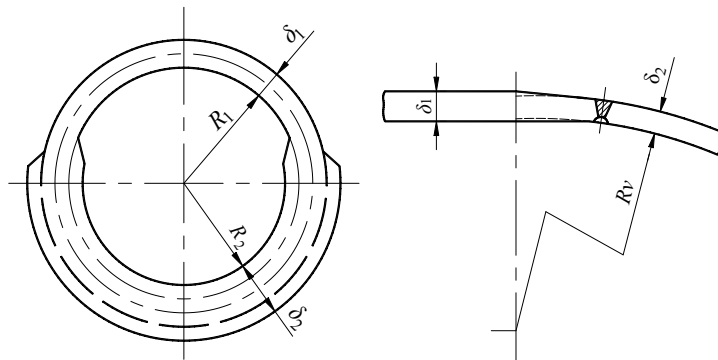


Figure 8.7.2.1 Butt welding of shell tube plate and shell plates Figure 8.7.2.2 Tapering of thicker end and shell plates

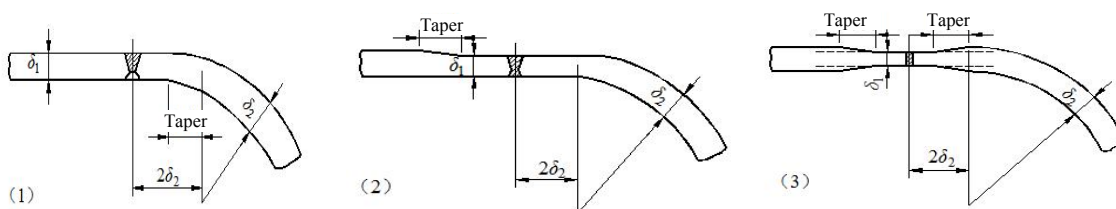


Figure 8.7.2.3 Tapering transition of shell portion

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.

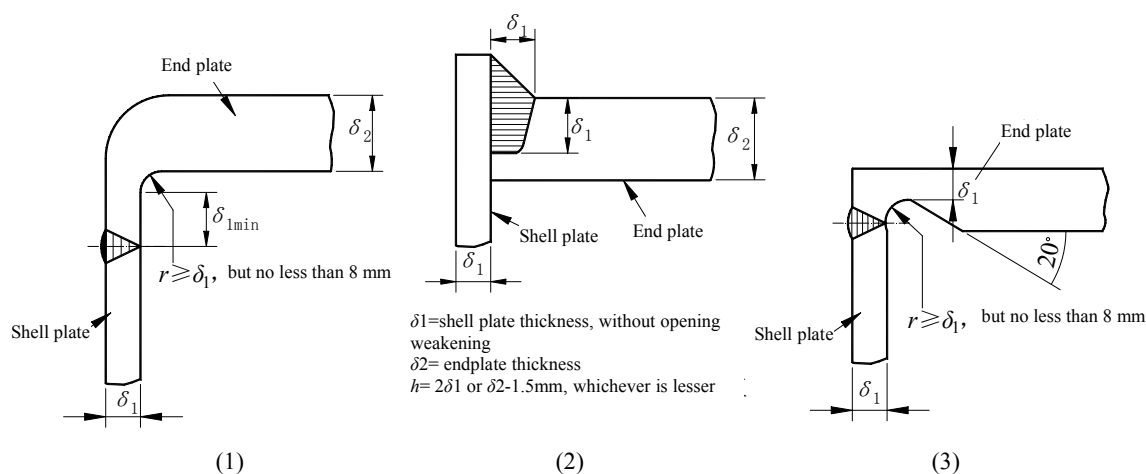


Figure 8.7.2.4 Attachment of flat ends to cylindrical and rectangular headers

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/mm².

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.

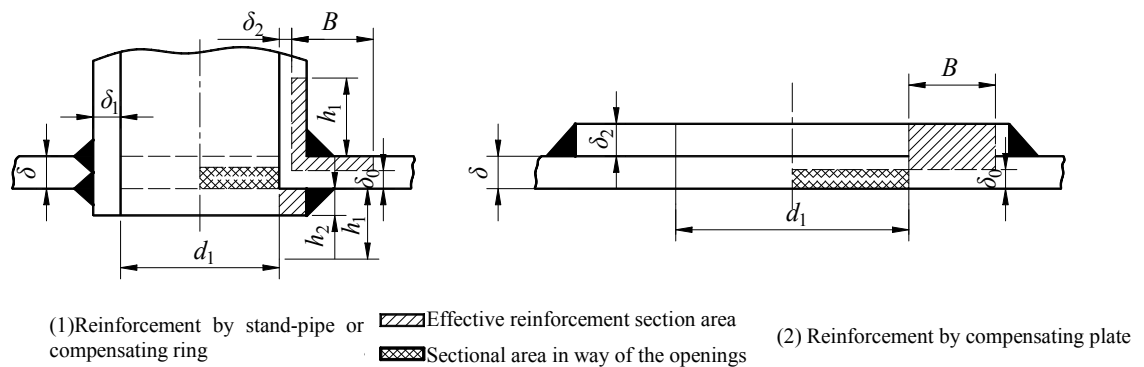


Figure 8.7.3.2 Reinforcement of Shell Holes

(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.,

$$A_4 = \delta_1 h \quad \text{mm}^2$$

- (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 (1) to (2) 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, 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.;

$$A_1 = 2\delta_2 B \quad \text{mm}^2$$

(2) surplus thickness of standpipe or compensating ring multiplied by effective height, in mm^2 , i.e.

$$A_2 = 2(\delta_1 - \delta_3) h_1 \quad \text{mm}^2$$

(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.,

$$A_3 = 2h_2\delta_1 \quad \text{mm}^2$$

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);

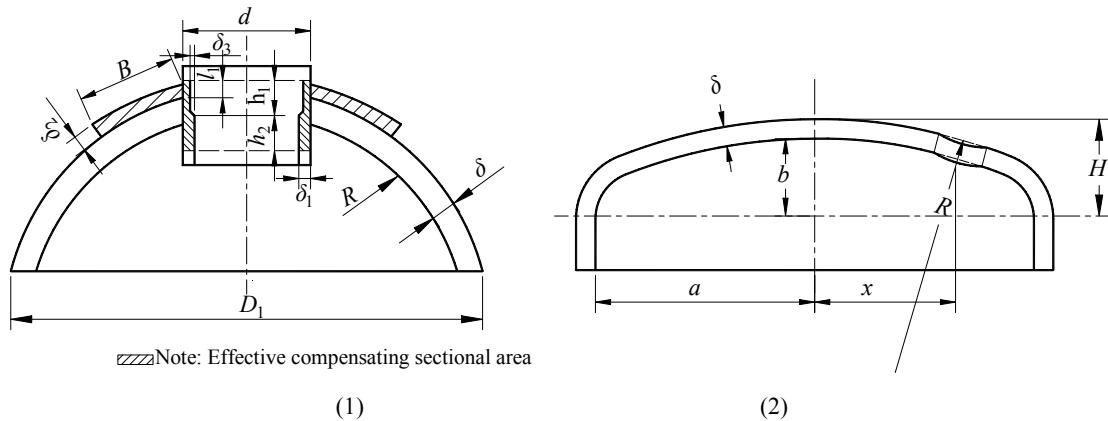


Figure 8.7.4.2 Reinforcement for Openings on Dished End Plates

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_0 —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 vessel sare 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 is equipment by which orders are transmitted from the navigating bridge to the steering gear power units. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables.

(5) Maximum ahead service speed is the greatest speed which the vessel is designed to maintain in service at sea at her deepest seagoing draught at maximum propeller RPM and corresponding engine MCR.

(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.

(7) Rudder actuator is the component which converts directly hydraulic pressure into mechanical action to move the rudder.

(8) Maximum working pressure is the maximum expected pressure in the system when steering gear is operated to comply with 9.1.3.1(1) of this Section.

(9) Declared steering angle limits are the operational limits in terms of maximum steering angle of propulsion and steering systems other than traditional arrangements for a ship's directional control (e.g. azimuth propulsion arrangements or water jet propulsion systems, but not limited to them), or equivalent, according to the manufacturer's guidelines for safe operation, also taking into account the ship's speed or propeller torque/speed or other limitation; the declared steering angle limits are to be declared by the directional control system manufacturer for each vessel specific non-traditional steering means.

9.1.2 Plans and documents

9.1.2.1 The following plans and documents are to be submitted for approval:

(1) details of steering gear construction, including documents of strength calculations for principal component parts and materials selected etc.;

(2) steering gear hydrostatic power system, including documents of relief valve's setting and delivery capacity etc.;

(3) power supply system;

(4) control, monitoring alarm system.

9.1.3 Equipment requirements

9.1.3.1 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.

9.1.3.2 For the main steering gear composed of two sets of steering gear power units, the auxiliary steering gear may be dispensed, provided that:

(1) the main steering gear is capable of operating the rudder as required in 9.1.3.2 of this Section while any one of the steering gears is out of operation;

(2) the main steering gear is so arranged that after a single failure in its piping system or in one of the power units the defect can be isolated so that steering capability can be maintained or speedily regained.

9.1.3.3 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.

9.1.3.4 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.

9.1.3.5 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.

9.1.3.6 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.

9.1.3.7 The steering gear compartment is to be readily accessible, and provided with suitable arrangements to ensure working access to steering gear machinery and controls.

9.1.4 Basic performance

9.1.4.1 The main steering gear and rudder stock is to be:

(1) of adequate strength and capable of putting the rudder over from 35° on one side to 35° the other side with the ship 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. For the propulsion and steering systems other than traditional arrangements for a ship's directional control, the main steering arrangements (equivalent to the main steering gear) are to be capable of changing direction of the ship's directional control system from one side to the other at declared steering angle limits at an average rotational speed of not less than 2.3°/s with the ship running ahead at the maximum ahead service speed;

(2) operated by power where necessary to meet the requirements of (1) above and in any case when, excluding strengthening for navigation in ice, a rudder stock is over 120 mm diameter in way of the tiller. For the propulsion and steering systems other than traditional arrangements for a vessel's directional control, the main steering arrangements are to be operated by power;

(3) so designed that they will not be damaged at maximum astern speed; however, this design requirement need not be proved by trials at maximum astern speed and maximum rudder angle.

9.1.4.2 The auxiliary steering gear is to be:

(1) of adequate strength and capable of steering the ship at navigable speed and of being brought speedily into action in an emergency;

(2) 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. For the propulsion and steering systems other than traditional arrangements for a ship's directional control, the auxiliary steering arrangements (equivalent to the auxiliary steering gear) are to be capable of changing direction of the ship's directional control system from one side to the other at declared steering angle limits at an average rotational speed of not less than 0.5°/s; with the ship running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greater;

(3) operated by power where necessary to meet the requirements above and in any case when, excluding strengthening for navigation in ice, a rudder stock is over 230 mm diameter in way of the tiller. For the propulsion and steering systems other than traditional arrangements for a vessel's directional control, where the propulsion power exceeds 2,500 kW per thruster unit, the auxiliary steering arrangements are to be operated by power.

9.1.4.3 Main and auxiliary steering gear power units are to be:

(1) arranged to re-start automatically when power is restored after a power failure;

(2) capable of being brought into operation from a position in the navigation bridge;

(3) in the event of a power failure to any one of the steering gear power units, an audible and visual alarm is to be given in the navigation bridge.

9.1.5 Monitoring and alarms

9.1.5.1 The alarm and monitoring requirements for the steering gear are to be in accordance with Table 9.1.5.1 and comply with the relevant requirements of PART 5. The failures likely to cause uncontrolled movements of rudder as indicated in the Table below are to be clearly identified. In the event of detection of such failure, the rudder is to stop in the current position without manual intervention or is to return to the midship/neutral position.

Alarm and Monitoring Requirements

Table 9.1.5.1

No.	Item	Alarm and monitoring	Location	Note
1	Steering gear power unit	Power supply failure	Navigation bridge	-
2	Steering gear circuit and motor	Broken connections and overload	Navigation bridge and main control position in engine room	-
3	Steering gear motor	Indication of running		
4	Steering gear control system	Power supply failure	Navigation bridge	-
5		Earth fault on AC and DC circuits		If applicable (e.g. the control system is connected to main power)

				supply through transformer)
6		Loop failures in closed loop systems(short circuit, broken connections and earth faults)		-
7		Data communication errors		If programmable electronic system is used
8		Computer hardware and software failures		
9		Deviation alarm		Deviation alarm is to be initiated if the rudder's actual position does not reach the set point within acceptable time limits for the closed loop control systems (e.g. follow-up control and autopilot). Deviation alarm may be caused by mechanical, hydraulic or electrical failures.
10	Hydraulic oil tank of steering gear	Low level	Navigation bridge and machinery space	Each oil tank is to be monitored; dispensed if the vessel length is less than 45 m
11	Angular position of rudder	Rudder angle indication	Navigation bridge and steering gear compartment	See 9.1.3.4 of this PART
12	Automatic rudder arrangement	Failure	Navigation bridge	-
13		Indication of operation		
14	Hydraulic oil	High temperature	Navigation bridge	If fitted with oil cooler
15	Hydraulic oil filter	High pressure difference	Navigation bridge	If oil filter is fitted
16	Steering gear (power or control) hydraulic system	Hydraulic locking	Navigation bridge	See 9.1.5.6

9.1.5.2 Short circuit protection and an overload alarm are to be provided for the circuits and motors referred to in Paragraph .2 in 9.1.9.5 of this PART. Protection against excess current, including starting current, if provided, is to be 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. The overcurrent protection may be dispensed where the power is supplied by the electronic inverter with restrictions at the circuit carrying full-load current of steering gear motor (e.g., speed control). However, the setting value of overload alarm is not to exceed the normal load current of the electronic inverter. 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.

9.1.5.3 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.

9.1.5.4 Where the power driving auxiliary steering gears as required in 9.1.4.2.3 of this Section is from motors for other purposes, the requirements of 9.1.5.2 in this Section may be waived for fishing vessels with total capacity less than 1600 tons, provided that CCS considers the requirements for auxiliary steering gears in 9.1.4.3 and 9.1.9.1.3 as well as requirements for protective devices are complied with.

9.1.5.5 For fishing vessels with length less than 45 m, the short-circuit protection and power failure alarm can only comply with requirements of 9.1.5.2 in this PART.

9.1.5.6 Where hydraulic locking, caused by a single failure, may lead to loss of steering, an audible and visual alarm, which identifies the failed system, is to be provided in the navigation bridge.

The alarm is to be activated whenever:

- (1) position of the variable displacement pump control system does not correspond with given order; or
- (2) incorrect position of 3-way full flow valve in constant delivery pump system is detected. "

The following provisions are added after Paragraph 9.1.5.1: "Graphitic cast iron may be also accepted for low-stress parts fitted for double sets, provided that reliable use evidence and relevant background materials can be provided.

9.1.6 Materials and tests

9.1.6.1 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 CCS 《Materials and Welding Code》. Grey iron is also acceptable for double sets of low stress components with reliable basis and relevant background materials. Gray-cast iron shall not be used for the hydraulic cylinders.

9.1.6.2 Approved flexible hose assemblies may be installed between two points where flexibility is required and there will be no tortuosity during normal operation. The length of hoses are to ensure flexibility and normal mechanical operation.

9.1.6.3 Flexible hose assemblies are to be high-pressure hydraulic hoses manufactured according to the requirements of Chapter 2 in this PART and suitable to all fluids, pressures, temperatures and related ambient conditions.

9.1.6.4 The bursting pressure of flexible hoses is not to be lower than 4 times designed pressure.

9.1.6.5 Factory Test

(1) The pipes, valves and other parts in hydraulic piping system of hydraulic power steering gear are to comply with the related requirements for class I piping in Chapter 2 of this PART.

(2) The pressure parts designed in accordance with 9.1.7.1 of this Section are to be tested in accordance with the related requirements for class I pressure vessels in Chapter 8 of this PART.

(3) A hydraulic power unit pump is to be subject to a type test. The type test is to be carried out at workshop for a duration of not less than 100 h according to the following:

① the test arrangements are to be such that the pump may run in idling conditions, and at maximum delivery capacity at maximum working pressure;

② during the test, idling periods are to be alternated with periods at maximum delivery capacity at maximum working pressure. The passage from one condition to another is to occur at least as quickly as on board;

③ during the whole test, no abnormal heating, excessive vibration or other irregularities are permitted;

④ after the test, the pump is to be disassembled and inspected;

Type test may be waived for a power unit which has been proven to be reliable in marine service.

(4) For a diesel engine of a hydraulic power unit, see Chapter 5 of this PART.

(5) For an electric motor of a hydraulic power unit, see Chapter 3, PART 3 of the Rules.

(6) After testing of each part and completion of general installation, the steering gear is to be subject to the final inspection and operation test.

9.1.6.6 Testing on board

After installation on board the vessel, the steering gear is to be subject to a hydraulic tightness test under 1.25 times the design pressure and a running test in mooring condition.

9.1.6.7 Sea trials

The steering gear is to be tried out on sea trial in order to demonstrate satisfaction that the requirements of this Section have been met. The trial is to include the operation of the following:

(1) the steering gear, including demonstration of the performances required in 9.1.4.1 (1) and 9.1.4.2 (2) of this Section.

If the vessel cannot be tested at the deepest seagoing draught, steering gear trials are to be conducted at a displacement as close as reasonably possible to full-load displacement on either of the following conditions:

① where the rudder is fully submerged (zero speed waterline) and the vessel is in an acceptable trim condition; or

② where the rudder load and torque at the specified trial loading condition have been predicted and extrapolated to the full load condition.

In any case for the main steering gear trial, the speed of ship corresponding to the number of maximum continuous revolution of main engine could apply; for controllable pitch propellers, the propeller pitch is to be at the maximum design pitch approved for the maximum continuous ahead R.P.M. at the main steering gear trial.

(2) the steering gear units, including transfer between steering gear power units.

(3) the isolation of one power actuating system, checking the time for regaining steering capability.

(4) the hydraulic fluid recharging system.

(5) the emergency power supply required in 9.1.9.6 of this Section;

(6) the steering gear controls, including transfer of control and local control;

(7) the means of communication between the wheelhouse, engine room and the steering gear compartment;

(8) the alarms and indicators required in this Chapter;

(9) where steering gear is designed to avoid hydraulic locking this feature is to be demonstrated.

The trials in (2), (3), (4), (7), (8) and (9) above may be carried out during mooring trial.

9.1.7 Construction and design

9.1.7.1 The steering gear components, subject to internal pressure, are to be designed in accordance with the relevant requirements of Chapter 8 of this PART for Class I pressure vessels, in addition to the permissible stress specified in this Section. Accumulators, if fitted, are to comply with the relevant requirements of Chapter 8 of this PART.

9.1.7.2 Where the components subject to pressure are designed in accordance with the requirements of 9.1.7.1 of this Section, the permissible primary general membrane stress is not to exceed the lower of the following values, whichever is less:

$$\frac{R_m}{A} \text{ or } \frac{R_{eH}}{B}$$

Where: R_m —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 or B —safety coefficient given by Table 9.1.7.2.

Safety coefficient A or B**Table 9.1.7.2**

Safety coefficient	Forged steel	Cast steel	Nodular graphite cast iron
A	3.5	4	5
B	1.7	2	3

9.1.7.3 All welded joints within the pressure boundary of steering gear or connecting parts transmitting mechanical loads are to be full penetration type or of equivalent strength. The welding details and welding procedures are to be subject to approval of CCS.

9.1.7.4 The construction of steering gear components is to be such as to minimize local concentrations of stress.

9.1.7.5 When determining the dimensions of piping and other steering gear components subjected to internal hydraulic pressure, the design pressure is to be at least equal to the greater of the following:

- (1) 1.25 times the maximum working pressure;
- (2) the relief valve setting.

9.1.7.6 All the steering gear components and the rudder stock are to be of sound and reliable construction. Any essential component which is not duplicated, where appropriate, is to use anti-friction bearings such as ball bearings, roller bearings or sleeve bearings which are to be permanently lubricated or provided with lubrication fittings.

9.1.7.7 All steering gear components transmitting mechanical forces to the rudder stock, which are not protected against overload by structural rudder stops or mechanical buffers, are to have a strength at least equivalent to that of the rudder stock in way of the tiller.

9.1.7.8 Oil seals between non-moving parts forming part of the external pressure boundary are to be of the metal upon metal type or of an equivalent type.

Oil seals between moving parts forming part of the external pressure boundary are to be duplicated, so that the failure of one seal does not render the actuator inoperative. Alternative arrangements providing equivalent protection against leakage may be accepted.

9.1.7.9 Pipes, joints, valves, flanges and other fittings are to comply with the requirements for Class I piping in Chapter 2 of this PART. The design pressure is to be in accordance with 9.1.7.5.

9.1.7.10 For relevant requirements to rudder, rudder stock, tiller and quadrant, refer to PART TWO of the Rules.

9.1.8 Hydraulic system

9.1.8.1 Pipes, joints, valves, flanges and other fittings in hydraulic piping of hydraulic power steering gear are to comply with the requirements for Class I piping in Chapter 2 of this PART. The design pressure is to be in accordance with 9.1.7.5.

9.1.8.2 Relief valves

(1) 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. The setting of the relief valves is not to exceed the design pressure. The valves are to be of adequate nominal diameter and so arranged as to avoid an

undue rise in pressure above the design pressure.

(2) Relief valves fitted as required in 9.1.8.2(1) are to comply with the following:

- ① the setting pressure is not to be less than 1.25 times the maximum working pressure;
- ② the minimum 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.

9.1.8.3 Isolating valves

For rudder actuators with non-duplicated units, isolating valves are to be fitted at the connection of pipes to the hydraulic cylinders, and are to be directly fitted on the hydraulic cylinders.

9.1.8.4 Filters

Arrangements to maintain the cleanliness of the hydraulic fluid are to be provided taking into account the type and design of the hydraulic system.

9.1.8.5 Level alarm

A low level alarm is to be provided for the circulating oil tank of each hydraulic system to give the earliest practicable indication of hydraulic fluid leakage. Audible and visual alarms are to be given in the navigation bridge and in the machinery space where they can be readily observed.

Arrangements for bleeding air from the hydraulic system are to be provided, where necessary.

9.1.8.6 Discharge device

The hydraulic system of the steering device, if necessary, shall be provided with a deflating device.

9.1.8.7 Hydraulic locking

Where the steering gear is so arranged that more than one system (either power or control) can be simultaneously operated, the risk of hydraulic locking caused by single failure is to be considered.

9.1.8.8 Storage tank

A fixed storage tank having sufficient capacity to recharge at least one power actuating system including the circulating oil tank is to be provided, where the main steering gear is required to be power operated. 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.

9.1.8.9 Arrangement

(1) The power piping for hydraulic steering gears is to be so arranged that transfer between units can be readily effected.

(2) 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.

(3) Connection to other hydraulic systems is not allowed.

9.1.9 Power supply and control systems

9.1.9.1 Steering gear control is to be provided:

- (1) for the main steering gear, both in the navigation bridge and in the steering gear compartment;
- (2) where the main steering gear is arranged according to 9.1.3.2 of this Section, by two independent control systems, both operable from the navigating bridge. This does not require duplication of the steering wheel or steering lever. Where the control system consists of a hydraulic telemotor, a second independent system need not be fitted;
- (3) for the auxiliary steering gear, in the steering gear compartment and, if power operated, it is also to be operable from the navigating bridge and is to be independent of the control system for the main steering gear.

9.1.9.2 Main and auxiliary steering gear control systems operable from the navigating bridge are to comply with the following:

(1) Means are to be provided in the steering gear compartment for disconnecting any control system operable from the navigating bridge from the steering gear it serves.

(2) The system is to be capable of being brought into operation from a position in the navigation bridge.

9.1.9.3 The angular position of the rudder is to be:

(1) if the main steering gear is power operated, indicated in the navigation bridge. The rudder angle indication is to be independent of the steering gear control system;

(2) recognizable in the steering gear compartment.

9.1.9.4 Where applicable, following standard signboard is to be fitted at a suitable place on steering control position in the bridge or incorporated into operating instruction mentioned in 9.1.10.3 of this Section.

Caution: In Some Circumstances When Two Power Units Are Running Simultaneously the Rudder May Not Respond to Helm. If This Happens Stop Each Pump in Turn Until Control Is Regained.

The above signboard is related to steering gears provided with two identical power units intended for simultaneous operation, and normally provided with either their own control systems or two separate (partly or mutually) control systems which are/may be operated simultaneously.

9.1.9.5 Source of electrical power and cable installation

(1) Means for indicating that motors of electric and electrohydraulic steering gear are running is to be installed in the navigation bridge and at a suitable main machinery control position.

(2) 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 aforesaid 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.

(3) When in a vessel of less than 1,600 gross tonnage an auxiliary steering gear which is required in 9.1.4.2.3 of this Section to be 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.

(4) Each main and auxiliary steering gear electric control system, if 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. For above-mentioned main and auxiliary steering gear, short circuit protection is only to be provided for power circuits of control system.

(5) 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. The requirements may be relaxed for vessels less than 45 m in length.

9.1.9.6 Where the rudder stock is required to be over 230 mm diameter in way of the tiller (excluding strengthening for navigation in ice), or where the propulsion power exceeds 2,500 kW per thruster unit (applying to propulsion and steering systems other than traditional arrangements for a fishing vessel's directional control), an alternative power supply, sufficient at least to supply the steering gear power unit or the steering arrangements which complies with the requirements of 9.1.4.2.2 of this Section and also its associated control system and the rudder angle indicator, is to be provided automatically, within 45 s, either from the emergency source of electrical power or from an independent source of power located in the steering gear compartment. This independent source of power is to be used only for this purpose and have a capacity to maintain continuous operation for at least 10 min.

9.1.9.7 Where the alternative power source for steering gear is an independent engine driven hydraulic pump located in the steering gear compartment, automatic starting arrangements for the engine are to comply with the relevant requirements relating to the automatic starting arrangements of emergency generators.

9.1.10 Arrangement

9.1.10.1 In general, the steering gear is to be reliably secured to the seating with sufficient rigidity by fitting bolts or bolts and thrust plates.

9.1.10.2 The steering gear compartment is to be:

(1) readily accessible and, as far as practicable, separated from machinery spaces;

(2) provided with suitable arrangements to ensure working access to steering gear machinery and controls. These arrangements are to include handrails and gratings or other non-slip surfaces to ensure suitable working conditions in the event of hydraulic fluid leakage.

9.1.10.3 Suitable operating instructions with a block diagram showing the change-over procedures for actuating systems and control systems of steering gear are to be permanently displayed in the navigation bridge

and in the steering gear compartments.

9.1.10.4 A means of communication is to be provided between the navigation bridge and the steering gear compartment.

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 Plans and documents

9.2.2.1 The following drawing data shall be submitted for approval:

- (1) Windlass arrangement plan showing all of the components of the anchoring/mooring system such as the prime mover, shafting, cable lifter, anchors and chain cables; mooring winches, wires and fairleads, if they form part of the windlass machinery; brakes; controls; etc.;
- (2) Dimensions, materials, welding details, as applicable, of all torque-transmitting (shafts, gears, clutches, couplings, coupling bolts, etc.) and all load bearing (shaft bearings, cable lifter, sheaves, drums, bed-frames, etc.) components of the windlass and of the winch, where applicable, including brakes, chain stopper (if fitted) and foundation;
- (3) Hydraulic system, to include: piping diagram along with system design pressure; safety valves arrangement and settings; material specifications for pipes and equipment; typical pipe joints, as applicable; and technical data and details for hydraulic motors;
- (4) Electric one line diagram along with cable specification and size; motor controller; protective device rating or setting; as applicable;
- (5) Control, monitoring and instrumentation arrangements;
- (6) Engineering analyses for torque-transmitting and load-bearing components demonstrating their compliance with recognized standards or codes of practice. Analyses for gears are to be in accordance with a recognized standard;
- (7) Plans and data for windlass electric motors including associated gears rated 50 kW and over;
- (8) Calculations demonstrating that the windlass prime mover is capable of attaining the hoisting speed, the required continuous duty pull, and the overload capacity are to be submitted if the load testing(including overload capacity) of the entire windlass unit is not carried out at the shop.

9.2.2.2 The following plans and documents are to be submitted for information:

- (1) Windlass design specifications; anchor and chain cable particulars; anchorage depth; performance criteria; standard of compliance;
- (2) Operation and maintenance procedures for the anchor windlass are to be incorporated in the vessel operations manual.

9.2.3 General requirements

9.2.3.1 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.

9.2.3.2 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.

9.2.3.3 Prime movers and transmission gearing are to be protected against over-moment and impact.

9.2.3.4 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.

9.2.3.5 The piping of hydraulic windlass is to comply with relevant requirements of Section 5 in CHAPTER 2 and of Section 7 in CHAPTER 4.

9.2.4 Working capacity of windlasses

9.2.4.1 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 $42.5d^2$ N for graded anchor chain made of high-quality steel and $37.5 d^2$ N (d being anchor chain diameter, in mm) for graded anchor chain made of ordinary steel at the mean speed as specified in 9.2.4.2 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

9.2.4.2 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.

9.2.5 Protection and brake devices

9.2.5.1 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.

9.2.5.2 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.

9.2.5.3 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.

9.2.5.4 Reels are to be provided with cable arrangements to enable uniform reeling of cables.

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 PART3.

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 The components having important roles in the power transfer system shall be manufactured from steel, cast iron or ductile iron conforming to the CCS Rules for Materials and Welding of this specification.

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 double-reels and winches with auxiliary reel and friction drum and their 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 Applicable scope

11.1.1.1 This Section applies to fishing vessels no less than 90 m in length in non-restricted waters.

11.1.2 Bilge suction arrangement

11.1.2.1 At least two bilge suction are to be provided within each refrigerated fish hold, normally in way of the fore and aft central longitudinal plane. In all cases, water is to be capable of being drained continuously from the compartments to the bilge suction. Bilge wells are to be provided where necessary. Where the length of a fish hold is less than 9 m, only one bilge suction is to be provided at the aft end of the hold.

11.1.2.2 A water level alarm is to be fitted for the water at the bottom of refrigerated fish hold.

11.1.2.3 A grating cover is to be fitted on the refrigerated fish hold sewage well, with the passage area no less than 5 times cross-sectional area in the suction pipe, and the sewage well volume can be reduced to 0.1m³.

11.1.3 Size of tank air pipes

11.1.3.1 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 inner diameter of tank air pipe can be reduced to 38 mm if the volume is no more than 0.5m³.

11.1.3.2 Where the tank is fitted with overflow pipes complying with requirements, the inner diameter of air pipe is not to be less than 38 mm.

11.1.4 Steam pipes

11.1.4.1 Steam pipes are to be maintained in a spacing of no less than 150 mm when arranged along the fuel oil tank wall. Appropriate protective means are to be provided when steam pipes are arranged adjacent to cables.

11.1.5 Periodically unattended machinery spaces

11.1.5.1 The manoeuvring position of seawater inlet valve is to be arranged considering that an operator needs to spend at least 10 min to reach to and close the valve when the water enters the space; such manoeuvring position is to be arranged above the immersion water level of such machinery space possibly due to pipeline damage during full load of the fishing vessel.



CHINA CLASSIFICATION SOCIETY

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OCEAN-GOING STEEL FISHING
VESSELS**

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PART THREE ELECTRICAL INSTALLATIONS

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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.

1.1.2.1 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 (1) to (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 Plans and documents

1.1.4.1 The following plans and documents are to be submitted for approval:

- (1) Electrical loading evaluation of main and emergency sources of electrical power.
- (2) Calculations for short-circuit currents (for ships with generators having a total capacity of more than 250 kVA and capable of being connected in parallel).
- (3) Analysis for coordination of protective devices in compliance with the requirements of 2.3.1.1 of this PART (for ships with generators having a total capacity of more than 250 kVA and capable of being connected in parallel).

Diagrams of power systems, in which the following are to be indicated:

- ① main ratings of motors, transformers, batteries, electrical and electronic equipment;
- ② all feeders connected to main and emergency switchboards;
- ③ section boards (if fitted) and distribution boards;
- ④ type, cross-sectional area and current loadings of cables;
- ⑤ rating and setting of protective devices (such as short-circuit, overloading, reverse power and unloading protection);
- ⑥ remote stops;
- ⑦ insulation level monitoring and alarm;
- ⑧ interlocks.

Arrangement of main electrical equipment, in which the positions of the following items are to be indicated:

- ① main and emergency generators;
- ② main and emergency switchboards (or emergency accumulator battery charging and discharging boards);
- ③ emergency accumulator batteries;
- ④ electrical equipment for essential services (see 1.1.2 of this Chapter).
- (6) Schematic diagrams of main lighting.
- (7) Arrangement of main lighting.
- (8) Schematic diagrams of emergency lighting, temporary emergency lighting (if fitted), and additional emergency lighting (if fitted).
- (9) Arrangement of emergency lighting, temporary emergency lighting (if fitted), and additional emergency lighting (if fitted).
- (10) Schematic diagrams of internal communication systems, including:
 - ① engine-room telegraph system;
 - ② essential telephone system;
 - ③ common emergency alarm lifesaving;
 - ④ cable broadcasting system;
 - ⑤ other alarm systems (including engineers' alarm system, fish cabin and cold storage door false closing alarm system, fire detection and fire alarm system, watertight door closing alarm system, fire extinguishing agent pre-release alarm system, etc.).

(11) Arrangement of internal communication systems, including:

- ① engine-room telegraph system;
- ② essential telephone system;
- ③ common emergency alarm lifesaving;
- ④ cable broadcasting system;

⑤ other alarm systems (including engineers' alarm system, fish cabin and cold storage door false closing alarm system, fire detection and fire alarm system, watertight door closing alarm system, fire extinguishing agent pre-release alarm system, etc.).

1.1.4.2 The specifications for all electrical systems of the ship should be submitted for reference.

1.1.4.3 Additional plans and documents may be required as deemed necessary.

1.1.5 Testing

1.1.5.1 Electrical equipment specified in 1.1.1.2 and 1.1.2 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.

1.1.5.2 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.
- (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.

Ambient Temperature

Table 1.2.1.1(1)

Medium	Location	Temperature, (°C)
Air	In enclosed spaces	0~45
	In spaces subject to temperatures over 45°C(or 40°C) or below 0°C	According to temperatures in such spaces
	On the open deck	-25~45
Water		32

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.

1.2.1.2 The electrical equipment installed on ships sailing/operating in polar waters should also take into account the expected environmental conditions of the polar waters they sail through.

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

1.2.3.1 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 charging Not connected to the batteries during charging	Voltage	+30~−25	—	—
	Voltage	+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 in spection 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. The rated power shall be appropriate for the actual use of the generator set¹.

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 them agneticcompass, 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:

IP××

|| — 2nd characteristic numeral (see Table 1.3.2.1-2)

| — 1st characteristic numeral (see 1.3.2.1-1)

— Characteristic letters

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

¹ Applicable to generator sets that apply for survey and certification on and after July 1, 2020, or generator sets installed on newbuilding ships with construction contracts signed on or after July 1, 2020.

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,	Lighting fixtures	Heating appliances	Cooking	Accessories (e.g., switches,
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	IP34	×	—	×	×	×	×	—	IP55

Refrigerated rooms, fish processing rooms	danger of water and mechanical damage		—	—	×	—	×	×	—	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;

(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.

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.

Note ③: The specific requirements refer to 2.4.2 and 2.4.4 of Section 4, Chapter 2, PART 4.

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.

1.3.3.7 In spaces with explosive dust deposits, if electrical equipment is required to be installed, these electrical equipment shall meet the following requirements:

- (1) The enclosure protection level is at least IP55;
- (2) In the case of continuous operation, the maximum surface temperature should be at least 75K lower than the ignition temperature of this type of dust layer with a thickness of 5mm.

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 maybe 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 voltages of AC distribution systems are not to exceed the values given in Table 2.1.2.1(1). The maximum voltages of DC distribution systems are not to exceed the values given in Table 2.1.2.1(2).

Maximum Voltages of AC Distribution Systems

Table 2.1.2.1(1)

No.	Application	Max. voltage (V)
1	For power equipment permanently installed and connected by permanent wiring.	15,000
2	(1) For heating and cooking equipment permanently installed and connected by permanent wiring, except space heaters. (2) For portable equipment, which is not hand-held during operation, and with connection by socket outlet which incorporates an earth continuity conductor of a size in accordance with 1.3.4.5 of this PART	1000
3	(1) For lighting permanently installed (2) For socket outlets supplying the following (which are not specified in items 2 and 4 in the table): ① equipment with double insulation; ② equipment earthed by earth continuity conductors of a size in accordance with 1.3.4.5 of this PART	250

4	For socket outlets used in spaces where particular risks due to exposure and conductivity may exist: (1) supplied with or without the use of isolating transformers; (2) where a safety isolating transformer is used supplying one consuming device only. Both wires of such systems are to be insulated from earth	55 ^① 250
5	Instrumentation and control equipment ^②	55 ^③ 250

Note: ① For socket outlets with rated voltage up to 24V, the maximum voltage is 55V.

② For the control voltage of distribution systems operating at a voltage above 500 V shall not be higher than 230V, except for those whose voltage is not higher than 1000V and all the control equipment in the power distribution system are enclosed in the corresponding control cabinets.

③ For instrumentation and control equipment with rated voltage up to 48V, the maximum voltage is 55V.

Maximum Voltages of DC Distribution Systems

Table 2.1.2.1(2)

No.	Application	Max. voltage (V)
1	Power equipment	1,500
2	Cooking equipment, heating equipment, lighting and socket outlets	500
3	Communication equipment, instrumentation	250
4	Socket outlets supplying power for life boats/rafts	55

2.1.2.2 The final sub-circuits with a current rating greater than 16A should not supply more than one device, except when supplying only an outlet with a current rating not greater than 32A.

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, 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 over currents 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 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;

(2) 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);

(3) 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 In the case of substantial reduction of speed of generators, the protective devices associated with generators are to remain effective.

2.3.5.6 Emergency generators are to be protected against short-circuit. Audible and visual alarm signals are to be given in the event of over-currents of emergency generators, which are not to lead to tripping of the circuit breakers of emergency generators.

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.

2.3.8.3 Circuits supplying consuming devices protected individually against overload (e.g. motors) may be provided with short-circuit protection only.

2.3.8.4 The protection of the steering gear circuits is to comply with Section 1 of CHAPTER 9 of PART THREE.

2.3.8.5 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.

2.3.8.6 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.

2.3.9.2 Protection of steering gear motors is to comply with Section 1 of CHAPTER 9 of PART TWO.

2.3.9.3 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.

2.3.9.5 For intermittent duty motors, the current setting and the delay characteristics for protective devices are to be chosen after considering the actual service condition.

2.3.9.6 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 to there duction 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 indicator sand 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**

2.4.1.1 A 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.

2.4.5 Automatic connecting and disconnecting of main generating set

2.4.5.1 Requirements of paragraph 2.4.5.2 to 2.4.5.6 are to be met where start, stop and load sharing between generators, is controlled by an automation system.

2.4.5.2 The following alarms are to be arranged:

- (1) variations in bus bar voltage from the rated value (high and low);
- (2) variations in bus bar frequency from the rated value (high and low);
- (3) automatic load shedding;
- (4) failure in automatic switch-on of circuit breaker of generator;
- (5) automatic tripping of circuit breaker of generator;

(6) failure in load distribution (with the necessary time delay, see paragraph 3.1.7.6 of Chapter 3 for the percentage of load distribution).

2.4.5.3 Means are to be provided to avoid two or more than two generating sets being switched on the common bus-bar of main switchboard simultaneously.

2.4.5.4 After a blackout due to short circuit, the generator circuit breaker is permitted to be switched on only once.

2.4.5.5 Where the standby generating set has been started as a result of a prolonged main bus-bar voltage or frequency fluctuation, the running generating set is to be stopped and disconnected from the switchboard prior to connection of the standby generating set.

2.4.5.6 Automatic starting attempts which fail are to be limited to restrict consumption of starting energy.

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 TWO 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 2.5.3 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 alleyways, stairways and exits;
 - 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 2.

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 the signal equipments required in 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 2.5.2.1(4), 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 outside the main power supply space and above the highest continuous deck as far as possible, and 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) Devices as described in Paragraphs ①, ② and ③ in 2.5.2.1(4) of this PART may be dispensed if independent storage batteries for emergency service and capable of supplying power in the specified time are installed at the appropriate positions.;

(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 TWO 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 are to comply with relevant requirements of CHAPTER 10 of PART 2.

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 are 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, fish processing spaces, freezer rooms, refrigerated fish holds, food tanks 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 poles.

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 2.7.1.3 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. Fishing vessels with the total weight of no less than 500 tons may not comply with the requirements aforesaid.

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 switch boards, 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.

2.9.1.3 Each consumer is to be supplied by an independent final sub-circuit from its distribution switchboard.

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.

- └─machinery spaces;
- Bridge—└─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.

2.10.4.8 Each electrically operated bell or other equivalent warning system is to be separately protected against short circuit.

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 2.

2.10.6.6 Alarms of refrigerating systems are to comply with relevant requirements as described in PART 4.

2.10.6.7 Water level alarms of fish holds are to comply with relevant requirements as described in 3.2.2.4 of PART 2.

2.10.6.8 Alarms of side thrusters are to comply with relevant requirements as described in 7.3.7 of PART 2.

2.10.6.9 Alarms of oil heaters are to comply with relevant requirements as described in 8.5.5 of PART 2.

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 2 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	Abbrev	Max. rated conductor temp. (°C)	
		Normal operation	Short circuit
Ethylene propylene rubber	EPR	90	250
High modulus or hard grade ethylene propylene rubber	HEPR	90	250
Cross-linked polyethylene	XLPE	90	250
Silicone rubber	S95	95 ^②	350 ^①
Cross-linked polyolefin material for halogen-free cables	HF90	90	250

Notes: ① Applicable only to power cables and not appropriate for tinned copper conductors.

② The maximum rated conductor temperature for silicone rubber is 180°C, but the practical maximum working temperature is limited by the sheathing materials.

2.13.3 Choice of protective covering

2.13.3.1 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.

2.13.3.2 In permanently wet spaces, metallic sheaths are to be used for cables with hygroscopic insulation.

2.13.3.3 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). Where cables for services, required to be operable under fire conditions, including their supply cables, pass through high fire risk areas¹, they are to be so arranged that a fire in any of these areas or zones does not affect the operation of the service in any other area or zone. This may be achieved by either of the following:

(1) Cables being of a fire resistant type are installed and run continuously to keep the fire integrity within the high fire risk area, as shown in Figure 2.13.3.3 (1);

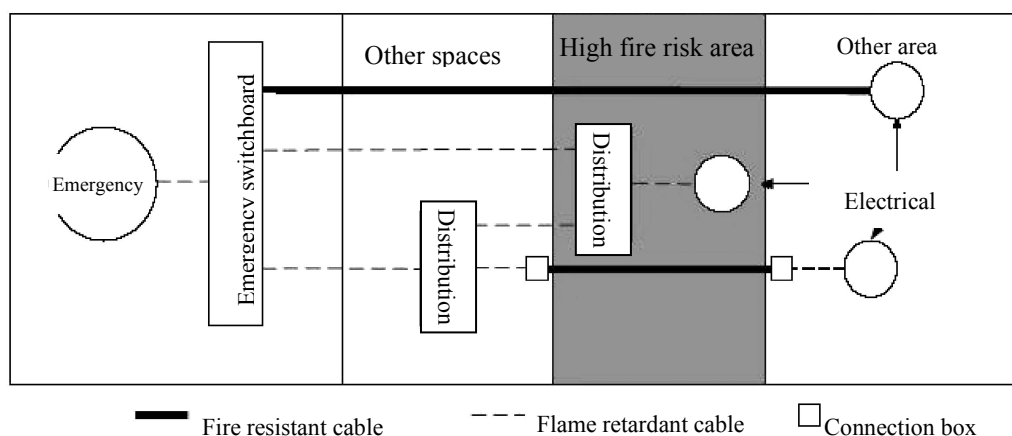


Figure 2.12.3.3 (1) Cables for Services under Fire Conditions

(2) At least two-loops/radial distributions run as widely apart as is practicable and so arranged that in the event of damage by fire at least one of the loops/radial distributions remains operational.”

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;

¹The “high fire risk areas” are defined as follows:

- (1) class A machinery spaces and other machinery spaces where propulsion machinery, boilers, fuel oil devices, internal combustion engines, generator sets and refrigerators (using flammable liquid) are fitted;
- (2) spaces containing fuel treatment equipment or other highly flammable substances;
- (3) galley and pantries containing cooking appliances;

(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. 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.

Current Ratings for PVC Insulated Cables with Maximum Working Temperature 60°C (Based on Ambient Temperature of 45°C) Table 2.13.5.1

insulation	Thermoset compounds			Silicone rubber and mineral insulation		
Maximum rated conductor temp	90a			95°C		
mm ²	Single core	2 cores	3 or 4 cores	Single core	2 cores	3 or 4 cores

1	16	14	11	20	17	14
1.5	23	20	16	26	22	18
2.5	30	26	21	32	27	22
4	40	34	28	43	37	30
6	52	44	36	55	47	39
10	72	61	50	76	65	53
16	96	82	67	102	87	71
25	127	108	89	135	115	95
35	157	133	110	166	141	116
50	196	167	137	208	177	146
70	242	206	169	256	218	179
95	293	249	205	310	264	217
120	339	288	237	359	305	251
150	389	331	272	412	350	288
185	444	377	311	470	400	329
240	522	444	365	553	470	387
300	601	511	421	636	541	445

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 2.13.6.1 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
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 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.

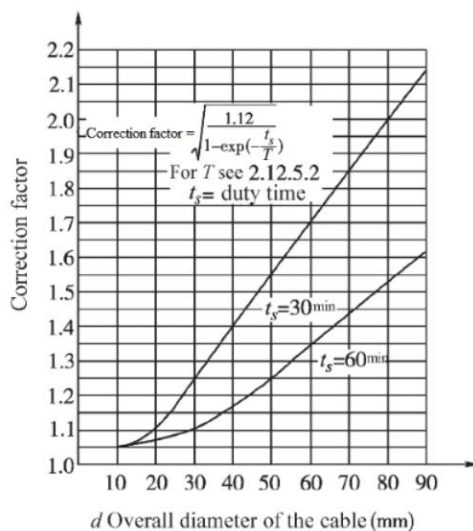
Note ①: Cables are said to be bunched when two or more are contained within a single conduit, trunking or duct, or if not enclosed, are not separated from each other.

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

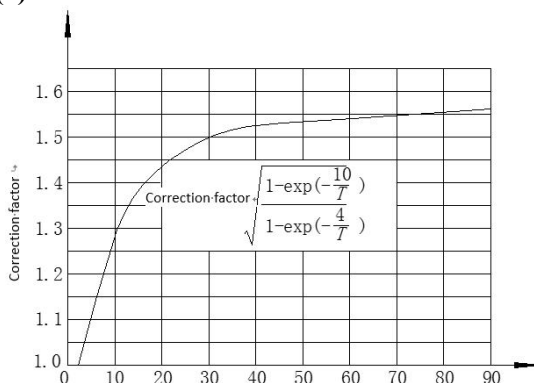
(1) For half-hour and one-hour services, the corresponding correction factors given by Figure 2.13.6.3(1) may be applied.

(2) 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

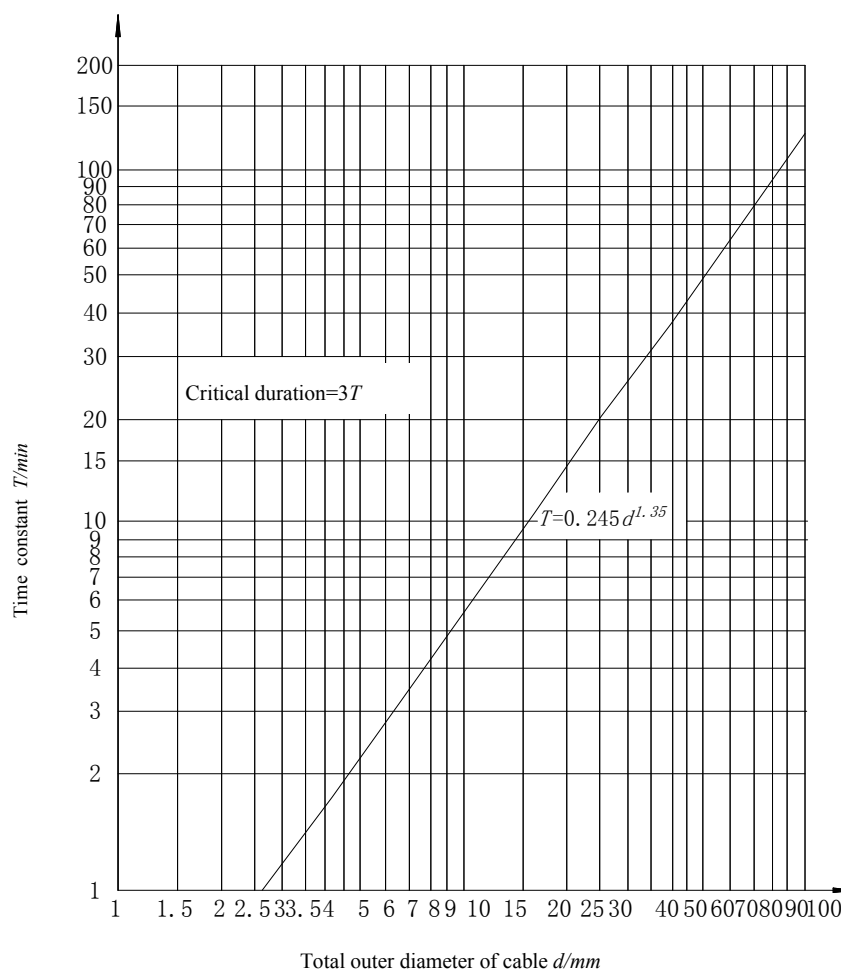


Figure 2.13.6.3(2)-2 Relations of Time Constant T and Total Outer Diameter of Cable

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.

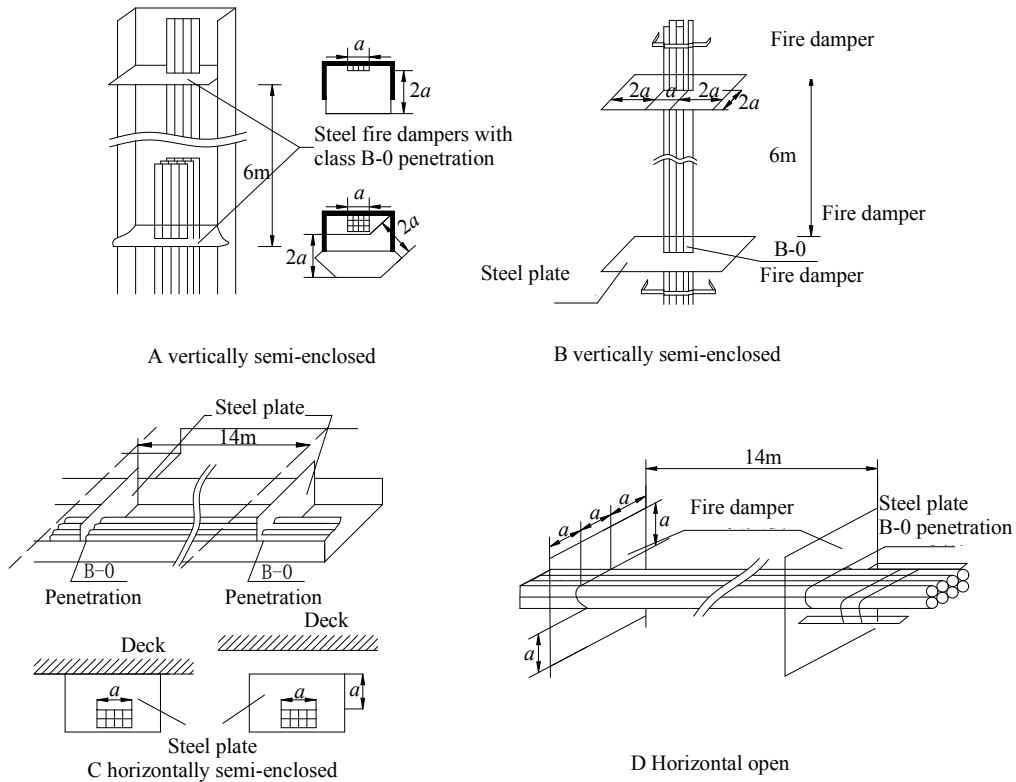


Figure 2.13.10.2 Locations of Fire Dampers

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);

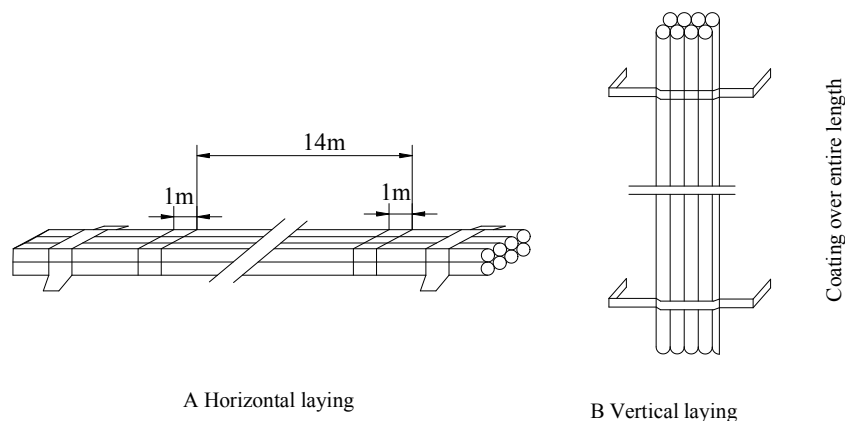


Figure 2.13.10.4 Locations of Flame-proof Coating

(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 D (mm)	Minimum internal radius of bend (mm)
Insulation	Outer covering		
Thermoplastic materials and elastic materials	Not armoured or not braided	≤ 25	$4D$
		> 25	$6D$
	Metal sheathed, braided or armoured	Any	$6D$
	Metal thread armoured, metal strip armoured or metal sheathed	Any	$6D$
	Synthetic polyester/metal sheathed slice or combined sheathed	Any	$8D$
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

Table 2.13.19.1(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.

2.13.21 Earthing of metal sheathings or coverings of cables

2.13.21.1 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 300mm 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 70mm² or steel bars having a minimum cross-section 100mm². 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 70mm².

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 8%.

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 2, 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 2 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 bus bar 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 over temperature 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 $\geq 1500\text{kW}$
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 2 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 CCS Rules for Materials and Welding.

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	-	-
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															
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 thermos sensitive 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.

3.1.3.2 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 over currents 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 2 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):

$$\text{Insulation resistance} = \frac{\text{Rated voltage (V)}}{1000 + \text{Rated capacity (kVA or kW)}} \quad \text{M}\Omega$$

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 b. Motors which will be reversed or braked by reversely connecting the power source during operation	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 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 °C.

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

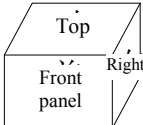
Earth wire.....green alternated with yellow

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

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

3.3.1.1 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 2 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 Ω , 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 2.13.2.2 of this PART.

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

3.4.6.1 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
	B15d	250
	B15s	50
		200W / 4A
		15W / 2A
		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 lampsoperating 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 lampsoperating 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 (applicable to reversible main engines).

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 3.11.1.5

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 and above are to be provided with means to maintain the same degree of protection whether the plug is inserted or withdrawn.

Section 13 UNINTERRUPTIBLE POWER SYSTEM

3.13.1 Applicable scope

3.13.1.1 The UPS units, to which this Section applies, may provide an alternative power supply or transitional power supply, in lieu of independent accumulator batteries, to services as defined in 2.5.2 and 2.5.4 of Chapter 2 of

this PART.

3.13.2 Plans and documents

3.13.2.1 The following plans and documents are to be submitted for approval:

- (1) General plan;
- (2) Electrical schematic diagram;
- (3) Technical specifications of the products.

3.13.2.2 The following drawings and documents should be submitted for reference:

- (1) External wiring diagram;
- (2) Specifications list of supporting electrical appliances;
- (3) Product instruction manual.

3.13.3 Design and construction

3.13.3.1 UPS units are to be constructed in accordance with IEC 62040, or an acceptable a standard.

3.13.3.2 The operation of the UPS is not to depend upon external services.

3.13.3.3 The type of UPS unit employed is to be appropriate to the power supply requirements of the connected load equipment.

3.13.3.4 An external bypass is to be provided.

3.13.3.5 The UPS unit is to be monitored and audible and visual alarm is to be given in a normally attended location for:

- (1) power supply failure (voltage and frequency) to the connected load;
- (2) UPS earth fault;
- (3) operation of battery protective device;
- (4) when the battery is being discharged; and
- (5) when the bypass is in operation for on-line UPS units.

3.13.4 Performance

3.13.4.1 The output power is to be maintained for the duration required for the connected equipment as stated in 2.5.2 and 2.5.4 of Chapter 2 of this PART.

3.13.4.2 No additional circuits are to be connected to the UPS unit without verification that the UPS unit has adequate capacity. The UPS battery capacity is, at all times, to be capable of supplying the designated loads for the time specified in Chapter 2 of this PART.

3.13.4.3 On restoration of the input power, the rating of the charge unit is to be sufficient to recharge the batteries while maintaining the output supply to the load equipment.

3.13.5 Testing and survey

3.13.5.1 UPS units of 50 kVA and over are to be surveyed by CCS Surveyors during manufacturing and testing.

3.13.5.2 Appropriate testing is to be carried out to demonstrate that the UPS unit is suitable for its intended environment. This is expected to include as a minimum the following tests:

- (1) Functionality, including operation of alarms;
- (2) Temperature rise;
- (3) Ventilation rate;
- (4) Battery capacity.

3.13.5.3 Where the supply is to be maintained without a break following a power input failure, this is to be verified after installation by practical test.



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PART FOUR REFRIGERATING AND QUICK-FREEZING INSTALLATIONS

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CHAPTER 1 GENERAL

Section 1 GENERAL REQUIREMENTS

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 Plans and documents

1.1.2.1 The following plans and documents are to be submitted for approval. Where necessary, additional plans and documents may be required:

- (1) General arrangement of insulated chambers (including neighbouring tanks and holds);
- (2) Detailed plans showing the construction of insulation within refrigerated chambers;
- (3) Details of insulation of piping and supports;
- (4) General arrangement of refrigerating machinery space and ;
- (5) Ventilation details of refrigerating machinery space;
- (6) Arrangement of air cooling system;
- (7) Arrangements of air cooler defrosting and drainage;
- (8) Arrangement of brine grids or refrigerant grids in refrigerated chambers and method of construction;
- (9) Piping diagrams of refrigerant, brine and cooling water systems;
- (10) Arrangements of drainage and ventilation in refrigerated chambers;
- (11) Arrangement of temperature measuring system in refrigerated chambers;
- (12) Schematic diagrams of automatic control, safety and alarm systems (including the specifications, types and functions).

1.1.2.2 The following plans and documents are to be submitted for information:

- (1) Specifications for refrigerating plant (including centralized control and monitoring) and for insulation of refrigerated chambers;
- (2) Calculations for refrigerating capacity.

1.1.2.3 Where R717 is used as the refrigerant, the following drawings are to be attached for review:

- (1) Arrangement of ammonia detection and alarm system;
- (2) Arrangement and calculation of water spray system;
- (3) Arrangement of water curtain system and safety protection equipment.

Note: Plans and documents of the products which have been approved by CCS need not be resubmitted for approval.

1.1.3 Refrigerants

1.1.3.1 The following refrigerants are permitted for use:

- (1) R717: Ammonia (NH_3);
- (2) R134a: Tetrafluoroethane (CH_2FCF_3);
- (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).
- (4) R507A: Mixture of R125 (50%) + R143a (50%) . R125 is pentafluoroethane (CHF_2CF_3) ; R143a is trifluoroethane (CH_3CF_3) .
- (5) R407C: Mixture of R32 (23%) + R125 (25%) + R134a (52%) . R32 is difluoromethane; R125 is pentafluoroethane (CHF_2CF_3) ; R134a is tetrafluoroethane (CH_2FCF_3).

1.1.3.2 Where other refrigerants are to be used, relevant information is to be submitted to CCS for approval.

1.1.4 Operating conditions

1.1.4.1 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°.

1.1.4.2 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 PART 5.

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 Alternative solutions

1.1.7.1 Alternative solutions can be accepted by CCS when found to represent the same level of safety and availability as the solutions required by this rule. Such an acceptance may be given without builder's, owner's or operator's consent.

1.1.7.2 Verification is necessary when alternative solutions are proposed. It is the obligation of the party applying for using alternative solution to ensure that relevant verification is carried out during construction.

1.1.8 Others

1.1.8.1 Except with the consent of CCS, refrigerating units of refrigerating fish catches are to be completely separated from air-conditioning or household refrigerating machinery.

1.1.8.2 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.

1.1.8.3 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.

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.

2.1.3 Design pressure

2.1.3.1 The design pressure of the high pressure side and the low pressure side of the refrigerating plant is to be not less than the values given in Table 2.1.3.1 respectively.

Design Pressure of Refrigerating Plant

Table 2.1.3.1

Refrigerant	Design pressure of high pressure side ^① (MPa)	Design pressure of low pressure side ^② (MPa)
R717	2.2	1.7
R134a	1.4	1.1
R404A	2.5	2.0
R507A	2.5	2.0
R407C	2.4	1.9

Note:

① High pressure side means the pressed parts of the compressor between its exhausting side and expansion valve.

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.

2.1.3.2 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.

2.1.3.3 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 2.1.3.1 in this PART.

Section 2 REFRIGERATION COMPRESSOR

2.2.1 Reciprocating compressors

2.2.1.1 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 2.1.3.1 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 2.2.1.1.

For shaftshaving one cylinder per crank: $C=1.0$;

For shaftshaving several cylinders, with 90° between adjacent cylinders on the same crankpin: $C=1.05$;

For shaftshaving several cylinders, with 60° between adjacent cylinders on the same crankpin: $C=1.18$;

For shaftshaving 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 2.2.1.1.

Arrangement of Cranks and Cylinders

Table 2.2.1.1

Number of crankpins	Number of cylinders per crank	Angle between adjacent cylinders (°)
1 或 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

2.2.1.2 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.

2.2.1.3 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.

2.2.1.4 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 2.2.1.1 in this PART.

2.2.1.5 Fillets and oil holes on the crankshafts are to be rounded to an even contour and smooth finish.

2.2.1.6 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.

2.2.2 Strength of materials for the compressor crankshafts

2.2.2.1 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 600N/mm²;
- (2) carbon and carbon-manganese steel forgings (quenched and tempered): not exceeding 700N/mm²;
- (3) spheroidal or nodular graphite iron castings: 370 to 800N/mm²;
- (4) carbon and carbon-manganese steel castings: 400 to 550N/mm²;
- (5) grey iron castings: not less than 300N/mm².

The use of alloy steel castings and forgings is to be approved by CCS.

2.2.3 Dismounting requirements

2.2.3.1 The main bearings of refrigeration compressors are to be removed, checked and replaced without dismantling crankshafts, pistons and connecting rods.

2.2.4 Screw refrigeration compressors

2.2.4.1 The materials for screw refrigeration compressor rotors, are to comply with the relevant provisions of Chapter 5 of Part 1 of CCS Rules for Materials and Welding if being of forged steel, and Chapter 7 of Part 1 of CCS Rules for Materials and Welding if being of ductile iron.

2.2.4.2 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.

2.2.4.3 Gear box is to comply with the relevant provisions of CHAPTER 6, PART 2.

Section 3 PRESSURE VESSELS, PIPING AND ACCESSORIES

2.3.1 Pressure vessels

2.3.1.1 Pressure vessels with hydrofluorocarbon refrigerants are to be constructed in accordance with the relevant provisions for Class II pressure vessels specified in PART 2 (Chapter 8) and CCS Rules for Materials and Welding. Pressure vessels with R717 refrigerant are to be constructed in accordance with the relevant provisions for Class I pressure vessels specified in PART 2 (Chapter 8) and CCS Rules for Materials and Welding. The design pressure is to comply with Table 2.1.3.1 in this PART.

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 2.

2.3.2.2 Refrigerant piping is to comply with the provisions, related to piping grade, of CHAPTER 2, PART 2:

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 R717 refrigerant. Nickel steel is not to be used for pressure vessels and piping with R717 refrigerant. Magnesium alloy is not to be used for hydrofluorocarbon refrigerant, and zinc is not to be used for R717 and hydrofluorocarbon refrigerants.

2.3.2.4 Pipes for the condensers are to be made of corrosion-resistant material. In case of hydrofluorocarbon refrigerants, corrosion-resistant seamless copper or titanium pipes are to be used.

2.3.2.5 Refrigerant and brine pipelines are to be seamless, of which R717 refrigerating pipes and brine pipes are to be of seamless steel. Brine pipes can also be of plastic pipes, but they shall be approved by CCS and be certified to be suitable for cold brine at low temperatures, in addition to meeting the relevant requirements in Section 4, Chapter 2 of PART 2. Pipe fittings for the R717 refrigerating unit are to be made of steel, but malleable cast iron may be accepted. Pipe fittings for the hydrofluorocarbon refrigerating 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 R717 refrigerant pipes; red copper ring or polytetrafluoroethylene is to be used for hydrofluorocarbon refrigerant pipes; 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 Cast iron valves shall not be used for R717 refrigerant pipes.

2.3.2.9 R717 refrigerant pipes are not to pass through accommodation spaces and control spaces, service spaces.

2.3.2.10 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 of hydrofluorocarbon 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 hydrofluorocarbon 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 200m³.

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 Part 5

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 fishcatches 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) R717refrigerant 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 circulating 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 制冷装置应设置下列安全系统: 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) the compressor will stop automatically when the concentration of leaking ammonia reaches 300 ppm.
- (5) failure of seawater circulating pumps.

Section 4 LOCATION OF REFRIGERATING MACHINERY SPACE OR UNIT

2.4.1 Arrangements of refrigerating unit

2.4.1.1 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.

2.4.1.2 When the vessel length is not less than 60m, refrigerating unit with hydrofluorocarbon refrigerant is to be installed in a separate refrigerating machinery space as far as possible.

2.4.1.3 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.

2.4.1.4 R717 refrigerating machinery space is not to be adjacent to accommodation spaces, wards or control rooms.

2.4.1.5 R717 refrigerating machinery space should have at least two outwards-opening access 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. Access 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 system that can be manual operated from outside.

2.4.1.6 When access to R717 refrigerating machinery space is adjacent to accommodation spaces, wards or control rooms, the access shall be separated from them by airtight bulkheads or decks.

2.4.1.7 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.

2.4.1.8 The penetrations of the cables and pipes from refrigerating machinery space into gastight bulkheads and decks are to be gastight construction.

2.4.1.9 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 negative pressure ventilation system. The ventilation is to provide at least 30 air changes per hour in the refrigerating machinery space.

The ventilation system for R717 refrigerating machinery space is to be separated from other ventilation systems for other spaces. The suction ducts of the ventilation systems are to be constructed of steel or other equivalent material, and the outlets are to be located in safe positions far away from air inlets for such spaces and other spaces as well as commonly occupied places.

In the case of hydrofluorocarbon refrigerating machinery spaces, the suction inlets of exhaust pipes are to be 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 The ventilation fan is not to be the ignition source of ammonia in the R717 refrigerating machinery space. The ventilation fan shall be of non-sparking type and the fans motors shall be of explosion-proof type.

2.4.2.5 If hydrofluorocarbon 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 Water spray system

2.4.3.1 The R717 refrigerating machinery space shall be equipped with a water spray system which shall run independently and can also be used for water curtain system.

2.4.3.2 The nozzles are to be positioned such that the spray is directed over the entire area containing the ammonia refrigerating machinery.

2.4.3.3 The supply water of water spray system is to be pressurized. The pressurization system is composed of two pumps and a water tank that can maintain 30-minute capacity of all nozzles within the protected area at the same time, and the water tank shall be equipped with the required safe relief device, pressure gauge, water level controller and liquid level gauge.

2.4.3.4 The system shall automatically maintain the required water pressure and level. Under the condition of low pressure and low water level, audible and visual alarm signals shall be displayed in refrigeration machinery space and the control room.

2.4.3.5 When the concentration of ammonia reaches 300ppm in the R717 refrigerating machinery space, the water spray system shall automatically start.

2.4.3.6 All electrical equipments in the R717 refrigerating machinery space is to be to IP55 enclosure if water spray system is fitted in the space.

2.4.4 Refrigerant leakage detection and alarm

2.4.4.1 A fixed ammonia detection system with alarm device is to be installed inside and outside the R717 refrigeration machinery spaces. Manual leakage alarm transmitters are to be provided outside such spaces.

2.4.4.2 Ammonia detectors are to be explosion-proof and designed, manufactured and tested in accordance with accepted standards.

2.4.4.3 The arrangement of ammonia detectors are to cover all refrigeration machinery (including the processing containers) in the refrigeration machinery spaces, and the exhaust pipe of the ventilation system of the spaces and the passageway leading to the spaces are also to be equipped with a detector for each.

2.4.4.4 Audible and visual alarm signals shall be displayed in the refrigeration machinery spaces and passageway to the spaces as well as in the control room and the bridge. Refrigerant leakage shall be detected at three levels with set points not higher than:

(1) 150ppm: start Level 1 alarm;

(2) 300ppm: access dangerous, automatically shutdown ammonia refrigerating compressor and refrigerant circulation pump, close the quick-closing valve on the ammonia delivering pipe, automatically activate water sprinkler system, and start Level 2 alarm;

(3) 5000ppm: De-energising of non-Ex protected electrical equipment, and start Level 3 alarm.

2.4.4.5 When other refrigerants are used, portable leakage detection equipments can be provided considering the possible choking hazard caused by refrigerant leakage.

2.4.5 Safety protection equipment

2.4.5.1 At least the following safety protection equipment are to be provided outside the R717 refrigeration machinery spaces, 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 eye washers;
- (5) 2 barrels of boric acid, 30 kg/barrel;
- (6) 2 emergency flashlights;
- (7) 1 electrical insulation resistance meter.

Section 5 SPACES WITH REFRIGERATION INSTALLATIONS OF DIRECT EXPANSION TYPE

2.5.1 General requirements

2.5.1.1 This section only applies to spaces with refrigeration installations of direct expansion type.

2.5.1.2 Spaces with refrigeration installations of direct expansion type, such as refrigeration machinery spaces, refrigerated fish holds and quick-freezing processing spaces, shall meet the requirements of this section in addition to other requirements of this PART.

2.5.1.3 The quick-freezing processing spaces mentioned in this section refer to the processing spaces with quick-freezing devices.

2.5.2 Refrigeration machinery spaces

2.5.2.1 The refrigeration machinery spaces with refrigeration installations of direct expansion type shall comply with the requirements of section 4 in the PART.

2.5.3 Refrigerated fish holds

2.5.3.1 In refrigerated fish holds where personnel may be entered, the exits shall be arranged so that escape is easy, preferably by inclined stairs. The escapeways shall be suited for carrying a disabled person out of the hold. Exit doors shall open outwards. Access doors and hatches shall either be operable from both sides or be fitted with catches to prevent inadvertent closing.

2.5.3.2 In case R717 is the refrigerant, refrigerated fish holds should also meet the following requirements:

- (1) gas masks shall be placed close to the normal access to the hold.
- (2) an ammonia detection system shall be fitted. Alarm shall be triggered when ammonia concentration

reaches 150ppm. The detectors shall be explosion-proof type, suitable for use in the low temperature environment and shall be calibrated for same.

(3) arrangements for mechanical ventilation of the hold in case of R717 refrigerant leakage shall be available. The ventilation may be either fixed or portable type.

2.5.4 Quick-freezing processing spaces

2.5.4.1 At least two exits from the space shall be provided, and exit doors shall open outwards. If R717 is the refrigerant the location of the exits shall be such that possible refrigerant leakage will not block access to both exits.

2.5.4.2 If R717 being the refrigerant, additional mechanical ventilation shall be available in case of leakage is detected. The ventilation capacity shall be at least six air changes per hour. Ventilation outlets shall be located away from ventilation inlets to other spaces and away from areas where personnel is normally present.

2.5.4.3 In case R717 is the refrigerant, the quick-freezing processing space shall be equipped with an ammonia detection system. Detectors shall be explosion-proof type, and located at ventilation suction points and at suitable locations within the space. Optic and audible alarm signals shall be displayed within the space and in way of accesses to the space as well as in the control room and the bridge. Detectors shall be set three levels with set points not higher than:

- (1) 150ppm: start Level 1 alarm, and evacuate the space;
- (2) 300ppm: start Level 2 alarm, and automatically start additional ventilation;
- (3) 500ppm: start Level 3 alarm, automatically shutdown ammonia circulation pump, and close the quick-closing valve on the ammonia delivering pipe;

When other refrigerants are used, portable leakage detection equipments can be provided considering the possible choking hazard to personnel in the quick-freezing processing spaces caused by refrigerant leakage.

2.5.4.4 If R717 is used as refrigerant, the ventilation fan motors shall be of explosion-proof type and the fans shall be of non-sparking type.

2.5.4.5 In case R717 is the refrigerant, Gas masks and hermetically sealed filters shall be available in a glass door case located outside each entrance to the quick-freezing processing space. Outside all access doors water screens and eye washes shall be provided.

Section 6 SAFETY DEVICES

2.6.1 Relief valves and safety valves

2.6.1.1 A pressure relief valve and/or safety disc is to be fitted between each compressor and its discharge 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 or a safe place above deck. No closing appliances are to be permitted in the backflow pipes. 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 design pressure of high pressure side given in Table 2.1.3.1, according to different refrigerants.

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.

2.6.1.2 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 or relief valves, the discharge being led to a safe place above deck. If the discharge directly being led to the atmosphere, the outlet shall be protected from rain and snow, and protective nets made of corrosion-resistant materials shall be installed to prevent foreign matter from entering. When R717 refrigerant is used, the outlet shall be located in the highest possible safe position onboard and vertical upwards.

In the hydrofluorocarbon refrigerant 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.

2.6.1.3 The opening pressure or bursting pressure of relief valves and/or safety discs of refrigerant pressure vessels is to be not greater than the design pressure of the system or components given in Table 2.1.3.1, according to different refrigerants. The delivery capacity is to comply with the requirements of Subparagraph (3), Paragraph 8.4.2.3(3), Chapter 8, Part 2.

2.6.1.4 If a relief valve and a safety disc are equipped on the refrigerant pressure vessel in series, a pressure gauge showing intermediate pressure is to be fitted between them.

2.6.1.5 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.

2.6.2 Emergency drainage

2.6.2.1 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.

2.6.2.2 Refrigerant systems for refrigerating plants other than R717 refrigerant are to be equipped with facilities for emergency drainage of refrigerants into the atmosphere.

2.6.3 Emergency stopping devices

2.6.3.1 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.

2.6.4 Alarm buttons in refrigerated fish holds and safe operation rules

2.6.4.1 Alarm buttons are to be fitted in refrigerated fish holds for seeking help from cabs and refrigerating machinery spaces.

2.6.4.2 Nameplates detailing the safety and emergency operation rules for refrigerating systems are to be installed at appropriate locations on board.

Section 7 QUICK-FREEZING INSTALLATIONS

2.7.1 Design requirements

2.7.1.1 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.

2.7.2 Heat insulation and protection

2.7.2.1 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.

2.7.2.2 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.

2.7.3 Plate freezers

2.7.3.1 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.

2.7.3.2 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.

2.7.3.3 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.

2.7.3.4 The defrosting of plate freezers are to be provided with effective control measures to prevent liquid from flowing back.

2.7.4 Lighting

2.7.4.1 The quick-freezing room is to be provided with sufficient lighting.

CHAPTER 3 REFRIGERATED FISH HOLDS

Section 1 CONSTRUCTION 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 pass 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 $5\text{mm}/^{\circ}\text{C}$.

3.1.4 Installation requirements for distant thermometers

3.1.4.1 Where only 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 Thermal 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. The thermal insulation materials used are to have adequate resistance to fire and flame spread, and are also to be subject to approval by CCS with their adhesives. If the thermal insulating materials are formed by chemical foam, the technology is to be reviewed by CCS, and tested according to the accepted standards (such as GB 8624-2012 or equivalent standards).

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.

3.2.2 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	1.5 <i>P</i>	1.0 <i>P</i>
Compressors	1.5 <i>P</i>	1.0 <i>P</i>
Cast-in-block crankcases and cylinders	1.5 <i>P</i>	1.0 <i>P</i>
Separate cylinders or cylinder blocks or housings (screw type)	1.2 <i>P</i>	0.8 <i>P</i>
Crankcases separated from cylinders	2.0 <i>P</i>	1.0 <i>P</i>
Valves and fittings	1.5 <i>P</i>	1.0 <i>P</i>
Pressure piping, welded fabricated headers, air coolers, etc		
Note ①: <i>P</i> is design pressure, as shown in Table 2.1.3.1. ②: Nitrogen or carbon dioxide or compressed air is generally used for leak test, but only nitrogen can be used for leak test for R717 refrigerant system components. The parts are to be submerged in water for inspection during the test. Alternative methods for leak test may be considered if practicable. ③: For components not suitable for hydraulic test, if pneumatic test is used instead of hydraulic test, the testing schedule should be submitted and agreed by CCS.		

4.1.1.2 The parts and components exposed to the pressure of brine or cooling water are to be hydraulically tested at 2.0*P*, 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 1.5*P*.

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 4.2.9.1 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, accessplugs 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 therefrigerated 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 4.2.6.1.

Total Rise Values**Table 4.2.6.1**

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 Test for ammonia detection and alarm system (if any)

4.2.8.1 The operation test is to be conducted after the ammonia detection and alarm system is installation on board. However, for the action effectiveness of alarm and safety protection, under the condition of ensuring equivalence, simulated detection test can be conducted.

4.2.9 Other tests

4.2.9.1 The required number of air changes and the uniform distribution of air volumes in refrigerated fish holds are to be verified.

4.2.9.2 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.

4.2.9.3 Defrosting operation test is to be conducted for air coolers before or after refrigeration test.

4.2.9.4 Defrosting operation test is to be conducted for electric defrosting, hot exhaust defrosting and hot brine defrosting devices.



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RULES FOR CONSTRUCTION OF OCEAN-GOING STEEL FISHING VESSELS

2021

PART FIVE CONTROL, MONITORING, ALARM AND SAFETY SYSTEM

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CHAPTER 1 GENERAL

Section 1 ROTATING MACHINES

1.1.1 General requirements

1.1.1.1 This PART applies to control, monitor, alarm and safety systems (hereinafter referred to as "automated systems") for machinery and electrical installations installed on ocean-going steel fishing vessels.

1.1.1.2 Fishing vessels with automated systems complying with the requirements of this PART are to be adaptable to all sailing conditions, including maneuvering.

1.1.1.3 The safety of the ships with automated systems complying with the requirements of this PART is to be same as that of the fishing vessels with machinery spaces being attended. Means are to be provided to ensure that the machinery and electrical equipment can be manually and effectively operated from a local position in case of failure of the automated systems.

1.1.1.4 Marine automation applies to the following:

(1) the ship's propulsion plant can be remotely controlled from the bridge control station with the engine room attended by watch-keepers;

(2) the ship's propulsion plant can be remotely controlled from the bridge control station with the machinery spaces (including engine room centralized control station or room) periodically unattended;

(3) the machinery and electrical installations are capable of being operated with continuous supervision by watch-keepers from a centralized control station or room in the engine room.

1.1.1.5 The automated systems of marine cover the following mechanical and electrical equipments:

(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.

1.1.1.6 All remote controls of bridges are to be performed in the centralized control stations of machinery spaces (if fitted).

1.1.1.7 All components of automated systems are to operate normally and stably in the long term with correct characteristics and accuracy.

1.1.2 Environmental conditions

1.1.2.1 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.

1.1.2.2 Electrical equipment in the remote control and automated systems are to comply with relevant requirements of environmental conditions in PART 3.

1.1.2.3 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°C to +55°C;

② Bridges and other compartments: 0°C to +55°C;

③ Electronic equipment are not to fail at +70°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 $2\sim 13.2\text{Hz}$; the acceleration amplitude is to be $\pm 6.86\text{ m/s}^2$ where the frequency is $13.2\sim 100.0\text{Hz}$.

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 $2\sim 25\text{Hz}$; the acceleration amplitude is to be 39.2 m/s^2 where the vibration frequency is $25.0\sim 100.0\text{Hz}$.

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 .

1.1.3 Working conditions

1.1.3.1 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.

1.1.3.2 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.

1.1.4 Tests

1.1.4.1 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.

1.1.4.2 Automated systems are to be subject to tests together with monitored electrical and mechanical equipment according to the test program approved by CCS.

1.1.5 Definitions

1.1.5.1 For the purpose of this PART:

(1) *Automatic control* means self-regulating control carrying out predetermined orders to operate the machinery without action by an operator.

(2) *Remote control* means control of a device by an operator from a distance through mechanical, electrical, electronic, pneumatic, hydraulic, electromagnetic (radio) or optical means or combination thereof.

(3) *Local control* means direct manual control by an operator of machinery through a device located on or adjacent to the controlled machinery.

(4) *Control stations (rooms)* means spaces fitted with monitoring means capable of controlling the machinery and electrical installations. They are mainly divided into four categories as follows in this PART:

① *centralized control station (room) of engine room* (abbreviated to CCS) means a control station (room) in which all monitoring means for automated equipment in engine room are concentrated;

② *bridge control station* (abbreviated to BCS) means a control station monitoring the propelling plant and other equipment in bridge;

③ *local control station* (abbreviated to LCS) means a control station where machinery and electrical installations are locally controlled;

④ *other control stations* mean control stations except the above-mentioned three ones.

(5) *Safety systems* mean systems which will operate automatically for safeguarding the machinery or electrical equipment in question in the following three modes of operation in case of serious faults endangering the main propulsion machinery, boilers, electric generating plants and other essential machinery or electrical equipment:

Mode a: immediate shutdown, e.g. emergency stop of main engines, emergency cutoff of boiler fuel oil supply and emergency cutoff of electric power supply to consumers. And such machinery or equipment is not to be put into operation again if without the manual resetting;

Mode b: the operation of the machinery is temporarily adjusted to the prevailing conditions, e.g., by reducing the output or rotation speed of the machinery;

Mode c: the normal operating conditions are restored by starting of standby machinery.

(6) *Alarm* means a visual and audible signal of a predetermined out-of-limits parameter for the monitored machinery or system, which can identify the particular fault condition and its location within the machinery spaces, which can identify the particular fault condition and its location within the machinery spaces.

(7) *Group alarm* means a common alarm activated by any abnormal conditions of the monitored machinery or system.

(8) *Fail-safe principle* means that upon failure or malfunction of a component or system, the output automatically reverts to a predetermined design state of least critical consequence.7-2

(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 ship.

(10) *Emergency shutdown device* means a device independent of any control system and intended for manual activation in an emergency to stop the operation of machinery and electrical installations, e.g. emergency stop button of main engines, emergency cutoff button of boiler fuel oil supply and emergency cutoff button of electric power supply to consumers.

(11) *Redundancy design* means standby technical means to be used in case of system or equipment fault, by which a corresponding function can be taken over to continue an action or an original function is restored to continue the operation condition.

1.1.6 Plans and documents

1.1.6.1 The plans and documents associated with equipment automation systems covered by this PART are to be submitted to CCS for approval in triplicate:

(1) Plans of all automatic control and remote control systems, including principles, functions and operating instructions;

(2) Parameters of automatic control (including control principle);

(3) Measurement display point;

(4) Alarm points (including the control station, room, and alarm mode for alarm signal display), the inspection method of the alarm system and the description of the self-inspection function;

(5) Safety system project, working principle;

(6) The installation location and quantity of monitoring point sensors;

(7) Description of the layout and monitoring functions (including control conversion) of control rooms, stations, screens, and stations;

(8) System plans of the power source (including electricity, air pressure, and hydraulic pressure) of the automation system.

1.1.6.2 The list of equipment related to the engine room automation system is to be submitted to CCS for reference.

1.1.6.3 Additional plans and documents are to be submitted for approval as deemed necessary by CCS.

Section 2 CONTROL SYSTEMS

1.2.1 General requirements

1.2.1.1 Control systems include automatic and remote control systems.

1.2.1.2 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.

1.2.1.3 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.

1.2.1.4 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.

1.2.1.5 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.

1.2.2 Independence

1.2.2.1 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.

1.2.2.2 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.

1.2.3 Inspection of control systems

1.2.3.1 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.

1.2.4 Power sources of control systems

1.2.4.1 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.

1.2.4.2 Hydraulic power sources and piping of control systems are to comply with relevant requirements of CHAPTERS 2 and 4 of PART 2. 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.

1.2.4.3 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

1.3.1 Classification of failures

1.3.1.1 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.

1.3.2 Fail safe, inspection and power sources

1.3.2.1 Safety systems are to be designed according to the fail safe principle and requirements of 1.2.1 of this PART.

1.3.2.2 The inspection of safety systems is to comply with requirements of 1.2.3 of this PART.

1.3.2.3 Power sources of safety systems are to comply with requirements of 1.2.4 of this PART.

1.3.3 Independence of Safety Systems

1.3.3.1 Safety systems class I as specified in 1.3.1 of this PART are to be independent of control systems and alarm systems.

1.3.3.2 Safety systems class II and class III as specified in 1.3.1 of this PART are to be independent of other systems as far as practicable.

1.3.4 Overriding

1.3.4.1 The safety protection action class I as specified in 1.3.1 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.

1.3.4.2 Relevant control stations are to be provided with light display when an overriding action is operated. The safety systems are to automatically recover functions.

1.3.5 Special performance

1.3.5.1 Safety systems are to be so designed that safety and alarm systems will not function once stop is triggered due to unnecessary interference.

1.3.5.2 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 1.3.1 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.

1.3.5.3 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)

1.4.1 General requirements

1.4.1.1 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.

1.4.1.2 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 1.3.1 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.

1.4.1.3 The alarm system is to be capable of indicating all faults occurred at the same time without causing mutual interference, including transponder.

1.4.1.4 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.

1.4.2 Inspection and self-monitoring of alarm systems

1.4.2.1 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.

1.4.2.2 The alarm system is to be capable of self-inspection if having equipment shared with the control and safety systems.

1.4.2.3 The alarm system is to be detected when the monitored mechanical and electrical equipment is running.

1.4.2.4 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.

1.4.3 Displays

1.4.3.1 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.

1.4.4 Power supply of alarm systems

1.4.4.1 Where the main power supply fails, the independent standby battery pack is to be automatically switched and an alarm will be given.

Section 5 CONTROL STATIONS (ROOMS)

1.5.1 Arrangement of control stations (rooms)

1.5.1.1 The control station (room) involved in this Section refers to the bridge control station, the centralized control station (room) in the engine room and the local control station.

1.5.1.2 Centralized control rooms (stations) of machinery spaces are to be generally located in the machinery spaces with wide horizon, least vibrations and low noise level while the ship operates at sea. Otherwise, its position is to be subject to the approval by CCS.

1.5.1.3 The Centralized control station (room) within the machinery spaces is to be of the sound-proof construction, with the window glass of the shatter-resistant type. The Centralized control station (room) is to have two means of access located as far remote from each other as practicable, and one of which is to be as far as possible situated near the escape trunk of the machinery spaces or the special purpose escape trunk.

1.5.1.4 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.

1.5.1.5 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.

1.5.1.6 The design, equipment and installation of remote control stations are to ensure the safe and reliable operation and local control of propulsion machinery.

1.5.1.7 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.

1.5.2 Transfer of control

1.5.2.1 Transfer of control between control stations is to be possible to the machinery and electrical equipment under common control from such stations, either when these machinery and electrical equipment are in normal operation or in case of their failures. Such changeover is not to seriously affect the operating conditions of the machinery and electrical equipment.

1.5.2.2 The transfer of control between the centralized control station (room) and bridge control station is to be possible only at the centralized control station (room), and the transfer of control between the local control station and centralized control station (room) or bridge control station is to be possible only at the local 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 number of testing instruments in the machinery space may be reduced based on primary parameters where appropriate, and an emergency release device of remote control system is to be fitted in the machinery space and is to be locked at ordinary times.

1.5.2.3 Changeover between control stations is to be so arranged that it may be effected only with the acceptance of the station taking control.

1.5.2.4 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.

1.5.2.5 Where the manual control gear of the main engine or other machinery and electrical equipment is extended directly to the centralized control station (room) by means of mechanical linkage, the provision of corresponding local control station may be exempted.

Section 6 REMOTE CONTROL OF BRIDGE

1.6.1 General requirements

1.6.1.1 The provisions of this section apply to fishing vessels with remote control systems for propulsion devices. When the vessel is less than 30 m, the requirements may be relaxed as appropriate subject to the approval of CCS.

1.6.1.2 Fishing vessels to be controlled remotely in navigation bridges with described in this section are to be provided with control stations (rooms) of navigation bridges.

1.6.1.3 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. For units using controllable pitch propellers, the remote control system is to control the pitch of the propellers under all sailing and operating conditions. Remote control systems are to be fitted with devices preventing the overload of the propulsion machinery when necessary. 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.

1.6.1.4 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. In particular, lack of power (electric, pneumatic, hydraulic) or changeover of control is not to lead to major and sudden change in propulsion power or propulsion direction.

The bridge control station shall implement effective monitoring and control transfer for the devices described in 1.6.1.3 of this section. 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 the control transfer of steering gears.

1.6.1.5 The control requirements of propulsion devices refer to 1.7.2 of this chapter.

1.6.1.6 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.

1.6.1.7 For remote control of main propulsion machinery at the navigation bridge, each separate propeller is to be controlled with single control device. All relevant devices are to be automatically operated, including devices preventing overload of propulsion machinery and long-term running in the restricted vibration speed ranges. Where multiple propellers are to be designed to operate simultaneously, they may be controlled by a control device.

1.6.1.8 The control system of navigation bridge is to be independent of the transmitting system for other purposes, but two systems may be controlled by a control rod.

1.6.1.9 Sensory identifications other than visual ones are to be generally provided at the center of the control lever.

1.6.1.10 The lever only for speed control may be provided with red marks.

1.6.1.11 For various operation instructions transmitted from the control device of the bridge, including change from maximum forward running speed to full-speed astern running, the automatic sequence control is to be completed in the allowable time interval of main engine.

1.6.1.12 The remote control system is to be provided with override in compliance with the requirements of safety system in this PART as far as possible. The override button is to be so arranged to preclude inadvertent operation.

1.6.1.13 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.

1.6.1.14 Bridge control stations 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.

1.6.1.15 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.

1.6.2 Equipment

1.6.2.1 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).

1.6.3 Table of automatic control and monitoring items

1.6.3.1 For fishing vessels with navigation bridge control station, the automatic monitoring items (if fitted) are to meet the requirements of Table 1.6.3.1.

1.6.3.2 The designations used in Table 1.6.3.1 of this Section are defined as follows:

—: not required;

*: only required for trunk piston diesel engines;

I : Category I protective action, such as emergency shutdown of the engine, fuel oil cutoff of boiler and cutoff of electric power supply, etc.;

II : Category II protective action, such as reducing the speed of rotation or the output of machinery;

III: Category III protective action, such as starting and putting into operation of standby pump or standby unit.

G_I: group alarm activated by Category I protective action;

G_{II}: group alarm activated by Category II protective action

Y: group alarm for general faults.

1.6.3.3 Where "per cylinder" appears in the column "Remark" of Table 1.6.3.1 of this Section, it applies only to crosshead diesel engines, and for trunk piston diesel engines, "fitted on manifold outlet" may be used to replace the "per cylinder".

1.6.3.4 For fishing vessels below 60m only equipped with bridge remote control, only group alarms activated by Category I and Category II protection actions as defined in Table 1.6.3.1 of this Section are to be provided in the bridge control station.

**Automatic Control and Monitoring Items for Ships with Bridge Remote Control Table
1.6.3.1**

Item	Bridge Control Station		Mode of protective control action	Mode of alarm at bridge control station	Remark
	Display	Limit alarm			

1	2	3	4	5	6
1 Main diesel engine					
1.1 Fuel oil system					
Fuel oil inlet pressure	Pressure	Low	III	<i>Y</i>	Fitted after filter
Fuel oil temperature or viscosity (before injection pumps)	Temp. or viscosity	Low or high	—	<i>Y</i>	Only for heavy oil
Leakage from high pressure fuel pipes	—	Leakage	—	<i>Y</i>	
Level of fuel oil in daily service tanks	—	Low	—	<i>Y</i>	High-level alarm also required, if no suitable overflow arrangement provided
Common rail fuel oil pressure	—	Low	—	<i>Y</i>	
1.2 Lubricating oil system					
Lub-oil inlet pressure to main bearing & thrust bearing	Pressure	Low	III	<i>Y</i>	Necessary for crosshead diesel engines
			II	<i>G_{II}</i>	
		Excessively low	I	<i>G_I</i>	
Lub-oil inlet pressure to crosshead bearing	Pressure	Low	III	<i>R</i>	Required if separate lub-oil system installed for crosshead diesel engines
			II	<i>G_{II}</i>	
		Excessively low	I	<i>G_I</i>	
Lub-oil inlet pressure to camshaft	Pressure	Low	III	<i>Y</i>	
		Excessively low	I	<i>G_I</i>	
Lub-oil inlet temperature to camshaft	Temp.	High	—	<i>Y</i>	
*Lub-oil filter differential pressure	Pressure	Great	—	<i>Y</i>	
Lub-oil inlet temperature	Temp.	High	—	<i>Y</i>	
Thrust bearing pad temperature or bearing temperature	Temp.	High	II	<i>G_{II}</i>	Necessary for crosshead diesel engines
		Excessively high	I	<i>G_I</i>	
Oil mist concentration in crankcase(or main, crank, crosshead bearing temperature or lubricating oil outlet	—	High	II	<i>G_{II}</i>	Applicable to low speed crosshead diesel engines

Item	Bridge Control Station		Mode of protective control action	Mode of alarm at bridge control station	Remark
	Display	Limit alarm			
1	2	3	4	5	6
temperature of the above bearing or other equivalent devices)					
*Oil mist concentration in crankcase (or main, crank bearing temperature or lubricating oil outlet temperature of the above bearing or other equivalent devices)	—	High	I	G_I	Applicable to medium/high speed diesel engines specified in 9.7.6, Ch.9, Pt.3; one oil mist detector for each engine having two independent outputs for initiating the alarm and shutdown would satisfy the requirement for independence between alarm and shutdown systems
Flow rate of cylinder lubricator. Each apparatus	—	Small	II	G_{II}	Required for trunk piston diesel engines if necessary for safe operation of the engines
Oil level in lub-oil circulating tank	—	Low	—	Y	Necessary for crosshead diesel engines; individual level alarms required for the tanks if separate lub-oil systems installed (e.g. camshaft, rocker arms, etc.) for crosshead diesel engines
Common rail servo oil pressure	—	Low	—	Y	
1.3 Turbocharger system					
Turbocharger lub-oil inlet pressure	Pressure	Low	—	Y	Unless provided with a self-contained lubricating oil system integrated with the turbocharger
Turbocharger lub-oil outlet temp each bearing	Temp.	High	—	Y	Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific

Item	Bridge Control Station		Mode of protective control action	Mode of alarm at bridge control station	Remark
	Display	Limit alarm			
1	2	3	4	5	6
					intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative
Speed of turbocharger	Speed	High	—	—	Applicable to Class B and C turbochargers
1.4 Piston cooling system (Necessary for crosshead diesel engines)					
Piston coolant inlet pressure	Pressure	Low	III	Y	The slowdown is not required if the coolant oil taken from the main cooling system of the engine
		Excessively low	II	G _{II}	
Piston coolant outlet flow	—	Low	II	G _{II}	Per cylinder; where outlet flow cannot be monitored due to engine design, alternative arrangement may be accepted
Piston coolant outlet temperature	Temp.	High	II	G _{II}	Per cylinder
Level of piston coolant in expansion tank	—	Low	—	Y	
1.5 Seawater cooling system					
Pressure of cooling seawater	Pressure	Low	III	Y	
1.6 Cylinder fresh cooling water system					
Cylinder water inlet pressure or flow	Pressure or flow	Low	III	Y	Only cylinder coolant inlet pressure required for crosshead diesel engines
		Excessively low	II	G _{II}	
Cylinder water outlet temperature (from each cylinder) Cylinder water outlet temperature (general)	Temp.	High	II	G _{II}	Required for crosshead diesel engines where one common cooling space without individual stop valves is employed for all cylinder jackets. For trunk piston diesel engines, alarm and slowdown only for cylinder water outlet temperature (general) and two

Item	Bridge Control Station		Mode of protective control action	Mode of alarm at bridge control station	Remark
	Display	Limit alarm			
1	2	3	4	5	6
					separate sensors required
Oily contamination of main engine cooling water system	—	Contaminated	—	—	Necessary for crosshead diesel engines; required where main engine cooling water is used in fuel and lubricating oil heat exchangers
Level of cylinder cooling water in expansion tank	—	Low	—	Y	
1.7 Starting and control air systems					
Starting air pressure before main shut-off valve	Pressure	Low	—	Y	
Control air pressure	Pressure	Low	—	Y	
Safety air pressure	Pressure	Low	—	Y	Necessary for crosshead diesel engines
1.8 Scavenge air system					
Scavenge air receiver pressure	Pressure	—	—	—	Necessary for crosshead diesel engines
Scavenge air box temperature (fire)	Temp.	High	II	G _{II}	
Scavenge air receiver water level	—	High	—	Y	
*Scavenge air receiver temperature	Temp.	High	—	Y	
1.9 Exhaust gas system					
Exhaust gas temp. after each cylinder	Temp.	High	II	G _{II}	For trunk piston diesel engines having a power of more than 500 kW per cylinder only
Exhaust gas temperature after each cylinder. Deviation from average	—	Great	—	Y	
Exhaust gas temperature before each turbocharger	Temp.	High	—	Y	Necessary for crosshead diesel engines
Exhaust gas temperature after each turbocharger	Temp.	High	—	Y	
1.10 Fuel valve coolant					
Pressure of fuel valve coolant	Pressure	Low	III	Y	The requirement is to be

Item	Bridge Control Station		Mode of protective control action	Mode of alarm at bridge control station	Remark
	Display	Limit alarm			
1	2	3	4	5	6
Temperature of fuel valve coolant	Temp.	High	—	Y	complied with if the crosshead diesel engine is fitted with a separate fuel valve cooling system
Level of fuel valve coolant in expansion tank	—	Low	—	Y	
1.11 Engine speed/direction of rotation					
Speed	Speed	Overspeed	I	G_I	
Direction of rotation	Direction of rotation	Wrong way	—	Y	Necessary for crosshead diesel engines
1.12 Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Loss	—	Y	Indication of voltage may be replaced by indicating lamp

Section 7 AUTOMATION REQUIREMENTS FOR MANNED DUTY IN CENTRALIZED CONTROL ROOM OF MACHINERY SPACES

1.7.1 General requirements

1.7.1.1 Fishing vessels to be controlled remotely in this mode to some extent are to be provided with 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.

1.7.1.2 Control stations of bridges (rooms) are to monitor, control and switch devices as specified in Section 6 of this PART. 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.

1.7.1.3 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.

1.7.1.4 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.

1.7.1.5 When the propulsion machinery is running normally, the centralized control room (station) is to be constantly attended and serve as the local control station.

1.7.1.6 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.

1.7.1.7 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.

1.7.1.8 Local control stations are to be provided with actions to guarantee effective manual operation of mechanical and electrical equipment nearby when automated systems fail.

1.7.2 Control of propulsion machinery

1.7.2.1 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.

1.7.2.2 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.

1.7.2.3 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.

1.7.2.4 The propulsion machinery is enable to be re-started after the control lever passing by the stop position after emergency stop or automatic stop.

1.7.2.5 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.

1.7.2.6 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.

17.2.7 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.

17.2.8 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.

1.7.2.9 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.

1.7.2.10 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.

1.7.2.11 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.

1.7.2.12 The clutching and de-clutching of propulsion machinery clutches are to be generally performed at the zero position of blade of controllable pitch propeller.

1.7.3 Control of generating sets

1.7.3.1 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.

1.7.3.2 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.

1.7.3.3 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.

1.7.3.4 Where emergency generating sets are provided with overspeed protection devices, other emergency stop protection devices do not need to be fitted.

1.7.4 Control of auxiliary boilers

1.7.4.1 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.

1.7.4.2 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.

1.7.4.3 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.

1.7.4.4 When the outlet pressure of boiler fuel pump drops to the alarm value, the standby pump of fuel is to be started automatically.

1.7.4.5 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.

1.7.4.6 The standby feed pump is to be started automatically when the outlet pressure of boiler feed pump drops to the alarm value.

1.7.5 Control of other devices

1.7.5.1 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.

1.7.5.2 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.

1.7.5.3 Where the fuel is heated electrically, the arrangement, control and alarm are to comply with relevant requirements of CHAPTER 4 of this PART 2.

1.7.5.4 Air compressors are to be automatically started and stopped according to the set pressure.

1.7.5.5 Where side propellers are fitted, audible and visual alarms are to be given in the bridge, and necessary protective devices are to be fitted.

1.7.6 Fire detection and accident fire alarm systems of machinery spaces

1.7.6.1 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.

1.7.6.2 Fire detection systems are to be based on self-inspection principle.

1.7.6.3 Detectors are to generally cover all hazardous areas. However, the detectors may be dispensed in the visible range of centralized control stations.

1.7.6.4 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.

1.7.7 Fire control

1.7.7.1 High-pressure fuel injection pipes of diesel engines are to be enclosed by metal hoses or sheath, and oil leakage is to be alarmed.

1.7.7.2 High and low oil level alarm devices are to be fitted where the fuel oil service tank is provided with an automatic refueling device.

1.7.8 Table of automatic control and monitoring items

1.7.8.1 For fishing vessels with manned duty in centralized control room of machinery spaces, the automatic monitoring items (if fitted) are to meet the requirements of Table 1.7.8.1.

1.7.8.2 The designations used in Table 1.7.8.1 of this Section are defined as follows:

—: not required;

*: only required for trunk piston diesel engines;

I : Category I protective action, such as emergency shutdown of the engine, fuel oil cutoff of boiler and cutoff of electric power supply, etc.;

II : Category II protective action, such as reducing the speed of rotation or the output of machinery;

III: Category III protective action, such as starting and putting into operation of standby pump or standby unit.

1.7.8.3 Where "per cylinder" appears in the column "Remark" of Table 1.7.8.1 of this Section, it applies only to crosshead diesel engines, and for trunk piston diesel engines, "fitted on manifold outlet" may be used to replace the "per cylinder".

1.7.8.4 For the equipment marked with "▲" in Table 1.7.8.1 of this Section, if all of the single alarms and display items provided locally or in the vicinity of the engine are confirmed by CCS, the engine room central control station may be exempted from the single alarms and display items as required in Table 1.7.8.1. Only one group alarm for general faults and one fault display are to be provided in this case.

Automatic Control and Monitoring Items for Ships with manned duty in centralized control room of

machinery spaces

Table 1.7.8.1

Item	Centralized control station (room) of engine compartment		Safety system action category	Alarm method of bridge control station	Remark
	Display	Limit alarm			
1	2	3	4	5	6
1 Main diesel engine					
1.1 Fuel oil system					
Fuel oil inlet pressure	Pressure	Low	III	R	Fitted after filter
Fuel oil temperature or viscosity (before injection pump)	Temperature or viscosity	Low and high	—	Y	Only for heavy oil
Leakage of high-pressure fuel pipe	—	Leakage	—	Y	
Level of fuel oil in daily service tanks	—	Low	—	Y	High-level alarm also required, if no suitable overflow arrangement provided
Common rail fuel oil pressure	—	Low	—	Y	
1.2 Lubricating oil system					
Lub-oil inlet pressure to main bearing & thrust bearing	Pressure	Low	III	R	Necessary for crosshead diesel engines
			II	G _{II}	
		Excessively low	I	G _I	
Lub-oil inlet pressure to crosshead bearing	Pressure	Low	III	R	Required if separate lub-oil system installed for crosshead diesel engines
			II	G _{II}	
		Excessively low	I	G _I	
Lub-oil inlet pressure to camshaft	Pressure	Low	III	R	
		Excessively low	I	G _I	
Lub-oil inlet temperature to camshaft	Temperature	High	—	Y	
*Lub-oil filter differential pressure	Pressure	High	—	Y	
Lub-oil inlet temperature	Temperature	High	—	Y	
Thrust pad bearing temperature or bearing lubricating oil outlet temperature	Temperature	High	II	G _{II}	Necessary for crosshead diesel engines
		Excessively high	I	G _I	
Main, crank, crosshead bearing oil outlet temperature or oil mist concentration in crankcase	—	High	II	G _{II}	Applicable to low-speed diesel engines
*Oil mist concentration in crankcase	—	High	I	G _I	Applicable to medium and high speed diesel; one oil mist detector for each engine having two independent outputs for initiating the alarm and shutdown would satisfy the requirement for independence between alarm and shutdown systems
Flow rate of cylinder lubricator (each apparatus)	—	Small	II	G _{II}	Required for trunk piston diesel engines if necessary for safe operation of the engines
Oil level in lub-oil	—	Low	—	Y	Necessary for crosshead diesel engines;

Item	Centralized control station (room) of engine compartment		Safety system action category	Alarm method of bridge control station	Remark
	Display	Limit alarm			
1	2	3	4	5	6
circulating tank					individual level alarms required for the tanks if separate lub-oil systems installed (e.g. camshaft, rocker arms, etc.) for crosshead diesel engines
Common rail servo oil pressure	—	Low	—	Y	
1.3 Turbocharger system					
Turbocharger lub-oil inlet pressure	Pressure	Low	—	Y	Unless provided with a self-contained lubricating oil system integrated with the turbocharger
Turbocharger lub-oil outlet temp each bearing	Temperature	High	—	Y	Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design, alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.
Speed of turbocharger	Speed	High	—	—	Applicable to class B and class C turbochargers
1.4 Piston cooling system (Necessary for crosshead diesel engines)					
Piston coolant inlet pressure	Pressure	Low	III	Y	The slowdown is not required if the coolant oil taken from the main cooling system of the engine
		Excessively low	II	G _{II}	
Piston coolant outlet flow	—	Low	II	G _{II}	Per cylinder; where outlet flow cannot be monitored due to engine design, alternative arrangement may be accepted
Piston coolant outlet temperature	Temperature	High	II	G _{II}	Per cylinder
Level of piston coolant in expansion tank	—	Low	—	Y	
1.5 Seawater cooling system					
Pressure of cooling seawater	Pressure	Low	III	Y	
1.6 Cylinder fresh cooling water system					
Cylinder water inlet pressure or flow	Pressure or flow	Low	III	Y	Only cylinder coolant inlet pressure required for crosshead diesel engines
		Excessively low	II	G _{II}	
Cylinder water outlet temperature (from each cylinder) or Cylinder water outlet temperature (general)	Temperature	High	II	G _{II}	Required for crosshead diesel engines where one common cooling space without individual stop valves is employed for all cylinder jackets. For trunk piston diesel engines, alarm and slowdown only for cylinder water outlet temperature (general) and two separate sensors required
Oily contamination of main engine cooling water system	—	Contaminated	—	—	Necessary for crosshead diesel engines; required where main engine cooling water is used in fuel and lubricating oil heat exchangers

Item	Centralized control station (room) of engine compartment		Safety system action category	Alarm method of bridge control station	Remark
	Display	Limit alarm			
1	2	3	4	5	6
Level of cylinder cooling water in expansion tank	—	Low	—	Y	
1.7 Starting and control air systems					
Starting air pressure before main shut-off valve	Pressure	Low	—	S	
Control air pressure	Pressure	Low	—	S	
Safety air pressure	Pressure	Low	—	S	Necessary for crosshead diesel engines
1.8 Scavenging system					
Scavenge air receiver pressure	Pressure	—	—	—	Necessary for crosshead diesel engines
Scavenge air box temperature (fire)	Temperature	High	II	G _{II}	
Scavenge air receiver water level	—	High	—	Y	
*Scavenge air receiver temperature	Temperature	High	—	Y	
1.9 Exhaust gas system					
Exhaust gas temp. after each cylinder	Temperature	High	II	G _{II}	For trunk piston diesel engines having a power of more than 500 kW per cylinder only
Exhaust gas temperature after each cylinder. Deviation from average	—	Large	—	R	
Exhaust gas temperature before each turbocharger	Temperature	High	—	R	Necessary for crosshead diesel engines
Exhaust gas temperature after each turbocharger	Temperature	High	—	R	
1.10 Fuel valve coolant					
Pressure of fuel valve coolant	Pressure	Low	III	R	The requirement is to be complied with if the crosshead diesel engine is fitted with a separate fuel valve cooling system
Temperature of fuel valve coolant	Temperature	High	—	Y	
Level of fuel valve coolant in expansion tank	—	Low	—	Y	
1.11 Engine speed/direction of rotation					
Speed	Speed	Overspeed	I	G _I	
Direction of rotation	Direction of rotation	Wrong way	—	S	Necessary for crosshead diesel engines
1.12 Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Voltage, pneumatic and hydraulic pressure	Voltage loss	—	Y	Indication of voltage may be replaced by indicating lamp
2 Diesel engines driving generators [▲]					
Lub-oil inlet pressure	Pressure	Low	—	Y	
		Excessively low	I		
Fuel oil temperature or	Temperature	Low and high	—	Y	Only for heavy oil

Item	Centralized control station (room) of engine compartment		Safety system action category	Alarm method of bridge control station	Remark
	Display	Limit alarm			
1	2	3	4	5	6
viscosity (before injection pumps)	or viscosity				
Exhaust gas temperature after each cylinder	Temperature	High	—	Y	For engine power > 500 kW per cylinder only
Lub-oil inlet temperature	—	High	—	Y	
Temperature of cooling water or cooling air outlet	Temperature	High	—	Y	
Pressure or flow of cooling water	—	Low	—	Y	
Speed	—	Overspeed	I	Y	
Starting air pressure	Pressure	Low	—	Y	
High-pressure fuel pipe	—	Leakage	—	Y	
Oil mist concentration in crankcase	—	High	I	Y	Applicable to diesel engines specified in 5.3.6.1 of PART 3; one oil mist detector for each engine having two independent outputs for initiating the alarm and shutdown would satisfy the requirement for independence between alarm and shutdown systems
Level in fuel oil daily service tank	—	Low	—	Y	
Level in cooling water expansion tank	—	Low	—	Y	Fitted if such system is provided with the expansion box and is not connected to the main engine system
Common rail fuel oil pressure	—	Low	—	Y	
Common rail servo oil pressure	—	Low	—	Y	
Speed of turbocharger	Speed	High	—	—	Applicable to class B and class C turbochargers
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Voltage loss	—	Y	Indication of voltage may be replaced by indicating lamp
3 Electric generating plant[▲]					
Bus bar voltage	Voltage	High and low	—	Y	
Bus bar frequency	Frequency	High and low	—	Y	
Load shedding	—	When in operation	—	Y	
Automatic switch-on of circuit breaker	—	Failure	—	Y	
Tripping of automatic circuit breaker	—	When in operation	—	Y	
Failure of load distribution	—	Failure		Y	Fitted if automatic load distribution is adopted
4 Gearbox					

Item	Centralized control station (room) of engine compartment		Safety system action category	Alarm method of bridge control station	Remark
	Display	Limit alarm			
1	2	3	4	5	6
Lubricating oil temperature		High	III		No less than 1500kW
Lubricating oil inlet pressure		Low	I		
5 Shafting (applicable to the propulsion machinery with power no less than 750kW)					
Rear bearing temperature of tail pipe		High	III		The sensor can be fitted near the rear bearing
Shafting bearing temperature		High	I		In case of no less than 1500kW
Thrust bearing lubricating oil or thrust block temperature		High	III		
6 Controllable pitch propeller systems					
Hydraulic oil pressure		Low		S	Jointly displayed with “remote control system fault” in the navigation bridge
Hydraulic oil level of gravity tank or backpressure of oil pump		Low	III		Applicable to the propulsion machinery with the power no less than 750 kW
7 Clutches					
Control power of clutch		Low		S	Applicable to the propulsion machinery with the power no less than 750 kW; if caused by the operation failure
8 Oil purifier (Applicable to the propulsion machinery with the power no less than 750 kW)					
Oil temperature		High or low	III	S	In case of local independent indication, the combined alarm device can be fitted at the central alarm control panel.
Accidental discharge of rotor drum/ water seal failure/water contained in the output oil similar conditions			III	S	
9 Steering gear					
Failure of steering gear		Failure		S	
Steering gear overload		Overload		S	
Phase fault		Fault		S	Applicable to the propulsion machinery with power no less than 750kW
Control system failure		Failure		S	Applicable to the propulsion machinery with power no less than 750kW
10 Tank liquid level					
Daily fuel tank		Low	III	S	High level alarm is to be increased for the tank controlled automatically or remotely
Expansion tank		Low	III	S	
Sump oil, oil discharge tank or fuel overflow tank		High	III	S	Only applicable to the oil discharge tank for the propulsion machinery with power less than 750kW

Item	Centralized control station (room) of engine compartment		Safety system action category	Alarm method of bridge control station	Remark
	Display	Limit alarm			
1	2	3	4	5	6
Gravity oil tank of tail pipe		Low	III	S	High level alarm is to be increased for the tank controlled automatically or remotely
Lubricating oil collection chassis /tank of main engine		Low	III	S	
Hydraulic oil tank of steering gear		Low	III	S	
11 Fire detection system					
Fire alarm		Accident fire		S	Only applicable to the accident fire of machinery space for the propulsion machinery with power less than 750kW
Fault		Fault	III		Applicable to the propulsion machinery with power no less than 750kW
12 Miscellaneous					
Failure of remote control system		Failure		S	Not applicable to the propulsion machinery with power less than 750 kW
Failure of alarm system		Failure	III		
Failure of safety system		Failure	III		
Tripping of safety system		Failure	III		
Auxiliary automatic switch over		Failure	III		
Bilge water level/Sewage well position at machinery spaces		High	III		
13 Auxiliary steam boilers (applicable to the propulsion machinery with power no less than 750kW)					
Release of safety system		Release	III		
Steam pressure		Low or high	III		
Water level		Low or high	III		
Failure of circulating water pump		High	III		
Condensate water salinity		High	III		
Condensate water oil stain		High	III		

Section 8 PERIODICALLY UNATTENDED MACHINERY SPACES

1.8.1 General requirements

1.8.1.1 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. In addition to the requirements described in this Section, the navigation bridge control station and the centralized control station (room) in the machinery space are also to meet the general requirements of Sections 6 and 7 of this Chapter, respectively.

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.

1.8.1.2 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 17.1.6 in this PART are complied with.

1.8.1.3 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.

1.8.1.4 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.

1.8.1.5 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.

1.8.1.6 In the unattended period, the safety level of fishing vessels is to be the same as the safety level requirements for attended machinery spaces.

1.8.2 Main propulsion machinery

1.8.2.1 In addition to complying with requirements of 1.7.2 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.

1.8.2.2 When fishing vessels are sailing on sea (including maneuvering), propulsion directions, speeds and propeller pitch (if provided) are to be fully controlled from the navigation bridge.

1.8.2.3 The control station of the navigation bridge is to be provided with an emergency stopper for main propulsion machinery independently of the control system of the navigation bridge, but the actuator may not be independent and its arrangement is to prevent false operation.

1.8.2.4 The local control function of local control station for the main propulsion machinery is not to be affected in the event of a fault or failure of any part in the automatic or remote control system of other control stations or propulsion machinery.

1.8.3 Electric generating sets

1.8.3.1 The control of generating set is to comply with requirements of 1.7.3 of this PART.

1.8.3.2 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.

1.8.3.3 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.

1.8.3.4 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.

1.8.3.5 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.

1.8.3.6 The bridge is to enable starting and switching the standby generating set remotely.

1.8.4 Auxiliary boilers

1.8.4.1 The control of auxiliary boilers is to comply with requirements of 1.7.4 in this PART. In addition, pumps driven by motor are to be automatically started successfully in case of power recovery after power failure.

1.8.5 Other devices

1.8.5.1 The control of other devices is to comply with relevant requirements of 1.7.5 of this PART.

1.8.5.2 The engine compartment is to be provided with bilge high water level alarm. The bilge water alarm level is to be such that the bilge water will not rise to the top plate of double-layer bilge. Water level sensors are to be so arranged to prevent false alarm during normal inclination and swing.

1.8.5.3 The bilge well is to be capable of holding the normal water discharge in the unattended cycle. Where the bilge pump is capable of being automatically started, a smaller bilge well is to be provided to hold the normal water discharge for a long period appropriately, but greater bilge water inflow than the discharge capacity of pump, too long pump operation time or too frequent starting is to be alarmed, and its discharge is to also comply with relevant requirements on pollution prevention. Refer to Table 1.8.12.1 of this Chapter for relevant monitoring items.

1.8.5.4 Alarms as required in 1.8.5.2 and 1.8.5.3 above are to be fitted in the centralized control station of engine compartment, control station of navigation bridge and accommodation space of marine engineers.

1.8.5.5 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.

1.8.5.6 Control stations controlling valves are to indicate the valves opening or closing.

1.8.5.7 Air receivers for starting and control are to be automatically charged.

1.8.6 Calling system of marine engineer

1.8.6.1 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.

1.8.6.2 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.

1.8.7 Fire detection and accident fire alarm systems of machinery spaces

1.8.7.1 Fire detection and accident fire alarm systems of periodically unattended machinery spaces are to comply with relevant requirements of 1.7.6 of this PART.

1.8.7.2 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.

1.8.8 Fire control and fighting

1.8.8.1 Fire control and fighting are to comply with relevant requirements of 1.7.7 of this PART.

1.8.8.2 Periodically unattended machinery spaces are to be provided with a main fire pump which can be started by the bridge remotely.

1.8.9 Locking devices of automatic starting

1.8.9.1 Main and auxiliary engines started automatically or remotely are to be provided with locking devices

preventing false automatic or remote startup during the overhaul.

1.8.10 Additional requirements of alarm systems

1.8.10.1 Alarm displays are to be so arranged to identify the specific conditions and positions of faults in the machinery spaces.

1.8.10.2 Where the watch officer of the navigation bridge is the only person on duty, the alarm system is to enable the watch officer to be aware of the following when the equipment fault is monitored at the local control station:

- (1) A fault has occurred;
- (2) The occurred fault has been noticed (e.g., response and silencing);

(3) The fault has been eliminated. Such function can be achieved by other communication means between the control station of the navigation bridge, accommodation space of marine engine and machinery spaces (centralized control station of engine compartment or local control station).

1.8.10.3 Occurred faults are to be displayed in the navigation bridge in form of combined alarm. However, fault alarms of propulsion machinery deceleration or automatic stop are to be distinguished.

1.8.10.4 Alarm systems are to be tested during the normal operation of monitored mechanical and electrical equipment. If feasible, means are to be provided to test sensors at the accessible position without affecting the operation of mechanical and electrical equipment.

1.8.10.5 An alarm is to be given for separate fault when any power source of alarm system fails. Where the alarm system may be adversely affected due to the disconnection of power source, the standby power source may be switched to supply power continuously.

1.8.10.6 If the alarm has been acknowledged, and the second fault has occurred before the elimination of the first fault, the visual and audible alarm signal is to be transmitted again. The alarm given for the transient fault is to be maintained before being acknowledged.

1.8.10.7 The alarm system is to be so designed that its function is independent of the safety system and control system. In the event of fault or malfunction of other systems, the normal operation of the alarm system is not to be affected.

1.8.11 Additional requirements of safety system

1.8.11.1 The safety system is to give an alarm during operation.

1.8.11.2 To avoid unnecessary stop of mechanical and electrical equipment, the safety system is to act in the following methods after the alarm system acts, to minimize the harm:

- (1) Starting and launching the standby equipment;
- (2) Reducing load or stopping operation.

1.8.11.3 Safety systems of mechanical and electrical equipment in different units are to be independent of each other. In the event of a fault in one safety system, the normal operation of the other safety system is not to be affected.

1.8.11.4 Visual and audible alarms are to be given at the control station after the action of the safety system to indicate the reasons of the safety system action.

1.8.12 Table of automatic control and monitoring items

1.8.12.1 For fishing vessels with periodically unattended machinery spaces, the automatic monitoring items (if fitted) are to meet the requirements of Table 1.8.12.1.

1.8.12.2 The designations used in Table 1.8.12.1 of this Section are defined as follows:

—: not required;

*: only required for trunk piston diesel engines;

I : Category I protective action, such as emergency shutdown of the engine, fuel oil cutoff of boiler and cutoff of electric power supply, etc.;

II : Category II protective action, such as reducing the speed of rotation or the output of machinery;

III: Category III protective action, such as starting and putting into operation of standby pump or standby unit;

S: single alarm;

G_I: group alarm activated by Category I protective action;

G_{II}: group alarm activated by Category II protective action

R: group alarm for serious faults;

Y: group alarm for general faults.

1.8.12.3 Where "per cylinder" appears in the column "Remark" of Table 1.8.12.1 of this Section, it applies only to crosshead diesel engines, and for trunk piston diesel engines, "fitted on manifold outlet" may be used to replace the "per cylinder".

1.8.12.4 For the equipment marked with "▲" in Table 1.8.12.1 of this Section, if all of the single alarms and display items provided locally or in the vicinity of the engine are confirmed by CCS, the engine room central control station may be exempted from the single alarms and display items as required in Table 1.8.12.1. Only one group alarm for general faults and one fault display are to be provided in this case.

Automatic Control and Monitoring Items of Fishing Vessels with Periodically Unattended Machinery Space

Table 1.8.12.1

Item	Centralized control station (room) of engine compartment		Safety system action category	Alarm method of bridge control station	Remark
	Display	Limit alarm			
1	2	3	4	5	6
1 Main diesel engine					
1.1 Fuel oil system					
Fuel oil inlet pressure	Pressure	Low	III	R	Fitted after filter
Fuel oil temperature or viscosity (before injection pump)	Temperature or viscosity	Low and high	—	Y	Only for heavy oil
Leakage of high-pressure fuel pipe	—	Leakage	—	Y	
Level of fuel oil in daily service tanks	—	Low	—	Y	High-level alarm also required, if no suitable overflow arrangement provided
Common rail fuel oil pressure	—	Low	—	Y	
1.2 Lubricating oil system					
Lub-oil inlet pressure to main bearing & thrust bearing	Pressure	Low	III	R	Necessary for crosshead diesel engines
			II	G _{II}	
		Excessively low	I	G _I	
Lub-oil inlet pressure to crosshead bearing	Pressure	Low	III	R	Required if separate lub-oil system installed for crosshead diesel engines
			II	G _{II}	
		Excessively low	I	G _I	
Lub-oil inlet pressure to camshaft	Pressure	Low	III	R	
			I	G _I	
		Excessively low	I	G _I	
Lub-oil inlet temperature to camshaft	Temperature	High	—	Y	
*Lub-oil filter differential pressure	Pressure	High	—	Y	
Lub-oil inlet temperature	Temperature	High	—	Y	

Item	Centralized control station (room) of engine compartment		Safety system action category	Alarm method of bridge control station	Remark
	Display	Limit alarm			
1	2	3	4	5	6
Thrust pad bearing temperature or bearing lubricating oil outlet temperature	Temperature	High	II	G_{II}	Necessary for crosshead diesel engines
		Excessively high	I	G_I	
Main, crank, crosshead bearing oil outlet temperature or oil mist concentration in crankcase	—	High	II	G_{II}	Applicable to low-speed diesel engines
*Oil mist concentration in crankcase	—	High	I	G_I	Applicable to medium and high speed diesel; one oil mist detector for each engine having two independent outputs for initiating the alarm and shutdown would satisfy the requirement for independence between alarm and shutdown systems
Flow rate of cylinder lubricator (each apparatus)	—	Small	II	G_{II}	Required for trunk piston diesel engines if necessary for safe operation of the engines
Oil level in lub-oil circulating tank	—	Low	—	Y	Necessary for crosshead diesel engines; individual level alarms required for the tanks if separate lub-oil systems installed (e.g. camshaft, rocker arms, etc.) for crosshead diesel engines
Common rail servo oil pressure	—	Low	—	Y	
1.3 Turbocharger system					
Turbocharger lub-oil inlet pressure	Pressure	Low	—	Y	Unless provided with a self-contained lubricating oil system integrated with the turbocharger
Turbocharger lub-oil outlet temp each bearing	Temperature	High	—	Y	Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design, alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.
Speed of turbocharger	Speed	High	—	—	Applicable to class B and class C turbochargers
1.4 Piston cooling system (Necessary for crosshead diesel engines)					
Piston coolant inlet pressure	Pressure	Low	III	Y	The slowdown is not required if the coolant oil taken from the main cooling system of the engine
		Excessively low	II	G_{II}	
Piston coolant outlet flow	—	Low	II	G_{II}	Per cylinder; where outlet flow cannot be monitored due to engine design, alternative arrangement may be accepted
Piston coolant outlet temperature	Temperature	High	II	G_{II}	Per cylinder
Level of piston coolant in expansion tank	—	Low	—	Y	
1.5 Seawater cooling system					
Pressure of cooling seawater	Pressure	Low	III	Y	

Item	Centralized control station (room) of engine compartment		Safety system action category	Alarm method of bridge control station	Remark
	Display	Limit alarm			
1	2	3	4	5	6
1.6 Cylinder fresh cooling water system					
Cylinder water inlet pressure or flow	Pressure or flow	Low	III	Y	Only cylinder coolant inlet pressure required for crosshead diesel engines
		Excessively low	II	G _{II}	
Cylinder water outlet temperature (from each cylinder) or Cylinder water outlet temperature (general)	Temperature	High	II	G _{II}	Required for crosshead diesel engines where one common cooling space without individual stop valves is employed for all cylinder jackets. For trunk piston diesel engines, alarm and slowdown only for cylinder water outlet temperature (general) and two separate sensors required
Oily contamination of main engine cooling water system	—	Contaminated	—	—	Necessary for crosshead diesel engines; required where main engine cooling water is used in fuel and lubricating oil heat exchangers
Level of cylinder cooling water in expansion tank	—	Low	—	Y	
1.7 Starting and control air systems					
Starting air pressure before main shut-off valve	Pressure	Low	—	S	
Control air pressure	Pressure	Low	—	S	
Safety air pressure	Pressure	Low	—	S	Necessary for crosshead diesel engines
1.8 Scavenging system					
Scavenge air receiver pressure	Pressure	—	—	—	Necessary for crosshead diesel engines
Scavenge air box temperature (fire)	Temperature	High	II	G _{II}	
Scavenge air receiver water level	—	High	—	Y	
*Scavenge air receiver temperature	Temperature	High	—	Y	
1.9 Exhaust gas system					
Exhaust gas temp. after each cylinder	Temperature	High	II	G _{II}	For trunk piston diesel engines having a power of more than 500 kW per cylinder only
Exhaust gas temperature after each cylinder. Deviation from average	—	Large	—	R	
Exhaust gas temperature before each turbocharger	Temperature	High	—	R	Necessary for crosshead diesel engines
Exhaust gas temperature after each turbocharger	Temperature	High	—	R	
1.10 Fuel valve coolant					
Pressure of fuel valve coolant	Pressure	Low	III	R	The requirement is to be complied with if the crosshead diesel engine is fitted with a separate fuel valve cooling system
Temperature of fuel valve coolant	Temperature	High	—	Y	
Level of fuel valve coolant	—	Low	—	Y	

Item	Centralized control station (room) of engine compartment		Safety system action category	Alarm method of bridge control station	Remark
	Display	Limit alarm			
1	2	3	4	5	6
in expansion tank					
1.11 Engine speed/direction of rotation					
Speed	Speed	Overspeed	I	G_I	
Direction of rotation	Direction of rotation	Wrong way	—	S	Necessary for crosshead diesel engines
1.12 Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Voltage, pneumatic and hydraulic pressure	Voltage loss	—	Y	Indication of voltage may be replaced by indicating lamp
2 Diesel engines driving generators[▲]					
Lub-oil inlet pressure	Pressure	Low	—	Y	
		Excessively low	I		
Fuel oil temperature or viscosity (before injection pumps)	Temperature or viscosity	Low and high	—	Y	Only for heavy oil
Exhaust gas temperature after each cylinder	Temperature	High	—	Y	For engine power > 500 kW per cylinder only
Lub-oil inlet temperature	—	High	—	Y	
Temperature of cooling water or cooling air outlet	Temperature	High	—	Y	
Pressure or flow of cooling water	—	Low	—	Y	
Speed	—	Overspeed	I	Y	
Starting air pressure	Pressure	Low	—	Y	
High-pressure fuel pipe	—	Leakage	—	Y	
Oil mist concentration in crankcase	—	High	I	Y	Applicable to diesel engines specified in 5.3.6.1 of PART 3; one oil mist detector for each engine having two independent outputs for initiating the alarm and shutdown would satisfy the requirement for independence between alarm and shutdown systems
Level in fuel oil daily service tank	—	Low	—	Y	
Level in cooling water expansion tank	—	Low	—	Y	Fitted if such system is provided with the expansion box and is not connected to the main engine system
Common rail fuel oil pressure	—	Low	—	Y	
Common rail servo oil pressure	—	Low	—	Y	
Speed of turbocharger	Speed	High	—	—	Applicable to class B and class C turbochargers
Power supply for control-safety-alarm systems (electrical, pneumatic and hydraulic pressure)	Electrical, pneumatic and hydraulic pressure	Voltage loss	—	Y	Indication of voltage may be replaced by indicating lamp

Item	Centralized control station (room) of engine compartment		Safety system action category	Alarm method of bridge control station	Remark
	Display	Limit alarm			
1	2	3	4	5	6
3 Electric generating plant▲					
Bus bar voltage	Voltage	High and low	—	Y	
Bus bar frequency	Frequency	High and low	—	Y	
Load shedding	—	When in operation	—	Y	
Automatic switch-on of circuit breaker	—	Failure	—	Y	
Tripping of automatic circuit breaker	—	When in operation	—	Y	
Failure of load distribution	—	Failure		Y	Fitted if automatic load distribution is adopted
4 Gearbox					
Lubricating oil temperature		High	III		No less than 1500kW
Lubricating oil inlet pressure		Low	I		
5 Shafting (applicable to the propulsion machinery with power no less than 750kW)					
Rear bearing temperature of tail pipe		High	III		The sensor can be fitted near the rear bearing
Shafting bearing temperature		High	I		In case of no less than 1500kW
Thrust bearing lubricating oil or thrust block temperature		High	III		
6 Controllable pitch propeller systems					
Hydraulic oil pressure		Low		S	Jointly displayed with “remote control system fault” in the navigation bridge
Hydraulic oil level of gravity tank or backpressure of oil pump		Low	III		Applicable to the propulsion machinery with the power no less than 750 kW
7 Clutches					
Control power of clutch		Low		S	Applicable to the propulsion machinery with the power no less than 750 kW; if caused by the operation failure
8 Oil purifier (Applicable to the propulsion machinery with the power no less than 750 kW)					
Oil temperature		High or low	III	S	In case of local independent indication, the combined alarm device can be fitted at the central alarm control panel.
Accidental discharge of rotor drum/ water seal failure/water contained in the output oil similar conditions			III	S	
9 Steering gear					

Item	Centralized control station (room) of engine compartment		Safety system action category	Alarm method of bridge control station	Remark
	Display	Limit alarm			
1	2	3	4	5	6
Failure of steering gear		Failure		S	
Steering gear overload		Overload		S	
Phase fault		Fault		S	Applicable to the propulsion machinery with power no less than 750kW
Control system failure		Failure		S	Applicable to the propulsion machinery with power no less than 750kW
10 Tank liquid level					
Daily fuel tank		Low	III	S	High level alarm is to be increased for the tank controlled automatically or remotely
Expansion tank		Low	III	S	
Sump oil, oil discharge tank or fuel overflow tank		High	III	S	Only applicable to the oil discharge tank for the propulsion machinery with power less than 750kW
Gravity oil tank of tail pipe		Low	III	S	High level alarm is to be increased for the tank controlled automatically or remotely
Lubricating oil collection chassis /tank of main engine		Low	III	S	
Hydraulic oil tank of steering gear		Low	III	S	
11 Fire detection system					
Fire alarm		Accident fire		S	Only applicable to the accident fire of machinery space for the propulsion machinery with power less than 750kW
Fault		Fault	III		Applicable to the propulsion machinery with power no less than 750kW
12 Miscellaneous					
Failure of remote control system		Failure		S	Not applicable to the propulsion machinery with power less than 750 kW
Failure of alarm system		Failure	III		
Failure of safety system		Failure	III		
Tripping of safety system		Failure	III		
Auxiliary automatic switchover		Failure	III		
Bilge water level/Sewage well position at machinery spaces		High	III		
13 Auxiliary steam boilers (applicable to the propulsion machinery with power no less than 750kW)					
Release of safety system		Release	III		
Steam pressure		Low or high	III		

Item	Centralized control station (room) of engine compartment		Safety system action category	Alarm method of bridge control station	Remark
	Display	Limit alarm			
1	2	3	4	5	6
Water level		Low or high	III		
Failure of circulating water pump		High	III		
Condensate water salinity		High	III		
Condensate water oil stain		High	III		

1.8.12.5 The automatic switching of essential auxiliary machinery is as specified in Table 1.8.12.5. The display during switching is to comply with requirements of 1.4.4 of this PART.

Automatic Switching of Essential Auxiliary Machinery

Table 1.8.12.5

Auxiliary equipment ×: shall be set ...: optional	Automatic switching	Starting and power supply recovery after whole vessel power failure	Note
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.

1.8.12.6 Each alarm is to be provided with independent audible and visual signals.

Section 9 COMPUTER BASED SYSTEMS

1.9.1 General requirements

1.9.1.1 This Section applies to on-board computer based systems which provide control, alarm, monitoring, safety or internal communication functions of engine compartment or whole vessel, including programmable electronic system. This Section does not apply to loading instruments and radio communication and navigation equipment with detailed performance standard by IMO.

1.9.1.2 Computer based systems are to perform various per-determined functions in various operation conditions (including emergency), based on the following factors:

- (1) No danger is to be caused to personnel;
- (2) No fishing vessels and their equipment are to be damaged;
- (3) The operation of non-computer equipment and systems is not to be affected (e.g., main engines and auxiliary engines);
- (4) The environment is not to be damaged;
- (5) The availability of system is not to be affected;
- (6) Repair and maintenance are to be facilitated.

1.9.1.3 Where the design or arrangement not consistent with the requirements of this Section, the engineering analysis in accordance with relevant international or Chinese national standards is to be submitted to and approved by CCS. The failure of class III system may result in serious consequence, so non-conventional techniques (e.g., radio communication technology) are allowed to be applied only upon approval by CCS when sufficient evidences are provided to prove the acceptability and reliability of systems.

1.9.1.4 Class II and class III computer systems are to be provided with protective means to prevent the unintentional or unauthorized modification of programs by operators. Any modifications after performance tests witnessed by the Surveyor of CCS are to be recorded and traceable. Major modifications (if any) are to be submitted to CCS for approval.

1.9.1.5 The modifications of parameters such as characteristic value and setting value of class III computer based systems are to be approved by CCS.

1.9.2 System categories

1.9.2.1 Computer systems may be classified into three categories: class I, class II and class III as shown in Table 1.9.2.1 according to the extent of damage which may be caused by single fault. Such damage is caused by an incident rather than being caused directly. Redundancy is not taken into account during system classification.

Computer Based System Categories

Table 1.9.2.1

Category	Effect	System function	Example
I	Failure of those systems will not lead to dangerous situations for human safety, safety of the fishing vessel and/or threat to the environment	——Monitoring function and daily management function	——Maintenance supporting systems ——Daily information processing
II	Failure of those systems could eventually lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment	——Monitoring and alarm functions ——Control functions which are necessary to maintain the vessel in its normal operational and habitable conditions	——Monitoring and alarm devices ——Liquid tank capacity measuring equipment ——Auxiliary engine control systems ——Remote control system of main propulsion machinery ——Fire detection and extinguishing systems ——Bilge water systems ——Governors
III	Failure of those systems could immediately lead to dangerous situations for human safety, safety of the vessel and/or threat to the environment	——Control functions for maintaining the fishing vessel's propulsion and steering ——Vessel safety function	——Mechanical protection systems or equipment ——Combustor control systems ——Electronic oil injectors of internal combustion engines ——Propulsion and steering control systems ——Generator synchronization unit

1.9.2.2 The classification of computer based systems may be varied somewhat deepening on different types and dimensions of fishing vessels, working duration and frequency of personnel at the hazardous area, system complexity and possibility to prevent damage.

1.9.2.3 Where provided with independent and effective standby systems or other means to avoid risks, class III systems may be reduced to class II systems.

1.9.3 System design

1.9.3.1 In various operation circumstances (including emergency), computer based systems are to ensure the following:

- (1) Execution of necessary automatic operation;
- (2) Acceptance of user's instructions;
- (3) Providing correct information for users.

1.9.3.2 The system is to be so designed to provide sufficient response time for completing all functions in various processing conditions, taking into account the maximum load and required maximum working capacity as well as network communication speed.

1.9.3.3 Computer based systems are to be so designed that they can be easily and safely operated by personnel without professional computer knowledge. Otherwise, relevant training is to be provided to operators.

1.9.3.4 Faults and restart of computer based systems are not to result in non-defined or dangerous state. When the power supply is recovered after failure, computer based systems are to be re-started and operated in a short time according to the pre-determined sequence, with functions recovered rapidly.

1.9.3.5 The system is to be so designed that the fault of other parts of the system or the whole system will not be caused by single fault in the system; such fault is to be limited in the faulted module. The redundancy design (e.g., standby equipment) is to be adopted when necessary, and such equipment is to recover its function.

1.9.3.6 To facilitate maintenance and replacement, the hardware is to be composed by replaceable modules, and is to be standardized and modularized as far as practicable. To reduce the number of spare parts, types of modules are to be minimized. The construction of each replaceable component is to be so designed to facilitate safe operation. Plug-in modules and connectors (including electrical connections) are to be provided with marks for identifications and are to be so designed to ensure correct connection.

1.9.3.7 Systems undertaking important functions are to be saved by permanent-storage components, to avoid loss or errors of applied programs, characteristic curves and limit values.

1.9.3.8 Software of Class II and class III computer based systems is to be so designed to comply with the following requirements:

- (1) The software is to be confidential and encapsulated;
- (2) The program of the operating system is to adapt to the development, installation and subsequent modifications in all stages of the service period;
- (3) The software is to be subject to system test which is to be documented. These tests are to include all software functions, important functional combinations, operation characteristics, relevance and using requirements in all operation modes (including operations in case of emergency and fault). Where the software is modified somewhat, the tests are to be also changed correspondingly;
- (4) The software is to be so designed to prevent the operator from modifying the programs and fixed data related to fishing vessels.

1.9.3.9 Computer based systems are to be provided with self-inspection function. Visual and audible alarm signals are to be given for all faults leading to loss of important functions.

1.9.3.10 Faults, which affect essential internal functions and cannot be displayed by computer based systems, are to be displayed by equipment independently of computer.

1.9.3.11 External power sources of computer based systems is to be provided with fault monitoring, and visual and audible alarm signals are to be given in the event of a fault. Where the redundant system is used, each

system is to be supplied by the independent final sub-circuit.

1.9.3.12 Computer based systems are to achieve the pre-determined automatic monitoring functions, and their control systems, alarm systems and safety systems are to be designed in accordance with the independence requirements of 12.4.1 and 12.5.2 in this Chapter.

1.9.3.13 When the computer system is used for essential functions related to propulsion, steering and fishing vessels safety, standby systems or emergency measures, independently of computer based systems preferably, are to be provided.

1.9.4 Data communication

1.9.4.1 The reliability extent of data communication is to be determined based on different computer systems and specific using conditions, and class II and class III systems are to comply with requirements of 1.9.4.2 and 1.9.4.9 in this chapter.

1.9.4.2 Data communication lines are to automatically check the continuity of lines and network connections. An alarm is to be given in the event of abnormalities.

1.9.4.3 The system is to automatically switch to the least dangerous state in the event of a fault of data communication.

1.9.4.4 Where the same data communication line serves as two or more essential functions, such line is to be in redundancy design.

1.9.4.5 The changeover switch of the redundancy line is not to interfere with the continuous operation of data communication or functions

1.9.4.6 To ensure the normal switching between systems, standard ports are to be adopted as far as practicable.

1.9.4.7 Where the data communication is lost due to the fault of single component, means are to be provided for automatic recovery of data communication.

1.9.4.8 The loss of data communication is not to affect the capacity to operate essential equipment by alternative means.

1.9.4.9 Means are to be provided to ensure the data integrity and timely recover damaged or invalid information.

1.9.4.10 The data communication line is to be capable of transmitting necessary information in sufficient time to avoid blockage.

1.9.5 Additional requirements of wireless data communication

1.9.5.1 In addition to the requirements of 1.9.4 in this Chapter, the wireless data communication of class II system is to also comply with requirements of 1.9.5.2 to 1.9.5.4 in this Chapter. The wireless data communication of class III system is to also comply with requirements of 1.9.1.3.

1.9.5.2 Where functions required for continuous operation of essential services depend on wireless data communication, alternative control measures are to be provided and to be put into use in the acceptable time.

1.9.5.3 Approved international radio communication system protocols are to be adopted for wireless data communication and are to comply with the following requirements:

(1) Information integrity: Faults are to be prevented, inspected, diagnosed and corrected, so that the received information (compared with transmitted information) is not damaged or changed;

(2) Configuration and equipment verification: The protocols are to be only connected with the equipment contained in the system design;

(3) Information encryption: Confidential and/or essential data contents are to be protected;

(4) Security management: Network assets are to be protected to prevent illegal access to network assets.

1.9.5.4 The wireless system is to comply with requirements of International Telecommunication Union and flag country authority for radio frequency and power level.

1.9.6 Input and output devices

1.9.6.1 Input and output devices of computer based systems are to be so designed to facilitate the user's operation, and to be designed and laid out based on the principle of ergonomics.

1.9.6.2 Operation keyboards of computer are to comply with the following requirements:

(1) Where the operation or functions of devices may be changed by means of keyboard, appropriate means (e.g., setting a password) are to be provided to limit unauthorized personnel against such operation;

(2) Where the operation of a key may lead to hazardous operation, means are to be provided to prevent against faults caused by single-key action, e.g., special lock key, or two or more keys.

1.9.6.3 The computer display is to comply with the following requirements:

(1) Dimensions, color and resolution rate of texts and charts shown on the display are to be easily read from the operator's normal position in case of various operation lighting. The brightness and contrast are to be adjusted according to the surrounding ambient conditions;

(2) The displayed information is to have logic priority;

(3) Where the alarm information is shown on the color display, the alarm state is to be clear even during the original color fault.

1.9.6.4 Where the display replaces the general indicator alarm display in class II and class III computer systems, the following requirements are to be complied with:

(1) The display is to be clear at bright ambient conditions, and the data and information shown on the display are to be easily read by operators at the normal operation position;

(2) The display is to clearly show all alarms;

(3) The display is to appropriately show the difference before and after the fault alarm is acknowledged, but such difference is not to be shown only by different colors;

(4) Store devices and output ports are to be provided, in order to record and output the fault content and fault occurring time;

(5) The centralized monitoring and alarm system of engine compartment is to be provided with 1 standby display or lamp panel at least, or 1 printer for recording the fault contents and fault occurring time;

(6) The display is to still operate normally during normal power supply or failure;

(7) Where the parameters and alarm are shown on the same display, the display is not to affect the alarm signal.

1.9.7 Graphic user interface

1.9.7.1 The shown information is to be clear and easy to understand based on the importance and relevance of functions. The contents on the screen are to be reasonably arranged, and their expression is to be only limited to the data related to users.

1.9.7.2 When general graphic user interface is used, only necessary functions in relevant processes can be applied.

1.9.7.3 In each operation mode of graphic user interface system, the alarm is to be superior to the visual and audible alarm of other information, and to be distinguished from other information.

1.9.8 Tests and verification

1.9.8.1 Computer based systems are to be tested and verified in accordance with requirements of Table 1.9.8.1. Refer to the Annex 1 of this chapter for the definitions and explanations in Table 1.9.8.1.

Tests and Verification of Computer Based Systems

Table 1.9.8.1

SN	Tests and verification	System categories		
		I	II	III
1.	Quality system certification document			

	Software quality plan		M	M
	Inspection of parts (only for hardware) supplied by distributors		M	M
	Quality control in production		M	M
	Completion test report	M	M	S
	Traceability of software	M	M	S
2.	Instructions for hardware and software			
	Instructions for software		M	S
	Instructions for hardware		M	S
	Fault analysis on relevant safety functions			S
3.	Software test documents			
	Documents of software test based on the quality plan		M	S
	Analysis on effectiveness of programmable program for related safety functions			S
4.	Hardware test			
	Tests in accordance with CCS <i>CCS Guidelines for Type Approval Test of Electric and Electronic Products (2006)</i> .		W	W
5.	Software test			
	Module test		M	S
	Sub-system test		M	S
	System test		M	S
6.	Performance test			
	Integrated test		M	W
	Fault simulation		W	W
	Factory acceptance test	M	W	W
7.	On-board test			
	Complete system test	M	W	W
	Integration test		W	W
	Evidence to prove the capacity of electromagnetic compatibility by the radio function operation		W	W
8.	Modification	M	W	W
	Test after modification	M	S/W	S/W

Notes: M - Documents retained and submitted by manufacturers as required

S - Documents to be inspected by CCS

W - To be witnessed by CCS

Appendix 1 Definitions and Notes for Computer System Testing and Verification

1.1 Quality system certification documents

1.1.1 Software quality plan: An activity plan for the software life cycle should be developed, and the plan should specify relevant procedures, responsibilities and system documents, including configuration management.

1.1.2 Inspect parts supplied by distributors (hardware only): Demonstrate that parts and/or assemblies meet technical specifications.

1.1.3 Quality control in production: Documents related to quality assurance measures in production.

1.1.4 Completion test report: a report generated based on finished product tests and test results records.

1.1.5 Traceability of software: Modifications to programming content and data and changes to versions must be carried out and recorded according to the procedures.

2.1 Hardware and Software Description

2.1.1 software description: The software should be described, for example:

- a description of the basic software and communication software installed in each hardware unit;
- description of the application software (non-programming list);
- Describe the mutual constraints and dependencies between functions, capabilities, modules and other components.

2.1.2 Hardware description: The hardware should be described, for example:

- a system block diagram illustrating the arrangement, input and output devices and interconnections;
- wiring diagram;
- detailed description of input and output equipment;
- Detailed description of the power supply.

2.1.3 Failure analysis for safety-related functions only (e.g. FMEA): Appropriate methods should be used for analysis, such as:

- fault tree analysis;
- Risk Analysis;
- Potential Failure Modes and Effects Analysis (FMEA) or Failure Modes, Effects and Criticality Analysis (FMECA).

The purpose is to demonstrate that the system can fail safely under a single fault, and then to find a way to ensure that the operating system is not lost or degraded to the point where it fails to meet the acceptable performance standards specified by CCS.

3.1 Software test certificate

3.1.1 Documentation of software testing in accordance with the quality plan: Validation and approval procedures should be established, such as:

- experiment method;
- generate a test outline;
- simulation.

3.1.2 Analysis of the effectiveness of programmable procedures for safety-related functions: Specific assurance methods shall be designed to verify and validate the satisfaction, such as:

- multiple programs;
- program analysis and testing to detect formatting errors and interpretation deviations;
- Simple structure.

4.1 Hardware test

4.1.1 The tests conducted in accordance with CCS Guidelines for Type Approval Tests of Electrical and Electronic Products (2006) are type approval tests. CCS may give special consideration to tests witnessed and approved by other IACS member classification societies.

5.1 Software test

5.1.1 Module test: The software module test should prove that each module should be able to achieve its intended function and not perform non-preset functions.

5.1.2 Subsystem test: The subsystem test should verify that each module can interact correctly to achieve its intended function and not perform non-preset functions.

5.1.3 System test: The system test shall verify that the subsystems can interact correctly, provide functions according to the specified requirements, and do not perform non-preset functions.

6.1 Performance test

6.1.1 Integration test: Programmable electronic system integration test shall be carried out using satisfactory system test software and using predetermined system components as far as practicable.

6.1.2 Fault simulation: Fault simulation shall be performed as realistically as possible to demonstrate proper system fault detection and system response functions. Any desired failure analysis results should be observed.

6.1.3 Factory acceptance test: The factory acceptance test is to be carried out according to the test program accepted by CCS. The tests are to be based on demonstrating that the system meets the requirements specified by CCS.

7.1 Onboard tests

7.1.1 Complete system test: The complete system including actual hardware components and final application software should be tested according to the approved test program.

7.1.2 Integration test: The onboard test is to verify that the functions under all system integration conditions can be implemented correctly.

7.1.3 For wireless communication equipment, it is to be verified during mooring and sea trials that no malfunction will occur due to electromagnetic interference under predetermined operating conditions, and it is also to be verified that it will not cause other equipment malfunctions when transmitting information wirelessly. In a Class II or Class III computer system, if the electromagnetic interference of the wireless data communication equipment is found to cause equipment failure, the equipment should be replaced and/or the arrangement of the equipment should be changed to avoid further failures.

8.1 Modification

8.1.1 Modification test: Modifications to approved systems are to be notified in advance and to the satisfaction of CCS, see 1.9.1.4 of this Chapter.



China Classification Society

RULES FOR CONSTRUCTION OF OCEAN-GOING STEEL FISHING VESSELS

2021

PART SIX LIFTING APPLIANCES

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CHAPTER 1 GENERAL

Section 1 GENERAL PROVISIONS

1.1.1 Application

1.1.1.1 Unless expressly provided otherwise in this Part, lifting appliances of fishing vessels are to comply with CCS RULES FOR LIFTING APPLIANCES OF SHIPS AND OFFSHORE INSTALLATIONS.

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 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.

1.1.2 Definitions

1.1.2.1 *Winch* means a mechanical device that is drum or warping cone with one or more horizontally-mounted winding ropes.

1.1.2.2 *Air-space cable crane* means cable hoisting appliances with a safe working load of not more than 9.8kN.

CHAPTER 2 DERRICK SYSTEMS

Section 1 MASTS AND DERRICK POSTS

2.1.1 General requirements

2.1.1.1 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

2.1.1.2 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 supported by at least two decks and effectively connected to the main hull structure, 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 2 AIR-SPACE CABLE CRANE

2.2.1 General requirements

2.2.1.1 The material and safety factor of uprights both ends of air-space cable crane are to comply with the relevant provisions of Section 4 of Chapter 2 of CCS RULES FOR LIFTING APPLIANCES OF SHIPS AND OFFSHORE INSTALLATIONS.

2.2.1.2 The material of cable of air-space cable crane is to comply with the relevant provisions of 5.4 of Chapter 5 of CCS RULES FOR LIFTING APPLIANCES OF SHIPS AND OFFSHORE INSTALLATIONS. The safety factor of cable of air-space cable crane is to comply with the provisions of 2.1.6 of Chapter 2 of CCS RULES FOR LIFTING APPLIANCES OF SHIPS AND OFFSHORE INSTALLATIONS.

2.2.1.3 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.

2.2.1.4 Wire ropes used for air-space cable cranes are to adopt wire strand cores.

CHAPTER 3 MACHINERY, ELECTRICAL INSTALLATIONS AND CONTROL ENGINEERING SYSTEMS

Section 1 GENERAL PROVISIONS

3.1.1 General requirements

3.1.1.1 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.

3.1.1.2 Maneuvering handwheel or handle with automatic reset is to be provided with obvious grading.

3.1.1.3 Joysticks, handwheels or handles that are not automatic reset are to be provided with stop devices to prevent self-shifting.

3.1.1.4 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.

CHAPTER 4 TESTING

Section 1 TESTS FOR LIFTING APPLIANCES

4.1.1 Testing of air-space cable crane

4.1.1.1 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 to comply with the provisions of 7.4 of Chapter 7 of CCS RULES FOR LIFTING APPLIANCES OF SHIPS AND OFFSHORE INSTALLATIONS. 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.

4.1.2 Testing of gantry

4.1.2.1 The test load and method are to comply with the provisions of 7.4 of Chapter 7 of CCS RULES FOR LIFTING APPLIANCES OF SHIPS AND OFFSHORE INSTALLATIONS.

4.1.2.2 After the test, the gantry and other stressed parts are to be examined for deformation or other defects.

Section 2 RE-TESTING FOR LIFTING APPLIANCES

4.2.1 General requirements

4.2.1.1 Unless expressly provided otherwise, repeated tests for air-space cable crane and gantry are to comply with the provisions of 7.5 of Chapter 7 of CCS RULES FOR LIFTING APPLIANCES OF SHIPS AND OFFSHORE INSTALLATIONS.

4.2.1.2 The test loads for air-space cable crane are to comply with the provisions of 4.1.1 of this Chapter.

4.2.1.3 The test loads for gantry are to comply with the provisions of 4.1.2.1 of this Chapter.

Section 3 DEFECTS THAT ARE NOT ALLOWED

4.3.1 General requirements

4.3.1.1 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.

4.3.1.2 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.

4.3.1.3 Excessive wear or corrosion or 5 per cent of broken wires rope in any length of ten times the wire rope diameter takes place, it is to be replaced.

4.3.1.4 The brake liner wears excessively and the fastenings securing the liner expose out in the friction surface, it is to be replaced.

4.3.1.4 The transmitting gear tooth is broken or its rim, sprocket or hub is cracked, it is not allowed to continue using them.

