RUSSIAN MARITIME REGISTER OF SHIPPING

RULES

FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS

PART XVII

DISTINGUISHING MARKS AND DESCRIPTIVE NOTATIONS IN THE CLASS NOTATION SPECIFYING STRUCTURAL AND OPERATIONAL PARTICULARS OF SHIPS

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RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS

Rules for the Classification and Construction of Sea-Going Ships of Russian Maritime Register of Shipping have been approved in accordance with the established approval procedure and come into force on 1 January 2021.

The present edition of the Rules is based on the 2020 edition taking into account the amendments and additions developed immediately before publication.

The procedural requirements, unified requirements, unified interpretations and recommendations of the International Association of Classification Societies (IACS) and the relevant resolutions of the International Maritime Organization (IMO) have been taken into consideration.

The Rules are published in the following parts:

Part I "Classification";

Part II "Hull";

Part III "Equipment, Arrangements and Outfit";

Part IV "Stability";

Part V "Subdivision";

Part VI "Fire Protection";

Part VII "Machinery Installations";

Part VIII "Systems and Piping";

Part IX "Machinery";

Part X "Boilers, Heat Exchangers and Pressure Vessels";

Part XI "Electrical Equipment";

Part XII "Refrigerating Plants";

Part XIII "Materials";

Part XIV "Welding";

Part XV "Automation";

Part XVI "Structure and Strength of Fiber-Reinforced Plastic Ships";

Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships";

Part XVIII "Additional Requirements for Structures of Container Ships and Ships, Dedicated Primarily to Carry their Load in Containers". The text of the Part is identical to IACS UR S11A "Longitudinal Strength Standard for Container Ships" (June 2015) and S34 "Functional Requirements on Load Cases for Strength Assessment of Container Ships by Finite Element Analysis" (May 2015);

Supplement to Rules and Guidelines of Russian Maritime Register of Shipping "IACS Procedural Requirements, Unified Requirements, Unified Interpretations and Recommendations".

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Part XVIII and Supplement to Rules and Guidelines of Russian Maritime Register of Shipping are published in electronic format in English only.

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REVISION HISTORY[1]
(purely editorial amendments are not included in the Revision History)

Amended paras/chapters/sections	Information on amendments	Number and date of the Circular Letter	Entry-into-force date
Para 1.2.1	Heading of para has been amended	312-11-1473c of 26.11.2020	01.01.2021
Paras 1.2.1.2, 1.2.1.3	New paras with definitions for length and displacement have been introduced in compliance with the provisions of IACS UR I2 (Rev.4 Dec 2019)	312-11-1473c of 26.11.2020	01.01.2021
Figure 1.2.2.1	Symbol for the length has been specified	312-11-1473c of 26.11.2020	01.01.2021
Para 1.2.2.4	Requirements have been specified in compliance with the provisions of IACS UR I2 (Rev.4 Dec 2019)	312-11-1473c of 26.11.2020	01.01.2021
Para 1.2.2.7	Symbol for the ship's length has been specified	312-11-1473c of 26.11.2020	01.01.2021
Para 1.2.3.2.1.1	Definitions for the length, distance x and displacement have been specified in the explication to Formulae. Numbering of Formulae has been corrected	312-11-1473c of 26.11.2020	01.01.2021
Formula (1.2.3.2.1.1-1) (formerly 1.2.3.2.1-1)	Formulae for determination of factors $f_{a_{i,1}}$ and $f_{a_{i,2}}$ have been specified	312-11-1473c of 26.11.2020	01.01.2021
Formula (1.2.3.2.1.1-2) (formerly 1.2.3.2.1-2)	Formula for determination of force has been specified	312-11-1473c of 26.11.2020	01.01.2021
Para 1.2.3.2.1.2	Definition for the displacement has been specified in the explication to Formulae	312-11-1473c of 26.11.2020	01.01.2021
Formula (1.2.3.2.1.2-2)	Formula for determination of force has been specified	312-11-1473c of 26.11.2020	01.01.2021
Para 1.2.3.2.2	Definitions for the displacement and ship displacement factor have been specified in the explication to Formulae	312-11-1473c of 26.11.2020	01.01.2021

[1] Amendments and additions introduced at re-publication or by new versions based on circular letters or editorial amendments.

Amended paras/chapters/sections	Information on amendments	Number and date of the Circular Letter	Entry-into-force date
Table 1.2.12.2	Symbol for the length has been specified	312-11-1473c of 26.11.2020	01.01.2021
Para 1.2.13.2.1	Definitions for $F_{IB,1}$, C, B, L_B, D and A_{wp} have been specified in the explication to Formulae	312-11-1473c of 26.11.2020	01.01.2021
Figures 1.2.13.2.1-1 and 1.2.13.2.1-2	Symbol for the breadth has been specified	312-11-1473c of 26.11.2020	01.01.2021
Paras 1.2.13.3.1 and 1.2.13.4.1	Symbol for the length has been specified	312-11-1473c of 26.11.2020	01.01.2021
Para 3.6.3.8	Requirements for prevention of lubricating oil and hydraulic oil leakages into seawater have been specified	313-67-1486c of 01.03.2020	01.03.2021
Table 5.6.3	Table containing data on equipment of ships with bow chain stoppers and bow fairleads has been introduced (for the Russian version of the Rules only)	314-20-1481c of 10.12.2020	15.01.2021
Paras 5.6.8 — 5.6.15	New para 5.6.8 containing requirements for type of bow chain stoppers has been introduced considering IACS Recommendation No. 13 (Rev.3 July 2020). Existing paras 5.6.8 — 5.6.14 and references thereto have been renumbered 5.6.9 — 5.6.15 accordingly	314-20-1481c of 10.12.2020	15.01.2021
Para 5.6.16	New para 5.6.16 containing requirements for agreement of documentation in accordance with Mooring Equipment Guidelines (MEG 4) has been introduced considering IACS Recommendation No. 13 (Rev.3 July 2020). Procedure of verification of ship's compliance with the provisions of Mooring Equipment Guidelines (MEG 4) has been specified	314-20-1481c of 10.12.2020 312-11-1527c of 18.03.2021	15.01.2021 19.04.2021

Amended paras/chapters/sections	Information on amendments	Number and date of the Circular Letter	Entry-into-force date
Para 5.6.17	New para 5.6.17 containing correction requirements for the chain bearing surface of the bow fairleads has been introduced considering IACS Recommendation No. 13 (Rev.3 July 2020). Para has been deleted in connection with transfer of requirements to para 5.6.16.2	314-20-1481c of 10.12.2020 312-11-1527c of 18.03.2021	15.01.2021 19.04.2021
Chapter 7.6	Chapter has been amended considering experience in application of the Rules	313-67-1486c of 01.03.2020	01.03.2021
Para 7.7.1.1	The term "standard sized valves" has been replaced by the term "standard series of valves"	312-11-1527c of 18.03.2021	19.04.2021
Table 10.7.6.2.3-1	Values of coefficients have been specified in connection with the information on misprints received from the developer of the Finnish-Swedish Ice Class Rules	312-11-1527c of 18.03.2021	19.04.2021
Appendix to Section 10	Requirements for dimensions of letters have been specified in Note 4 in accordance with the Finnish-Swedish Ice Class Rules	312-11-1527c of 18.03.2021	19.04.2021
Chapter 19.3	New Chapter with the requirements for subdivision has been introduced	312-11-1527c of 18.03.2021	19.04.2021
Section 21	New Section with the requirements for ships and offshore installations equipped with position-keeping/position mooring systems has been introduced	312-11-1523c of 12.03.2021	15.04.2021
Section 22	New Section containing requirements for assignment of new distinguishing mark **CON-M** specifying the necessity for monitoring of critical structural areas has been introduced	312-11-1537c of 29.03.2021	01.05.2021

1 REQUIREMENTS FOR POLAR CLASS SHIPS

1.1 POLAR CLASS DESCRIPTIONS AND APPLICATION

1.1.1 Application.

1.1.1.1 The requirements for polar class ships apply to ships constructed of steel and intended for independent navigation in ice-infested polar waters.

The requirements of this Section apply to ships contracted for construction on or after 1 July 2017.

N o t e . The "contracted for construction" date means the date on which the contract to build the ship is signed between the prospective owner and the shipbuilder. For further details regarding the date of "contracted for construction", refer to 1.1.2, Part I "Classification".

1.1.1.2 Ships that comply with the requirements of 1.2 and 1.3 can be considered for a polar class notation specified in Table 1.1.1.2. These requirements are additional to the RS requirements for ships without ice class assigned. If the hull and machinery are constructed such as to comply with the requirements of different polar classes, then both the hull and machinery shall be assigned the lower of these classes in the Certificate of Classification. Compliance of the hull or machinery with the requirements of a higher polar class shall also be indicated in the Certificate of Classification in column "Other characteristics".

T a b l e 1.1.1.2

Polar class descriptions

Polar class	Ice description (based on WMO Sea Ice Nomenclature)
PC1	Year-round operation in all polar waters
PC2	Year-round operation in moderate multi-year ice conditions
PC3	Year-round operation in second-year ice which may include multi-year ice inclusions
PC4	Year-round operation in thick first-year ice which may include old ice inclusions
PC5	Year-round operation in medium first-year ice which may include old ice inclusions
PC6	Summer/autumn operation in medium first-year ice which may include old ice inclusions
PC7	Summer/autumn operation in thin first-year ice which may include old ice inclusions

1.1.1.3 Ships which are assigned a polar class notation and complying with the relevant requirements of 1.2 and 1.3 may be given an ice class mark **Icebreaker**.

"**Icebreaker**" refers to any ship having an operational profile that includes escort or ice management functions, having powering and dimensions that allow it to undertake aggressive operations in ice-covered waters.

1.1.1.4 For ships which are assigned a polar class notation, the hull form and propulsion power plant shall be such that the ship can operate independently and at continuous speed in a representative ice condition, as defined in Table 1.1.1.2 for the corresponding polar class.

For ships and ship-shaped floating facilities which are intentionally not designed to operate independently in ice, such operational intent or limitations shall be explicitly stated in the Certificate of Classification.

1.1.1.5 For ships which are assigned a polar class notation **PC1** to **PC5**, bows with vertical sides, and bulbous bows generally shall be avoided. Bow angles shall in general be within the range specified in 1.2.3.1.5.

1.1.1.6 For ships which are assigned a polar class notation **PC6** and **PC7**, and are designed with a bow with vertical sides or bulbous bows, operational limitations (restricted from intentional ramming) in design conditions shall be stated in the Certificate of Classification.

1.1.2 Polar Classes.

1.1.2.1 The polar class (**PC**) notations and descriptions are specified in Table 1.1.1.2. It is the responsibility of the shipowner to select an appropriate polar class. The descriptions in Table 1.1.1.2 are intended to guide shipowners, designers and Administrations in selecting an appropriate polar class to comply with the requirements for the ship in intended voyage or service areas.

1.1.2.2 The polar class notation is used throughout this Section to convey the differences between classes with respect to operational capability and strength.

1.1.3 Upper and Lower Ice Waterlines.

1.1.3.1 The upper and lower ice waterlines upon which the design of the ship has been based shall be indicated in the Certificate of Classification. The upper ice waterline (UIWL) shall be defined by the maximum draughts fore, amidships and aft. The lower ice waterline (LIWL) shall be defined by the minimum draughts fore, amidships and aft.

1.1.3.2 The lower ice waterline shall be determined with due regard to the ship's ice-going capability in the ballast loading conditions. The propeller shall be fully submerged at the lower ice waterline.

1.2 STRUCTURAL REQUIREMENTS FOR POLAR CLASS SHIPS

1.2.1 Application and definitions.

1.2.1.1 The requirements of this Section apply to polar class ships in compliance with 1.1.

1.2.1.2 The length L_{UI} is the distance, in m, measured horizontally from the fore side of the stem at the intersection with the UIWL to the after side of the rudder post, or the centre of the rudder stock if there is no rudder post. L_{UI} shall not to be less than 96 %, and need not be greater than 97 %, of the extreme length of the UIWL measured horizontally from the fore side of the stem.

1.2.1.3 The ship displacement D_{UI} is the displacement, in kt, of the ship corresponding to the UIWL. Where multiple waterlines are used for determining the UIWL, the displacement shall be determined from the waterline corresponding to the greatest displacement.

1.2.2 Hull areas.

1.2.2.1 The hull of all polar class ships is divided into areas reflecting the magnitude of the loads that are expected to act upon them. In the longitudinal direction, there are four regions: bow (B), bow intermediate (BI), midbody (M) and stern (S). Besides, the bow intermediate, midbody and stern regions are further divided in the vertical direction into the bottom (b), lower (l) and ice belt regions. The extention of ice strengthening region shall be determined in compliance with Fig. 1.2.2.1.

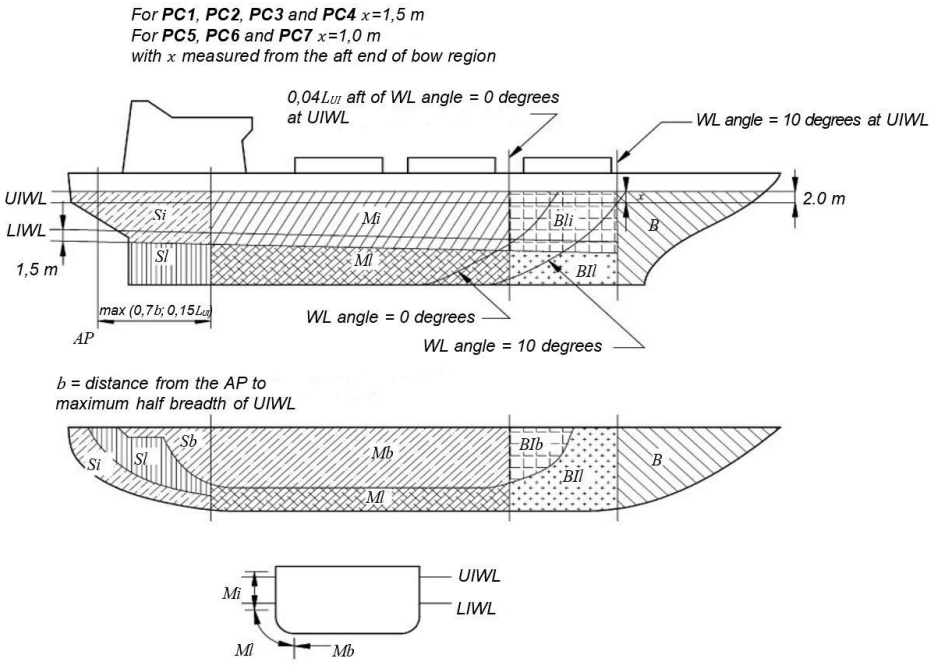


Fig. 1.2.2.1
Hull area extents

1.2.2.2 The UIWL and LIWL are as defined in 1.1.3.

1.2.2.3 Fig. 1.2.2.1 notwithstanding, at no time shall the boundary between the bow and bow intermediate regions be forward of the intersection point of the line of the stem and the ship baseline.

1.2.2.4 Fig. 1.2.2.1 notwithstanding, the aft boundary of the bow region need not be more than $0{,}45L_{UI}$ aft of the fore side of the stem at the intersection with the UIWL.

1.2.2.5 The boundary between the bottom and lower regions shall be taken at the point where the shell is inclined 7° from horizontal.

1.2.2.6 If a ship is intended to operate astern in ice regions, the aft section of the ship shall be designed using the bow and bow intermediate hull ice belt requirements.

1.2.2.7 If the ship is assigned the ice class mark **Icebreaker**, the forward boundary of the stern region shall be at least 0,04L_{UI} forward of the section where the parallel ship side at the UIWL ends.

1.2.3 Design ice loads.

1.2.3.1 General.

1.2.3.1.1 A glancing impact on the bow is the design scenario for determining the scantlings required to resist ice loads.

1.2.3.1.2 The design ice load is characterized by an average pressure P_{avg} uniformly distributed over a rectangular load patch of height b and width w.

1.2.3.1.3 Within the bow area of all polar classes, and within the bow intermediate ice belt area of polar classes **PC6** and **PC7**, the ice load parameters are functions of the actual bow shape. To determine the ice load parameters P_{avg}, b and w, it is required to calculate the following ice load characteristics for subregions of the bow area; shape coefficient f_{a_i}, total glancing impact force F_i, line load Q_i and pressure P_i.

1.2.3.1.4 In other ice-strengthened areas, the ice load parameters P_{avg}, b_{NonBow} and w_{NonBow} are determined independently of the hull shape and based on a fixed load patch aspect ratio, $AR = 3{,}6$.

1.2.3.1.5 Design ice forces calculated according to 1.2.3.2.1.1 are applicable for bow forms where the buttock angle γ at the stem is positive and γ less than 80 deg. and the normal frame angle β' at the centre of the foremost sub-region, as defined in 1.2.3.2.1, is greater than 10 deg.

1.2.3.1.6 Design ice forces calculated according to 1.2.3.2.1.2 are applicable for ships which are assigned the polar class **PC6** or **PC7** and have a bow form with vertical sides. The requirements of 1.2.3.2.1.2 shall apply where the normal frame angles β' at the considered sub-regions, as defined in 1.2.3.2.1, are between 0 and 10 deg.

1.2.3.1.7 For ships which are assigned the polar class **PC6** or **PC7**, and equipped with bulbous bows, the design ice forces on the bow shall be determined according to 1.2.3.2.1.2. In addition, the design forces shall not be taken less than those specified in 1.2.3.2.1.1, assuming $f_a = 0{,}6$ and AR = 1,3.

1.2.3.1.8 For ships with bow forms other than those defined in 1.2.3.1.5 to 1.2.3.1.7, design forces shall be determined according to the procedures approved by the Register.

1.2.3.1.9 Ship structures that are not directly subjected to ice loads may still experience inertial loads of stowed cargo and equipment resulting from ship/ice interaction. These inertial loads, based on accelerations determined according to the procedure approved by the Register, shall be considered in the design of these structures.

1.2.3.2 Glancing impact load characteristics.

The parameters defining the glancing impact load characteristics are reflected in the class factors listed in Tables 1.2.3.2-1 and 1.2.3.2-2.

Table 1.2.3.2-1

Class factors to be used for calculations according to 1.2.3.2.1.1

Polar class	Crushing failure class factor CF_C	Flexural failure class factor CF_F	Load patch dimensions class factor CF_D	Displacement class factor CF_{DIS}	Longitudinal strength class factor CF_L
PC1	17,69	68,60	2,01	250	7,46
PC2	9,89	46,80	1,75	210	5,46
PC3	6,06	21,17	1,53	180	4,17
PC4	4,50	13,48	1,42	130	3,15
PC5	3,10	9,00	1,31	70	2,50
PC6	2,40	5,49	1,17	40	2,37
PC7	1,80	4,06	1,11	22	1,81

Table 1.2.3.2-2

Class factors to be used for calculations according to 1.2.3.2.1.2

Polar class	Crushing failure class factor CF_C	Line load class factor CF_{QV}	Pressure class factor CF_{PV}
PC6	3,43	2,82	0,65
PC7	2,60	2,33	0,65

1.2.3.2.1 Bow area.

In the bow area, the force F, line load Q, pressure P and load patch aspect ratio AR associated with the glancing impact load scenario are functions of the hull angles measured at the UIWL. The influence of the hull angles is captured through calculation of a bow shape coefficient f_a. The hull angles are defined in Fig. 1.2.3.2.1.

The waterline length of the bow region shall generally be divided into 4 sub-regions of equal length. The force F, line load Q, pressure P and load patch aspect ratio AR shall be calculated with respect to the mid-length position of each sub-region (each maximum of F, Q and P shall be used in the calculation of the ice load parameters P_{avg}, b and w).

1.2.3.2.1.1 The bow area load characteristics are determined as follows:

shape coefficient f_{a_i}:

$$f_{a_i} = \min\left(f_{a_{i,1}}; f_{a_{i,2}}; f_{a_{i,3}}\right) \quad \text{(1.2.3.2.1.1-1)}$$

$$f_{a_{i,1}} = \left(0{,}097 - 0{,}68 \cdot \left({}^{x}/_{L_{UI}} - 0{,}15\right)^2\right) \cdot \alpha_i / \left(\beta'_i\right)^{0{,}5};$$

$$f_{a_{i,2}} = 1{,}2 \cdot CF_F / \left(\sin(\beta'_i) \cdot CF_C \cdot {D_{UI}}^{0{,}64}\right);$$

$$f_{a_{i,3}} = 0{,}60;$$

force F, in MN:

$$F_i = f_{a_i} \cdot CF_C \cdot {D_{UI}}^{0{,}64}; \quad \text{(1.2.3.2.1.1-2)}$$

load patch aspect ratio AR:

$$AR = 7{,}46 \cdot \sin(\beta'_i) \geq 1{,}3; \quad \text{(1.2.3.2.1.1-3)}$$

line load Q, in MN/m:

$$Q_i = F_i^{0{,}61} CF_D / AR_i^{0{,}35}; \quad \text{(1.2.3.2.1.1-4)}$$

pressure P, in MPa:

$$P_i = F_i^{0{,}22} CF_D^2 AR_i^{0{,}3} \quad \text{(1.2.3.2.1.1-5)}$$

where i = sub-region considered;
L_{UI} = ship length, in m, as defined in 1.2.1.2;
x = distance, in m, from the fore side of the stem at the intersection with the UIWL to station under consideration;
a = waterline angle, in deg. (refer to Fig. 1.2.3.2.1);
β' = normal frame angle, in deg., measured as per normal to the outer shell (refer to Fig. 1.2.3.2.1);
D_{UI} = ship displacement, in kt, as defined in 1.2.1.3, but not less than 5 kt;
CF_C = crushing failure class factor according to Table 1.2.3.2-1;
CF_F = Flexural failure Class Factor according to Table 1.2.3.2-1;
CF_D = load patch dimensions class factor according to Table 1.2.3.2-1.

1.2.3.2.1.2 The bow area load characteristics for bow forms defined in 1.2.3.1.6 shall be determined according to the following formulae:

shape coefficient, f_{a_i}:

$$f_{a_i} = \alpha_i/30; \quad (1.2.3.2.1.2\text{-}1)$$

force F, in MN:

$$F_i = f_{a_i} \cdot CF_{CV} \cdot {D_{UI}}^{0,47}; \quad (1.2.3.2.1.2\text{-}2)$$

line load Q, in MN/m:

$$Q_i = F_i^{0,22} CF_{QV}; \quad (1.2.3.2.1.2\text{-}3)$$

pressure P, in kPa:

$$P_i = F_i^{0,56} CF_{PV} \quad (1.2.3.2.1.2\text{-}4)$$

where i = sub-region considered;
a = waterline angle, deg. (refer to Fig. 1.2.3.2.1);
D_{UI} = ship displacement, in kt, as defined in 1.2.1.3, but not less than 5 kt;
CF_{CV} = crushing failure class factor according to Table 1.2.3.2-2;
CF_{QV} = line load class factor according to Table 1.2.3.2-2;
CF_{PV} = pressure class factor according to Table 1.2.3.2-2.

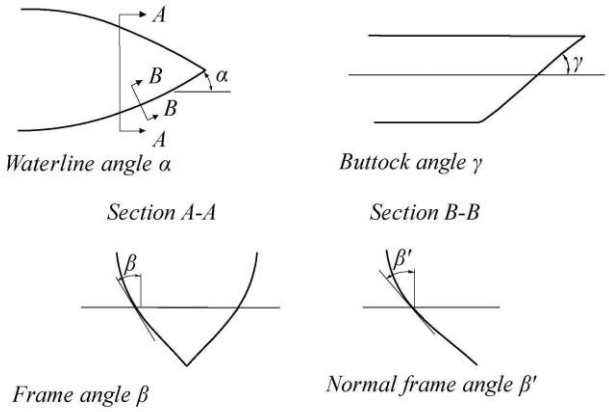


Fig. 1.2.3.2.1
Definition of hull angles

N o t e s : β' = normal frame angle at upper ice waterline, in deg.;
α = upper ice waterline angle, in deg.;
γ = buttock angle at upper ice waterline (angle of buttock line measured from horizontal), in deg.;
$\text{tg}\beta = \text{tg}\alpha/\text{tg}\gamma$;
$\text{tg}\beta' = \text{tg}\beta \cdot \cos\alpha$.

1.2.3.2.2 Hull areas other than the bow.

In the hull areas other than the bow, the force F_{NonBow}, in MN, and line load Q_{NonBow}, in MN/m, used in the determination of the load patch dimensions b_{NonBow}, w_{NonBow} and design pressure P_{avg} are determined according to the following formulae:

$$F_{NonBow} = 0{,}36 CF_C DF; \quad (1.2.3.2.2\text{-}1)$$

$$Q_{NonBow} = 0{,}639 F_{NonBow}^{0,61} CF_D \quad (1.2.3.2.2\text{-}2)$$

where CF_C = crushing failure class factor according to Table 1.2.3.2-1;
DF = ship displacement factor:
$DF = D_{UI}{}^{0,64}$ if $D_{UI} \leq CF_{DIS}$;
$DF = CF_{DIS}{}^{0,64} + 0{,}10\ (D_{UI} - CF_{DIS})$ if $D_{UI} > CF_{DIS}$;
D_{UI} = ship displacement, in kt, as defined in 1.2.1.3, but not less than 10 kt;
CF_{DIS} = displacement class factor according to Table 1.2.3.2-1.

1.2.3.3 Design load patch.

In the bow area, and the bow intermediate ice belt area for ships with class notation **PC6** and **PC7**, the design load patch has dimensions of width w_{Bow}, in m, and height, b_{Bow}, in m, shall be determined according to the following formulae:

$$w_{Bow} = F_{Bow}/Q_{Bow}; \quad (1.2.3.3\text{-}1)$$

$$b_{Bow} = Q_{Bow}/P_{Bow} \quad (1.2.3.3\text{-}2)$$

where F_{Bow} = maximum force F_i, in kN, in the bow area according to 1.2.3.2.1;
Q_{Bow} = maximum line load Q_i, in MN/m, in the bow area according to 1.2.3.2.1;
P_{Bow} = maximum pressure P_i, in MPa, in the bow area according to 1.2.3.2.1.

In other hull areas, the design load patch has dimensions of width, w_{NonBow}, in m, and height, b_{NonBow} in m, shall be determined according to the following formulae:

$$w_{NonBow} = F_{NonBow}/Q_{NonBow}; \quad (1.2.3.3.2\text{-}1)$$

$$b_{NonBow} = w_{NonBow}/3{,}6 \quad (1.2.3.3.2\text{-}2)$$

where F_{NonBow} = force, in kN, according to 1.2.3.2.2;
Q_{NonBow} = line load, in MN/m, according to 1.2.3.2.2.

1.2.3.4 Pressure within the design load patch.

1.2.3.4.1 The average pressure P_{avg}, in MPa, within a design load patch is determined as follows:

$$P_{avg} = F/(b \cdot w) \quad (1.2.3.4.1)$$

where $F = F_{Bow}$ or F_{NonBow} as appropriate for the hull area under consideration, in MN;
$b = b_{Bow}$ or b_{NonBow} as appropriate for the hull area under consideration, in m;
$w = w_{Bow}$ or w_{NonBow} as appropriate for the hull area under consideration, in m.

1.2.3.4.2 Areas of higher, concentrated pressure exist within the load patch. In general, smaller areas have higher local pressures. Accordingly, the peak pressure factors listed in Table 1.2.3.4.2 are used to account for the pressure concentration on localized structural members.

Table 1.2.3.4.2

Peak pressure factors

Structural member		Peak pressure factor PPF_i
Plating	Transversely-framed	$PPF_p = (1{,}8 - s) \geq 1{,}2$
	Longitudinally-framed	$PPF_p = (2{,}2 - 1{,}2s) \geq 1{,}5$
Frames in transverse framing systems	With load distributing stringers	$PPF_t = (1{,}6 - s) \geq 1{,}0$
	With no load distributing stringers	$PPF_t = (1{,}8 - s) \geq 1{,}2$
Frames in bottom structures		$PPF_s = (1{,}6 - s) \geq 1{,}0$
Load carrying stringers; side longitudinals;		$PPF_s = 1{,}0$ if $S_w \geq 0{,}5w$ $PPF_s = 2{,}0 - 2{,}0 \cdot S_w/w$ if $S_w < 0{,}5w$

Structural member		Peak pressure factor PPF_i
web frames		
where s = frame or longitudinal spacing, in m; S_w = web frame spacing, in m; w = ice load patch width, in m.		

1.2.3.5 Hull area factors.

Associated with each hull ice-strengthened areas is an area factor that reflects the relative magnitude of the load expected in that area. The area factors *AF* for each hull area are specified in Table 1.2.3.5-1.

Table 1.2.3.5-1

Hull area factors *AF*

Hull area		Area	Polar class						
			PC1	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**
Bow (B)	All	B	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Bow Intermediate (BI)	Ice belt	BI_i	0,90	0,85	0,85	0,80	0,80	1,00[1]	1,00[1]
	Lower	BI_l	0,70	0,65	0,65	0,60	0,55	0,55	0,50
	Bottom	BI_b	0,55	0,50	0,45	0,40	0,35	0,30	0,25
Midbody (M)	Ice belt	M_i	0,70	0,65	0,55	0,55	0,50	0,45	0,45
	Lower	M_l	0,50	0,45	0,40	0,35	0,30	0,25	0,25
	Bottom	M_b	0,30	0,30	0,25	[2]	[2]	[2]	[2]
Stern (S)	Ice belt	S_i	0,75	0,70	0,65	0,60	0,50	0,40	0,35
	Lower	S_l	0,45	0,40	0,35	0,30	0,25	0,25	0,25
	Bottom	S_b	0,35	0,30	0,30	0,25	0,15	[2]	[2]

[1] Refer to 1.2.3.1.3.
[2] Ice strengthening is not required.

In the event that a structural member spans across the boundary of a hull area, the largest hull area factor shall be used in the scantling determination of the member.

The values of hull area factors of stern ice belt S_i and stern lower S_l of ships having propulsion arrangements with azimuth thrusters are specified in Table 1.2.3.5-2.

Table 1.2.3.5-2

Hull area		Area	Polar class						
			PC1	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**
Stern (S)	Ice belt	S_i	0,90	0,85	0,80	0,75	0,65	0,55	0,50
	Lower	S_l	0,60	0,55	0,50	0,45	0,40	0,40	0,40
	Bottom	S_b	0,5	0,30	0,30	0,25	0,15	[1]	[1]

[1] Ice strengthening is not required.

For ships assigned the ice class mark **Icebreaker**, the area factor AF, for each hull area is specified in Table 1.2.3.5-3.

Table 1.2.3.5-3

Hull area		Area	Polar class						
			PC1	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**
Bow (B)	All	B	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Bow Intermediate (BI)	Ice belt	BI_i	0,90	0,85	0,85	0,85	0,85	1,00	1,00
	Lower	BI_l	0,70	0,65	0,65	0,65	0,65	0,65	0,65
	Bottom	BI_b	0,55	0,50	0,45	0,45	0,45	0,45	0,45
Midbody (M)	Ice belt	M_i	0,70	0,65	0,55	0,55	0,55	0,55	0,55
	Lower	M_l	0,50	0,45	0,40	0,40	0,40	0,40	0,40
	Bottom	M_b	0,30	0,30	0,25	0,25	0,25	0,25	0,25

Hull area		Area	Polar class						
			PC1	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**
Stern (S)	Ice belt	S_i	0,95	0,90	0,80	0,80	0,80	0,80	0,80
	Lower	S_l	0,55	0,50	0,45	0,45	0,45	0,45	0,45
	Bottom	S_b	0,35	0,30	0,30	0,30	0,30	0,30	0,30

1.2.4 Shell plate requirements.

1.2.4.1 The required minimum shell plate thickness t, in mm, is determined by the formula

$$t = t_{net} + t_s \tag{1.2.4.1}$$

where t_{net} = plate thickness required to resist ice loads according to 1.2.4.2, in mm;
t_s = corrosion and abrasion allowance according to 1.2.11, in mm.

1.2.4.2 The thickness of shell plating required to resist the design ice load t_{net}, in mm, depends on the orientation of the framing.

In the case of transversely-framed plating ($\Omega \geq 70$ deg.), including all bottom plating, i.e. in hull areas BI_b, M_b and S_b, the net thickness shall be determined by formula

$$t_{net} = 500s\left(\left(AF \cdot PPF_p \cdot P_{avg}\right)/\sigma_y\right)^{0,5}/(1 + s/2b). \tag{1.2.4.2-1}$$

In the case of longitudinally-framed plating ($\Omega \leq 20$ deg.), when $b \geq s$, the net thickness shall be determined by formula

$$t_{net} = 500s\left(\left(AF \cdot PPF_p \cdot P_{avg}\right)/\sigma_y\right)^{0,5}/(1 + s/2l). \tag{1.2.4.2-2}$$

In the case of longitudinally-framed plating ($\Omega \leq 20$ deg.), when $b < s$, the net thickness shall be determined by formula

$$t_{net} = 500s\left(\left(AF \cdot PPF_p \cdot P_{avg}\right)/\sigma_y\right)^{0,5} \cdot (2b/s - (b/s)^2)^{0,5}/(1 + s/2l). \tag{1.2.4.2-3}$$

where Ω = smallest angle between the chord of the waterline and the line of the main framing according to Fig. 1.2.4.2, in deg.;
s = transverse frame spacing in transversely-framed ships or longitudinal frame spacing in longitudinally-framed ships, in m;
AF = hull area factor from Table 1.2.3.5-3;
PPF_p = peak pressure factor from Table 1.2.3.4.2;
P_{avg} = average patch pressure according to Formula (1.2.3.4.1), in MPa;
σ_y = minimum upper yield stress of the material, in N/mm^2;
b = height of design load patch, in m, where $b \geq (l - s/4)$ in the case determined by Formula (1.2.4.2-1);
l = distance between frame supports, i.e. equal to the frame span as given in 1.2.5.5, but not reduced for any fitted end brackets, in m. When a load-distributing stringer is fitted, the length l need not be taken larger than the distance from the stringer to the most distant frame support.

When $20° < \Omega < 70°$, net thickness of the shell plating shall be determined by linear interpolation.

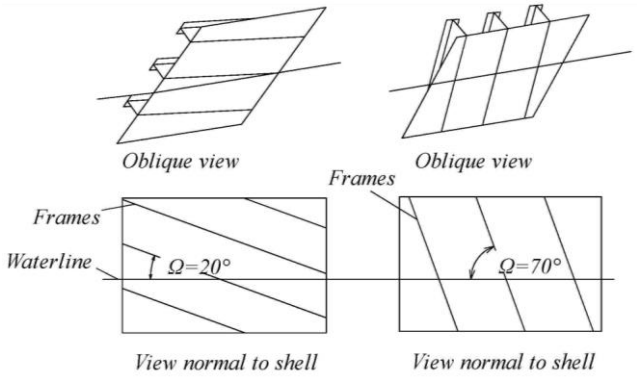


Fig. 1.2.4.2
Shell framing angle Ω

1.2.5 Framing. General.

1.2.5.1 Framing members of polar class ships shall be designed to withstand the ice loads defined in 1.2.3.

1.2.5.2 The term "framing member" refers to transverse and longitudinal local frames, load-carrying stringers and web frames in the hull strengthening regions (refer to Fig. 1.2.2.1).

1.2.5.3 The strength of a framing member is dependent upon the fixity that is provided at its supports. Fixity can be assumed where framing members are either continuous through the support or attached to a supporting section with a connection bracket. In other cases, simple support shall be assumed unless the connection can be demonstrated to provide significant rotational restraint. Fixity shall be ensured at the support of any framing which terminates within an ice-strengthened area.

1.2.5.4 The intersections of framing members with plate structures shall be executed in accordance with 3.10.2.4.5, Part II "Hull". The details for securing the ends of framing members at supporting sections, shall comply with 1.7.2.2 and 2.5.5, Part II "Hull".

1.2.5.5 The effective span of a framing member shall be determined on the basis of its moulded length. If end brackets are fitted, the effective span may be reduced in accordance with 3.10.2.2.3, Part II "Hull". Brackets shall be configured to ensure stability in the elastic and post-yield response regions.

1.2.5.6 When calculating the section modulus and shear area of a framing member, net thicknesses of the web, flange and attached shell plating shall be used. The shear area of a framing member may include that material contained over the full depth of the member, i.e. web area including portion of flange, if fitted, but excluding attached shell plating.

1.2.5.7 The actual net effective shear area A_w, in cm^2, of a transverse or longitudinal local frame shall be determined by formula

$$A_w = ht_{wn} \sin \varphi_w / 100 \qquad (1.2.5.7)$$

where h = height of stiffener, in mm, refer to Fig. 1.2.5.7;
t_{wn} = net web thickness, in mm;
$t_{wn} = t_w - t_c$;
t_w = as built web thickness, in mm (refer to Fig. 1.2.5.7);
t_c = corrosion deduction, in mm, to be subtracted from the web and flange thickness (according to 3.10.4.1, Part II "Hull", but not less than t_s as required by 1.2.11.3);
φ_w = smallest angle between shell plate and stiffener web, measured at the midspan of the stiffener (refer to Fig. 1.2.5.7). The angle φ_w may be taken as 90 deg., provided the smallest angle is not less than 75 deg.

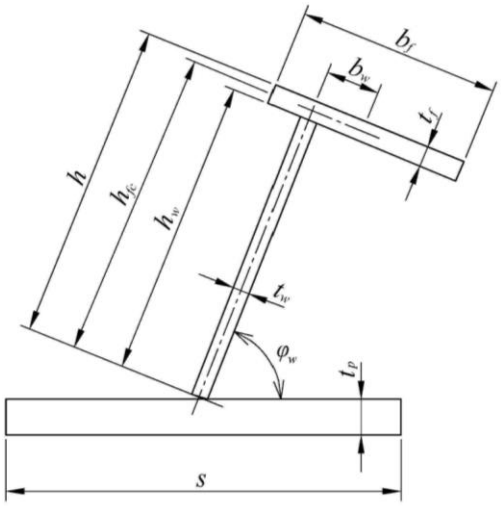


Fig. 1.2.5.7
Stiffener geometry

1.2.5.8 When the cross-sectional area of the attached plate flange exceeds the cross-sectional area of the local frame, the actual net effective plastic section modulus Z_p, in cm^3, of a transverse or longitudinal frame shall be determined by formula

$$Z_p = A_{pn}t_{pn}/20 + \frac{h_w^2 t_{wn}\sin\varphi_w}{2000} + A_{fn}\left(h_{fc}\sin\varphi_w - b_w\cos\varphi_w\right)/10 \qquad (1.2.5.8\text{-}1)$$

where h, t_{wn}, t_c, and φ_w are as given in 1.2.5.7 and s as given in 1.2.4.2;
A_{pn} = net cross-sectional area of the local frame, in cm^2;
t_{pn} = fitted net shell plate thickness, in mm, complying with t_{net} as required by 1.2.4.2;
h_w = height of local frame web, in mm (refer to Fig. 1.2.5.7);
A_{fn} = net cross-sectional area of local frame flange, in cm^2;
h_{fc} = height of local frame measured to centre of the flange area, in mm (refer to Fig. 1.2.5.7);
b_w = distance from mid thickness plane of local frame web to the centre of the flange area, in mm (refer to Fig. 1.2.5.7).

When the cross-sectional area of the local frame exceeds the cross-sectional area of the attached plate flange, the plastic neutral axis is located a distance z_{na}, in mm, above the attached shell plate, and when the cross-sectional area of the attached plate flange exceeds the cross-sectional area of the local frame, the actual net effective plastic section modulus, Z_p, in cm^3, of a transverse or longitudinal frame is given by:

$$z_{na} = \left(100A_{fn} + ht_{wn} - 1000t_{pn}s\right)/2t_{wn} \qquad (1.2.5.8\text{-}2)$$

$$Z_p = t_{pn}s\left(z_{na} + \frac{t_{pn}}{2}\right)\sin\varphi_w + \left(\frac{\left((h_w - z_{na})^2 + z_{na}^2\right)t_{wn}\sin\varphi_w}{2000} + A_{fn}\cdot\frac{\left(h_{fc} - z_{na}\right)\sin\varphi_w - b_w\cos\varphi_w}{10}\right). \qquad (1.2.5.8\text{-}3)$$

1.2.5.9 In case, when $20° < \Omega < 70°$, where Ω is defined as specified in 1.2.4.2, linear interpolation shall be used.

1.2.6 Framing. Local frames in bottom structures and transverse local frames in side structures.

1.2.6.1 The local frames in bottom structures (i.e. hull regions B_{lb}, M_b and S_b) and transverse local frames in side structures shall be dimensioned such that the combined effects of shear and bending do not exceed the plastic strength of the member. The plastic strength is defined by the magnitude of midspan load that causes the development of a plastic collapse

mechanism. For bottom structure the patch load shall be applied with the dimension b parallel with the frame direction.

1.2.6.2 The actual net effective shear area of the frame A_w, in cm^2, as defined in 1.2.5.7, shall comply with the following condition: $A_w \geq A_t$, where

$$A_t = \left(100^2 \cdot 0{,}5LL \cdot s\left(AF \cdot PPF \cdot P_{avg}\right)\right)/\left(0{,}577\sigma_y\right) \qquad (1.2.6.2)$$

where LL = length of loaded portion of span = lesser of a and b, in m;
a = frame span as defined in 1.2.5.5, in m;
b = height of design ice load patch as defined in 1.2.3.3;
s = transverse frame spacing, in m;
AF = hull area factor according to 1.2.3.5;
PPF_t = peak pressure factor PPF_t or PPF_s as appropriate according to Table 1.2.3.4.2;
P_{avg} = average pressure within load patch as defined in 1.2.3.4;
σ_y = minimum upper yield stress of the material, in N/mm^2.

1.2.6.3 The actual net effective plastic section modulus of the frame with effective flange Z_p as defined in 1.2.5.8, shall comply with the following condition: $Z_p \geq Z_{pt}$, where Z_{pt}, in cm^3, shall be the greater calculated on the basis of two load conditions: ice load acting at the midspan of the transverse frame; and the ice load acting near a support.

$$Z_{pt} = 100^3 LL \cdot Y \cdot s\left(AF \cdot PPF \cdot P_{avg}\right)a \cdot A_1/\left(0{,}577\sigma_y\right) \qquad (1.2.6.3)$$

where AF, PPF, P_{avg}, LL, b, s, a and σ_y are as given in 1.2.6.2;
$Y = 1 - 0{,}5(LL/a)$;
A_1 = maximum of:
$A_{1A} = 1/(1 + j/2 + k_w j/2[(1 - a_1^2)^{0,5} - 1])$;
$A_{1B} = \left(1 - 1/(2a_1 \cdot Y)\right)/\left(0{,}275 + 1{,}44k_z^{0,7}\right)$;
$j = 1$ for framing with one simple support outside the ice-strengthened areas;
$j = 2$ for framing without any simple supports;
$a_1 = A_t/A_w$;
A_t = minimum shear area of transverse frame as given in 1.2.6.2, in cm^2;
A_w = effective net shear area of transverse frame (calculated according to 1.2.5.7), in cm^2;
$k_w = 1/\left(1 + 2A_{fn}/A_w\right)$, with A_{fn} as given in 1.2.5.8;
$k_z = z_p/Z_p$, in general;
$k_z = 0{,}0$, when the frame is arranged with end bracket;
z_p = sum of individual plastic section moduli of flange and shell plate as fitted, in cm^3;
$z_p = \left(b_f t_{fn}^2/4 + b_{eff} t_{pn}^2/4\right)/1000$;
b_f = flange breadth, in mm, refer to Fig. 1.2.5.7;
t_{fn} = net flange thickness, in mm;
$t_{fn} = t_f - t_c$ (t_c as given in 1.2.5.7);
t_f = as-built flange thickness, in mm, refer to Fig. 1.2.5.7;
t_{pn} = the fitted net shell plate thickness, in mm (not to be less than t_{net} as given in 1.2.4);
b_{eff} = effective width of shell plate flange, in mm;
$b_{eff} = 500s$;
Z_p = actual net effective plastic section modulus determined according to 1.2.5.8.

1.2.6.4 The scantlings of the frame shall meet the structural stability requirements of 1.2.9.

1.2.7 Framing. Longitudinal local frames in side structures.

1.2.7.1 Longitudinal local frames in side structures shall be dimensioned such that the combined effects of shear and bending do not exceed the plastic strength of the member. The plastic strength is defined by the magnitude of midspan load that causes the development of a plastic collapse mechanism.

1.2.7.2 The actual net effective shear area of the longitudinal frame A_w as defined in 1.2.5.7, shall comply with the following condition: $A_w \geq A_L$, where

$$A_L = 100^2\left(AF \cdot PPF_s \cdot P_{avg}\right) \cdot 0{,}5 b_1 a / \left(0{,}577\sigma_y\right), \text{ in cm}^2 \qquad (1.2.7.2)$$

where AF = hull area factor according to 1.2.3.5;
PPF_s = refer to Table 1.2.3.4.2;
P_{avg} = average pressure within load patch according to 1.2.3.4;
$b_1 = k_0 b_2$, in m;
$k_0 = 1 - 0{,}3/b'$;
$b' = b/s$;
b = height of design ice load patch according to 1.2.3.3;
s = spacing of longitudinal frames, in m;
$b_2 = b(1 - 0{,}25b')$, in m, if $b' < 2$;
$b_2 = s$, in m, if $b' \geq 2$;
a = effective span of longitudinal local frame according to 1.2.5.5;
σ_y = minimum upper yield stress of the material, in N/mm^2.

1.2.7.3 The actual net effective plastic section modulus of the longitudinal frame with effective flange Z_p as defined in 1.2.5.8, shall comply with the following condition: $Z_p \geq Z_{pL}$, where

$$Z_{pL} = 100^3\left(AF \cdot PPF_s \cdot P_{avg}\right) b_1 a^2 A_4 / 8\sigma_y, \text{ in cm}^3 \qquad (1.2.7.3)$$

where AF, PPF_s P_{avg}, b_1, a and σ_y are as given in 1.2.7.2;
$A_4 = 1/(2 + k_{wl}[(1 - a_4^2)^{0,5} - 1])$;
$a_4 = A_L/A_w$;
A_L = minimum shear area for longitudinal as given in 1.2.7.2, in cm^2;
A_w = net effective shear area of longitudinal (calculated according to 1.2.5.7), in cm^2;
$k_w = 1/\left(1 + 2A_{fn}/A_w\right)$, with A_{fn} as given in 1.2.5.8.

1.2.7.4 The scantlings of the longitudinals shall meet the structural stability requirements of 1.2.9.

1.2.8 Framing. Web frame and load-carrying stringers.

1.2.8.1 Web frames and load-carrying stringers shall be designed to withstand the ice load patch as defined in 1.2.3. The load patch shall be applied at locations where the capacity of these members under the combined effects of bending and shear is minimised.

1.2.8.2 Web frames and load-carrying stringers shall be dimensioned such that the combined effects of shear and bending do not exceed the plastic strength of the member. The plastic strength is defined by the magnitude of midspan load that causes the development of a plastic collapse mechanism. Where the structural configuration is such that members do not form part of a grillage system, the appropriate peak pressure factor (PPF) from Table 1.2.3.4.2 shall be used. Lightening holes and cut-outs shall be accordance with 3.10.2.4.8, Part II "Hull".

1.2.8.3 For determination of scantlings of load-carrying stringers, web frames supporting local frames, or web frames supporting load-carrying stringers forming part of a structural grillage system, appropriate methods as outlined in 1.2.17 shall normally be used.

1.2.8.4 The scantlings of web frames and load-carrying stringers shall meet the structural stability requirements of 1.2.9.

1.2.9 Framing. Structural stability.

1.2.9.1 To prevent local buckling in the web, the ratio of web height h_w to net web thickness h_{wn} of any framing member shall not exceed:

for flat bar sections:

$$h_w/h_{wn} \leq 282/\sigma_y^{0,5}; \qquad (1.2.9.1\text{-}1)$$

for bulb, tee and angle sections:

$$h_w/h_{wn} \leq 805/\sigma_y^{0,5} \qquad (1.2.9.1\text{-}2)$$

where h_w = web height;
h_{wn} = net web thickness;
σ_y = minimum upper yield stress of the material, in N/mm^2.

1.2.9.2 Framing members for which it is not practicable to meet the requirements of 1.2.9.1 (e.g. load-carrying stringers or deep web frames) are required to have their webs effectively stiffened. The scantlings of the web stiffeners shall ensure the structural stability of the framing member. The minimum net web thickness for these framing members shall not be less than determined according the following formula:

$$h_{wn} = 2{,}63 \cdot 10^{-3} c_1 \sqrt{\sigma_y/(5{,}34 + 4(c_1/c_2)^2)} \qquad (1.2.9.2)$$

where $c_1 = h_w - 0{,}8h$, in mm;
h_w = web height of stringer/web frame, in mm (refer to Fig. 1.2.9.2);
h = height of framing member penetrating the member under consideration (0 if no such framing member), in mm (refer to Fig. 1.2.9.2);
c_2 = spacing between supporting structure oriented perpendicular to the member under consideration, in mm (refer to Fig. 1.2.9.2);
σ_y = minimum upper yield stress of the material, in N/mm^2.

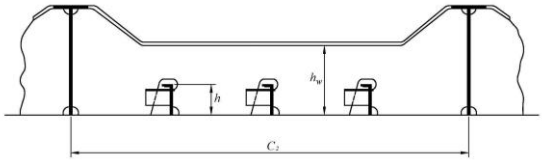


Fig. 1.2.9.2
Parameter definition for web stiffening

1.2.9.3 In addition, the following shall be satisfied:

$$t_{wn} \geq 0{,}35 t_{pn} \left(\sigma_y/235\right)^{0,5} \qquad (1.2.9.3)$$

where σ_y = minimum upper yield stress of the material, in N/mm^2;
t_{wn} = net thickness of the web, in mm;
t_{pn} = net thickness of the shell plate in way the framing member, in mm.

1.2.9.4 To prevent local flange buckling of welded profiles, the following shall be satisfied:

.1 the flange width b_f, in mm, shall not be less than five times the net thickness of the web t_{wn};

.2 the flange outstand b_{out}, in mm, shall meet the following requirement:

$$b_{out}/t_{fn} \leq 155/\sigma_y^{0,5} \qquad (1.2.9.4.2)$$

where t_{fn} = net thickness of flange, in mm;
σ_y = minimum upper yield stress of the material, in N/mm^2.

1.2.10 Plated structures.

1.2.10.1 Plated structures are those stiffened plate elements in contact with the hull and subject to ice loads. These requirements are applicable to an inboard extent which is the lesser of:

.1 web height of adjacent parallel web frame or stringer; or

.2 2,5 times the depth of framing that intersects the plated structure.

1.2.10.2 The thickness of the plating and the scantlings of attached stiffeners shall be such that the degree of end fixity necessary for the shell framing is ensured.

1.2.10.3 The stability of the plated structure shall adequately withstand the ice loads defined in 1.2.3.

1.2.11 Corrosion/abrasion additions and steel renewal.

1.2.11.1 Effective protection against corrosion and ice-induced abrasion is recommended for all external surfaces of the shell plating for polar class ships.

1.2.11.2 The values of corrosion/abrasion additions, t_S, in mm, to be used in determining the shell plate thickness are listed in Table 1.2.11.2.

Table 1.2.11.2

Corrosion/abrasion additions for shell plating

Hull area	t_s, in mm					
	With effective protection			Without effective protection		
	PC1 to **PC3**	**PC4** and **PC5**	**PC6** and **PC7**	**PC1** to **PC3**	**PC4** and **PC5**	**PC6** and **PC7**
B, BI_i	3,5	2,5	2,0	7,0	5,0	4,0
BI_l, M_i, S_i	2,5	2,0	2,0	5,0	4,0	3,0
M_l, S_l, BI_b, M_b, S_b	2,0	2,0	2,0	4,0	3,0	2,5

1.2.11.3 Polar class ships shall have a minimum corrosion/abrasion addition of t_S = 1,0 mm applied to all internal structures within the ice-strengthened hull areas, including plated members adjacent to the shell, as well as stiffener webs and flanges.

1.2.11.4 Steel renewal for ice strengthened structures is required when the gauged thickness is less than t_{net} + 0,5 mm.

1.2.12 Materials.

1.2.12.1 Steel grades of plating for hull structures shall be determined according to Table 1.2.12.4 and 1.2.12.5 based on the as-built thickness, the polar class and the material class of structural members according to 1.2.12.2.

1.2.12.2 Material classes specified in Table 1.2.3.7-1, Part II "Hull" are applicable to polar class ships regardless of the ship's length. In addition, material classes for weather and sea exposed structural members and for members attached to the weather and sea exposed plating are specified in Table 1.2.12.2. Where the material classes in Table 1.2.3.7-1, Part II "Hull" and in Table 1.2.12.2 differ, the higher material class shall be applied.

Table 1.2.12.2

Material classes for structural members of polar ships

Structural members	Material class
Shell plating within the bow and bow intermediate ice belt hull areas (B, BI_i)	II
All weather and sea exposed secondary and primary (as defined in Table 1.2.3.7-1, Part II "Hull") structural members outside $0{,}4L_{UI}$ amidships	I
Plating materials for stem and stern frames, rudder horn, rudder, propeller nozzle, shaft brackets, ice skeg, ice knife and other appendages subject to ice impact loads	II
All inboard framing members attached to the weather and sea-exposed plating including any contiguous inboard member within 600 mm of the shell plating	I
Weather-exposed plating and attached framing in cargo holds of ships which by nature of their trade have their cargo hold hatches open during cold weather operations	I
All weather and sea exposed special (as defined in Table 1.2.3.7-1, Part II "Hull") structural members within $0{,}2L_{UI}$ from *FP*	II

1.2.12.3 Regardless of polar class, steel grades for all shell plates situated below the level of 0,3 m below the lower waterline (refer to Fig. 1.2.12.3) and attached framing of hull

structures and appendages shall be obtained from Table 1.2.3.7-2, Part II "Hull" for structural members specified in Table 1.2.12.2.

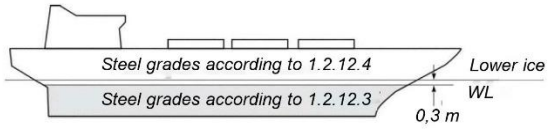


Fig. 1.2.12.3
Steel grade requirements for submerged and weather exposed shell plating

1.2.12.4 Steel grades for shell plates in the region of alternating waterlines and above according to Fig. 1.2.12.3, and attached framing of hull structures and appendages shall be obtained from Table 1.2.12.4.

Table 1.2.12.4

Steel grades for weather exposed plating

Thickness t, in mm	Material Class I				Material Class II				Material Class III					
	PC1 to **PC5**		**PC6** and **PC7**		**PC1** to **PC5**		**PC6** and **PC7**		**PC1** to **PC3**		**PC4** and **PC5**		**PC6** and **PC7**	
	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT
$t \leq 10$	B	AH	B	AH	B	AH	B	AH	E	EH	E	EH	B	AH
$10 < t \leq 15$	B	AH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
$15 < t \leq 20$	D	DH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
$20 < t \leq 25$	D	DH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
$25 < t \leq 30$	D	DH	B	AH	E	EH2	D	DH	E	EH	E	EH	E	EH
$30 < t \leq 35$	D	DH	B	AH	E	EH	D	DH	E	EH	E	EH	E	EH
$35 < t \leq 40$	D	DH	D	DH	E	EH	D	DH	F	FH	E	EH	E	EH
$40 < t \leq 45$	E	EH	D	DH	E	EH	D	DH	F	FH	E	EH	E	EH
$45 < t \leq 50$	E	EH	D	DH	E	EH	D	DH	F	FH	F	FH	E	EH

N o t e s : 1. Includes weather-exposed plating of hull structures and appendages, as well as their outboard framing members, situated above a level of 0,3 m below the lowest ice waterline.
2. Grades D, DH are allowed for a single strake of side shell plating not more than 1,8 m wide from 0,3 m below the lowest ice waterline.

1.2.12.5 Materials of castings shall comply with the requirements of Part XIII "Materials" for specified design temperature.

1.2.13 Longitudinal strength.

1.2.13.1 Application.

1.2.13.1.1 A ramming impact on the bow is the design scenario for the evaluation of the longitudinal strength of the hull.

1.2.13.1.2 Intentional ramming shall not be considered as a design scenario for ships which are designed with vertical or bulbous bows. Hence the longitudinal strength requirements specified in 1.2.13 shall not be considered for ships with stem angle γ_{stem} equal to or larger than 80 deg.

1.2.13.1.3 When determine design loads, ice loads shall only be combined with still water loads. The combined stress state shall be evaluated against permissible bending and shear stresses at different sections along the ship's length. In addition, sufficient buckling strength shall also be verified.

1.2.13.2 Design vertical ice force at the bow.

1.2.13.2.1 The design vertical ice force at the bow F_{IB}, MN, shall be taken as:

$$F_{IB} = \min(F_{IB,1}; F_{IB,2}) \qquad (1.2.13.2.1\text{-}1)$$

where $F_{IB,1} = 0{,}534 \cdot K_I^{0,15} \cdot \sin^{0,2}(\gamma_{stem}) \cdot (D_{UI} \cdot K_h)^{0,5} \cdot CF_L$; (1.2.13.2.1-2)

$F_{IB,2} = 1{,}20 CF_F$; (1.2.13.2.1-3)

$K_I = \text{indentation parameter} = K_f / K_h$;

.1 for the case of a blunt bow form:

$K_f = \left(2C \cdot B^{1-eb}/(1+e_b)\right)^{0,9} \text{tg}(\gamma_{stem})^{-0,9(1+eb)}$;

.2 for the case of wedge bow form (α_{stem} < 80°), e_b = 1 and the above simplifies to:

$K_f = \left(\text{tg}(\alpha_{stem})/\text{tg}^2(\gamma_{stem})\right)^{0,9}$;

K_h = $0{,}01A_{wp}$, in MN/m;

CF_L = longitudinal strength class factor from Table 1.2.3.2.1;

e_b = bow shape exponent which best describes the waterplane (refer to Figs. 1.2.13.2.1-1 and 1.2.13.2.1-2);

e_b = 1,0 for a simple wedge bow form;

e_b = 0,4 to 0,6 for a spoon bow form;

e_b = 0 for a landing craft bow form;
an approximate e_b determined by a simple fit is acceptable;

γ_{stem} = stem angle to be measured between the horizontal axis and the stem tangent at the upper ice waterline, deg. (buttock angle as per Fig. 1.2.3.2.1 measured on the centreline);

α_{stem} = waterline angle measured in way of the stem at the upper ice waterline (UIWL), in deg. (refer to Fig. 1.2.13.2.1-1);

C = $1/(2 \cdot (L_B/B_{UI})^{e_b})$;

B_{UI} = moulded breadth corresponding to the UIWL;

L_B = bow length used in the equation $y = B_{UI}/2 \cdot (x/L_B)^{e_b}$, in m (refer to Figs. 1.2.13.2.1-1 and 1.2.13.2.1-2);

D_{UI} = ship displacement, in kt, as defined in 1.2.1.3, not to be taken less than 10 kt;

A_{wp} = waterline area corresponding to the UIWL;

CF_F = flexural failure class factor from Table 1.2.3.2.1.

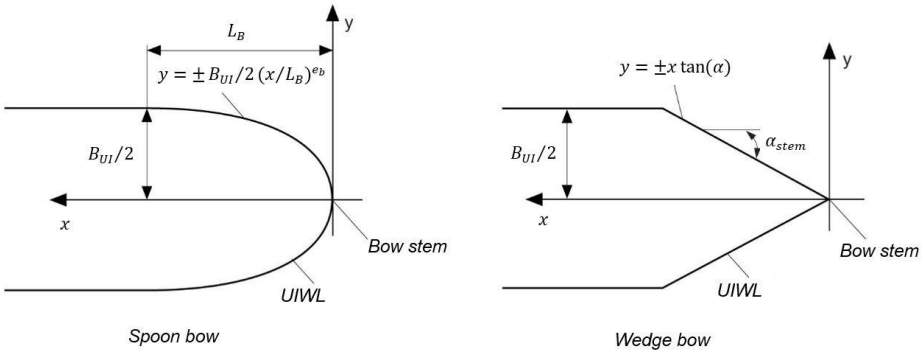


Fig. 1.2.13.2.1-1
Bow shape definition

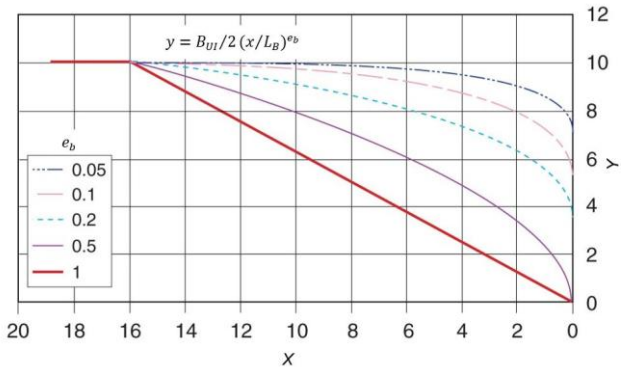


Fig. 1.2.13.2.1-2
Illustration of e_b effect on the bow shape for $B_{UI} = 20$ and $L_b = 16$

1.2.13.3 Design vertical shear force.

1.2.13.3.1 The design vertical ice shear force F_I, in MN, along the hull girder shall be determined by formula

$$F_I = C_f F_{IB} \qquad (1.2.13.3.1)$$

where C_f = longitudinal distribution factor to be taken as follows:
for positive shear force
C_f = 0,0 in sections 0,0 ≤ x/L_{UI} ≤ 0,6;
C_f = $\frac{10}{3} x/L_{UI}$ – 2 in sections 0,6 < x/L_{UI} < 0,9;
C_f = 1,0 in sections 0,9 ≤ x/L_{UI} ≤ 1,0; for negative shear force
C_f = 0,0 in section x/L_{UI} = 0,0;
C_f = –0,25 x/L_{UI} in sections 0,0 < x/L_{UI} < 0,2;
C_f = –0,5 in sections 0,2 ≤ x/L_{UI} ≤ 0,6;
C_f = 2,5 x/L_{UI} – 2 in sections 0,6 < x/L_{UI} < 0,8;
C_f = 0,0 in sections 0,8 ≤ x/L_{UI} ≤ 1,0;
x = distance from of the design section to the aft perpendicular, in m;
L_{UI} = ship length measured on the UIWL according to 1.2.1.2.

1.2.13.3.2 The applied vertical shear stresses shall be determined according to 1.6.5.1, Part II "Hull" by substituting the design vertical ice shear force N_w, in kN, for the design vertical wave shear force F_I, in kN.

1.2.13.4 Design vertical ice bending moment.

1.2.13.4.1 The design vertical ice bending moment M_I shall be determined by formula

$$M_I = 0{,}1 C_m L_{UI} \sin^{-0,2}(\gamma_{stem})\, F_{IB} \qquad (1.2.13.4.1)$$

where L_{UI} = ship length measured on UIWL according to 1.2.1.2;
γ_{stem} = according to 1.2.13.2.1;
F_{IB} = design vertical ice force at the bow, in MN;
C_m = longitudinal distribution factor for design vertical ice bending moment to be taken as follows:
C_m = 0,0 in section x/L_{UI} = 0,0;
C_m = 2,0 x/L_{UI} in sections 0,0 < x/L_{UI} < 0,5;
C_m = 1,0 in sections 0,5 ≤ x/L_{UI} ≤ 0,7;
C_m = 2,96 – 2,8x/L_{UI} in sections 0,7 < x/L_{UI} < 0,95;
C_m = 0,3 in section x/L_{UI} = 0,95;
C_m = 6,0 – 6,0x/L_{UI} in sections 0,95 < x/L_{UI} < 1,0;
C_m = 0,0 in section x/L_{UI} = 1,0;
x = distance from the design section to the aft perpendicular, in m.

Where applicable, draught dependent quantities shall be determined at the waterline corresponding to the loading condition under consideration.

1.2.13.4.2 The applied vertical bending stress σ_a shall be determined according to 1.6.5.1, Part II "Hull" by substituting the design vertical ice bending moment M_w, in kN, for the design vertical wave bending moment. The ship still water bending moment shall be taken as the maximum sagging moment.

1.2.13.5 Longitudinal strength criteria.

1.2.13.5.1 The strength criteria provided in Table 1.2.13.5-1 shall be satisfied. The design stress is not to exceed the permissible stress.

Table 1.2.13.5-1

Longitudinal strength criteria

Failure mode	Applied stress	Permissible stress when $\sigma_y/\sigma_u \leq 0,7$	Permissible stress when $\sigma_y/\sigma_u > 0,7$
Tension	σ_a	$\eta\sigma_y$	$\eta 0,41(\sigma_u + \sigma_y)$
Shear	τ_a	$\eta\sigma_y/3^{0,5}$	$\eta 0,41(\sigma_u + \sigma_y)/3^{0,3}$
Buckling	σ_a	σ_c for plating and for web plating of stiffeners $\sigma_c/1,1$ for stiffeners	
	τ_a	τ_c	

where σ_a = applied vertical bending stress, in N/mm^2;
τ_a = applied vertical shear stress, in N/mm^2;
σ_y = minimum upper yield stress of the material, in N/mm^2;
σ_u = ultimate tensile strength of material, in N/mm^2;
σ_c = critical buckling stress in compression, according to 1.6.5.3, Part II "Hull", in N/mm^2;
τ_c = critical buckling stress in shear, according to 1.6.5.3, Part II "Hull", in N/mm^2;
η = 0,8.
η = 0,6 for ships with ice class mark **Icebreaker**.

1.2.14 Stem and sternframe construction.

1.2.14.1 Polar class ships shall have a solid section stem made of steel. The stems and sternframes of polar class ships and icebreakers of **PC1** and **PC**, as well as the sternframes of polar class **PC1**, **PC2**, **PC3**, **PC4** and **PC5** ships, shall be made of forged or cast steel. Stems and sternframes welded of cast or forged parts are admissible.

1.2.14.2 In **PC3**, **PC4**, **PC5**, **PC6**, **PC7** polar class ships and polar class icebreakers less than **PC4**, a stem of combined structure (a bar with thickened plates welded thereto) or plate structure may be used. Welding seams of the combined or plated structure stems shall be made with full penetration in compliance with the requirements of Part XIV "Welding".

In **PC6** and **PC7** polar class ships stemframes of combined structure or plate structure may be used.

1.2.14.3 In **PC3**, **PC4**, **PC5**, **PC6**, **PC7** polar class ships, the stem shall be strengthened by a centre line web having its section depth equal to hp at least (refer to Table 1.2.14.3) with a face plate along its free edge or a longitudinal bulkhead fitted on the ship centreline, on the entire stem length from the keel plate to the nearest deck or platform situated above the area *B* (refer to Fig. 1.2.2.1). The thickness of this plate shall not be less than that of the brackets according to 1.2.14.4. In all polar class icebreakers and **PC1**, **PC2** polar class ships, a longitudinal bulkhead may be substituted for the centre line web.

Table 1.2.14.3

h_p, in m				
PC7	**PC6**	**PC5**	**PC4**	**PC3**
0,6	0,6	1,0	1,3	1,5

1.2.14.4 Within the vertical extent defined in 1.2.14.3, the stem shall be strengthened by horizontal webs at least 0,6 m in depth and spaced not more than 0,6 m apart. Where in line with side stringers, the webs shall be attached to them. In stems of combined or plate type, the webs shall be extended beyond the welded butts of the stem and shell plating.

Above the deck or platform located higher than the upper boundary of region *B*, the spacing of horizontal webs may gradually increase to 1,2 m in polar class icebreakers and **PC1**, **PC2**, **PC3** polar class ships, and to 1,5 m in ships of other polar class.

The web thickness shall be adopted not less than half the stem plate thickness according to 1.2.14.7. The free edges of webs shall be strengthened with face plates welded to the frames at their ends. The side stringers of the fore peak shall be connected to the webs fitted in line with them.

In case of a full bow, vertical stiffeners may be required additionally to be fitted to the stem plates.

1.2.14.5 Where the stern frame has an appendage (ice knife), the clearance between the latter and the rudder plate shall not exceed 100 mm. The appendage shall be reliably connected to the stern frame. Securing the appendage to plate structures is not permitted.

1.2.14.6 In icebreakers, the lower edge of solepiece shall be constructed with a slope of 1:8 beginning from the propeller post.

1.2.14.7 Cross-sectional area of the stem A_{st}, in cm^2, irrespective of configuration shall not be less than determined by formula

$$A_{st} = c_k c_t f(D) \qquad (1.2.14.7\text{-}1)$$

where c_k = coefficient according to Table 1.2.14.7;
$f(D)$ = $31D + 137$ if $D < 5$ kt;
$f(D)$ = $100D^{2/3}$ if $D \geq 5$ kt;
D = displacement of the ship, in kt;
c_t = coefficient equal to 1,0 for polar class ships; 1,4 for icebreakers.
c_k = coefficient according to Table 1.2.14.7.

Table 1.2.14.7

c_k						
PC7	**PC6**	**PC5**	**PC4**	**PC3**	**PC2**	**PC1**
0,54	0,54	0,66	1,02	1,25	1,40	1,55

Section modulus Z_{st}, in cm^3, of the stem cross-sectional area to the axis perpendicular to the centreline, shall be not less than determined by formula

$$Z_{st} = 1{,}2Q_{bow} \qquad (1.2.14.7\text{-}2)$$

where Q_{bow} = line load according to 1.2.3.2.1, in kN/m.

To be included in the design cross-sectional area of a combined or plate stem are areas of shell plates and centreline girder or of longitudinal bulkhead on the centreline on a breadth not exceeding ten times the thickness of relevant plates.

The plate thickness of stem plate t_{net}^{stem}, in mm, of combined or plate stem, shall be not less than determined by formula

$$t_{net}^{stem} = 1{,}2t_{net}a_b/s\sqrt{\sigma_y/\sigma_{y1}} \qquad (1.2.14.7\text{-}3)$$

where t_{net} = net thickness of outer shell according to 1.2.4.2;
s = transverse frame spacing, in m;
a_b = distance between the brackets, in m;
σ_y = minimum upper yield stress of outer shell material, in N/mm^2;
σ_{y1} = minimum upper yield stress of stem material, in N/mm^2.

1.2.15 Appendages.

1.2.15.1 All appendages shall be designed to withstand forces appropriate for the location of their attachment to the hull structure or their position within a hull area.

1.2.15.2 Load definition and response criteria shall be determined by the Register.

1.2.16 Local details.

1.2.16.1 For the purpose of transferring ice-induced loads to supporting structure (bending moments and shear forces), local design details shall comply with the RS requirements.

1.2.16.2 The loads carried by a member in way of cut-outs shall not cause instability. Where necessary, the structure shall be stiffened.

1.2.17 Direct calculations.

1.2.17.1 Application.

Direct calculations shall be used for load carrying stringers and web frames forming part of a grillage system and shall not to be utilised as an alternative to the analytical procedures prescribed for the shell plating and local frame requirements specified in 1.2.4, 1.2.6 and 1.2.7.

Direct calculations shall be made by the finite element method in the static nonlinear elastoplastic design. While calculating, the nonlinear dependence between the stresses and deformations shall be considered, if the yield stress reached.

The tensile diagram with linear hardening shall be used to describe the material properties.

1.2.17.2 Requirements for finite element model (FEM).

3-D finite element model shall be used for calculations. The model dimensions shall be specified so that to include web frames forming part of a grillage system in the ice reinforcement area as given in 1.2.2, and to comply with the minimum requirements to the finite element model as specified in Table 1.2.17.2-1.

Table 1.2.17.2-1

Minimum requirements for finite element model dimensions

Boundary	Type of side structure	
	Double side structure	Single side structure
Fore	Transverse bulkhead	
Aft	Transverse bulkhead	
Upper	Upper deck	Deck, platform or double bottom, located above icebelt region
Lower	Double bottom	Deck, platform or double bottom, located above icebelt region

The FEM model shall represent the geometry of the hull form.

Boundary conditions for FEM model shall comply with the requirements given in Table 1.2.17.2-2.

Structures to be modelled shall include side shell, web frames, stringers, local frames, inner skin and attached local frames, web stiffeners and brackets.

Structural idealization shall reasonably represent the non-linear behavior of the structure with the following minimum requirements to be satisfied:

shell elements shall be used for representing the side shell, inner skin, web frames, stringers, and local frames web and flange;

beam elements shall be used for representing local frames outside ice belt region;

rod elements shall be used for representing web stiffeners.

Table 1.2.17.2-2

Boundary conditions

Location of finite element model boundaries	Translational			Rotational		
	δ_x	δ_y	δ_z	θ_x	θ_y	θ_z
Top and bottom boundaries	–	×	×	×	×	×
Fore and aft boundaries	×	×	–	×	×	×
Note. × – fixed.						

Mesh size shall be selected such that the modelled structures reasonably represent the non-linear behavior of the structures with the following minimum requirements to be satisfied:

it is preferable to use quadrilateral elements that are nearly square in shape, the aspect ratio of the elements shall be kept below 1/3;

triangular elements shall be avoided as much as practical;

web of the web frames shall be divided into at least five elements;

web of the local frames shall be divided into at least three elements;

areas where high local stress or large deflections are expected could be modeled with finer mesh, while the areas outside ice belt region could be modelled with coarser mesh.

Finite elements thickness shall be equal to the net thickness of the structure.

1.2.17.3 Acceptance criteria.

The direct calculation shall demonstrate that ultimate structural capacity of the grillage structure, P_{ult}, in MPa, is not less than the design ice pressure within the hull area under consideration, as specified in 1.2.3.4. The criteria shall be satisfied for representative locations of the design load patch, as specified in 1.2.17.4.

The ultimate structural capacity of the grillage structure shall be calculated in accordance with 1.2.17.5.

1.2.17.4 Load patch.

The design load patch specified in 1.2.3.3 shall be applied, without being combined with any other load.

The design load patch shall be applied normal to the side shell plating.

The load patch shall be located where the bending and shear capacity of the web frame or load carrying stringer is minimized. The minimum required locations of the design load patch are as follows:

top edge of the load patch is in line with top boundary of the ice belt, at the central web frame of the grillage;

bottom edge of the load patch is in line with the bottom boundary of the ice belt, at the central web frame of the grillage;

load patch centroid is located at the midspan of the central web frame of the grillage;

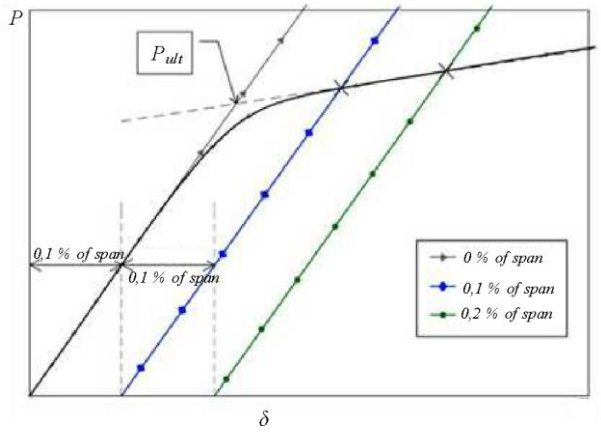
load patch centroid is located at the midspan of the central load carrying stringer of the grillage.

1.2.17.5 Ultimate structural capacity.

The ultimate structural capacity of the grillage shall be based on a non-linear static FEM analysis with the gradually increasing loads. The load increment shall be sufficiently fine to ensure the accuracy of the curve ($P - \delta$).

The analysis shall reliably capture buckling of the elements by the method agreed with the Register.

Ultimate structural capacity P_{ult} shall be based on pressure-deflection ($P - \delta$) curve using modified tangent intersection method according to Fig. 1.2.17.5.



N o t e . P – pressure applied to the grillage structure;

δ – maximum deflection of the web frame or load-carrying stringer in the grillage structure.

Fig. 1.2.17.5
Ultimate structural capacity calculation using tangent intersection method

1.2.17.6 Requirements for software.

FEM computation program shall be able to address the aspects of non-linear material behavior, structural idealization, meshing, load application and elasto-plastic calculations according to the requirements specified in 1.2.17.1 — 1.2.17.5. In addition, applicable software shall be able to address all possible computational errors.

1.2.18 Welding.

1.2.18.1 All welding within ice-strengthened areas shall be of the double continuous type.

1.2.18.2 Continuity of strength shall be ensured at all structural connections.

1.3 MACHINERY REQUIREMENTS FOR POLAR CLASS SHIPS

1.3.1 Application.

The requirements of this Chapter apply to main propulsion, steering gear, emergency and essential auxiliary systems essential for the safety of the ship and the survivability of the crew.

1.3.2 General.

1.3.2.1 Drawings and particulars to be submitted:

.1 details of the environmental conditions and the required ice class for the machinery, if different from ship's ice class;

.2 detailed drawings of the main propulsion machinery. Description of the main propulsion, steering, emergency and essential auxiliaries shall include operational limitations. Information on essential main propulsion load control functions;

.3 description detailing how main, emergency and auxiliary systems are located and protected to prevent problems from freezing, ice and snow and evidence of their capability to operate in intended environmental conditions;

.4 calculations and documentation indicating compliance with the requirements of this Chapter.

1.3.2.2 System design.

1.3.2.2.1 Machinery and supporting auxiliary systems shall be designed, constructed and maintained to comply with the requirements of periodically unmanned machinery spaces with respect to fire safety. Any automation plant (i.e. control, alarm, safety and indication systems) for essential systems installed shall be maintained to the same standard.

1.3.2.2.2 Systems, subject to damage by freezing, shall be drainable.

1.3.2.2.3 Single screw vessels classed **PC1** to **PC5** inclusive shall have means provided to ensure sufficient ship operation in the case of propeller damage including CP-mechanism.

1.3.3 Materials.

1.3.3.1 Materials exposed to sea water.

Materials exposed to sea water, such as propeller blades, propeller hub and blade bolts shall have an elongation not less than 15 % on a test piece the length of which is five times the diameter.

Charpy V-notch impact test (determination of impact energy KV for sharply-notched specimen) shall be carried out for other than bronze and austenitic steel materials. Test pieces taken from the propeller castings shall be representative of the thickest section of the blade. An average impact energy KV value of 20 J taken from three Charpy V-notch tests shall be obtained at –10 ºC.

1.3.3.2 Materials exposed to sea water temperature.

Materials exposed to sea water temperature shall be of steel or other approved ductile material. An average impact energy KV value of 20 J taken from three tests shall be obtained at –10 ºC.

1.3.3.3 Material exposed to low air temperature.

Materials of essential components exposed to low air temperature shall be of steel or other approved ductile material.

An average impact energy KV value of 20 J taken from three Charpy V-notch tests shall be obtained at 10 °C below the lowest design temperature.

1.3.4 Ice interaction load.

1.3.4.1 Propeller ice interaction.

The present requirements cover open and ducted type propellers situated at the stern of a ship having controllable pitch or fixed pitch blades. Ice loads on bow propellers and pulling type propellers shall be agreed with the Register.

The given loads are expected, single occurrence, maximum values for the whole ships service life for normal operational conditions.

These loads do not cover off-design operational conditions, for example when a stopped propeller is dragged through ice.

These requirements considering loads due to propeller ice interaction apply also for azimuthing (geared and podded) thrusters. However, ice loads due to ice impacts on the body of azimuthing thrusters are not covered by this Section.

The loads given in 1.3.4 are total loads (unless otherwise stated) during ice interaction and shall be applied separately (unless otherwise stated) and are intended for component strength calculations only. The different loads given here shall be applied separately.

F_b is a force bending a propeller blade backwards when the propeller mills an ice block while rotating ahead.

F_f is a force bending a propeller blade forwards when a propeller interacts with an ice block while rotating ahead.

1.3.4.2 Ice class factors.

Table 1.3.4.2 below lists the design ice thickness and ice strength index to be used for estimation of the propeller ice loads.

Table 1.3.4.2

Ice class	H_{ice}, in m	S_{ice}	S_{qice}
PC1	4,0	1,2	1,15
PC2	3,5	1,1	1,15
PC3	3,0	1,1	1,15
PC4	2,5	1,1	1,15
PC5	2,0	1,1	1,15
PC6	1,75	1	1
PC7	1,5	1	1
where H_{ice} = ice thickness for machinery strength design; S_{ice} = ice strength index for blade ice force; S_{qice} = ice strength index for blade ice torque.			

1.3.4.3 Design ice loads for open propeller.

1.3.4.3.1 Maximum backward blade force F_b, in kN:

when $D < D_{limit}$:

$$F_b = -27S_{ice}[nD]^{0,7}[EAR/Z]^{0,3}[D]^2; \quad (1.3.4.3.1\text{-}1)$$

when $D \geq D_{limit}$:

$$F_b = -23S_{ice}[nD]^{0,7}[EAR/Z]^{0,3}(H_{ice})^{1,4}[D]^2 \quad (1.3.4.3.1\text{-}2)$$

where D_{limit} = $0{,}85(H_{ice})^{1,4}$;
n = nominal rotational speed (at MCR free running condition) for CP-propeller and 85 % of the nominal rotational speed (at MCR free running condition) for a FP-propeller (regardless driving engine type).

F_b shall be applied as a uniform pressure distribution to an area on the back (suction) side of the blade for the following load cases:

.1 load case 1: from $0{,}6R$ to the tip and from the blade leading edge to a value of 0,2 chord length;

.2 load case 2: a load equal to 50 % of the F_b shall be applied on the propeller tip area outside of $0{,}9R$;

.3 load case 5: for reversible propellers a load equal to 60 % of the F_b shall be applied from $0{,}6R$ to the tip and from the blade trailing edge to a value of 0,2 chord length.

Refer to load cases 1, 2 and 5 in Table 1 of the Appendix.

1.3.4.3.2 Maximum forward blade force F_f, in kN:
when $D < D_{limit}$:

$$F_f = 250[EAR/Z][D]^2; \quad (1.3.4.3.2\text{-}1)$$

when $D \geq D_{limit}$:

$$F_f = 500\frac{1}{\left(1-\frac{d}{D}\right)}H_{ice}[EAR/Z][D] \quad (1.3.4.3.2\text{-}2)$$

where $D_{limit} = \frac{2}{\left(1-\frac{d}{D}\right)}H_{ice}$; (1.3.4.3.2-3)

d = propeller hub diameter, in m;
D = propeller diameter, in m;
EAR = expanded blade area ratio;
Z = number of propeller blades.

F_f shall be applied as a uniform pressure distribution to an area on the face (pressure) side of the blade for the following loads cases:

.1 load case 3: from $0{,}6R$ to the tip and from the blade leading edge to a value of 0,2 chord length;

.2 load case 4: a load equal to 50 % of the F_f shall be applied on the propeller tip area outside of $0{,}9R$;

.3 load case 5: for reversible propellers a load equal to 60 % F_f shall be applied from $0{,}6R$ to the tip and from the blade trailing edge to a value of 0,2 chord length.

Load cases 3, 4 and 5 – refer to Table 1 of the Appendix.

1.3.4.3.3 Maximum blade spindle torque $Q_{s\max}$.

Spindle torque $Q_{s\max}$, in kNm, around the spindle axis of the blade fitting shall be calculated both for the load cases described in 1.3.4.3.1 and 1.3.4.3.2 for F_b and F_f. If these spindle torque values are less than the default value given below, the default minimum value shall be used. Default value:

$$Q_{s\max} = 0{,}25Fc_{0,7} \quad (1.3.4.3.3)$$

where $c_{0,7}$ = length of the blade chord at $0{,}7R$ radius, in m;
F = either F_b or F_f which ever has the greater absolute value.

1.3.4.3.4 Maximum propeller ice torque applied to the propeller $Q_{\max}$, in kNm:
when $D < D_{limit}$:

$$Q_{\max} = 105(1-d/D)S_{qice}\left(P_{0,7}/D\right)^{0,16}\left(t_{0,7}/D\right)^{0,6}(nD)^{0,17}D^3; \quad (1.3.4.3.4\text{-}1)$$

when $D \geq D_{limit}$:

$$Q_{\max} = 202(1-d/D)S_{qice}H_{ice}^{1,1}\left(P_{0,7}/D\right)^{0,16}\left(t_{0,7}/D\right)^{0,6}(nD)^{0,17}D^{1,9} \quad (1.3.4.3.4\text{-}2)$$

where D_{limit} = $1{,}8H_{ice}$;
S_{qice} = ice strength index for blade ice torque;
$P_{0,7}$ = propeller pitch at $0{,}7R$, in m;
$t_{0,7}$ = max thickness at $0{,}7R$, in m;
n = the rotational propeller speed, in rps, at bollard condition. If not known, n shall be taken according to Table 1.3.4.3.4.

Table 1.3.4.3.4

Propeller type	n
CP propellers	n_n
FP propellers driven by turbine or electric motor	n_n
FP propellers driven by diesel engine	$0{,}85n_n$
where n_n = nominal rotational speed at MCR, free running condition.	

For CP propellers, propeller pitch $P_{0,7}$ shall correspond to MCR in bollard condition. If not known, $P_{0,7}$ shall be taken as $0{,}7P_{0,7n}$, where $P_{0,7}$ is propeller pitch at MCR free running condition.

1.3.4.3.5 Maximum propeller ice thrust (applied to the shaft at the location of the propeller). Maximum forward propeller ice thrust:

$$T_f = 1{,}1F_f; \quad (1.3.4.3.5\text{-}1)$$

Maximum backward propeller ice thrust:

$$T_b = 1{,}1F_b. \quad (1.3.4.3.5\text{-}2)$$

1.3.4.4 Design ice loads for ducted propeller.

1.3.4.4.1 Maximum backward blade force F_b:

when $D < D_{limit}$:

$$F_b = -9{,}5S_{ice}(EAR/Z)^{0,3}(nD)^{0,7}D^2; \quad (1.3.4.4.1\text{-}1)$$

when $D \geq D_{limit}$:

$$F_b = -66S_{ice}(EAR/Z)^{0,3}(nD)^{0,7}(H_{ice})^{1,4}D^{0,6} \quad (1.3.4.4.1\text{-}2)$$

where $D_{limit} = 4H_{ice}$;
n shall be taken as in 1.3.4.3.1.

F_b shall be applied as a uniform pressure distribution to an area on the back side for the following load cases (refer to Table 2 of the Appendix):

.1 load case 1: on the back of the blade from $0{,}6R$ to the tip and from the blade leading edge to a value of 0,2 chord length;

.2 load case 5: for reversible rotation propellers a load equal to 60 % of F_b is applied on the blade face from $0{,}6R$ to the tip and from the blade trailing edge to a value of 0,2 chord length.

1.3.4.4.2 Maximum forward blade force F_f, in kN:

when $D < D_{limit}$:

$$F_f = 250(EAR/Z)D^2; \quad (1.3.4.4.2\text{-}1)$$

when $D \geq D_{limit}$:

$$F_f = 500\frac{1}{(1-\frac{d}{D})}H_{ice}[EAR/Z]D \quad (1.3.4.4.2\text{-}2)$$

where $D_{limit} = \frac{2}{(1-\frac{d}{D})}H_{ice}$, in m. (1.3.4.4.2-3)

F_f shall be applied as a uniform pressure distribution to an area on the face (pressure) side for the following load case (refer to Table 2 of the Appendix):

.1 load case 3: on the blade face from 0,6R to the tip and from the blade leading edge to a value of 0,5 chord length;

.2 load case 5: a load equal to 60 % F_f shall be applied from 0,6R to the tip and from the blade leading edge to a value of 0,2 chord length.

1.3.4.4.3 Maximum propeller ice torque applied to the propeller $Q_{\max}$, in kNm, is the maximum torque on a propeller due to ice-propeller interaction:

when $D < D_{limit}$:

$$Q_{\max} = 74(1 - d/D)S_{qice}\left(P_{0,7}/D\right)^{0,16}\left(t_{0,7}/D\right)^{0,6}(nD)^{0,17}D^3; \quad (1.3.4.4.3\text{-}1)$$

when $D \geq D_{limit}$:

$$Q_{\max} = 141(1 - d/D)S_{qice}H_{ice}^{1,1}\left(P_{0,7}/D\right)^{0,16}\left(t_{0,7}/D\right)^{0,6}(nD)^{0,17}D^{1,9} \quad (1.3.4.4.3\text{-}2)$$

where $D_{limit} = 1{,}8H_{ice}$, in m;
n = rotational propeller speed, in rps, at bollard condition.

If not known, *n* shall be taken according to Table 1.3.4.4.3.

For CP propellers, propeller pitch $P_{0,7}$ shall correspond to MCR in bollard condition. If not known, $P_{0,7}$ shall be taken as 0,7$P_{0,7n}$, where $P_{0,7n}$ is propeller pitch at MCR free running condition.

Table 1.3.4.4.3

Propeller type	n
CP propellers	n_n
FP propellers driven by turbine or electric motor	n_n
FP propellers driven by diesel engine	0,85n_n
where n_n = nominal rotational speed at MCR, free running condition.	

1.3.4.4.4 Maximum blade spindle torque for CP-mechanism design $Q_{s\max}$.

Spindle torque $Q_{s\max}$, in kNm, around the spindle axis of the blade fitting shall be calculated for the load case described in 1.3.4.1. If these spindle torque values are less than the default value given below, the default value shall be used.

Default value:

$$Q_{s\max} = 0{,}25Fc_{0,7} \quad (1.3.4.4.4)$$

where $c_{0,7}$ = length of the blade section at 0,7R radius;
F = either F_b or F_f whichever has the greater absolute value.

1.3.4.4.5 Maximum propeller ice thrust (applied to the shaft at the location of the propeller). Maximum forward propeller ice thrust:

$$T_f = 1{,}1F_f. \quad (1.3.4.4.5\text{-}1)$$

Maximum backward propeller ice thrust:

$$T_b = 1{,}1F_b. \quad (1.3.4.4.5\text{-}2)$$

1.3.4.5 Reserved.

1.3.4.6 Design loads on propulsion line.

1.3.4.6.1 Torque.

The propeller ice torque excitation for shaft line dynamic analysis shall be described by a sequence of blade impacts which are of half sine shape and occur at the blade. The torque due to a single blade ice impact as a function of the propeller rotation angle is then:

$$Q(\varphi) = C_q Q_{max} \sin(\varphi(180/\alpha_i)) \text{ when } \varphi = 0 \dots \alpha_i;$$

$$Q(\varphi) = 0 \text{ when } \varphi = \alpha_i \dots 360. \quad (1.3.4.6.1\text{-}1)$$

C_q and α_i parameters are given in Table 1.3.4.6.1.

Table 1.3.4.6.1

Torque excitation	Propeller-ice interaction	C_q	α_i
Case 1	Single ice block	0,5	45
Case 2	Single ice block	0,75	90
Case 3	Single ice block	1,0	135
Case 4	Two ice blocks with 45 degree phase in rotation angle	0,5	45

The total ice torque is obtained by summing the torque of single blades taking into account the phase shift 360 deg/*Z*. The number of propeller revolutions during a milling sequence shall be determined by the formula

$$N_Q = 2H_{ice}. \quad (1.3.4.6.1\text{-}2)$$

The number of impacts is ZN_Q (refer to Fig. 1 in the Appendix).

Milling torque sequence duration is not valid for pulling bow propellers, which shall be agreed with the Register in each particular case.

The response torque at any shaft component shall be analysed considering excitation torque $Q(\varphi)$ at the propeller, actual engine torque Q_e and mass elastic system.

Q_e = actual maximum engine torque at considered speed.

Design torque along propeller shaft line.

The design torque Q_r of the shaft component shall be determined by means of torsional vibration analysis of the propulsion line. Calculations shall be carried out for all excitation cases given above and the response shall be applied on top of the mean hydrodynamic torque in bollard condition at considered propeller rotational speed.

1.3.4.6.2 Maximum response thrust (maximum thrust along the propeller shaft line).

Maximum thrust along the propeller shaft line shall be calculated with the formulae below. The factors 2,2 and 1,5 take into account the dynamic magnification due to axial vibration. Alternatively the propeller thrust magnification factor may be calculated by dynamic analysis.

Maximum shaft thrust forwards, in kN:

$$T_r = T_n + 2{,}2T_f. \quad (1.3.4.6.2\text{-}1)$$

Maximum shaft thrust backwards, in kN:

$$T_r = 1{,}5T_b \quad (1.3.4.6.2\text{-}2)$$

where T_n = propeller bollard thrust, in kN;
T_f = maximum forward propeller ice thrust, in kN;
T_b = maximum backward propeller ice thrust, in kN.

If hydrodynamic bollard thrust T_n is not known, T_n shall be taken according to Table 1.3.4.6.2.

Table 1.3.4.6.2

Propeller type	T_n
CP propellers (open)	1,25 T
CP propellers (ducted)	1,1 T
FP propellers driven by turbine or electric motor	T
FP propellers driven by diesel engine (open)	0,85 T
FP propellers driven by diesel engine (ducted)	0,75 T
where T = nominal propeller thrust at MCR at free running open water conditions.	

1.3.4.6.3 Blade failure load for both open and nozzle propeller.

The force is acting at 0,8R in the weakest direction of the blade and at a spindle arm of 2/3 of the distance of axis of blade rotation of leading and trailing edge which ever is the greatest.

The blade failure load F_{ex}, in kN, is determined by formula

$$F_{ex} = \frac{0{,}3ct^2\sigma_{ref}}{0{,}8D-2r} \cdot 10^3 \qquad (1.3.4.6.3)$$

where σ_{ref} = $0{,}6\sigma_{0,2} + 0{,}4\sigma_u$;

σ_u and $\sigma_{0,2}$ = representative values for the blade material;

c, t and r = respectively the actual chord length, thickness and radius of the cylindrical root section of the blade at the weakest section outside root fillet, and typically will be at the termination of the fillet into the blade profile.

1.3.5 Design.

1.3.5.1 Design principle.

The strength of the propulsion line shall be designed:

for maximum loads in 1.3.4;

such that the plastic bending of a propeller blade shall not cause damages in other propulsion line components;

with sufficient fatigue strength.

1.3.5.2 Azimuthing main propulsors.

In addition to the above requirements special consideration shall be given to the loading cases which are extraordinary for propulsion units when compared with conventional propellers. Estimation of the loading cases shall reflect the operational realities of the ship and the thrusters. In this respect, for example, the loads caused by impacts of ice blocks on the propeller hub of a pulling propeller shall be considered. Also loads due to thrusters operating in an oblique angle to the flow shall be considered. The steering mechanism, the fitting of the unit and the body of the thruster shall be designed to withstand the loss of a blade without damage. The plastic bending of a blade shall be considered in the propeller blade position, which causes the maximum load on the studied component.

Azimuth thrusters shall also be designed for estimated loads due to thruster body/ice interaction as per 1.2.15.

1.3.5.3 Blade design.

1.3.5.3.1 Maximum blade stresses.

Blade stresses shall be calculated using the backward and forward loads given in section 1.3.4.3 and 1.3.4.4. The stresses shall be calculated with recognised and well-documented FE-analysis or other acceptable alternative method.

The stresses on the blade shall not exceed the allowable stresses σ all for the blade material given below.

Calculated blade stress for maximum ice load shall comply with the following:

$$\sigma_{calc} < \sigma_{all} = \sigma_{ref}/S \qquad (1.3.5.3.1\text{-}1)$$

where S = 1,5;
σ_{ref} = reference stress, defined as:

σ_{ref} = $0{,}7\sigma_u$; or (1.3.5.3.1-2)

σ_{ref} = $0{,}6\sigma_{0,2} + 0{,}4\sigma_u$, whichever is less (1.3.5.3.1-3)

where σ_u and $\sigma_{0,2}$ = representative values for the blade material.

1.3.5.3.2 Blade edge thickness.

The blade edge thicknesses t_{edge} and tip thickness t_{tip} shall be greater than t_{edge} determined by formula

$$t_{edge} \geq xSS_{ice}\sqrt{3p_{ice}/\sigma_{ref}} \qquad (1.3.5.3.2)$$

where x = distance from the blade edge measured along the cylindrical sections from the edge and shall be 2,5 % of chord length, however not to be taken greater than 45 mm. In the tip area (above $0{,}975R$) x shall be taken as 2,5 % of $0{,}975R$ section length and shall be measured perpendicularly to the edge, however not to be taken greater than 45 mm;
S = safety factor;
S = 2,5 for trailing edges;
S = 3,5 for leading edges;
S = 5 for tip;
S_{ice} = according to 1.3.4.2;
p_{ice} = ice pressure;
p_{ice} = 16 MPa for leading edge and tip thickness;
σ_{ref} = according to 1.3.5.3.1.

The requirement for edge thickness shall be applied for leading edge and in case of reversible rotation open propellers also for trailing edge. Tip thickness refers to the maximum measured thickness in the tip area above $0{,}975R$. The edge thickness in the area between position of maximum tip thickness and edge thickness at $0{,}975R$ shall be interpolated between edge and tip thickness value and smoothly distributed.

1.3.5.3.3 to **1.3.5.4.2** Reserved.

1.3.5.5 Reserved.

1.3.5.6 Prime movers.

1.3.5.6.1 The main engine shall be capable of being started and running the propeller with the CP in full pitch.

1.3.5.6.2 Provisions shall be made for heating arrangements to ensure ready starting of the cold emergency power units at an ambient temperature applicable to the polar class of the ship.

1.3.5.6.3 Emergency power units shall be equipped with starting devices with a stored energy capability of at least three consecutive starts at the design temperature in 1.3.5.6.2 above. The source of stored energy shall be protected to preclude critical depletion by the automatic starting system, unless a second independent means of starting is provided. A second source of energy shall be provided for an additional three starts within 30 min, unless manual starting can be demonstrated to be effective.

1.3.6 Machinery fastening loading accelerations.

1.3.6.1 Essential equipment and main propulsion machinery supports shall be suitable for the accelerations as indicated in as follows. Accelerations shall be considered acting independently.

1.3.6.2 Longitudinal impact accelerations a_l.

Maximum longitudinal impact acceleration at any point along the hull girder, in m/s^2, is determined by the formula

$$a_l = (F_{IB}/\Delta)\{[1{,}1\tan(\gamma+\varphi)] + [7H/L]\} \quad (1.3.6.2)$$

where φ = maximum friction angle between steel and ice, normally taken as 10 deg.;
γ = bow stem angle at waterline, in deg.;
Δ = displacement;
L = length between perpendiculars, in m;
H = distance from the waterline to the point being considered, in m;
F_{IB} = vertical impact force, defined in 1.2.13.2.1;
F_i = total force normal to shell plating in the bow area due to oblique ice impact, defined in 1.2.3.2.1.

1.3.6.3 Vertical acceleration a_v.

Combined vertical impact acceleration at any point along the hull girder, in m/s^2, is determined by the formula

$$a_v = 2{,}5(F_{IB}/\Delta)F_x \quad (1.3.6.3)$$

where F_x = 1,3 at *FP*;
F_x = 0,2 at midships;
F_x = 0,4 at *AP*;
F_x = 1,3 at *AP* for ships conducting ice breaking astern.

Intermediate values to be interpolated linearly.

1.3.6.4 Transverse impact acceleration a_t.

Combined transverse impact acceleration at any point along hull girder, in m/s^2, is determined by the formula

$$a_t = 3F_iF_x/\Delta \quad (1.3.6.4)$$

where F_x = 1,5 at FP;
F_x = 0,25 at midships;
F_x = 0,5 at AP;
F_x = 1,5 at AP for ships conducting ice breaking astern.

Intermediate values to be interpolated linearly.

1.3.7 Auxiliary systems.

1.3.7.1 Machinery shall be protected from the harmful effects of ingestion or accumulation of ice or snow. Where continuous operation is necessary, means shall be provided to purge the system of accumulated ice or snow.

1.3.7.2 Means shall be provided to prevent damage due to freezing, to tanks containing liquids.

1.3.7.3 Vent pipes, intake and discharge pipes and associated systems shall be designed to prevent blockage due to freezing or ice and snow accumulation.

1.3.8 Sea inlets and cooling water systems.

1.3.8.1 Cooling water systems for machinery that are essential for the propulsion and safety of the vessel, including sea chests inlets, shall be designed for the environmental conditions applicable to the ice class.

1.3.8.2 At least two sea chests shall be arranged as ice boxes for class **PC1** to **PC5** ships. The calculated volume for each of the ice boxes shall be at least 1 m^3 for every 750 kW of the total installed power. For **PC6** and **PC7** there shall be at least one icebox located preferably near centre line.

1.3.8.3 Ice boxes shall be designed for an effective separation of ice and venting of air.

1.3.8.4 Sea inlet valves shall be secured directly to the ice boxes. The valve shall be a full bore type.

1.3.8.5 Ice boxes and sea chests shall have vent pipes and shall have shut off valves connected direct to the shell.

1.3.8.6 Means shall be provided to prevent freezing of sea chests, ice boxes, ship side valves and fittings above the load waterline.

1.3.8.7 Efficient means shall be provided to re-circulate cooling seawater to the ice box. Total sectional area of the circulating pipes shall not be less than the area of the cooling water discharge pipe.

1.3.8.8 Detachable gratings or manholes shall be provided for ice boxes. Manholes shall be located above the deepest load line. Access shall be provided to the ice box from above.

1.3.8.9 Openings in ship sides for ice boxes shall be fitted with gratings, or holes or slots in shell plates. The net area through these openings shall be not less than 5 times the area of the inlet pipe. The diameter of holes and width of slot in shell plating shall be not less than 20 mm. Gratings of the ice boxes shall be provided with a means of clearing. Clearing pipes shall be provided with screw-down type non return valves.

1.3.9 Ballast tanks.

1.3.9.1 Efficient means shall be provided to prevent freezing in fore and after peak tanks and wing tanks located above the water line and where otherwise found necessary.

1.3.10 Ventilation system.

1.3.10.1 The air intakes for machinery and accommodation ventilation shall be located on both sides of the ship.

1.3.10.2 Accommodation and ventilation air intakes shall be provided with means of heating.

1.3.10.3 The temperature of inlet air provided to machinery from the air intakes shall be suitable for the safe operation of the machinery.

1.3.11 Reserved.

1.3.12 Alternative design.

1.3.12.1 As an alternative – a comprehensive design study may be submitted and may be requested to be validated by an agreed test programme.

APPENDIX

Table 1

Load cases for open propeller

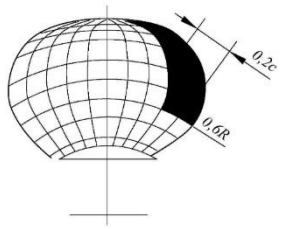
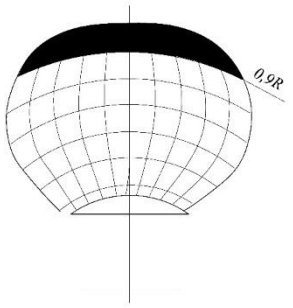
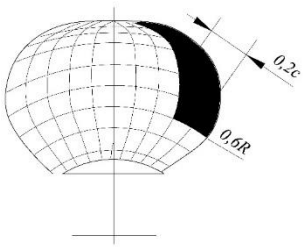
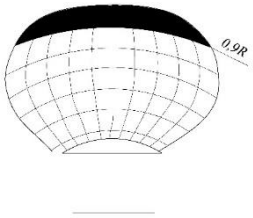
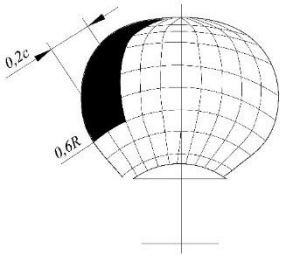
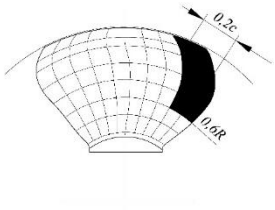
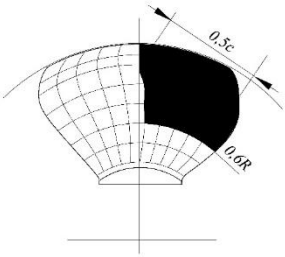
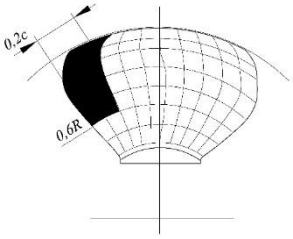
	Force	Loaded area	Right handed propeller blade seen from back
Load case 1	F_b	Uniform pressure applied on the back of the blade (suction side) to an area from 0,6R to the tip and from the leading edge to 0,2 times the chord length	
Load case 2	50 % of F_b	Uniform pressure applied on the back of the blade (suction side) on the propeller tip area outside of 0,9R	
Load case 3	F_f	Uniform pressure applied on the blade face (pressure side) to an area from 0,6R to the tip and from the leading edge to 0,2 times the chord length	
Load case 4	50 % of F_f	Uniform pressure applied on propeller face (pressure side) on the propeller tip area outside of 0,9R	
Load case 5	60 % of F_f or F_b which one is greater	Uniform pressure applied on propeller face (pressure side) to an area from 0,6R to the tip and from the trailing edge to 0,2 times the chord length	

Table 2

Load cases for ducted propeller

Load case 1	F_b	Uniform pressure applied on the back of the blade (suction side) to an area from 0,6R to the tip and from the leading edge to 0,2 times the chord length	
Load case 3	F_f	Uniform pressure applied on the blade face (pressure side) to an area from 0,6R to the tip and from the leading edge to 0,5 times the chord length	
Load case 5	60 % of F_f or F_b which one is greater	Uniform pressure applied on propeller face (pressure side) to an area from 0,6R to the tip and from the trailing edge to 0,2 times the chord length	

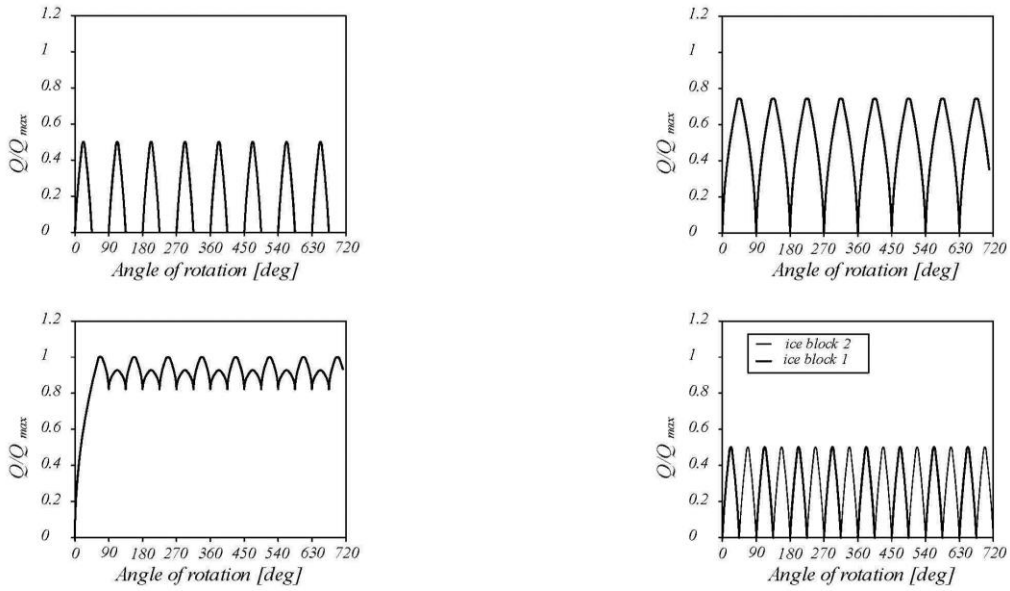


Fig. 1
The shape of the propeller ice torque excitation for 45, 90, 135 degrees single blade impact sequences and 45 degrees double blade impact sequence (two ice pieces) on a four bladed propeller

2 TECHNICAL REQUIREMENTS FOR ESCORT TUGS

2.1 GENERAL

2.1.1 Scope of application.

2.1.1.1 The technical requirements for escort tugs apply to tugs intended for escort service. These requirements are additional to the requirements of Parts I — XV of the Rules.

2.1.1.2 Tugs complying with the requirements of the present Section may be assigned the descriptive notation **Escort tug** added to the character of classification.

2.1.2 Definitions and explanations.

For the purpose of this Section the following definitions and explanations have been adopted.

Assisted ship means the ship being escorted by the escort tug.

Escort characteristics:

maximum steering pull of the tug F_s, in t, at the escort test speed V, in knots, (refer to Fig. 2.1.2);

manoeuvring time t, in s.

Escort service means steering, braking and otherwise controlling the assisted ship.

Escort test speed means the speed, in knots, of the assisted ship during full scale trials.

Escort tug means a tug which in addition to towing and ship handling operations is intended for escort services.

Full scale trials mean sea trials of the escort tug to determine escort characteristics.

Manoeuvring time means a minimum manoeuvring time, in s, from maintained oblique position of the tug (from the centerline of the assisted ship) giving the maximum transverse steering force on one side of the assisted ship to mirror position on the other side.

Maximum steering pull of the tug means the maximum transverse steering force, in t, exerted by the tug on the stern of the assisted ship at the escort test speed of 8 and/or 10 knots.

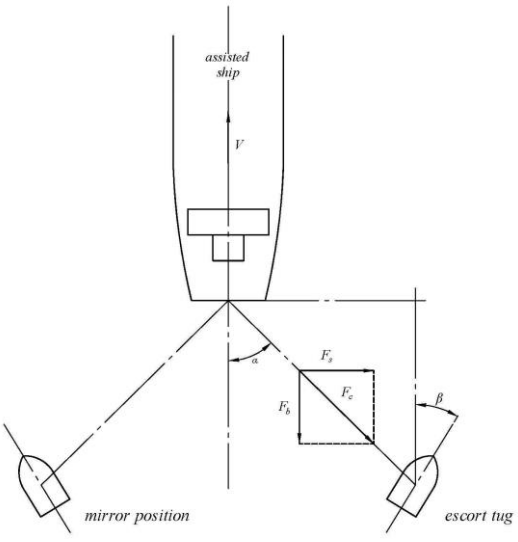


Fig. 2.1.2
Typical working mode of the escort tug
F_s = steering pull; F_b = braking force; F_t = towing line tension; α = towing line angle; β = oblique angle; V = speed of the assisted ship

2.1.3 Technical documentation.

2.1.3.1 Technical documentation to be submitted to the Register for approval shall include the following:

.1 towing arrangement plan required for escort service including towing line path and minimum breaking strength of towing line components and strength of appropriate structures;

.2 preliminary calculation of maximum steering pull of the tug at the escort test speed of 8 and/or 10 knots including propulsion components of the escort tug for balancing of oblique angular position of the tug;

.3 preliminary tug stability calculations for escorting service;

.4 plan of full scale trials.

2.2 TECHNICAL REQUIREMENTS

2.2.1 Arrangement and design.

2.2.1.1 A bulwark shall be fitted all around the exposed weather deck.

2.2.1.2 The towing winch intended for escort service shall be fitted with a load reducing system in order to prevent overload caused by dynamic oscillation in the towing line, and shall be capable of paying out the towing line if the pull exceeds 50 % of the breaking strength of the towing line.

2.2.1.3 The towing line components shall have a minimum breaking strength of at least 2,2 times the maximum towing pull as measured during the full scale trials (refer to 2.3).

2.2.1.4 In case of escort service of oil tankers and/or oil recovery vessels, supply vessels, ships intended for the carriage of explosives and inflammable cargoes, the requirements of 11.1.3, Part VIII "Systems and Piping" shall be complied with.

2.2.2 Stability.

2.2.2.1 Stability of escort tugs shall be checked for the following loading conditions:

.1 maximum operational draught at which towing or escorting operations may be carried out, with 100 % of stores;

.2 minimum operational draught at which towing or escorting operations may be carried out, with 10 % of stores;

.3 intermediate condition with 50 % of stores, and for escort tugs provided with cargo holds, additionally:

.4 ship with full cargo in holds and full stores;

.5 ship with full cargo in holds and 10 % of stores.

2.2.2.2 For given loading conditions, there shall be taken into account, inter alia, weight of spare towlines and towlines for towing winches.

2.2.2.3 For ships engaged in escort operations, the maximum heeling lever determined in accordance with 2.2.2.5 shall comply with the following criteria:

.1 $A \geq 1{,}25 \cdot B$;

.2 $C \geq 1{,}40 \cdot D$;

.3 $\theta_e \leq 15$

where A = righting lever curve area measured from the heeling angle θ_e to a heeling angle of 20° (refer to Fig. 2.2.2.3.3-1);

B = heeling lever curve area measured from the heeling angle θ_e to a heeling angle of 20° (refer to Fig. 2.2.2.3.3-1);

C = righting lever curve area measured from the zero heel to the heeling angle θ_d (refer to Fig. 2.2.2.3.3-2);

D = heeling lever curve area measured from zero heel to the heeling angle θ_d (refer to Fig. 2.2.2.3.3-2);

θ_d = heeling angle, in deg., corresponding to the second intersection between heeling lever curve and the righting lever curve or the angle of down-flooding, whichever is less;

θ_e = heeling angle, in deg., corresponding to the first intersection between heeling lever curve and the righting lever.

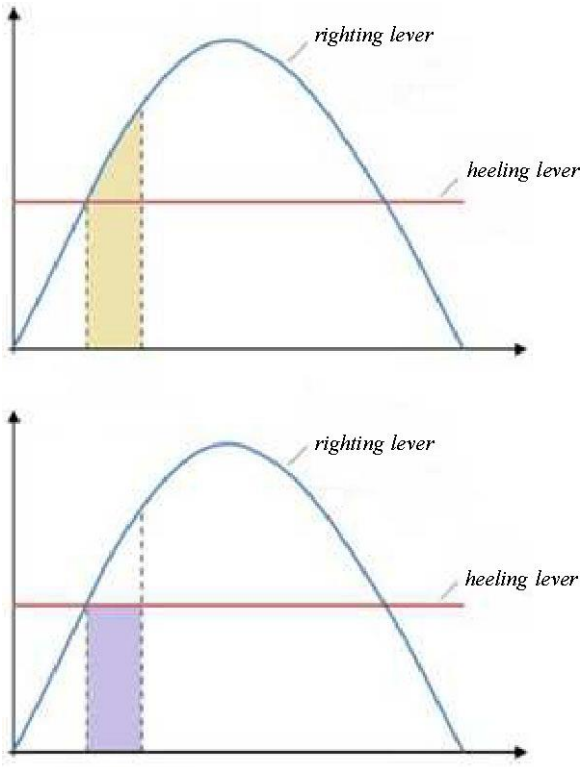


Fig. 2.2.2.3.3-1

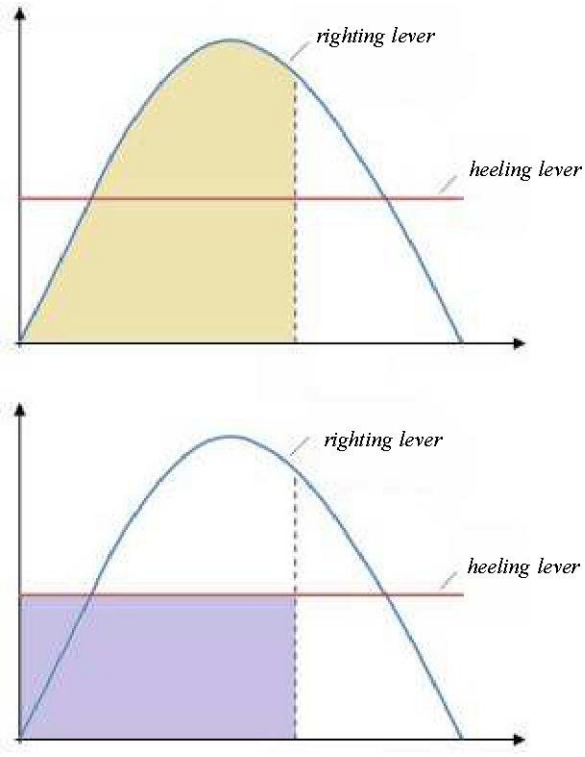


Fig. 2.2.2.3.3-2

2.2.2.4 A minimum freeboard at stern measured on centerline shall be at least $0{,}005L$.

2.2.2.5 Heeling lever for escort operations.

2.2.2.5.1 For the evaluation of the stability particulars during escort operations, the tug is considered to be in an equilibrium position determined by the combined action of the hydrodynamic forces acting on hull and appendages, the thrust force and the towline force as shown in Fig. 2.2.2.5.1.

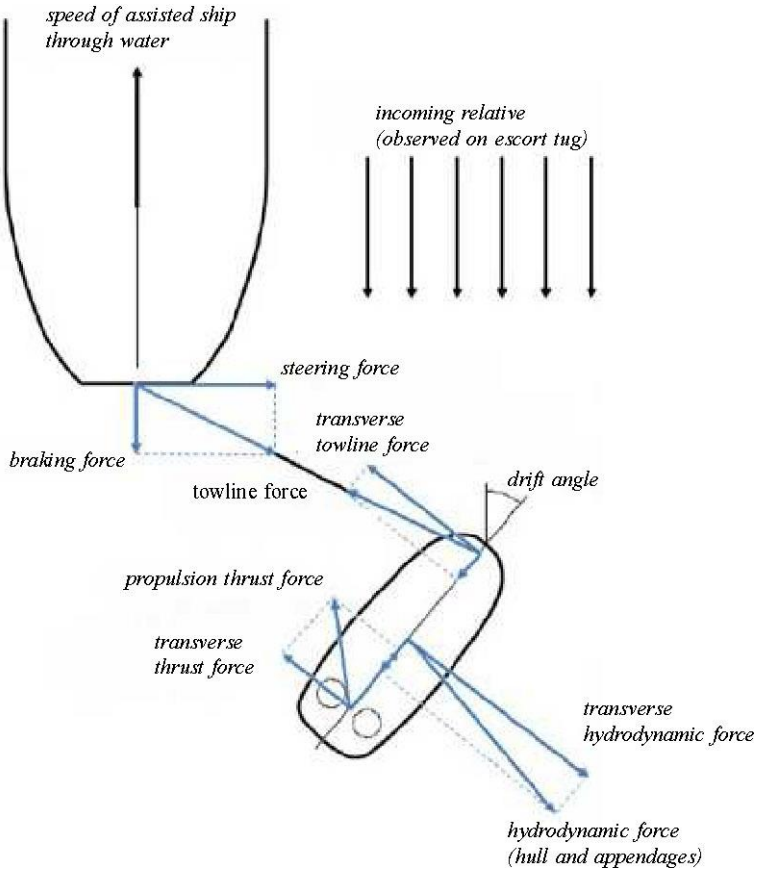


Fig. 2.2.2.5.1

2.2.2.5.2 At design stage, the steering force, breaking force, heeling angle and heeling lever may be determined by model test or calculation. On completion of the tug's construction, the values of maximum steering force and maximum heeling angle of the tug are specified by full scale tests or numerical simulations in accordance with the procedure approved by the Register.

2.2.2.5.3 For each loading condition, the evaluation of the equilibrium positions shall be performed over the applicable escort speed range, whereby the speed of the assisted ship through the water shall be considered (the typical escort speed range is 6 — 10 knots).

2.2.2.5.4 For each relevant combination of loading condition and escort speed, the maximum heeling lever shall be used for the evaluation of the stability particulars.

2.2.2.5.5 For the purpose of stability calculations, the heeling lever shall be taken as constant.

2.3 FULL SCALE TRIALS

2.3.1 Plan of full scale trials.

2.3.1.1 Prior to the full scale trials the plan of the trials, the approved Stability Booklet, as well as preliminary calculations of the ship's escort characteristics and the tug's stability during escort service shall be submitted to surveyor to the Register.

2.3.1.2 The plan of full scale trials shall stipulate determination of the tug's maximum transverse steering force at the speed of the assisted ship of 8 and/or 10 knots, the maximum angle of static heel at the specified modes, as well as the tug's manoeuvring time (refer to Fig. 2.1.2).

2.3.1.3 The plan shall include a list of measuring instruments, description of mandatory manoeuvres, a towing arrangement scheme for expected escort modes, design loads of strong points of the tug, as well as data of the safe working load of the strong points of the assisted ship.

2.3.2 Procedure of trials.

2.3.2.1 Full scale trials shall be carried out on:

.1 the first ship out of the series of ships, then every fifth ship of the series (i.e. sixth, eleventh, etc.) provided their propulsion plant is identical;

.2 every ship of non-series construction.

2.3.2.2 The trials shall be carried out in favourable weather (recommended limitation of wind force is 10 m/s, sea state 2), with the operating load of the tug equal to 50 – 10 % of provisions. Current velocity in the area of the trials (if any) shall be measured both upstream and down stream.

2.3.2.3 Displacement or power of the assisted ship shall be sufficient to maintain the heading and speed with the help of the autopilot during the necessary tug manoeuvring.

2.3.2.4 The following data shall be recorded continuously in real time mode during trials for later analysis:

.1 position of the assisted ship in relation to the escort tug;

.2 towing line tension;

.3 escort test speed;

.4 angle of the tug heel during escort service;

.5 length and angle of the towing line from the centerline of the assisted ship;

.6 manoeuvring time from maintained oblique position of the tug on one side of the assisted ship to mirror position on the other side at the maximum tension value of towing line and the maximum towing line angle from the centerline of the assisted ship (but not more than 60°);

.7 angle of heel due to sudden loss of thrust.

2.4 REPORTING

2.4.1 Report in tabular form on the results of the tug's trials to determine the escort characteristics and including records of the parameters measured in real time mode shall be agreed with the surveyor to the Register attending the trials and be forwarded to the RS Head Office for consideration. The Report shall contain calculation of the steering pull value taking into account the time of the tug's transfer to the mirror position. The Report shall be accompanied with the escort tug's stability calculation based on results of full scale trials.

2.4.2 Results of full scale trials are documented in the Act issued by surveyor to the Register.

2.4.3 Upon satisfactory results of full scale trials and consideration of stability calculation specified in 2.4.1, in the Classification Certificate issued for the tug the descriptive notation **Escort tug** is added to the character of classification, and in the column "Other characteristics" the following entry shall be made: "During escort service the maximum steering pull is equal to ..... t, with the escort test speed 8 (or 10) knots and the minimum manoeuvring time .....s". In case the measurements were taken at two values of escort test speed (8 and 10 knots), the data of both speeds shall be recorded.

3 REQUIREMENTS FOR THE EQUIPMENT OF SHIPS IN COMPLIANCE WITH THE DISTINGUISHING MARKS ECO AND ECO-S IN THE CLASS NOTATION

3.1 GENERAL

3.1.1 Scope of application.

The requirements for the equipment of ships in compliance with the distinguishing marks **ECO** and **ECO-S** in the class notation have been developed taking into account the following international instruments as amended:

.1 Annexes I, II, IV, V, VI to MARPOL 73/78 and IMO resolutions specified in Table 3.2.2;

.2 provisions of the International Convention on the Control of Harmful Anti-Fouling Systems on Ships, 2001;

.3 International Code on Intact Stability, 2008, for all types of ships covered by IMO Instruments, which was adopted by IMO resolution MSC.267(85), as amended;

.4 provisions of IACS UR L5 "Onboard computers for stability calculations" (Rev.3, June 2017);

.5 Regulation (EU) No. 1257/2013 of the European Parliament and of the Council of 20 November 2013 on Ship Recycling and Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009;

.6 provisions of Directive 99/32/EU with amendments to Directive 2005/33/EU;

.7 provisions of the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer.

The requirements of this Section are applied during survey of ships for assigning the distinguishing marks **ECO** and **ECO-S** in the class notation (refer to 3.2.1).

3.1.2 Terms. Definitions.

Anti-fouling systems mean coatings, paints, surface treatment and devices that are used on a ship to control or prevent attachment of unwanted organisms.

Attained Energy Efficiency Design Index (Attained EEDI) means the EEDI value achieved by an individual ship in compliance with regulation 20 of chapter 4 in Annex VI to MARPOL 73/78.

Ballast water system means a system comprising tanks for ballast water with associated piping, pumps and ballast water treatment system, where provided.

Bilge alarm means a device giving off a signal whenever the oil content in the effluent exceeds 15 ppm or 5 ppm (whatever is applicable).

Bilge separator means any combination of a separator, filter or coalescer, and also a single unit designed to produce an effluent with oil content not exceeding 15 ppm or 5 ppm (whatever is applicable).

Bilge water means water accumulated in the bilge of ship's machinery spaces which may be contaminated with oil.

Chemical tanker means a ship constructed or adapted for the carriage in bulk of any liquid product listed in Chapter 17 of the IBC Code.

Discharge to sea means any discharge from ships to sea of harmful substances or effluents containing such substances including any escape, disposal, spilling, leaking, pumping, emitting or emptying.

Emission to air means any emission to air from ships subject to control by Annex VI to MARPOL 73/78.

Fire-fighting systems mean shipboard fixed fire-fighting systems containing fire-fighting substances with different ozone depleting potential (ODP) and global warming potential (GWP) values.

Garbage means garbage generated during normal operation of the ship, sorted, stored and disposed of/incinerated in accordance with the provisions of Annex V to MARPOL 73/78.

New ship (for the purpose of application of the requirements for energy efficiency) means a ship:

for which the building contract is placed on or after 1 January 2013; or

in the absence of a building contract, the keel of which is laid or which is at a similar stage of construction on or after 1 July 2013; or

the delivery of which is on or after 1 July 2015.

NLS tanker means a ship constructed or adapted to carry a cargo of noxious liquid substances in bulk and includes an "oil tanker" as defined in Annex I to MARPOL 73/78 when certified to carry a cargo or part cargo of noxious liquid substances.

Noxious liquid substance (NLS) means any substance indicated in the Pollution Category column of Chapters 17 and 18 of the International Bulk Chemical Code (IBC Code).

Oil means petroleum in any form including crude oil, fuel oil, sludge, oil refuse and refined products (other than those petrochemicals which are subject to the provisions of Annex II to MARPOL 73/78) and, without limiting the generality of the foregoing, includes the substances listed in appendix I to Annex I to MARPOL 73/78.

Oil residues mean oil residues generated during normal operation of the ship and include the following:

used lubricating and hydraulic oils;

fuel oil and lubricating oil leaked from the ship's machinery and systems;

sludge from fuel oil and lubricating oil separators, from bilge separators.

Passenger ship means a ship that carries more than 12 passengers.

Refrigeration systems means shipboard systems (cargo refrigeration plants, air conditioning and refrigeration systems) containing refrigerants with different ozone depleting potential (ODP) and global warming potential (GWP) values.

Required Energy Efficiency Design Index (Required EEDI) means the maximum value of Attained EEDI that is allowed by regulation 21 of chapter 4 in Annex VI to MARPOL 73/78 for the specific ship type and size.

Sanitary and domestic waste waters mean drainage from wash basins, showers, laundries, wash tubes and scuppers, drainage from sinks and equipment of galleys and spaces annexed to galleys.

Segregated ballast means the ballast water introduced into a tank which is completely separated from the cargo oil and fuel oil system and which is permanently allocated to the carriage of ballast or to the carriage of ballast or cargoes other than oil or noxious liquid substances.

Sewage means sewage generated during normal operation of the ship and includes drainage as defined in Annex IV to MARPOL 73/78.

Sewage system means a system comprising the following equipment:

sewage holding tank with associated piping; or

sewage treatment plant and sewage holding tank;

discharge pipeline with pumps and standard discharge connectors.

SO_x Emission Control Areas mean areas where emission of sulphur oxides is limited as defined in Annex VI to MARPOL 73/78 and Directive 99/32/EU, as amended.

3.2 CLASSIFICATION

3.2.1 Application.

The requirements of this Section apply to the equipment and systems for prevention of pollution from emissions to air and discharges to sea and are aimed at prevention of environmental pollution in case of emergency.

Ships complying with the requirements of this Section may be assigned the following distinguishing marks in the class notation:

ECO – the distinguishing mark in the class notation, which identifies compliance with the basic requirements for controlling and limiting operational emissions and discharges as well as requirements for prevention of oil and NLS spills during cargo operations and bunkering (the requirements are specified in 3.5);

ECO-S – the distinguishing mark in the class notation, which identifies compliance with more stringent requirements than those for assignment of the distinguishing mark **ECO** in the class notation (the requirements are specified in 3.6).

It is recommended to assign the above distinguishing marks in the class notation to the following ships:

ECO – to newbuildings and existing ships;

ECO-S – to newbuildings, existing passenger and coastal ships.

3.2.2 Requirements for ships with the distinguishing marks ECO and ECO-S in the class notation.

Table 3.2.2

Requirements	Distinguishing marks in the class notation	
	ECO	**ECO-S**
The following requirements regarding prevention of air pollution shall be met on ships:		
3.5.2.2 Prevention of pollution by emission from marine diesel engines	×	×
3.6.2.2 Prevention of pollution by emission from marine diesel engines	–	×
3.5.2.3 Prevention of pollution by refrigerant emission	×	×
3.6.2.3 Prevention of pollution by refrigerant emission	–	×
3.5.2.4 Prevention of pollution by fire extinguishing media emission	×	×
3.6.2.4 Prevention of pollution by fire extinguishing media emission	–	×
3.5.2.5 and **3.6.2.5** Prevention of pollution by volatile organic compounds emission	×	×
3.5.2.6 and **3.6.2.6** Prevention of pollution by emissions from shipboard incinerators.	×	×
3.5.2.7 Energy efficiency of ship	×	×
3.6.2.7 Energy efficiency of ship	×	×
The following requirements regarding prevention of pollution of the marine environment shall be met on ships:		
3.5.3.2 Discharge of cargo residues	×	×
3.6.3.2 Discharge of cargo residues	–	×
3.5.3.3 Structural measures and equipment for prevention of oil spills during cargo operations and bunkering	×	×
3.6.3.3 Structural measures and equipment for prevention of oil spills during cargo operations and bunkering	–	×
3.5.3.4 Prevention of pollution at bilge water discharge	×	×
3.6.3.4 Prevention of pollution at bilge water discharge	–	×
3.5.3.5 Prevention of pollution by garbage	×	×
3.6.3.5 Prevention of pollution by garbage	–	×
3.5.3.6 Prevention of pollution by sewage	×	×
3.6.3.6 Prevention of pollution by sewage	–	×
3.5.3.7 and **3.6.3.7** Control of harmful anti-fouling systems	×	×
3.5.3.8 and **3.6.3.8** Prevention of lubricating oil and hydraulic oil leakages into seawater	×	×
3.5.3.9 Prevention of pollution in case of the hull damage	×	×
3.6.3.9 Prevention of pollution in case of the hull damage	–	×
The following requirements regarding prevention of pollution at ship recycling shall be met on ships:		
3.5.4 and **3.6.5** Prevention of pollution at ship recycling	×	×

3.2.3 Any ship shall have **AUT1** or **AUT2** distinguishing automation mark of the machinery installation in the class notation.

3.3 APPLICATION OF INTERNATIONAL INSTRUMENTS' REQUIREMENTS

3.3.1 The requirements of this Section are based on international instruments, the main of which are specified in 3.1. At the same time, some provisions of the requirements of this Section are more stringent than the requirements of the relevant international instruments.

3.3.2 Required compliance of the ship's systems and equipment with international instruments.

Table 3.3.2

Ship's systems and equipment	International instrument
15 ppm bilge separators	IMO resolution MEPC.107(49)
15 ppm bilge alarms	IMO resolution MEPC.107(49)
Oil discharge monitoring and control systems	IMO resolution MEPC.108(49), as amended
Oil/water interface detectors	IMO resolution MEPC.5(XIII), as amended
Shipboard incinerators	Regulation 16 of Annex VI to MARPOL 73/78, IMO resolution MEPC.76(40) or MEPC.244(66)
Sewage treatment plants	IMO resolution MEPC.159(55) or MEPC.227(64)
Cargo vapour collection systems of oil tankers	Regulation 15 of Annex VI to MARPOL 73/78, MSC/Circ.585
Marine diesel engines	Regulation 13 of Annex VI to MARPOL 73/78, NOx Technical Code
Exhaust gas cleaning systems to reduce the emission of sulphur oxides (SO_x)	Regulation 14 of Annex VI to MARPOL 73/78, IMO resolution MEPC.259(68)

3.3.3 International regulations and standards for use of fuel oil on ships, bunkering, sampling and testing of fuel oil.

Table 3.3.3

Required processes, specifications	International instrument
Sampling of fuel oil	IMO resolution MEPC.182(59), GOST 2517-85
Standard marine fuel oil	ISO 8217
Bunkering of ships	Regulation 18 of Annex VI to MARPOL 73/78
Fuel oil sulphur content test	ISO 8754

3.4 CERTIFICATES AND TECHNICAL DOCUMENTATION REQUIRED FOR ASSIGNING THE DISTINGUISHING MARKS ECO OR ECO-S IN THE CLASS NOTATION

3.4.1 Air Pollution Prevention Certificates:

.1 International Air Pollution Prevention Certificate (IAPP) with Supplement issued by any Administration or under the authorization thereof; or

International Air Pollution Prevention Certificate (form 2.4.6) with Supplement (form 2.4.23), issued in compliance with 1.11, Part III "Survey of Ships in Compliance with International Conventions, Codes, Resolutions and Rules for the Equipment of Sea-Going Ships" of the Guidelines on Technical Supervision of Ships in Service; or

Pollution from Ships Prevention Certificate (form 2.4.18rf).

.2 Engine International Air Pollution Prevention Certificate (EIAPP), issued by any Administration or under the authorization thereof; or

Engine International Air Pollution Prevention Certificate (form 2.4.40) with Supplement (form 2.4.41), issued in compliance with 1.11, Part III "Survey of Ships in Compliance with International Conventions, Codes, Resolutions and Rules for the Equipment of Sea-Going Ships" of the Guidelines on Technical Supervision of Ships in Service;

.3 SO_x Emission Compliance Certificate (SECC) issued by any Administration or under the authorization thereof; or

SO_x Emission Compliance Certificate (form 2.4.42), issued by the Register under the authorization of any Administration;

.4 International Energy Efficiency Certificate (IEEC) issued by any Administration or under the authorization thereof; or

International Energy Efficiency Certificate (form 2.4.3) with Supplement (form 2.4.3.1), issued in compliance with 1.11, Part III "Survey of Ships in Compliance with International Conventions, Codes, Resolutions and Rules for the Equipment of Sea-Going Ships" of the Guidelines on Technical Supervision for Ships in Service; or

Energy Efficiency Certificate (form 2.4.3rf) with Supplement (form 2.4.3.1rf).

3.4.2 Operating procedures and ship's technical documentation in respect of air pollution prevention:

.1 approved Technical File of the engine on the NO_x emission for each engine subject to survey in accordance with the NO_x Technical Code, including the engine fitted with NO_x-reducing device as an engine component;

.2 approved EGCS – SO_x Technical Manual (ETM) (where applicable);

.3 drawings of any exhaust gas cleaning system which shall be approved in compliance with the IMO Guidelines;

.4 approved Onboard Monitoring Manual (OMM) (where applicable);

.5 approved SO_x Emission Compliance Plan (SECP) (where applicable);

.6 Record Book of SO_x-Reducing Device Parameters;

.7 approved documentation on the ship's fuel oil system confirming possibility of ready change over to low-sulphur content fuel oil when approaching SO_x emission control areas established under Annex VI to MARPOL 73/78 or Directive 99/32/EU accordingly (where applicable);

.8 procedure for preparing the ship's fuel oil system for operation in the SO_x emission control area (SECA) (where applicable);

.9 Fuel Oil Management Plan, Fuel Oil Record Book;

.10 incinerator systems diagram;

.11 refrigerating operations management procedure;

.12 refrigerating systems diagrams, list of refrigerants used;

.13 fire-fighting systems diagrams, list of fire extinguishing media used in these systems;

.14 Volatile Organic Compound (VOC) Management Plan;

.15 Energy Efficiency Design Index (EEDI) Technical File (where applicable);

.16 Ship Energy Efficiency Management Plan (SEEMP).

3.4.3 Marine Environment Pollution Prevention Certificates:

.1 International/Non-international Oil Pollution Prevention Certificate (IOPP) issued by the Flag State Maritime Administration or an organization recognized by it (the Register draws up the International Oil Pollution Prevention Certificate (form 2.4.5) with Supplement (forms 2.4.20 or 2.4.26) or the Pollution from Ships Prevention Certificate (form 2.4.18rf), as applicable, in compliance with the provisions of Part III "Survey of Ships in Compliance with International Conventions, Codes, Resolutions and Rules for the Equipment of Sea-Going Ships" of the Guidelines on Technical Supervision for Ships in Service);

.2 International/Non-international Sewage Pollution Prevention Certificate issued by the Flag State Maritime Administration or an organization recognized by it (the Register draws up the International Sewage Pollution Prevention Certificate (form 2.4.9) or the Pollution from Ships Prevention Certificate (form 2.4.18rf), as applicable, in compliance with the provisions of Part III "Survey of Ships in Compliance with International Conventions, Codes, Resolutions and Rules for the Equipment of Sea-Going Ships" of the Guidelines on Technical Supervision for Ships in Service);

.3 Certificate of Compliance of Equipment and Arrangements of the Ship with the Requirements of Annex V to MARPOL 73/78 (form 2.4.15) (where applicable); or

Pollution from Ships Prevention Certificate (form 2.4.18rf);

.4 International Anti-Fouling System Certificate issued by the Flag State Maritime Administration or an organization recognized by it (the Register, under the authorization of the Maritime Administration, draws up the International Anti-Fouling System Certificate (forms 2.4.30 or 2.4.30ec) with the Records of Anti-Fouling Systems (forms 2.4.31 or 2.4.31ec) or the Statement of Compliance of Anti-Fouling System (form 2.4.30.1) with the Record of Anti-Fouling System (form 2.4.31.1), where applicable, or Declaration on Compliance of Anti-Fouling System with AFS Convention, if applicable (refer to 3.5.3.8.3));

.5 International Ballast Water Management Certificate issued by the Flag State Maritime Administration or an organization recognized by it (the Register, under the authorization of the Maritime Administration, draws up the International Ballast Water Management Certificate (form 2.5.4) or Statement of Compliance with the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM) (form 2.5.4.1), as applicable, in compliance with the provisions of Part III "Survey of Ships in Compliance with International Conventions, Codes, Resolutions and Rules for the Equipment of Sea-Going Ships" of the Guidelines on Technical Supervision for Ships in Service);

.6 Certificate on Inventory of Hazardous Materials (for the ships covered by the requirements of the Regulation (EU) No. 1257/2013 of the European Parliament and of the Council of 20 November 2013 on Ship Recycling and operating under the EU flag) or Statement of Compliance (for ships flying flags other than EU flags, calling ports or at anchorage within EU states) and/or Statement on Inventory of Hazardous Materials (for ships covered by the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009, if no documents shall be issued under the Regulation (EU) No. 1257/2013 of the European Parliament and of the Council of 20 November 2013 on Ship Recycling), issued upon the results of the ship survey in compliance with the provisions of relevant conventions, regulations.

The documents mentioned above shall be supplemented by Part I of the Inventory of hazardous materials. The Certificate/Statement with Part I of the Inventory of hazardous materials shall be permanently available on board throughout the ship's operating life. Part I of the Inventory of hazardous materials shall be kept updated and appropriately revised, especially after any repair, ship conversion or sale.

The following documents shall be available on board to confirm the readiness for recycling:

Ready for recycling certificate (in accordance with the Regulation (EU) No. 1257/2013 of the European Parliament and of the Council of 20 November 2013 on Ship Recycling); or

Ready for recycling statement (in compliance with the requirements of the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009, and on the grounds of authorization from the Maritime Administration).

The documents mentioned above shall be drawn up upon the results of the final survey in accordance with the applicable provisions of the conventions, EU regulation;

.7 International Pollution Prevention Certificate for the Carriage of Noxious Liquid Substances in Bulk or International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk, issued by the Flag State Maritime Administration or an organization recognized by it (the Register draws up forms 2.4.7/2.4.10 or the Pollution from Ships Prevention Certificate (form 2.4.18rf), as applicable, in compliance with the provisions of Part III "Survey of Ships in Compliance with International Conventions, Codes, Resolutions and Rules for the Equipment of Sea-Going Ships" of the Guidelines on Technical Supervision for Ships in Service).

3.4.4 Operating procedures and ship's technical documentation in respect of marine environment pollution prevention:

.1 ship's general arrangement plan and tanks plan;

.2 approved documentation confirming compliance of the oil tanker with the requirements for double hull construction in accordance with regulation 19 of Annex I to MARPOL 73/78;

.3 approved documentation confirming compliance of the ship with the requirements for protective location of fuel oil tanks (refer to 3.5.3.9.5 — 3.5.3.9.7 and 3.6.3.9.2);

.4 approved Shipboard Oil Pollution Emergency Plan or Shipboard Marine Pollution Emergency Plan (for Oil and Noxious Liquid Substances) considering regulation 37.4 of Annex I to MARPOL 73/78 in relation to fast access to computerized shore-based software for calculation of damage stability and residual structural strength, as well as Oil Record Book, Parts I and II (regulations 17 and 36 of Annex I to MARPOL 73/78);

.5 approved Shipboard Marine Pollution Emergency Plan for Noxious Liquid Substances (regulation 17 of Annex II to MARPOL 73/78), approved Procedures and Arrangement Manual (regulation 14 of Annex II to MARPOL 73/78) and Cargo Record Book (regulation 15 of Annex II to MARPOL 73/78);

.6 approved Transfer of Oil Cargo between Oil Tankers at Sea (STS Operations) Plan (for oil tankers, where available);

.7 approved Ballast Water Management Plan;

.8 approved Ship's Guidelines for Safe Water Ballast Exchange at Sea (where applicable);

.9 Ballast Water Record Book;

.10 approved ship's software for planning water ballast exchange at sea (where applicable);

.11 Biofouling Management Plan and Biofouling Record Book in compliance with IMO resolution MEPC.207(62);

.12 approved ship's software for calculation of intact trim, stability and strength as well as damage trim and stability;

.13 Sewage Management Plan and procedure for sewage record keeping;

.14 sewage system diagram and sanitary and domestic waste waters system diagram;

.15 procedure for keeping records on detection and elimination of impermissible operating leakages of petroleum products i.e. fuel oil, hydraulic oil, etc.;

.16 diagrams of manifolds in cargo areas, as well as branch pipes and flanges for fuel oil and oil bunkering, oil residues and oily water discharge indicating the trays and appliances for prevention of spillage of Oil and Noxious Liquid Substances carried in bulk;

.17 diagrams and drawings of fuel oil system, bilge system, oil discharge, monitoring and control system for ballast and flushing water, ballast water system;

.18 Garbage Management Plans, placards and Garbage Record Book, diagrams and drawing of equipment for the prevention of pollution by garbage.

3.5 TECHNICAL REQUIREMENTS FOR ASSIGNING THE DISTINGUISHING MARK ECO IN THE CLASS NOTATION

3.5.1 Application.

3.5.1.1 The provisions of this Chapter cover the requirements on emissions to air from sources of power, oil tanker cargo systems and service systems onboard, as well as requirements for discharges to sea from sources of power, from ship's systems and equipment of machinery spaces and from cargo areas of oil tankers, chemical tankers and NLS tankers, from sewage systems, anti-fouling systems, as well as the requirements for the prevention of pollution by garbage.

3.5.1.2 The required documentation is specified in 3.4.

3.5.2 Prevention of air pollution.

3.5.2.1 General.

3.5.2.1.1 Fuel oil supplied to the ship shall not contain inorganic acids or chemical wastes that can endanger a ship, bring harm to the crew or that can add to air pollution.

3.5.2.1.2 Fuel oil shall be controlled in accordance with Fuel Oil Management Plan, Fuel Oil Record Book.

Quality of ordered fuel oil and quality of received fuel oil according to bunker delivery note shall be documented in Fuel Oil Record Book (refer to regulations 18.3 and 18.4 of Annex VI to MARPOL 73/78, as well as Directive 99/32/EU, as amended).

Fuel Oil Management Plan shall comprise adequate procedures for replacement of fuel oil in order to make sure that fuel oil burnt in the engine in the SO_x emission control area is of the required quality. Relevant ship's log shall contain evidence that the fuel oil of the required quality was used in relevant areas.

3.5.2.1.3 SECP shall be readily available in all ships using exhaust gas cleaning system to reduce SO_x emission to confirm compliance with the requirements of regulations 14.1 and 4.14 of Annex VI to MARPOL 73/78.

This Plan shall list all ship's plants for burning fuel oil, which comply with the operating requirements specified in the above regulations by adoption of the approved system specified above.

3.5.2.1.4 Bunker delivery note shall be accompanied by sample of supplied fuel oil properly sealed and signed by representatives of the bunkering company, ship master or ship officer responsible for bunkering operations. Bunker delivery note shall be kept onboard for three years. Fuel oil sample shall be stored under ship's officers control until the end of consumption but not less than 12 months from the date of supply.

This note shall confirm that a fuel oil is supplied in accordance with regulations 14 and 18 of Annex VI to MARPOL 73/78, i.e. sulphur content in the supplied fuel oil complies with the applicable requirements and there are no inorganic acids and chemical wastes in this fuel oil.

For the purpose of cross-reference, the number of sample shall be stated in the note.

3.5.2.1.5 Sampling equipment and testing procedures shall comply with provisions of documents specified in 3.3.3.

In order to fulfill the requirements of IMO resolution MEPC.182(59) in respect of method and place of fuel oil sampling the ship shall be fitted with the sampling device of approved structure (irrespective whether the fuel oil supplier has a sampling device for installation on the inlet header of receiving ship or not).

3.5.2.2 Prevention of pollution by emission from marine diesel engines.

3.5.2.2.1 NO_x emission restrictions are applied to engines permanently fitted onboard of power output more than 130 kW, except engines that are part of any equipment used in emergency solely onboard the ships where they are installed and engines on lifeboats.

3.5.2.2.2 Level of emission from engines on all ships shall comply with Annex VI to MARPOL 73/78.

3.5.2.2.3 Appropriate certificates shall be issued to marine engines of power more than 130 kW (except emergency ones and those for lifeboats) and to exhaust gas cleaning systems to reduce SO_x emission (if applicable) in accordance with 3.4.1.

3.5.2.2.4 Where NO_x-reducing device is used, it shall be considered as the engine component. When for NO_x reduction a selective catalytic reduction (SCR) system is used, the requirements of IMO resolution MEPC.291(71) shall be complied with.

3.5.2.2.5 Measurements of NO_x emission level from diesel engines with exhaust gas cleaning system to reduce NO_x emission or without it shall comply with methods specified in the NO_x Technical Code. Measurements and tests shall be performed and documented in accordance with the provisions of the Guidelines on Marine Diesel Engines Survey in Compliance with the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines.

3.5.2.2.6 When a ship operates outside the SO_x emission control areas the maximum sulphur content in fuel oil used or transported to use on board the ship shall not exceed 0,50 % by mass. When an exhaust gas cleaning system is used, the SO_x (ppm)/CO_2 (% v/v) ratio shall not exceed 21,7.

3.5.2.2.7 During operation of ships in the territorial seas, coastal zones and EU ports the sulphur content in fuel oil shall not exceed values specified in EU Council Directive 1999/32/EU, as amended (articles 3 and 4).

3.5.2.2.8 During operation of passenger ships engaged on the regular voyages to/from the EU ports the sulphur content in fuel oil shall not exceed values specified in Directive 2005/33/EU (article 4a).

3.5.2.2.9 Transition from one type of fuel oil to another while coming in and out of the SO_x emission control areas specified in Annex VI to MARPOL 73/78, as well as while coming in and out of the EU territorial waters including mooring and anchoring in the EU ports shall be registered in the ship's log.

3.5.2.2.10 During survey of engines fitted with the exhaust gas cleaning systems to reduce SO_x emission, the compliance with SO_x emission norms specified in the Guidelines for On-Board Exhaust GAS-SO_x Cleaning System (IMO resolution MEPC.259(68)) shall be confirmed.

3.5.2.3 Prevention of pollution by refrigerant emission.

3.5.2.3.1 The requirements of the present Section for prevention of pollution by refrigerant emission are applied to cargo refrigerating plants, air conditioning plants and refrigerating systems of all ships.

The said requirements are not applied to autonomous home air-conditioners, refrigerators and freezers permanently sealed and having no connections for refrigerant charging onboard.

3.5.2.3.2 In accordance with provisions of the Montreal Protocol 1987 criteria for refrigerant emission are limited by requirements relative to qualities of used refrigerants in relation to their ozone depleting potential (ODP) and global warming potential (GWP).

3.5.2.3.3 It is not allowed to use ozone-depleting substances on ships.

The following substances may be used as refrigerants onboard:

natural refrigerants (such as, ammonia (NH_3) or carbonic acid (CO_2));

hydro fluorocarbon (HFC) with ODP = 0 and GWP < 3500.

3.5.2.3.4 The Refrigerant Management Procedure shall be implemented on board the ships to control presence of leaks which shall contain as a minimum the following issues:

operation of refrigerating plants to prevent/minimize possible leaks;

periodicity of inspections of refrigerating plants aimed at finding leaks and keeping records of their quantity;

performing corrective actions if leaks exceed norms, operating limitations to prevent such leaks.

Corrective actions shall be performed before the quantity of leaks reaches 10 % of the total quantity of refrigerant in each system.

3.5.2.3.5 In order to regenerate a refrigerant, compressors shall be able to discharge refrigerant from the system into the relevant receiver of the liquid refrigerant. Additionally, regenerating units shall be fitted to discharge refrigerant from the system into the existing refrigerant receivers or appropriate receivers.

3.5.2.3.6 When different types of refrigerants are used, measures shall be provided to prevent mixing of such substances.

3.5.2.3.7 In order to make sure there are no emissions to air or that they are reduced to minimum, refrigerants in the refrigerating systems shall be controlled by appropriate method to discover all types of leaks, including those that are usually not discovered by the automatic leak detection system.

One of the following methods or combination thereof may be used:

leak detection system appropriate for the used refrigerant with signaling if refrigerant is found outside refrigerating system;

measuring of refrigerant level in the refrigerating system with low level signaling;

registering refrigerant level in special journal at certain intervals (once in a week as a minimum) to find out minor leaks.

3.5.2.4 Prevention of pollution by fire extinguishing media emission.

3.5.2.4.1 Natural fire extinguishing media (such as argon, nitrogen, CO_2) used in fixed fire extinguishing systems are not considered as ozone depleting substances.

3.5.2.4.2 When other fire extinguishing media (for instance, hydrofluorocarbons (HFC) are used in fixed fire extinguishing systems, the media shall have the following properties: GWP < 4000, ODP = 0.

3.5.2.5 Prevention of pollution by volatile organic compounds emission.

3.5.2.5.1 In order to prevent emission of VOC from oil tankers carrying crude oil, petroleum products, as well as from chemical tankers carrying chemical cargoes with flashpoint < 60 °C, standards for cargo vapour discharge systems shall be applied according to IMO MSC/Circ.585.

3.5.2.5.2 Approved technical documentation for the cargo vapour discharge system including principal diagram of the pipeline for vapour collection on oil tanker with indication of location and purpose of all control and safety arrangements as well as cargo transfer instruction shall be available onboard. This instruction shall contain information on the maximum permissible speed of cargo transfer, maximum pressure drop in the ship vapour collection system at different speeds of loading, operation threshold of each high-speed or vacuum valve etc.

3.5.2.5.3 In Appendix to the International Air Pollution Prevention (IAPP) Certificate there shall be a note on the presence of cargo vapour collection system fitted and approved in accordance with IMO MSC/Circ.585.

3.5.2.5.4 An approved VOC Management Plan shall be available on board the ship.

3.5.2.6 Prevention of pollution by emission from shipboard incinerators.

3.5.2.6.1 Shipboard incinerators shall be type-approved in accordance with IMO resolution MEPC.76(40) or MEPC.244(66), as applicable.

3.5.2.6.2 Approved diagrams of the incinerator systems, the copy of Incinerator Type Approval Certificate as well as incinerator operational manual shall be available on board the ship.

3.5.2.6.3 In the Certificates (Supplements) given in 3.4.1.1 and 3.4.3.3, Certificate shall contain notes on shipboard incinerator corresponding to IMO resolution MEPC.76(40) or MEPC.244(66), as applicable.

3.5.2.6.4 Operation of incinerators shall be in accordance with regulation 16 of Annex VI to MARPOL 73/78 and the approved Garbage Management Plan, and be recorded in the Garbage Record Book specified in regulations 10.2 and 10.3 of Annex V to MARPOL 73/78, respectively.

3.5.2.7 Energy efficiency.

3.5.2.7.1 New ship of 400 gross tonnage and above shall be constructed and operated in compliance with chapter 4 in Annex VI to MARPOL 73/78 (IMO resolution MEPC.203(62), as amended) in terms of energy efficiency depending on the ship type and propulsion plant.

3.5.2.7.2 Each (new and existing) ship of 400 gross tonnage and above, except platforms (including floating offshore oil-and-gas production units), mobile offshore drilling units irrespective of propulsion plants and any non-self-propelled ship, shall keep on board and implement Ship Energy Efficiency Management Plans (SEEMP).

3.5.3 Prevention of marine environment pollution.

3.5.3.1 General.

Compliance with the requirements shall be confirmed in accordance with 3.2 — 3.4.

3.5.3.2 Discharge of contaminated water and water polluted with noxious liquid substances from cargo areas of ships.

3.5.3.2.1 Discharge criteria apply to tankers carrying crude oil, petroleum products or noxious substances in bulk.

3.5.3.2.2 Discharge of contaminated ballast water or washing water from the area of cargo tanks of oil tankers shall be carried out by the system of automatic measuring, record and control of discharge of ballast and washing water. Discharge criteria shall be in compliance with Annex I to MARPOL 73/78.

3.5.3.2.3 Each tanker designed for the carriage of noxious substances in bulk shall be equipped with pumps and pipelines, providing stripping of each tank carrying cargoes with pollution categories X, Y and Z, in the way that the quantity of residues in the tank and associated piping does not exceed 75 l in accordance with Annex II to MARPOL 73/78. Discharge of contaminated water to sea shall be carried out by means specified in Annex II to MARPOL 73/78.

3.5.3.2.4 The above discharges and discharge to shore reception facilities shall be documented in the Oil Record Book, or Cargo Record Book, for oil tankers and chemical tankers, respectively.

3.5.3.3 Structural measures and equipment for prevention of oil spills during cargo operations and bunkering.

3.5.3.3.1 Oil tankers, chemical tankers and NLS tankers shall have fitted and implemented means and arrangements to reduce the possibility of oil or NLS spill on deck reaching the sea.

3.5.3.3.2 To keep cargo spills within the cargo area, provision shall be made for a permanent continuous coaming on the cargo deck extending from side to side and from a point $0{,}2L$ forward of amidships to the aft end of the cargo deck with the height dimensions given in Table 3.5.3.3.2:

Table 3.5.3.3.2

Height dimensions of continuous coamings		
Ships of 100000 t deadweight and above	$0{,}2L$ forward of amidships	0,25 m
	Aft end of cargo deck	0,30 m
Ships of less than 100000 t deadweight	$0{,}2L$ forward of amidships	0,10 m
	Aft end of cargo deck	0,30 m

3.5.3.3.3 To collect possible oil spills during cargo operations the main deck in the cargo area shall be fitted with a system for collection of the spilled cargo with its accumulation in a holding tank or a slop tank.

Collection of the spilled cargo may be performed using particular pump and pipes located in the cargo area or by gravity drainage through specially provided pipes. The system shall be provided with means for removal of cargo residues from the pipes, when the collection of the spilled cargo is over.

Automatic gravity drainage shall be used during cargo operations where cargo spills may occur, and shall not be used under normal conditions when at sea. For gravity drainage, each pipe of deck system shall be arranged with a manually operated valve opened only during cargo operations and an automatic scupper.

3.5.3.3.4 On oil tankers, chemical tankers and NLS tankers, the points where cargo hoses are connected to cargo manifolds shall be fitted with pipes for drainage of leaks to a holding tank or a slop tank.

The trays shall have the following minimum dimension:

tray length shall be so that the cargo manifold doesn't extend beyond forward and aft ends of the tray;

width – at least 1,8 m, at that the spill tray extends at least 1,2 m outboard of the end of the manifold flange;

minimum depth – 0,3 m.

3.5.3.3.5 Oil tankers, chemical tankers and NLS tankers shall be fitted with means to adequately support hoses in way of ship's side abreast of manifolds. The support shall preferably be arranged as a horizontal curved plate or pipe section.

3.5.3.3.6 Oil tankers, chemical tankers and NLS tankers shall be fitted with a closed sounding system with high and maximum level alarms in cargo tanks. Alternatively, a high level alarm may be accepted in combination with a closed sounding system, provided the alarm is independent from the sounding system.

3.5.3.3.7 Fuel oil, lubricating oil and other petroleum products bunker tanks on all ships shall be fitted with high level alarm to prevent overfilling.

3.5.3.3.8 Locations on the open deck in the area of fuel and lubricating oil manifolds, standard connections for oil residues discharge (located outside the bunkering station areas), vent and overflow pipes, other areas where petroleum products and NLS spill may occur shall be fitted with spill trays or restricted by sufficient coamings to prevent their escape to sea.

These requirements shall not be applied to locations of receiving fuel and lubricating oil manifolds provided on general location area together with cargo manifolds, the locations of which shall be fitted with trays according to 3.5.3.3.4.

Oil and fuel bunkering stations located in the provided spaces shall be fitted with deck scupper system for collection of spill with its accumulation in the relevant holding tank.

3.5.3.3.9 Any oil tanker involved in STS operations shall carry on board an approved plan how to conduct STS operations (STS Operations Plan) in compliance with IMO resolution MEPC.186(59).

3.5.3.4 Prevention of pollution at oil contaminated and bilge water discharge.

3.5.3.4.1 The requirements for filtering equipment and for discharge of oily bilge water in compliance with regulations 14 and 15 of Annex I to MARPOL shall apply to all ships as specified thereof.

3.5.3.4.2 In addition to the requirements of Annex I to MARPOL 73/78, each ship shall be fitted with the oil contaminated bilge water holding tank of sufficient capacity agreed with the Register for bilge water storage and disposal to reception facilities.

3.5.3.5 Prevention of pollution by garbage.

3.5.3.5.1 The requirements to garbage management and the availability of Garbage Management Plans and placards shall apply to all ships in compliance with Annex V to MARPOL 73/78 regardless the ship gross tonnage and permissible number of persons on board.

3.5.3.5.2 A ship shall be equipped with the marked containers with tight covers for garbage, collection and storage prior to its discharge to the sea in the allowed areas in accordance with the regulations 3 – 6 of Annex V to MARPOL 73/78 or prior to its incineration in the ship incinerators or discharge to shore reception facilities.

3.5.3.5.3 If a ship is fitted with the food wastes comminuter, which provides for comminution to particles not exceeding 25 mm in size, comminuted food wastes shall be

directed to a dedicated separate holding tank when the ship is operating within the areas where the discharge of such wastes is prohibited.

3.5.3.6 Prevention of pollution by sewage.

3.5.3.6.1 A ship shall be provided with a Certificate specified in 3.4.3.2.

3.5.3.6.2 All ships shall be fitted with a sewage holding tank and sewage treatment plant of sufficient capacity having a Certificate of Type Approval in compliance with IMO resolution MEPC.159(55) or MEPC.227(64), as applicable.

The above holding tank of sufficient capacity shall be fitted with the effective visual indication means of its capacity with visual and audible alarm activated at 80 % filling of the tank. Means shall be provided to aerate holding tank to maintain oxygen concentration required to prevent the development of anaerobic conditions in the tank.

3.5.3.6.3 All ships equipped with a pipeline for discharge of untreated sewage shall be fitted with pipelines with a standard discharge connection in accordance with regulation 10 of Annex IV to MARPOL 73/78 for sewage discharge to reception facilities.

3.5.3.6.4 All ships equipped with a pipeline for discharge of untreated sewage shall be provided with calculations of the rate of discharge of untreated sewage approved by the Register upon authorization of the Administration. These calculations shall be drawn up according to Recommendation on Standards for the Rate of Discharge of Untreated Sewage from ships in compliance with IMO resolution MEPC.157(55).

3.5.3.6.5 All sewage discharges, whether to sea or to shore-based reception facilities shall be recorded in compliance with 3.4.4.13 with indication of date, location and quantity of sewage discharged. In cases where untreated sewage is discharged to sea, the record shall include information on the ship's speed which shall correspond to the approved rate of discharge and the distance to the nearest shore (more 12 nautical miles[1]) at the moment of discharge.

3.5.3.6.6 Untreated sewage, including sludge from sewage treatment plant shall be discharged overboard by means of a pipeline separate from a pipeline for discharge of treated sewage. In case of common piping, provision shall be made for means of its cleaning, e.g. by washing.

3.5.3.7 Anti-fouling systems.

3.5.3.7.1 Anti-fouling systems (coatings) containing organo-tin compounds (Tributyltin (TBT)) as the active ingredients are not permitted.

3.5.3.7.2 Ships of 400 gross tonnage and above shall carry one of Certificates, Statement or Declaration of Compliance of Anti-Fouling System with the International Convention on the Control of Harmful Anti-Fouling Systems of Ships, 2001 (AFS Convention).

3.5.3.7.3 Ships having a length of 24 m (IC66) and more but of less than 400 gross tonnage shall carry declarations on compliance of their anti-fouling systems with AFS Convention in accordance with form of Addenda 2 to Annex 4 to AFS Convention or with Annex III of EU Regulation 782/2003 (Regulation 5 of Annex 4 to AFS Convention).

3.5.3.8 Prevention of lubricating oil and hydraulic oil leakages into seawater.

3.5.3.8.1 Requirements for prevention of leakages of lubricating oil and hydraulic oil into seawater shall be applied in the following cases:

if oil-lubricated stern tube bearings and sealing arrangements are provided;

if there is a possibility that lubricating oil will spill into the seawater from the lubricating oil system of the steering gear bearing;

if seawater cooled engines are provided;

if there is a probability that oil from the hydraulic system will spill into the seawater.

3.5.3.8.2 Occurrence of lubricating oil and hydraulic oil operating leakages into seawater shall be continuously monitored. If evidence of leakage is found, corrective actions shall be

[1] Hereinafter a nautical mile is equal to 1852 m.

initiated and recorded in the ship's log. For this purpose all the insignificant oil leaks shall be monitored by the approved manual or automatic methods.

3.5.3.8.3 In case of oil-lubricated stern tube bearings and/or sealing arrangements, the above requirements shall be considered in addition to the requirements for oil level indicators and low level alarm of lubricating oil tanks as well as environmental safety of stern tube arrangements (refer to 5.6.4 and 5.7, Part VII "Machinery Installations").

3.5.3.9 Prevention of pollution in case of the hull damage.

3.5.3.9.1 The ship with the descriptive notations **Oil tanker** or **Oil/ore carrier** or **Chemical tanker** in the class notation shall be provided with double hull and double bottom in the cargo area in accordance with regulation 19 of Annex I to MARPOL 73/78.

3.5.3.9.2 Requirements to the damage trim and stability characteristics specified in 3.3, Part V "Subdivision" shall be used during flooding of any compartment, if provisions of 3.4 of the above Part do not specify more rigid requirements.

3.5.3.9.3 Any ship shall be fitted with the onboard software to calculate intact trim, stability and strength and to calculate damaged ship trim and stability.

3.5.3.9.4 Oil tankers of 600 t deadweight and over, as well as other ships, with an aggregate fuel oil tanks capacity 600 m^3 and over shall have prompt access to computerized, shore-based damage stability and residual structural strength calculation programs in accordance with regulation 37.4 of Annex I to MARPOL 73/78.

3.5.3.9.5 Ships having an aggregate fuel oil tanks capacity 600 m^3 and over shall have double hull and double bottom to protect fuel oil tanks in accordance with regulation 12A of Annex I to MARPOL 73/78, irrespective of capacity of each fuel oil tank.

3.5.3.9.6 Location of suction wells in fuel oil tanks shall comply with the requirements of regulation 12A.10 of Annex I to MARPOL 73/78.

3.5.3.9.7 The valves for fuel oil pipelines located at a distance less than *h* from the ship's bottom shall be arranged at a distance of not less than *h*/2 from the ship's bottom (refer to Fig. 3.5.3.9.7).

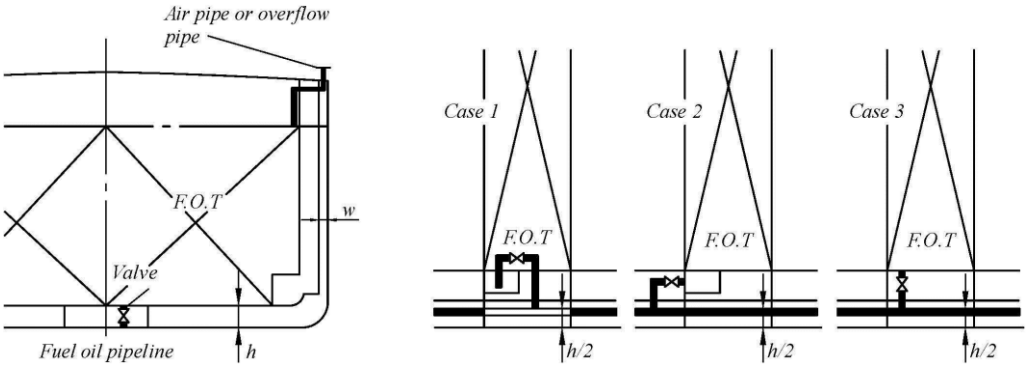


Fig. 3.5.3.9.7

S y m b o l s :
h = the minimum distance of fuel oil tanks location from the moulded line of the bottom shell plating, in m;
w = the minimum distance of fuel oil tanks location from the moulded line of the side shell plating, in m;
F.O.T. = fuel oil tank.

3.5.3.10 Segregated ballast tanks.

3.5.3.10.1 Segregated ballast tanks shall be provided on ships with the descriptive notation **Oil tanker** or **Oil/ore carrier** or **Chemical tanker** in the class notation.

3.5.3.10.2 The capacity of the segregated ballast tanks shall be so determined that the ship may operate safely on ballast voyages without recourse to the use of cargo tanks for water ballast.

3.5.4 Prevention of pollution at ship recycling.

3.5.4.1 The ships covered by the requirements of the Regulation (EU) No. 1257/2013 of the European Parliament and of the Council of 20 November 2013 on Ship Recycling and operating under the EU flag, and/or covered by the requirements of the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009, shall have Certificates or Statements specified in 3.4.3.6. For the ships, which are not covered by the above mentioned requirements, these documents may be issued on a voluntary basis.

3.5.5 Environmental responsibilities.

All ships shall have a responsible environmental officer onboard.

This officer shall be responsible for the following:

checking the compliance with the environment pollution prevention requirements;

monitoring the implementation of the relevant procedures;

maintaining the relevant ships' logs;

education and training of personnel in the relevant environmental practices.

The responsible environmental officer may delegate authorities to other crew members remaining responsible for the organization of environment protection measures on board the ship.

3.6 TECHNICAL REQUIREMENTS FOR ASSIGNING THE DISTINGUISHING MARK ECO-S IN THE CLASS NOTATION

3.6.1 Introduction.

3.6.1.1 The provisions of this Chapter cover the requirements for emissions to air from sources of power, cargo systems of oil tankers and service systems on board the ship, as well as the requirements for discharges to sea from sources of power, shipboard systems and equipment of machinery spaces, from cargo areas of oil tankers, chemical tankers and NLS tankers, from sewage systems, anti-fouling systems of the ship, as well as the requirements for prevention of pollution by garbage.

3.6.1.2 Requirements for assigning the distinguishing mark **ECO-S** in the class notation are more stringent as regards prevention of air and marine environment pollution as compared to the requirements for assigning the distinguishing mark **ECO** in the class notation.

3.6.1.3 The required documentation is listed in 3.4.

3.6.2 Prevention of air pollution.

3.6.2.1 General.

3.6.2.1.1 Compliance with the requirements shall be confirmed in accordance with 3.2 — 3.4.

3.6.2.1.2 Fuel oil to be used onboard shall comply with the requirements 3.5.2.2.6 — 3.5.2.2.8.

3.6.2.2 Prevention of pollution by emission from marine diesel engines.

3.6.2.2.1 Compliance with the requirements shall be confirmed in accordance with 3.5.2.2.1 — 3.5.2.2.5 and 3.5.2.2.9 — 3.5.2.2.10.

3.6.2.3 Prevention of pollution by refrigerant emission.

3.6.2.3.1 The requirements of this Section for prevention of pollution by refrigerant emission shall comply with the requirements of 3.5.2.3.

3.6.2.3.2 The following substances may be used as refrigerants onboard:

natural refrigerants (such as, ammonia (NH_3) or carbonic acid (CO_2));

hydrofluorocarbon (HFC) with ODP=0 and GWP<1890.

3.6.2.3.3 Structural and operational requirements shall comply with 3.5.2.3.4 — 3.5.2.3.7.

3.6.2.4 Prevention of pollution by fire extinguishing media emission.

3.6.2.4.1 Natural fire extinguishing media (such as argon, nitrogen, CO_2) used in fixed fire extinguishing systems are not considered as ozone depleting substances.

3.6.2.4.2 When other fire extinguishing media (for instance, hydrofluorocarbons (HFC) are used in fixed fire extinguishing systems, the media shall have the following properties: GWP < 1650, ODP = 0.

3.6.2.5 Prevention of pollution by volatile organic compounds emission.

In order to prevent emission of VOC from oil tankers carrying crude oil, petroleum products or chemical cargoes with flashpoint < 60 °C, the requirements of 3.5.2.5 shall be applied.

3.6.2.6 Prevention of pollution by emission from shipboard incinerators.

Shipboard incinerator shall comply with the requirements of 3.5.2.6.

3.6.2.7 Energy efficiency.

3.6.2.7.1 Energy efficiency shall be provided in compliance with the requirements in 3.5.2.7.

3.6.3 Prevention of marine environment pollution.

3.6.3.1 General.

Compliance with the requirements shall be confirmed in accordance with 3.2 — 3.4.

3.6.3.2 Discharge of cargo residues.

3.6.3.2.1 Discharge criteria for cargo residues for tankers carrying crude oil, petroleum products or noxious substances in bulk are specified in 3.5.3.2.

3.6.3.2.2 Each tanker designed for the carriage of noxious substances in bulk shall be equipped with pumps and pipelines, providing stripping of each tank carrying cargoes with pollution categories X, Y and Z, in the way that the quantity of residues in the tank and

associated piping does not exceed 50 l in accordance with Annex II to MARPOL 73/78. Discharge of contaminated water to sea shall be carried out by means specified in Annex II to MARPOL 73/78.

3.6.3.2.3 Cargo tanks shall have smooth inner surfaces and be equipped with cargo wells for efficient stripping. Horizontal framing shall be avoided as far as practicable. Corrugated bulkheads may be allowed with the maximum horizontal angle of corrugations of 65°.

3.6.3.2.4 A washing system with the cleaning machines so arranged that all the surfaces of each tank be washed is obligatory.

3.6.3.2.5 On chemical tankers type 3 as defined in 2.1.2 of the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code), cargo tanks shall be located at a distance of at least 0,76 from the shell plating.

3.6.3.3 Structural measures and equipment for prevention of oil spills during cargo operations and bunkering.

3.6.3.3.1 Oil tankers, chemical tankers and NLS tankers shall have fitted and implemented means and arrangements to reduce the possibility of oil or NLS spill on deck reaching the sea according to 3.5.3.3.2.

3.6.3.3.2 To collect possible oil spills during cargo operations the main deck in the cargo area shall be fitted with a system for collection of the spilled cargo according to 3.5.3.3.3.

3.6.3.3.3 On oil tankers, chemical tankers and NLS tankers where cargo hoses are connected to cargo manifolds, the provision shall be made for spill trays with dimensions and pipes according to 3.5.3.3.4.

3.6.3.3.4 In the drainage collecting system, shutoff valves shall be provided to stop the drainage into collecting tanks.

3.6.3.3.5 Oil tankers, chemical tankers and NLS tankers shall be fitted with means to support hoses according to 3.5.3.3.5.

3.6.3.3.6 Oil tankers, chemical tankers and NLS tankers shall be fitted with a closed sounding system with high and maximum level alarms.

3.6.3.3.7 Equipment of tanks for fuel oil, lubricating oil and other petroleum products bunkering in all ships, as well as equipment of bunkering stations, vent and overflow pipes and other areas where petroleum products spills may occur shall comply with the requirements of 3.5.3.3.7 and 3.5.3.3.8.

3.6.3.3.8 In addition to the requirements specified in 3.5.3.3.8, locations on the open deck in the areas of receiving fuel and oil manifolds shall be fitted with a system for collection of the spilled fuel and oil with its accumulation in a holding tank or a slop tank.

Collection of the spilled fuel and oil may be performed using particular pump and pipes located in the areas of receiving fuel and oil manifolds or by gravity drainage through specially provided pipes.

Automatic gravity drainage shall be used during bunkering operation where fuel and oil spills may occur. For gravity drainage, each pipe of deck system shall be arranged with a manually operated stop valve opened only during bunkering operation and an automatic scupper or non-disconnectable drainage arrangement preventing vapour discharge to the atmosphere.

3.6.3.4 Prevention of pollution at oil contaminated water discharge.

3.6.3.4.1 Oil contaminated water discharge requirements apply to all ships according to regulations 15 and 34 of Annex I to MARPOL 73/78.

3.6.3.4.2 The maximum oil content at the outlet of bilge separators fitted onboard shall not exceed 5 ppm.

3.6.3.4.3 The above separators in all cases shall be fitted with 5 ppm bilge alarm and automatic shut-off valve.

3.6.3.4.4 Each ship shall be fitted with the holding tank in compliance with 3.5.3.4.2. A bilge water slop tank shall be additionally installed as means of preliminary cleaning with arrangements for settled oil discharge to oil residue (sludge) tanks to be provided, in

compliance with the application of the concept of an Integrated Bilge Water Treatment System (IBTS) (refer to IMO MEPC.1/Circ.642).

3.6.3.4.5 Where a washing system of gas side of boilers and/or soot economizers are provided, a separate holding tank(s) for washing water collection with pipe connection for collected water discharge to reception facilities shall be installed. Holding tank(s) shall be fitted with pipeline for discharge of settled water overboard, if applicable.

3.6.3.4.6 Where a discharge pipeline to overboard is provided, a holding tank shall consist of blocks for better water settling. Washing water supplied to tank shall be cleaned/filtered by means of specially provided filtering elements for soot collection, or by equivalent means. In such case, a holding tank shall be provided with drains of floating substances from the water surface that lead to oil residue (sludge) tank or its equivalent.

3.6.3.4.7 Where settled water may be discharged from a holding tank using filtering equipment specified in 3.6.3.4.2, which shall be confirmed by a firm (manufacturer) of the filtering equipment and bilge alarms, in addition to the requirements of 3.6.3.4.6, a holding tank shall be provided with transfer pipelines to oily bilge water holding or slop tank required by 3.6.3.4.4.

3.6.3.5 Prevention of pollution by garbage.

3.6.3.5.1 Prevention of pollution by garbage shall comply with the requirements of 3.5.3.5.

3.6.3.5.2 A ship having the descriptive notation **Passenger ship** in the class notation shall be fitted with the food wastes comminuters, which shall provide for comminution to particles not exceeding 25 mm in size, and incinerators, which shall be type approved according to IMO resolutions MEPC.76(40) or MEPC.244(66), as applicable, to provide full shipboard waste incineration when allowed.

3.6.3.6 Prevention of pollution by sewage.

3.6.3.6.1 Prevention of pollution by sewage shall be in accordance with 3.5.3.6.

3.6.3.6.2 Ships having the descriptive notation **Passenger ship** in the class notation shall have a sewage holding tank of sufficient capacity to allow storage of both sewage ("black water") and sanitary and domestic waste waters ("grey water") while the ship is in the area where discharge is prohibited. The holding tank shall be fitted as specified in 3.5.3.6.2.

3.6.3.6.3 The sewage treatment plant of ships having the descriptive notation **Passenger ship** in the class notation shall be capable to treat both sewage ("black water") and sanitary and domestic waste waters ("grey water").

When the ship is operated in special areas defined in compliance with the amendments to Annex IV to MARPOL 73/78 in IMO resolution MEPC.200(62), the above plant shall have a Certificate of type approval for sewage treatment plants in compliance with IMO resolution MEPC.227(64), including provisions specified in 4.2 of the resolution.

3.6.3.7 Control of harmful anti-fouling systems.

The requirements of 3.5.3.7 are applicable.

3.6.3.8 Prevention of lubricating oil and hydraulic oil leakages into seawater.

The requirements specified in 3.5.3.8 shall be met.

When environmentally hazardous refrigerants are used, the sterntube seals shall be so designed as to prevent leakage out of the seal housing when operated within the specified modes. Permissible leakage of non-toxic and biologically neutral refrigerants are not considered as pollution from ships.

3.6.3.9 Prevention of pollution in case of the hull damage.

3.6.3.9.1 For ships with aggregate capacity of fuel oil tanks 600 m^3 and above, the requirements of 3.5.3.9 shall apply.

3.6.3.9.2 For ships with aggregate capacity of fuel oil tanks less than 600 m^3, all fuel oil tanks shall be located at a distance of at least 0,76 m from the shell plating. This requirement shall not apply to small fuel oil tanks with the capacity not exceeding 30 m^3.

3.6.3.9.3 All oil residue (sludge) tanks and oily bilge water holding tanks shall be located at a distance of at least 0,76 m from the shell plating. This requirement shall not apply to such small tanks with the capacity not exceeding 30 m^3.

3.6.3.9.4 Cargo and slop tanks of oil tankers of less than 5000 t deadweight shall be protected throughout the length by ballast tanks or compartments not intended for carriage of pollutants located in compliance with the requirements of regulation 19.6.1 (from the ship's bottom shell plating) and regulation 19.6.2 for the distance *w* (from the ship's side shell plating) of Annex I to MARPOL 73/78.

On ships other than oil tankers, all cargo tanks designed and intended for carrying oil shall be located at a distance of at least 0,76 m from the shell plating.

3.6.3.10 Segregated ballast tanks.

Requirements of 3.5.3.10 are applicable.

3.6.4 Additional technical means.

3.6.4.1 In case of failure of essential machinery of the ship's propulsion plant responsible for maintaining the ship's manoeuvrability in case of emergency, alternative means shall be provided to keep the ship's manoeuvrability.

The following means may be used as alternative (as far as applicable):

two- and multi-shaft propulsion plants;

stern tube arrangements with the possibility of their repair without ship docking and using environmentally friendly media for lubrication and stern tube bearing cooling;

auxiliary retractable azimuth thrusters to keep the ship's speed and course in case of main propulsion plant damage;

four-blade propellers with detachable blades to ensure propulsion in case of damage to a blade where the opposite blade is removed;

"Power take-in" system to transmit the power from an auxiliary electric power plant to the propeller in case of main engine failure;

thrusters in case of main steering gear damage.

3.6.4.2 In addition to the navigational equipment and systems complying with the basic (main applicable) requirements of Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships, a ship shall be fitted with an automatic ground collision avoidance system, and the information on the ship's maneuvering characteristics shall be available on the navigation bridge.

3.6.5 Prevention of pollution at ship recycling. The requirements of 3.5.4 are applicable.

3.6.6 Environmental responsibilities.

The requirements of 3.5.5 are applicable.

3.7 RECORDS

3.7.1 As a result of applying the requirements of this Section, the following records shall be issued:

.1 Classification Certificate (form 3.1.2) with the distinguishing marks **ECO** or **ECO-S** in the class notation;

.2 Report on Survey of the Ship (form 6.3.10).

4 REQUIREMENTS FOR THE EQUIPMENT OF SHIPS IN COMPLIANCE WITH THE DISTINGUISHING MARK ANTI-ICE IN THE CLASS NOTATION

4.1 GENERAL

4.1.1 Scope of application.

4.1.1.1 The requirements for the equipment of ships and FOP in compliance with the distinguishing mark **ANTI-ICE** in the class notation apply to ships and FOP (hereinafter for this Section referred to as "the ships") the design and equipment of which provide effective icing protection. These requirements are additional to the requirements of Part I "Classification", Part III "Equipment, Arrangements and Outfit", Part VIII "Systems and Piping" and Part XI "Electrical Equipment" of the Rules for the Classification and Construction of Sea-Going Ships, as well as Part II "Life-Saving Appliances", Part III "Signal Means", Part IV "Radio Equipment" and Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships.

4.1.1.2 Ships complying with the requirements of this Section may be assigned with the distinguishing mark **ANTI-ICE** added to the character of classification.

4.1.1.3 The distinguishing mark **ANTI-ICE** in the class notation may be assigned to ships under construction and in service.

4.1.2 Definitions and explanations.

For the purpose of this Section the following definitions and explanations have been adopted.

Anti-icing is prevention of ice formation on the ship's structures and equipment by means of their heating or relevant covering.

De-icing is removal of ice appearing on the ship's hull, structures and equipment.

Icing is a process of ice accretion on the ship's hull, structures and equipment due to sea water splashes or freezing of moisture condensating on the hull from the atmosphere.

Icing protection is a set of design and organizational measures aimed at reduction of the ship's icing and reduction of labour input into ice removal during operation of the ship.

Icing Protection Manual is a document describing actions of the ship's crew to provide icing protection. The scope of the Manual and contents of the information contained therein depend on the ship's type, purpose and area of navigation; they shall be chosen in the most efficient way and agreed with the Register.

4.1.3 Technical documentation.

4.1.3.1 The following technical documentation shall be submitted to the Register for approval to assign the distinguishing mark **ANTI-ICE** in the class notation:

.1 list of technical solutions applied onboard the ship and ensuring compliance with the requirements of this Section;

.2 arrangement plan of de-icing and anti-icing means with indication of their heating capacity;

.3 calculations of heating capacity of anti-icing systems equipment;

.4 electrical single-line diagram of anti-icing systems with heating cables (if any);

.5 circuit diagrams of steam and/or thermal liquids anti-icing systems (if any).

4.1.3.2 The following documents shall be kept onboard:

.1 Icing Protection Manual (only for ships without the distinguishing mark **WINTERIZATION** in the class notation);

.2 Stability Booklet approved by the Register, including loading conditions considering icing.

4.2 TECHNICAL REQUIREMENTS FOR ASSIGNING THE DISTINGUISHING MARK ANTI-ICE IN THE CLASS NOTATION

4.2.1 General.

4.2.1.1 Ships with the distinguishing mark **ANTI-ICE** in the class notation shall, as a rule, be fitted with a tank of a shape providing effective water flow under all operating loading cases.

4.2.1.2 The following anti-icing means may be used:

.1 heating of structures and equipment by means of steam, thermal liquid or heating cables;

.2 use of permanent (awnings, casings) or removable (covers) protective covers;

.3 application of grid structures for platforms, stairs of outer ladders, gangways etc.

4.2.1.3 Besides heating of structures the following de-icing means may be used:

.1 washing and firing of ice by means of hot water or steam;

.2 anti-icing liquids;

.3 manual mechanical means including pneumatic instrument.

4.2.1.4 If steam systems are used for anti-icing the requirements of Section 18, Part VIII "Systems and Piping" shall be complied with.

4.2.1.5 If thermal liquid systems are used for anti-icing the requirements of Section 20, Part VIII "Systems and Piping" shall be complied with.

4.2.1.6 If systems with heating cables are used for anti-icing the requirements of 15.4, Part XI "Electrical Equipment" shall be complied with.

4.2.2 Stability and subdivision.

4.2.2.1 Ships with the distinguishing mark **ANTI-ICE** in the class notation shall comply with the requirements of Parts IV "Stability" and V "Subdivision".

4.2.3 Equipment, arrangements and outfit.

4.2.3.1 Platforms of outer ladders as well as platforms for servicing arrangements and equipment fitted on open decks shall have a grid structure or be equipped with heating elements.

4.2.3.2 Outer ladders located on the escape routes to life-saving appliances as well as muster stations to life-saving appliances (including guard rails) shall be equipped with anti-icing means.

4.2.3.3 Coamings of outer doors leading to the accommodation superstructure spaces shall be heated. Decks in areas of exit from the said spaces shall be equipped with anti-icing means.

4.2.3.4 A passage from the accommodation superstructure spaces to the equipment fitted in the fore part of the ship shall be provided on tankers, including chemical tankers and gas carriers. This passage shall be provided with anti-icing means.

4.2.3.5 Side scuttles in the wheelhouse providing the arc of visibility required by 3.2, Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships according to the ship's class shall be heated.

Windshield wipers on the said side scuttles (if any) shall be heated as well.

4.2.3.6 Shell doors, visor-type bow doors, cargo doors in the fore part of ro-ro ships shall be fitted with means for effective ice removal or other means to provide working capacity of the said appliances in case of icing (for example, with ice-breaking hydraulic cylinders).

4.2.3.7 Design of seals of cargo hatches, shell doors and other closing appliances providing the ship's operation in accordance with its main purpose shall preclude freezing of condensate inside seals.

4.2.3.8 Anti-icing shall be provided for the following arrangements and equipment:

.1 anchor and mooring equipment including (but not limited to) winches, capstans, windlasses, chain stoppers, drums, control panels;

.2 arrangements for emergency towing of tankers, including chemical tankers and gas carriers;

.3 hook releasing devices of lifeboats;

.4 launching appliances of survival craft (falls on drums, sheaves, winches of launching appliances, winch breaks and other elements engaged in launching);

.5 liferafts, including hydrostatic releasing devices.

The Register may require taking measures to prevent icing of additional equipment and arrangements in accordance with the ship's main purpose.

4.2.3.9 Lifeboats shall be of enclosed type and be equipped with the relevant heating elements to prevent icing and blocking of access hatches and/or doors.

4.2.3.10 Proper locations shall be provided on board for at-sea storage of removable covers used to prevent icing of equipment and fittings.

4.2.3.11 In addition to the emergency outfit specified in Section 9, Part III "Equipment, Arrangements and Outfit", ships with the distinguishing mark **ANTI-ICE** in the class notation shall have the necessary de-icing outfit (crowbars, ice-axes, axes, shovels, spades) kept in places of permanent storage and having the relevant marking.

4.2.4 Systems and piping.

4.2.4.1 Sufficient number of scuppers and freeing ports shall be provided for the effective water flow from open decks. Scuppers and freeing ports shall be located so as to preclude water stagnation on decks under all operating loading cases.

4.2.4.2 Air heads of ballast tanks and fresh water tanks shall be fitted with the relevant heating devices.

4.2.4.3 Design of air intakes of main, auxiliary and emergency power plants as well as of ventilation of spaces, which are of great importance for the ship's safety, shall preclude their icing that may cause air duct blockage.

4.2.4.4 Measures shall be taken to preclude freezing of liquid in the pipelines of fire extinguishing systems by means of their effective drying or heating.

Fire hydrants, monitors, fittings and other equipment of fire extinguishing systems fitted on open decks shall be protected from icing by means of heating or removable covers.

Cut-off valve of water and foam fire extinguishing systems shall be fitted in enclosed heated spaces or shall be heated.

4.2.4.5 Hot water or steam supply shall be provided for de-icing on open decks.

4.2.4.6 In addition to 4.2.4.1 — 4.2.4.5 the following items shall be heated on tankers, including chemical tankers and gas carriers:

.1 ventilation valves and pressure/vacuum valves (P/V valves) of cargo tanks and secondary barriers;

.2 level, pressure, temperature gauges and gas analysers in cargo tanks located on open decks, if necessary;

.3 inert gas system elements containing water and located on open decks;

.4 emergency shut-down system (ESD) on gas carriers.

4.2.4.7 Drives of remotely operated fittings of tankers, including chemical tankers and gas carriers, fitted on open decks shall be equipped with anti-icing means.

4.2.4.8 Pipelines equipped with electrical heating shall comply with the requirements of 5.8, Part VIII "Systems and Piping".

4.2.5 Electrical equipment, signal means, radio and navigational equipment.

4.2.5.1 The following electrical equipment, signal means, radio and navigational equipment located on open decks shall be designed so that to prevent icing or shall be heated:

.1 aerials of radio and navigational equipment (excluding rod aerials), aerial matching devices (if fitted on open decks);

.2 navigation lights;

.3 whistles;

.4 COSPAS-SARSAT satellite emergency position-indicating radio beacons;

.5 main and emergency lighting of open decks;

.6 TV cameras used during operation of the ship in accordance with its main purpose;

.7 aerials of telemetric and dynamic positioning systems;

.8 remote control stopping arrangements of pumps for oil contaminated water and sewage disposal to reception facilities.

4.2.5.2 If consumers, which according to 9.3.1, Part XI "Electrical Equipment" shall be fed from the emergency source of electrical power, are fitted with electrical heating, their heating elements shall be also fed from the emergency source of electrical power.

4.3 TESTS

4.3.1 Approved Icing Protection Manual shall be submitted to the Register prior to tests (only for ships without the distinguishing mark **WINTERIZATION** in the class notation).

4.3.2 Anti-icing means shall be tested including demonstration of their operation for the purpose specified and measurement of their heating capacity.

4.4 RECORDS

4.4.1 As a result of applying the requirements of this Section, the following records shall be issued:

.1 Classification Certificate (form 3.1.2) with the distinguishing mark **ANTI-ICE** in the class notation;

.2 Report on Survey of the Ship (form 6.3.10).

5 REQUIREMENTS FOR THE EQUIPMENT OF OIL TANKERS FOR CARGO OPERATIONS WITH OFFSHORE TERMINALS

5.1 GENERAL

5.1.1 Scope of application.

5.1.1.1 The requirements for the equipment of oil tankers for cargo operations with offshore terminals are additional to those of Part I "Classification", Part III "Equipment, Arrangements, and Outfit", Part VI "Fire Protection", Part VIII "Systems and Piping", Part IX "Machinery", Part XI "Electrical Equipment" and Part XV "Automation".

5.1.1.2 A distinguishing mark **BLS-SPM** may be added to the character of classification of ships equipped with the bow loading system and complying with the requirements of this Section in the full scope.

A distinguishing mark **BLS** may be added to the character of classification of ships equipped with the bow loading system and complying with the requirements of this Section except for 5.6.2 — 5.6.10 and 5.6.13 — 5.6.15.

A distinguishing mark **SPM** may be added to the character of classification of ships which are not equipped with the bow loading system but complying with the requirements in 5.6.2 — 5.6.10 and 5.6.13 — 5.6.15.

The mark **SPM** may be also added to the character of classification of ships carrying liquefied gas in bulk.

5.1.1.3 Distinguishing marks **BLS-SPM**, **BLS** and **SPM** may be assigned to ships under construction and in service.

5.1.2 Definitions.

Bow loading coupler is a device of special design which is a part of the bow loading system and which is used to connect the cargo hose of the offshore terminal to the ship cargo system.

Bow loading system (BLS) is a set of ship equipment located in the fore end of a ship and intended for loading the cargo to the ship from offshore terminals.

Offshore terminal is a ship or offshore structure which is used for mooring of the oil tanker for loading the cargo.

Single point mooring (SPM) is a floating or stationary offshore structure intended for mooring the oil tankers or floating offshore oil-and-gas production units and for offloading at sea or at anchorage.

5.1.3 Technical documentation.

5.1.3.1 The following technical documentation (where applicable) shall be submitted to the Register to assign distinguishing marks **BLS-SPM**, **BLS** or **SPM** in the class notation:

.1 BLS general arrangement plan with an indication of the cargo system and mooring equipment including: bow loading coupler, guide roller, chain stopper, traction winch, hawse storage reel, BLS hull structures, control stations;

.2 description and drawings of the bow loading coupler;

.3 calculation and drawings of hull strengthenings for bow hawses and chain stoppers;

.4 fire protection diagram for BLS area;

.5 diagram and calculation of ventilation of BLS special spaces;

.6 drawings of BLS components and assembly units, which surfaces shall be protected by the materials precluding spark formation;

.7 drawings of electrical equipment layout and cable laying in BLS spaces;

.8 BLS circuit diagrams;

.9 BLS diagrams of electric connections;

.10 diagrams of BLS hydraulic system;

.11 BLS operating manual;

.12 BLS test program (to be approved by the RS Branch Office for supervision during construction).

5.1.3.2 The Register may require additional documents to those listed in 5.1.3.1 proceeding from BLS design features.

5.2 SHIP STRUCTURE

5.2.1 Oil tankers equipped with BLS shall be fitted with CPP and thrusters or active means of ship's steering (AMSS) to enable sufficient maneuverability and ship stabilization during cargo operations.

5.2.2 Ships equipped with the dynamic positioning system shall be fitted with the devices for surveillance, verification, manual correction of the automated thrusters and automated propulsion system.

5.3 SHIP'S SPACES

5.3.1 Spaces where bow loading coupler and disconnecting couplings of the cargo pipeline are located, as well as the areas within the radius of 3 m from them are considered as hazardous zone 1 in accordance with 19.2.3, Part XI "Electrical Equipment".

5.3.2 Spaces adjacent to hazardous spaces and zones shall not open thereto and shall be equipped with the ventilation system providing at least 8 air changes per hour.

5.3.3 A space accommodating the bow loading coupler shall be provided with natural ventilation.

5.4 OPENINGS AND THEIR CLOSING APPLIANCES

5.4.1 Entrances, air inlets and other openings to machinery, service spaces and control stations shall not be faced to bow loading couplers and shall be located at a distance of at least 10 m from them.

5.4.2 Doors closing BLS shall comply with the requirements of 7.4, Part III "Equipment, Arrangements and Outfit".

5.4.3 Doors closing BLS, when in the open position, shall be protected from the contact with the metal parts of the equipment taken from the terminal by hardwood or equivalent electric insulating materials and by materials precluding spark formation.

5.4.4 When securing the BLS door there shall be no friction of spark-forming metals.

5.5 ANCHOR ARRANGEMENT

5.5.1 For the anchor arrangement of oil tankers fitted with BLS, design or procedural measures shall be taken to prevent its operation during loading the cargo through BLS.

5.6 MOORING ARRANGEMENT

5.6.1 Ships intended for operation with single point mooring (SPM) and having distinguishing marks **BLS-SPM** or **SPM** in the class notation shall be equipped with the mooring arrangement complying with the requirements of 5.6.2 — 5.6.10, 5.6.13 — 5.6.15.

5.6.2 The choice of the breaking strength of the mooring line shall be confirmed by the calculation.

Mooring lines shall comply with the requirements of 4.2, Part III "Equipment, Arrangements and Outfit".

Two mooring lines shall be used for mooring of ships of 150000 t deadweight and above. Each mooring line shall end with a chafing chain of 8 m in length and 76 mm in diameter.

The chain used for the chafing chain shall meet the requirements of 3.6, Part XIII "Materials" and shall be taken as follows:

Grade 3 for ships having a deadweight of up to 350000 t;

Grade R4 for ships of 350000 t deadweight and above.

5.6.3 The ship shall be equipped with one or two bow chain stoppers for the chain of 76 mm in diameter and one or two bow fairleads of at least 600×450 mm according to Table 5.6.3.

Table 5.6.3

Ship deadweight, in t	Number of bow chain stoppers	Number of bow fairleads	Safe working load (SWL), in kN
≤100000	1	1	2000
>100000 and <150000	1	1	2500
≥150000	2	2	3500

5.6.4 Bow chain stopper shall be capable of holding the chain of 76 mm in diameter in closed position and shall be designed so that in the open position the said segment of chain and its connection details would freely pass through. The upper yield stress of bow stopper material shall be determined based on the load of at least 2,0 *SWL*.

5.6.5 Bow chain stoppers shall be located between 2,7 and 3,7 m inboard from the bow fairleads, provided the bow fairlead, stopper and vertical roller (if any) or the winch drum or capstan drum shall be aligned.

5.6.6 In way of the chain stopper location the deck shall be sufficiently strengthened to withstand horizontal loads equal to 2,0 *SWL*.

5.6.7 The chain stopper shall remain in the closed position when the driving energy disappears. The chain stopper shall be manually driven to be opened.

5.6.8 Smit type towing bracket fittings shall not be used as bow chain stoppers.

5.6.9 A single bow fairlead shall be located at the ship centerline. Where two fairleads are fitted they shall be arranged symmetrically on each side of ship's centerline at a distance of 2 to 3 m between them.

The fairlead shall be oval or round in shape, the radius of fairlead rounding shall be at least 3,5 of the chain diameters.

The upper yield stress of fairlead material shall be determined based on the load of at least 2,0 *SWL* as specified in 5.6.3.

Hull strengthenings in way of the bow fairlead shall be calculated to take up the load equal to 2,0 *SWL* directed at an angle of ±45° in the horizontal plane and ±15° in the vertical plane from the fairlead axis.

5.6.10 The arrangement components which are in contact with the chafing chain shall be protected by materials precluding spark formation.

5.6.11 BLS mooring machinery shall comply with the requirements of 1.2, 6.1, 6.4, Part IX "Machinery".

5.6.12 BLS traction winch shall be fitted with a manual drive of drum for release of the hawser when the driving energy disappears.

5.6.13 Where a chain stopper is provided, the braking force of the automatic brake of BLS mooring machinery as required in 6.4.3.1, Part IX "Machinery" may be reduced to the value enabling paying out of the hawser with the constant tension equal to the rated pull of the drive.

5.6.14 The pull at a reel of the mooring winch or capstan used for BLS operation with SPM shall be at least 147 kN.

5.6.15 Where SPM pick-up rope is kept onboard, the winch storage drum used to stow the SPM pick-up rope shall be sufficient size to accommodate the rope of 150 m in length and of 80 mm in diameter.

5.6.16 Verification of ship's compliance with the provisions specified in 4.3 of Mooring Equipment Guidelines (MEG 4).

5.6.16.1 Upon request from the shipowner, the Register may carry out an expertise of the technical documentation and survey of the ship in order to confirm that the ship is equipped in accordance with 4.3 of Mooring Equipment Guidelines (MEG 4), published by the Oil Companies International Marine Forum, 2018, as amended.

5.6.16.2 The chain bearing surface of the bow fairleads described in 4.3 of MEG 4 shall have a diameter at least seven times that of the associated chain.

5.6.16.3 In case of satisfactory results of the review of the technical documentation by the RS Head Office or RS Branch Office duly authorized by the RS Head Office as well as satisfactory survey of the equipment by the RS surveyor, the document of compliance is issued confirming the fulfilment of the provisions of this para and 4.3 of Mooring Equipment Guidelines (MEG 4). The possibility of issuing the document of compliance and the document content shall be agreed upon with the RS Head Office.

5.7 SPECIAL ARRANGEMENT

5.7.1 Where a ship with BLS is provided with a special emergency towing arrangement it shall comply with the requirements of 5.6.10 in addition to those specified in 5.7, Part III "Equipment, Arrangements and Outfit".

5.8 SYSTEMS AND PIPING

5.8.1 Cargo system.

5.8.1.1 Cargo piping shall comply with the requirements of 9.2.3 — 9.2.7; 9.3.7, 9.5, Part VIII "Systems and Piping", considering the following:

.1 other facilities to ensure galvanic intrinsic safety may be used instead of those specified in 9.3.7, Part VIII "Systems and Piping" upon agreement with the Register;

.2 BLS piping shall be self-draining with a drainage to the cargo tank;

.3 provision shall be made for a tray of sufficient capacity with a drainage system for ships having in way of bow loading coupler a spraying system precluding cargo spills propagation.

5.8.1.2 Remote-controlled valves shall comply with the requirements of 4.1.1.2 — 4.1.1.5, Part VIII "Systems and Piping".

5.8.2 Hydraulic systems.

5.8.2.1 Hydraulic systems shall comply with the requirements of 7.3, Part IX "Machinery".

5.8.2.2 Hydraulic accumulators shall be located in the space not communicating with the hazardous spaces as specified in 5.3.1.

5.8.2.3 Hydraulic accumulators shall be provided with devices capable of being manually activated when driving energy disappears.

5.8.2.4 Design of the hydraulic drive of the bow loading coupler and chain stopper shall prevent its opening when driving energy disappears.

5.8.2.5 The possibility of manual disconnection of bow loading coupler from the terminal cargo hose in case of hydraulic system failure shall be provided from the local station.

5.9 SOUNDING ARRANGEMENTS AND AUTOMATION

5.9.1 Cargo control during BLS operation shall be realized from BLS control station that may be located either in the wheelhouse or in a specially equipped room in the fore part of the ship.

The control station shall be equipped with all necessary monitoring and control instruments to carry out all operations for ship positioning and monitoring of the ship mooring and loading parameters.

Where the BLS control station is located in the fore part of the ship, the requirements of 5.10.2 and 5.12 shall be met.

5.9.2 To provide ship positioning the BLS control station shall be equipped with the following:

.1 control system for the controllable pitch propellers of the main propulsion plant (if any);

.2 thrusters control system;

.3 main engine(s) emergency shutdown arrangement;

.4 steering gear(s) control system;

.5 radar display;

.6 log display;

.7 device for monitoring of dynamic positioning system parameters (if any).

5.9.3 To provide monitoring of ship mooring parameters the BLS control station shall be equipped with the following:

.1 devices for indication and logging by recording device (if any) of hawser and cargo hose tension with actuation of alarm for maximum value;

.2 devices for indication and logging by recording device (if any) of chain tension in chain stopper.

5.9.4 To provide monitoring of ship loading parameters the BLS control station shall be equipped with the following:

.1 device for indication of bow loading coupler position;

.2 device for cargo system valves position indication;

.3 device for cargo tanks level indication and high level alarm;

.4 device for cargo pipe pressure indication at BLS inlet;

.5 device for signal transmission from ship to terminal for cargo pump stop and cargo valve closing on the terminal.

5.9.5 Bow loading coupler, chain stopper, cargo system valves shall be provided with position indicators (open-closed).

5.9.6 BLS control system shall provide blocking of the bow loading coupler inlet valve from being opened until receiving a confirmation that the following actions have been carried out:

.1 terminal cargo hose is properly connected to the bow loading coupler;

.2 sufficient number of ship cargo system valves and BLS cut-off valve are opened, oil tanker is ready for loading the cargo.

5.9.7 BLS control system shall provide blocking of the bow loading coupler inlet valve from being opened in case of BLS mooring arrangement blackout or failure.

5.9.8 Quick-acting emergency shutdown system (ESD) shall be provided for the bow loading coupler. ESD shall provide two operating modes:

.1 first emergency shutdown mode (ESD-1) which shall provide the following:

giving a signal for cargo pump stop on the terminal;

closing the bow loading coupler inlet valve and the terminal discharge valve upon receipt of a signal of emergency pressure drop at ship cargo system inlet;

.2 second emergency shutdown mode (ESD-2) which shall provide the following:

giving a signal for cargo pump stop on the terminal;

closing the terminal discharge valve, the bow loading coupler inlet valve and the BLS cut-off valve upon receipt of a signal of emergency pressure drop at ship cargo system inlet;

disconnection of bow loading coupler;

opening of chain stopper.

ESD-1 and ESD-2 commands shall be given from the BLS control station by means of appropriate controls (buttons, switches). After issuing the command the execution of all the above mentioned functions shall be performed sequentially in automatic mode.

Where ESD-1 mode is deactivated before the above mentioned sequence of operations has been carried out, the operations shall be completed automatically. In this case the bow loading coupler inlet valve and the BLS cut-off valve shall be fully closed.

Where ESD-2 mode is deactivated before the above mentioned sequence of operations has been carried out, the operations shall be immediately interrupted except for the bow loading coupler inlet valve and the BLS cut-off valve which shall be fully closed.

Controls for activation of ESD-1 and ESD-2 modes shall be protected from unauthorized use.

5.9.9 Additionally to automatic system specified in 5.9.7, provision shall be made for back-up manual system of emergency disconnection of bow loading coupler by means of which the independent operations for releasing the chain stopper and the locking arrangement of the bow loading coupler shall be provided.

5.9.10 The sequence and time of cargo operations in the emergency disconnection mode shall ensure minimum cargo leakage and preclude the hydraulic shock in the cargo pipeline.

The time of closing of the bow loading coupler inlet valve and the BLS cut-off valve shall be at least 25 s both in automatic and manual modes. The shorter time of closing shall be proved by the calculation confirming the absence of possibility of hydraulic shock in the cargo pipeline.

5.10 FIRE PROTECTION

5.10.1 Boundaries of spaces where BLS cargo system equipment is located shall comply with the requirements of 2.4, Part VI "Fire Protection".

5.10.2 BLS control station in the fore part of the ship shall comply with the following requirements:

.1 BLS control station shall be of "A-60" class boundaries;

.2 maintenance of surplus pressure shall be provided in the space;

.3 an emergency exit from the space shall be provided.

5.10.3 Fire-fighting equipment and systems shall comply with the requirements of Section 3, Part VI "Fire Protection".

5.10.4 The area where BLS cargo and mooring arrangements are located shall be protected by the foam fire extinguishing system independent from the main system.

5.11 ELECTRICAL EQUIPMENT

5.11.1 Electrical equipment shall comply with the requirements of Part XI "Electrical Equipment".

5.11.2 Electrical equipment fitted in the hazardous areas shall comply with the requirements 2.9, 2.10, 19.2.3 and 19.2.4, Part XI "Electrical Equipment".

5.11.3 Lighting of the loading area and the boundary along it shall provide efficient visual monitoring of the mooring arrangement, cargo hose connection, cargo hose and water surface around.

5.12 COMMUNICATIONS

5.12.1 Where the BLS control station is located in the fore part of the ship, provision shall be made for two-way internal communications between the wheelhouse and the cargo control room in accordance with 3.3.2, Part VII "Machinery Installations" and 7.2, Part XI "Electrical Equipment".

5.12.2 Two-way communications shall be provided between the BLS control station and the terminal.

5.12.3 Emergency communications shall be provided between the BLS control station and the terminal.

5.12.4 Provision shall be made for direct and indirect means enabling to check communications between the BLS control station and the terminal in case of failures and faults during cargo operations.

5.13 TESTS

5.13.1 All BLS systems and components shall be tested after their installation onboard in accordance with the programs approved by the Register.

5.13.2 The first cargo operation on the prototype ship of the series using BLS shall be carried out in the presence of the surveyor to the Register. At that the BLS operation for the purpose specified shall be checked in accordance with the operating manual.

Whether the surveyor to the Register shall attend the first cargo operations on board the other ships of the series shall be determined proceeding from the BLS tests on board the prototype ship.

5.14 RECORDS

5.14.1 The following records shall be issued on the basis of application of the requirements of this Section:

.1 Classification Certificate (form 3.1.2) with the distinguishing mark **BLS-SPM**, **BLS** or **SPM** in the class notation;

.2 Report on Survey of the ship (form 6.3.10).

6 REQUIREMENTS FOR HELICOPTER FACILITIES

6.1 GENERAL

6.1.1 Application.

6.1.1.1 Requirements for helicopter facilities are additional to those of Part I "Classification", Part II "Hull", Part III "Equipment, Arrangements and Outfit", Part VI "Fire Protection", Part VIII "Systems and Piping", Part XI "Electrical Equipment" of the Rules for the Classification and Construction of Sea-Going Ships and Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships.

6.1.1.2 Ships and fixed offshore platforms (hereinafter referred to as "ships" for this Section) complying with the requirements of this Section may be assigned with the following distinguishing marks added to the character of classification:

.1 **HELIDECK** – for ships fitted with helidecks and complying with the requirements specified in 6.2, 6.3, 6.4.1, 6.6 and 6.7;

.2 **HELIDECK-F** – for ships fitted with the helicopter refuelling facilities and complying with the requirements specified in 6.4.2 (as applicable), 6.5.1 and 6.5.2 (as applicable) in addition to those of 6.1.1.2.1;

.3 **HELIDECK-H** – for ships fitted with a hangar and complying with the requirements of this Section in a full scope.

6.1.1.3 Distinguishing marks **HELIDECK**, **HELIDECK-F** or **HELIDECK-H** may be assigned to ships under construction and in service.

6.1.1.4 Ships shall also meet the requirements of International Civil Aviation Organization (ICAO) and the Flag State (if any) for ensuring safe operation of helicopters which shall be confirmed by the relevant statement or certificate issued by the appropriate Civil Aviation Authority.

6.1.2 Definitions.

Deck integrated foam nozzles are foam nozzles recessed into or edge mounted on the helideck.

D-value is the largest dimension of the helicopter used for assessment of the helideck when its rotors are turning. It establishes the required area of foam application.

Final approach and take-off area (FATO) is a defined area over which the final phase of the approach manoeuvre to hover or landing of the helicopter is intended to be completed and from which the take-off manoeuvre is commenced.

Foam-making branch pipes are air-aspirating nozzles in tube shape for producing and discharging foam, usually in straight stream only.

Hangar is a purpose-built space for helicopter storage and/or maintenance and repair.

Helicopter facility is a helideck with helicopter refueling facilities and a hangar.

Helicopter landing area is an area on a ship designated for occasional or emergency landing of helicopters but not designed for routine helicopter operations.

Helideck is a purpose-built helicopter take-off and landing area including all structures, firefighting appliances and other equipment necessary for the safe operation of helicopters.

Hose reel foam station is a hose reel fitted with a foam-making branch pipe and non-collapsible hose, together with fixed foam proportioner and fixed foam concentrate tank, mounted on a common frame.

Limited obstacle sector is a 150° sector outside the take-off and approach sector that extends outward from a helideck where objects of limited height are permitted.

Monitor foam station is a foam monitor, either self-inducing or together with separate fixed foam proportioner, and fixed foam concentrate tank, mounted on a common frame.

Obstacle free sector is the take-off and approach sector which totally encompasses the safe landing area and extends over a sector of at least 210°, within which only specified obstacles are permitted.

Touchdown and lift-off area (TLOF) is a dynamic load-bearing area on which a helicopter may touchdown or lift off. For a helideck it is presumed that the FATO and the TLOF will be coincidental.

6.1.3 Technical documentation.

6.1.3.1 The following technical documentation shall be submitted to the Register for approval (as applicable) to assign distinguishing marks **HELIDECK**, **HELIDECK-F** or **HELIDECK-H** in the class notation:

.1 structural helideck and hangar deck drawings with indication of design loads;

.2 scantlings determination of helideck and hangar deck, as well as of deck- and bulkhead stiffeners in way of helicopter tie-down points;

.3 general arrangement plan of a helicopter facility elements with indication of escape routes, tie-down points, location of fire-fighting equipment and life-saving appliances, arrangement plan and specification of lighting and illumination means;

.4 drawing of helideck safety net;

.5 diagram of power driving gear for the helideck safety net hoisting and lowering, if any;

.6 diagram of helideck drainage system;

.7 diagram of fuel oil loading, transfer, storage and helicopter refuelling system;

.8 diagram of off-grade aviation fuel collection, storage and defueling system;

.9 diagram of nitrogen system for aviation fuel;

.10 electric diagram of main and emergency lighting in the spaces of helicopter facility arrangement;

.11 circuit diagram of helideck lighting and illumination means;

.12 drawings of electrical equipment layout and cable laying on the helideck, in hangar and in other spaces of helicopter facility arrangement;

.13 documentation on helideck and hangar deck covering;

.14 helicopter facility test program (to be approved by the RS Branch Office for supervision during construction);

.15 diagram of obstacle restriction and removal approved by the Flag State Civil Aviation Authority (to be submitted for information);

.16 drawing of helideck and obstacle marking (colour, dimensions and configuration of marks shall be indicated), approved by the Flag State Civil Aviation Authority (to be submitted for information).

6.1.3.2 Helicopter facility operation manual containing equipment description, a checklist of inspections, guidance for the safe operation and equipment maintenance procedures shall be provided on board. This operation manual shall also contain the procedures and precautions to be followed during helicopter refuelling operations developed in accordance with the recognized safe practices.

For mobile offshore drilling units (MODU) and fixed offshore platforms (FOP) this operation manual can be included in the operating manual to be developed in compliance with the requirements of Chapter 14 of the Code for the Construction and Equipment of Mobile Offshore Drilling Units, 2009.

6.1.3.3 The Register may require additional documents to those listed in 6.1.3.1 proceeding from the ship design features.

6.2 HELIDECK DESIGN

6.2.1 Helideck arrangement with regard to provision of horizontal and vertical sectors for helicopter approach, landing and take-off shall comply with the requirements of ICAO and the Flag State (if any).

6.2.2 Helideck arrangement shall provide:

.1 free helicopter approach to helideck;

.2 safety of helicopter take-off and landing operations and maintenance personnel;

.3 helideck location at a maximum possible distance from the ship's hazardous spaces and areas.

6.2.3 Helideck may have any configuration in plan view, generally, circle or regular polygon. In any case FATO shall be of sufficient size to contain an area within which can be drawn a circle of diameter not less than *D* of the largest helicopter the helideck is intended to serve, where *D* is the largest dimension of the helicopter when the main and tail rotors are turning.

6.2.4 If the helideck forms the ceiling of a deckhouse or superstructure it shall be of "A-60" class.

6.2.5 Helideck shall be made of steel. Aluminum alloys may be used provided the following:

.1 a helideck, irrespective of its type and location, shall be subject to a survey in case of fire on the helideck or in close proximity;

.2 if a helideck is located above the deckhouse or similar structure, the following conditions shall be additionally satisfied:

.2.1 the deckhouse top and bulkheads below the helideck shall have no openings;

.2.2 windows below the helideck shall be provided with steel covers.

.3 surfaces of the steel and aluminium alloy structures contacting at the point of connection and exposed to sea water shall be separated by gaskets made of non-absorbent electrically insulating material. Bolts, nuts and washers connecting the steel and aluminium structures shall be made of stainless steel. Bolts shall be installed in the bushes made of non-absorbent electrically insulating material which structure shall exclude the contact of aluminium alloy and steel. The aluminium alloy structure insulated from the steel structure shall be grounded to the ship's hull;

.4 bimetal materials shall be approved by the Register, and certificates shall be issued for them by the Register.

6.2.6 Helideck on FOP shall be sloping or prominent for drainage to avoid accumulation of rain water and fuel spills on FATO surface. Inclination of these sloping or prominent surfaces shall be about 1:100. Sagging of helideck surface induced by helicopter at rest shall not lead to accumulation of fuel spills on FATO surface.

6.2.7 Helidecks and helicopter refuelling areas shall be clearly marked and provided with coamings and/or gutters to prevent fuel oil leakage from spreading.

6.2.8 Design of the helideck being the upper deck or superstructure or deckhouse shall comply with the following requirements:

.1 deck longitudinals shall be installed parallel to the helicopter axis at the take-off and landing;

.2 thickness of deck plating, section modulus and web cross-sectional area of longitudinals and beams shall be determined according to 3.2.4.1 — 3.2.4.3, Part II "Hull" at Q determined as per Formula (3.2.3.4) of Part II "Hull" and l_a and l_b equal to 0,3 m. In Formula (3.2.3.4) Q_0 shall be taken equal to the maximum take-off weight of the helicopter, $k_d = 3$, $n_0 = 2$, $n = 1$;

.3 scantlings of deep members and pillars as well as thickness of deck plating for the helicopter having skid instead of wheels shall be determined by direct calculation.

6.2.9 Helideck not being a part of the upper deck or superstructure or deckhouse shall comply with the following requirements:

.1 the plating thickness, section modulus and web cross-sectional area of longitudinals and beams shall be determined according to 6.2.8 of this Part and 2.12 of Part II "Hull" both for the short superstructure deck or deckhouse of the relevant tier;

.2 dimensions of stanchions and struts shall be determined according to 2.9 of Part II "Hull" as for the pillars;

.3 dimensions of beams, stanchions and struts shall be determined with due regard to inertia force from the deck structure weight. Accelerations for determination of inertia forces shall be determined as per 1.3.3.1 and 1.3.4.4 of Part II "Hull";

.4 aluminium alloys may be used. Strength and stability of helidecks from aluminium alloys may be determined by the model tests to be conducted in the presence of the RS representative according to the approved program.

6.3 EQUIPMENT OF HELIDECKS

6.3.1 The helideck surface shall be smooth, no steps or recesses in FATO are generally allowed. As an exception, the steps on the FATO perimeter line (outside the helideck white perimeter line) shall not exceed 250 mm in height, and within the FATO (within the helideck white perimeter line) shall not exceed 25 mm in height. Objects the function of which requires that they be located on the helideck within the FATO shall only be present provided they do not cause a hazard to helicopter operations.

As an exception, for ships which keels are laid before 1 January 2012, the steps within the FATO of height not exceeding 60 mm with the edge slop 1/3 are allowed.

6.3.2 The helideck, including its marking, and hangar deck shall have a skid-resistant surface.

6.3.3 For helicopter operation in winter period easily detachable rope net, rather of natural fiber (sisal), diameter of 20 mm and maximum mesh dimensions 200 × 200 mm, shall be provided along the perimeter of the FATO.

Recommended dimensions of the net, depending on the overall helicopter length, are determined by sufficiency to cover the landing area:

6 × 6 m at helicopter length less than 15 m;

12 × 12 m at helicopter length from 15 to 20 m;

15 × 15 m at helicopter length more than 20 m.

The net shall be reliably secured to the deck along the FATO perimeter and fixed to it in any 1,5 m and shall be tightened with a load not less than 2225 N.

The dismounted net shall be kept onboard.

6.3.4 Outboard edges of the helideck shall be provided with fixed or hinged safety net of at least 1,5 m in width, made of fire-resistant flexible material.

For MODU and FOP, as well as for sea-going ships, which keels are laid before 1 January 2012, outboard edge of the fixed safety net shall not rise above the plane of FATO more than 0,25 m, and the net shall be inclined upwards at an angle of at least 10°.

For MODU and FOP, as well as for sea-going ships, which keels are laid on and after 1 January 2012, outboard edge of the fixed safety net shall not rise above the plane of FATO, and the net shall be inclined upwards at an angle of at least 10°.

Hinged safety net in tumble position shall comply with the same requirements.

The safety net shall be strong enough to withstand, without damage, a 75 kg mass being dropped, and the net shall provide hammock effect for person falling into it rather than the trampoline effect produced by some rigid materials.

6.3.5 In addition to the requirements of 6.3.4 the hinged safety net shall comply with the following requirements:

.1 safety net shall be reliably secured in a hoist position;

.2 safety net shall be reliably fixed in a hinged position so as to prevent its hoist due to the effect of airflow from the helicopter rotor;

.3 safety net hoisting and lowering shall be performed so as to minimize the risk of personnel falling overboard during the operations;

4. any failure of power driving gear for safety net hoisting shall not prevent from its lowering by hand.

6.3.6 To minimize the risk of personnel or equipment sliding from the helideck, the outboard edges of the helideck shall have coamings of recommended height of 50 mm. The coamings shall also meet the requirements of 6.2.7.

6.3.7 The helideck in way of helicopter parking place and maintenance areas, as well as the hangar (if any) shall be equipped with the tie-down points and means for fastening of helicopter maintenance facilities (if any), flush type is preferable. Connection dimensions,

arrangement plan and design forces of tie-down points shall be selected for fastening of one or several types of helicopter taking into account the requirements of 6.3.1.

6.3.8 Where handrails associated with access/escape points exceed the elevation of the FATO by more than 0,25 m, they shall be made collapsible and removable. They shall be collapsed or removed whilst helicopter manoeuvres are in progress.

6.4 FIRE PROTECTION

6.4.1 Fire protection of helidecks.

6.4.1.1 The helideck shall be provided with both main and emergency means of escape and access for fire-fighting and rescue personnel. These shall be located as far apart from each other as practicable, and preferably on the opposite sides of the helideck.

If more than 50 % of the helideck area is projected from the main ship structure, it is recommended to arrange two entrances to helideck within the range of such overhanging parts that is providing at least one exit from helideck to windward side in case of fire.

6.4.1.2 Helideck shall be protected by a fixed foam fire extinguishing system according to item 20 of Table 3.1.2.1 of Part VI "Fire Protection".

For helidecks the foam system shall contain at least two fixed foam monitors or deck integrated foam nozzles. In addition, at least two hose reels fitted with a foam-making branch pipe and non-collapsible hose sufficient to reach any part of the helideck shall be provided.

The minimum foam system discharge rate shall be determined by multiplying the *D*-value area by 6 l/min/m^2.

The minimum foam system discharge rate for deck integrated foam nozzle systems shall be determined by multiplying the overall helideck area by 6 l/min/m^2.

Each monitor shall be capable of supplying at least 50 % of the minimum foam system discharge rate, but not less than 500 l/min.

Where foam monitors are installed, the distance from the monitor to the farthest extremity of the protected area shall be not more than 75 % of the monitor throw in still air conditions.

The minimum discharge rate of each hose reel shall be at least 400 l/min. The quantity of foam concentrate shall be adequate to allow operation of all connected discharge devices for at least 5 min.

The location and characteristics of the equipment of the foam fire extinguishing system shall provide extinguishing of fire on helicopter high-level units.

6.4.1.3 For helicopter landing areas, at least two portable foam applicators or two hose reel foam stations shall be provided, each capable of discharging a minimum foam solution discharge rate, in accordance with Table 6.4.1.3.

Table 6.4.1.3

Category	Helicopter overall length (*D*-value), in m	Minimum foam solution discharge rate, in l/min
H1	up to but not including 15 m	250
H2	from 15 m up to but not including 24 m	500
H3	from 24 m up to but not including 35 m	800

The quantity of foam concentrate shall be adequate to allow operation of all connected discharge devices for at least 10 min. For tankers and oil recovery ships fitted with a deck foam system, an alternative arrangement, taking into account the type of foam concentrate to be used may be considered.

6.4.1.4 Manual release stations capable of starting necessary pumps and opening required valves, including the fire main system, if used for water supply, shall be located at each monitor and hose reel. In addition, a central manual release station shall be provided at a protected location. The foam system shall be designed to discharge foam with nominal flow and at design pressure from any connected discharge devices within 30 s of activation.

6.4.1.5 Activation of any manual release station shall initiate the flow of foam solution to all connected hose reels, monitors, and deck integrated foam nozzles.

6.4.1.6 The system and its components shall be designed to withstand ambient temperature changes, vibration, humidity, shock impact and corrosion normally encountered on the open deck, and shall be manufactured and tested in accordance with the requirements of 3.13, Part VI "Fire Protection".

6.4.1.7 A minimum nozzle throw of at least 15 m shall be provided with all hose reels and monitors discharging foam simultaneously. The discharge pressure, flow rate and discharge pattern of deck integrated foam nozzles shall be based on tests that demonstrate the nozzle's capability to extinguish fires involving the largest size helicopter for which the helideck is designed.

6.4.1.8 Monitors, foam-making branch pipes, deck integrated foam nozzles and couplings shall be constructed of brass, bronze or stainless steel. Piping, fittings and related components, except gaskets, shall be designed to withstand exposure to temperatures up to 925 °C.

6.4.1.9 The foam concentrate shall be demonstrated effective for extinguishing aviation fuel spill fires, shall be suitable for application with sea water and shall conform to performance standards not inferior to those acceptable to ICAO. Where the foam storage tank is on the exposed deck, freeze protected foam concentrates shall be used, if appropriate, for the area of operation.

6.4.1.10 Any foam system equipment installed within the take-off and approach obstacle free sector shall not exceed a height of 0,25 m. Any foam system equipment installed in the limited obstacle sector shall not exceed the height permitted for objects in this area.

6.4.1.11 All manual release stations, monitor foam stations (refer to Definitions), hose reel foam stations, hose reels and monitors shall be provided with a means of access that does not require travel across the helideck or helicopter landing area.

6.4.1.12 Oscillating monitors, if used, shall be pre-set to discharge foam in a spray pattern and have a means of disengaging the oscillating mechanism to allow rapid conversion to manual operation.

6.4.1.13 If a foam monitor with flow rate up to 1,000 l/min is installed, it shall be equipped with an air-aspirating nozzle.

If a deck integrated nozzle system is installed, then the additionally installed hose reel shall be equipped with an air-aspirating handline nozzle (foam branch pipes).

Use of non-air-aspirating foam nozzles (on both monitors and the additional hose reel) is permitted only where foam monitors with a flow rate above 1,000 l/min are installed.

If only portable foam applicators or hose reel stations are provided, these shall be equipped with an air-aspirating handline nozzle (foam branch pipes).

6.4.1.14 The number and position of fire hydrants shall be such that at least two jets of water may reach any part of the helideck.

6.4.1.15 In close proximity to the helideck the following fire-fighting outfit shall be provided and stored near the means of access to that helideck:

.1 at least two dry powder fire extinguishers having a total capacity not less than 45 kg;

.2 carbon dioxide fire extinguishers having a total capacity not less than 18 kg or equivalent; fire extinguishers shall be equipped with flexible nozzles for extinguishing a fire in the upper part of a helicopter;

.3 at least two nozzles of an approved dual-purpose type with hoses sufficient to reach any part of the helideck;

.4 at least two sets of fireman's outfits in addition to those required by item 10 of Table 5.1.2, Part VI "Fire Protection";

.5 at least the following equipment stored to provide its immediate use and protection from weather exposure:

adjustable wrench;
blanket (fire resistant);
cutter with at least 60 cm handle;
hook, grab or salving;
hacksaw, heavy duty, complete with 6 spare blades;
ladder;
lift line of 5 mm diameter and 15 m in length;

pliers, side-cutting;
set of assorted screwdrivers;
harness knife complete with sheath;
large crowbar (recommended);
3 pairs of fire resistant gloves (recommended);
large rescue axe (recommended);
side cutting pliers (tin snips) or equivalent cutting tool (recommended).

6.4.1.16 Drainage facilities in way of helidecks shall be constructed of steel or other arrangements providing equivalent fire safety; lead directly overboard independent of any other system; and designed so that drainage does not fall onto any part of the unit.

6.4.2 Fire protection of hangars and spaces where helicopter refuelling and maintenance facilities are located.

6.4.2.1 Structural fire protection, fixed fire extinguishing systems and fire detection and alarm systems and fire-fighting outfit for hangars and spaces where helicopter refuelling and maintenance facilities are located shall be similar to those of category A machinery spaces.

6.4.2.2 The boundary structures of hangars and spaces where helicopter refuelling and maintenance facilities are located shall be made of steel.

6.4.2.3 Refuelling station for helicopters shall meet the following requirements:

.1 the boundaries and means of closing openings at the station shall secure gas tightness thereof. Doors leading to the station shall be of steel;

.2 deck covering shall preclude spark formation. Arrangements and machinery shall be so arranged and located as to exclude the possibility of spark formation;

.3 pipelines and cables passing through the boundaries of the station shall not cause loss of its gas tightness;

.4 storage tank fuel pumps shall be provided with means which permit remote shutdown from a safe location in the event of a fire. Where a gravity-fuelling system is installed, equivalent closing arrangements shall be provided to isolate the fuel source;

.5 where several fuel tanks are fitted, the fuel system design shall provide for fuel supply to the helicopter being refuelled only from one tank at a time;

.6 provision shall be made for the arrangement whereby a fuel spillage may be collected and drained into an off-grade fuel tank;

.7 fuel oil piping shall be of steel or equivalent material, as short as possible, and protected against damage;

.8 the refuelling facility shall incorporate a metering device to record the quantity of supplied fuel, a flexible hose with a nozzle fitted with a self-closing valve and a device to prevent over-pressurization of the fuel system.

6.4.2.4 The number and position of the hydrants shall be such that at least three jets of water may reach any part of the hangar.

6.4.2.5 "NO SMOKING" signs shall be displayed at appropriate locations in hangars and spaces where helicopter refuelling and maintenance facilities are located.

6.4.2.6 Storage of flammable liquids and materials, paint materials, lubricating oils, hydraulic liquids and any types of fuel in hangar is not allowed.

6.5 SYSTEMS AND PIPING

6.5.1 Helicopter refuelling systems.

6.5.1.1 Shipboard helicopter refuelling system shall comply with the requirements actual in the Civil Aviation of Flag State in part of bunkering, storage, cleaning, quality control and fuel filling. Refuelling facilities shall be certified (approved) for compliance with the requirements of the Flag State aviation regulations.

6.5.1.2 All the equipment used in refuelling operations shall be effectively earthed. All the equipment, arrangements, machinery and deck coverings shall be manufactured and installed so as to prevent spark formation.

6.5.1.3 As a rule, tanks used for storage of helicopter fuel shall be located on the open deck in specially designed area, which shall be:

.1 as remote as practicable from accommodation and machinery spaces, escape routes and embarkation stations, as well as from locations containing sources of ignition;

.2 isolated from areas containing sources of vapour ignition;

.3 the fuel storage area shall be provided with arrangements whereby fuel spillage may be collected and drained to off-grade fuel tank;

.4 where tanks for storage of helicopter fuel and off-grade fuel tanks are located in enclosed spaces, such tanks shall be surrounded by cofferdams filled with inert gas;

.5 in cofferdams referred to in 6.5.1.3.4 the length of oil fuel line and the number of its detachable joints shall be kept to a minimum, and its valves shall be located in easily accessible places, generally, on the open deck;

.6 cofferdams referred to in 6.5.1.3.4 shall not be connected to any piping system serving other spaces.

6.5.1.4 Provision shall be made for fuel jettisoning from tanks of the helicopter located on the helideck or in hangar to the off-grade fuel tank. Provision shall be made for off-grade fuel delivery to the shore or ship's tanks.

6.5.1.5 Tanks used for storage of helicopter fuel and associated equipment shall be protected against physical damage and from a fire in an adjacent space or area. Tanks shall be protected against direct sunrays.

6.5.1.6 When equipping tanks for the storage of helicopter fuel with facilities for their emergency jettisoning precautions shall be taken to prevent the tank jettisoned from impact against ship's structures. The tanks shall be as remote as practicable from survival craft muster and embarkation stations and survival craft launching stations.

6.5.1.7 The fuel tanks shall be made of materials which resist attacks by corrosion and helicopter fuel.

Fuel may be stored both in transported and fixed tanks.

Tanks shall be efficiently secured, closed and bonded. The tanks shall be readily accessible for inspection.

Tanks and piping for anti-crystallization fluids shall be made of stainless steels.

6.5.1.8 Each fuel oil tank shall be fitted with filling, outlet, sounding and air pipes. The end of a filling pipe shall not be more than 300 mm above a tank bottom. It is recommended to use closed-type flowmeters. The sounding pipe shall end 30 to 50 mm above a tank bottom and shall be laid to the open deck.

6.5.1.9 Air pipes of fuel oil tanks shall be laid to a height of at least 2,4 m above the open deck. Open ends of air pipes shall be spaced at a distance of at least 10 m from air intakes and openings of enclosed spaces with ignition sources, and from a deck machinery and equipment, which may present an ignition hazard, and shall be fitted with flame-arresting meshes or other fittings approved by the Register.

6.5.1.10 A fuel oil pump shall take in fuel oil simultaneously from one tank only. Pipelines shall be made of steel or equivalent material, shall be short (where possible) and shall be protected against damages.

6.5.1.11 Fuel oil pumps shall be provided with shutdown means positioned in a remote safe place. Service tanks shall be provided with quick-closing valves driven from outside the tank area.

6.5.1.12 All pipelines and equipment of the system for bunkering, storage and fuelling shall be electrically continuous and shall be earthed to the ship hull.

6.5.1.13 Fuel pipelines shall have no stagnant sections. Where it is structurally impossible to avoid stagnant sections, provision shall be made for pipe drainage by means of nitrogen purging or another way of pipeline emptying. The lower parts of piping system shall be provided with drain cocks to remove sediment to off-grade fuel tank.

6.5.1.14 Helicopter refuelling system shall be so designed as to provide free access for its maintenance, fuel sampling and repair.

6.5.2 Ventilation system of hangars and spaces where helicopter refuelling and maintenance facilities are located.

6.5.2.1 Hangars and spaces where helicopter refuelling and maintenance facilities are located shall be provided with mechanical exhaust ventilation sufficient to give at least 10 air changes per hour. Fans shall be of flameproof design and shall meet the requirements of 5.3.3, Part IX "Machinery" and 19.3.4, Part XI "Electrical Equipment".

6.6 ELECTRICAL EQUIPMENT

6.6.1 Electrical equipment and electric wiring of hangars and spaces where helicopter refuelling and maintenance facilities are located shall comply with the requirements of 2.9, Part XI "Electrical Equipment".

6.6.2 Lighting and illumination means for helidecks shall comply with the requirements of 6.9, Part XI "Electrical Equipment" of the Rules for the Classification and Construction of Sea-Going Ships and the Flag State Civil Aviation requirements.

6.7 COMMUNICATIONS

6.7.1 To ensure helicopter operation the ship shall be equipped with necessary radio and meteorological equipment in compliance with the Flag State Civil Aviation requirements.

6.8 TESTS

6.8.1 All systems and components of the helicopter facility when installed onboard shall be tested according to the programs approved by the Register.

6.8.2 Upon request of the Flag State Civil Aviation flight trials and/or test flights may be performed on ships in compliance with the Flag State regulatory documents.

6.9 RECORDS

6.9.1 As a result of applying the requirements of this Section, the following records shall be issued:

.1 Classification Certificate (form 3.1.2 and 3.1.2P) with the distinguishing mark **HELIDECK**, **HELIDECK-F** or **HELIDECK-H** in the class notation;

.2 Report on Survey of the Ship (form 6.3.10).

7 REQUIREMENTS FOR SHIP EQUIPMENT TO ENSURE LONG-TERM OPERATION AT LOW TEMPERATURE

7.1 GENERAL

7.1.1 Application.

7.1.1.1 The requirements for ship equipment and FOP (hereinafter for this Section referred to as "the ships") to ensure long-term operation at low temperature apply to ships intended for operation in cold climatic conditions, including the Gulf of Saint Lawrence, northern part of the Baltic Sea, the Arctic Ocean and Antarctic Seas, and are additional to the requirements of Part I "Classification", Part II "Hull", Part III "Equipment, Arrangements and Outfit", Part VII "Machinery Installations", Part VIII "Systems and Piping", Part IX "Machinery", Part XI "Electrical Equipment" and Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, Part II "Life-Saving Appliances", Part III "Signal Means", Part IV "Radio Equipment" and Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships, as well as the Rules for the Cargo Handling Gear of Sea-Going Ships.

7.1.1.2 For ships complying with the requirements of this Section a distinguishing mark **WINTERIZATION(DAT)** may be added to the character of classification at the shipowner's request. Design ambient temperature shall be indicated in brackets, for example: **WINTERIZATION(–40)**.

7.1.1.3 The necessary conditions for assigning the distinguishing mark **WINTERIZATION(DAT)** are as follows:

.1 availability of ice class not less than **Arc4** in compliance with 2.2.3, Part I "Classification". At shipowner's request the distinguishing mark **WINTERIZATION(DAT)** may be assigned to ships of ice class **Ice3** and below, in this case the extent of compliance with the requirements of this Section shall be determined by the Register upon agreement with the shipowner considering the intended operational conditions and structural particulars of the ship;

.2 availability of the distinguishing mark **ANTI-ICE** for ships fitted with equipment for icing protection in compliance with Section 4.

7.1.1.4 The distinguishing mark **WINTERIZATION(DAT)** may be assigned to ships under construction and in service.

7.1.2 Definitions, explanations and abbreviations.

For the purpose of this Section the following definitions, explanations and abbreviations have been adopted.

Accommodation spaces are spaces complying with the requirements of 1.5.2, Part VI "Fire Protection".

Design ambient temperature (DAT) is the outside air temperature, in °C, used as the criterion for selection and testing of materials and equipment subject to low temperatures.

Design temperature of the structure is the temperature, in °C, assumed for choosing of construction material. When the Rules or this Section contain no additional provisions, the design ambient temperature is assumed as a design temperature of the structure.

Enclosed space is a space with a direct access to the open deck which is fitted with an appropriate closure.

IBC Code – International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk.

LSA Code – International Life-Saving Appliances Code.

MARPOL 73/78 – International Convention for the Prevention of Pollution from Ships, 1973 and Protocol, 1978 thereto.

Open space is a space with a direct access to the open deck which is not fitted with closure or shall be kept open for long periods as regards operational conditions of equipment installed in this space.

Pollutant means any substance, which falls within the limits for marine disposal in compliance with MARPOL 73/78.

Working liquids mean fuel and lubricating materials, and hydraulic oils, except for marine fuel, necessary for normal operation of a ship and its equipment.

7.1.3 Technical documentation.

7.1.3.1 The following technical documentation shall be submitted to the Register for approval to assign the distinguishing mark **WINTERIZATION(DAT)** in the class notation:

.1 list of technical solutions applied onboard the ship and ensuring compliance with the requirements of this Section;

.2 single-line diagrams of electric heating systems (electric heating appliances, systems utilizing heating cables).

7.1.3.2 On board the ship the Manual on operation of ship at low temperature (Winterization Manual) shall be available.

7.1.3.3 When supplying onboard the machinery, equipment, arrangements, outfit, as well as foam concentrate, specified in this Section, the certificates confirming the possibility of their application at design ambient temperature (DAT) shall be provided to the RS surveyor.

7.1.3.4 Technical documentation on products to be submitted for approval in addition to the requirements of the Rules is specified in the relevant chapters of this Section. Technical documentation on products shall include test programs for the equipment specified in this Section and subject to long-term exposure to low temperature.

7.2 DESIGN TEMPERATURES

7.2.1 Design ambient temperature value is established by the shipowner according to the ship purpose and service conditions.

7.2.2 The following standard values of design ambient temperature are stipulated by this Section: –30 °C (the distinguishing mark **WINTERIZATION(–30)**); –40 °C (the distinguishing mark **WINTERIZATION(–40)**); –50 °C (the distinguishing mark **WINTERIZATION(–50)**).

Application of this requirements for design ambient temperatures above –30 °C and intermediate values shall be determined by the Register upon agreement with the shipowner.

7.2.3 Design ambient temperature shall not be assumed above the temperature specified in 1.2.3.3 of Part II "Hull" for the appropriate ice class.

7.2.4 Design temperature of hull structures shall be assumed according to 1.2.3.4 of Part II "Hull". In this case, design ambient temperature shall be assumed as the value of T_A.

7.2.5 For equipment and machinery installed on the open decks, as well as in the open spaces, the design ambient temperature shall be assumed as design temperature of structures. For equipment and machinery installed in unheated enclosed spaces exposed to the environment and adjoining unheated adjacent enclosed spaces the design ambient temperature shall be assumed as the design temperature. For equipment and machinery installed in unheated enclosed spaces exposed to the environment and adjoining heated adjacent enclosed spaces the temperature of 20 °C above the design ambient temperature shall be assumed as the design temperature of structure.

7.3 GENERAL REQUIREMENTS

7.3.1 Cargo and slop tanks of oil tankers of less than 5000 t deadweight shall be protected throughout the length by ballast tanks or compartments not intended for carriage of pollutants located in compliance with the requirements of regulation 19.6.1 (from the ship's bottom shell plating) and regulation 19.6.2 for the distance *w* (from the ship's side shell plating) of Annex I to MARPOL 73/78.

On ships other than oil tankers, all cargo tanks designed and intended for carrying oil shall be located at a distance of at least 0,76 m from the shell plating.

On chemical tankers type 3 as defined in 2.1.2 of the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code), or NLS tankers, cargo tanks shall be located at a distance of at least 0,76 from the shell plating.

Location of cargo and slop tanks (if any) of chemical tankers relative to shell plating shall comply with the requirements of regulation 2.6 of the IBC Code depending on the ship's type. Therewith, for carriage of selected vegetable oils onboard the type 3 chemical tankers the requirements of regulation 4.1.3 of Annex II to MARPOL 73/78 shall be met. Other type 3 chemical tankers, as well as tankers intended for carriage of hazardous substances in bulk shall be fitted with cargo and slop tanks located at least at 760 mm distance from the shell plating.

7.3.2 For ships with aggregate capacity of fuel oil tanks less than 600 m^3, all fuel oil tanks shall be located at a distance of at least 0,76 m from the shell plating. This requirement shall not apply to small fuel oil tanks with the capacity not exceeding 30 m^3.

7.3.3 All oil residue (sludge) tanks, tanks intended for storage of working liquids and oily bilge water holding tanks shall be located at a distance of at least 0,76 m from the shell plating. This requirement shall not apply to such small tanks with the capacity not exceeding 30 m^3.

7.3.4 In addition to the requirements of Annex I to MARPOL 73/78, each ship shall be fitted with oil residue holding tank(s) as well as oily bilge water holding tank(s) of sufficient capacity agreed with the Register, for the total retention on board of accumulated oil residues (sludge) and oily bilge water during voyages in polar waters and disposal to reception facilities.

7.3.5 Navigation bridge wings shall be closed.

Angles of view shall meet the requirements of 3.2, Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships. Bridge front, rear and side windows (including wings) shall be inclined from the vertical plane top out, at an angle of not less 10° and not more than 25°.

7.3.6 Exit from corridors of accommodations to the open deck shall be arranged through the heated companions.

7.3.7 A heated deckhouse shall be provided as a shelter for crew while performing the following functions: observation of the environment during the ship's movement or using guards whilst in a port.

7.4 EQUIPMENT, ARRANGEMENTS AND OUTFIT

7.4.1 Anchor arrangement.

7.4.1.1 Materials for manufacture of anchor shall meet the requirements of Section 8, Part XIII "Materials".

7.4.1.2 Materials for manufacture of anchor chain shall meet the requirements of 7.12.7.

7.4.1.3 Materials of castings for manufacture of anchor hawse pipe shall meet the requirements of 7.12.4.

The RS certificates issued for anchor hawse pipes to be installed onboard the ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** shall contain an indication whether it is allowed to use them at appropriate design ambient temperature.

7.4.1.4 Anchor stoppers shall meet the requirements of 3.6.1, Part III "Equipment, Arrangements and Outfit".

The RS certificates issued for anchor stoppers to be installed onboard the ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** shall contain an indication whether it is allowed to use them at appropriate design ambient temperature.

7.4.2 Mooring appliances.

7.4.2.1 Materials of castings for manufacture of mooring bollards, fairleaders and other mooring appliances shall meet the requirements of 7.12.4.

The RS certificates issued for mooring appliances to be installed onboard the ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** shall contain an indication whether it is allowed to use them at appropriate design ambient temperature.

7.4.2.2 Chain stoppers for single-point mooring to offshore terminals shall meet the requirements of 7.4.1.4.

7.4.3 Towing arrangement.

7.4.3.1 Materials of castings for manufacture of bitts, towing bollards, fairleaders, chocks, roller and other towing arrangement shall meet the requirements of 7.12.4.

The RS certificates issued for mooring appliances to be installed onboard the ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** shall contain an indication whether it is allowed to use them at appropriate design ambient temperature.

7.4.3.2 Chains of emergency towing arrangement shall meet the requirements of 7.12.7.

7.4.4 Side scuttles.

7.4.4.1 Side scuttles of wheelhouse and cargo control room shall be provided with heating in compliance with 4.2.3.6 of this Part.

7.4.4.2 Onboard the ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** the side scuttles with double glass shall be installed in accommodation spaces.

7.4.4.3 When the cargo deck is viewed through the side scuttles of master's cabin, at least one of these side scuttles shall be provided with heating.

7.4.4.4 External access or other equivalent means for cleaning of side scuttles of navigation bridge and cargo control room shall be provided.

7.4.5 Hatchways, shell doors, cargo doors.

7.4.5.1 Materials for manufacture of cargo hatch covers and hatchways of cargo tanks, shell doors, cargo doors, including seals shall meet the requirements of 7.12.1 — 7.12.6.

7.4.5.2 Hydraulic liquids and lubricating oils shall be suitable for use at design ambient temperature.

7.4.5.3 The RS certificates issued for cargo hatch covers and cargo tanks, shell doors, cargo doors to be installed onboard the ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** shall contain an indication whether it is allowed to use them at appropriate design ambient temperature.

7.4.6 Signal means.

7.4.6.1 Manually operated flashing red light visible from astern to indicate when the ship is stopped shall be provided onboard. The flashing light shall have a range of visibility of at least 2 nautical miles. Construction and characteristics of the light shall meet the applicable requirements of 3.1.6 and 3.2.1, Part III "Signal Means" of the Rules for the Equipment of Sea-Going Ships. Arc of visibility in horizontal and vertical plane shall be the same as for stern lights in compliance with 3.1.2, Part III "Signal Means" of the Rules for the Equipment of Sea-Going Ships.

7.4.6.2 The light specified in 7.4.6.1 shall be effective at design ambient temperature or at the temperature stated in 3.1.3.3, Part III "Signal Means" of the Rules for the Equipment of Sea-Going Ships (whichever is lower).

7.5 STABILITY AND SUBDIVISION

The ship shall be provided with a reliable draught measurement system whereby the forward and aft draughts can be easily determined.

7.6 MACHINERY INSTALLATIONS

7.6.1 Means shall be provided to ensure that machinery may be brought into operation from the dead ship condition without external aid (refer also to 2.1.6, Part VII "Machinery Installations"), as well as storage and supply of fuel to the emergency diesel-generator with pour point temperature being 5 °C lower than design ambient temperature indicated in brackets of the distinguishing mark **WINTERIZATION(DAT)**. As an alternative, self-contained portable arrangements may be provided on board to ensure that machinery may be brought into operation from the dead ship condition.

7.6.2 Based on their design, the machinery, shafting, boilers and other pressure vessels, as well as pipelines of systems and fittings, shall remain operative during the ship stay at design ambient temperature.

7.6.3 Air supply to main engines shall not lead to overcooling of machinery space. Technical means shall be provided to exclude increase of mechanical load on cylinders and pistons and bearings of main engines due to the harmful effect of reduced temperatures of scavenging air.

7.6.4 In general, at least two auxiliary boilers shall be provided onboard the ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)**.

7.7 SYSTEMS AND PIPING

7.7.1 Fittings, formed components, expansion joints.

7.7.1.1 Materials for manufacture of fittings, expansion joints and formed components of pipelines to be installed on the open decks, as well as in the open unheated spaces shall meet the requirements of 7.12.1 — 7.12.6.

For products and seals manufactured of rubber as well as materials of organic origin in fittings, cold endurance type tests may be replaced by checking the operability of assembled fittings in low temperatures. For this purpose, a sample of each standard series of valves shall be conditioned within 6 h at a temperature of 10 °C lower than design ambient temperature indicated in brackets of the distinguishing mark **WINTERIZATION(DAT)**. Immediately after removal from the refrigerating chamber, 10 cycles of closing and opening of the fittings shall be made, after which hydraulic tests are carried out with working pressure at normal temperature.

7.7.1.2 The RS certificates issued for fittings, expansion joints and formed components of pipelines to be installed onboard the ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** and installed on the open decks, as well as in the open unheated spaces shall contain an indication whether it is allowed to use them at appropriate design ambient temperature.

7.7.1.3 Side fittings installed above the load waterline shall meet the requirements of 4.3.1.2 of "Systems and Piping".

7.7.2 Ballast and sewage systems.

7.7.2.1 Ballast system shall meet the requirements of 8.3.2, Part VIII "Systems and Piping".

7.7.2.2 Discharge pipeline of ballast system shall be provided with heating.

7.7.2.3 Where submerged electrically-driven ballast pumps are used, their serviceability at design ambient temperature shall be ensured and documented; and the relevant information shall be introduced into the certificates issued by the Register.

7.7.2.4 Hydraulic liquids used as working media for ballast pumps driving and remotely controlled fittings shall be suitable for use at design ambient temperature.

7.7.2.5 Sewage holding tanks and pipelines leading thereto shall be located in heated spaces or provided with heating.

7.7.3 Fire-fighting systems and outfit.

7.7.3.1 All fire pumps, including emergency fire pump, shall be located in compartments maintained above freezing. Where fixed water-based firefighting systems are located in a space separate from the main fire pumps and use their own independent sea suction, this sea suction shall be also capable of being cleared of ice accumulation.

7.7.3.2 Design of water fire main system and foam fire extinguishing system shall meet the requirements of 3.2 and 3.7, Part VI "Fire Protection" considering the requirements of 4.2.4.4.

7.7.3.3 A foam concentrate for foam fire extinguishing system shall be approved by the Register and be stored in the space with positive temperature.

7.7.3.4 Air-foam nozzles intended for installation onboard the ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** shall work properly at required design ambient temperature and shall have the relevant Register approval.

7.7.3.5 Fire hoses shall meet the requirements of 5.1.4, Part VI "Fire Protection" They shall be approved by the Register and be suitable for operation at design ambient temperature.

Fire hoses need not be connected to the fire main at all times, and may be stored in protected locations near the hydrants.

7.7.3.6 The fire extinguishers shall be located in positions protected from freezing temperatures, as far as practical. Locations subject to freezing shall be provided with fire

extinguishers capable of operation under the polar service temperature according to 5.1.9.15.7, Part VI "Fire Protection".

7.7.3.7 The firefighter's outfits shall be stored in warm locations on the ship. The radio communication equipment shall be operable at the polar service temperature.

7.7.4 Systems of tankers and combination carriers.

7.7.4.1 Cargo system.

7.7.4.1.1 Where submerged electrically-driven ballast pumps are used, their serviceability at design ambient temperature shall be ensured and documented and the relevant information shall be introduced into the certificates issued by the Register.

7.7.4.1.2 Hydraulic liquids used as working media for ballast pumps driving and remotely controlled fittings shall be suitable for use at design ambient temperature.

7.7.4.1.3 The RS certificates issued for cargo hoses of oil and chemical tankers shall contain an indication whether it is allowed to use them at design ambient temperature.

7.7.4.2 Bow loading system.

7.7.4.2.1 Materials of components of the bow loading system shall meet the requirements of 7.12.1 — 7.12.6.

7.7.4.2.2 Hydraulic liquids and lubricating oils shall be suitable for use at design ambient temperature.

7.7.4.2.3 The RS certificates issued for bow loading system to be installed onboard the ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** shall contain an indication whether it is allowed to use it at appropriate design ambient temperature.

7.7.4.3 Inert gas system.

7.7.4.3.1 Sea water supply pipeline for deck water seal, a gas scrubber and other equipment of inert gas system shall be fitted with heating.

7.7.5 Ventilation system.

7.7.5.1 In addition to the requirements of Section 12, Part VIII "Systems and Piping" the ventilation system shall meet the requirements of 4.2.4.3.

7.8 DECK MACHINERY

7.8.1 Materials used for manufacture of deck machinery components shall comply with the requirements of 7.12.1 — 7.12.6.

7.8.2 The RS certificates issued for deck machinery intended for installation onboard the ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** shall contain an indication whether it is allowed to use it at appropriate design ambient temperature.

7.8.3 Hydraulic liquids and lubricating oils shall be suitable for use at design ambient temperature.

7.9 LIFE-SAVING APPLIANCES

7.9.1 General requirements for life-saving appliances.

7.9.1.1 Life-saving appliances shall comply with the requirements of Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships; at that, they shall be in the operating condition when stored at design ambient temperature.

7.9.1.2 The RS certificates issued for life-saving appliances intended for ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** shall contain an indication whether it is allowed to use them at appropriate design ambient temperature.

7.9.1.3 Life-saving appliances intended for ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** shall be marked **W(–40)** and **W(–50)** accordingly.

7.9.1.4 Sufficient emergency rations for the maximum expected time of rescue shall be provided onboard.

7.9.2 Lifeboats.

7.9.2.1 Lifeboats shall be of an enclosed type and shall comply with the following additional requirements with regard to Section 6, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships:

.1 a lifeboat shall provide accommodation for a specified number of persons in warm clothes with personal survival kits stipulated by 7.9.6.2;

.2 a lifeboat keel shall be provided with additional strip of steel or other equivalent material to protect the keel from contact with ice; adequate protection is allowed;

.3 a lifeboat engine shall be equipped with a means for its cold start at design ambient temperature within 2 min from the start; a starter shall be driven from two independent sources of power;

.4 cooling system of a lifeboat engine shall ensure its operation at design ambient temperature;

.5 a lifeboat propeller shall be properly protected from damage by ice;

.6 lifeboat engine fuel oil and oils used shall provide engine safe operation at design ambient temperature;

.7 a lifeboat cockpit shall be electrically heated;

.8 lifeboat scuttles which provide the required visibility from a control station shall be heated;

.9 prior to launching, a lifeboat shall be fitted with a two-way VHF radiotelephone apparatus in compliance with the requirements of 12.2 or 12.3, Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships; apparatus shall be operable at appropriate design ambient temperature;

.10 drinking water shall be stored in containers that allow for expansion due to freezing;

.11 a lifeboat shall be additionally supplied with a food ration in the quantity equal to 30 % of the ration required by the LSA Code to account for high rates of energy expenditure under cold conditions;

.12 a lifeboat on-load release mechanism shall be provided with heating or other measures ensuring safe actuation of a release mechanism at design ambient temperature shall be taken;

.13 a suitable icing removal mallet or another tool for ice accretion removal complying with the requirements of 4.2.3.11 shall be available in the vicinity of a lifeboat as additional means;

.14 immersion suits shall be of the insulated type.

7.9.3 Rescue boats.

7.9.3.1 Rescue boats shall comply with the following additional requirements with regard to Section 6, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships:

.1 only rigid rescue boats shall be used;

.2 safe starting of the engine at design ambient temperature shall be provided;

.3 rescue boat engine fuel oil and oils used shall provide engine safe operation at design ambient temperature;

.4 prior to launching, a rescue boat shall be fitted with a two-way VHF radiotelephone apparatus in compliance with the requirements of 12.2 or 12.3, Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships; apparatus shall be operable at appropriate design ambient temperature.

7.9.4 Liferafts.

7.9.4.1 Liferafts shall comply with the following additional requirements with regard to Section 6, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships:

.1 inflation of a liferaft shall be completed within 3 min at design ambient temperature;

.2 containers of inflatable liferafts and hydrostatic release units shall be provided with heating or other measures to ensure ease launching, inflation and release of liferafts at design ambient temperature shall be taken;

.3 a manual inflation pump that is proven to be effective at design ambient temperature shall be stored in a heated space in the vicinity of the inflatable liferaft;

.4 liferafts shall be additionally supplied with a food ration in the quantity equal to 30 % of the ration required by the LSA Code to account for high rates of energy expenditure under cold conditions;

.5 a suitable icing removal mallet or another tool for ice accretion removal complying with the requirements of 4.2.3.11 shall be available in the vicinity of the liferafts as a secondary means.

7.9.5 Launching appliances of lifeboats, rescue boats and liferafts.

7.9.5.1 Launching appliances of lifeboats, rescue boats and liferafts shall comply with the following additional requirements with regard to Section 6, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships:

.1 materials used for their manufacture shall comply with the requirements of 7.12.1 — 7.12.6;

.2 hydraulic liquids and lubricating oils used in launching and embarkation appliances shall be suitable for use at design ambient temperature;

.3 electric motors and winches of launching appliances, automatic release hook shall be provided with heating or removable covers; if heating is not provided, a suitable icing removal mallet or another tool for ice accretion removal complying with the requirements of 4.2.3.11 shall be available in the vicinity of the launching appliance as a secondary means;

.4 electric motors, hydraulic drives, winches, brakes and other components of the launching appliance shall be effective at design ambient temperature, their operability shall be confirmed by appropriate testing;

.5 drums with falls, sheaves, winches, winch brakes and other components of the equipment engaged in launching shall be provided with heating or other measures ensuring safe launching of survival craft and rescue boats at design ambient temperature shall be taken.

7.9.6 Group and personal survival kits.

7.9.6.1 In addition to the equipment listed in Section 6, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships, group and personal kits intended to support survival in the survival craft afloat as well as following abandoning ship to ice or to land shall be provided.

Personal survival kits (PSK) complying with the requirements of 7.9.6.2 shall be carried onboard the ship with a distinguishing mark **WINTERIZATION(DAT)** in the class notation whenever voyages are expected to encounter mean daily temperatures below 0 °C.

Group survival kits (GSK) complying with the requirements of 7.9.6.4 shall be carried onboard the ship with a distinguishing mark **WINTERIZATION(DAT)** in the class notation whenever voyages are expected to encounter ice conditions which may prevent the launching and operation of survival craft or a potential of abandonment onto ice or land is identified for conditions of voyages.

Sufficient number of group and personal survival kits (as applicable) shall be carried to cover at least 110 % of the rated complement of the ship.

7.9.6.2 A personal survival kit shall be stored so that it may be easily retrieved in an emergency situation (in cabins or in dedicated lockers near muster and embarkation stations).

A personal survival kit shall consist at least of the following items:

.1 clothing, that provides sufficient thermal insulation to maintain the body temperature and protection to prevent frostbite:

head protection – 1;

neck and face protection – 1;

hand protection – mitts – 1 pair;

hand protection – gloves – 1 pair, if they are not permanently attached to thermal protective aid;

foot protection – socks – 1 pair;

foot protection – boots – 1 pair;

.2 personal thermal protective aid complying with the requirements of 6.6, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships – 1;

.3 approved immersion suit – 1 (not required, if an immersion suit is provided for every person onboard in compliance with 4.2.3.2, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships);

.4 miscellaneous:

skin protection cream – 1 pack;

sunglasses – 1 pair;

whistle – 1;

drinking mug – 1;

pen knife – 1;

handbook (Arctic Survival) – 1;

carrying bag – 1.

Personal survival kits shall not be opened and used for training purposes and the following notice written in English or the language understood by the crew shall be displayed wherever they are stored:

"CREW MEMBERS AND PASSENGERS ARE REMINDED THAT THEIR PERSONAL SURVIVAL KIT IS FOR EMERGENCY SURVIVAL USE ONLY. NEVER REMOVE ITEMS OF SURVIVAL CLOTHING OR TOOLS FROM THE PERSONAL SURVIVAL KIT CARRYING BAG – YOUR LIFE MAY DEPEND ON IT".

7.9.6.3 In addition to the equipment listed in 7.9.6.2, it is recommended to include the following items in a personal survival kit:

thermal underwear – 1 set;

handwarmers for 240 h;

survival candle – 1;

matches – 2 boxes;

impact-heated thermosoles for boots – 1 pair;

thermotowels for local body warming – 1 pack;

disposable diapers – 1 pack.

7.9.6.4 Group survival kit shall be stored in containers so that they may be easily retrieved in emergency; in general, containers shall be located adjacent to survival craft and be stowed on cradles; containers shall be waterproof and floatable and be designed so that they may be easily lowered onto ice and moved over the ice or land.

A group survival kit shall consist of the following items:

.1 group equipment:

tents – 1 per 6 persons;

mattresses (air or foam material mattresses) – 1 per 2 persons;

sleeping bags – 1 per 2 persons;

stove – 1 per tent;

stove fuel – 0,5 1 per person;

matches – 2 boxes per tent;

flashlight – 1 per tent;

snow shovel – 1 per tent;

GSK container – 1;

.2 spare personal survival kit, complying with the requirements of 7.9.6.2, without immersion suit as specified in 7.9.6.2.3.

7.9.6.5 In addition to the equipment listed in 7.9.6.4, it is recommended to include the following items in a group survival kit:

fuel paste – 2 tubes per stove;

ware with lid for cooking on fire – 1 per tent;

fortified health drink – 5 packets per person;

candles and holders – 5 per tent;

snow saw – 1 per tent;

snow knife – 1 per tent;

tarpaulin – 1 per tent;

foot protection – boots – 1 pair per person.

7.9.6.6 It is recommended to provide air mattresses included in a group survival kit with a self-inflation system.

7.9.6.7 Where a shot gun or hunting rifle is provided to protect survivors from wildlife, it shall be stored in a secure location readily available in an emergency.

7.10 CARGO GEAR

7.10.1 Cargo handling gear.

7.10.1.1 Materials for manufacture of cargo handling gear elements shall meet the requirements of 3.1 of the Rules for the Cargo Handling Gear of Sea-Going Ships and the requirements of 7.12.1 — 7.12.6.

Design ambient temperature is assumed as design temperature of the structure.

7.10.1.2 When cargo-handling gear is equipped with operator's cabin it shall be provided with heating and fitted with window wiper.

Control panels of the cranes not fitted with cabins, as well as derricks, shall have heating or relevant shelter.

7.10.1.3 Necessary means for cold start of machinery of cargo handling gear at design ambient temperature shall be provided.

7.10.1.4 For hydraulic and electro-hydraulic cargo handling gear, heating of hydraulic liquid shall be provided.

7.10.1.5 Hydraulic liquids and lubricating oils shall be suitable for use at design ambient temperature.

7.10.1.6 The RS certificates issued for cargo handling gear to be installed onboard the ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** shall contain an indication whether it is allowed to use it at appropriate design ambient temperature.

7.10.2 Devices for cargo securing on open decks.

7.10.2.1 Materials of devices for securing cargo on open decks, including guides for fastening of deck containers shall meet the requirements of 7.12.1 — 7.12.4.

7.10.2.2 The RS certificates issued for devices for securing cargo on open decks intended for installation onboard the ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** shall contain an indication whether it is allowed to use them at appropriate design ambient temperature.

7.11 ELECTRICAL, RADIO AND NAVIGATIONAL EQUIPMENT

7.11.1 Installation of cables.

7.11.1.1 Cables to be installed on the open decks and in the open unheated spaces shall be tested at following temperatures:

.1 for ships with distinguishing marks **WINTERIZATION(–30)** at temperature of –40 °C and **WINTERIZATION(–40)** at temperature of –50 °C;

.2 for ships with distinguishing marks **WINTERIZATION(–50)** at the temperature of –60 °C;

.3 when design ambient temperature is below –50 °C the testing temperature shall be 10 °C lower than the design ambient temperature.

7.11.1.2 Cable intended for installation on open decks shall have indications in the RS Certificate/Type Approval Certificate whether it is allowed to use it at appropriate temperatures.

7.11.1.3 Materials for manufacture of cable fastening parts (hangers, cable boxes, pipes) and cable sealing shall meet the requirements of 7.12.1 — 7.12.4.

7.11.1.4 Means shall be provided to protect cable installed on open decks from mechanical damage at manual ice removal.

7.11.2 Equipment.

7.11.2.1 All electric motors, switchboards and control panels provided on the open decks and in the open unheated spaces shall be equipped with the means of anticondensation heating.

7.11.2.2 All electrical equipment intended for installation on the open decks and in the open unheated spaces shall be tested for cold endurance according to 10.5.4.2, Part IV "Technical Supervision during Manufacture of Products" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships at the temperature in the chamber being 10 °C lower than the design ambient temperature or at the temperature of –40 °C (whichever is lower).

The RS certificates issued for electrical equipment to be installed on the open decks and in the open unheated spaces of ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** shall contain an indication whether it is allowed to use it at appropriate design ambient temperature.

7.11.2.3 All radio equipment intended for installation on the open decks and in the open unheated spaces shall be tested for cold endurance according to the requirements specified in 8.4 of IEC 60945:2002 at the working temperature in the chamber being 10 °C lower than the design ambient temperature.

The RS certificates issued for radio equipment to be installed on the open decks and in the open unheated spaces of ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** shall contain an indication whether it is allowed to use it at appropriate design ambient temperature.

7.11.2.4 All navigational equipment intended for installation on the open decks and in the open unheated spaces shall be tested for cold endurance according to the requirements specified in 8.4 of IEC 60945:2002 at the working temperature in the chamber being 10 °C lower than the design ambient temperature.

The RS certificates issued for navigational equipment to be installed on the open decks and in the open unheated spaces of ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** shall contain an indication whether it is allowed to use it at appropriate design ambient temperature.

7.11.2.5 The list of navigational equipment onboard the ships with a distinguishing mark **WINTERIZATION(DAT)** in the class notation shall meet the requirements of 2.2.3, Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships in respect of additional requirements for the icebreakers, ships of ice classes **Arc4** — **Arc9**, as well as ships of all polar classes.

7.11.3 Lighting and signal means.

7.11.3.1 Ships shall be equipped with at least two suitable searchlights which shall be controllable from conning positions.

7.11.3.2 Searchlights specified in 7.11.3.1 shall be installed to provide, as far as is practicable, all-round illumination suitable for mooring, astern manoeuvres and emergency towing.

7.11.3.3 Searchlights specified in 7.11.3.1 shall be designed so as to prevent icing or shall be provided with heating.

7.11.4 Electrical heating appliances.

7.11.4.1 Electrical heating fed from emergency sources of electrical power shall be provided for the following ship spaces:

.1 wheelhouse;
.2 radioroom (if any);
.3 main machinery control room;
.4 cargo control room;
.5 fire extinguishing station;
.6 one of public spaces (for instance, messroom);
.7 hospital;
.8 engineering workshop.

7.11.4.2 Heating appliances capacity fitted in the above spaces shall provide positive temperature in these spaces at design ambient temperature.

7.11.4.3 Emergency sources of electrical power shall ensure supply of the above heating appliances during the time period stated in 9.3.1, Part XI "Electrical Equipment".

7.11.4.4 Battery compartments shall be heated in compliance with the requirements of 13.3, Part XI "Electrical Equipment". Heating appliances, where fitted, shall be fed from emergency source of electrical power. Thus, it is allowed to perform heating, when power is supplied only from the emergency source of electrical power, by any means in compliance with the international and national standards for explosive atmosphere.

7.12 MATERIALS

7.12.1 Materials used for hull structures and ship machinery items subject to the technical supervision of the Register in accordance with the relevant Parts of the Rules shall comply with the requirements of Part XIII "Materials" and with the Register approved standards and/or with the Register agreed specifications.

7.12.2 Steel plates and sections for hull structural members intended for prolonged exposure to low service temperatures shall be selected in accordance with 1.2.3, Part II "Hull" with due regard to the adopted value of design ambient temperature. Proceeding from the selected strength level and service conditions, the requirements for steel are specified in 3.2, 3.5, 3.13, 3.14 and 3.17 of Part XIII "Materials".

If the hull structural steel rolled products selected for hull structural members exceed 50 mm in thickness or if design service temperature of hull structural members is below –50 °C, the use of hull structural steel marked with index "Arc" is recommended.

Steel for machinery and equipment foundations installed on the open decks, in open and enclosed unheated spaces shall comply with the requirements of 1.2.3.1, Part II "Hull" for structural members of category I.

The design temperature of structure shall be assumed according to 7.2.

7.12.3 Welded and seamless steel structural tubes shall comply with the requirements of 3.4, Part XIII "Materials".

The material of pipes for systems shall be selected proceeding from their purpose, with regard to their operating temperature and the requirements of Table 2.1-4, Part IX "Materials and Welding" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk for the minimum design temperature of –55 °C.

7.12.4 The material of steel forgings and castings for the components of ship equipment, machinery and fittings installed on the open decks and in the open unheated spaces of ships shall comply with the requirements of 3.7 or 3.8, Part XIII "Materials" accordingly, or with the Register approved standards and/or Register agreed specifications.

The material shall be selected proceeding from the purpose of the forgings and castings, and with regard to their operating temperature and the requirements of 3.5, Part XIII "Materials".

7.12.5 Grey iron and ductile cast iron of ferritic structure is not permitted for the manufacture of components of ship equipment, machinery and fittings installed on the open decks and in the open unheated spaces of ships with a distinguishing mark **WINTERIZATION(DAT)** in the class notation.

7.12.6 Plastics, gasket and seal materials, as well as materials of organic origin used for ship equipment, machinery and fittings and for systems installed on open the decks and in the open unheated spaces of ships shall comply with the applicable requirements of Section 6, Part XIII "Materials", with the Register approved standards and/or with the Register agreed specifications. In addition, a documentary confirmation of the above materials reliability at design temperature or test reports issued by the laboratories recognized by the Register, another classification society (ACS) or authorized state authorities shall be submitted.

7.12.6.1 The underwater hull and sides of at least 1,0 m above the upper boundary of the ice strake shall have an ice resistant coating (unless clad steel is used for ice strake plating where the appropriate electrochemical protection is provided). The coating supply documentation shall be agreed between the shipowner, the shipyard and the coating manufacturer and shall be submitted to the Register for review.

When applying several layers of protective ice resistant coating for ice class ships and icebreakers, using of different colour for each layer is recommended.

7.12.6.2 The paint coatings of hull structures, machinery and equipment intended for prolonged exposure to low service temperature shall provide required resistance at the design temperature of the structure. The coating supply documentation shall be agreed between the

shipowner, the shipyard and the coating manufacturer and shall be submitted to the Register for review.

7.12.7 The use of anchor and mooring chain cables of category 1 is not permitted.

The material for anchor and mooring chain cables shall comply with the requirements of 3.6 and Section 7 of Part XIII "Materials", as well as with the Register approved standards and/or with the Register agreed specifications. The maximum impact test temperature is equal to –20 °C.

The results of steel test at operating temperature shall be submitted to the Register.

7.13 TESTS

7.13.1 Tests for cold endurance of materials and products prototypes specified in this Section are generally carried out by manufacturer (enterprise) or laboratories recognized by classification societies or authorized state authorities in accordance with the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships. Test results may apply to serial products provided the applied materials are identical. In particular cases, e.g. where a product cannot be testes due to its weight and size characteristics, such tests may be replaced by verification of materials and components conformity to the design temperatures. The possibility of such replacement shall be agreed with the Register at the stage of technical documentation and test program review.

7.14 RECORDS

7.14.1 As a result of applying the requirements of this Section, the following records shall be issued:

.1 Classification Certificate (forms 3.1.2 and 3.1.2P) with the distinguishing mark **WINTERIZATION(DAT)** in the class notation;

.2 Report on Survey of the Ship (form 6.3.10).

8 REQUIREMENTS FOR PROPULSION PLANT REDUNDANCY

8.1 SCOPE OF APPLICATION AND MARKS IN THE CLASS NOTATION

8.1.1 Compliance with the requirements of this Section is mandatory for the ships, which are assigned according to the requirements of 2.2.28, Part I "Classification" one of the following distinguishing marks added to the class notation:

.1 **RP-1** – when the propulsion plant provides for the redundancy of its components, except the main engine, reduction gear, shafting and propeller; at that a single failure in any component of systems and equipment serving the said components shall not lead to the loss of propulsion, power and ship's steering;

.2 **RP-1A** – when the propulsion plant provides for the redundancy of its components, except the main engine, reduction gear, shafting and propeller; at that a single failure in any component of the propulsion plant, its auxiliary machinery and systems shall not lead to the loss of propulsion and ship's steering;

.3 **RP-1AS** – when the propulsion plant provides for the redundancy of its components, as required for **RP-1A**, and at that the main engines or the engines of the alternative propulsion plant are located in independent machinery spaces in such a way that the loss of one compartment due to fire or flooding shall not lead to the loss of propulsion, power and ship's steering;

.4 **RP-2** – when the propulsion plant provides for the redundancy of its components and consists of several propulsion plants; at that a single failure in any component of the propulsion plant and steering gear shall not lead to the loss of propulsion, power and ship's steering;

.5 **RP-2S** – when the propulsion plant provides for the redundancy of its components, as required for **RP-2** and is located in two independent machinery spaces in such a way that the loss of one compartment due to fire or flooding shall not lead to the loss of propulsion, power and ship's steering.

8.1.2 Distinguishing marks **RP-1**, **RP-1A**, **RP-1AS**, **RP-2** or **RP-2S** may be assigned to the ships under construction and in service.

8.2 DEFINITIONS AND EXPLANATIONS

8.2.1 The alternative propulsion plant means the totality of machinery, systems and arrangements producing thrust for the ship's motion in emergency conditions in case of a failure of the main propulsion plant. A standby emergency engine, electric motor or shaft generator applied as a propulsion motors, may be used as the alternative propulsion plant. Total capacity of the alternative propulsion plant shall be at least one eighth of the total capacity of the main propulsion plant.

Auxiliary machinery and systems of the propulsion plant mean all the support systems (fuel system, lubricating oil system, cooling system, compressed air system, hydraulic system, etc.) required for normal operation of the propulsion machinery and propeller.

Main propulsion plant means the totality of machinery, systems and arrangements producing thrust for the ship's motion and comprising propulsion machinery of approximately equal capacity, auxiliary machinery and supporting systems, propellers, as well as all necessary monitoring, control and alarm systems. When the main propulsion plant consists of several engines, each of propulsion engines is considered the main one. When each propulsion plant in two-shaft or more propulsion plant is fully independent, every plant is considered as the main propulsion plant.

Marine power plant means the totality of machinery, systems and arrangements that provides the ship with all types of energy and may consists of the following components: main propulsion plant, alternative propulsion plant, electrical power plant, auxiliary machinery.

Power of the propulsion plant means the total power of the propulsion machinery installed onboard the ship. Unless otherwise stated, the capacity of the propulsion plant shall not include the capacity produced by the propulsion machinery but used under normal operating conditions for other purpose than the ship's propulsion (e.g., power of the shaft generator).

Propulsion device/propeller means the machinery (propeller, azimuth thruster, water jet propellers, etc.) converting mechanical energy of the propulsion machinery into thrust for the ship's motion.

Propulsion machinery means the machinery (diesel, turbine, electric motor, etc.) producing mechanical energy for the propeller drive.

Redundancy of the propulsion plant means single or repeated duplication of its components when the propulsion plant is arranged in such a way that a single failure of one of its active or passive components does not lead to the loss of propulsion and ship's steering under the external conditions specified in the Rules.

Single failure in the propulsion plant means a failure either in an active component (main engine, generator, their local control system, remotely controlled valve, etc.) or in a passive component (pipeline, power cable, manually controlled valve, etc.) not leading to failures of other components.

8.3 TECHNICAL DOCUMENTATION

8.3.1 To assign the distinguishing marks **RP-1**, **RP-1A**, **RP-1AS**, **RP-2** or **RP-2S** added to the class notation of the ship, the following documentation shall be submitted to the Register for approval (where applicable):

.1 calculation results demonstrating that a single failure does not lead to the loss of propulsion and ship's steering according to 8.5.3 (for ships with the distinguishing marks **RP-1A**, **RP-1AS**, **RP-2** or **RP-2S**). As an alternative, the results of the model or full-scale tests may be submitted;

.2 qualitative failure analysis for propulsion and steering (in compliance with Section 11, Part VII "Machinery Installations") or Failure Mode and Effect Analysis (FMEA) of the propulsion plant components based on the failure tree or the equivalent risk analysis agreed with the Register;

.3 torsional vibration calculations in compliance with 3.2.7.5.11, Part I "Classification"; at that the possibility of long-term operation of the alternative propulsion plant shall be considered separately.

8.3.2 The program of mooring and sea trials of the ship shall contain verification of the ship compliance with the requirements of this Chapter.

8.4 REQUIREMENTS FOR SHIPS WITH DISTINGUISHING MARK RP-1 IN THE CLASS NOTATION

8.4.1 All the components comprising the following auxiliary machinery and systems of the main propulsion plant shall be subject to redundancy:

.1 fuel oil system, including settling tanks, except the fuel oil filling, transfer and separation system;

.2 lubricating oil system of the propulsion machinery, reduction gear, shafting bearings, sterntube bearings, etc., except the oil filling, transfer and separation system;

.3 hydraulic systems providing operation of the propulsion unit couplings, controllable pitch propellers, reverse deflectors of water jet propellers, etc.;

.4 sea water and fresh water cooling systems serving the main propulsion plant;

.5 fuel heating systems in storage tanks serving the main propulsion plant;

.6 starting systems (air, electrical, hydraulic) serving the propulsion plant;

.7 electrical power sources;

.8 ventilation plants, where necessary, for example supplying air for cooling of primary movers;

.9 monitoring, alarm and control systems.

8.4.2 A single failure in the auxiliary pumps and components of the systems indicated in 8.4.1, including damage of fixed piping, shall not lead to the loss of propulsion and ship's steering. To meet this requirement, the necessary by-pass piping and redundancy of equipment (pumps, heaters, etc.) shall be provided in the systems. In case of a single failure, reduction of the main engine output may be allowed but not exceeding 50 %.

8.4.3 Provision shall be made for disconnection of the sections of systems and piping where a failure occurred from the properly functioning sections.

8.4.4 The ship shall be provided with the main and auxiliary steering gears in compliance with 2.9 of Part III "Equipment, Arrangement and Outfit". Control of the main and auxiliary steering gears shall be independent and provided both on the navigation bridge and in the steering gear compartment.

8.5 REQUIREMENTS FOR SHIPS WITH DISTINGUISHING MARK RP-1A IN THE CLASS NOTATION

8.5.1 In addition to the requirements of 8.4, the ships with distinguishing mark **RP-1A** in the class notation shall meet the requirements of 8.5.

8.5.2 The main propulsion plant shall consist of two or more propulsion machinery, at that one reduction gear, one propulsion electric motor, one shaftline and one propeller are allowed. One of the propulsion machinery may be the alternative propulsion plant. Therewith, for independent systems serving the redundant machinery, there is no need to comply with the requirements of 8.4.2 regarding the redundancy of each component of the system.

8.5.3 In case of a single failure in the main propulsion plant, the existing propulsion machinery or the alternative propulsion plant shall provide the following under any conditions of ship's loading:

.1 ship's motion at a speed of 6 knots or 50 % of the specified speed of ship according to 1.1.3, Part II "Hull", whichever is less, at a sea state 5 as per Beaufort scale;

.2 ship's steering sufficient for obtaining the safe position as regard to stability and maintenance of this position at a sea state 8 as per Beaufort scale;

.3 compliance with the requirements of 8.5.3.1 and 8.5.3.2 for at least 72 h; for ships the maximum duration of which voyage is less than 72 h, the above time may be restricted by the maximum duration of the voyage.

8.5.4 The alternative propulsion plant shall be put into operation not later than in 5 min after a failure in the main propulsion plant.

8.5.5 A single failure leading to the loss of one or more generators may be accepted, provided the Failure Mode and Effect Analysis (FMEA) demonstrates that after a failure sufficient power is produced to provide the ship's propulsion and steering in compliance with the requirements of 8.5.3 without the standby generator putting into operation.

After a failure the electrical power shall be sufficient to start the heaviest consumer without the electrical load imbalance.

At that the standby electrical pumps may not be considered for the electrical load balance while operating the alternative propulsion plant.

8.5.6 The main switchboard shall consist of two sections. In case of a failure in one section, the remaining one shall be capable to supply power to the following consumers:

.1 drives of the alternative propulsion plant and steering gears, including the hinged equipment;

.2 equipment for transmitting propulsive thrust;

.3 propulsion electrical motor, where available;

.4 propeller;

.5 auxiliary machinery and propulsion plant systems;

.6 monitoring, alarm and control systems.

8.5.7 Monitoring, alarm and control systems of the alternative propulsion plant shall be independent of the systems of the main propulsion plant.

8.6 REQUIREMENTS FOR SHIPS WITH DISTINGUISHING MARK RP-1AS IN THE CLASS NOTATION

8.6.1 In addition to the requirements of 8.5, the ships with distinguishing mark **RP-1AS** in the class notation shall meet the requirements of 8.6.

8.6.2 The main propulsion plant shall be fitted with at least two main engines located, at least, in two independent engine rooms according to 8.6.3 and 8.6.4. Non-redundant components of the main propulsion plant (reduction gear, propeller, shaftline, propulsion electric motor) common for several main engines shall be located in an independent space separated from the engine rooms with the main engines by a watertight bulkhead of "A-0" class fire integrity according to 2.7.1.2, Part II "Hull".

8.6.3 The bulkhead separating the engine rooms indicated in 8.6.2 shall be watertight bulkhead of "A-60" class fire integrity according to 2.7.1.2, Part II "Hull".

When the engine rooms are separated by cofferdams, tanks or other compartments, the bulkheads shall be at least of "A-0" class fire integrity but not lower than required for the adjacent spaces and compartments in Section 2, Part VI "Fire Protection".

8.6.4 When the closures are provided in the bulkheads indicated in 8.6.2 and 8.6.3, they shall meet the requirements of 7.12, Part III "Equipment, Arrangements and Outfit". These closures may not be considered as the emergency exits of the engine rooms.

8.7 REQUIREMENTS FOR SHIPS WITH DISTINGUISHING MARK RP-2 IN THE CLASS NOTATION

8.7.1 In addition to the requirements of 8.4 and applicable requirements of 8.5, the ship shall meet the requirements of 8.7.

8.7.2 The ship shall be fitted with at least two independent main propulsion plants.

In case of a single failure in one propulsion plant, at least 50 % of the ship propulsion power shall remain available and provide propulsion and ship's steering under any loading conditions.

8.7.3 In case of a single failure in one propulsion plant, the following requirements shall be met:

.1 a failure shall not affect the remaining propulsion plant, if it was operative at the moment of a failure (in particular, the drive power and speed shall not be significantly modified);

.2 the remaining propulsion plant, if not operative at the moment of a failure, shall be kept in hot standby in order to be ready for operation within 45 s after a failure;

.3 safety measures shall be provided for the failed propulsion plant, in particular, interlocking of shafting.

8.7.4 The ship shall be fitted with at least two independent steering gears according to 2.9, Part III "Equipment, Arrangements and Outfit". At that at a single failure of one steering gear, the remaining gear shall remain operative, as well as in case of a failure in the synchronizing system.

The ship's steering shall be provided under the conditions indicated in 8.5.3 even in case when one of the rudders is blocked at the maximum hard-over angle, at that the possibility shall be provided of the rudder shifting to the position parallel to the ship centreline and fixing the rudder in this position.

8.7.5 When only the azimuth thrusters are provided as propellers and devices for the ship control, at least two independently operated propulsion plants shall be provided.

The ship's steering shall be provided under conditions indicated in 8.5.3 even in case when one of the azimuth thrusters is blocked or disconnected, at that the possibility shall be provided of the thruster shifting to the position parallel to the ship centreline and fixing the thruster in this position.

8.8 REQUIREMENTS FOR SHIPS WITH DISTINGUISHING MARK RP-2S IN THE CLASS NOTATION

8.8.1 In addition to the requirements of 8.4, applicable requirements of 8.5 and the requirements of 8.7, the ship shall meet the requirements of 8.8.

8.8.2 The ship shall be fitted with at least two independent propulsion plants (including reduction gear, propeller and shafting) according to 8.7.2 and 8.7.3 and located, as a minimum, in two independent engine rooms.

8.8.3 The longitudinal bulkhead separating the engine rooms indicated in 8.8.2 shall be watertight bulkhead of "A-60" class fire integrity according to 2.7.1.2, Part II "Hull".

When the machinery rooms are separated by the cofferdams, tanks or other compartments, the bulkheads shall be at least of "A-0" class fire integrity but not lower than required for the adjacent spaces and compartments in Section 2, Part VI "Fire Protection".

8.8.4 When closures are provided in the longitudinal bulkhead indicated in 8.8.2, they shall meet the requirements of 7.12, Part III "Equipment, Arrangements and Outfit".

These closures may not be considered as the emergency exits of the machinery rooms.

8.8.5 The ship shall be fitted with at least two independent steering gears in compliance with 8.7.4 located, as a minimum, in two independent steering gear compartments.

8.8.6 The longitudinal bulkhead separating the steering gear compartments shall be watertight bulkhead of at least "A-0" class fire integrity according to 2.7.1.2, Part II "Hull".

8.8.7 The main sources of electrical power shall be located in separate compartments according to 8.8.3 and 8.8.4 that in case of fire or flooding in one compartment, power supply to the consumers indicated in 8.5.6 shall be provided.

8.8.8 The main switchboard shall be divided in two sections according to 8.5.6.

Each section shall be located in a separate compartment. The bulkhead separating the main switchboard compartments shall comply with the requirements of 8.8.3 and 8.8.4.

8.8.9 Automation, monitoring and control systems of the propulsion plants and steering gears shall be located in such a way that the loss of one engine rooms due to fire or flooding may lead to the loss of one propulsion plant or one steering gear only.

Control stations shall be arranged in such a way that in case of fire or flooding in one machinery space or one steering gear compartment the control functions shall be provided.

9 REQUIREMENTS FOR SHIPS EQUIPPED FOR USING GASES OR LOW-FLASHPOINT FUELS

9.1 GENERAL

9.1.1 Application.

The requirements of this Section apply to ships using gases or other low-flashpoint fuels. In addition to these requirements, the ship shall comply with requirements of the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code).

If the ship is an LNG gas carrier and uses cargo as fuel, it shall comply with requirements of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) and the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk.

If a gas carrier use as fuels gas other than liquefied natural gas (LNG) or other low flashpoint fuels as fuel, the present requirements and the requirements of the IGF Code shall be complied with in addition to the IGC Code requirements.

In addition to sea-going ships, the requirements of this Section apply to other offshore installations subject to the RS technical supervision, oil-and-gas production units and other offshore installations. The relevant national requirements applicable to these installations shall be taken into account additionally to the present requirements.

9.1.2 Class notation.

Ships fitted for the use of gas fuel in compliance with this Section are assigned a distinguishing mark **GFS** (Gas Fuelled Ship) added to the character of classification.

9.1.3 Terms and definitions.

In addition to the below mentioned, the definitions specified in 1.2, Part I "Classification" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk are applicable to the requirements of this Section.

Non-hazardous atmosphere means air environment where gas concentration is lower than the level corresponding to activating an alarm on high gas concentration in the air.

Bunkering means transfer of liquid or gaseous fuel from land based or floating facilities to ships' fixed tanks or connection of transported tanks to the fuel supply system.

Dual fuel engine means a heat engine so designed that both gas and fuel oil may be used as fuel, simultaneously or separately.

Gas means a fluid having a vapour pressure exceeding 0,28 MPa absolute at a temperature of 37,8 °C.

Gas-safe machinery space means closed gas-safe space with gas fuel consumers, explosion safety of which is ensured by installation of gas-containing equipment in gastight enclosures (piping, ducting, partitions) for gas fuel bleed-off, and the inner space of partitions and ducting shall be considered gas-dangerous.

Gas-safe space means a space other than a gas-dangerous space.

Gas area means an area where gas-containing systems and equipment are located, including the weather deck spaces above them.

Gas fuel means any hydrocarbon fuel having at the temperature of 37,8 °C the absolute pressure of saturated vapours according to Reid equal to 0,28 MPa and above.

Gas-dangerous machinery space means enclosed gas-dangerous space with gas fuel consumers, explosion safety of which in case of gas fuel leakage is ensured by emergency shutdown (ESD) of all machinery and equipment which may be an ignition source.

Gas-dangerous space means a space in the gas area which is not equipped with approved device to ensure that its atmosphere is at all times maintained in a gas-safe condition. It is subdivided into explosion hazardous zones 0, 1, 2 the boundaries of which are specified in 9.9.2.

Gas-containing systems mean systems intended for storage, feed, supply and discharge of gas to ship consumers.

Master gas fuel valve means an automatic valve installed at gas supply pipeline to each engine located outside machinery space where the equipment for gas fuel combustion is used.

Fuel oil means liquid hydrocarbon petroleum-derived fuel which complies with the requirements specified in 1.1.2, Part VII "Machinery Installations".

Enclosed space means any space inside of which, in the absence of mechanical ventilation, natural ventilation is restricted in such a way that any explosive atmosphere is not subject to natural dispersion.

Open space means a space open from one or several sides in all parts of which effective natural ventilation is arranged via permanently open openings in the side partitions and in the above located deck.

Semi-enclosed space means a space restricted by decks and bulkheads where natural ventilation is available but its efficiency sufficiently differs from normal at the weather deck.

Tank connection space means a space surrounding all tank connections and tank valves that is required for tanks with such connections in enclosed spaces.

Gas fuel storage room means a room where gas fuel storage tanks are located.

Fuel preparation room means any space containing pumps, compressors or vaporizers for fuel preparation purposes.

Gas consumer means any ship equipment using gas as a fuel.

Gas engine means an engine capable of operating only on gas, and not able to switch over to operation on any other type of fuel.

Multi-fuel engine means an engine capable of using two or more different fuels that are separate from each other.

Fuel storage tank means a tank designed as an initial gas fuel tank for storage on board the ship in liquid or compressed gaseous form.

CNG tank means compressed gas fuel storage tank.

LNG tank means liquefied gas fuel storage tank.

A, B and C type tanks mean independent fuel storage tanks complying with the requirements for A, B and C type independent tanks specified in the IGF Code.

Fuel containment system means the arrangement for the storage of fuel including tank connection spaces. The fuel containment system includes a primary and, where fitted, a secondary barriers, associated insulation and any intervening spaces, and adjacent structures, if necessary for the support of these elements. If the secondary barrier is part of the hull structure, it may be a boundary of the fuel storage hold space. The spaces around the fuel tank are defined as follows:

.1 fuel storage hold space means a space enclosed by the ship's structures in which a fuel containment system is situated. If tank connection spaces are located in the fuel storage hold space, it will also be a tank connection space;

.2 interbarrier space means the space between a primary and a secondary barrier, whether or not completely or partially occupied by insulation or other material; and

.3 fuel storage tank connection space means a space surrounding all fuel storage tank connections and tank valves that are required for such tanks in enclosed spaces.

Filling limit (FL) means the maximum liquid volume in a fuel tank relative to the total tank volume when the liquid fuel has reached the reference temperature.

Reference temperature means the temperature corresponding to the vapour pressure of the fuel in a fuel tank at the set pressure of the pressure relief valves (PRVs).

Vapour pressure means the equilibrium pressure of the saturated vapour above the liquid, in MPa, absolute at a specified temperature.

Secondary barrier means the liquid-resisting outer element of a fuel containment system designed to afford temporary containment of any envisaged leakage of liquid fuel through the primary barrier and to prevent the lowering of the temperature of the ship's structure to an unsafe level.

Source of release means a point or location from which a gas, vapour, mist or liquid may be released into the atmosphere so that an explosive atmosphere could be formed.

IGF Code means the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels.

9.1.4 Technical documentation.

In addition to the technical documentation specified in Section 3, Part I "Classification", the following technical data and ship documents confirming fulfillment of the Rules shall be submitted to the Register:

.1 drawings of fuel tanks arrangement with their distances from side plating and the bottom specified;

.2 drawings of supports and other structures to ensure fastening and limiting shifting of fuel tanks;

.3 calculations of heat emission from the flame which may occur during the fire affecting gas fuel tanks and other equipment and spaces related to gas fuel;

.4 drawings and diagrams of systems and piping for gas fuel specifying such assemblies as compensators, flange joints, stop and control valves and fittings, drawings of quick-closing arrangements of the gas fuel system, diagrams of gas fuel preparation, heating and pressure control, calculations of stresses in piping containing gas fuel at a temperature below –110 °C;

.5 drawings of safety and vacuum safety valves of fuel storage tanks;

.6 drawings and descriptions of all systems and arrangements for the measurement of fuel amount and characteristics, and for gas detection;

.7 diagrams of gas fuel pressure and temperature control and regulating systems;

.8 drawings and calculations of bilge and ballast systems in gas-hazardous spaces;

.9 diagrams and calculations of gas-dangerous spaces ventilation;

.10 diagrams and calculations of gas-freeing system;

.11 circuit diagrams of electric drives and control systems for fuel preparation plants, ventilation of hazardous spaces and airlocks;

.12 circuit diagrams of electric measurement and alarm systems for equipment related to the use of gas fuel;

.13 general arrangement drawings of electrical equipment related to the use of gas fuel;

.14 drawings of cable laying in hazardous spaces and areas;

.15 drawings of earthing for electrical equipment, cables, piping located in gas-dangerous spaces;

.16 technical background of electrical equipment fitness;

.17 ship general arrangement drawings specifying the layout of the following:

gas fuel storage tanks and any openings in them;

spaces for fuel storage and preparation and any openings to them;

doors, hatches and any other openings into hazardous spaces and areas;

venting pipes and air inlet and outlet locations of a ventilation system of hazardous spaces and areas;

doors, scuttles, companions, ventilation duct outlets locations and other openings in spaces adjacent to hazardous area;

.18 data on the properties of gas fuel intended for the use on board the ship;

.19 analysis of risks related to the use and storage of gas fuel and possible consequences of its leakages according to IACS Recommendations No. 146[1].

The analysis shall consider the risks of damage of hull structural members and failure of any equipment after accident related to the use of gas fuel. The results of risk analysis shall be taken into account in the operating manual;

.20 regarding the LNG tanks, the technical documentation shall be submitted in the extent required for approval of a cargo tank for carrying LNG in compliance with the requirements of the IGF Code.

Regarding the CNG tanks, the technical documentation shall be submitted in the extent required for approval of a cargo tank for carrying CNG on board the gas carrier in compliance with the Rules for the Classification and Construction of CNG Gas Carriers.

When the standard cylinders are used, the calculation of permissible pressure shall be submitted.

[1] Refer to Supplement to rules and guidelines of Russian Maritime Register of Shipping "IACS Procedural Requirements, Unified Requirements, Unified Interpretations and Recommendations" (published in electronic format as a separate edition).

9.2 GENERAL REQUIREMENTS FOR SHIP STRUCTURE

9.2.1 All dimensions of hull structure elements, except those specially mentioned in this Chapter, shall be determined in accordance with the requirements of the Rules for the Classification and Construction of Sea-going Ships depending on purpose and structural type of the ship.

9.2.2 Onboard location of fuel storage tanks.

9.2.2.1 Fuel storage tanks both in liquefied (LNG) and compressed (CNG) condition may be located directly on the open deck of the ship or in special enclosed spaces in the ship's hull. In the enclosed spaces, liquefied gas fuel shall be stored at the pressure not exceeding 1 MPa.

Where a fuel storage tank is located on the weather deck or in a special enclosure designed as a semi-enclosed space, provision shall be made for sufficient natural ventilation to prevent accumulation of escaped gas.

Membranes ensuring a seal between a deck and fuel storage tank shall be provided where the fuel storage tank gets through the upper weather deck. Therewith, the space located below the membranes may be considered as an enclosed gas-dangerous space, and the space above the membranes may be considered as an open space.

Gas fuel storage tanks shall not be installed under the survival craft except for the liferafts in compliance with 4.1.1.4, Part II "Live-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships.

9.2.2.2 Fuel storage tanks shall be protected against mechanical damage.

When fuel is carried in a fuel containment system requiring a complete or partial secondary barrier:

.1 fuel storage hold spaces shall be segregated from the sea by a double bottom/inner bottom; and

.2 ship shall have longitudinal bulkheads forming side tanks.

9.2.2.3 The fuel storage tanks shall be protected from external damage caused by collision or grounding in the following way:

.1 fuel tanks shall be located at a minimum distance of $B/5$ or 11,5 m, whichever is less, measured inboard from the ship side at right angles to the centreline at the level of the summer load line draught.

where B = the greatest moulded breadth of the ship at the summer load line draught) (refer to SOLAS regulation II-1/2.8).

As an alternative, the calculation method specified in 5.3.4 of the IGF Code may be used to determine the acceptable location of fuel tanks;

.2 boundaries of each fuel tank shall be taken as the extreme outer longitudinal, transverse and vertical limits of the tank structure including its valves;

.3 for independent tanks the protective distance shall be measured to the tank shell (the primary barrier of the tank containment system). For membrane tanks, such distance shall be measured to the bulkheads surrounding the tank insulation;

.4 in no case shall the boundary of the fuel tank be located closer to the shell plating or aft terminal of the ship than as follows:

.4.1 for passenger ships: *B*/10 but in no case less than 0,8 m. However, this distance shall not be greater than *B*/15 or 2 m, whichever is less, where the shell plating is located inboard for *B*/5 or 11,5 m, whichever is less, as specified in 9.2.3.1;

.4.2 for cargo ships:

.4.2.1 for $V_c \leq 1000$ m^3 – 0,8 m;

.4.2.2 for 1000 m^3 $< V_c <$ 5000 m^3 – 0,75 + $V_c \times 0{,}2/4000$ m;

.4.2.3 for 5000 m$^3 \leq V_c <$ 30000 m^3 – 0,8 + V_c/25000 m; and

.4.2.4 for $V_c \geq$ 30000 m^3 – 2 m

where V_c corresponds to 100 % of the gross design volume of the individual fuel storage tank at 20 °C, including domes and appendages;

.5 the lowermost boundary of the fuel storage tank shall be located above the minimum distance of $B/15$ or 2,0 m, whichever is less, measured from the moulded line of the bottom shell plating at the centreline;

.6 for multi-hull ships, the value *B* may be specially considered;

.7 fuel storage tanks shall be located abaft a transverse plane at $0{,}08L$ measured from the forward perpendicular in accordance with SOLAS regulation II-1/8.1 for passenger ships, and abaft the collision bulkhead for cargo ships

where L = length as defined in the International Convention on Load Lines (refer to SOLAS regulation II-1/2.5).

9.2.3 Drip trays.

9.2.3.1 Drip trays for spilled liquefied gas shall be fitted where liquefied gas leakage may occur which can cause damage to the ship structure or where limitation of the area, which is effected from a spill, is necessary.

Drip trays for collection of leaks are necessary in the following cases:

.1 when the tank is located on the open deck, drip trays shall be provided to protect the deck from leakages from tank connections and other sources of leakage;

.2 when the tank is located below the open deck but the tank connections are on the open deck, drip trays shall be provided to protect the deck from leakages from tank connections and other sources of leakage;

.3 when the tank and the tank connections are located below the deck, all tank connections shall be located in a tank connection space. Drip trays in this case are not required.

9.2.3.2 Drip trays shall be made of suitable material.

9.2.3.3 The drip tray shall be thermally insulated from the ship's structure so that the surrounding hull or deck structures are not exposed to unacceptable cooling, in case of leakage of liquid fuel.

9.2.3.4 Each drip tray shall be fitted with a drain valve to enable rain water to be discharged overboard.

9.2.3.5 Each drip tray shall have sufficient capacity to ensure that the maximum amount of spill according to the risk assessment can be handled.

9.2.4 Machinery spaces.

9.2.4.1 In order to minimize the probability of gas explosion in a machinery space containing gas-fuelled machinery one of the following two alternatives of machinery space arrangement may be applied:

.1 gas-safe machinery spaces: arrangements in machinery spaces are such that the spaces are considered gas safe under all conditions, normal as well as unplanned conditions, i.e. inherently gas safe.

In a gas-safe machinery space a single failure cannot lead to release of fuel gas into the machinery space;

.2 ESD protected machinery spaces: arrangements in machinery spaces are such that the spaces are considered non-hazardous under normal conditions, but under certain abnormal conditions may have the potential to become hazardous. In the event of abnormal conditions involving gas hazards, emergency shutdown (ESD) of non-safe equipment (ignition sources) and machinery shall be automatically executed while equipment or machinery in use or active during these conditions shall be of a certified safe type and have relevant certificates.

In an ESD protected machinery space, a single failure resulting in gas release into the space is allowable provided that the gas is removed by venting.

Failures leading to dangerous gas concentrations, e.g. gas pipe or gasket ruptures are covered by explosion pressure relief devices and ESD arrangements.

9.2.4.2 Requirements for gas-safe machinery spaces.

.1 single failure within the fuel system shall not lead to gas release into the machinery space;

.2 all gas piping within machinery space boundaries shall be enclosed in a gas tight enclosure.

9.2.4.3 Requirements for ESD protected machinery spaces.

.1 ESD protection shall be limited to machinery spaces that are intended for periodically unmanned operation.

.2 measures shall be applied to protect against explosion and damage of areas outside the machinery space and ensure redundancy of power supply. At least the following measures and arrangements shall be provided:

gas detector;

shut-off valve;

redundancy;

efficient ventilation.

9.2.4.4 Gas supply piping without a gastight external enclosure within machinery spaces may be accepted under the following conditions:

.1 engines for generating propulsion power and electric power shall be located in two or more machinery spaces not having any common boundaries unless it can be documented that a single failure will not affect both spaces;

.2 gas machinery space shall contain only a minimum of such necessary equipment, components and systems as are required to ensure that the gas machinery maintains its function;

.3 fixed gas detection system arranged to automatically shutdown the gas supply, and disconnect all electrical equipment or installations not of a certified safe type, shall be fitted.

9.2.4.5 Distribution of engines between the different machinery spaces shall be such that shutdown of fuel supply to any one machinery space does not lead to an unacceptable loss of power.

9.2.4.6 ESD protected machinery spaces separated by a single adjacent bulkhead shall have sufficient strength to withstand the effects of local gas explosion in either space, without affecting the integrity of the adjacent space and equipment within that space.

9.2.4.7 ESD protected machinery spaces shall have a geometrical shape that will minimize the accumulation of gases or formation of gas pockets.

9.2.4.8 The ventilation system of ESD protected machinery spaces shall be arranged in accordance with 9.7.

9.2.4.9 Requirements for location and protection of fuel piping:

.1 fuel piping shall not be located less than 800 mm from the ship's side;

.2 fuel piping shall not pass directly through accommodation spaces, service spaces, electrical equipment rooms or control stations;

.3 fuel piping passing through ro-ro cargo spaces, special category spaces and on weather decks shall be protected against mechanical damage.

.4 gas fuel piping in ESD protected machinery spaces shall be located, as far as practicable, from the electrical installations and tanks containing flammable liquids.

9.2.4.10 Gas fuel piping in ESD protected machinery spaces shall be protected against mechanical damage.

9.2.4.11 Requirements for fuel preparation room design.

Fuel preparation rooms shall be located on the open deck or within an open space unless those rooms are arranged and fitted in accordance with the requirements for tank connection spaces.

In such case, regardless of the room location the following requirements shall be complied with:

.1 fuel preparation room, regardless of location, shall be arranged to safely contain cryogenic leakages;

.2 material of the boundaries of the fuel preparation room shall have a design temperature corresponding with the lowest temperature it can be subjected to in a probable maximum leakage scenario unless the structures forming the boundaries of the space, i.e. bulkheads and decks, are provided with suitable thermal protection;

.3 a fuel preparation room shall be arranged to prevent surrounding hull structure from being exposed to unacceptable cooling, in case of leakage of cryogenic liquids;

.4 a fuel preparation room shall be designed to withstand the maximum pressure build up during such a leakage. Alternatively, pressure relief venting to a safe location (mast) may be provided.

9.2.5 Requirements for bilge systems.

9.2.5.1 Bilge systems installed in areas where gas or other low-flashpoint fuels may be present shall be segregated from the bilge system of spaces where fuel cannot be present.

9.2.5.2 Where fuel is carried in a fuel containment system requiring a secondary barrier, suitable drainage arrangements for dealing with any leakage into the hold or insulation spaces through the adjacent ship structure shall be provided. The bilge system shall not lead to pumps in safe spaces. Means of detecting such leakages shall be provided.

9.2.5.3 The hold or interbarrier spaces of type A independent tanks for liquid gas shall be provided with a bilge system suitable for handling liquid fuel in the event of fuel tank leakage or rupture.

9.2.6 Requirements for arrangement of entrances and other openings in enclosed spaces.

9.2.6.1 Direct access shall not be permitted from a gas-safe area to a gas-dangerous area. Where such openings are necessary for operational reasons, an airlock, which complies with 9.2.7, shall be provided.

9.2.6.2 If a fuel preparation room is approved to be located below deck, the room shall, as far as practicable, have an independent access directly from the open deck. Where a separate access from deck is not practicable, an airlock, which complies with the requirements of 9.2.7, shall be provided.

9.2.6.3 Unless access to the tank connection space is independent and directly from the open deck, it shall be arranged as a bolted hatch. The space containing the bolted hatch is a hazardous space.

9.2.6.4 If access to an ESD protected machinery space is from another enclosed space of the ship, the entrances shall be arranged with an airlock, which complies with the requirements of 9.2.7.

9.2.6.5 For inerted spaces, access arrangements shall be such that unintended entry by personnel shall be prevented. If access to such spaces is not from the open deck, sealing arrangements shall prevent leakages of inert gas to adjacent spaces.

9.2.7 Requirements for airlocks.

9.2.7.1 An airlock is a space enclosed by gastight bulkheads with two substantially gastight doors spaced at least 1,5 m and not more than 2,5 m apart. Unless subject to the requirements of the International Convention on Load Lines, the door coaming shall not be less than 300 mm in height. The doors shall be self-closing without any holding back arrangements.

9.2.7.2 Airlocks shall be mechanically ventilated at overpressure relative to the adjacent hazardous area or space.

9.2.7.3 The airlock shall be designed in a way that no gas can be released to safe spaces in case of the most critical event in the gas-dangerous space separated by the airlock. The events shall be evaluated in the risk analysis according to 9.1.4.19.

9.2.7.4 Airlocks shall have a simple geometrical form. They shall provide free and easy passage, and shall have a deck area not less than 1,5 m^2. Airlocks shall not be used for other purposes, e.g. as store rooms.

9.2.7.5 An audible and visual alarm system to give a warning on both sides of the airlock shall be provided to indicate if more than one door is moved from the closed position.

9.2.7.6 For gas-safe spaces with access from hazardous spaces below deck where the access is protected by an airlock, upon loss of underpressure in the hazardous space access to the space shall be restricted until the ventilation is reinstated. Audible and visual alarms shall be given at a manned location to indicate both loss of pressure and opening of the airlock doors when pressure is lost.

9.2.7.7 Essential equipment required for safety shall not be de-energized and shall be of a certified safe type. This may include lighting, fire detection, public address and general alarms systems.

9.3 DESIGN OF GAS FUEL TANKS

9.3.1 General requirements for gas fuel storage.

9.3.1.1 Natural gas in a liquid state may be stored with a maximum allowable relief valve setting (MARVS) of up to 1,0 MPa.

9.3.1.2 The maximum allowable working pressure (MAWP) of the gas fuel tank shall not exceed 90 % of the maximum allowable relief valve setting (MARVS).

9.3.1.3 A fuel containment system located below deck shall be gastight towards adjacent spaces.

9.3.1.4 All tank connections, fittings, flanges and tank valves shall be enclosed in gastight tank connection spaces, unless the tank connections are on the open deck. The space shall be able to contain leakage from the tank without overpressure in case of leakage from the tank connections.

A tank connection space may be required also for tanks on open deck for ships where restriction of hazardous areas is safety critical. A tank connection space may also be necessary in order to provide environmental protection for essential safety equipment related to the gas fuel system (tank valves, safety valves and instrumentation). A tank connection space may also contain equipment such as vaporizers or heat exchangers. Such equipment is considered to only contain potential sources of release, but not sources of ignition. In such case, such a tank connection space shall not be considered as a fuel preparation room.

9.3.1.5 Pipe connections to the fuel storage tank shall be mounted above the highest liquid level in the tanks, except for fuel storage tanks of type C. Connections below the highest liquid level may, however, also be accepted for other tank types after special consideration.

9.3.1.6 Each gas fuel storage tank (LNG or CNG) shall be equipped with a remote operated isolation shutoff valve located at any piping connected to the tank or directly on the tank. A branch pipe between the tank and the isolation valve which release LNG in case of pipe failure shall have equivalent safety to the type C tank, with permissible stress not exceeding the least of values R_m/2,5 or R_e/1,2, where R_e is a minimum yield stress at room temperature, and R_m is a minimum tensile strength at room temperature.

9.3.1.7 The material of the structures of the tank connection space shall have a design temperature corresponding to the lowest temperature that can be subject to in a probable maximum leakage scenario. The tank connection space shall be designed to withstand the maximum pressure build up during such a leakage. Alternatively, pressure relief venting to a safe location (mast) may be provided.

9.3.1.8 The probable maximum leakage into the tank connection space shall be determined based on design calculations using the operating parameters of detection and shutdown systems.

9.3.1.9 If connected below the liquid level of the tank, piping shall be protected by a secondary barrier up to the first valve.

9.3.1.10 If LNG tanks are located on the open deck, steel structures shall be protected against potential leakages from tank connections and other sources of leakage by use of drip trays. The material shall have a design temperature corresponding to the temperature of fuel carried at atmospheric pressure. The normal operation pressure of tanks shall be taken into consideration for protecting the steel structures of the ship.

9.3.1.11 Means shall be provided to safely empty liquefied gas storage tanks.

9.3.1.12 It shall be possible to empty, purge and vent fuel storage tanks with fuel piping systems. Instructions for carrying out these procedures shall be available on board. Inerting shall be performed with inert gas prior to venting with dry air to avoid an explosion hazardous atmosphere in tanks and fuel pipelines. Requirements to the inerting system are specified in 9.9.

9.3.1.13 For single fuel (gas only) main engines at least two gas fuel storage tanks of approximately equal capacity shall be provided and they shall be located in separate spaces.

9.3.1.14 All fuel storage tanks shall be provided with a pressure relief system appropriate to the design of the fuel containment system and the fuel being carried. Fuel storage hold spaces, interbarrier spaces, tank connection spaces and tank cofferdams, which may be subject to pressures beyond their design capabilities, shall also be provided with a suitable pressure relief system. Pressure relief system shall be independent of the pressure control systems specified in 9.4.

9.3.2 Liquefied gas storage tanks (LNG tanks).

9.3.2.1 LNG tanks shall be designed in compliance with the requirements of Section 6.4 of the IGF Code and manufactured by the firms having a Recognition Certificate for Manufacturer.

9.3.2.2 All LNG tanks shall be fitted with safety valves in compliance with the requirements specified in 3.19.1, Part VI "Systems and Piping" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk.

9.3.2.3 The outlets of vent pipes from the pressure relief valves shall be located at least *B*/3 or 6 m, whichever is greater, above the weather deck and 6 m above the working area and forward and aft gangways. Gas outlet piping system shall be designed so that the outgoing gas shall be directed upwards and the possibility of water and snow ingress into the system shall be kept to minimum.

9.3.2.4 All gas outlets shall be located at a distance of at least 10 m from:

the nearest air inlet or openings in the accommodation and service spaces and control stations or from other gas-safe spaces;

outlets in the machinery space.

9.3.2.5 LNG tanks shall be provided with the pressure control system specified in 9.4.

9.3.3 Compressed gas storage tanks (CNG tanks).

9.3.3.1 CNG tanks shall be designed in compliance with the requirements of Part X "Boilers, Heat Exchangers and Pressure Vessels" or other applicable standards for design of gas storage pressure vessels agreed upon with the Administration. Standard cylinders, for which it is necessary to make calculation of permitted pressure, and specially designed pressure vessels may be used as CNG tanks.

9.3.3.2 Each compressed gas storage tank shall be equipped with safety valves with cracking pressure less than design pressure of the tank. Safety valves of CNG tanks located in the hull or on the open deck shall be connected with gas outlet pipes. The outlets of vent pipes from the pressure relief valves shall comply with requirements specified in 9.3.2.3 and 9.3.2.4.

9.3.3.3 Adequate means shall be provided to depressurize the tank in case of fire, which can affect the tank.

9.3.3.4 Storage of CNG in enclosed spaces is generally not acceptable, but may be permitted provided the following is fulfilled in addition to 9.3.1.4 and 9.3.1.6:

.1 adequate means are provided to depressurize and inert the tank in case of fire which can affect the tank;

.2 all surfaces within such enclosed spaces containing the CNG storage are provided with suitable thermal protection against any high-pressure gas leakages and resulting condensation unless the bulkheads are designed for the lowest temperature that can arise from gas expansion leakage; and

.3 a fixed fire-extinguishing system is installed in the enclosed spaces containing the CNG storage. In addition, special arrangements for extinguishing of jet-fires shall be provided.

9.3.3.5 CNG tanks shall be secured on the hull in a manner which will prevent their movement under static or dynamic loads. Tanks with supports shall be designed for a static angle of heel of 30°. The supports and fittings shall be designed with due regard to loads determined in accordance with 6.4.9.4 of the IGF Code.

9.3.4 Regulations for portable liquefied gas fuel tanks.

9.3.4.1 The design of the tank shall comply with the requirements of IGF Code for type C independent tanks. The tank support (container frame or truck chassis) shall be designed for the intended purpose.

9.3.4.2 Portable fuel tanks shall be located in dedicated areas fitted with:

.1 mechanical protection of the tanks depending on location and damage hazard during cargo operations;

.2 if located on open deck: spill protection and water spray and cooling systems; and

.3 if located in an enclosed space: the space shall be considered as a tank connection space.

9.3.4.3 Portable fuel tanks shall be secured to the deck when connected to the ship systems. The arrangement for supporting and fixing the tanks shall be designed for the maximum expected static and dynamic inclinations, as well as the maximum expected values of acceleration, taking into account the ship characteristics and the position of the tanks.

9.3.4.4 Consideration shall be given to the strength and the effect of the portable fuel tanks on the ship's stability.

9.3.4.5 Connections to the ship's fuel piping systems shall be made by means of approved flexible hoses or other suitable means designed to provide sufficient flexibility.

9.3.4.6 Arrangements shall be provided to limit the quantity of fuel spilled in case of inadvertent disconnection or rupture of the non-permanent connections.

9.3.4.7 The pressure relief system of portable tanks shall be connected to a fixed venting system.

9.3.4.8 Control and monitoring systems for portable fuel tanks shall be integrated in the ship's control and monitoring system. A safety system for portable fuel tanks shall be integrated in the ship's safety system (e.g. shutdown systems for tank valves, gas detection systems).

9.3.4.9 Safe access to tank connections for the purpose of inspection and maintenance shall be ensured.

9.4 STORED FUEL PRESSURE AND TEMPERATURE CONTROL SYSTEM

9.4.1 With the exception of liquefied gas fuel tanks designed to withstand the full gauge vapour pressure of the fuel under conditions of the upper ambient design temperature, liquefied gas fuel tanks' pressure and temperature shall be maintained at all times within their design range by one of the following methods:

.1 reliquefaction of vapours;

.2 thermal oxidation of vapours;

.3 pressure accumulation;

.4 liquefied gas fuel cooling.

The method chosen shall ensure maintaining tank pressure below the set pressure of the tank pressure relief valves for a period of 15 days assuming the full tank at normal service pressure and the ship in nonworking condition, i.e. only power for domestic load is generated.

9.4.2 The overall capacity of the system shall be such that it can control the pressure within the design conditions without venting to atmosphere. The system shall be sized in a sufficient way also in case of no or low consumption. Venting of fuel vapour for controlling the tank pressure is not acceptable except in emergencies.

LNG tanks' pressure and temperature shall be controlled and maintained within the design range at all times including after activation of the safety system required in 9.10.4.4 for a period of minimum 15 days. The activation of the safety system alone is not deemed as an emergency situation.

9.4.3 For worldwide service, the upper ambient design temperature shall be 32 °C for sea water and 45 °C for air. For service in particularly hot or cold zones, these design temperatures shall be increased or decreased as agreed upon with the Register.

9.4.4 The reliquefaction system shall be designed and calculated in one of the following ways:

.1 a direct system where evaporated fuel is compressed, condensed and returned to the fuel tanks;

.2 an indirect system where fuel or evaporated fuel is cooled or condensed by refrigerant without being compressed;

.3 a combined system where evaporated fuel is compressed and condensed in a fuel/refrigerant heat exchanger and returned to the fuel tanks; or

.4 if the reliquefaction system produces a waste stream containing methane during pressure control operations within the design conditions, these waste gases shall, as far as reasonably practicable, be disposed of without venting to atmosphere.

9.4.5 Thermal oxidation can be done by either consumption of the vapours according to the regulations for consumers specified in 9.4 or in a dedicated gas combustion unit (GCU). It shall be demonstrated that the capacity of the oxidation system is sufficient to consume the required quantity of vapours. In this regard, periods of slow steaming and no consumption from propulsion plant or other consumers of the ship shall be considered.

9.4.6 Refrigerants or auxiliary agents used for cooling of fuel shall be compatible with the fuel they may come in contact with (not causing any hazardous reaction or excessively corrosive products). In addition, when several refrigerants or agents are used, these shall be compatible with each other.

9.4.7 The redundancy of the system and its supporting auxiliary services shall be such that in case of a single failure (of mechanical non-static component or a component of the control system) the fuel tank pressure and temperature can be maintained by another system or service.

9.4.8 Heat exchangers that are necessary for maintaining the pressure and temperature of the fuel tanks within their design ranges shall have redundancy unless they have a capacity in excess of 25 % of the largest required capacity for pressure control and they can be repaired on board without external sources.

9.5 FUEL SYSTEM

9.5.1 General requirements for fuel pipelines.

9.5.1.1 Fuel pipes and all the other piping needed for a safe and reliable operation and maintenance shall be colour marked in accordance with EN ISO 14726:2008 or equivalent.

9.5.1.2 Where tanks or piping are separated from the ship's structure by thermal isolation, provision shall be made for electrically bonding to the ship's structure both the piping and the tanks. All gasketed pipe joints and hose connections shall be electrically bonded.

9.5.1.3 All pipelines or components which may be isolated in a liquid full condition shall be provided with relief valves.

9.5.1.4 Pipelines which may contain low temperature fuel shall be thermally insulated to an extent which will minimize condensation of moisture.

9.5.1.5 Wall thickness of pipes under internal pressure shall be at least equal to that determined by Formula (2.3.1), Part VII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships with regard to additional requirements specified in 2.2.1 — 2.2.4, Part VI "Systems and Piping" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk.

9.5.1.6 During manufacture of fuel system pipelines and selection of connections, requirements specified in 2.3 to 2.5, Part VI "Systems and Piping" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk shall be complied with.

9.5.2 Bunkering stations.

9.5.2.1 The bunkering station shall be located on open deck so that sufficient natural ventilation is provided. Closed or semi-enclosed bunkering stations shall be subject to special consideration within the risk assessment in accordance with IACS Recommendation No. 146.

The bunkering station shall not be installed near the survival craft except for the liferafts required in compliance with 4.1.1.4, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships.

The special consideration shall as a minimum include the following:

.1 segregation towards other areas on the ship;

.2 hazardous area plans for the ship;

.3 requirements for forced ventilation;

.4 requirements for leakage detection (e.g. gas detection and low temperature detection);

.5 safety actions related to leakage detection (e.g. gas detection and low temperature detection);

.6 access to bunkering station from non-hazardous areas through airlocks;

.7 monitoring of bunkering station by direct line of sight or by CCTV.

9.5.2.2 Connections and piping shall be so positioned and arranged that any damage to the fuel piping does not cause damage to the ship's fuel containment system resulting in an uncontrolled gas discharge.

9.5.2.3 Arrangements shall be made for safe management of any spilled fuel.

9.5.2.4 Suitable means shall be provided to relieve the pressure and remove liquid contents from pump suctions and bunker lines. Liquid shall be discharged to the LNG tanks or other suitable location.

9.5.2.5 The surrounding hull or deck structures shall not be exposed to unacceptable cooling in case of leakage of fuel.

9.5.2.6 For CNG bunkering stations, low temperature steel shielding shall be fitted to protect against low temperatures if the escape of cold jets impinging on surrounding hull structure is possible.

9.5.2.7 The bunkering manifold shall be designed to withstand the external loads during bunkering. The connections at the bunkering station shall be of dry-disconnect type equipped

with additional safety dry break-away coupling/self-sealing quick release. The couplings shall be of a standard type.

9.5.2.8 An arrangement for purging fuel bunkering lines with inert gas shall be provided.

9.5.2.9 The bunkering system shall be so arranged that no gas is discharged to the atmosphere during filling of storage tanks.

9.5.2.10 A manually operated stop valve and a remote operated shutdown valve in series, or a combined manually operated and remote valve shall be fitted in every bunkering line close to the connecting point. It shall be possible to operate the remote valve in the control location for bunkering operations and/or from another safe location.

9.5.2.11 Means shall be provided for draining any fuel from the bunkering pipes upon completion of operation.

9.5.2.12 Bunkering lines shall be arranged for inerting and gas freeing. When not engaged in bunkering, the bunkering pipes shall be free of gas, unless the consequences of not gas freeing is evaluated and approved.

9.5.2.13 In case bunkering lines are arranged with a cross-over it shall be ensured by suitable isolation arrangements that no fuel is transferred inadvertently to the ship side not in use for bunkering.

9.5.2.14 A ship-shore link (SSL) or an equivalent means for automatic and manual ESD communication to the bunkering source shall be fitted.

9.5.2.15 The actuation time (from the trigger of the alarm to full closure) of the remote operated valve required by 9.5.2.10 shall be adjusted and be not greater than:

$$3600U/BR\ s$$

where U = ullage volume at operating signal level, in m^3;
BR = maximum bunkering rate agreed between ship and shore facility, in m^3/h; or 5 s, whichever is the least.

The actuation time may be increased if the calculation demonstrates that it is required due to hydraulic impact hazard.

9.5.3 Requirements for redundancy of fuel supply systems.

9.5.3.1 For single fuel installations the fuel supply system shall be arranged with full redundancy and segregation all the way from the fuel tanks to the consumers so that a leakage in one system does not lead to an unacceptable loss of power.

9.5.3.2 For single fuel installations, the fuel storage shall be divided between two or more tanks. The tanks shall be located in separate compartments.

9.5.3.3 For type C tank only, one tank may be accepted if two completely separate tank connection spaces are provided for the one tank.

9.5.4 Safety of gas supply systems.

9.5.4.1 Fuel storage tank inlets and outlets shall be provided with valves located as close to the tank as possible. Valves required to be operated during normal operation and bunkering which are not readily accessible shall be remotely operated. Tank valves whether accessible or not shall be automatically operated when the safety system required in Table 9.10.4.4 is activated for automatic closure of the tank valve.

9.5.4.2 The main gas supply line to each gas consumer or set of consumers shall be equipped with a manually operated stop valve and an automatically operated master gas fuel valve coupled in series or a combined manually and automatically operated valve. The valves shall be situated in the part of the piping that is outside the machinery space containing gas consumers, and placed as near as possible to the installation for gas treatment, if fitted. The master gas fuel valve shall automatically cut off the gas supply to the machinery space with gas consuming engines when activated by the safety system required in Table 9.10.4.4.

9.5.4.3 The automatic master gas fuel valve shall be operable from safe locations on escape routes inside a machinery space containing a gas consumer, the engine control room, if applicable; outside the machinery space, and from the navigation bridge.

9.5.4.4 Each gas consumer shall be provided with a double block and bleed valves arrangement. These valves shall be arranged as specified in 9.5.4.4.1 and 9.5.4.4.2 so that when the safety system required in Table 9.10.4.4 is activated this will cause the shut-off valves that are in series to close automatically and the bleed valve to open automatically and:

.1 two shut-off valves shall be in series in the gas fuel pipe to the gas consuming equipment. The bleed valve shall be in a pipe that vents to a safe location in the open air from that portion of the gas fuel piping that is between the two valves in series; or

.2 the functions of one of the shut-off valves in series and the bleed valve can be incorporated into one valve body, so arranged that the flow to the gas utilization unit will be blocked and the ventilation opened.

9.5.4.5 The two valves shall be of the fail-to-close type, while the bleed valve shall be fail-to-open.

9.5.4.6 The double block and bleed valves shall also be used for normal stop of the engine.

9.5.4.7 In cases where the master gas fuel valve is automatically shutdown, the complete gas supply branch downstream of the double block and bleed valve shall be automatically ventilated assuming possible reverse flow from the engine to the pipe.

9.5.4.8 There shall be one manually operated shutdown valve in the gas supply line to each engine upstream of the double block and bleed valves to assure safe isolation during maintenance of engines.

9.5.4.9 For single-engine installations and multi-engine installations, where a separate master valve is provided for each engine, the master gas fuel valve and the double block and bleed valve functions can be combined.

9.5.4.10 For each main gas supply line entering an ESD protected machinery space, and each gas supply line to high pressure installations means shall be provided for rapid detection of a rupture in the gas line in the machinery space. When rupture is detected a valve shall be automatically shut off, the shutdown shall be time delayed to prevent blockout due to abrupt load variations. This valve shall be located in the gas supply line before it enters the machinery space or as close as possible to the point of entry inside the machinery space. It can be a separate valve or combined with other functions, e.g. the master valve.

9.5.4.11 Fuel pipes passing through enclosed spaces outside the machinery spaces shall be protected by a secondary enclosure. This enclosure can be a ventilated duct or a double wall piping system. The duct or double wall piping system shall be mechanically ventilated with 30 air changes per hour, and gas detection as required in 9.10.4 shall be provided. This requirement may be omitted for fully welded fuel gas vent pipes passing through mechanically ventilated spaces.

9.5.5 Fuel supply in gas-safe machinery spaces.

9.5.5.1 Fuel piping in gas-safe machinery spaces shall be completely enclosed in external pipes or ducts fulfilling one of the following conditions:

.1 the gas piping shall be a double wall piping system with the gas fuel contained in the inner pipe. The space between the concentric pipes shall be pressurized with inert gas at a pressure greater than the gas fuel pressure. Suitable alarms shall be provided to indicate a loss of inert gas pressure between the pipes. When the inner pipe contains high pressure gas, the system shall be so arranged that the pipe between the master gas valve and the engine is automatically purged with inert gas when the master gas valve is closed; or

.2 the gas fuel piping shall be installed within a ventilated pipe or duct. The air space between the gas fuel piping and the wall of the outer pipe or duct shall be equipped with mechanical underpressure ventilation having a capacity of at least 30 air changes per hour. This ventilation capacity may be reduced to 10 air changes per hour provided automatic filling

of the duct with nitrogen upon detection of gas is arranged for. The fan motors shall comply with the required explosion protection in the installation area. The ventilation outlet shall be screened and placed in a position where there are no flammable sources.

9.5.5.2 Pipes other than fuel pipelines including cable protection pipes may be made with double walls or enclosed in the ducts specified in 9.5.5.1.1 provided that they are not a flammable source and do not affect the integrity of double-wall pipes or duct. Double-wall pipes or duct shall contain only pipes or cables required for operation of gas fuel supply installation and test devices.

9.5.5.3 The connecting of gas piping and ducting of internal combustion engines leading to the gas injection valves shall be completely covered by the ducting. The arrangement of ducting shall facilitate replacement and maintenance of injection valves and cylinder covers. The double ducting is also required for all gas pipes on the engine itself, until gas is injected into the chamber. If gas is supplied into the air inlet directly on each individual cylinder during air intake to the cylinder on a low pressure engine, such that a single failure will not lead to release of fuel gas into the machinery space, double ducting may be omitted on the air inlet pipes.

9.5.6 Gas fuel supply in ESD protected machinery spaces.

9.5.6.1 The pressure in the gas fuel supply system pipelines in ESD protected machinery spaces shall not exceed 1 MPa.

9.5.6.2 The gas fuel supply lines shall have a design pressure not less than 1 MPa.

9.5.7 Regulations for the design of ventilated duct, outer pipe against inner pipe gas leakage.

9.5.7.1 The design pressure of the outer pipe or duct of fuel systems shall not be less than the maximum working pressure of the inner pipe. Alternatively, for fuel piping systems with a working pressure greater than 1 MPa, the design pressure of the outer pipe or duct shall not be less than the maximum built-up pressure arising in the annular space considering the local instantaneous peak pressure in way of any rupture and the ventilation arrangements.

9.5.7.2 For high-pressure fuel piping, the design pressure of the ducting shall be taken as the higher of the following:

.1 the maximum built-up pressure: static pressure in way of the rupture resulting from the gas flowing in the annular space;

.2 local instantaneous peak pressure in way of the rupture: this pressure shall be taken as the critical pressure determined by the following formula:

$$p = p_0 \left(\frac{2}{k+1}\right)^{k/(k-1)} \qquad (9.5.7.2.2)$$

where p_0 = maximum working pressure of the inner pipe;
k = C_p/C_v – constant pressure specific heat divided by the constant volume specific heat;
k = 1,31 for CH_4.

The tangential membrane stress of a straight pipe shall not exceed the tensile strength divided by 1,5(R_m/1,5) when subjected to the above pressure. The pressure ratings of all other piping components shall reflect the same level of strength as straight pipes.

As an alternative to using the peak pressure in accordance with Formula (9.5.7.2.2), the peak pressure resulted from the tests conducted can be used.

9.5.7.3 Verification of the strength shall be based on calculations demonstrating the duct or pipe integrity. As an alternative to calculations, the strength can be verified by tests.

9.5.7.4 For low pressure fuel piping the duct shall be dimensioned for a design pressure not less than the maximum working pressure of the fuel pipe. The duct shall be pressure tested to show that it can withstand the expected maximum pressure at fuel pipe rupture.

9.5.8 Requirements for compressors and pumps.

9.5.8.1 If compressors or pumps are driven by shafting passing through a bulkhead or deck, the bulkhead penetration shall be of gastight type.

9.5.8.2 Compressors and pumps shall undergo special tests to ensure their suitability for use within a marine environment. The following, at least, shall be considered:

.1 environmental conditions;

.2 shipboard vibrations and accelerations;

.3 effects of pitch heave and roll motions;

.4 gas composition.

9.5.8.3 Arrangements shall be made to ensure that under no circumstances liquefied gas can be introduced in the gas control section or gas-fuelled machinery, unless the machinery is designed to operate with gas in liquid state.

9.5.8.4 Compressors and pumps shall be fitted with accessories and instrumentation necessary for efficient and reliable function.

9.6 GAS FUEL CONSUMERS ON BOARD SHIP

9.6.1 General requirements for internal combustion engines.

9.6.1.1 The exhaust gas system shall be equipped with explosion relief ventilation sufficiently dimensioned to prevent excessive explosion pressures in the event of ignition failure of one cylinder followed by ignition of the unburned gas in the system.

9.6.1.2 For engines where the space below the piston is in direct communication with the crankcase, a detailed evaluation regarding the hazard potential of fuel gas accumulation in the crankcase shall be carried out and reflected in the safety concept of the engine.

9.6.1.3 Each engine other than two-stroke cross-head type diesel engines shall be fitted with vent systems independent of other engines for crankcases and sumps.

9.6.1.4 Where gas can leak directly into the working media of auxiliary system (lubricating oil, cooling water), appropriate means shall be fitted after the engine outlet to extract gas in order to prevent gas dispersion. The gas extracted from the working media of auxiliary systems shall be vented to a safe location in the atmosphere.

9.6.1.5 For engines fitted with ignition systems, prior to admission of gas fuel, correct operation of the ignition system on each unit shall be verified.

9.6.1.6 A means shall be provided to monitor and detect poor combustion or misfiring. In the event that it is detected, gas operation may be allowed provided that the gas fuel supply to the concerned cylinder is shut off and provided that the operation of the engine with one cylinder cut-off is acceptable with respect to torsional vibrations.

9.6.1.7 For engines starting on fuels in accordance with 9.1.1, if combustion has not been detected by the engine monitoring system within an engine specific time after the opening of the fuel supply valve, the fuel supply valve shall be automatically shut off. Means to ensure that any unburnt fuel mixture is purged away from the exhaust system shall be provided.

9.6.1.8 Premixed engines using fuel gas mixed with air before turbocharger shall be located in ESD protected machinery spaces.

9.6.2 Requirements for dual fuel internal combustion engines.

9.6.2.1 In case of shutoff of the gas fuel supply, the engines shall be capable of continuous operation by oil fuel only, without interruption.

9.6.2.2 An automatic system shall be fitted to change over from gas fuel operation to oil fuel operation and vice versa with minimum deviations of the engine power from the mean value. Acceptable reliability shall be demonstrated through testing. In case of unstable operation on engines when gas firing, the engine shall automatically change to oil fuel mode. Manual activation of gas system shutdown shall always be possible.

9.6.2.3 In case of a normal stop or an emergency shutdown, the gas fuel supply shall be shut off not later than the ignition source. It shall not be possible to shut off the ignition source without first or simultaneously closing the gas supply to each cylinder or to the complete engine.

9.6.3 Requirements for gas-only engines.

9.6.3.1 In case of a normal stop or an emergency shutdown, the gas fuel supply shall be shut off not later than the ignition source. It shall not be possible to shut off the ignition source without first or simultaneously closing the gas supply to each cylinder or to the complete engine.

9.6.4 Requirements for multi-fuel engines

9.6.4.1 In case of shutoff of one fuel supply, the engines shall be capable of continuous operation by an alternative fuel with minimum deviations of the engine power.

9.6.4.2 An automatic system shall be fitted to change over from one fuel operation to an alternative fuel operation with minimum deviations of the engine power from the mean value. Acceptable reliability shall be demonstrated through testing. In the case of unstable operation

on an engine when using a particular fuel, the engine shall automatically change to an alternative fuel mode. Manual activation shall always be possible.

Table 9.6.4.2

	Gas only		Dual fuel	Multi fuel
Ignition medium	Spark	Pilot fuel	Pilot fuel	N/A
Main fuel	Gas	Gas	Gas and/or oil fuel	Gas and/or liquid

9.6.5 Requirements for main and auxiliary boilers.

9.6.5.1 Each boiler shall have a dedicated forced draught system. A crossover between boiler force draught systems may be fitted for emergency use providing that any relevant safety functions are maintained.

9.6.5.2 Combustion chambers and uptakes of boilers shall be designed to prevent any accumulation of gaseous fuel.

9.6.5.3 Burners shall be designed to maintain stable combustion after ignition under all operational conditions.

9.6.5.4 For main propulsion boilers an automatic system shall be provided to change from gas fuel operation to oil fuel operation without interruption of boiler firing.

9.6.5.5 Gas nozzles and the burner control system shall be configured such that gas fuel can only be ignited by an established oil fuel flame, unless the boiler and ignition system is designed and approved by the Administration to light on gas fuel.

9.6.5.6 There shall be arrangements to ensure that gas fuel flow to the burner is automatically cut off unless satisfactory ignition has been established and maintained.

9.6.5.7 On the fuel pipe of each gas burner a manually operated shut-off valve shall be fitted.

9.6.5.8 Provisions shall be made for automatically purging the gas supply piping to the burners by means of an inert gas after the extinguishing of these burners.

9.6.5.9 The automatic fuel changeover system in accordance with 9.6.5.4 shall be monitored with alarms to ensure continuous availability.

9.6.5.10 Arrangements shall be made that, in case of flame failure of all operating burners, the combustion chambers of the boilers are automatically purged before relighting.

9.6.5.11 Arrangements shall be made to enable the boilers purging sequence to be manually activated.

9.6.6 Requirements for gas turbines.

9.6.6.1 Unless designed with the strength to withstand the worst-case overpressure due to ignited gas leaks, pressure relief systems shall be suitably designed and fitted to the exhaust system, taking into consideration the explosions due to gas leaks. Pressure relief systems within the exhaust uptakes shall be lead to a safe location, away from personnel.

9.6.6.2 The gas turbine may be fitted in a gastight enclosure arranged in accordance with the ESD principle (refer to 9.2.4.3 and 9.5.6), however a pressure above 1 MPa in the gas supply piping may be accepted within this enclosure.

9.6.6.3 Gas detection systems and shutdown functions shall be as outlined for ESD protected machinery spaces.

9.6.6.4 Ventilation for the enclosure shall be as specified in 9.8 for ESD protected machinery spaces, but shall in addition be arranged with full redundancy (2 × 100 % capacity fans from different electrical circuits).

9.6.6.5 For other than single-fuel gas turbines, an automatic system shall be fitted to change over easily and quickly from gas fuel operation to oil fuel operation and vice-versa with minimum deviations of the engine power from the mean value.

9.6.6.6 Means shall be provided to monitor and detect poor combustion that may lead to unburnt fuel gas in the exhaust gas system during operation. In the event that it is detected, the fuel gas supply shall be shutdown.

9.6.6.7 Each turbine shall be fitted with an automatic shutdown device when maximum exhaust temperatures are exceeded.

9.7 FIRE PROTECTION

9.7.1 General.

9.7.1.1 Fire protection shall comply with the requirements of this Section of Part VI "Fire Protection" depending on the purpose of the ship.

9.7.2 Structural fire protection.

9.7.2.1 Any boundary of accommodation spaces, service spaces, control stations, escape routes, machinery spaces facing gas fuel storage tanks on the open deck, shall be shielded by A-60 class divisions. These A-60 class divisions shall extend up to the underside of the deck of the navigation bridge. Gas fuel storage tanks shall be segregated from cargo and arranged in accordance with the requirements of the International Maritime Dangerous Goods (IMDG) Code where these tanks are considered a class 2.1 package.

9.7.2.2 Fuel storage hold spaces and ventilation ducts serving these spaces shall be separated from accommodation, service, cargo and machinery spaces by class A-60 fire structures. They may be separated from other spaces with low fire risk by class A-0 fire structures. The space containing fuel containment system shall be separated from the machinery spaces of category A or other rooms with high fire risks. The separation shall be done by a cofferdam of at least 900 mm with insulation of A-60 class. When determining the insulation of the space containing fuel containment system from other spaces with lower fire risks, the fuel containment system shall be considered as a machinery space of category A. The boundary between spaces containing fuel containment systems shall be either a cofferdam of at least 900 mm or A-60 class division. For type C tanks, the fuel storage hold space may be considered as a cofferdam.

The following "other rooms with high fire risk" shall as a minimum be considered, but not be restricted to:

.1 cargo spaces except cargo tanks for liquids with flashpoint above 60 °C and except cargo spaces for general cargo apart from dangerous goods which may not be fitted with fixed fire extinguishing systems (in passenger ships engaged in short voyages, in passenger ships of less than 1000 gross tonnage, as well as in cargo ships of less than 2000 gross tonnage constructed or intended only for the carriage of ore, coal, grain, green timber, non-combustible cargoes and cargoes of minor fire risk – refer to Footnote 10 of Table 3.1.2.1, Part VI "Fire Protection");

.2 vehicle, ro-ro and special category spaces;

.3 service spaces (high risk) on passenger ships carrying up to 36 passengers, cargo and oil tankers: galleys, pantries containing cooking appliances, saunas, paint lockers and store-rooms having areas of 4 m^2 or more, spaces for the storage of flammable liquids and workshops other than those forming part of the machinery space (refer to 2.2.1.5 (*9*), 2.3.3 (*9*), 2.4.2 (*9*) of Part VI "Fire Protection");

.4 accommodation spaces of greater fire risk on passenger ships carrying more than 36 passengers: saunas, sale shops, barber shops and beauty parlours and public spaces containing furniture and furnishing of other than restricted fire risk and having deck area of 50 m^2 or more (refer to 2.2.1.3 (*8*) of Part VI "Fire Protection").

9.7.2.3 Gas pipes led through ro-ro spaces on open deck shall be provided with special guards to prevent vehicle collision damage.

9.7.2.4 Where more than one machinery space is arranged on board the ship, they shall be separated by class A-60 divisions.

9.7.2.5 Any space containing equipment for the fuel preparation such as pumps, compressors, heat exchangers, vaporizers and pressure vessels shall be regarded as a machinery space of category A and provided with a fixed fire-extinguishing system complying with the requirements of 3.1.2, Part VI "Fire Protection" taking into account necessary concentrations/application rate required for extinguishing gas fires.

9.7.2.6 The bunkering station shall be separated by class A-60 divisions towards machinery spaces of category A, accommodation spaces, control stations and high fire risk spaces, except for spaces such as tanks, voids, auxiliary machinery spaces of little or no fire risk, sanitary and other similar spaces where the insulation standard may be reduced to class A-0.

9.7.2.7 The gas fuel hold space shall not be used for machinery or equipment that may have a fire risk (refer also to 9.7.2.2).

9.7.2.8 If an ESD protected machinery spaces is separated by a single boundary, the boundary shall be of A-60 class division.

9.7.3 Water fire main system.

9.7.3.1 The water fire main system shall comply with the requirements of 3.2, Part VI "Fire Protection" with due regard to the purpose of the ship.

9.7.3.2 Where fire main pumps are used for the water spray system, the required pump capacity shall be determined for the case of both the water fire main system and the water spray system being in operation.

9.7.3.3 Where FST are located on open deck, the fire water mains shall be provided with a shut-off valve to isolate the damaged pipe section with the system remaining operable all the time.

9.7.4 Water spray system.

9.7.4.1 A water spray system shall be installed for cooling and fire prevention to cover exposed parts of FSTs located on open deck. The water spray system shall also provide coverage for exposed structures of superstructures, compressor rooms and pump rooms, cargo control rooms, bunkering stations and any other normally occupied spaces that face the FST on the open decks if the distance between them does not exceed 10 m.

9.7.4.2 The system shall be designed to cover all areas specified in 9.7.4.1 with an application rate as follows:

.1 10 l/min/ per 1 m^2 for horizontal surfaces;

.2 4 l/min/ per 1 m^2 for vertical surfaces.

9.7.4.3 Stop valves shall be fitted in the water spray application main supply line, at intervals not exceeding 40 m for the purpose of isolating damaged sections. Alternatively, the system may be divided into two or more sections that may be operated independently, provided the necessary controls are located together in a readily accessible position not likely to be inaccessible in case of fire in the areas protected.

9.7.4.4 Connection of the water fire main system to the water spray system shall be provided through a stop valve fitted on the exposed deck area in a safe position outside the bunkering station area.

9.7.4.5 Remote start of pumps supplying the water spray system and remote operation of valves shall be located in a readily accessible safe position which is not likely to be cut off in case of fire.

9.7.4.6 The nozzles of the water spray system shall be of a full bore type and ensure an effective distribution of water throughout the areas being protected.

9.7.5 Dry chemical powder fire-extinguishing system.

9.7.5.1 To protect the bunkering station area and cover all possible leak points a dry chemical powder system complying with the requirements of Part VI "Fire Protection" shall be provided. The capacity of the dry chemical powder fire-extinguishing system shall be at least 3,5 kg/s and the power capacity shall be sufficient for a minimum of 45 s discharges.

9.7.6 Fire detection and alarm system.

9.7.6.1 In gas fuel storage spaces and in ventilation ducts leading thereto, a fire detection system of an approved type shall be provided.

The system shall ensure clear identification of the activated detector and determine its location.

9.7.6.2 A smoke detection system cannot be considered as an efficient and quick-acting means of fire detection in accordance with 9.7.6.1, unless other fire detecting equipment is provided additionally.

9.7.7 Fire-fighting outfit.

9.7.7.1 Two portable dry chemical powder fire extinguishers, each of at least 5 kg capacity shall be provided, one of which shall be located in the vicinity of the bunkering station.

9.7.7.2 The machinery space where the gas fuel is heavier than air shall be provided with two dry chemical powder extinguishers of at least 5 kg capacity each, located at the entrance.

9.8 VENTILATION

9.8.1 General.

9.8.1.1 Any ducting used for the ventilation of hazardous spaces shall be separate from that used for the ventilation of non-hazardous spaces. The ventilation shall be operable at all temperatures and environmental conditions the ship will be operating in.

9.8.1.2 Electric motors for ventilation fans shall not be located in ventilation ducts for hazardous spaces unless the motors are certified for the same hazard zone as the space served.

9.8.1.3 Design of ventilation fans serving spaces containing gas sources shall comply with the following:

.1 ventilation fans shall not produce a source of vapour ignition in either the ventilated space or the ventilation system associated with the space. Ventilation fans and fan ducts, in way of fans only, shall be intrinsically safe defined as follows:

.1.1 for impellers or housings of non-metallic material, due regard being paid to the elimination of static electricity;

.1.2 impellers and housings of non-ferrous metals;

.1.3 impellers and housings of austenitic stainless steel;

.1.4 impellers of aluminum alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous materials is fitted in way of the impeller, due regard being paid to static electricity and corrosion between ring and housing; or

.1.5 any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm tip design clearance;

.2 under no circumstances shall the radial air gap between the impeller and the casing be less than 0,1 of the diameter of the impeller shaft in way of the bearing but not less than 2 mm. The gap need not be more than 13 mm;

.3 any combination of an aluminium or magnesium alloy fixed or rotating component and a ferrous fixed or rotating component, regardless of tip clearance, is considered a sparking hazard and shall not be used in hazardous areas.

9.8.1.4 Ventilation systems required to avoid any gas accumulation shall consist of independent fans, each of sufficient capacity, unless otherwise specified in these requirements.

9.8.1.5 Air inlets for hazardous enclosed spaces shall be taken from areas that, in the absence of the considered inlet, would be non-hazardous. Air inlets for non-hazardous enclosed spaces shall be taken from non-hazardous areas at least 1,5 m away from the boundaries of any hazardous area. Where the inlet duct passes through a more hazardous space, the duct shall be gastight and have overpressure relative to this space.

9.8.1.6 Air outlets from non-hazardous spaces shall be located outside hazardous areas.

9.8.1.7 Air outlets from hazardous enclosed spaces shall be located in an open area that, in the absence of the considered outlet, would be of the same or lesser hazard than the ventilated space.

9.8.1.8 The required capacity of the ventilation plant is normally based on the total volume of the room. An increase in required ventilation capacity may be necessary for rooms having a complicated form.

9.8.1.9 Non-hazardous spaces with entry openings to a hazardous area shall be arranged with an air lock and be maintained at overpressure relative to the external hazardous area. The overpressure ventilation shall be arranged according to the following:

.1 during initial start-up or after loss of overpressure ventilation, before energizing any electrical installations not certified safe for the space in the absence of pressurization, it shall be required to:

.1.1 proceed with purging (at least 5 air changes) or confirm by measurements that the space is non-hazardous; and

.1.2 pressurize the space;

.2 operation of the overpressure ventilation shall be monitored and in the event of failure of the overpressure ventilation the following shall be performed:

.2.1 an audible and visual alarm shall be given at a manned location; and

.2.2 if overpressure cannot be immediately restored, automatic or programmed disconnection of electrical installations shall be required.

9.8.1.10 Non-hazardous spaces with entry openings to a hazardous enclosed space shall be arranged with an air lock and the hazardous space shall be maintained at underpressure relative to the non-hazardous space. Operation of the exhaust ventilation in the hazardous space shall be monitored and in the event of failure of the exhaust ventilation the following shall be performed:

.1 an audible and visual alarm shall be given at a manned location; and

.2 if underpressure cannot be immediately restored, automatic or programmed disconnection of electrical installations according to a recognized standard shall be required at a non-hazardous area.

9.8.1.11 As acceptable measures to confirm the ventilation capacity required in 9.8.1.10.1 may be adopted means of the following or equivalent:

.1 monitoring of the ventilation electric motor or fan operation combined with underpressure indication; or

.2 monitoring of the ventilation electric motor or fan operation combined with ventilation flow indication; or

.3 monitoring of ventilation flow rate to indicate that the required air flow rate is established.

9.8.2 Requirements for ventilation of tank connection spaces.

9.8.2.1 The tank connection space shall be provided with an effective mechanical forced exhaust ventilation system. A ventilation capacity of at least 30 air changes per hour shall be provided. The rate of air changes may be reduced if other adequate means of explosion protection are installed. The equivalence of alternative installations shall be demonstrated by a risk assessment.

9.8.2.2 Approved automatic fail-safe fire dampers shall be fitted in the ventilation duct for the tank connection space.

9.8.3 Requirements for ventilation of machinery spaces.

9.8.3.1 The ventilation system for machinery spaces containing gas-fuelled consumers shall be independent of all other ventilation systems.

Spaces enclosed in the boundaries of machinery spaces (such as purifier's room, engine room workshops and store rooms) are considered an integral part of machinery spaces containing gas-fuelled consumers and, therefore, their ventilation system does not need to be independent of the one of machinery spaces.

9.8.3.2 ESD protected machinery spaces shall have ventilation with a capacity of at least 30 air changes per hour. The ventilation system shall ensure a good air circulation in all spaces, and in particular ensure that any formations of gas pockets in the room are detected. As an alternative, arrangements whereby under normal operation the machinery spaces are ventilated with at least 15 air changes per hour are acceptable provided that if gas is detected in the machinery space, the number of air changes will automatically be increased to 30 per hour.

9.8.3.3 For ESD protected machinery spaces the ventilation arrangements shall provide sufficient redundancy to ensure a high level of ventilation availability as defined in a standard agreed upon with the Register.

9.8.3.4 The number and power of the ventilation fans for ESD protected machinery spaces and for double pipe ventilation systems for gas-safe machinery spaces shall be such

that the capacity is not reduced by more than 50 % of the total ventilation capacity if a fan with a separate circuit from the main switchboard or emergency switchboard or a group of fans with common circuit from the main switchboard or emergency switchboard, is inoperable.

9.8.4 Requirements for ventilation of fuel preparation rooms.

9.8.4.1 Fuel preparation rooms shall be fitted with effective mechanical ventilation system of the underpressure type providing a ventilation capacity of at least 30 air changes per hour.

9.8.4.2 The number and power of the ventilation fans shall be such that the capacity is not reduced by more than 50 %, if a fan with a separate circuit from the main switchboard or emergency switchboard or a group of fans with common circuit from the main switchboard or emergency switchboard, is inoperable.

9.8.4.3 Ventilation systems for fuel preparation rooms shall be in operation when pumps or compressors are working.

9.8.5 Requirements for ventilation of bunkering stations.

Bunkering stations that are not located on the open deck shall be suitably ventilated to ensure that any vapour being released during bunkering operations will be removed outside. If the natural ventilation is not sufficient, mechanical ventilation shall be provided in accordance with the risk assessment as specified in 9.5.2.1.

9.8.6 Requirements for ventilation of ducts and double pipes.

9.8.6.1 Ducts and double pipes containing fuel piping shall be fitted with effective mechanical ventilation system of the extraction type providing a ventilation capacity of at least 30 air changes per hour. This requirement is not applicable to double pipes in the machinery space if the requirements of 9.5.5.1.1 are complied with.

9.8.6.2 The ventilation system for double piping and for gas valve unit spaces in gas-safe machinery spaces shall be independent of all other ventilation systems.

Double wall piping and gas valve unit spaces in gas safe engine-rooms are considered an integral part of the fuel supply systems and, therefore, their ventilation system does not need to be independent of other fuel supply ventilation systems provided such fuel supply systems contain only gaseous fuel.

9.8.6.3 The ventilation inlet for the double wall piping or duct shall always be located in a non-hazardous area away from ignition sources. The inlet opening shall be fitted with a suitable wire mesh guard and protected from ingress of water.

9.8.6.4 The capacity of the ventilation for a pipe duct or double pipes may be below 30 air changes per hour if a flow velocity of minimum 3 m/s is ensured. The flow velocity shall be calculated for the duct with fuel pipes and other components installed.

9.9 INERTING AND ATMOSPHERE CONTROL

9.9.1 Inerting of fuel tanks.

9.9.1.1 A piping system shall be arranged to enable each fuel tank to be safely gas-freed, and to be safely filled with fuel from a gas-free condition. The system shall be arranged to minimize the possibility of gas or air pockets remaining after changing the atmosphere.

9.9.1.2 The system shall be designed to eliminate the possibility of a flammable mixture existing in the fuel tank during any part of the atmosphere change operation by utilizing an inerting medium as an intermediate step.

9.9.1.3 Gas sampling points shall be provided for each fuel tank to monitor the progress of atmosphere change.

9.9.1.4 Inert gas utilized for gas freeing of fuel tanks may be provided externally to the ship.

9.9.2 Atmosphere control within fuel storage hold spaces (other than type C tanks).

9.9.2.1 Interbarrier and fuel storage hold spaces associated with liquefied gas fuel containment systems requiring full or partial secondary barriers shall be inerted with a suitable dried inert gas and kept inerted with make-up gas provided by a shipboard inert gas generation plant, or by shipboard storage, which shall be sufficient for normal consumption for at least 30 days.

9.9.2.2 The spaces referred to in 9.9.2.1 requiring only a partial secondary barrier may be filled with dry air provided that the ship maintains a stored charge of inert gas or is fitted with an inert gas generation plant sufficient to inert the largest of these spaces, and provided that the configuration of the spaces and the relevant vapour detection systems, together with the capability of the inerting arrangements, ensures that any leakage from the LNG tanks will be rapidly detected and inerting effected before a dangerous condition can develop.

Equipment to produce sufficient amount of suitable quality dry air shall be provided to satisfy the expected demand.

9.9.3 Environmental control of spaces surrounding type C tanks.

9.9.3.1 Spaces surrounding LNG tanks shall be filled with suitable dry air and be maintained in this condition with dry air provided by suitable air drying equipment. This requirement is only applicable for LNG tanks where condensation and icing due to cold surfaces is are possible.

9.9.4 Requirements for inerting.

9.9.4.1 Arrangements to prevent back-flow of fuel vapour into the inert gas system shall be provided. To prevent the return of flammable gas to any gas-safe spaces the inert gas supply line shall be fitted with two shutoff valves in series with a venting valve in between (double block and bleed valves). In addition, a closable non-return valve shall be installed between the double block and bleed arrangement and the fuel system. These valves shall be located outside gas-safe spaces.

9.9.4.2 Where the connections to the fuel piping systems are non-permanent, two non-return valves may be substituted for the valves specified in 9.9.4.1

9.9.4.3 The arrangements shall be such that each space being inerted can be isolated and the necessary controls and relief valves, etc. shall be provided for controlling pressure in these spaces.

9.9.4.4 Where insulation spaces are continually supplied with an inert gas as part of a leak detection system, means shall be provided to monitor the quantity of gas being supplied to individual areas and spaces.

9.9.5 Inert gas production and storage on board.

9.9.5.1 Inert gas generation plant shall be capable of producing inert gas with at no time greater than 5 % oxygen content by volume.

A continuous-reading oxygen content meter shall be provided at the inert gas generator output and shall be fitted with an alarm set at a maximum of 5 % oxygen content by volume.

9.9.5.2 An inert gas system shall be fitted with pressure controls and monitoring arrangements appropriate to the fuel containment system.

9.9.5.3 Where a nitrogen generator or nitrogen storage facilities are installed in a separate compartment outside the machinery space, this compartment shall be fitted with a mechanical extraction ventilation system with the capacity of at least 6 air changes per hour. A low oxygen alarm shall be fitted.

9.9.5.4 Inert gas pipelines shall only be laid through well ventilated spaces. Pipelines in enclosed spaces shall:

be fully welded;

have only a minimum of flange connections as needed for fitting of valves;

and be as short as possible.

9.10 MONITORING, CONTROL AND AUTOMATION SYSTEMS

9.10.1 General.

9.10.1.1 Monitoring, control and automation systems shall comply with the requirements of 2.4, Part XV "Automation".

9.10.2 Pressure, level and temperature monitoring.

9.10.2.1 Each gas fuel tank shall be provided with devices for remote monitoring from the bridge and local monitoring of fuel pressure and temperature. The devices shall be clearly marked with upper and lower range values of allowable working pressure. Provision shall be made for upper and lower pressure alarms in the tank (where vacuum protection is required by tank design) which shall be activated before safety valve operation.

9.10.2.2 The gas fuel inlet pipe shall be fitted with a device for pressure control between the inlet valve and shore connection.

9.10.2.3 On the gas fuel outlet piping following the pump and on the gas fuel inlet piping following the inlet valve shall be provided with a pressure control device.

9.10.2.4 In the drain well of LNG tank storage space, level indicators and temperature indicating devices shall be fitted. As a result of temperature sensor activation, the main gas valve of the tank shall be automatically closed. Upper level indicator shall activate an alarm.

The "level indicator" is understood as a device designed to indicate an alarm status only, e.g. a float switch installed in LNG tank storage space.

9.10.2.5 The LNG tanks shall be provided with level indicators as well as arrangements giving visual and audible lower liquid level signals and ensuring automatic shutdown of motors of fixed and submersible fuel pumps with subsequent visual and audible alarm. These signals shall be given at the navigation bridge, continuously manned central control station or onboard safety centre.

9.10.3 Overflow preventing of gas fuel tanks.

9.10.3.1 Storage tanks for liquefied gas shall not be filled to more than a volume equivalent to 98 % full at the reference temperature as defined in 9.1.3. A loading limit curve for actual fuel loading temperatures shall be prepared from the following formula:

$$LL = FL\ \rho_R/\rho_L$$

where LL = loading limit, in %, determined according to 9.1.3;
FL = filling limit, in %, the maximum level of liquid volume in a fuel tank relative to the total tank volume where the liquid fuel has reached the reference temperature, in such case, 98 %;
ρ_R = relative density of fuel at the reference temperature; and
ρ_L = relative density of fuel at the loading temperature.

9.10.3.2 In cases where the tank insulation and tank location make the probability very small for the tank contents to be heated up due to an external fire, special considerations may be made to allow a higher loading limit than calculated using the reference temperature, but never above 95 %. This also applies in cases where a second system for pressure maintenance is installed (refer to 9.4). However, if the pressure can only be maintained/controlled by fuel consumers, the loading limit as calculated in 9.10.3.1 shall be used.

9.10.3.3 The alternative loading limit option specified in 9.10.3.2 is understood to be an alternative to 9.10.3.1 and shall only be applicable when the calculated loading limit using the formulae in 9.10.3.1 gives a lower value than 95 %.

9.10.3.4 Each CNG tank shall be provided with means to prevent exceeding the design pressure when receiving fuel and signaling that 95 % of the design pressure has been reached.

9.10.4 Gas leaks control in spaces.

9.10.4.1 All enclosed gas-dangerous spaces shall be provided with effective gas detection systems in areas of its possible accumulation and leakage. The number of detectors to be

fitted in each space is subject to special consideration in each case with due regard to the size and configuration of the space. When the gas concentration equal to 20 % of the lower explosion limit is reached in the controlled space, visual and audible alarm is to be given on the bridge. In ventilation ducts containing gas-fuel pipes, the alarm shall be given when the concentration equal to 30 % of the lower explosion limit is reached. If the concentration equal to 40 % of the lower explosion limit is reached, measures (at least those stated in Table 9.10.4.4) to automatically shut down gas-fuel supply to the space shall be taken.

9.10.4.2 In the gas-dangerous machinery spaces, two independent systems are required to control gas supply to the machinery space.

9.10.4.3 In gas-safe machinery spaces at least two detectors of the gas supply control system shall be fitted to activate alarm at reaching 30 % of the lower explosion limit.

9.10.4.4 Where gas-fuel leakage is found and in case of system failure, the safety system shall automatically activate regulating functions stated in Table 9.10.4.4.

9.10.5 Ventilation capacity monitoring.

9.10.5.1 Any loss of the required ventilating capacity shall give an audible and visual alarm on the navigation bridge or in a continuously manned central control station or safety centre.

9.10.5.2 As acceptable means to monitor the ventilation system capacity the means specified in 9.8.1.11 may be adopted.

Table 9.10.4.4

Monitored parameter	Alarm	Automatic closure of master gas fuel valve[7]	Automatic shutdown of gas supply to consumers in machinery space	Notes
Gas detection in gas fuel tank storage room above 20 % LEL	×			
Gas detection by two detectors[1] in gas fuel tank storage room above 40 % LEL	×	×		
Fire detection in gas fuel tank storage room	×	×		
Bilge well high level in gas fuel tank storage room	×			
Bilge well low temperature in gas fuel tank storage room	×	×		
Gas detection in the duct between gas fuel tank and machinery space containing gas consumers above 20 % LEL	×			
Gas detection by two detectors[1] in the duct between gas fuel tank and machinery space containing gas consumers above 40 % LEL	×	×[2]	×[2]	
Gas detection in gas compressor room above 20 % LEL	×			
Gas detection by one of two detectors[1] in gas compressor room above 40 % LEL	×			
Gas detection in the duct inside machinery space containing gas consumers above 30 % LEL	×			If double pipes are provided for gas supply to consumers
Gas detection by two detectors[1] in a duct inside machinery space containing gas consumers above 40 % LEL	×		×[3]	If double pipes are provided for gas supply to consumers
Gas detection in machinery space containing gas consumers above 20 % LEL	×			Gas detectors are required for protection of gas-dangerous machinery spaces only
Gas detection by one of two detectors[1] in machinery space containing gas consumers above 40% LEL	×		×	Gas detectors are required only for protection of gas-dangerous machinery spaces containing gas consumers. The non-explosion proof equipment in the machinery spaces with gas consumers shall be also disconnected
Loss of ventilation in the duct between tank and machinery space containing gas consumers[6]	×		×[2,4]	
Loss of ventilation in the duct inside machinery space containing gas consumers[6]	×		×[3,4]	If double pipes are provided for gas supply to consumers
Loss of ventilation in machinery space containing gas consumers	×		×	For protection of gas-dangerous machinery spaces only
Fire detection in machinery space containing gas consumers	×		×	
Abnormal gas pressure in gas supply pipe	×		×[4]	
Failure in valve control system	×		×[5]	Time delay as found necessary
Automatic shutdown of engine (engine failure)	×		×[5]	
Emergency shutdown of engine (manually or by operator)	×		×	

[1] Two independent gas detectors located close to each other are required for redundancy reasons. If gas detectors are of self-monitoring type, the installation of a single gas detector is permitted.

[2] If the gas fuel tank is supplying gas to more than one consumer and different supply pipes are completely separated and fitted in separate ducts with an individual master valve fitted outside of the duct, only the master valve leading into the duct where gas or loss of ventilation is detected shall close.

[3] If the gas fuel is supplied to more than one consumer and different supply pipes are completely separated and fitted in separate ducts with an individual master valve fitted outside of the duct and machinery space, only the master valve leading into the duct where gas or loss of ventilation is detected shall close.

[4] This parameter shall not lead to shutdown of gas supply for single-fuel gas engines. Applicable for dual-fuel gas engines only.

[5] Only for the case of 3 valves activation, as specified in 9.5.4.4.

[6] If the duct is protected by inert gas (refer to 9.5.5.1.1), then loss of inert gas pressure shall lead to the same actions, as specified in this table.

[7] Valves specified in 9.5.4.1.

9.11 ELECTRICAL EQUIPMENT

9.11.1 General.

9.11.1.1 Electrical equipment shall comply with the requirements of Part VII "Electrical Equipment" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk. The hazardous zones shall be classified in accordance with 9.11.2.

9.11.2 Classification of hazardous zones, spaces and areas.

9.11.2.1 The classification of hazardous zones shall be in compliance with IEC 60079-10 and IEC 60092-502. If a dangerous space is not covered by 9.11.2, refer to the above standards.

9.11.2.2 Zone 0: the internal areas of gas fuel storage tanks, gas fuel pipelines, pipelines from safety valves of gas fuel storage tanks and any air pipelines from equipment containing gas.

9.11.2.3 Zone 1:

tank connection spaces, fuel storage hold spaces and interbarrier spaces;

fuel preparation rooms arranged with ventilation according to 9.8.4;

areas on open deck, or semi-enclosed spaces on deck, within 3 m of any fuel tank outlet, gas or vapour outlet, bunker manifold valve, other fuel valve, fuel pipe flange, fuel preparation room ventilation outlets and fuel tank openings for pressure release provided to permit the flow of small volumes of gas or vapour mixtures caused by thermal variation;

areas on open deck or semi-enclosed spaces on deck, within 1,5 m of fuel preparation room entrances, fuel preparation room ventilation inlets and other openings into zone 1 spaces;

areas on the open deck within spillage coamings surrounding gas bunker manifold valves and 3 m beyond these, up to a height of 2,4 m above the deck;

enclosed or semi-enclosed spaces in which pipes containing fuel are located, e.g. ducts around fuel pipes, semi-enclosed bunkering stations;

the ESD-protected machinery space is considered a non-hazardous area during normal operation, but will require equipment required to operate following detection of gas leakage to be certified as suitable for zone 1;

a space protected by an airlock is considered as non-hazardous area during normal operation, but will require equipment required to operate following loss of differential pressure between the protected space and the hazardous area to be certified as suitable for zone 1;

except for type C tanks, an area within 2,4 m of the outer surface of a fuel containment system where such surface is exposed to the weather.

N o t e s : 1. Fuel storage hold spaces containing type C tanks with all potential leakage sources in a tank connection space and having no access to any hazardous area, shall be considered non-hazardous.

2. Where the fuel storage hold spaces include potential leak sources, e.g. tank connections with pipelines and valves, they shall be considered hazardous zone 1.

3. Where the fuel storage hold spaces include bolted access to the tank connection space, they shall be considered hazardous zone 2.

9.11.2.4 Zone 2:

area within 1,5 m surrounding open or semi-enclosed spaces of zone 1;

space containing bolted hatch to tank connection space.

9.11.3 Electrical equipment required for ship's propulsion, power generation, manoeuvring, anchorage and mooring, emergency fire pumps shall not be located within spaces separated from hazardous zones by air locks or shall be of a certified safe type.

9.12 PERSONNEL PROTECTION

9.12.1 Where the equipment of the gas containing system is installed in enclosed spaces of the ship, provision shall be made for at least two sets of protective equipment each permitting personnel to enter and work in spaces filled with natural gas.

9.12.2 A set of protective equipment, specified in 9.12.1 shall include the following:

.1 one self-contained breathing apparatus not using stored oxygen with a capacity of at least 1200 l of free air;

.2 tight-fitting goggles, gloves, intrinsically safe protective clothing and boots;

.3 steel-cored rescue line with an intrinsically safe belt;

.4 explosion-proof lamp.

9.12.3 For breathing apparatuses mentioned in 9.12.2.1, fully charged air bottles with a total free air capacity of 3600 l for each breathing apparatus shall be provided.

9.12.4 Medicines and medical first-aid equipment shall be available on board for persons suffering from burns, frostbites (including cryogenic ones) as well as intoxication with natural gas or products of incomplete fuel burning.

9.12.5 The following operating documentation shall be available on board:

.1 gas fuel bunkering instructions;

.2 inerting and gas freeing instructions;

.3 instructions for using gas fuel;

.4 instructions describing the crew actions in emergencies which may arise during operations with gas fuel.

9.12.6 A plan of periodic audits and maintenance of equipment related to the use of gas as fuel shall be provided on board.

10 REQUIREMENTS FOR BALTIC ICE CLASS SHIPS

10.1 GENERAL

10.1.1 Requirements for the Baltic ice class ships comply with the requirements of the Finnish-Swedish Ice Class Rules, 2017 and apply to the ships operating in the Baltic Sea area in winter and water areas of other seas with similar ice conditions.

10.2 BALTIC ICE CLASSES

10.2.1 Ships complying with the requirements of this Section may be assigned to the Baltic ice classes as follows:

.1 ice class **IA Super**: ships with such structure, engine output and other properties that they are normally capable of navigating in difficult ice conditions without the assistance of icebreakers;

.2 ice class **IA**: ships with such structure, engine output and other properties that they are capable of navigating in difficult ice conditions, with the assistance of icebreakers when necessary;

.3 ice class **IB**: ships with such structure, engine output and other properties that they are capable of navigating in moderate ice conditions, with the assistance of icebreakers when necessary;

.4 ice class **IC**: ships with such structure, engine output and other properties that they are capable of navigating in light ice conditions, with the assistance of icebreakers when necessary;

.5 ice class **II**: ships that have a steel hull and that are structurally fit for navigation in the open sea and that, despite not being strengthened for navigation in ice, are capable of navigating in very light ice conditions with their own propulsion machinery;

.6 ice class **III**: ships that do not belong to the ice classes referred to in 10.2.1.1 — 10.2.1.5.

10.3 ICE CLASS DRAUGHT

10.3.1 Upper and lower ice waterlines.

10.3.1.1 The upper ice waterline (UIWL) is the envelope of the highest points of the waterlines at which the ship is intended to operate in ice. The line may be a broken line.

The lower ice waterline (LIWL) is the envelope of the lowest points of the waterlines at which the ship is intended to operate in ice. The line may be a broken line.

10.3.2 Maximum and minimum draught fore and aft.

10.3.2.1 The maximum and minimum ice class draughts at fore and aft perpendiculars shall be determined in accordance with UIWL and LIWL.

Restrictions on draughts when operating in ice shall be documented and kept on board readily available to the master. The maximum and minimum ice class draughts fore, amidships and aft shall be determined and indicated in Section "Other Characteristics" of a Classification Certificate. If the summer load line in fresh water is anywhere located at a higher level than UIWL, the ship's sides shall be provided with a warning triangle and with an ice class draught mark at the maximum permissible ice class draught amidships (refer to Appendix), which are also specified in the Classification Certificate.

The draught and trim, limited by the UIWL, shall not be exceeded when the ship is navigating in ice. The salinity of the sea water along the intended route shall be taken into account when loading the ship.

The ship shall always be loaded down at least to the LIWL when navigating in ice. Any ballast tank, situated above the LIWL and needed to load down the ship to this water line, shall be equipped with devices to prevent the water from freezing. In determining the LIWL, regard shall be paid to the need for ensuring a reasonable degree of ice-going capability in ballast. The propeller shall be fully submerged, if possible entirely below the ice. The forward draught shall be at least $(2 + 0{,}00025\Delta)h_0$ but need not exceed $4h_0$

where Δ = displacement of the ship, in t, on the maximum ice-class draught according to 10.3.1.1;
h_0 = level ice thickness, in m, according to 10.5.2.1.

10.4 ENGINE OUTPUT

10.4.1 Definitions and explanations.

10.4.1.1 The engine output P is the maximum output the propulsion machinery can continuously deliver to the propellers.

The dimensions of the ship and some other parameters are defined below (refer to Fig. 10.4.1.1):

L – length of the ship between the perpendiculars, in m;

L_{BOW} – length of the bow, in m;

L_{PAR} – length of the parallel midship body, in m;

B – breadth of the ship, in m;

T – draught of the ship, in m;

A_{wf} – area of the waterline of the bow, in m^2;

α – the angle of the waterline at *B*/4, in deg.;

j_1 – the rake of the stem at the centerline, in deg. φ_1 = 90° for a ship with a bulbous bow;

j_2 – the rake of the bow at *B*/4, in deg.;

ψ – flare angle calculated as $\psi = \arctan(\tan\varphi/\sin\alpha)$, in deg., using angles α and φ. For 10.4.3 flare angle is calculated using $\varphi = \varphi_2$;

D_p – diameter of the propeller, in m;

H_M – thickness of the brash ice in mid channel, in m;

H_F – thickness of the brash ice layer displaced by the bow, in m.

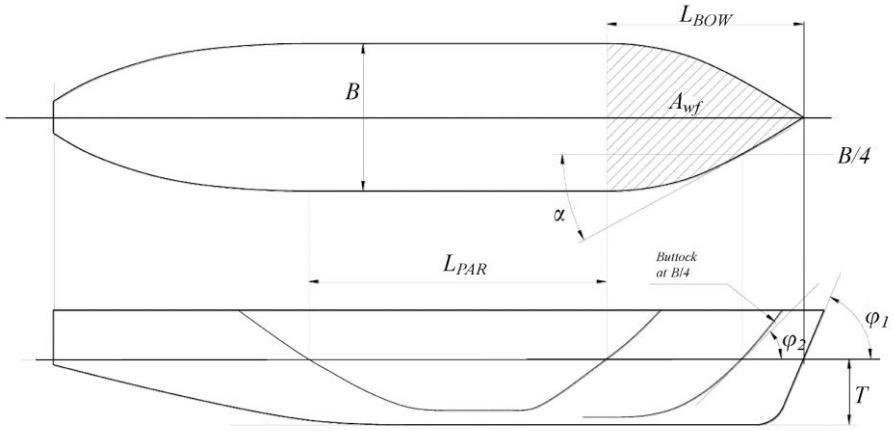


Fig. 10.4.1.1
Determination of the geometric quantities of the hull

10.4.2 The engine output shall not be less than that determined in 10.4.3.

Irrespective of the engine output determination by Formula (10.4.3-1), the engine output shall not be less than 1000 kW for ice classes **IA**, **IB** and **IC** and not less than 2800 kW for ice class **IA Super**.

10.4.3 The engine output requirement shall be calculated for two draughts. The engine output shall not be less than the greater of these two outputs.

In the calculations the ship's parameters specified in 10.4.1.1 which depend on the draught shall be determined at the appropriate draught, but L and B shall be determined only at the UIWL.

$$P = K_e \frac{(R_{CH}/1000)^{3/2}}{D_P}, \text{ in kW} \qquad (10.4.3\text{-}1)$$

where K_e = shall be taken according to Table 10.4.3;
R_{CH} = the ice resistance in Newton of the ship in a channel with brash ice and a consolidated surface layer, in N.

Table 10.4.3

Coefficient K_e for ships with conventional propulsion systems

Number of propellers	CP propeller or electric or hydraulic propulsion machinery	FP propeller
1	2,03	2,26
2	1,44	1,60
3	1,18	1,31

$$R_{CH} = C_1 + C_2 + C_3 C_\mu (H_F + H_M)^2 \left(B + C_\psi H_F\right) + C_4 L_{PAR} H_F^2 + C_5 \left(\frac{LT}{B^2}\right)^3 \frac{A_{wf}}{L}, \qquad (10.4.3\text{-}2)$$

where C_μ = $0{,}15\cos\varphi_2 + \sin\psi\sin\alpha$, C_μ shall be taken equal or larger than 0,45;
C_ψ = $0{,}047\psi - 2{,}115$, and C_ψ = 0, if ψ < 45°;
H_F = $0{,}26 + (H_M B)^{0,5}$;
H_M = 1,0 m for ice classes **IA** and **IA Super**;
H_M = 0,8 m for ice class **IB**;
H_M = 0,6 m for ice class **IC**;
C_1 = 0 for ice classes **IA**, **IB** and **IC**;

$$C_1 = f_1 \frac{BL_{PAR}}{2(T/B) + 1} + (1 + 0{,}021\varphi_1)(f_2 B + f_3 L_{BOW} + f_4 L_{BOW})$$

for ice class **IA Super**;
f_1 = 23 N/m^2;
f_2 = 45,8 N/m;
f_3 = 14,7 N/m;
f_4 = 29 N/m^2.
C_2 = 0 for ice classes **IA**, **IB** and **IC**;

$$C_2 = (1 + 0{,}063\varphi_1)(g_1 + g_2 B) + g_3 (1 + 1{,}2\frac{T}{B})\frac{B^2}{\sqrt{L}}$$

for ice class **IA Super**;
g_1 = 1530 N;
g_2 = 170 N/m;
g_3 = 400 N/m^{1,5}.
C_3 = 845;
C_4 = 42;
C_5 = 825;

If the value of the term $\left(\frac{LT}{B^2}\right)^3$ is less than 5, the value 5 shall be used and if the value of the term is more than 20, the value 20 shall be used.

10.4.4 The use of K_e or R_{CH} values based on more exact calculations or values based on model tests may be approved. Such an approval will be given on the understanding that it can be revoked if experience of the ship's performance in practice motivates this. The design requirement for ice classes is a minimum speed of 5 knots in the following brash ice channels:
H_M = 0,6 m for ice class **IC**;
H_M = 0,8 m for ice class **IB**;
H_M = 1,0 m for ice class **IA**;
H_M = 1,0 m and a 0,1 m thick consolidated layer of ice for ice class **IA Super**.

10.5 HULL STRUCTURAL DESIGN

10.5.1 General.

The method for determining hull scantlings is based on certain assumptions concerning the nature of the ice load on the structure. These assumptions are based on full-scale observations made in the northern Baltic.

It has thus been observed that the local ice pressure on small areas can reach rather high values. This pressure may be well in excess of the normal uniaxial crushing strength of sea ice. The explanation is that the stress field in fact is multiaxial.

Further, it has been observed that the ice pressure on a frame can be higher than on the shell plating at midspacing between frames. The explanation for this is the different flexural stiffness of frames and shell plating. The load distribution is assumed to be as shown in Fig. 10.5.1-1.

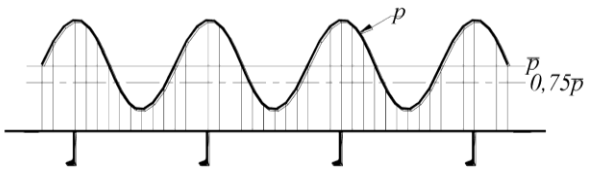


Fig. 10.5.1-1
Ice load distribution on a ship's side

The formulae and values given in this section may be substituted by direct analysis if they are deemed by the administration or the classification society to be invalid or inapplicable for a given structural arrangement or detail. Otherwise, direct analysis is not to be utilized as an alternative to the analytical procedures prescribed by explicit requirements specified in 10.5.3 – 10.5.5.

Direct analyses shall be carried out using the load patch defined in 10.5.2 (p, h and l_a). The pressure to be used is 1,8p where p is determined according to 10.5.2.2. The load patch shall be applied at locations where the capacity of the structure under the combined effects of bending and shear is minimized. In particular, the structure shall be checked with a load centred at the UIWL, 0,5h_0 below the LIWL, and positioned at several vertical locations in between. Several horizontal locations shall also be checked, especially the locations centred at the mid-span or -spacing. Furthermore, if the ice load length l_a cannot be determined directly from the arrangement of the structure, several values of l_a shall be checked using corresponding values for c_a.

The acceptance criterion for designs is that the combined stresses from bending and shear, using the von Mises yield criterion, are lower than the yield point σ_y. When the direct calculation is using beam theory, the allowable shear stress is not to be larger than 0,9τ_y, where $\tau_y = \sigma_y/\sqrt{3}$.

If scantlings derived from these regulations are less than those required by the Register for a not ice strengthened ship, the latter shall be used.

N o t e s : 1. The frame spacings and spans defined in the following text are normally (in compliance with the requirements of the RS normative documents for the ship in question) assumed to be measured along the plate and perpendicular to the axis of the stiffener for plates, along the flange for members with a flange, and along the free edge for flat bar stiffeners. For curved members the span (or spacing) is defined as the chord length between span (or spacing) points. The span points are defined by the intersection between the flange or upper edge of the member and the supporting structural element (stringer, web frame, deck or bulkhead). Fig. 10.5.1-2 illustrates the determination of span and spacing for curved members.

2. The effective breadth of the attached plate to be used for calculating the combined section modulus of the stiffener and attached plate shall be given the value determined in compliance with the

requirements specified in 1.6 of Part II "Hull". The effective breadth shall in no case be more than what is stated in the RS normative documents for the ship in question.

3. The requirements for the section modulus and shear area of the frames, stringers and web frames in 10.5.4, 10.5.5 and 10.5.6 are in accordance with the effective member cross section. For cases where the member is not normal to the plating, the required section properties shall be increased in accordance with the requirements specified in 1.6.1.4 of Part II "Hull".

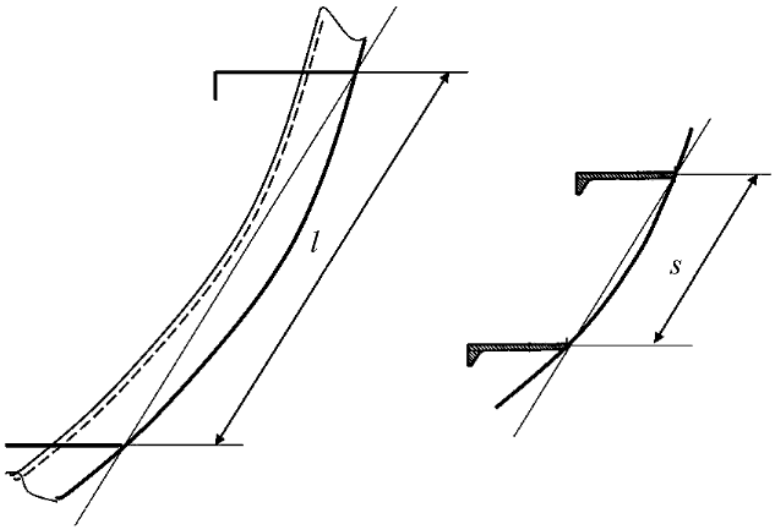


Fig. 10.5.1-2
Definition of the frame span (left) and frame spacing (right) for curved members

10.5.1.1 Hull regions.

For the purpose of this Chapter, the ship's hull is divided into regions as follows (refer also to Fig. 10.5.1.1):

Bow region: from the stem to a line parallel to and $0{,}04L$ aft of the forward borderline of the part of the hull where the waterlines run parallel to the centerline. For ice classes **IA Super** and **IA**, the overlap over the borderline need not exceed 6 m, for ice classes **IB** and **IC** this overlap need not exceed 5 m.

Midbody region: from the aft boundary of the Bow region to a line parallel to and $0{,}04L$ aft of the aft borderline of the part of the hull where the waterlines run parallel to the centerline. For ice classes **IA Super** and **IA**, the overlap over the borderline need not exceed 6 m, for ice classes **IB** and **IC** this overlap need not exceed 5 m.

Stern region: from the aft boundary of the midbody region to the stern.

L shall be taken in accordance with 1.1.3 of Part II "Hull".

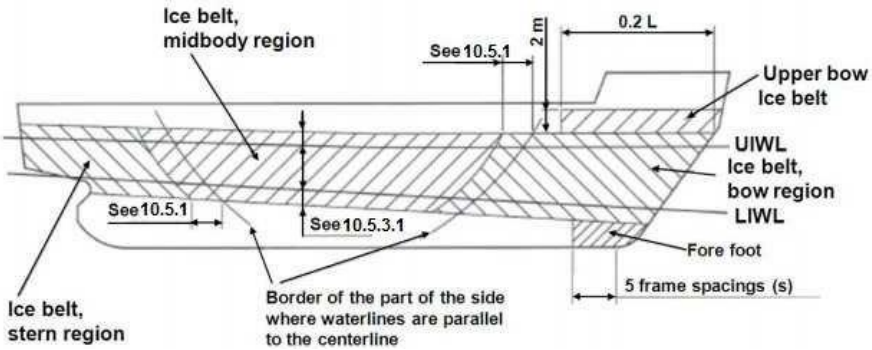


Fig. 10.5.1.1
Ice strengthened regions of the hull

10.5.2 Ice load.

10.5.2.1 Height of the ice load area.

An ice-strengthened ship is assumed to operate in open sea conditions corresponding to a level ice thickness not exceeding h_0. The design ice load height h of the area actually under ice pressure at any particular point of time is, however, assumed to be only a fraction of the ice thickness. The values for h_0 and h are given in the following Table:

Table 10.5.2.1

Ice class	h_0, in m	h, in m
IA Super	1,0	0,35
IA	0,8	0,30
IB	0,6	0,25
IC	0,4	0,22

10.5.2.2 Ice pressure.

The design ice pressure is determined by the following formula:

$$p = c_d c_p c_a p_0, \text{ in MPa} \qquad (10.5.2.2)$$

where c_d = a factor which takes account of the influence of the size and engine output of the ship. The factor c_d is taken as maximum 1,0 and is determined by the following formula:

$$c_d = \frac{ak + b}{1000}$$

where $k = \frac{\sqrt{\Delta P}}{1000}$;

a and b are given in the following Table:

Table 10.5.2.2-1

	Region			
	bow		midbody and stern	
	$k \leq 12$	$k > 12$	$k \leq 12$	$k > 12$
a	30	6	8	2
b	230	518	214	286

Δ = displacement of the ship at a maximum ice class draught, in t (refer to 10.3.1);

P = actual continuous engine output of the ship, in kW (refer to 10.4.2) available when sailing in ice. If additional power sources are available for propulsion power (e.g. shaft motors) in addition to the power of the main engine(s), they shall also be included in the total engine output used as the basis for hull scantling calculations. The engine output used for the calculation of the hull scantlings shall be clearly stated on the shell expansion drawing;

c_p = factor that reflects the magnitude of the load expected in the hull area in question relative to the bow area load.

The value of c_p is calculated according to Table 10.5.2.2-2.

Table 10.5.2.2-2

Baltic class	Region		
	bow	midbody	stern
IA Super	1,0	1,0	0,75
IA	1,0	0,85	0,65
IB	1,0	0,70	0,45
IC	1,0	0,50	0,25

c_a = factor which takes account of the probability that the full length of the area under consideration will be under pressure at the same time.

The value of c_a is calculated using the following formula:

$c_a = \sqrt{l_0/l_a}$, 0,35 ≥ c_a ≥ 1,0

where l_0 = 0,6 m;
Values of l_a shall be taken according to Table 10.5.2.2-3.

p_0 = nominal ice pressure; the value 5,6 MPa shall be used.

Table 10.5.2.2-3

Structure	Type of framing	l_a, in m
Shell	transverse	Frame spacing
	longitudinal	1,7 × frame spacing
Frames	transverse	Frame spacing
	longitudinal	Span of frame
Ice stringer		Span of stringer
Web frame		2 × web frame spacing

10.5.3 Shell plating.

10.5.3.1 Vertical extension of ice strengthening for plating (ice belt).

The vertical extension of the ice belt shall be determined as given in Table 10.5.3.1 (refer to Fig. 10.5.1.1).

Table 10.5.3.1

Ice class	Hull region	Above UIWL	Below LIWL
IA Super	bow	0,60 m	1,20 m
	midbody		
	stern		1,0 m
IA	bow	0,50 m	0,90 m
	midbody		0,75 m
	stern		
IB and IC	bow	0,40 m	0,70 m
	midbody		0,60 m
	stern		

In addition, the following areas shall be strengthened.

Fore foot. For ice class **IA Super**, the shell plating below the ice belt from the stem to a position five main frame spacings abaft of the point where the bow profile departs from the keel line shall be ice-strengthened in the same way as the bow region.

Upper bow ice belt. For ice classes **IA Super** and **IA** on ships with an open water service speed equal to or exceeding 18 knots, the shell plate from the upper limit of the ice belt to 2 m above it and from the stem to a position at least $0{,}2L$ abaft of the forward perpendicular shall be ice-strengthened in the same way as the midbody region. A similar strengthening of the bow region is also recommended for a ship with a lower service speed when, on the basis of the model tests, for example, it is evident that the ship will have a high bow wave.

Side scuttles shall not be situated in the ice belt. If the weather deck in any part of the ship is situated below the upper limit of the ice belt (e.g. in way of the well of a raised quarter decker), the bulwark shall be given at least the same strength as is required for the shell in the ice belt. The strength of the construction of the freeing ports shall meet the same requirements.

10.5.3.2 Plate thickness in the ice belt.

For transverse framing, the thickness of the shell plating shall be determined by the following formula:

$$t = 667s\sqrt{\frac{f_1 p_{pl}}{\sigma_y}} + t_c, \text{ in mm.} \qquad (10.5.3.2\text{-}1)$$

For longitudinal framing, the thickness of the shell plating shall be determined by the following formula:

$$t = 667s\sqrt{\frac{p}{f_2 \sigma_y}} + t_c, \text{ in mm} \qquad (10.5.3.2\text{-}2)$$

where s = frame spacing, in m;
p_{pl} = $0{,}75p$, in MPa;
p = as given in 10.5.2.2;
$f_1 = 1{,}3 - \frac{4{,}2}{(h/s+1{,}8)^2}$; maximum 1,0;

$$f_1 = \begin{cases} 0{,}6 + \frac{0{,}4}{(h/s)} & \text{when } h/s \le 1 \\ 1{,}4 - 0{,}4(h/s) & \text{when } 1 \le h/s \le 1{,}8 \end{cases}$$

where h as given in 10.5.2.1;
σ_y = yield stress of the material, in MPa, for which the following values shall be used:
σ_y = 235 MPa for normal-strength hull structural steel;
σ_y = 315 MPa or higher for high-strength hull structural steel.
t_c = increment for abrasion and corrosion, in mm; t_c shall normally be 2 mm; if a special surface coating surface coating, shown by experience to be capable of withstanding abrasion by ice, is applied and maintained, and the documents listed in Section 8.6 of the Guidelines for the Application of the Finnish-Swedish Ice Class Rules are submitted to the Register, the increment may be reduced to 1 mm upon agreement with the shipowner. In such case, the scantlings determined for normally increment for abrasion and corrosion shall be indicated in hull structural drawing. A special entry shall be made in the Classification Certificate of such ships (refer to 2.3.1, Part I "Classification").

10.5.4 Frames.

10.5.4.1 Vertical extension of ice strengthening for framing.

The vertical extension of the ice strengthening of framing shall be determined according to Table 10.5.4.1.

Where an upper bow ice belt is required (refer to Fig. 10.5.1.1), the ice-strengthened part of the framing shall be extended to at least the top of this ice belt.

Where the ice-strengthening would go beyond a deck or tank top, the tank bottom plating of a tank ot tank top by no more than 250 mm, it can be terminated at that deck, top or bottom plating of the tank or tank top.

Table 10.5.4.1

Baltic ice class	Hull region	Above UIWL	Below LIWL
IA Super	bow	1,2 m	Down to tank top or below top of the floors
	midbody		2,0 m
	stern		1,6 m
IA, **IB** and **IC**	bow	1,0 m	1,6 m
	midbody		1,3 m
	stern		1,0 m

10.5.4.2 Transverse frames.

10.5.4.2.1 Section modulus and shear area.

The section modulus of a main or intermediate transverse frame, in cm^3, shall be determined by the following formula:

$$Z = \frac{pshl}{m_t \sigma_y} \times 10^6. \qquad (10.5.4.2.1\text{-}1)$$

The effective shear area is calculated from the formula

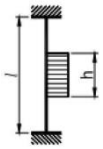
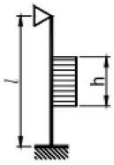
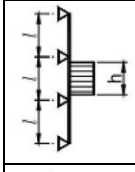
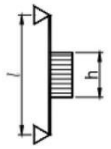
$$A = \frac{\sqrt{3} f_3 phs}{2\sigma_y} \times 10^4, \text{ in cm}^2 \qquad (10.5.4.2.1\text{-}2)$$

where p = ice pressure as given in 10.5.2.2, in MPa;
s = frame spacing, in m;
h = height of the load area as given in 10.5.2.1, in m;
l = span of the frame, in m;
m_t = $\frac{7m_0}{7-5h/l}$;
f_3 = 1,2 – factor which takes account of the maximum shear force versus the load location and the shear stress distribution;
σ_y = yield stress as in 10.5.3.2, in MPa;
m_0 = factor which takes the boundary conditions into account with the values taken according to Table 10.5.4.2.1

The boundary conditions are those for the main and intermediate frames. Load is applied at mid span.

Where less than 15 % of the span l of the frame is situated within the ice-strengthening area for frames as defined in 10.5.4.2.1, ordinary frame scantlings may be used.

Table 10.5.4.2.1

Boundary condition	m_0	Example
	7	Frames in a bulk carrier with top wing tanks
	6	Frames extending from the tank top to the main deck of a single-deck ship
	5,7	Continuous frames between several decks or stringers
	5	Frames extending between two decks only

10.5.4.2.2 Upper end of transverse framing.

The upper ends of the strengthened part of a main frame and of an intermediate ice frame shall be attached to a deck, top or bottom plating of a tank or an ice stringer (refer to 10.5.5).

The application of the requirements of this Section with respect to a frame that terminates above a deck or a stringer which is situated at or above the upper limit of the ice belt is not obligatory; in such case, the upper end of an intermediate frame may be connected to the adjacent frames by a horizontal member with the same scantlings as the main frame.

10.5.4.2.3 Lower end of transverse framing.

The lower ends of the strengthened part of a main frame and of an intermediate ice frame shall be attached to a deck, top or bottom plating of a tank, tank top or an ice stringer (refer to 10.5.5).

Where an intermediate frame terminates below a deck, top or bottom plating of a tank, tank or ice stringer which is situated at or below the lower limit of the ice belt, the lower end may be connected to the adjacent main frames by a horizontal member of the same scantlings as the main frames. In such case, the main frames below the lower edge of the ice belt shall be ice strengthened according to 10.5.4.1.

10.5.4.3 Longitudinal frames.

The requirements of this Section are applied to longitudinal frames with all end conditions.

10.5.4.3.1 Frames with and without brackets.

The section modulus of a longitudinal frame, in cm^3, shall be not less than determined by the following formula:

$$Z = \frac{f_4 phl^2}{m\sigma_y} 10^6 \qquad (10.5.4.3.1\text{-}1)$$

and effective shear area of a longitudinal frame, in cm^2, shall be not less than determined by the following formula:

$$A = \frac{\sqrt{3 f_4 f_5 phl}}{2\sigma_y} 10^4, \text{ cm}^2 \qquad (10.5.4.3.1\text{-}2)$$

where f_4 = 1–0,2h/s = factor which takes account of the load distribution over adjacent frames;
f_5 = 2,16 = factor which takes account of the maximum shear force versus the load location and the shear stress distribution;
p = ice pressure according to 10.5.2.2, in MPa;
h = height of load area according to 10.5.2.1, in m;
s = frame spacing, in m;
l = total span of the frame, in m;
m = boundary condition factor taken m = 13,3 for a continuous beam with brackets; where the boundary conditions deviate significantly from those of a continuous beam with brackets, the value of m may be reduced upon submission of the appropriate calculations;
σ_y = yield stress according to 10.5.3.2, in MPa.

While calculating the actual shear area of a longitudinal frame, the shear area of the brackets shall not be taken into account.

10.5.4.4 General on framing.

10.5.4.4.1 The attachment of frames to supporting structures.

Within the ice-strengthened area, frames shall be effectively attached to the supporting structures.

A longitudinal frame shall be attached to all the supporting web frames and bulkheads by brackets. When a transversal frame terminates at a stringer or deck, a bracket or similar construction shall be fitted. When a frame is running through the supporting structure, both sides of the web plate of the frame shall be connected to the structure (by direct welding, collar

plate or lug). When a bracket is installed, it shall have at least the same thickness as the web plate of the frame and the edge shall be appropriately stiffened against buckling.

10.5.4.4.2 Support of frames against instability, in particular tripping.

The frames shall be attached to the shell by a double continuous weld. No scalloping is allowed (except when crossing shell plate butts).

The web thickness of the frame shall be at least the maximum of the following values:

$$\frac{h_w\sqrt{\sigma_y}}{C}$$

where h_w = web height;
C = 282 = for flat bars;
C = 805 = for other cases;

$$\frac{t - t_c}{2}$$

where t = required thickness of the shell plating according to 10.5.3.2, in mm, for the purpose of calculating of which σ_y shall be taken equal to the yield strength of the frame;

9 mm.

Where there is a deck, top or bottom plating of a tank, tank top or bulkhead in lieu of a frame, the plate thickness of it shall comply with the requirements specified above, to a depth corresponding to the height of the adjacent frames. In such a case, the material properties of the deck, top or bottom plating of the tank, tank top or bulkhead and the frame height h_w of the adjacent frames shall be used in the calculations, and the constant *C* shall be 805.

Asymmetrical frames and frames which are not at right angles to the shell (web less than 90 deg. to the shell) shall be supported against tripping by brackets, intercoastals, stringers or similar, at a distance not exceeding 1,3 m. For frames with spans greater than 4 m, the extent of antitripping supports shall be applied to all ice-strengthening areas for all ice classes. For frames with spans less than or equal to 4 m, the extent of antitripping supports shall be applied to all ice-strengthening areas for ice class **IA Super**, to the bow and midbody regions for ice class **IA**, and to the bow region for ice classes **IB** and **IC**. Direct calculation methods may be applied to demonstrate the equivalent level of support provided by alternative arrangements.

10.5.5 Ice stringers.

10.5.5.1 Stringers within the ice belt.

The section modulus of a stringer situated within the ice belt (refer to 10.5.3.1), shall be taken not less than determined by the formula

$$Z = \frac{f_6 f_7 phl^2}{m\sigma_y} 10^6, \text{ in cm}^3. \qquad (10.5.5.1\text{-}1)$$

The effective shear area shall be taken not less than determined by the formula

$$A = \frac{\sqrt{3} f_6 f_7 f_8 phl}{2\sigma_y} \times 10^4, \text{ in cm}^2 \qquad (10.5.5.1\text{-}2)$$

where p = ice pressure as given in 10.5.2.2, in MPa;
h = height of load area as given in 10.5.2.1, in m.
The product ph shall not be taken as less than 0,15;
l = span of the stringer, in m;
m = boundary condition factor as defined in 10.5.4.3;
f_6 = 0,9 = factor which takes account of the distribution of load over the transverse frames;
f_7 = 1,8 = safety factor of stringers;

f_8 = 1,2 = factor that takes account of the maximum shear force versus the load location and the shear stress distribution;
σ_y = yield stress according to 10.5.3.2, in MPa.

10.5.5.2 Stringers outside the ice belt.

The section modulus of a stringer situated outside the ice belt but supporting ice-strengthened frames shall be taken not less than determined by the formula

$$Z = \frac{f_9 f_{10} phl^2}{m\sigma_y}(1 - h_s/l_s)10^6, \text{ in cm}^3. \quad (10.5.5.2\text{-}1)$$

The effective shear area shall be taken not less than determined by the formula

$$A = \frac{\sqrt{3 f_9 f_{10} f_{11} phl}}{2\sigma_y}(1 - h_s/l_s)10^4, \text{ in cm}^2 \quad (10.5.5.2\text{-}2)$$

where p = ice pressure as given in 10.5.2.2, in MPa;
h = height of the ice load area distribution according to 10.5.2.1, in m;
The product ph shall not be taken as less than 0,15;
l = span of stringer, in m;
m = boundary condition factor as defined in 10.5.4.3;
l_s = distance to the adjacent ice stringer, in m;
h_s = distance to the ice belt, in m;
f_9 = 0,8 = factor which takes account of the distribution of load over the transverse frames;
f_{10} = 1,8 = safety factor of stringers;
f_{11} = 1,2 = factor that takes account of the maximum shear force versus the load location and shear stress distribution;
σ_y = yield stress according to 10.5.3.2, in MPa.

10.5.5.3 Deck strips.

Narrow deck strips abreast of hatches and serving as ice stringers shall comply with the section modulus and shear area requirements in 10.5.5.1 and 10.5.5.2 respectively. In the case of very long hatches, the product ph may be taken less than 0,15 but in no case less than 0,10.

Regard shall be paid to the deflection of the ship's sides due to ice pressure with respect to very long (more than $B/2$) hatch openings, when designing weather deck hatch covers and their fittings.

10.5.6 Web frames.

10.5.6.1 Ice load.

The ice load transferred to a web frame from an ice stringer or from longitudinal framing shall be determined by the following formula:

$$F = f_{12} phS, \text{ in MN} \quad (10.5.6.1)$$

where p = ice pressure as given in 10.5.2.2, in MPa, in calculating c_a, however, l_a shall be taken $2S$.
h = height of load area as given in 10.5.2.1, in m.
The product ph shall not be taken as less than 0,15;
S = distance between web frames, in m;
f_{12} = 1,8 = safety factor of web frames.
In case the supported stringer is outside the ice belt, the force F shall be multiplied by $(1 - h_s/l_s)$ where h_s and l_s shall be taken as defined in 10.5.5.2.

10.5.6.2 Section modulus and shear area.

The section modulus and shear area of web frames shall be calculated by the following formulae.

The effective shear area

$$Z = \frac{M}{\sigma_y}\sqrt{\frac{1}{1-(\gamma A/A_a)^2}}10^6, \text{ in cm}^2 \qquad (10.5.6.2\text{-}1)$$

where Q = maximum calculated shear force under the ice load F as given in 10.5.6.1;
f_{13} = 1,1 = factor that takes account of the shear force distribution;
α = refer to Table 10.5.6.2;
σ_y = yield stress of the material according to 10.5.3.2.

Section modulus

$$Z = \frac{M}{\sigma_y}\sqrt{\frac{1}{1-(\gamma A/A_a)^2}}10^6, \text{ in cm}^3 \qquad (10.5.6.2\text{-}2)$$

where M = maximum calculated bending moment in web frame under the ice load F; this shall be taken as $M = 0{,}193Fl$;
γ = refer to Table 10.5.6.2;
A = required shear area;
A_a = actual cross sectional area of the web frame, $A_a = A_f + A_w$.

Table 10.5.6.2

Values of factors α and γ

A_f/A_w	0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
α	1,5	1,23	1,16	1,11	1,09	1,07	1,06	1,05	1,05	1,04	1,04
γ	0	0,44	0,62	0,71	0,76	0,80	0,83	0,85	0,87	0,88	0,89

where A_f = actual cross section area of free flange;
A_w = actual effective cross section area of web plate.

10.5.7 Stem.

10.5.7.1 The stem shall be made of rolled, cast or forged steel, or of shaped steel plates as shown in Fig. 10.5.7.1.

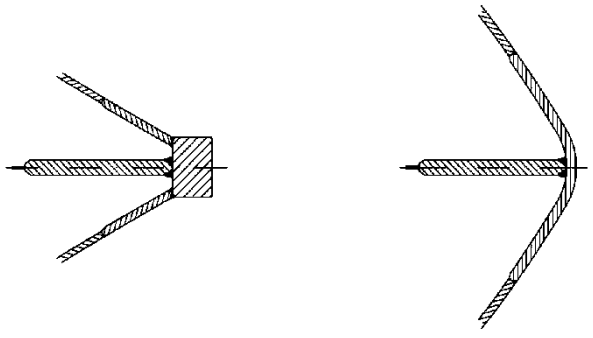


Fig. 10.5.7.1
Examples of suitable stems

The plate thickness of a shaped plate stem and, in the case of a blunt bow, any part of the shell where $\alpha \geq 30°$ and $\psi \geq 75°$ (refer to 10.4.1 for angle definitions), shall be not less than determined according to 10.5.3.2, assuming the following:

s = spacing of elements supporting the plate, in m;
$p_{PL} = p$, in MPa (refer to 10.5.3.2);
l_a = spacing of vertical supporting elements, in m.

The stem and the part of a blunt bow defined above shall be supported by floors or brackets spaced not more than 0,6 m apart and having a thickness of at least half the plate thickness. The reinforcement of the stem shall extend from the keel to a point 0,75 m above the UIWL or, if an upper bow ice belt is required (refer to 10.5.3.1), to the upper limit of this.

10.5.8 Stern.

The introduction of new propulsion arrangements with azimuthing thrusters or "podded" propellers, which provide an improved manoeuvrability, will result in increased ice loading of the stern region and the stern area. This fact shall be considered in the design of the aft/stern structure.

In order to avoid very high loads on propeller blade tips, the minimum distance between propeller(s) and hull (including stern frame) shall not be less than h_0 (refer to 10.5.2.1).

On twin and triple screw ships the ice strengthening of the shell and framing shall be extended to the double bottom for 1,5 m forward and aft of the side propellers.

Shafting and stern tubes of side propellers shall normally be enclosed within plated bossings. If detached struts are used, their design, strength and attachments to the hull shall comply with the requirements specified in 2.10 of Part II "Hull".

10.6 RUDDER AND STEERING ARRANGEMENTS

10.6.1 The scantlings of the rudder post, rudder stock, pintles, as well as the capability of the steering engine shall be determined according to the requirements of Section 2 "Equipment, Arrangements and Outfit". The requirements for ships of ice class **Arc4** shall also apply to the rudder and steering arrangements of Baltic ice class **IA** and for ships of ice class **Arc5** shall also apply to the rudder and steering arrangements of Baltic ice class **IA Super**. The maximum service speed of the ship to be used in these calculations shall not be taken less than that specified below:

IA Super – 20 knots;
IA – 18 knots;
IB – 16 knots;
IC – 14 knots.

If the actual maximum service speed of the ship is higher, that speed shall be used.

The local scantlings of rudders shall be determined assuming that the whole rudder belongs to the ice belt. Further, the rudder plating and frames shall be designed using the ice pressure p for the plating and frames in the midbody region.

For ice classes **IA** and **IA Super** the rudder (rudder stock and the upper part of the rudder) shall be protected from direct contact with intact ice by an ice knife that extends below the LIWL, if practicable (or equivalent means). When using flap-type rudders, the design of the ice knife shall ensure necessary strength of the rudder.

For ice classes **IA** and **IA Super** due regard shall be paid to the large loads that arise when the rudder is forced out of the midship position while going astern in ice or into ice ridges. Suitable arrangement such as rudder stoppers shall be installed to absorb these loads.

Relief valves for the hydraulic pressure in rudder turning mechanism(s) shall be installed. The components of the steering gear (e.g. rudder stock, rudder coupling, rudder horn etc.) shall be dimensioned to withstand loads causing yield stresses within the required diameter of the rudder stock.

10.7 PROPULSION MACHINERY

10.7.1 Scope.

These regulations apply to propulsion machinery covering open- and ducted-type propellers with controllable pitch or fixed pitch design for the ice classes **IA Super**, **IA**, **IB** and **IC**.

The given loads are the expected ice loads for the whole ship's service life under normal operational conditions, including loads resulting from the changing rotational direction of FP propellers. However, these loads do not cover off-design operational conditions, for example when a stopped propeller is dragged through ice.

The regulations also apply to azimuthing and fixed thrusters for main propulsion, considering loads resulting from propeller/ice interaction. However, the load models of the regulations do not include propeller/ice interaction loads when ice enters the propeller of a turned azimuthing thruster from the side (radially) or load cases when ice block hits on the propeller hub of a pulling propeller.

Ice loads resulting from ice impacts on the body of thrusters have to be estimated, but ice load formulae are not available.

10.7.2 Definitions, and symbols.

D – propeller diameter, in m.

R – propeller radius, in m.

c – chord length of blade section, in m.

$c_{0,7}$ – chord length of blade section at propeller radius r = 0,7R, in m.

d – external diameter of propeller hub (at propeller plane), in m.

D_{limit} – limit value for propeller diameter, in m.

F_b – maximum backward blade force for the ship's service life, in kN.

F_{ex} – ultimate blade load resulting from blade loss through plastic bending, in kN.

F_f – maximum forward blade force for the ship's service life, in kN.

F_{ice} – ice load, in kN.

$(F_{ice})_{max}$ – maximum ice load for the ship's service life, in kN.

h_0 – depth of the propeller centreline from LIWL, in m.

H_{ice} – thickness of maximum design ice block entering to propeller, in m.

I_e – equivalent mass moment of inertia of all parts on engine side of component under consideration, in kgm^2.

I_t – equivalent mass moment of inertia of the whole propulsion system, in kgm^2.

k – shape parameter for Weibull distribution.

m – slope for SN curve in log/log scale.

M_{BL} – blade bending moment, in kNm.

n – propeller rotational speed, in rev/s.

n_n – nominal propeller rotational speed at MCR in free running condition, in rev/s.

N_{class} – reference number of impacts per propeller rotational speed per ice class.

N_{ice} – total number of ice loads on propeller blade for the ship's service life.

N_R – reference number of load for equivalent fatigue stress (10^8 cycles).

N_Q – number of propeller revolutions during a milling sequence.

$P_{0,7}$ – propeller pitch at radius r = 0,7R, in m.

$P_{0,7n}$ – propeller pitch at radius r = 0,7R at MCR in free running condition, in m.

$P_{0,7b}$ – propeller pitch at radius r = 0,7R at MCR in bollard condition, in m.

Q – torque, in kNm.

$Q_{e\max}$ – maximum engine torque, in kNm.

$Q_{\max}$ – maximum torque on the propeller resulting from propeller/ice interaction, in kNm.

Q_{motor} – electric motor peak torque, in kNm.

Q_n – nominal torque at MCR in free running condition, in kNm.

Q_r – maximum response torque along the propeller shaft line, in kNm.

$Q_{\max}$ – maximum spindle torque of the blade for the ship's service life, in kNm.

Q_{sex} – maximum spindle torque due to blade failure caused by plastic bending, in kNm.

Q_{vib} – vibratory torque at considered component, taken from frequency domain open water torque vibration calculation (TVC), in kNm.

r – propeller radius, in m.

T – propeller thrust, in kN.

T_b – maximum backward propeller ice thrust for the ship's service life, in kN.

T_f – maximum forward propeller ice thrust for the ship's service life, in kN.

T_n – propeller thrust at MCR in free running condition, in kN.

T_r – maximum response thrust along the shaft line, in kN.

t – maximum blade section thickness, in m.

Z – number of propeller blades.

a_i – duration of propeller blade/ice interaction expressed in rotation angle, in deg.

α_1 – phase angle of propeller ice torque for blade order excitation component, in deg.

α_2 – phase angle of propeller ice torque for twice-the-blade order excitation component, in deg.

γ_v – reduction factor for fatigue; variable amplitude loading effect.

γ_m – reduction factor for fatigue; mean stress effect.

ρ – reduction factor for fatigue correlating the maximum stress amplitude to the equivalent fatigue stress for 10^8 stress cycles.

$\sigma_{0,2}$ – proof yield strength (at 0,2 % offset) of blade material, in MPa.

σ_{exp} – mean fatigue strength of blade material at 10^8 cycles to failure in sea water, in MPa.

σ_{fat} – equivalent fatigue ice load stress amplitude for 10^8 stress cycles, in MPa.

σ_{fl} – characteristic fatigue strength for blade material, in MPa.

σ_u – ultimate tensile strength of blade material, in MPa.

$\sigma_{ref} = 0{,}6\sigma_{0,2} + 0{,}4\sigma_u$, in MPa.

$\sigma_{ref2} = 0{,}7\sigma_u$ or

$\sigma_{ref2} = 0{,}6\sigma_{0,2} + 0{,}4\sigma_u$, whichever is less, in MPa.

σ_{st} – maximum stress resulting from F_b or F_f, in MPa.

$(\sigma_{ice})b_{\max}$ – principal stress caused by the maximum backward propeller ice load, in MPa.

$(\sigma_{ice})f_{\max}$ – principal stress caused by the maximum forward propeller ice load, in MPa.

$(\sigma_{ice})_{\max}$ – maximum ice load stress amplitude, in MPa.

Table 10.7.2

Definition of loads

	Definition	Use of the load in design process
F_b	The maximum lifetime backward force on a propeller blade resulting from propeller/ ice interaction, including hydrodynamic loads on that blade. The direction of the force is perpendicular to 0,7R chord line (refer to Fig. 10.7.2)	Design force for strength calculation of the propeller blade.
F_f	The maximum lifetime forward force on a propeller blade resulting from propeller/ice interaction, including hydrodynamic loads on that blade. The direction of the force is perpendicular to 0,7R chord line.	Design force for calculation of strength of the propeller blade.
$Q_{s\max}$	The maximum lifetime spindle torque on a propeller blade resulting from propeller/ice interaction, including hydrodynamic loads on that blade.	In designing the propeller strength, the spindle torque is automatically taken into account because the propeller load is acting on the blade as distributed pressure on the leading edge or tip area.
T_b	The maximum lifetime thrust on propeller (all blades) resulting from propeller/ ice interaction. The direction of the thrust is the propeller shaft direction and the force is opposite to the hydrodynamic thrust.	Is used for estimation of the response thrust T_r. T_b can be used as an estimate of excitation for axial vibration calculations.
T_f	The maximum lifetime thrust on propeller (all blades) resulting from propeller/ ice interaction. The direction of the thrust is the propeller shaft direction acting in the direction of hydrodynamic thrust.	Is used for estimation of the response thrust T_r. T_f can be used as an estimate of excitation for axial vibration calculations.
$Q_{\max}$	The maximum ice-induced torque resulting from propeller/ice interaction on one propeller blade, including hydrodynamic loads on that blade.	Is used for estimation of the response torque along the propulsion shaft line and as excitation for torsional vibration calculations.
F_{ex}	Ultimate blade load resulting from blade loss through plastic bending. The force is acting on 0,8R. Spindle arm shall be taken as 2/3 of the distance between the axis of blade rotation and leading/trailing edge (whichever is the greater) at the 0,8R radius.	Blade failure load is used to dimension the blade bolts, pitch control mechanism, propeller shaft, propeller shaft bearing and trust bearing. The objective is to guarantee that total propeller blade failure should not cause damage to other components.
Q_r	Maximum response torque along the propeller shaft line, taking into account the dynamic behavior of the shaft line for ice excitation (torsional vibration) and hydrodynamic mean torque on propeller.	Design torque for propeller shaft line components.
T_r	Maximum response thrust along shaft line, taking into account the dynamic behavior of the shaft line for ice excitation (axial vibration) and hydrodynamic mean thrust on propeller.	Design thrust for propeller shaft line components.
F_{ti}	Maximum response force caused by ice block impacts on the thruster body or the propeller hub.	Design load for thruster body and slewing bearings.
F_{tr}	Maximum response force on the thruster body caused by ice ridge/thruster body interaction.	Design load for thruster body and slewing bearings.

10.7.3 Design ice conditions.

In estimating the ice loads of the propeller for ice classes, different types of operation as given in Table 10.7.3-1 were taken into account. The maximum design ice block entering the propeller is a rectangular ice block with the dimensions $H_{ice} \cdot 2H_{ice} \cdot 3H_{ice}$. The thickness of the ice block H_{ice} is given in Table 10.7.3-2.

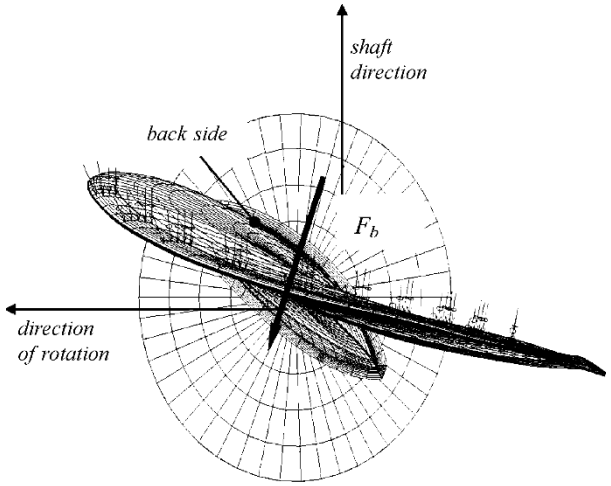


Fig. 10.7.2
Direction of force F_b.
Ice contact pressure at leading edge is shown with small arrows

Table 10.7.3-1

Operation characteristics

Ice class	Operation of the ship
IA Super	Operation in ice channels and in level ice The ship may proceed by ramming
IA, **IB**, **IC**	Operation in ice channels

Table 10.7.3-2

Thickness of the design maximum ice block entering the propeller

Ice class	**IA Super**	**IA**	**IB**	**IC**
H_{ice}	1,75 m	1,5 m	1,2 m	1,0 m

10.7.4 Materials.

10.7.4.1 Materials exposed to sea water.

Materials of components exposed to sea water, such as propeller blades, propeller hubs, and thruster body, shall have an elongation of not less than 15 % on a test specimen, the gauge length of which is five times the diameter.

A Charpy V-notch impact test shall be carried out for materials other than bronze and austenitic steel. An average impact energy value of 20 J taken from three tests shall be obtained at –10 ºC. For nodular cast iron, average impact energy of 10 J at –10 ºC is required accordingly.

10.7.4.2 Materials exposed to sea water temperature.

Materials exposed to sea water temperature shall be of steel or other ductile material. An average impact energy value of 20 J taken from three tests shall be obtained at –10 ºC. The nodular cast iron of a ferrite structure type may be used for relevant parts other than bolts. The average impact energy for nodular cast iron shall be 10 J at –10 ºC.

This requirement applies to blade bolts, CP mechanisms, shaft bolts, strut-pod connecting bolts etc. This does not apply to surface hardened components, such as bearings and gear teeth.

10.7.5 Design loads.

The loads specified in the Section are intended for component strength calculations only and are total loads including ice-induced loads and hydrodynamic loads during propeller/ice interaction.

The values of the parameters in the formulae in this section shall be given in the units shown in 10.7.2.

If the propeller is not fully submerged when the ship is in ballast condition, the propulsion system shall be designed according to ice class **IA** for ice classes **IB** and **IC**.

10.7.5.1 Design loads on propeller blades.

F_b is the maximum force experienced during the lifetime of the ship that bends a propeller blade backwards when the propeller mills an ice block while rotating ahead.

F_f is the maximum force experienced during the lifetime of the ship that bends a propeller blade forwards when the propeller mills an ice block while rotating ahead.

F_b and F_f originate from different propeller/ice interaction phenomena, not acting simultaneously. Hence they shall be applied to one blade separately.

10.7.5.1.1 Force F_b for open propellers.

$$F_b = 27[nD]^{0,7}\left[\frac{EAR}{Z}\right]^{0,3} D^2, \text{ in kN, when } D \le D_{limit}; \quad (10.7.5.1.1\text{-}1)$$

$$F_b = 27[nD]^{0,7}\left[\frac{EAR}{Z}\right]^{0,3} DH_{ice}^{1,4}, \text{ in kN, when } D > D_{limit} \quad (10.7.5.1.1\text{-}2)$$

where D_{limit} = 0,85 $H_{ice}^{1,4}$, in m;
n = n_n for a CP propeller;
n = 0,85n_n for a FP propeller.

10.7.5.1.2 Force F_f for open propellers.

$$F_f = 250\left[\frac{EAR}{Z}\right]D^2, \text{ in kN, when } D \le D_{limit}; \quad (10.7.5.1.2\text{-}1)$$

$$F_f = 500\left[\frac{EAR}{Z}\right]D\frac{1}{\left(1-\frac{d}{D}\right)}H_{ice}, \text{ in kN, when } D > D_{limit} \quad (10.7.5.1.2\text{-}2)$$

where $D_{limit} = \frac{2}{\left(1-\frac{d}{D}\right)}H_{ice}$, in m.

10.7.5.1.3 Loaded area on the blade for open propellers.

Load cases 1 – 4 shall be covered, as given in Table 10.7.5.1.3, for CP and FP propellers.

In order to obtain blade ice loads for a reversing propeller, load case 5 also shall be covered for FP propellers.

10.7.5.1.4 Maximum backward blade ice force F_b for ducted propellers.

$$F_b = 9{,}5[nD]^{0,7}\left[\frac{EAR}{Z}\right]^{0,3} D^2, \text{ in kN, when } D \le D_{limit}; \quad (10.7.5.1.4\text{-}1)$$

$$F_b = 66[nD]^{0,7}\left[\frac{EAR}{Z}\right]^{0,3} D^{0,6}H_{ice}^{1,4}, \text{ in kN, when } D > D_{limit} \quad (10.7.5.1.4\text{-}2)$$

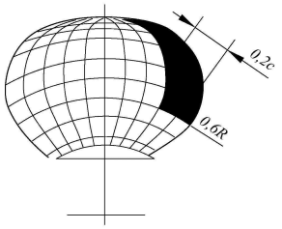
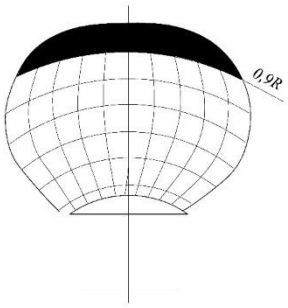
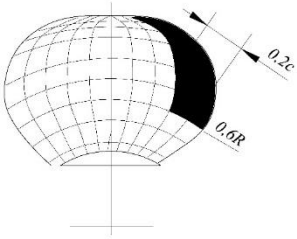
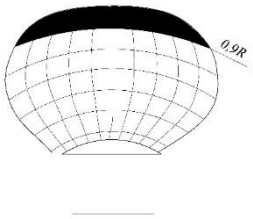
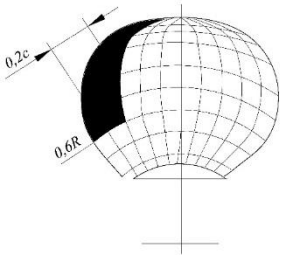
where D_{limit} = $4H_{ice}$, in m;
n = n_n for a CP propeller;
n = 0,85n_n for a FP propeller.

10.7.5.1.5 Maximum forward blade ice force F_f for ducted propellers.

$$F_f = 250\left[\frac{EAR}{Z}\right]D^2, \text{ in kN, when } D \le D_{limit}; \quad (10.7.5.1.5\text{-}1)$$

Table 10.7.5.1.3

Load cases for open propellers

	Force	Loaded area	Right-handed propeller blade seen from behind
Load case 1	F_b	Uniform pressure applied on the back of the blade (suction side) to an area from 0,6R to the tip and from the leading edge to 0,2 times the chord length	
Load case 2	50 % of F_b	Uniform pressure applied on the back of the blade (suction side) on the propeller tip area outside 0,9R radius	
Load case 3	F_f	Uniform pressure applied on the blade face (pressure side) to an area from 0,6R to the tip and from the leading edge to 0,2 times the chord length.	
Load case 4	50 % of F_f	Uniform pressure applied on propeller face (pressure side) on the propeller tip area outside 0,9R radius.	
Load case 5	60 % of F_f or F_b, whichever is greater	Uniform pressure applied on propeller face (pressure side) to an area from 0,6R to the tip and from the trailing edge to 0,2 times the chord length	

$$F_f = 500\left[\frac{EAR}{Z}\right] D \frac{1}{\left(1-\frac{d}{D}\right)} H_{ice}, \text{ in kN, when } D > D_{limit} \qquad (10.7.5.1.2\text{-}2)$$

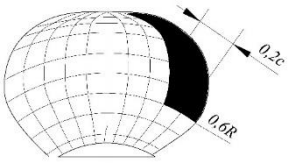
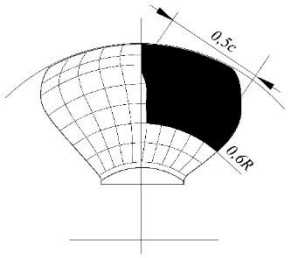
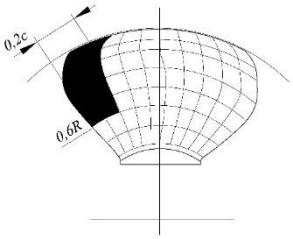
where $D_{limit} = \frac{2}{\left(1-\frac{d}{D}\right)} H_{ice}$, in m.

10.7.5.1.6 Loaded area on the blade for ducted propellers.

Load cases 1 and 3 shall be covered as given in Table 10.7.5.1.6 for CP and FP propellers. Load case 5 shall be covered for FP propeller, to cover ice loads when the propeller is reversed.

Table 10.7.5.1.6

Load cases for ducted propellers

	Force	Loaded area	Right-handed propeller blade seen from behind
Load case 1	F_b	Uniform pressure applied on the back of the blade (suction side) to an area from 0,6R to the tip and from the leading edge to 0,2 times the chord length	
Load case 2	F_f	Uniform pressure applied on the blade face (pressure side) to an area from 0,6R to the tip and from the leading edge to 0,5 times the chord length	
Load case 3	60 % of F_f or F_b, whichever is greater	Uniform pressure applied on propeller face (pressure side) to an area from 0,6R to the tip and from the trailing edge to 0,2 times the chord length	

10.7.5.1.7 Torque $Q_{s\max}$.

The spindle torque $Q_{s\max}$ around the axis of the blade fitting shall be determined both for the maximum backward blade force F_b and forward blade force F_f, which are applied as in Tables 10.7.5.1.3 and 10.7.5.1.6.

If the above method gives a value, which is less than the default value given by Formula (10.7.5.1.7), the default value shall be used:

$$Q_{s\max} = 0{,}25Fc_{0{,}7}, \text{ in kNm} \qquad (10.7.5.1.7)$$

where F – F_b or F_f, whichever is greater.

10.7.5.1.8 Load distributions for blade loads.

The Weibull-type distribution (probability that F_{ice} exceeds $(F_{ice})_{\max}$) is used for the fatigue design of the blade.

$$P\left(\frac{F_{ice}}{(F_{ice})_{\max}} \geq \frac{F}{(F_{ice})_{\max}}\right) = \exp\left(-\left(\frac{F}{(F_{ice})_{\max}}\right)^k \ln N_{ice}\right) \qquad (10.7.5.1.8)$$

where k = 0,75 shall be used for the ice force distribution of an open propeller;
k = 1,0 for that of a ducted propeller blade;
F_{ice} = random variable for ice loads on the blade, $0 < F_{ice} < (F_{ice})_{\max}$.

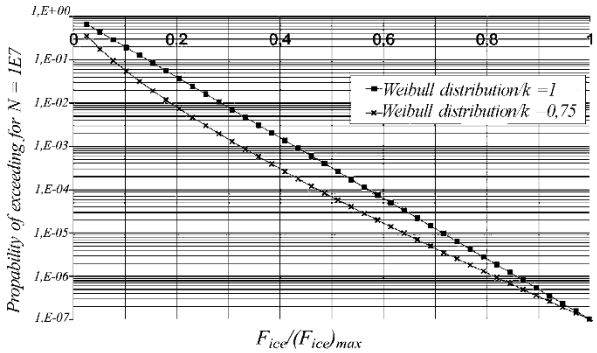


Fig. 10.7.5.1.8
The Weibull-type distribution

10.7.5.1.9 Number of ice loads.

The number of load cycles per propeller blade in the load spectrum shall be determined by the following formula:

$$N_{ice} = k_1 k_2 k_3 k_4 N_{class} n_n \qquad (10.7.5.1.9)$$

where

Ice class	**IA Super**	**IA**	**IB**	**IC**
Impacts in life N_{class}	$9 \cdot 10^6$	$6 \cdot 10^6$	$3{,}4 \cdot 10^6$	$2{,}1 \cdot 10^6$

Propeller location	Centre propeller Bow first operation	Wing propeller Bow first operation	Pulling propeller (wing and centre) Bow propeller or stern first operation
Propeller location factor k_1	1	2	3

Propeller type	open	ducted
Propeller type factor k_2	1	1,1

Type	fixed	azimuthing
Propulsion type factor k_3	1	1,2

The submersion factor k_4 is determined from the following equation:
$k_4 = 0{,}8 - f$ when $f < 0$;
$k_4 = 0{,}8 - 0{,}4f$ when $0 \le f \le 1$;
$k_4 = 0{,}6 - 0{,}2f$ when $1 < f \le 2{,}5$;
$k_4 = 0{,}1$ when $f > 2{,}5$

where the immersion function $f = \frac{h_0 - H_{ice}}{D/2} - 1$.

For components that are subject to loads resulting from propeller/ice interaction with all the propeller blades, the number of load cycles H_{ice} shall be multiplied by the number of propeller blades Z.

10.7.5.2 Axial design loads for open and ducted propellers.

10.7.5.2.1 Maximum thrusts T_f and T_b:

$T_f = 1{,}1F_f$, in kN; (10.7.5.2.1-1)

$T_b = 1{,}1F_b$, in kN. (10.7.5.2.1-2)

10.7.5.2.2 Design thrust along the propulsion shaft line.

The design thrust along the propeller shaft line T_r shall be calculated with the formulae below; the greater value of the forward and backward direction loads shall be taken as the design load for both directions. The factors 2,2 and 1,5 take into account the dynamic magnification resulting from axial vibration.

$T_r = T + 2{,}2T_f$, in kN; (10.7.5.2.2-1)

$T_r = 1{,}5T_b$, in kN. (10.7.5.2.2.-2)

If the hydrodynamic bollard thrust, T, is not known, T shall be taken as follows:

Propeller type	T
CP propellers (open)	$1{,}25T_n$
CP propellers (ducted)	$1{,}1T_n$
FP propellers driven by turbine or electric motor	T_n
FP propellers driven by diesel engine (open)	$0{,}85T_n$
FP propellers driven by diesel engine (ducted)	$0{,}75T_n$

Here T_n = nominal propeller thrust at MCR in the free running open water condition.

10.7.5.3 Torsional design loads.

10.7.5.3.1 Maximum torque on a propeller $Q_{\max}$ for open propellers.

$Q_{\max} = 10{,}9\left[1 - \frac{d}{D}\right]\left[\frac{P_{0,7}}{D}\right]^{0,16}(nD)^{0,17}D^3$, in kNm, when $D \le D_{limit}$;

$Q_{\max} = 20{,}7\left[1 - \frac{d}{D}\right]\left[\frac{P_{0,7}}{D}\right]^{0,16}(nD)^{0,17}D^{1,9}H_{ice}^{1,1}$, in kNm, when $D > D_{limit}$

where D_{limit} = $1{,}8H_{ice}$, in m;
n = rotational propeller speed in bollard condition. If not known, n shall be taken as follows:

Propeller type	n
CP propellers	n_n
FP propellers driven by turbine or electric motor	n_n
FP propellers driven by diesel engine	$0{,}85n_n$

For CP propellers, the propeller pitch, $P_{0,7}$ shall correspond to MCR in bollard condition. If not known, $P_{0,7}$ shall be taken as $0{,}7P_{0,7n}$, where $P_{0,7n}$ – propeller pitch at MCR in free running condition.

10.7.5.3.2 Maximum torque on a propeller $Q_{\max}$ for ducted propellers.

$Q_{\max} = 7{,}7\left[1 - \frac{d}{D}\right]\left[\frac{P_{0,7}}{D}\right]^{0,16}(nD)^{0,17}D^3$, in kNm, when $D \le D_{limit}$;

$Q_{\max} = 14{,}6\left[1 - \frac{d}{D}\right]\left[\frac{P_{0,7}}{D}\right]^{0,16}(nD)^{0,17}D^{1,9}H_{ice}^{1,1}$, in kNm, when $D > D_{limit}$

where D_{limit} = $1{,}8H_{ice}$, in m;
for n and $P_{0,7}$ – refer to 10.7.5.3.1.

10.7.5.3.3 Design torque for non-resonant shaft lines.

If there is no relevant first blade order torsional resonance in the operational speed range or in the range 20 % above and 20 % below the maximum operational speed (bollard condition), the following estimation of the maximum torque can be used:

in case of directly coupled two stroke diesel engines without flexible coupling

$Q_{peak} = Q_{e\max} + Q_{vib} + Q_{\max} I_e / I_t$, in kNm;

for other cases

$Q_{peak} = Q_{e\max} + Q_{\max} I_e / I_t$, in kNm.

All the torques and the inertia moments shall be reduced to the rotation speed of the component being examined.

If the maximum torque $Q_{e\max}$ is unknown, it shall be accorded the values specified in Table 10.7.5.3.3.

Table 10.7.5.3.3

Propeller type	$Q_{e\max}$
Propellers driven by electric motor	Q_{motor}
CP propellers not driven by electric motor	Q_n
FP propellers driven by turbine	Q_n
FP propellers driven by diesel engine	$0{,}75Q_n$
*Q_{motor} = the electric motor peak torque.	

10.7.5.3.4 Design torque for shaft lines having resonances

If there is first blade order torsional resonance in the operational speed range or in the range 20 % above and 20 % below the maximum operational speed (bollard condition), the design torque (Q_{peak}) of the shaft component shall be determined by means of torsional vibration analysis of the propulsion line. There are two alternative ways of performing the dynamic analysis:

time domain calculation for estimated milling sequence excitation;

frequency domain calculation for blade orders sinusoidal excitation.

The frequency domain analysis is generally considered conservative compared to the time domain simulation, provided that there is a first blade order resonance in the considered speed range.

10.7.5.3.4.1 Time domain calculation of torsional response

Time domain calculations shall be calculated for the MCR condition, MCR bollard conditions and for blade order resonant rotational speeds so that the resonant vibration responses can be obtained.

The load sequence given in this Chapter, for a case where a propeller is milling an ice block, shall be used for the strength evaluation of the propulsion line. The given load sequence is not intended for propulsion system stalling analyses.

The following load cases are intended to reflect the operational loads on the propulsion system, when the propeller interacts with ice, and the respective reaction of the complete system. The ice impact and system response causes loads in the individual shaft line components. The ice torque $Q_{\max}$ may be taken as a constant value in the complete speed range. When considerations at specific shaft speeds are performed, a relevant $Q_{\max}$ may be calculated using the relevant speed according to 10.7.5.3.

Diesel engine plants without an elastic coupling shall be calculated at the least favourable phase angle for ice versus engine excitation, when calculated in the time domain. The engine firing pulses shall be included in the calculations and their standard steady state harmonics can be used.

If there is a blade order resonance just above the MCR speed, calculations shall cover rotational speeds up to 105 % of the MCR speed.

The propeller ice torque excitation for shaft line transient dynamic analysis in the time domain is defined as a sequence of blade impacts which are of half sine shape. The excitation frequency shall follow the propeller rotational speed during the ice interaction sequence. The torque due to a single blade ice impact as a function of the propeller rotation angle is then defined using the following formula:

$Q(\varphi) = C_q Q_{\max} \sin(\varphi(180/\alpha_i))$ when $\varphi = 0 \ldots \alpha_i$ plus integer revolutions;

$Q(\varphi) = 0$ when $\varphi = \alpha_i \ldots 360$ plus integer revolutions;

φ – rotation angle from when the first impact occurs. Parameters C_q and α_i are specified in Table 10.7.5.3.4.1;

α_i = duration of propeller blade/ice interaction expressed in terms of the propeller rotation angle (refer to Fig. 10.7.5.3.4.1-1).

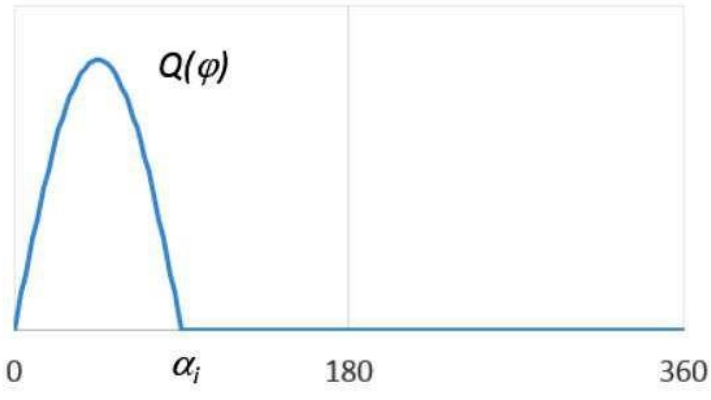


Fig. 10.7.5.3.4.1-1
Ice torque due to a single blade ice impact as a function of the propeller rotation angle.

Table 10.7.5.3.4.1

Torque excitation	Propeller/ice interaction	C_q	α_i, in deg.			
			Z=3	Z=4	Z=5	Z=6
Excitation case 1	Single ice block	0,75	90	90	72	60
Excitation case 2	Single ice block	1,0	135	135	135	135
Excitation case 3	Two ice blocks (phase shift $360/(2 \cdot Z)$, in deg.)	0,5	45	45	36	30
Excitation case 4	Single ice block	0,5	45	45	36	30

The total ice torque is obtained by summing the torque of single blades, while taking account of the phase shift 360°/Z (refer to Fig. 10.7.5.3.4.1-2). At the beginning and end of the milling sequence (within the calculated duration) linear ramp functions shall be used to increase C_q to its maximum value within one propeller revolution and vice versa to decrease it to zero (for examples, refer to Figs. 10.7.5.3.4.1-2 and 10.7.5.3.4.1-3).

The number of propeller revolutions during a milling sequence shall be calculated by the following formula:

$$N_Q = 2H_{ice}.$$

For blade order excitation, the number of impacts is $Z \cdot N_Q$.

A dynamic simulation shall be performed for all excitation cases at the operational rotational speed range. For a fixed pitch propeller propulsion plant, a dynamic simulation shall also cover the bollard pull condition with a corresponding rotational speed assuming the maximum possible output of the engine.

If a speed drop occurs until the main engine is at a standstill, this indicates that the engine may not be sufficiently powered for the intended service task. For the consideration of loads, the maximum occurring torque during the speed drop process shall be used.

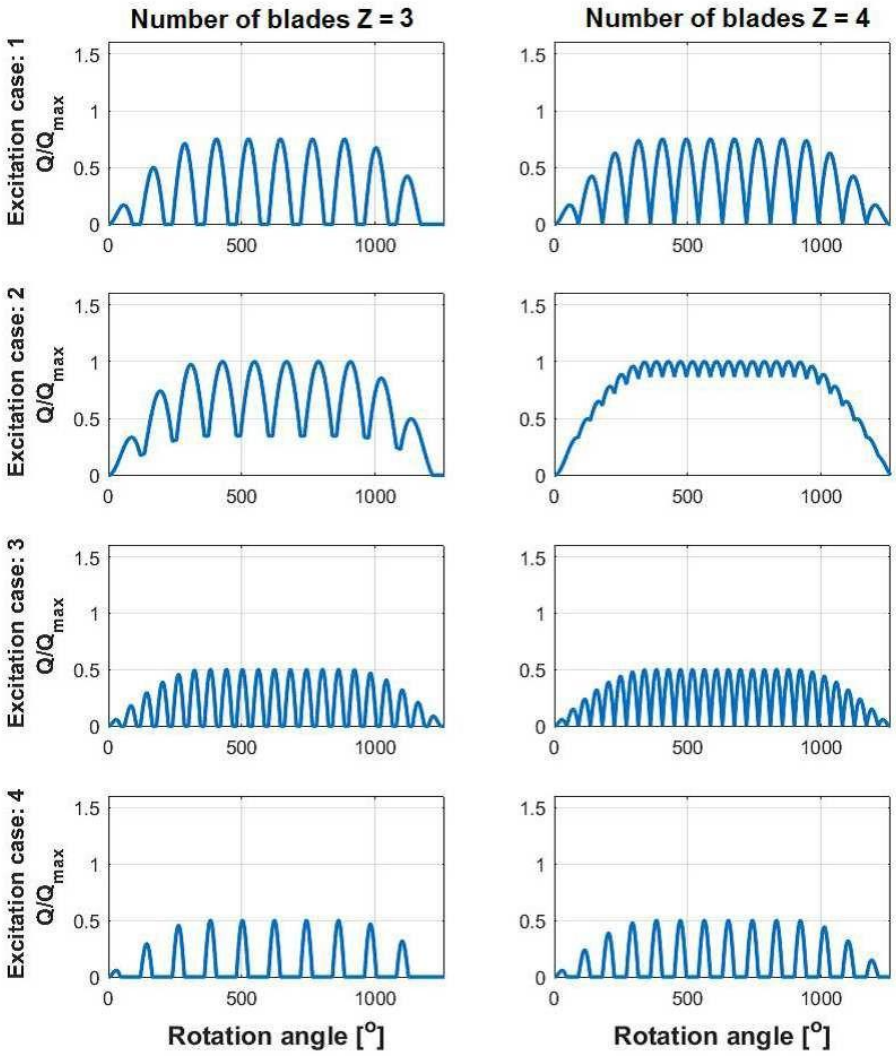


Fig. 10.7.5.3.4.1-2
Propeller ice torque excitation for propellers with 3 and 4 blades

For the time domain calculation, the simulated response torque typically includes the engine mean torque and the propeller mean torque. If this is not the case, the response torques

shall be obtained using the formula:

$$Q_{peak} = Q_{e\max} + Q_{rtd}$$

where Q_{rtd} = maximum simulated torque obtained from the time domain analysis.

10.7.5.3.4.2 Frequency domain calculation of torsional response

For frequency domain calculations, blade order and twice-the-blade-order excitation may be used. The amplitudes for the blade order and twice-the-blade-order sinusoidal excitation have been derived based on the assumption that the time domain half sine impact sequences were continuous, and the Fourier series components for blade order and twice-the-blade-order components have been derived.

The propeller ice torque is then:

$$Q_F(\varphi) = Q_{\max}\left(C_{q0} + C_{q1}\sin(ZE_0\varphi + \alpha_1) + C_{q2}\sin(2ZE_0\varphi + \alpha_2)\right), \text{ in kNm}$$

where the number of ice blocks in contact E_0 and the coefficient values are specified in Table 10.7.5.3.4.2.

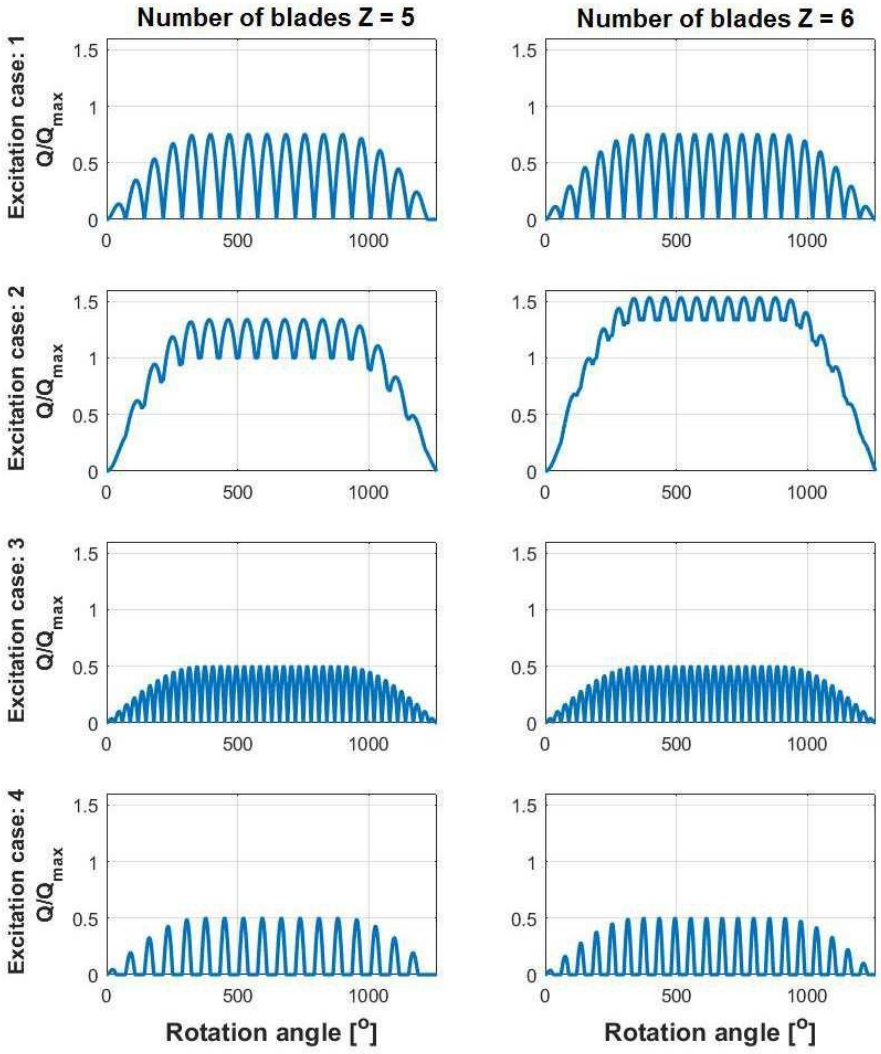


Fig. 10.7.5.3.4.1-3
Propeller ice torque excitation for propellers with 5 and 6 blades

The design torque for the frequency domain excitation case shall be obtained using the formula:

$$Q_{peak} = Q_{e\max} + Q_{vib} + \left(Q^{n}_{\max} C_{q0}\right) I_e / I_t + Q_{rf1} + Q_{rf2}$$

where $Q^{n}_{\max}$ = maximum propeller ice torque at the operation speed in consideration;
C_{q0} = coefficient with the values specified in Table 10.7.5.3.4.2;
Q_{rf1} = blade order torsional response from the frequency domain analysis;
Q_{rf2} = second order blade torsional response from the frequency domain analysis.

If the prime mover maximum torque $Q_{e\max}$ is not known, it shall be taken as given in Table 10.7.5.3.3.

10.7.5.3.4.3 Guidance for torsional vibration calculation.

The aim of time domain torsional vibration simulations shall estimate the extreme torsional load for the ship's lifespan. The simulation model can be taken from the normal lumped mass elastic torsional vibration model, including damping. For a time domain analysis, the model should include the ice excitation at the propeller, other relevant excitations and the mean torques provided by the prime mover and hydrodynamic mean torque in the propeller. The calculations should cover variation of phase between the ice excitation and prime mover excitation. This is extremely relevant to propulsion lines with directly driven combustion engines. Time domain calculations shall be calculated for the MCR condition, MCR bollard conditions and for resonant speed, so that the resonant vibration responses can be obtained.

Table 10.7.5.3.4.2

Torque excitation	C_{q0}	C_{q1}	α_1	C_{q2}	α_2	E_0
Torque excitation (Z=3)						
Excitation case 1	0,375	0,36	-90	0	0	1
Excitation case 2	0,7	0,33	-90	0,05	-45	1
Excitation case 3	0,25	0,25	-90	0	0	2
Excitation case 4	0,2	0,25	0	0,05	-90	1
Torque excitation (Z=4)						
Excitation case 1	0,45	0,36	-90	0,06	-90	1
Excitation case 2	0,9375	0	-90	0,0625	-90	1
Excitation case 3	0,25	0,25	-90	0	0	2
Excitation case 4	0,2	0,25	0	0,05	-90	1
Torque excitation (Z=5)						
Excitation case 1	0,45	0,36	-90	0,06	-90	1
Excitation case 2	1,19	0,17	-90	0,02	-90	1
Excitation case 3	0,3	0,25	-90	0,048	-90	2
Excitation case 4	0,2	0,25	0	0,05	-90	1
Torque excitation (Z=6)						
Excitation case 1	0,45	0,36	-90	0,05	-90	1
Excitation case 2	1,435	0,1	-90	0	0	1
Excitation case 3	0,3	0,25	-90	0,048	-90	2
Excitation case 4	0,2	0,25	0	0,05	-90	1

For frequency domain calculations, the load shall be estimated as a Fourier component analysis of the continuous sequence of half sine load sequences. First and second order blade components shall be used for excitation.

The calculation shall cover the entire relevant rpm range and the simulation of responses at torsional vibration resonances.

10.7.5.4 Blade failure load.

10.7.5.4.1 Bending force F_{ex}.

The ultimate load resulting from blade failure as a result of plastic bending around the blade root shall be calculated using Formula (10.7.5.4.1), or alternatively by means of an

appropriate stress analysis, reflecting the non-linear plastic material behaviour of the actual blade. In such a case, the blade failure area may be outside the root section. The ultimate load is assumed to be acting on the blade at the 0,8*R* radius in the weakest direction of the blade.

$$F_{ex} = \frac{300ct^2\sigma_{ref}}{0{,}8D-2r}, \text{ in kN} \qquad (10.7.5.4.1)$$

where c, t, and r are determined for the weakest blade section outside the root filet.

10.7.5.4.2 Spindle torque Q_{sex}.

The maximum spindle torque due to a blade failure load acting at 0,8 R shall be determined. The force that causes blade failure typically reduces when moving from the propeller centre towards the leading and trailing edges. At a certain distance from the blade centre of rotation, the maximum spindle torque will occur. This maximum spindle torque shall be defined by an appropriate stress analysis or using the equation given below.

$$Q_{sex} = \max\left(C_{LE0,8}; 0{,}8C_{TE0,8}\right) C_{spex} F_{ex}, \text{ in kNm;}$$

$$C_{spex} = 0{,}7(1-(4EAR/Z)^3)$$

where EAR = expanded blade area ratio.
If C_{spex} = below 0,3, a value of 0,3 shall to be used for C_{spex}.
$C_{LE0,8}$ = the leading edge portion of the chord length at 0,8R
$C_{TE0,8}$ = the trailing edge portion of the chord length at 0,8R.

The spindle torque values due to blade failure loads across the entire chord length are shown in Fig. 10.7.5.4.2.

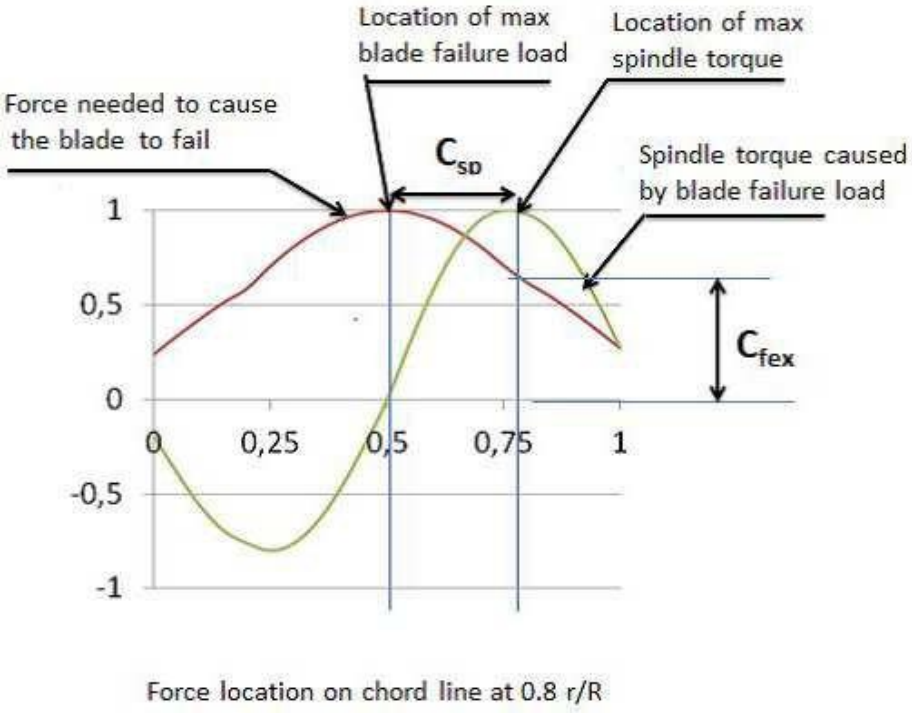


Fig. 10.7.5.4.2
Blade failure load and the related spindle torque when the force acts at a different location on the chord line at radius 0,8R

10.7.6 Design.

10.7.6.1 Design principle.

The strength of the propulsion line shall be designed according to the pyramid strength principle. This means that the loss of the propeller blade shall not cause any significant damage to other propeller shaft line components.

10.7.6.2 Propeller blade.

10.7.6.2.1 Calculation of blade stresses.

The blade stresses shall be calculated for the design loads given in 10.7.5.1.

Finite element analysis shall be used for stress analysis for final approval for all propellers. The following simplified formulae can be used in estimating the blade stresses for all propellers at the root area ($r/R < 0{,}5$). The root area dimensions based on Formula (10.7.6.2.1) can be accepted even if the FEM analysis would show greater stresses at the root area.

$$\sigma_{st} = C_1 \frac{M_{BL}}{100ct^2}, \text{ in MPa} \qquad (10.7.6.2.1)$$

where $C_1 = \frac{\text{actual stress}}{\text{stress obtained with beam equation}}$. If the actual value is not available, C_1 shall be taken as 1,6.

$$M_{BL} = (0{,}75 - r/R) \cdot R \cdot F$$

where $F = F_b$ or F_f, whichever is greater.

10.7.6.2.2 Acceptability criterion.

The following criterion for calculated blade stresses shall be fulfilled:

$$\frac{\sigma_{ref2}}{\sigma_{st}} \geq 1{,}3.$$

If FEM analysis is used in estimating the stresses, von Mises stresses shall be used.

10.7.6.2.3 Fatigue design of propeller blade.

The fatigue design of the propeller blade is based on an estimated load distribution for the service life of the ship and the *SN*-curve for the blade material. An equivalent stress that produces the same fatigue damage as the expected load distribution shall be calculated and the acceptability criterion for fatigue shall be fulfilled. The equivalent stress is normalised for 10^8 cycles.

If the following criterion is fulfilled, fatigue calculations according to this Chapter are not required.

$$\sigma_{exp} \geq B_1 {\sigma_{ref2}}^{B_2} \log(N_{ice})^{B_3}$$

where B_1, B_2 and B_3 = coefficients for open and ducted propellers are given in Table 10.7.6.2.3-1.

Table 10.7.6.2.3-1

	Open propeller	Ducted propeller
B_1	0,00328	0,00223
B_2	1,0076	1,0071
B_3	2,101	2,471

For calculation of equivalent stress two types of *SN*-curves are available:
two slope *SN*-curve (slopes 4,5 and 10), refer to Fig. 10.7.6.2.3-1;
one slope *SN*-curve (the slope can be chosen), refer to Fig. 10.7.6.2.3-2.

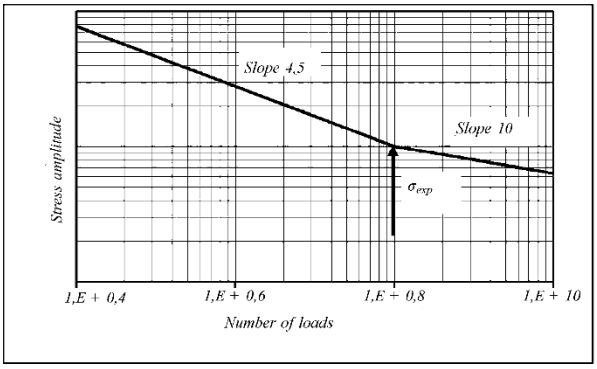


Fig. 10.7.6.2.3-1
Two-slope *SN*-curve

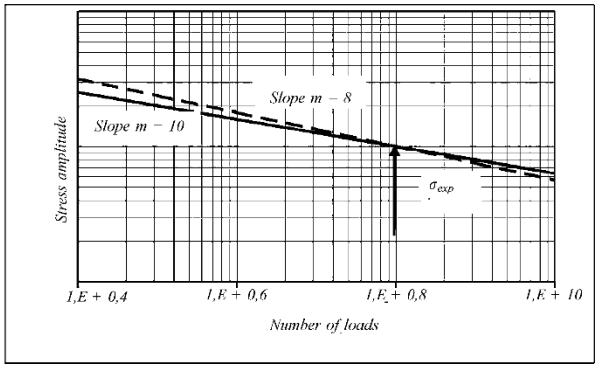


Fig. 10.7.6.2.3-2
Constant-slope *SN*-curve

The type of the *SN*-curve shall be selected to correspond to the material properties of the blade. If the *SN*-curve is not known, the two slope *SN*-curve shall be used.

10.7.6.2.3.1 Equivalent fatigue stress.

The equivalent fatigue stress for 10^8 stress cycles which produces the same fatigue damage as the load distribution is:

$$\sigma_{fat} = \rho(\sigma_{ice})_{\max} \qquad (10.7.6.2.3.1)$$

where $(\sigma_{ice})_{\max} = 0{,}5\left((\sigma_{ice})_{f\max} - (\sigma_{ice})_{b\max}\right)$.

In calculation of $(\sigma_{ice})_{\max}$, case 1 and case 3 (or case 2 and case 4) are considered as a pair for $(\sigma_{ice})_{f\max}$ and $(\sigma_{ice})_{b\max}$ calculations. Case 5 is excluded from the fatigue analysis.

10.7.6.2.3.2 Calculation of parameter ρ for two-slope *SN*-curve.

The parameter ρ relates the maximum ice load to the distribution of ice loads according to the regression formula

$$\rho = C_1(\sigma_{ice})_{\max}^{C_2}\sigma_{fl}^{C_3}\log(N_{ice})^{C_4} \qquad (10.7.6.2.3.2)$$

where $\sigma_{fl} = \gamma_\varepsilon\gamma_\nu\gamma_m\sigma_{exp}$.

The following values shall be used for the reduction factors if actual values are not available: γ_ε = 0,67, γ_ν = 0,75 and γ_m = 0,75.

The coefficients C_1, C_2, C_3 and C_4 are given in Table 10.7.6.2.3.2.

Table 10.7.6.2.3.2

	Open propeller	Ducted propeller
C_1	0,000747	0,000534
C_2	0,0645	0,0533
C_3	– 0,0565	– 0,0459
C_4	2,22	2,584

10.7.6.2.3.3 Calculation of parameter ρ for constant-slope *SN*-curve.

For materials with a constant-slope *SN*-curve, the factor ρ shall be calculated from the formula

$$\rho = \left(G\frac{N_{ice}}{N_R}\right)^{1/m}(\ln(N_{ice}))^{-1/k} \qquad (10.7.6.2.3.3)$$

where k =1,0 for ducted propellers;
k = 0,75 for open propellers.

Values for the parameter G are given in Table 10.7.6.2.3.3. Linear interpolation may be used to calculate the value for other m/k ratios than given in Table 10.7.6.2.3.3.

Table 10.7.6.2.3.3

Value for the parameter *G* for different m/k ratios

m/k	3	3,5	4	4,5	5	5,5	6	6,5	7	7,5	8	8,5	9	9,5	10	10,5	11	11,5	12
G	6	11,6	24	52,3	120	287,9	720	1871	5040	14034	40320	119292	362880	$1{,}133 \cdot 10^6$	$3{,}629 \cdot 10^6$	$11{,}899 \cdot 10^6$	$39{,}917 \cdot 10^6$	$136{,}843 \cdot 10^6$	$479{,}002 \cdot 10^6$

10.7.6.2.4 Acceptability criterion for fatigue.

The equivalent fatigue stress at all locations on the blade shall fulfil the following acceptability criterion

$$\frac{\sigma_{fl}}{\sigma_{fat}} \geq 1{,}5$$

where $\sigma_{fl} = \gamma_{\epsilon 1}\gamma_{\epsilon 2}\gamma_{\nu}\gamma_{\mathrm{m}}\sigma_{exp}$.

The following values shall be used for the reduction factors if actual values are not available: $\gamma_{\epsilon}=\gamma_{\epsilon 1}\gamma_{\epsilon 2}$ = 0,67, γ_{ν} = 0,75 and γ_{m} = 0,75.

10.7.6.3 Propeller bossing and CP mechanism.

The blade bolts, the CP mechanism, the propeller boss, and the fitting of the propeller to the propeller shaft shall be designed to withstand the maximum and fatigue design loads, as defined in 10.7.5.

The safety factor against yielding shall be greater than 1,3 and that against fatigue greater than 1,5. In addition, the safety factor for loads resulting from loss of the propeller blade through plastic bending as defined in 10.7.5.4 shall be greater than 1,0 against yielding.

10.7.6.4 Propulsion shaft line.

The shafts and shafting components, such as the thrust and sterntube bearings, couplings, flanges and sealings, shall be designed to withstand the propeller/ice interaction loads as given in 10.7.5. The safety factor against yielding shall be at least 1,3 and that against fatigue greater than 1,5; the safety factor for loads resulting from loss of the propeller blade through plastic bending shall be greater than 1,0.

10.7.6.4.1 Shafts and shafting components.

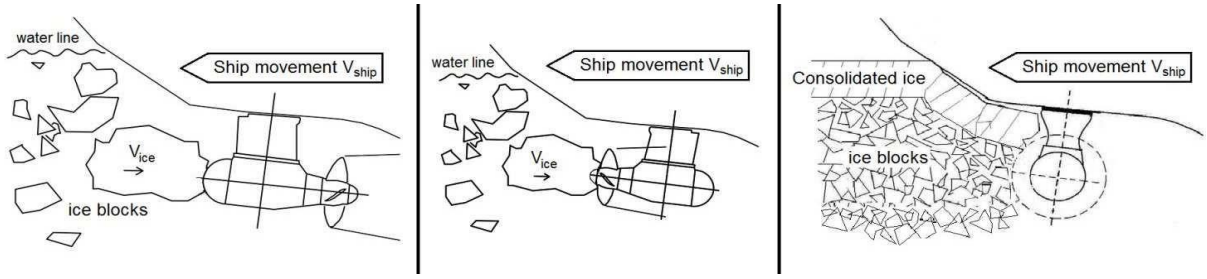
The ultimate load resulting from total blade failure as defined in 10.7.5.4 shall not cause yielding in shafts and shaft components. The loading shall consist of the combined axial, bending, and torsion loads, wherever this is significant. The minimum safety factor against yielding shall be not less than 1,0 for bending and torsional stresses.

10.7.6.5 Azimuthing main propulsors.

10.7.6.5.1 Design principle.

In addition to the above requirements for propeller blade dimensioning, azimuthing thrusters shall be designed for thruster body/ice interaction loads. Load formulae are given for estimating once in a lifetime extreme loads on the thruster body, based on the estimated ice condition and ship operational parameters. Two main ice load scenarios have been selected for defining the extreme ice loads. Examples of loads are illustrated in Fig. 10.7.6.5.1. In addition, blade order thruster body vibration responses may be estimated for propeller excitation. The following load scenario types are considered:

.1 ice block impact on the thruster body or propeller hub;
.2 thruster penetration into an ice ridge that has a thick consolidated layer;
.3 vibratory response of the thruster at blade order frequency.



Impact on thruster body | Impact on proper hub | Thruster penetration into the ice ridge

Fig. 10.7.6.5.1
Examples of load scenario types

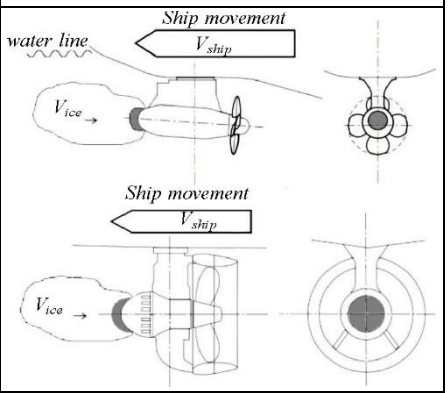
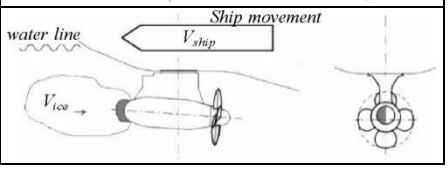
The steering mechanism, the fitting of the unit, and the body of the thruster shall be designed to withstand the plastic bending of a blade without damage. The loss of a blade shall be taken into account for the propeller blade orientation causing the maximum load on the component being studied. Top-down blade orientation typically places the maximum bending loads on the thruster body.

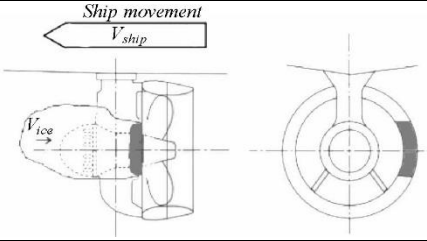
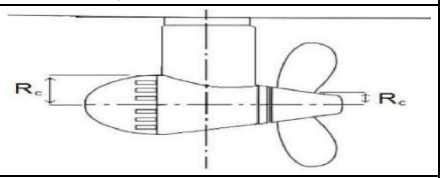
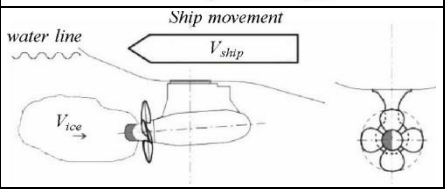
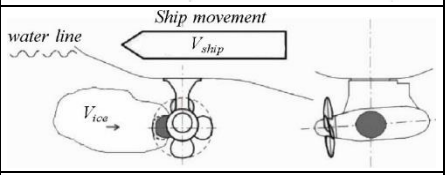
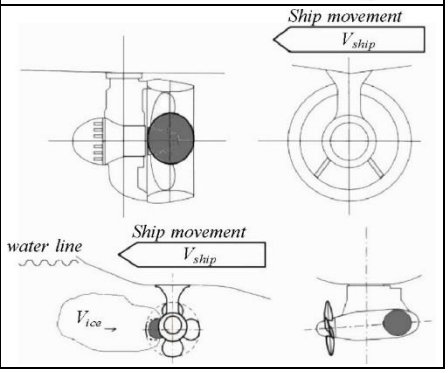
10.7.6.5.2 Extreme ice impact loads.

When the ship is operated in ice conditions, ice blocks formed in channel side walls or from the ridge consolidated layer may impact on the thruster body and the propeller hub. Exposure to ice impact is very much dependent on the ship size and ship hull design, as well as the location of the thruster. The contact force will grow in terms of thruster/ice contact until the ice block reaches the ship speed.

The thruster shall withstand the loads occurring when the design ice block defined in Table 10.7.3-2 impacts on the thruster body when the ship is sailing at a typical ice operating speed. Load cases for impact loads are given in Table 10.7.6.5.2-1. The contact geometry is estimated to be hemispherical in shape. If the actual contact geometry differs from the shape of the hemisphere, a sphere radius shall be estimated so that the growth of the contact area as a function of penetration of ice corresponds as closely as possible to the actual geometrical shape penetration.

Table 10.7.6.5.2-1

Load case	Force	Loaded area	Interaction pattern
Load case T1a Symmetric longitudinal ice impact on thruster	F_{ti}	Uniform distributed load or uniform pressure, which are applied symmetrically on the impact area	
Load case T1b Non-symmetric longitudinal ice impact on thruster	50 % of F_{ti}	Uniform distributed load or uniform pressure, which are applied on the other half of the impact area	

Load case	Force	Loaded area	Interaction pattern
Load case T1c Non-symmetric longitudinal ice impact on nozzle	F_{ti}	Uniform distributed load or uniform pressure, which are applied on the impact area. Contact area is equal to the nozzle thickness (H_{nz})*the contact height (H_{ice})	
Load case T2a Symmetric longitudinal ice impact on propeller hub	F_{ti}	Uniform distributed load or uniform pressure, which are applied symmetrically on the impact area	
Load case T2b Non-symmetric longitudinal ice impact on propeller hub	50 % of F_{ti}	Uniform distributed load or uniform pressure, which are applied on the other half of the impact area	
Load case T3a Symmetric lateral ice impact on thruster body	F_{ti}	Uniform distributed load or uniform pressure, which are applied symmetrically on the impact area	
Load case T3b Non-symmetric lateral ice impact on thruster body or nozzle	F_{ti}	Uniform distributed load or uniform pressure, which are applied on the impact area. Nozzle contact radius R to be taken from the nozzle length (L_{nz})	

The ice impact contact load shall be calculated using Formula (10.7.6.5.2). The related parameter values are given in Table 10.7.6.5.2-2. The design operation speed in ice can be derived from Tables 10.7.6.5.2-3 and 10.7.6.5.2-4, or the ship in question's actual design operation speed in ice can be used. The longitudinal impact speed in Tables 10.7.6.5.2-3 and 10.7.6.5.2-4 refers to the impact in the thruster's main operational direction. For the pulling propeller configuration, the longitudinal impact speed is used for load case T2, impact on hub; and for the pushing propeller unit, the longitudinal impact speed is used for load case T1, impact on thruster and cap. For the opposite direction, the impact speed for transversal impact is applied.

$$F_{ti} = C_{DMI} 34{,}5 R_c^{0,5} (m_{ice} v_s^2)^{0,333}, \text{ in kN} \qquad (10.7.6.5.2)$$

where R_c = the impacting part sphere radius, in m (refer to Fig. 10.7.6.5.2);
m_{ice} = the ice block mass, in kg;
v_s = the ship speed at the time of contact, in m/s;
C_{DMI} = the dynamic magnification factor for impact loads.

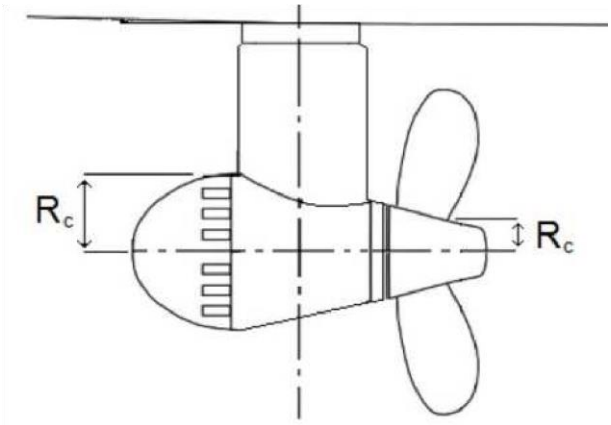


Fig. 10.7.6.5.2
Dimensions used for R_c

C_{DMI} shall be taken from Table 10.7.6.5.2-2, if unknown.

For impacts on non-hemispherical areas, such as the impact on the nozzle, the equivalent impact sphere radius shall be estimated using the equation below.

$R_{ceq} = (A/\pi)^{1/2}$, in m.

If the 2*R_{ceq} is greater than the ice block thickness, the radius is set to half of the ice block thickness. For the impact on the thruster side, the pod body diameter can be used as a basis for determining the radius. For the impact on the propeller hub, the hub diameter can be used as a basis for the radius.

Table 10.7.6.5.2-2

Baltic ice class	**IA Super**	**IA**	**IB**	**IC**
Thickness of the design ice block impacting thruster (2/3 of H_{ice}), in m	1,17	1,0	0,8	0,67
Extreme ice block mass m_{ice}, in kg	8670	5460	2800	1600
C_{DMI} (if unknown)	1,3	1,2	1,1	1

10.7.6.5.3 Extreme ice loads on thruster hull when penetrating an ice ridge.

In icy conditions, ships typically operate in ice channels. When passing other ships, ships may be subject to loads caused by their thrusters penetrating ice channel walls. There is usually a consolidated layer at the ice surface, below which the ice blocks are loose. In addition, the thruster may penetrate ice ridges when backing. Such a situation is likely in the case of **IA Super** ships in particular, because they may operate independently in difficult ice conditions. However, the thrusters in ships with lower ice classes may also have to withstand such a situation, but at a remarkably lower ship speed.

Table 10.7.6.5.2-3

Impact speeds for aft centerline thruster

Baltic ice class	**IA Super**	**IA**	**IB**	**IC**
Longitudinal impact in main operational direction, in m/s	6	5	5	5
Longitudinal impact in reversing direction (pushing unit propeller hub or pulling unit cover and cap impact), in m/s	4	3	3	3
Transversal impact in bow first operation, in m/s	3	2	2	2
Transversal impact in stern first operation (double acting ship), in m/s	4	3	3	3

Table 10.7.6.5.2-4

Impact speeds for aft wing, bow centerline and bow wing thrusters

Baltic ice class	**IA Super**	**IA**	**IB**	**IC**
Longitudinal impact in main operational direction, in m/s	6	5	5	5
Longitudinal impact in reversing direction (pushing unit propeller hub or pulling unit cover and cap impact), in m/s	4	3	3	3
Transversal impact, in m/s	4	3	3	3

In this load scenario, the ship is penetrating a ridge in thruster first mode with an initial speed. This situation occurs when a ship with a thruster at the bow moves forward, or a ship with a thruster astern moves in backing mode. The maximum load during such an event is considered the extreme load. An event of this kind typically lasts several seconds, due to which the dynamic magnification is considered negligible and shall not be taken into account.

The load magnitude shall be estimated for the load cases shown in Table 10.7.6.5.3-1, using Formula (10.7.6.5.3). The parameter values for calculations are given in Table 10.7.6.5.3-2 and Table 10.7.6.5.3-3. The loads shall be applied as uniform distributed load or uniform pressure over the thruster surface. The design operation speed in ice can be derived from Table 10.7.6.5.3-2 or Table 10.7.6.5.3-3. Alternatively, the actual design operation speed in ice of the ship in question can be used.

$$F_{tr} = 32 v_s^{0,66} H_r^{0,9} A_t^{0,74}, \text{ kN} \qquad (10.7.6.5.3)$$

where v_s = ship speed, in m/s;
H_r = design ridge thickness (the thickness of the consolidated layer is 18 % of the total ridge thickness), in m;
A_t = projected area of the thruster, in m^2.

When calculating the contact area for thruster-ridge interaction, the loaded area in the vertical direction is limited to the ice ridge thickness, as shown in Fig. 10.7.6.5.3.

10.7.6.5.4 Acceptability criterion for static loads.

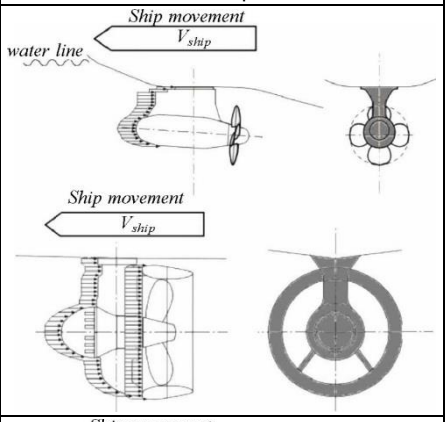
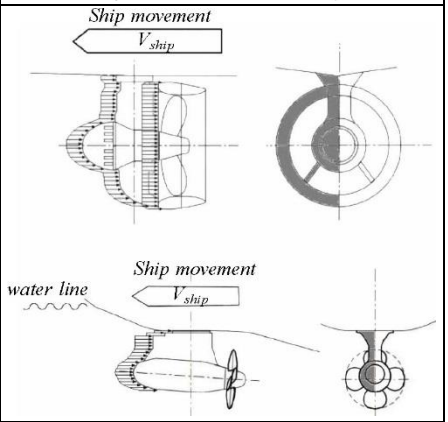
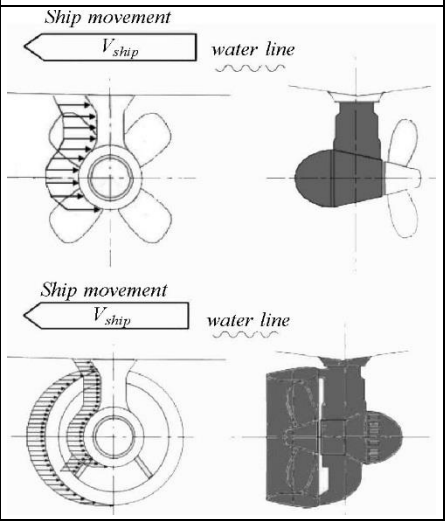
The stresses on the thruster shall be calculated for the extreme once-in-a-lifetime loads described in 10.7.6.5. The nominal von Mises stresses on the thruster body shall have a safety margin of 1,3 against the yielding strength of the material. At areas of local stress concentrations, stresses shall have a safety margin of 1,0 against yielding. The slewing bearing, bolt connections and other components shall be able to maintain operability without incurring damage that requires repair when subject to the loads given in 10.7.6.5.2 and 10.7.6.5.3 multiplied by a safety factor of 1,3.

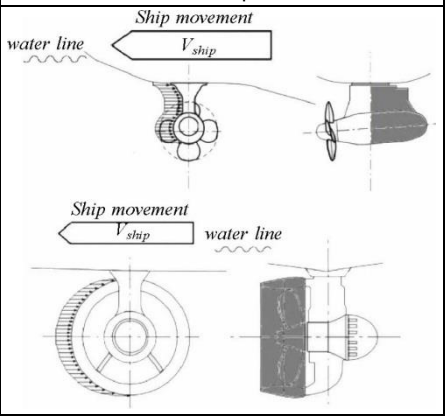
10.7.6.5.5 Thruster body global vibration.

Evaluating the global vibratory behavior of the thruster body is important, if the first blade order excitations are in the same frequency range with the thruster global modes of vibration, which occur when the propeller rotational speeds are in the high power range of the propulsion line.

Table 10.7.6.5.3-1

Load cases for ridge ice loads

Load case	Force	Loaded area	Interaction pattern
Load case T4a Symmetric longitudinal ridge penetration loads	F_{tr}	Uniform distributed load or uniform pressure, which are applied on the other half of the contact area	
Load case T4b Non-symmetric longitudinal ridge penetration loads	50 % of F_{tr}	Uniform distributed load or uniform pressure, which are applied on the other half of the contact area	
Load case T5a Symmetric lateral ridge penetration loads for ducted azimuthing unit and pushing open propeller unit	F_{tr}	Uniform distributed load or uniform pressure, which are applied symmetrically on the contact area	

Load case	Force	Loaded area	Interaction pattern
Load case T5b Non-symmetric lateral ridge penetration loads for all azimuthing units	50 % of F_{tr}	Uniform distributed load or uniform pressure, which are applied on the other half of the contact area	

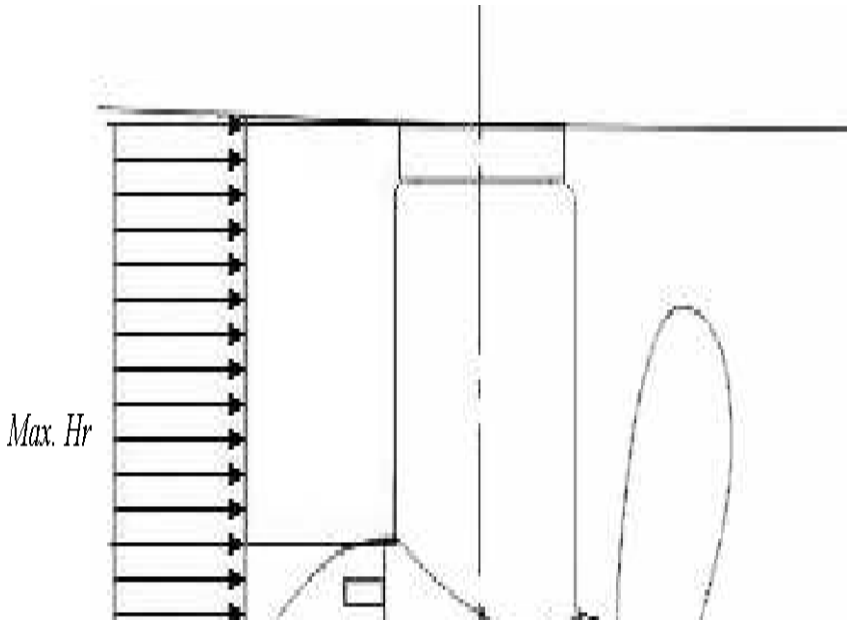


Fig. 10.7.6.5.3
The reduction of the contact area by the maximum ridge thickness.

Table 10.7.6.5.3-2

Parameters for calculating maximum loads when the thruster penetrates an ice ridge. Aft thrusters. Bow first operation

Baltic ice class	**IA Super**	**IA**	**IB**	**IC**
Thickness of the design ridge consolidated layer, in m	1,5	1,5	1,2	1,0
Total thickness of the design ridge, H_r, in m	8	8	6,5	5
Initial ridge penetration speed (longitudinal loads), in m/s	4	2	2	2
Initial ridge penetration speed (transversal loads), in m/s	2	1	1	1

Table 10.7.6.5.3-3

Parameters for calculating maximum loads when the thruster penetrates an ice ridge. Thruster first mode such as double acting ships

Baltic ice class	**IA Super**	**IA**	**IB**	**IC**
Thickness of the design ridge consolidated layer, in m	1,5	1,5	1,2	1,0
Total thickness of the design ridge H_r, in m	8	8	6,5	5
Initial ridge penetration speed (longitudinal loads), in m/s	6	4	4	4
Initial ridge penetration speed (transversal loads), in m/s	3	2	2	2

This evaluation is mandatory and it shall be shown that there is either no global first blade order resonance at high operational propeller speeds (above 50 % of maximum power) or that the structure is designed to withstand vibratory loads during resonance above 50 % of maximum power.

When estimating thruster global natural frequencies in the longitudinal and transverse direction, the damping and added mass due to water shall be taken into account. In addition to this, the effect of ship attachment stiffness shall be modelled.

10.7.7 Alternative design procedure.

10.7.7.1 Scope of application.

As an alternative to 10.7.5 and 10.7.6, a comprehensive design study may be carried out upon agreement with the Register. The study may be based on ice conditions given for different ice classes in 10.7.3, include fatigue and maximum load design calculations and fulfil the pyramid strength principle, as given in 10.7.6.1.

10.7.7.2 Loading.

Loads on the propeller blade and propulsion system shall be based on an acceptable estimation of hydrodynamic and ice loads.

10.7.7.3 Design levels.

The analysis shall indicate that all components transmitting random (occasional) forces, excluding propeller blade, are not subjected to stress levels in excess of the yield stress of the component material, with a reasonable safety margin. Cumulative fatigue damage calculations shall indicate a reasonable safety factor. Due account shall be taken of material properties, stress raisers, and fatigue enhancements.

Vibration analysis shall be carried out and shall indicate that the complete dynamic system is free from harmful torsional resonances resulting from propeller/ice interaction.

10.8 MISCELLANEOUS MACHINERY REQUIREMENTS

10.8.1 Starting arrangements.

The capacity of the air receivers shall be sufficient to provide without reloading not less than 12 consecutive starts of the propulsion engine, if this has to be reversed for going astern, or 6 consecutive starts if the propulsion engine does not have to be reversed for going astern.

If the air receivers serve any other purposes than starting the propulsion engine, they shall have additional capacity sufficient for these purposes.

The capacity of the air compressors shall be sufficient for charging the air receivers from atmospheric to full pressure in 1 h, except for a ship with the ice class **IA Super**, if its propulsion engine shall be reversed for going astern, in which case the compressor shall be able to charge the receivers in 30 min.

10.8.2 Cooling water system.

The cooling water system shall be designed to ensure supply of cooling water when navigating in ice.

For this purpose at least one cooling water inlet chest shall be arranged as follows:

.1 the sea inlet shall be situated near the centreline of the ship and well aft if possible;

.2 as guidance for design the volume of the chest shall be about 1 m^3 for every 750 kW engine output of the ship including the output of auxiliary engines necessary for the ship's service;

.3 the chest shall be sufficiently high to allow ice to accumulate above the inlet pipe;

.4 a pipe for discharge cooling water, allowing full capacity discharge, shall be connected to the chest;

.5 the open area of the strainer plates shall not be less than four times the inlet pipe sectional area.

If there are difficulties to meet the requirements of 10.8.2.2 and 10.8.2.3, two smaller chests may be arranged for alternating intake and discharge of cooling water, at that the requirements in 10.8.2.1, 10.8.2.4 and 10.8.2.5 shall be met.

Heating coils may be installed in the upper part of the sea chest.

Arrangements for using ballast water for cooling purposes may be useful as a reserve in ballast condition but cannot be accepted as a substitute for a sea inlet chest as described above.

APPENDIX

ICE CLASS DRAUGHT MARKING

Subject to 10.3.2, the ship's sides shall be provided with a warning triangle and with a draught mark at the maximum permissible ice class draught amidships (refer to Fig.). The purpose of the warning triangle is to provide information on the draught limitation of the vessel when it is sailing in ice for masters of icebreakers and for inspection personnel in ports.

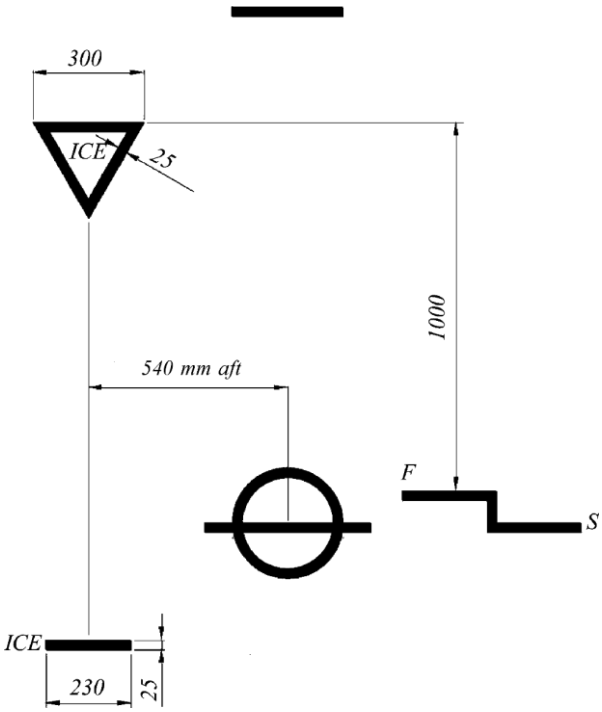


Fig.
Ice class draught marking

N o t e s: 1. The upper edge of the warning triangle shall be located vertically above the "ICE" mark, 1000 mm higher than the summer load line in fresh water but in no case higher than the deck line. The sides of the triangle shall be 300 mm in length.

2. The ice class draught mark shall be located 540 mm abaft the centre of the load line ring or 540 mm abaft the vertical line of the timber load line mark, if applicable.

3. The marks and figures shall be cut out of 5 — 8 mm plate and then welded to the ship's side. The marks and figures shall be painted in a red or yellow reflecting colour in order to make the marks and figures plainly visible even in ice conditions.

4. The dimensions of all letters shall be the same as those used in the load line mark.

11 REQUIREMENTS FOR LNG BUNKERING SHIPS

11.1 GENERAL PROVISIONS AND SCOPE OF APPLICATION

11.1.1 These requirements apply to the gas carriers engaged in transportation of liquefied natural gas (LNG) and intended to ensure the transfer of LNG on board the ships using LNG as a fuel (hereinafter referred to as "LNG bunkering ships").

A descriptive notation and distinguishing marks specified in 2.2.45.13, Part I "Classification" may be added to LNG bunkering ships complying with these requirements.

11.1.2 Descriptive notations and distinguishing marks in the class notation of LNG bunkering ships.

For gas carrier complying with the requirements of this Section, except Chapter 11.13, the descriptive notation **LNG bunkering ship** may be added to the class notation after the descriptive notation **Gas carrier**.

When additional functions related to servicing of ships using LNG as a fuel are available on board the ship and when the ship meets the requirements specified in 11.13, the one of the following (or several) distinguishing marks may be added to the character of classification. When additional functions related to servicing of ships using LNG as a fuel are available on board and when the LNG bunkering ship meets the requirements specified in 11.13, one of the following (or several) distinguishing marks shall be introduced in the class notation **LNG bunkering ship**:

RE – where the ship is designed to receive LNG from a gas fuelled ship for which the LNG fuel tanks shall be emptied;

IG-Supply – where the ship is designed to supply inert gas and dry air, to ensure gas-freeing and aeration in compliance with 6.10.4 of the International Code of Safety for Ships Using Gases or Other Low Flashpoint Fuels (IGF Code);

BOG – where boil-off gas generated during the bunkering operation are provided on board the ship.

11.1.3 Definitions.

L N G b u n k e r i n g s t a t i o n means space fitted with the following equipment:

hoses and piping connections used for liquid and vapour return lines, including the isolation shut-off valves and the emergency shut-down valves;

automation and alarm systems;

drip tray with its draining arrangement and other arrangements and systems intended for the ship structure protection;

gas and LNG leak detection systems;

associated fire-fighting systems.

L N G b u n k e r i n g c o n t r o l r o o m means a control room positioned in a safe location and intended for control of cargo pumps and valves, as well as where indication of fuel tank level and overfill alarm are provided.

E m e r g e n c y s h u t d o w n s y s t e m (E S D) means a system that safely and effectively stops the transfer of LNG and cargo vapour between the receiving ship and the bunkering ship in the event of an emergency during the bunkering operation, and puts the system in a safe condition.

B u n k e r i n g c o n n e c t i o n s mean liquid and vapour connections between ships used for liquid product transfer to receiving ship and product vapour return to the LNG bunkering ship (i.e. manifold for a system with flexible hose and before the swivel for a system with transfer arm).

E m e r g e n c y r e l e a s e c o u p l i n g (E R C) means a coupling located on the receiving ship bunkering manifold or on the LNG transfer system, which separates at a

predetermined section, when required, each separated section containing a self-closing shut-off valve, which seals automatically. An emergency release coupling can be activated:

by maximal allowable forces applied to the predetermined section;

by manual or automatic control, in case of emergency.

Quick connect/disconnect coupler (QCDC) means a manual or hydraulic mechanical device used to connect the LNG transfer system to the receiving ship manifold.

Sloshing means liquid oscillations effect at significant free surface in cargo and fuel tanks.

11.2 TECHNICAL DOCUMENTATION

11.2.1 In addition to technical documentation specified in 3.2, Part I "Classification" of these Rules and 6.1, Part I "Classification" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk, the following technical documentation shall be submitted:

.1 general arrangement of the ship with indication of LNG bunkering station, bunkering control station and escape routes;

.2 diagram and description of the cargo system; drawings of hose lines, swivels and transfer arms (where applicable);

.3 diagram and description of LNG vapour return transfer system; documentation for the reliquefaction system (where applicable); calculation of maximum allowable bunkering flow;

.4 technical documentation for ESD bunkering system;

.5 electrical single line diagrams for all intrinsically-safe circuits;

.6 general arrangement plan of electrical equipment in hazardous areas related to bunker operations;

.7 technical documentation for fire detection and alarm system as well as gas detection system of the bunkering installation, including location of gas detectors, connection lines, valves and sampling points on board the ship;

.8 technical documentation for gauging, alarm and pressure indication system in the cargo tanks and piping;

.9 technical documentation for control and alarm system of cargo pumps.

11.2.2 The following operating documentation shall be submitted:

.1 risk analysis related to gas fuel bunkering operations and potential consequences of leakage according to the procedure agreed with the Register. The analysis shall consider risks of damage of hull structural members and failure of any equipment due to the accident related to gas fuel leakage. The results of risk analysis shall be included in the ship's Operating Manual. The risk analysis shall be carried out considering IACS recommendation No. 142;

.2 operating instructions containing the procedures of bunkering, interting and control of cargo vapour return.

11.3 ARRANGEMENT OF LNG BUNKERING SHIP

11.3.1 LNG bunkering ship shall comply with the requirements of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk and the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code).

11.3.2 The LNG bunkering station shall be located on the open deck in the area with sufficient natural ventilation. The LNG bunkering station shall be physically separated or structurally shielded from accommodation and control stations.

11.3.3 Escape routes shall have safe access for crew engaged in operation. The LNG bunkering station shall be sufficiently illuminated from two floodlights located to minimize shadow areas on deck and high enough to minimize dazzle effect to personnel involved in bunkering operations.

11.3.4 The bunker connections shall be clearly visible from the navigation bridge and bunker operation control position where continuous watch is kept during the transfer. CCTV can be accepted as substitute for the direct view when it provides unobstructed view of the bunker connections.

11.3.5 Arrangement of work platforms in areas where liquid spill may occur shall exclude liquid spill accumulation at the platform surface. Gratings used in this location shall be suitable for low temperatures. Area under the gratings shall be equipped with spill collecting trays with drainage arrangements suitable for draining the accumulated spill overboard. The drain shall be fitted with a shut-off valve.

11.3.6 Drip trays and drainage arrangements shall be fitted below bunkering connections where LNG leakage may occur leading to the ship structure damage. Thermal sensors shall be positioned in way of bunkering connections in the drip tray.

The drip trays shall be made of stainless steel, and capable of being remotely drained over the ship's side without risk of structural damage to the ships involved in bunkering operations.

11.3.7 When bunker boiling point is lower than allowable temperature of the hull steel, the hull structure in the possible area of LNG spill shall be effectively protected from low temperature in case of a major bunker spill. Where water curtain is used for hull protection, the pumps shall be arranged with redundancy.

11.4 HULL AND STABILITY

11.4.1 The hull structure and stability of the LNG bunkering ship shall comply with the requirements of Part II "Ship Arrangement" and Part III "Stability. Subdivision. Freeboard" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk and the following additional requirements:

.1 LNG bunkering ship shall be able to abort bunkering operation at any stage in case of emergency. Therefore, cargo tanks on the ship shall not have restrictions on intermediate filling;

.2 internal transfer between cargo tanks within short period of time to avoid dangerous sloshing zone may be accepted during cargo and bunkering operations.

11.5 FIRE PROTECTION

11.5.1 Structural fire protection of LNG bunkering ship shall meet the requirements of Part V "Fire Protection" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk and the following additional requirements.

When applicable, the bunkering station shall be separated by fire-fighting divisions of class A-60 from other spaces. Fire integrity may be reduced to class A-0 for spaces and areas with low fire risk such as tanks with non-combustible medium, voids, auxiliary machinery spaces of no fire risk, sanitary and similar spaces.

11.5.2 Fire extinguishing systems of LNG bunkering ship shall meet the requirements of Part V "Fire Protection" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases and the following additional requirements:

.1 water spray system shall be fitted to protect the bunkering manifolds, associated piping, arms, loading hoses and the transfer area. The system capacity shall not be less than those specified in 3.3.2 of Part V "Fire Protection" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk;

.2 in the bunkering station area a permanently installed dry powder system shall cover all possible LNG leak points. The capacity shall be at least 3,5 kg/s for a maximum of 45 s discharges. The manual release shall be located at easily accessible and safe position outside the protected area;

.3 one dry powder fire-extinguisher of at least 5 kg capacity shall be located near the bunkering station.

11.5.3 Exhaust gas system shall meet the requirements of Part VIII "Systems and Piping" of these Rules, therewith, the outlets of the exhaust gas pipes of the internal combustion engines, boilers and incinerators shall be provided with spark arresters.

11.5.4 Use of equipment for disposing the evaporated cargo by thermal oxidation method not complying with the requirements of 4.3, Part VI "Systems and Piping" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk shall be prohibited during bunkering operations.

11.6 CARGO SYSTEM

11.6.1 The following components shall be obligatory included in the cargo system:
bunkering hoses and/or mechanical loading arms;
quick connect/disconnect coupler (QCDC);
emergency release coupling (ERC);
electrical insulating joint.

11.6.2 Cargo system and the bunkering fuel transfer procedure shall be so designed to avoid the release of gas or liquid to the atmosphere both from bunkering and receiving ships during bunkering operations.

11.6.3 Bunker transfer piping system for products with boiling point below –55 °C shall be thermally insulated to minimize heat leaks to transferred gas bunker and protect personnel from direct contact with cold surfaces.

11.6.4 Bunkering hoses.

11.6.4.1 Bunkering hoses shall meet the requirements of 5.11.7 of the IGC Code, applicable requirements of 6.2, Part VIII "Systems and Piping" of these Rules and shall have Type Approval Certificate (CTO). In addition to the above requirements, the requirements specified in 11.6.4.2 — 11.6.4.10 shall be complied with during the type testing of bunkering hoses.

11.6.4.2 All the applicable materials shall be compatible with each other and transported medium (LNG and LNG vapors). The end fittings shall be manufactured of stainless steel and comply with the IGC Code requirements.

11.6.4.3 The following characteristics shall be defined by the manufacturer of the bunkering hose and confirmed during type tests:
minimum working temperature;
maximum working load;
maximum design pressure;
minimum bend radius (MBR);
maximum allowable applied twist (MAAT).

11.6.4.4 Each hose type shall be subjected to a pressure cycle test at ambient temperature to demonstrate that the hose is capable of withstanding 2 000 pressure cycle test from zero to at least twice the specified maximum working pressure. The hose assembly shall be also subjected to a cryogenic temperature and pressure cycle test with a minimum of 200 combined test cycles. After the cycling test, the crushing test shall be carried out at the pressure at least 5 times exceeding the maximum working pressure at the minimum working temperature.

11.6.4.5 Each hose type shall be subjected to a bending cycle fatigue test, at ambient and cryogenic temperature (with 400 000 cycles without failure). In such case, the fatigue bend radius shall be accepted in accordance with the manufacturer's recommendation.

11.6.4.6 Each hose type shall be subjected to a crushing test at ambient temperature and cryogenic temperature. The hose assembly shall be held between two rigid plates at the length equivalent to the diameter of the hose and a force of 1000 N shall be applied ten times at the same location in the middle of each flexible hose.

11.6.4.7 Each hose type shall be subjected to a tensile test at ambient and minimum working temperature for determining the maximum working load.

11.6.4.8 Each hose type shall be subjected to a bending test at room and cryogenic temperature to ensure that the hose is capable of withstanding the maximum working pressure at MBR. Hose shall be gradually bent to the MBR and then pressurized to the maximum working pressure. Hose shall be examined for leaks whilst being held for 15 min at MBR. After pressure relief and hose unbending, it shall be examined for visual damage.

11.6.4.9 Each hose type shall be subjected to a tensile test at room and cryogenic temperature to ensure that the hose is capable of withstanding the maximum working pressure at MAAT. The hose assembly shall be gradually twisted to the MAAT and then pressurized to the

maximum working pressure. The hose shall be examined for leaks whilst being held for 15 min at MAAT. After pressure relief and hose unbending, it shall be examined for visual damage.

11.6.4.10 Electrical resistance between the two end fittings of the hose shall be measured, and the hose assembly shall be drained and supported above ground by non-conductive means. Electrically conductive hoses shall have a resistance of less than 10 Ohm. Electrically non-conductive hoses shall have a resistance of at least 25 kOhm.

11.6.5 Quick connect/disconnect coupler (QCDC).

11.6.5.1 QCDC shall have Type Approval Certificate (CTO). The QCDC shall be subjected to a hydraulic pressure test, at ambient temperature, to a pressure not less than 1,5 times the design pressure, to demonstrate that the QCDC is capable of withstanding its pressure without leaking.

11.6.5.2 Controls of QCDC shall be fitted with mechanical interlocking device to prevent unintended operation. In case of supply failure the QCDC shall not change the position (shall stay in "as-is" position).

11.6.6 Emergency release coupling (ERC).

11.6.6.1 Emergency release coupling (ERC) or break-away coupling shall be provided in the bunkering line. Adequacy shall be observed regarding the compatibility with hoses and the maximum axial and shear forces likely to be exerted on the break-away or the ERC during the bunkering operations. The ERC and break-away coupling shall have Type Approval Certificate (CTO).

11.6.6.2 ERC used in bunker connection shall be of "dry-break" type and be capable to self-disconnect upon application of force at any direction of ship's relative motion, which exceeds design loads, and at pressure surge exceeding the coupling design pressure.

ERC fitted in lines for transfer of gas fuel shall be capable to break-away through the ice accumulated on the coupling during the LNG transfer.

11.6.7 Electrical insulating joint.

Each electrical insulating joint shall be air tested. In this case, the resistance shall be at least 10 kOhm. Resistance of each insulating flange shall be measured when the LNG tank is completely filled and amounted to at least 1000 Ohm, but not exceed 1000 kOhm.

11.6.8 Cargo swivel.

Cargo swivel having Type Approval Certificate (CTO) shall be provided in the bunkering line. Swivels shall be subject to static and dynamic hydraulic pressure tests at the maximum working pressure. During the dynamic tests, at least two complete rotations in each direction shall be performed at normal conditions and minimum working temperature.

11.6.9 The bunkering line shall be suitably supported in such a way that to prevent the hose abrasion and to observe that the allowable bending radius is satisfied.

11.6.10 The cargo system shall be subjected in assembly to a hydraulic pressure test, at ambient temperature, to a pressure not less than 1,5 times the maximum design pressure of the system.

11.6.11 All welds of cargo system and hose line items shall be made with full penetration welding with 100 % inspection of welds by non-destructive examination.

11.6.12 The allowable LNG bunkering speed shall be determined by the characteristics of the receiving ship. The maximum LNG transfer velocity in the piping system and bunkering line shall not exceed 10 m/s in order to avoid the generation of static electricity and to limit the heat transfer due to friction inside the pipes.

The maximum LNG transfer velocity shall be determined considering the following:

management of the BOG generated during bunkering operation;

temperature and pressure of the LNG supplied to the receiving ship;

characteristics of the receiving tank;

maximum flow permitted by the ERC;

maximum flow permitted by the hose;

maximum flow permitted by the QCDC.

11.7 INERT GAS SYSTEM

11.7.1 Prior to the bunkering operations, the possibility shall be provided for tightness test of connections between the LNG bunkering and receiving ships. The procedure thereof shall be specified in the ship's Operating manual.

11.7.2 The relevant measures and procedures shall be provided for inerting the hose lines prior to filling them with bunkering fuel or LNG vapors, as well as inert-gas pressurization of bunkering fuel or LNG vapors from bunkering lines upon completion of cargo operations prior to disconnection. The cargo residuals shall be leading back to the cargo tanks.

11.8 GAS DETECTION SYSTEM

11.8.1 Installed onboard gas detection system shall be capable to measure gas concentration in the manifold connections area in addition to arrangements specified in Section 6, Part VIII "Instrumentation and Automation System" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk. Such system shall also provide a remote gas detection point for receiving ship.

11.8.2 Gas detection system at the manifold connection area shall provide continuous monitoring and activate alarm when concentration of hydrocarbons reaches 30 % of lower flammable limit (LFL).

11.8.3 Audible and visible alarm from the permanently installed gas detection system shall be located on the navigation bridge, in the bunkering operation control position and at the gas detector location.

11.9 ELECTRICAL EQUIPMENT

The requirements of this Chapter apply to electrical equipment of LNG bunkering ships and are addition to the requirements of Part XI "Electrical Equipment" of these Rules and Part VII "Electrical Equipment" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk.

11.9.1 The following systems of generation and distribution of electric energy are allowed:

.1 direct current:

.1.1 two-wire insulated;

.2 alternating current:

.2.1 single-phase, two-wire insulated;

.2.2 three-phase, three-wire insulated;

.2.3 three-phase, four-wire insulated.

11.9.1.3 In insulated distribution systems, no current-carrying part shall be earthed, other than the following:

.1 arrangements and systems for insulation resistance monitoring;

.2 components used for the radio interference suppression.

11.9.2 Earthed systems with hull return.

11.9.2.1 Earthed systems with hull return are not permitted, with the following exceptions:

.1 impressed-current cathodic protection systems;

.2 local earthed systems, such as starting and ignition systems of internal combustion engines, provided that any possible current does not flow directly through any hazardous areas and spaces;

.3 arrangements and systems for insulation resistance monitoring, provided that the circulation current of the device does not exceed 30 mA under the most unfavourable conditions;

.4 earthed intrinsically safe circuits;

.5 power supplies, control circuits and instrumentation circuits in non-hazardous areas where technical or safety reasons preclude the use of a system with no connection to earth, provided the current in the hull is limited to not more than 5 A in both normal and fault conditions;

.6 local earthed systems, such as power distribution systems in galleys and laundries to be fed through isolating transformers with the secondary windings earthed, provided that any possible resulting hull current does not flow directly through any hazardous areas and spaces.

11.9.3 Monitoring of circuits in hazardous areas.

11.9.3.1 The devices intended to continuously monitor the insulation resistance level of all separate distribution systems shall also monitor all circuits, other than intrinsically safe circuits, connected to apparatus in hazardous areas or passing through such areas.

11.9.3.2 An audible and visual alarm shall be given, at a manned position, in the event of an abnormally low level of insulation.

11.10 EMERGENCY SHUT-DOWN SYSTEM (ESD)

11.10.1 The requirements of Part VIII "Instrumentation and Automation System" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk shall apply in a full scope to emergency shut-down systems (ESD). The ESD system shall stop the applied pumps and vapour return compressors (if any) before the manifold valves are closed. Any activation of the ESD systems shall be implemented simultaneously on both bunkering facility and receiving ship.

11.10.2 Pendant with means of control for local manual activation position for the ESD system shall be provided on board the receiving ship. When an LNG bunkering ship may connect on board ESD system to those of the receiving ship, pendant is not required.

11.10.3 The ESD function shall be initiated in following circumstances:

.1 automatically, if the distance between a receiving ship and LNG bunkering ship exceeds safe operational envelope for transfer arrangement;

.2 when activating manual ESD button on ESD pendant;

.3 automatically at ERS activation.

11.10.4 Opening of main transfer valves shall not be possible unless ERS is re-assembled.

11.11 TRANSFER CONTROL SYSTEM

11.11.1 The transfer control system shall have provisions of automatic control of flow rate and limiting pressure in the transfer system. Parameters of the control system critical for the safe transfer shall have adjustable settings.

11.11.2 Deviations from set values specified in 11.11.1 shall activate audible and visual alarms at the bunker operations control position and on the navigation bridge.

11.11.3 The LNG transfer control system shall automatically reduce the LNG transfer rate when set values for pressure in the vapour return and/or vapour recovery system is exceeded.

11.11.4 If the LNG transfer rate exceeds a maximum value, alarm and automatic stop of transfer shall be activated and manifold valves closed.

11.11.5 The receiving ship shall have possibility to control LNG transfer flow rate by means of a ship-to-ship link, e.g. flexible cable and pendant with means of control.

11.11.6 Alarms and safety actions required for the LNG transfer system are specified in Table 11.11.6.

Table 11.11.6

Alarms and safety actions required for the LNG transfer system

Parameters	Alarm	Activation of the ESD systems	Automatic activation of ERC
Low pressure in the supply tank	×	×	
Sudden pressure drop at the fuel transfer pump	×	×	
High level in the receiving tank	×	×	
High pressure in the receiving tank	×	×	
LNG leak detection or vapour detection (anywhere)	×	×	
Gas detection around the bunkering pipe	×	×	
Manual activation of the ERC	×		
Safe working envelope of the loading arm exceeded	×	×	×
Disconnection of the ERC	×	×	

11.12 COMMUNICATION SYSTEMS

11.12.1 A communication system with back-up shall be provided between the LNG bunkering ship and the receiving ship.

11.12.2 Communications shall be maintained between the LNG bunkering ship and the receiving ship at all times during the bunkering operation. In the event that communications cannot be maintained, bunkering shall be stopped and not resumed until communications are restored.

11.12.3 The components of the communication system located in hazardous and safety zones shall be of a suitable frameproof type.

11.13 ADDITIONAL SERVICE FEATURES RELATED TO SERVICING OF SHIPS USING LNG AS FUEL

11.13.1 When the additional features related to ships servicing are provided on board the LNG bunkering ship using LNG as fuel and indicated by the distinguishing mark **RE** added to the character of classification, the BOG handling system of the LNG bunkering ship shall have the capacity allowing to handle the extra vapours generated during the cargo operation taking into account the increasing level in the receiving cargo tanks.

To confirm the ship compliance with the requirements applicable to ships with the distinguishing mark **RE**, the bunkering procedure for LNG receiving from a gas fueled ship with the required calculations shall be submitted.

11.13.2 When the additional features related to ships servicing are provided on board the LNG bunkering ship using LNG as fuel and indicated by the distinguishing mark **IG-Supply** added to the character of classification, the LNG bunkering ship shall be fitted with supply of inert gas and/or dry air to ensure gas freeing and aeration of fuel tanks in compliance with 6.10.4 of the IGF Code. The lines used for the inert gas shall be independent from the LNG liquid and vapour lines used for normal operation.

To confirm the ship compliance with the requirements applicable to ships with the distinguishing mark **IG-Supply**, a diagram of gas freeing system and procedure for gas freeing shall be submitted.

11.13.3 When the additional features related to ships servicing are provided on board the LNG bunkering ship using LNG as fuel and indicated by the distinguishing mark **BOG** added to the character of classification, the boil-off-gas system (BOG) generated during bunkering shall be provided. In such case, the LNG bunkering ship shall be capable of handling all or part of the boil-off gas from receiving ship, in addition to its own boil-off, generated during the LNG bunkering operation without release to the atmosphere. The boil-off gas handling capacity of the bunkering ship shall be indicated and justified by relevant calculations.

The following ways or their combination to the BOG dispose are allowed:

reliquefaction;

using gas as fuel in the ships fuel engine or boilers;

burning in the gas flaring unit in compliance with 4.3, Part VI "Systems and Piping" of the of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk.

To confirm the ship compliance with the requirements applicable to ships with the distinguishing mark **BOG**, the following documents shall be submitted:

bunkering procedure for boil-off gas management indicating the operations;

calculation of the maximum LNG vapour flow rate possible to be generated during the bunkering to be less than the capacity of boil-off gas unit specified in the bunkering procedure.

12 REQUIREMENTS FOR SHIPS FOR COMPLIANCE WITH THE DISTINGUISHING MARK IWS IN THE CLASS NOTATION

12.1 GENERAL PROVISIONS AND SCOPE OF APPLICATION

12.1.1 For the ships constructed in compliance with this Chapter, the distinguishing mark **IWS** (in-water survey) is added to the character of classification denoting the ship is fit for in-water survey.

12.1.3 The conditions for in-water survey are specified in 2.5 of Part II "Survey Schedule and Scope" of the Rules for the Classification Surveys of Ships in Service.

12.2 TECHNICAL DOCUMENTATION

Drawing of the marking on the side and bottom plating to identify the tanks shall be submitted in the scope of plan approval documentation for a ship under construction.

12.3 TECHNICAL REQUIREMENTS

The distinguishing mark **IWS** may be assigned to the ships complying with the following additional requirements.

12.3.1 A ship shall have distinguishing mark **TMS** in the class notation or propeller and shafting arrangement shall comply with the requirements of 2.11.2, Part II "Survey Schedule and Scope" of the Rules for the Classification Surveys of Ships in Service for the minimum interval between surveys of 5 years.

12.3.2 Interval between the complete survey of main AMSS (if installed on board) shall not be less than 5 years in accordance with 2.11.8, Part II "Survey Schedule and Scope" of the Rules for the Classification Surveys of Ships in Service.

12.3.3 Underwater hull shall be fitted with an effective corrosion protective system consisting of combination of coating and cathodic protection systems.

12.3.4 Possible underwater washing of sea chests shall be provided, where necessary. For this purpose, closures of intake gratings shall have such a structure to ensure safe opening and closure by a diver.

12.3.5 For the water-lubricated rudder bearings, shall be provided to enable the in-water measurement of clearance in the rudder stock and pintles.

12.3.6 Underwater hull shall be marked.

Transverse and longitudinal reference lines of about 300 mm in length and not less than 25 mm in width shall be indicated as marking. The marks shall be permanent and made by welding or similar way, of contrasting colour to the hull.

As a rule, the marks shall be placed as follows:

at the flat bottom in the regions of tank bulkhead intersection or integrity of floors of the bottom longitudinal girders;

on board in the areas of transverse framing (marking shall not be higher than 1 m above the hopper plating);

at the double bottom intersection with watertight floor in the area of the ship sides;

at all suction and exhaust sea inlets.

Letter and numeric codes shall be placed on the plating for identification of tank, suction and exhaust sea inlets.

13 REQUIREMENTS FOR OFFSHORE SERVICE VESSELS

13.1 MODU/FOP SUPPLY VESSELS

13.1.1 General.

For vessels intended to supply MODU/FOP and complying with the requirements of this Chapter, a descriptive notation **Supply vessel (OS)** may be added to the character of classification.

13.1.2 Hull.

The hull structure shall comply with 3.8, Part II "Hull".

13.1.3 Equipment, arrangements and outfit.

13.1.3.1 Access means to the spaces located under the open cargo deck shall comply with 7.1.6, Part III "Equipment, Arrangements and Outfit".

13.1.3.2 Access means to machinery and boiler spaces shall comply with 7.6.6 of Part III "Equipment, Arrangements and Outfit".

13.1.3.3 Location of ventilators shall comply with 7.8.4 of Part III "Equipment, Arrangements and Outfit".

13.1.4 Stability.

The ship's stability shall comply with 3.11 of Part IV "Stability".

13.1.5 Subdivision.

As regards the subdivision, the vessel shall comply with 3.4.9 of Part V "Subdivision".

13.1.6 Systems and piping.

Uptakes of boilers, exhaust pipes of main and auxiliary engines and incinerators shall comply with 11.1.3 of Part VIII "Systems and Piping".

13.2 STANDBY VESSELS

13.2.1 General.

For ships intended to carry out rescue and standby services in offshore areas of hydrocarbon production and complying with the requirements of this Chapter, a descriptive notation **Standby vessel** may be added to the character of classification.

13.2.2 Hull.

The hull structure shall comply with the applicable requirements of 3.8, Part II "Hull".

13.2.3 Equipment, arrangements and outfit.

13.2.3.1 Access means to the spaces located under the open cargo deck shall comply with 7.1.6 of Part III "Equipment, Arrangements and Outfit".

13.2.3.2 Access means to machinery and boiler spaces shall comply with 7.6.6 of Part III "Equipment, Arrangements and Outfit".

13.2.3.3 Location of ventilators shall comply with 7.8.4 of Part III "Equipment, Arrangements and Outfit".

13.2.3.4 The ship shall be arranged on each side with a clearly marked rescue zone with a length of not less than 5 m. Rescue zones shall be located well clear of the propellers as well as any discharges extended at least 2 m below the load waterline.

13.2.3.5 In the rescue zones area the ship's sides shall be free of appendages (fenders, etc.).

13.2.3.6 The access routes from rescue zones to survivors' accommodation as well as to helicopter winching area, where provided, shall have non-slip surface or wooden sheathings.

13.2.3.7 Deck in way of the rescue zone shall be free of any obstruction (air pipes, valves, small hatches, etc.), as far as practical. If any, proper arrangement shall be provided as protection against personnel injury.

13.2.3.8 Bulwark or railings in way of the rescue zone shall be of a type easy to open or remove.

13.2.3.9 Each rescue zone shall be provided with a scrambling net made of corrosion resistant in the marine environment and non-slip material of at least 5 m wide and length enough to extend at least 1 m from the deploying area in the rescue zone till the minimal service waterline.

13.2.3.10 The ship shall be provided with power assisted means capable of ensuring careful recovery of injured persons from the sea.

13.2.3.11 The ship shall be equipped with gears for towing of liferafts and rescue boats.

13.2.3.12 Bridge front and side windows shall be equipped with efficient storm shutters installed at any side of bulkhead. Strength of these shutters shall be equivalent to strength of the bulkhead. Storm shutters shall provide visibility from the bridge; they may be portable and stowed in an accessible position, so as to be readily mounted.

13.2.4 Life-saving appliances.

13.2.4.1 The ship shall be equipped with at least one fast rescue boat of type complying with LSA Code, permanently ready for use. The emergency source of power of the launching arrangement of a fast rescue boat shall provide operation of the launching arrangement for at least 4 h.

13.2.4.2 Type approved lifejackets shall be provided for 25 % of the number of survivors for which the ship is intended to carry.

13.2.5 Survivors' spaces.

13.2.5.1 The ship shall have a treatment room for casualties, a recovery room with beds, and enclosed space to accommodate survivors. These spaces shall be provided with lighting and means to control temperature and humidity suitable for the area of operation.

13.2.5.2 The designed capacity of survivor's spaces shall be determined considering 0,75 m^2 per person. This includes free floor space and floor space with loose furniture, fixed seating and/or fixed beds. Other fixed furniture, toilets and bathrooms shall be excluded.

13.2.5.3 At least one installation comprising a toilet, a wash basin and shower shall be provided for each group of 50 survivors.

13.2.6 Stability.

The ship's stability shall comply with 3.11 of Part IV "Stability".

13.2.7 Subdivision.

As regards the subdivision, the ship shall comply with 3.4.9 of Part V "Subdivision".

13.2.8 Systems and piping.

13.2.8.1 Uptakes of boilers, exhaust pipes of main and auxiliary engines and incinerators shall comply with 11.1.3 of Part VIII "Systems and Piping".

13.2.8.2 A decontamination area equipped with a shower system shall be arranged before entering to deckhouse accommodations from rescue zones.

13.2.9 Machinery installations.

The ship shall be fitted with at least two propulsion systems capable of moving the ship in the forward and aft direction.

13.2.10 Electrical equipment.

13.2.10.1 A searchlight shall be available on each side and adjustable from inside the navigation bridge. Each searchlight shall be able to provide an illumination level of 50 lx in clear air, within an area not less than 10 m diameter, to a distance of at least 250 m.

13.2.10.2 In addition to 6.7.1 of Part XI "Electrical Equipment", illumination of the following spaces shall be at least:

.1 150 lx of total illumination level for overboard spaces, at a distance of within 5 m from the ship side in the rescue zone and reception areas for survivors;

.2 50 lx of total illumination level for overboard spaces at a distance within 20 m from the ship side along the rescue zone and survivors reception area.

13.2.10.3 In addition to 6.1.1 of Part XI "Electrical Equipment" lighting with power from the main and emergency source shall be provided for the following spaces:

.1 storage spaces for rescue boats and their launching arrangements, reception areas for survivors and rescue zones;

.2 overboard spaces in the rescue zone, survivors' reception areas, in areas of rescue boats launching;

.3 helicopter winching areas and routes to this area from survivors' reception areas.

Time of lighting source from emergency source shall be at least 30 min.

13.3 ANCHOR HANDLING VESSELS

13.3.1 General.

For ships equipped for servicing (handling, heaving up and shifting) anchors and complying with the requirements of this Chapter, the descriptive notation **Anchor handling vessel** may be added to the character of classification.

For ships, equipped for anchor servicing and towing of floating facilities, the descriptive notation Anchor handling vessel, Tug may be added to the character of classification.

13.3.2 Documentation.

In addition to documentation specified in Section 3, Part I "Classification", the following documents shall be submitted (A – for approval; AG – for agreement, Fl – for information):

13.3.2.1 Arrangement plan of anchor handling equipment: anchor handling winches, shark jaws, towing pins, stern rollers, cargo handling gear, where available, including standard cargo placing on the deck (anchors, cables, chains, etc.) indicating the towing line path, extreme sectors, maximum design towing pull, maximum design load for each component (Fl).

13.3.2.2 For anchor handling winches:

.1 design criteria, including design loads and characteristics of emergency quick release system of towing line indicating the response time and remaining holding force after release) (Fl);

.2 strength calculation of winch drum with flanges, shaft couplings, housing and brakes (AG);

.3 assembly drawings and general view (A).

13.3.2.3 For shark jaw:

.1 design criteria, including design loads and characteristics of emergency quick release system in operational and dead ship conditions (Fl);

.2 strength calculation (AG);

.3 assembly drawings and general view (A).

13.3.2.4 For towing pins:

.1 design criteria, including design loads and characteristics of emergency release capabilities in operational and dead ship conditions (Fl);

.2 strength calculation (AG);

.3 assembly drawings and general view (A).

13.3.2.5 For stern rollers:

.1 design criteria, including design loads (Fl);

.2 strength calculation (AG);

.3 assembly drawings and general view (A).

13.3.2.6 Drawings of foundations and supports for winches, shark jaws, stern rollers and towing pins indicating the maximum design load (A).

13.3.2.7 Electrical power supply circuits and control system configuration of towing equipment and anchor handling equipment (A).

13.3.2.8 Arrangement plan (A) and technical specification of operator control stands (user interface) of towing equipment control systems and anchor handling equipment (AG).

13.3.2.9 Arrangement plan (A) and technical specification of communication means between the anchor operations control station and wheelhouse (AG).

13.3.2.10 Bollard pull estimation (Fl).

13.3.2.11 Bollard pull test procedure (A).

13.3.3 Hull.

The hull structure shall comply with the applicable requirements of 3.8, Part II "Hull".

13.3.4 Equipment, Arrangements and Outfit.

13.3.4.1 Design loads of arrangements specified in 13.3.2.3 to 13.3.2.5 shall be assumed in compliance with 5.4.2.2, Part III "Equipment, Arrangements and Outfit". In such case, the stress in these components shall not exceed 0,8 yield strength of their material.

13.3.4.2 Anchor handling winch shall be fitted with towing line tension measuring means.

13.3.5 Stability.

13.3.5.1 Stability of anchor handling vessels shall be checked for the following loading conditions:

.1 ship with full stores;

.2 maximum draught at which anchor handling operations may occur, with 67 % of stores;

.3 minimum draught at which anchor handling operations may occur, with 10 % of stores;

.4 ship with 10 % of stores (where the case is different from that specified in 13.3.5.1.3), and for anchor handling vessels provided with cargo holds, additionally:

.4 ship with full cargo in holds and full stores;

.5 ship with full cargo in holds and 10 % of stores.

13.3.5.2 For given loading conditions, weight of chains, spare towlines and towlines for towing winches shall be taken into account.

13.3.5.3 Stability of a vessel during anchor handling operations shall comply with the criteria specified in this Chapter. In other operating conditions the vessel's stability shall comply with the criteria specified in Section 2, Part IV "Stability" of the Rules and other applicable criteria.

13.3.5.3.1 The area between the righting lever curve and the heeling lever curve calculated in accordance with 13.3.5.4 and determined from the first intersection of the two curves, to the angle of the second intersection or the angle of down-flooding, whichever is less, shall not be less than 0,070 m·rad.

13.3.5.3.2 The maximum righting lever between the righting lever curve and the heeling lever curve calculated in accordance with 13.3.5.4 shall be at least 0,2 m.

13.3.5.3.3 The static angle at the first intersection between the righting lever curve and the heeling lever curve calculated in accordance with 13.3.5.4 shall not be greater than:

.1 the angle at which the righting lever equals half of the maximum righting lever;

.2 the deck edge immersion angle;

.3 15°, whichever is less.

13.3.5.3.4 A minimum freeboard at stern, on centreline, of at least $0{,}005L$ shall be maintained in all loading conditions, including vertical loads added (as per the definition of displacement Δ_2 given in 13.3.5.4).

In the event of the anchor retrieval operation specified in 13.3.5.9, a lower minimum freeboard may be accepted provided that due precautions are indicated in the operation plan.

13.3.5.4 A heeling lever HL_θ, in m, generated by the tension applied to the towline shall be determined by formula

$$HL_\theta = (M_{AH}/\Delta_2)\cos\theta,$$

where $M_{AH} = F_p(h \cdot \sin\alpha \cdot \cos\beta + y \cdot \sin\beta)$;

$F_v = F_p \cdot \sin\beta$;

F_p = permissible towline tension, in tm, which can be applied to the vessel during operation while working through specified towing pins. F_p shall in no circumstance be taken as greater than F_d;

F_d = design maximum towline tension, in tm, the maximum winch towing line pull or maximum static winch brake holding force, whichever is greater;

β = vertical angle, in deg., between the waterline and the vector at which the towline tension is applied determined at the maximum heeling moment angle and calculated as

$\text{arctg}(y/(h \cdot \sin\alpha))$;

β shall be taken not less than

$\arccos(1{,}5B_p/(F_p \cdot \cos\alpha))$;

B_p = maximum continuous pull (bollard pull), in tm;

h = vertical distance, in m, from the centre the propulsive force acts on the vessel to either:
the uppermost part at the towing pin, or
a point on a line defined between the highest point of the winch pay-out and the top of the stern or any physical restriction of tow line transverse movement;

α = horizontal angle, in deg., between the centreline and the vector at which the towline tension is applied to the vessel in the upright position;

y = transverse distance, in m, from the centreline to the outboard point at which the towline tension is applied to the vessel, calculated as

$y_0 + x \cdot \tan\alpha$;

y shall be taken not greater than $B/2$;

y_0 = transverse distance, in m, between the vessel centreline to the inner part of the towing pin or any physical restriction of the transverse tow line movement;

x = longitudinal distance, in m, between the stern and the towing pin or any physical restriction of the transverse tow line movement;

B = breadth of the vessel, in m;

Δ_2 = displacement of a vessel, including action of the vertical loads added F_v, at the centreline in the stern of the vessel.

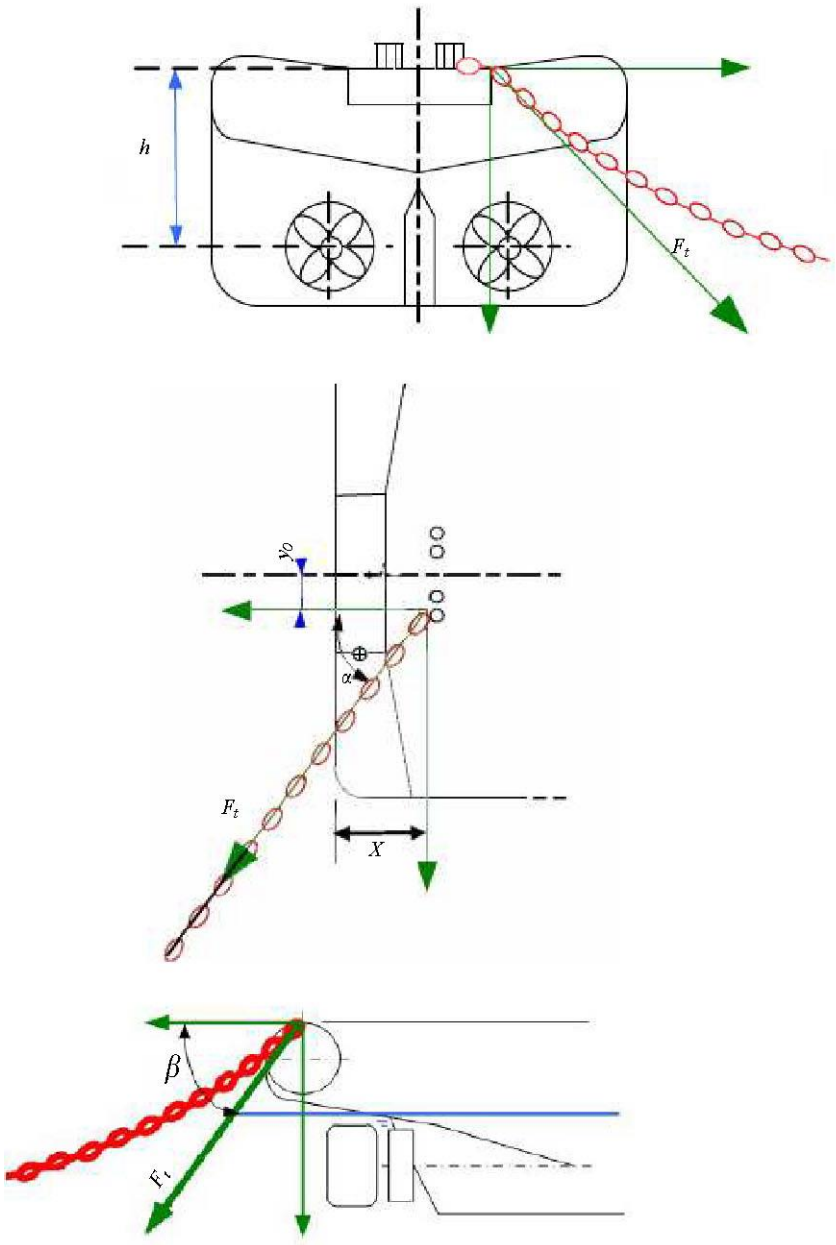


Fig. 13.3.5.4
Diagram showing the positions of angles α and β and distances h, x and y.
F_t shows the vector of the applied tow line tension

13.3.5.5 Stability of anchor handling vessels shall be checked for all towing pins with relevant maximum allowable tow line tension, and other structural elements restricting the towline movement.

13.3.5.6 For anchor handling vessels in loading conditions specified in 13.3.5.1.2 and 13.3.5.1.3 when applying the design tension F_d, for the towing pin nearest to centerline, stability criteria specified in 13.3.5.3 shall be met as a minimum for α equal to 5°.

13.3.5.7 The calculated permissible towline tension shall not be greater than the value specified in 13.3.5.8.

13.3.5.8 Permissible towline tension as function of α, defined in 13.3.5.6 can be calculated by direct stability calculations, provided that the following conditions are met:

.1 the heeling lever is calculated as defined in 13.3.5.4 for each α;

.2 all the stability criteria specified in 13.3.5.3 are met;

.3 α shall not be taken less than 5°, except for the case specified in 13.3.5.9;

.4 intervals of α shall be not be more than 5°, except for the cases where permissible towline tension does not exceed values calculated for more unfavourable values of α.

13.3.5.9 For operations to retrieve a stuck anchor, in which the vessel is on station above the anchor and the vessel has low or no speed, α may be taken as less than 5°.

13.3.5.10 Curves (or tables) of permissible tension as a function of permissible vertical centre of gravity (or metacentric height) for the draught and trim values covering all possible anchor handling operations shall be developed for each ship.

13.3.6 Subdivision.

13.3.6.1 Ships with the descriptive notation **Anchor handling vessel** shall comply with the requirements of 3.4.9, Part V "Subdivision".

13.3.6.2 In addition to 3.4.9, the ships with the descriptive notations **Anchor handling vessel**, **Tug** shall also comply with the requirements of 3.4.4, Part V "Subdivision".

13.3.7 Machinery.

13.3.7.1 Anchor handling winches shall comply with the applicable requirements of 6.1 and 6.5.5, Part IX "Machinery".

13.3.8 Electrical equipment.

13.3.8.1 Anchor handling winches shall be controlled from control stations where sufficient visibility of the winch drums is provided. Controls shall ensure single action control by one operator; therewith the selected operating mode shall be clearly distinguished from other modes provided. In case of control system failure, the arrangement shall be set in safe position.

13.3.8.2 Anchor handling winch shall be controlled both in anchor hoisting and dropping modes.

13.3.8.3 In compliance with 13.3.4.2, the information of towing line tension shall be displayed at the winch control panels or in the close vicinity thereof, as well as the data of the maximum permissible towing line tension, relevant vertical and horizontal angles to determine the towing line position according to the calculations made for each loading condition. The above information may be duplicated at ship steering position.

13.3.8.4 Controls (handles, buttons, etc.) for emergency disconnecting shall be protected against unintentional action of the personnel.

13.3.9 Bollard pull testing.

13.3.9.1 The following shall subject to testing for bollard pull measurement:

.1 the first ship out of the series, then every fifth ship of the series (i.e. sixth, eleventh, etc.) provided the propulsion plant is identical;

.2 every ship of non-series construction.

13.3.9.2 Prior to bollard pull tests, the test program, approved Stability Booklet, as well as the results of design assessment of bollard pull shall be submitted to the Register.

13.3.9.3 During the stationary pull tests the main engine(s) shall be operated at maximum torque corresponding to the maximum free running condition.

Actual output shall be checked during the testing.

13.3.9.4 During the normal operation of the ship, all auxiliary equipment, such as pumps, generators and other equipment driven by the main engine(s) or propeller shaft(s) shall be connected while testing.

13.3.9.5 Towing line measured between the ship's stern and the mooring bollard shall be at least 300 m in length. When the above towing line length may not be provided in the test place, the towing line length equal to at least two ship's length may be accepted.

13.3.9.6 At least 20 m depth shall be provided at the test place within a radius of 100 m around the ship. When 20 m depth may not be provided at the test place, the maximum depth equal to twice maximum ship's draught may be accepted.

13.3.9.7 The test shall be carried out with the ship's displacement corresponding to full ballast condition and half fuel capacity.

13.3.9.8 During the tests the ship shall be trimmed on an even keel or shall have a trim by stern not exceeding 2 % of the ship's length.

13.3.9.9 The tests shall be conducted at wind velocity not exceeding 5 m/s. Current speed at the test place shall not exceed 0,5 m/s in any direction.

13.3.9.10 The ship shall demonstrate the ability to keep to the heading set for at least 10 min developing power at the conditions specified in 13.3.9.3. The verified continuous bollard pull is the mean value of readings for 10-minute period.

13.3.9.11 Load cell that used during the tests shall be calibrated in the presence of the RS representative. The load cell error shall be at least +2 % at the temperature and range of loads applicable to the testing conditions.

13.3.9.12 An instrument for the continuous readout and a recording device for registration of bollard pull in graph form as function on time shall be both connected to the load cell.

Where practicable, both devices shall be located and continuously monitored from the shore.

13.3.9.13 The load cell shall be placed between the eye splice of the towing line and the bollard.

13.3.9.14 The towing line position during the tests shall have the minimum affect on the measuring results due to its friction with the towing arrangement components.

13.3.9.15 For the testing period, the communication system shall be installed between the ship and ashore personnel performing the continuous monitoring of the loading cell and the recording device ashore using VHF-communication or telephone.

13.3.10 Records.

13.3.10.1 Bollard pull testing report.

13.3.10.2 Report on Survey of the Ship (form 6.3.10).

13.3.10.3 Based on results of the bollard pull testing, the following entry shall be introduced in the Classification Certificate (form 3.1.2) in the Section "Other Characteristics": "Permanent static towing pull at the maximum free running condition of the propulsion plant…kW is…t".

13.3.10.4 Upon the shipowner's request, Bollard Pull Certificate (form 6.3.45) may be issued for a ship with the descriptive notation **Anchor handling vessel** or **Anchor handling vessel**, **Tug**.

14 REQUIREMENTS FOR SHIPS PREPARED FOR CONVERSION FOR THE USE OF GAS FUEL

14.1 GENERAL PROVISIONS AND APPLICATION

The requirements of this Section apply to ships prepared for conversion for the use of gas fuel. A distinguishing mark **GRS** (Gas Ready Ship) may be assigned to ships other than LNG gas carriers with the developed design aspects required to prepare the ship for the use of gas fuel.

Ship conversion project to be developed for assigning the ship the distinguishing mark **GRS** shall be aimed at reduction of expenses while converting the ship for the use of gas fuel, minimizing of hull works, maintenance of the existing hull structures and machinery to the maximum extent.

By the date of assignment the distinguishing mark **GRS**, the ship shall use only liquid fuel with the flashpoint above 60 °C, and the ship shall be prepared for conversion for the use of gas fuel. Where conversion is over, such ship shall meet the requirements of the International Code for Safety for Ships Using Gases or Other Low Flashpoint Fuels (IGF Code) and the requirements specified in Section 9 of this Part.

Upon completion of the ship conversion for the use of gas fuel, the ship shall be assigned the distinguishing mark **GFS**, therewith the distinguishing mark **GRS** shall be withdrawn.

14.2 DISTINGUISHING MARKS IN THE CLASS NOTATION

14.2.1 Ships prepared for the use of gas fuel in compliance with this Section shall be assigned with the distinguishing mark **GRS** added to the character of classification. Minimum extent of the requirements to be complied with for assigning the distinguishing mark **GRS** are related to design only and are specified in 14.5.

14.2.2 Apart from the distinguishing mark **GRS**, distinguishing marks specifying the ship's readiness for conversion to use gas fuel are provided when the following additional requirements, other than those specified in 14.5, are complied with on board the ship:

GRS-D – design of ship conversion is approved by the Register and the requirements specified in 14.6 are complied with on board the ship;

GRS-H – necessary hull reinforcements have been provided during the ship construction in the areas of GFST and other additional equipment installation in the extent specified in 14.7;

GRS-T – LNG tank has been installed on board during the ship construction and the requirements specified in 14.8 are complied with;

GRS-P – gas fuel piping and other special systems are installed on the ship and the requirements specified in 14.9 are complied with;

GRS-E – gas fuel consumers installed on board the ship are dual fuel and the requirements specified in 14.10 are complied with.

Where the appropriate requirements are complied with, a number of distinguishing marks, e.g. **GRS-D-H-T,** may be also assigned simultaneously in addition to the distinguishing mark **GRS**.

14.3 TERMS AND DEFINITIONS

In addition to the definitions specified in Section 9 of this Part and 1.2, Part I "Classification" of the Rules for the Classification and Construction for Ships Carrying Liquefied Gases in Bulk, the following definition has been adopted. Conversion means re-equipment of a ship not initially intended for the use of gas fuel in order to comply with the requirements of the IGF Code being in force at the date of conversion.

14.4 TECHNICAL DOCUMENTATION

In addition to technical documentation specified in Section 3 "Technical Documentation", the documentation listed in 9.1.4 for ships with the distinguishing mark **GFS** (Gas Fuelled Ship) shall be submitted to the Register.

Additionally, information related to the ship's conversion shall be submitted in the technical background or any other document indicating at least the following:

general ship's data after conversion;

components of systems and machinery required for the use of gas fuel to be installed during the ship's conversion;

components of systems and machinery required for the use of gas fuel to be installed during the ship's construction;

drawings of hull structures with necessary calculations that may be changed during the ship's conversion;

drawings of hull structures and foundations required for machinery subject to installation during the ship's conversion.

14.5 MINIMUM REQUIREMENTS FOR SHIPS WITH THE DISTINGUISHING MARK GRS IN THE CLASS NOTATION

14.5.1 Conversion design shall be approved for the ship to comply with the IGF Code requirements and RS Rules for ships with the distinguishing mark **GFS**. The design shall include approval of the technical documentation for GFST.

14.5.2 Area for installation of GFST shall be provided on board the ship according to 9.2.2. In case of an enclosed space, the design of systems to ensure explosion safety (ventilation, gas leaks control etc.) shall be provided.

14.5.3 GFSTs shall be taken into account in the stability calculations.

14.5.4 Necessary calculations of hull reinforcements for GFST installation and fuel preparation shall be made.

14.5.5 Ship engine shall permit conversion to gas fuel. Gas fuelled engine shall be type approved.

14.6 REQUIREMENTS FOR SHIPS WITH THE DISTINGUISHING MARK GRS-D IN THE CLASS NOTATION

14.6.1 Requirements of 14.5 shall be complied with.

14.6.2 Requirements of 9.2 shall be complied with at the extent allowing conversion without replanning of ship's spaces.

14.6.3 Requirements of 9.7.2 shall be complied with to the extent allowing the ship's conversion without changing the fire integrity class of hull structures.

14.6.4 Pump capacity of water fire main system shall comply with the requirements of 9.7.3 and 9.7.4.

14.6.5 Ventilation system shall comply with the requirements of 9.8.1 — 9.8.5.

14.6.6 Bilge system shall comply with the requirements of 9.2.5.

14.6.7 Electrical equipment shall comply with the requirements of 9.11.

14.7 REQUIREMENTS FOR SHIPS WITH THE DISTINGUISHING MARK GRS-H IN THE CLASS NOTATION

14.7.1 Requirements of 14.6 for ships with the distinguishing mark **GRS-D** in the class notation shall be complied with.

14.7.2 Necessary hull reinforcements shall be made in the areas of GFST installation and other additional equipment required for the use of gas fuel. Hull reinforcements, supports and foundations shall be calculated for the loads specified in 6.4.4 of the IGF Code.

14.8 REQUIREMENTS FOR SHIPS WITH THE DISTINGUISHING MARK GRS-T IN THE CLASS NOTATION

14.8.1 Requirements of 14.7 for ships with the distinguishing mark **GRS-H** in the class notation shall be complied with.

14.8.2 GFST complying with the requirements of 9.3 is installed on board the ship.

14.8.3 Filling and vent pipes from relief valves shall be installed on board the ship. Prior to conversion, the piping may be stored disassembled on board the ship.

14.9 REQUIREMENTS FOR SHIPS WITH THE DISTINGUISHING MARK GRS-P IN THE CLASS NOTATION

14.9.1 Requirements of 14.6 for ships with the distinguishing mark **GRS-D** shall be complied with.

14.9.2 Gas fuel piping and other special systems are installed on board the ship and the requirements specified in 9.4, 9.5 and 9.8 are complied with.

14.10 REQUIREMENTS FOR SHIPS WITH THE DISTINGUISHING MARK GRS-E IN THE CLASS NOTATION

14.10.1 Requirements of 14.6 for ships with the distinguishing mark **GRS-D** in the class notation.

14.10.2 All gas fuel consumers shall be installed on board the ship and comply with the requirements of 9.6.

14.10.3 Control, alarm and automation systems shall comply with the requirements of 9.10 and 9.7.6.

15 REQUIREMENTS FOR SHIPS NOT ALWAYS AFLOAT BUT SAFELY AGROUND (NAABSA SHIPS)

15.1 GENERAL

15.1.1 Application.

15.1.1.1 The requirements of this Section apply to NAABSA ships (Not Always Afloat But Safely Aground) which may lie aground in safety with partial or full hull baring in places fit for grounding the ships.

15.1.1.2 At the shipowner's discretion, one of the following distinguishing marks may be added to the character of classification of a ship complying with the requirements of this Section:

.1 **NAABSA1** – partial or full ship hull baring is permitted on plane homogeneous sand-and-shingle or sand-and-mud sea beds with no motion in calm water as harbours or sheltered areas.

.2 **NAABSA2** – in addition to distinguishing mark **NAABSA1** specified, motion and ship bow impact contact with sea bed at defined wave parameters are permitted.

.3 **NAABSA3** – in addition to distinguishing mark **NAABSA2**, hull baring of moored ship is permitted at specified distance from seashore line in rolling conditions with impact contact against the seabed in any point of the hull bottom.

15.2 REQUIREMENTS FOR HULL STRUCTURE

15.2.1 Requirements for hull structures specified in this Section are in addition to the requirements of Part II "Hull".

15.2.2 Symbols.

The following symbols have been adopted in this Chapter:

Δ_N = design displacement of NAABSA ship equal to the maximum value at the beginning of baring or upon emersion from the ground, but in all cases not more than summer load line displacement, in t;

L_{BN} = design length of ship's bottom along the keel line, in m;

L_N = design length of bottom, in m, considering the bow (*1*) and stern (*2*) external structural strengthening of hull (refer to Fig. 15.2.2.1);

Δd = change of midship mean draft relative to level d_N corresponding to design displacement ΔN, in m;

ψ_0 = design trim angle of the ship, in deg. (positive nose-up trim);

ψ_N = design sea bed slope angle along the ship, in deg.;

ψ_S = operating trim angle of the ship, in deg.;

ψ_{ON} = ship trim angle due to grounding on the move, in deg.;

R_{ON} = initial bow response to ship grounding on the move, in kN;

R_N^m = static end (local) response for the ship, in kN;

R_N^n = static nominal (distributed) response for the ship, in kN;

M_N = ship hull bending moment considering the sea bed response, in kN·m;

N_N = ship hull shear force considering the sea bed response, in kN;

B_N = width of flat horizontal section of the bottom, in m;

β_k = deadrise angle, in deg.;

h_k = design height of external structural protection below the keel line, in m;

v_N = design forward speed of ship upon grounding, in knots;

h_N = design (allowable) wave height for NAABSA conditions, in m.

In Fig. 15.2.2.1, the draft corresponding to design displacement is shown with a dotted line and the draft at hull baring is shown with a solid line.

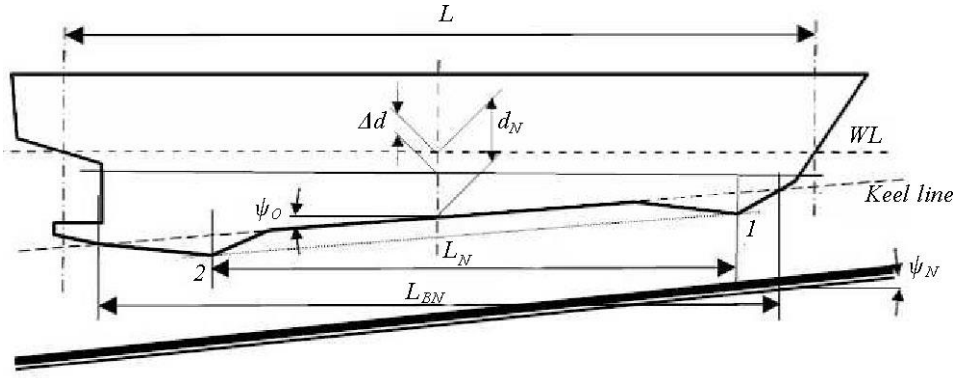


Fig. 15.2.2.1

15.2.3 Requirements for hull form.

15.2.3.1 For typical transverse sections of NAABSA ships are specified in Fig. 15.2.3.1. In the area of impact contact with sea bed it is recommended to reduce the width of the flat horizontal part of the bottom and to increase the deadrise angle.

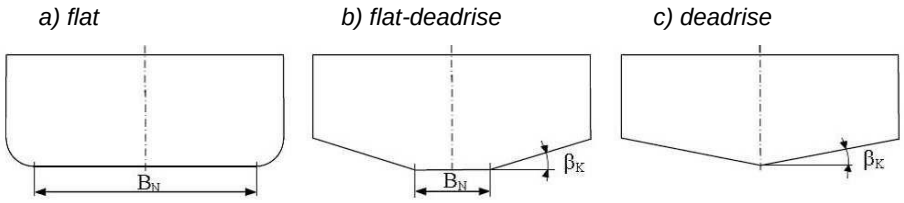


Fig. 15.2.3.1

15.2.4 Strengthened areas.

15.2.4.1 The strengthened bottom area over the hull length of NAABSA ships is divided into the following:

fore area – *A*;

midship area – *B*; and

aft area – *C*.

15.2.4.2 The length of strengthened bottom areas of NAABSA ships is defined according to Fig. 15.2.4.2

The aft boundary of the fore area is located at a distance L_A, in m, from the fore perpendicular equal to:

$$L_A = 0{,}3L(1 + 0{,}175\psi_0) - 20h_k \geq 2L_3, \text{ but not more than } 0{,}3L \qquad (15.2.4.2\text{-}1)$$

where L_3 = distance between point 3 (refer to Fig. 15.2.4.2) and fore perpendicular, in m;
h_k = design height of external structural protection below the keel line, in m.

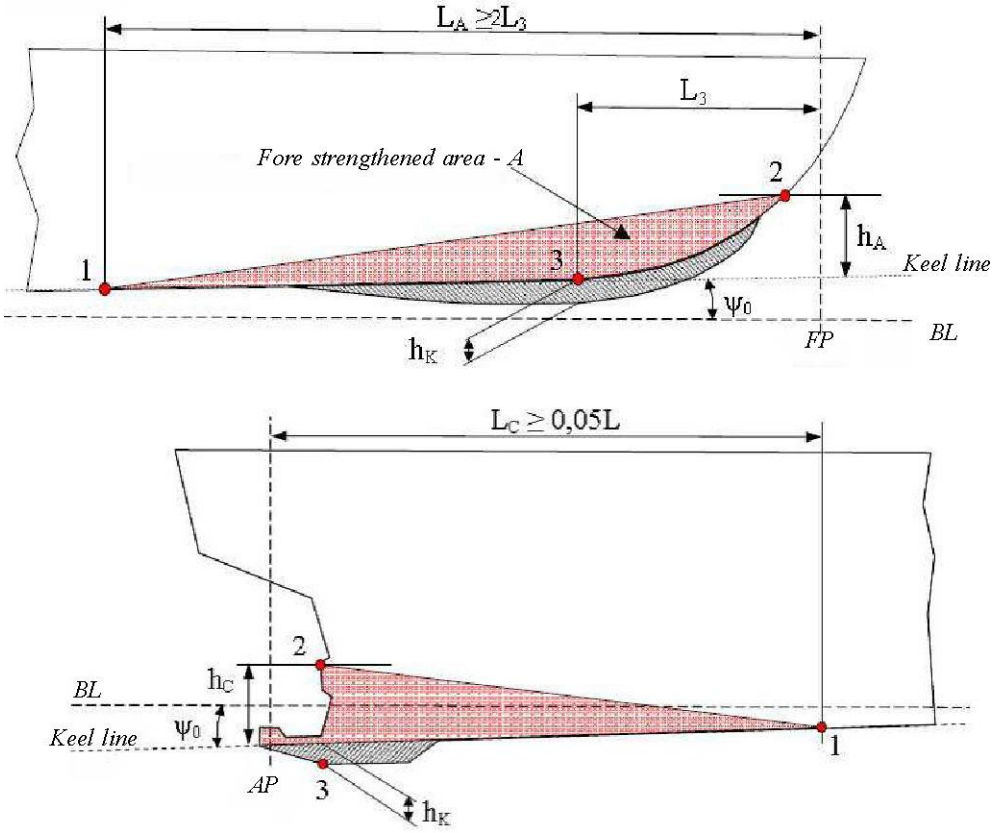


Fig. 15.2.4.2
1 – point of distance from perpendicular; *2* – upper boundary;
3 – point to determine the height of external structural protection

The forward boundary of the aft area is located at a distance L_C, in m, from the aft perpendicular equal to:

$$L_C = 0{,}3L(1 - 0{,}175\psi_0) - 20h_k \geq 0{,}05L_3, \text{ but not more than } 0{,}3L. \quad (15.2.4.2\text{-}2)$$

If the engine room is located in the aft of the ship, such an engine room shall be attributed to the strengthened area *C*.

The midship strengthened area *B* is located between fore and aft areas.

A distance between the upper boundary of the fore strengthened area and the keel line (refer to point 2 in Fig. 15.2.4.2) h_A, in m, is determined by the following formula:

$$h_A = 0{,}1\psi L - h_k \quad (15.2.4.2\text{-}3)$$

where ψ = design trim angle at rolling in the place of grounding, in rad; if no exact data is available, ψ is determined by Formula (1.3.3.1-4), Part II "Hull" as for a ship operating in restricted area of navigation **R3**.

A distance between the upper boundary of the aft strengthened area and the keel line (refer to point 2 in Fig. 15.2.4.2) h_C, in m, is determined by the following formula:

$$h_C = \frac{0{,}2\psi L}{3} - h_k. \quad (15.2.4.2\text{-}4)$$

A distance between the upper boundary of the midship strengthened area and the keel line h_B, in m, is determined by the formula:

$$h_C = (0{,}5B - B_k) \cdot \operatorname{tg}\theta - h_k \leq h_{AN} \quad (15.2.4.2\text{-}5)$$

where B_k = distance from *CL* to the nearest false keel side, in m;
h_{AN} = height to top of floors in case of curved lines and up to the lift point of bottom in case of simplified lines, in m;
θ = design heel angle at rolling in the place of grounding, in rad; if no exact data is available, θ is determined by Formula (1.3.3.1-5), Part II "Hull" as for a ship operating in restricted area of navigation **R3** at $\varphi_r = \varphi$.

15.2.5 Design.

15.2.5.1 For ships with the distinguishing mark **NAABSA2**, the double bottom is required to be fitted in the fore strengthened area. For ships with the distinguishing mark **NAABSA3**, the double bottom is required to be fitted extending along the entire length of the ship – from forepeak to afterpeak bulkhead.

15.2.5.2 For transverse framing system, the flooring shall be installed on each frame. For longitudinal framing system of bottom on ships with **NAABSA2** and **NAABSA3** marks, the flooring shall be installed at two frame spacing intervals.

15.2.5.3 A distance a_{BS}, in m, between bottom stringers, stringer and keel shall not exceed

$$a_{BS} = 1{,}4 + \frac{2{,}5L}{100} - \left(\frac{L}{100}\right)^2, \quad (15.2.5.3)$$

but not more than:

1,1 m – in strengthened area *A* for ships with the distinguishing mark **NAABSA2** and strengthened areas *A* and *C* for ships with the distinguishing mark **NAABSA3**;

2,2 m – in strengthened area *B* for ships with the distinguishing mark **NAABSA3**.

15.2.5.4 For the upper deck of NAABSA ships over 50 m long, the longitudinal framing system in the midship hull area is recommended.

15.2.5.5 Web frames and/or double side diaphragms shall be installed at least 4 frame spacing apart.

15.2.5.6 Plane longitudinal and transverse bulkheads shall be reinforced with vertical stiffeners. Corrugations of corrugated bulkheads shall be vertical.

15.2.5.7 False keels with different cross-section shapes arranged in different places under the bottom (refer to Fig. 15.2.5.7) can be used as external structural protection of NAABSA ships. Installed false keels shall be arranged in the plane of longitudinal bulkheads or bottom stringers. False keels shall be fastened to external shell plating by means of an intermediate member, i.e. a flat bar welded to the shell plating with an all-round continuous fillet weld. Connection of false keels to intermediate member shall comply with the requirements of 2.2.5.3, Part II "Hull". False keels shall terminate in the stiffened areas of shell plating and shall be gradually tapered at ends in height and width.

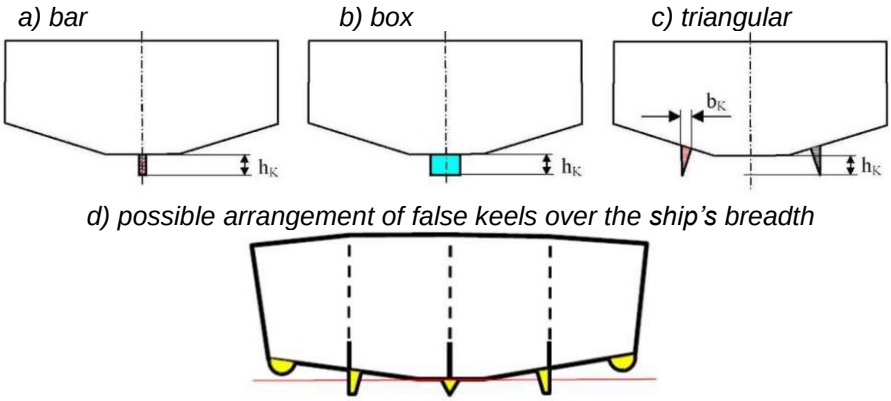


Fig. 15.2.5.7

15.2.5.8 For the longitudinal framing system of bottom on ships with the distinguishing marks **NAABSA2** or **NAABSA3**, the dock and bilge brackets shall be placed at each frame. It is recommended to install lightened dock and bilge brackets between the frames.

15.2.5.9 Support sections of beams.

For designing framing beams by allowable stresses, the support sections and design spans shall be determined according to 1.6.3.1, Part II "Hull".

For designing framing beams by limit state, the support section shall be taken considering availability of brackets and arranged as follows:

at the end of brackets with a free edge stiffened with a face plate;

in the middle of bracket side with unstiffened free edge.

15.2.5.10 Connections of beams shall comply with the requirements of 1.7.2, Part II "Hull". For areas of impact loads on ships with the distinguishing marks **NAABSA2** and **NAABSA3**, it is not recommended to use beam connections with technological gaps.

15.2.5.11 Holes in bottom framing webs.

15.2.5.11.1 Holes in bottom framing webs shall comply with the requirements specified in 2.3.5.2 and 2.4.2.7 of Part II "Hull".

15.2.5.12.2 Holes in primary framing webs for bottom beams in the areas where the bottom contacts the seabed shall be compensated by installation of fixings similar to the intersections specified in Table 3.10.2.4.5 of Part II "Hull". In the areas of impact loads it is recommended to use fixings with edges welded to shell.

15.2.6 Design loads.

15.2.6.1 Design local pressures p_i, in kPa, on the structural members immediately perceiving the seabed are determined by the formula

$$p_i = 10d_N(1 + 4/\sqrt{A_i}) \quad (15.2.6.1)$$

where d_N = refer to 15.2.2;
A_i = calculated area of the member strain zone, in m^2.

15.2.6.2 The required total area of contact with the seabed in case of full ship hull baring $A_N^{\min}$, in m^2, shall be at least

$$A_N^{\min} = g\Delta_N/R_0 \quad (15.2.6.2\text{-}1)$$

where R_0 = design nominal resistance of ground, in kPa, at least

$$R_0 > 10\Delta d. \quad (15.2.6.2\text{-}2)$$

For NAABSA ships, which are loaded/unloaded when grounded in safe mode with use of heavy wheeled and tracked vehicles:

$$R_0 = 100.$$

15.2.6.3 Design static load Q_{OS}, in kN, from the ground to check transverse strength of NAABSA ship hull compartment (refer to 15.2.8.11) is determined by the formula

$$Q_{OS} = k_\varphi R_N^n \frac{L_{OS}}{L_{BN}} \quad (15.2.6.3\text{-}1)$$

where k_φ = 1,5 – with no design-based justifications;
L_{OS} = length of ship compartment/hold, in m;
R_N^n = static response in case of ship hull baring, in kN.

For partial baring conditions:

$$R_N^n = g\Delta_N \frac{\Delta d}{d_N} \cdot \frac{\alpha}{C_b} \cdot. \quad (15.2.6.3\text{-}2)$$

For full baring conditions:

$$R_N^n = g\Delta_N \quad (15.2.6.3\text{-}3)$$

where α = waterplane area coefficient for summer load waterline.

For the recommended diagrams of design load application to ship compartments are specified in Fig. 15.2.6.3.

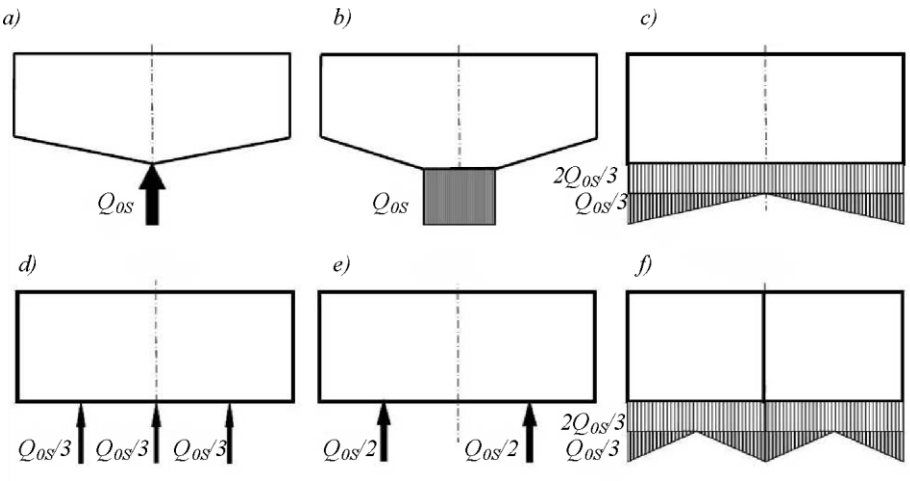


Fig. 15.2.6.3:
a – deadrise; *b* – flat-deadrise; *c* – flat; *d* – with three false keels;
e – with two false keels; *f* – flat with one longitudinal bulkhead at *CL*

If no calculations of ship baring and emersion processes are available, static end response of the ground R_N^m to ship hull, in kN, is determined by the following formula:

$$R_N^m = g\Delta_N \left[\frac{\mathrm{tg}(\psi_S - \psi_0 - \psi_S - \psi_{ON})}{6}\frac{L}{d_N}\right] + R_{ON}. \qquad (15.2.6.3\text{-}4)$$

For ships with the distinguishing mark **NAABSA1** R_{ON} = 0 and ψ_{ON}=0 shall be taken.

In any case for full hull baring conditions the value of static end response of the ground R_N^m, in kN, shall be at least

$R_N^m = 3g\Delta_N/12$ – for ship with the distinguishing mark **NAABSA1**;

$R_N^m = 4g\Delta_N/12$ – for ships with the distinguishing mark **NAABSA2**;

$R_N^m = 5g\Delta_N/12$ – for ships with the distinguishing mark **NAABSA3**.

15.2.6.4 Bending moments and shear forces for hull.

15.2.6.4.1 Bending moments and shear forces for hull of a ship which is periodically grounded in operation shall be determined for ships with the distinguishing mark **NAABSA1** and length over 50 m and for ships with the distinguishing mark **NAABSA2** and **NAABSA3** irrespective of the ship's length.

15.2.6.4.2 The values of maximum bending moments, in kNm, and shear forces, in kN, can be determined by approximation formulae specified in 15.2.6.4.3 – 15.2.6.4.6.

15.2.6.4.3 For full hull baring when aground and hull hogging of NAABSA ships of all levels:

$$M_N = 0{,}315\Delta_N L; \qquad (15.2.6.4.3\text{-}1)$$

$$N_N = -1{,}03\Delta_N. \qquad (15.2.6.4.3\text{-}2)$$

For partial hull baring of ships with the distinguishing mark **NAABSA1**, the obtained values can be reduced by replacing Δ_N with the nominal response of the ground R_N^n, but not more than twice.

15.2.6.4.4 In case of action of end force and hull sagging of ships with the distinguishing mark **NAABSA1**:

$$M_N = -0{,}363\Delta_N L; \qquad (15.2.6.4.4\text{-}1)$$

$$N_N = 2{,}45\Delta_N. \qquad (15.2.6.4.4\text{-}2)$$

15.2.6.4.5 In case of action of end force, including bow impact of ships with the distinguishing mark **NAABSA2**:

$$M_N = -0{,}629\Delta_N L; \qquad (15.2.6.4.5\text{-}1)$$

$$N_N = 3{,}27\Delta_N. \qquad (15.2.6.4.5\text{-}2)$$

15.2.6.4.6 In case of action of end force, including bow or stern impact of ships with the distinguishing mark **NAABSA3**:

$$M_N = -0{,}921\Delta_N L; \qquad (15.2.6.4.6\text{-}1)$$

$$N_N = 4{,}09\Delta_N. \qquad (15.2.6.4.6\text{-}2)$$

15.2.6.4.7 The formulae specified in 15.2.6.4.3 — 15.2.6.4.6 determine maximum values of bending moments in the midship area of the hull and shear forces on the bow and stern. In case of sagging due to end forces, including impacts forces, the obtained values shall be summed up algebraically with design bending moments for the ship in still water.

15.2.7 Ultimate section modulus of a ship's hull cross section.

Ultimate section modulus of hull cross section for NAABSA ships by the end of service life shall be not less than permissible residual ultimate section modulus of hull cross section $W_{LM}(bot)$, in cm^3, determined by the formula:

$$W_{LM}(bot) = 1{,}1 \cdot \frac{|0{,}92M_N + M_{SW}|}{R_{eH}} \cdot 10^3 \qquad (15.2.7.1)$$

where M_N = design bending moment according to 15.2.6.4, in kNm;
M_{SW} = design bending moment in case of ship sagging in still water, in kNm;
R_{eH} = upper yield stress of deck (bottom) material.

When determining ultimate section modulus of hull cross section of NAABSA ships by the end of service life, the following shall be taken into account:

wear of structural members is 30 %;

deformations of bottom structures breadthwise in design section are 50 % of the permissible values;

compressed flexible braces of the deck and upper part of sides are not allowed;

tension braces of the bottom with deformations are not allowed.

15.2.8 Dimensions of structural members.

15.2.8.1 Thickness of the bottom and bilge plating s, in mm, in the strengthened bottom area of NAABSA ships shall be at least:

$$s = 15{,}8ak\sqrt[\alpha]{\frac{k_p p}{k_\sigma R_{eH}}} \cdot m_n^{-1} \qquad (15.2.8.1)$$

where a = dimension of the smaller side of the panel, in m;
b = dimension of the larger side of the panel, in m;
$k_\alpha = \frac{1-\alpha+\pi\alpha/6}{1-\alpha+\pi\alpha/2}$ – ratio of panel sides;
$\alpha = a/b$;
k_p – safety factor taken equal to:
k_p= 1,5 in case of no external structural protection in the area concerned;
k_p= 1,0 if external structural protection is available in the area concerned;

p – design pressure of seabed, in kPa, according to 15.2.6.1 at $A_i = a \times b$;
k_σ – factor of allowable stresses taken equal to:
$k_\sigma = 0{,}95 - 0{,}42L/100$ in case of transverse framing system in the midship strengthened area;
$k_\sigma = 0{,}9$ – in other cases;
R_{eH} = upper yield stress, in MPa;
m_n = coefficient taken equal to:
$m_n = 0{,}75$ – in case of no external structural protection in the area concerned;
$m_n = 0{,}65$ – if external structural protection is available in the concerned area.

15.2.8.2 In the area of impact loads with no external structural protection in the area concerned the thickness of the bottom and bilge plating of ships with the distinguishing marks **NAABSA2** and **NAABSA3** shall be at least:

$$s = \frac{10{,}6}{R_{eH}} \cdot pb \qquad (15.2.8.2)$$

where R_{eH} = upper yield stress, in MPa;
p = design pressure of seabed, in kPa, according to 15.2.6.1 at $A_i = a \times b$;
b = dimension of the larger side of the panel, in m.

15.2.8.3 In all cases the thickness of the bottom and bilge plating shall be not less than that specified in 2.2.4.8, Part II "Hull".

15.2.8.4 Ultimate section modulus W_0, in cm^3, of cross section of primary members in the strengthened bottom area of NAABSA ships shall be at least:

$$W_0 = \frac{1000 k_p pal^2}{m k_\sigma R_{eH}} k_\alpha k_k m_n^{-1} \qquad (15.2.8.4)$$

where a = distance between primary members;
l = span length, in m;
$k_\alpha = 1 - \alpha^2/2 + \alpha^3/8$;
$\alpha = a/l$;
p – design pressure of seabed, in kPa, according to 15.2.6.1 at $A_i = 2a \times l$;
k_k = 0,914 – load distribution coefficient;
m_n = 0,75 – in case of no external structural protection in the area concerned;
m_n = 0,65 – if external structural protection is available in the area concerned;
m = 12 – bending moment coefficient;
k_σ = $0{,}95 - 0{,}42L/100$ – for bottom longitudinal girders in the midship strengthened area;
k_σ = 0,9 – in other cases;
R_{eH} – upper yield stress, in MPa;
k_p = 1,35 in case of no external structural protection in the area concerned;
k_p = 1,0 if external structural protection is available in the area concerned;

15.2.8.5 Actual section modulus of girder section is determined according to 3.10.4.2.6, Part II "Hull".

15.2.8.6 The beam web area in the strengthened bottom area of NAABSA ships f_c, in cm^2, shall be not less than the value determined by the formula

$$f_c = \frac{5 k_p pal(1 - \alpha/2)}{0{,}57 m_n k_\sigma R_{eH}} \qquad (15.2.8.6)$$

where k_p = 1,35 in case of no external structural protection in the area concerned;
k_p = 1,0 if external structural protection is available in the area concerned;
a = distance between primary members;
l – span length, in m;
$\alpha = a/l$;
p = design pressure of seabed, in kPa, according to 15.2.6.1 at $A_i = 2a \times l$;

k_k = 0,914 – load distribution coefficient;
m_n = 0,75 – in case of no external structural protection in the area concerned;
m_n = 0,65 – if external structural protection is available in the area concerned;
k_σ = $0{,}95-0{,}42L/100$ for longitudinal beams of bottom framing in the midship strengthened area;
k_σ = 0,9 – in other cases;
R_{eH} – upper yield stress, in MPa.

15.2.8.7 Actual area of web is determined according to 3.10.4.2.5, Part II "Hull".

15.2.8.8 Scantlings of floors, centre girder and bottom stringers shall be selected proceeding from the calculation of bottom grillage, using beam model. Design static loads on bottom grillage are determined according to 15.2.6.3. It is recommended to take into account the effect of brackets. If pillars are available, the interaction of bottom grillage with superstructures shall be considered.

Reduced stresses (by von Mises criterion) obtained by results of calculation shall not exceed:

$0{,}75 \cdot (0{,}95-0{,}42L/100) \cdot R_{eH}$ – for longitudinal framing in the strengthened area *B*;

$0{,}68 \cdot R_{eH}$ – in all other cases.

15.2.8.9 Dimensions of pillars and struts shall be not less than the those specified in 2.9, Part II "Hull". Compression loads shall be determined by calculation using beam model.

15.2.8.10 The web thickness of floors, bottom stringers, centre girder, bilge brackets and plates of transverse and longitudinal bulkheads adjoining the shell in the strengthened bottom area of NAABSA ships shall be not less than that specified in 2.2.4.9, Part II "Hull" where external structural protection is available in the area concerned and 2.4.4.3.2, Part II "Hull" where there is no external structural protection.

15.2.8.11 The webs of floors, bottom stringers, centre girder, bilge brackets and pates of transverse and longitudinal bulkheads adjoining the shell in strengthened bottom area of NAABSA ships shall be reinforced with stiffeners. The distance between stiffeners shall not exceed the distance between the bottom longitudinals in the area concerned. Stability of stiffeners shall be ensured in worn-out state at the end of structure service life.

15.2.8.12 The web thickness of floors, bottom stringers, centre girder, as well as bilge brackets and plates of transverse and longitudinal bulkheads adjoining the shell in strengthened bottom area of NAABSA ships shall be not less than that specified in 3.10.4.9.2, Part II "Hull". Design pressures shall be not less than those determined by the formula

$$p = 10d_N(1 + 4/\sqrt{A_i}) \cdot k_p \qquad (15.2.8.12)$$

where d_N = refer to 15.2.2;
A_i = calculated area of the member strain zone, in m^2;
k_p = 1,5 – safety factor;

15.2.8.13 Stems.

15.2.8.13.1 Stem construction shall comply with the requirements of 2.9, Part II "Hull".

15.2.8.13.2 The lower part of the stem on NAABSA ships at the transition area to keel shall protrude beyond the shell surface or shall be made as an outboard bar.

15.2.8.13.3 The approved cross section dimensions of the stem shall be checked based on the calculation of the curvilinear variable section beam, which rests on decks, platforms and transverse bulkheads. Design load shall be not less than the response of the seabed R_N^m according to 15.2.6 distributed as a triangle along the length L_3 (refer to 15.2.4.2); coefficient of allowable stresses shall be taken equal to k_σ=0,68.

15.2.8.13.4 The lower part of the sternframe on NAABSA ships at the transition area to keel shall protrude beyond the shell surface or shall be made as an outboard bar.

15.2.8.13.5 The approved dimensions of sternframe members shall be checked based on the direct strength calculation taking the coefficient of allowable stresses k_σ=0,68 and design end loads according to 15.2.6. If the solepiece is lifted in the stern direction at an angle of not less than 6° for ships with the distinguishing mark **NAABSA1**, 8° for ships with the distinguishing mark **NAABSA2** and 10° for ships with the distinguishing mark **NAABSA3**, the load is considered distributed in the form of a triangle, in other cases the load is evenly distributed.

15.3 EQUIPMENT, ARRANGEMENTS AND OUTFIT

The NAABSA ships shall have at least one embarkation ladder on each side. The length of such embarkation ladders shall equal the distance from the upper deck to the seabed to provide safe transfer of the crew. The design of embarkation ladders shall comply with the requirements of 6.20.7, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships.

15.4 STABILITY AND SUBDIVISION

15.4.1 The requirements of this Section are in addition to the requirements of Part IV "Stability" and Part V "Subdivision".

15.4.2 For the purpose of this Chapter the following symbols have been adopted:

L_1 – ship's length as determined in the Load Line Rules for Sea-Going Ships;

B – ship's breadth.

15.4.3 The Stability Booklet shall include the following:

.1 it shall be specified that in case of grounding and emersion the ship shall be trimmed in way to have the bottom plane parallel to the ground plane in the place of grounding;

.2 it shall be specified that during loading/unloading operations aground, the changes in ship load shall be strictly weighed. If the exact data on the height of the centre of gravity is not available, the height of centre of gravity shall be taken equal to the upper dimensional limit;

.3 it shall be specified that prior to emersion, the ship trim and stability afloat shall be estimated to confirm that the ship complies with all applicable requirements for stability and that the load line draught is not exceeded.

15.4.4 Under all loading conditions to be encountered in service (icing disregarded), the trim and stability of an intact ship shall be sufficient to meet the requirements of 3.3 and 3.4, Part V "Subdivision" after obtaining the following bottom damages located anywhere in the ship length:

.1 longitudinal extent – $^1/_3\,(L_1^{2/3})$ or 14,5 m (whichever is less);

.2 transverse extent – $B/6$ or 10 m (whichever is less);

.3 vertical extent – $B/20$ or 2 m (whichever is less).

16 REQUIREMENTS FOR BOILER MONITORING SYSTEMS

16.1 GENERAL PROVISIONS AND APPLICATION

16.1.1 Distinguishing mark **BMS** (Boiler Monitoring System) may be added to the character of classification of ships fitted with boiler plant monitoring system that allows not to carry out internal surveys of steam boilers at the presence of the RS surveyor. This Section specifies technical and organizational requirements for the ships with the distinguishing mark **BMS**, which shall be followed to allow the survey carried out by the chief engineer to be credited by the Register as boiler internal survey. Documentation on the performed internal survey shall be presented to the attending RS surveyor who shall carry out the remaining scope of the boiler survey.

16.1.2 To assign the distinguishing mark **BMS**, the initial survey shall be performed to confirm that the boiler design and technical condition make it possible for the crew to perform the survey, that the ship is fitted with appropriate boiler condition control and monitoring system, and that the ship's chief engineer is qualified to partially perform the scope of boiler survey.

16.1.3 Distinguishing mark **BMS** may be assigned to auxiliary oil-fired steam boilers and waste-heat boilers with working pressure not exceeding 2,0 MPa.

16.1.4 Distinguishing mark **BMS** may be assigned to both ships with new boilers and boilers in service.

16.1.5 Distinguishing mark **BMS** can be withdrawn at the discretion of the shipowner or proceeding from the results of ship survey carried out by the RS surveyor. After that, the ship's boiler plant shall be submitted to the Register on a common basis.

16.2 TERMS AND DEFINITIONS

In addition to the below mentioned, the definitions specified in Chapter 1.2, Part X "Boilers, Heat Exchangers and Pressure Vessels" and in 1.1.1, Part I "Classification" of the Rules for the Classification and Construction of Sea-Going Ships are applicable to the requirements of this Section.

M o n i t o r i n g means continuous process of reading and recording item's parameters under control, which are assumed essential for the life duration, and comparing these parameters with specified values.

B o i l e r w a t e r means water inside the boiler and all its components.

F e e d w a t e r means water supplied by feed water pumps to the steam boiler to generate steam; it is a mixture of condensate and make-up water.

M a k e - u p water means water added to the feed water for replenishing the leaks and condensate losses; it is a mixture of distillate and chemically treated water.

C o n d e n s a t e means water generated in the condensate and feed water system upon the waste steam condensation.

D i s t i l l a t e means water generated in the desalinating plant by evaporation and condensation of sea water.

16.3 TECHNICAL AND OPERATING DOCUMENTATION

16.3.1 For steam boilers, the ship's Instruction on maintaining boiler water and chemistry quality shall be developed. This document shall provide recommendations on pre-boiler and in-boiler water treatment and on prevention of scale formation and other factors leading to boiler plant excessive wear. This document shall be developed considering the requirements of instructions developed by boiler firms (manufacturers), standard instructions and applicable industry standards. The content and availability of this document on board the ship shall be checked by the RS surveyor during the initial survey for assigning the distinguishing mark **BMS** to the ship.

16.3.2 Instruction on maintaining boiler water and chemistry quality shall contain:

.1 specification and brief description of water preparation process and equipment applied;

.2 schedule, scope and methods of water quality control;

.3 list and diagram of the sampling points;

.4 make-up, feed, boiler water and condensate quality standards;

.5 list of reagents necessary for water treatment and for ship's water laboratory;

.6 data on filter regeneration (if applicable);

.7 recommendations on boiler conservation for the period when they are not in operation.

16.3.3 The ship shall be provided with ship's boiler monitoring log-book. The following shall be recorded in the log-book:

data on boiler maintenance in accordance with the manufacturer’s recommendations and boiler survey results;

results of water chemical analyses;

measures taken to provide the feed and boiler water quality standards;

measures taken for burner units maintenance in accordance with the manufacturer's recommendations;

periodic testing of automatic burner unit interlocking and protecting devices as specified in Chapter 5.3, Part X "Boilers, Heat Exchangers and Pressure Vessels".

16.4 ADDITIONAL REQUIREMENTS FOR THE SHIPS WITH THE DISTINGUISHING MARK BMS

16.4.1 Additional requirements for boiler plants of ships with distinguishing mark BMS.

16.4.1.1 Special devices shall be provided for metering the chemicals and adding them to boiler and feed water.

16.4.1.2 Regular facilities shall be provided for collecting representative samples from boiler and feed water at safe temperature (e.g. by installing a sample cooler).

16.4.1.3 Facilities shall be provided for continuous early detection of excessive salinity, which shall immediately alarm when salt water is detected in the system.

16.4.1.4 Facilities shall be provided in condensate and feed water system for continuous early detection of oil products or transported goods in the boiler and feed water.

16.4.1.5 To remove oxygen, the feed water shall be kept in an open tank (e.g. in observation tank, hot well or a special deaerator) at temperature of at least 80 °C.

16.4.1.6 Regular facilities shall be provided for monitoring pressure difference before and after exhaust boilers.

16.4.2 Boiler, feed and make-up water quality monitoring.

16.4.2.1 Feed water shall contain minimum dissolved salts, gases, organics and insoluble suspended solids. The main water quality indicators to be controlled within the monitoring process are total hardness, chloride, oxygen and oil products content.

16.4.2.2 Boiler water quality shall be maintained and documented in accordance with recommended limiting values of boiler and feed water quality indicators as specified by the boiler manufacturer. Where there are no any special instructions from the boiler manufacturer, the boiler and feed water quality requirements specified in Table 16.4.2 for steam boilers with working pressure not exceeding 2 MPa shall be followed.

Table 16.4.2

Recommended boiler and feed water quality standards

Water type	Quality indicator	Measurement unit	Gas-tube boilers	Water-tube and composite boilers
Feed water	Total hardness	mg-eq/l	not more than 0,5	not more than 0,3
	Oil and oil products	mg/l	not more than 3	not more than 3
	Oxygen	mg/l	not more than 0,1	not more than 0,1
	Chlorides	mg/l	not more than 50	not more than 15
Condensate	Chlorides	mg/l	not more than 50	not more than 15
Distillate[3]	Total hardness	mg-eq/l	–	not more than 0,05
Make-up water[3]	Total hardness	mg-eq/l	not more than 8	not more than 5
Boiler water	Chlorides	mg/l	not more than 8000	not more than 1200
	Base number	mg/l	150 – 200	150 – 200
	Residual hardness	mg-eq/l	not more than 0,4	not more than 0,2
	Total salinity	mg/l	not more than 13000	not more than 3000
	Phosphate number[1]	mg/l	30 – 60	30 – 60
	Nitrate number[1]	mg/l	75 – 100[2]	75 - 100[2]

[1] To be monitored for boilers with phosphate/nitrate water treatment.
[2] The nitrate number shall be 50 % of the actual base number.
[3] To be monitored during make-up water preparation.

16.4.2.3 Water quality shall be regularly checked using regular facilities and periodical water analysis in land-based laboratories. Boiler and feed water shall be monitored with the use of on-board regular facilities at least every 24 h. Boiler and feed water analysis results shall be recorded in a ship's log book.

16.4.2.4 Boiler water analysis in land-based laboratories shall be carried out at least once a month, and results shall be kept on board the ship.

16.4.2.5 In any cases, deviation of boiler water quality from the prescribed standards shall be immediately corrected. Acceptable methods of maintaining water quality are maximum condensate return, surface and bottom blowdown, pre-boiler chemical treatment of the feed and make-up water, in-boiler chemical water treatment. Another method to ensure water quality may be adopted instead of chemical treatment, provided that its equivalence is substantiated.

16.4.2.6 Boiler water quality shall be annually analyzed by the shipowner and corrected, if necessary. Measures to improve the boiler water quality shall be developed to prevent hard deposit formation and corrosion damages; these measures shall be based on analyses (examinations) of hard deposits found in boiler and corrosion damages.

16.5 SURVEYS

16.5.1 Initial survey.

16.5.1.1 Initial survey for assigning the distinguishing mark **BMS** to the ship shall be carried out by the RS surveyor in the scope of special survey, including internal survey and furnace inspection.

16.5.1.2 During initial survey for assigning the distinguishing mark **BMS** to the ship, the RS surveyor shall check boiler's overall technical condition in accordance with 16.4.1, compliance with the requirements of 16.4.2 and availability of the log-books required.

16.5.1.3 The boiler shall comply with strength and design requirements of the RS rules as specified in Part X "Boilers, Heat Exchangers and Pressure Vessels". The boiler shall not have indications of any damages, which were not documented and agreed with the Register during the last repair. Plugged tubes are not allowed. The boiler heating surfaces shall be free of soot, sludge, ripple or metal overheat marks. The boiler components shall not have any visible deformations or damages.

16.5.2 Periodical surveys.

16.5.2.1 Periodical internal surveys of boiler's water/steam and furnace/fire sides for ships with boiler plant monitoring system and distinguishing mark **BMS** shall be performed by the crew against requirements of 2.9.3, Part II "Survey Schedule and Scope" of the Rules for the Classification Surveys of Ships in Service without participation of the RS surveyor. The Report on Survey supplemented with photos of the boiler's components subject to internal survey shall be signed by the chief engineer.

16.5.2.2 Internal surveys of boiler's water/steam side shall be performed by the crew at least once a year but not more than 30 days before annual ship survey. If the boiler has components not accessible for internal survey, the internal survey shall be followed by hydraulic tests with test pressure equal to 1,25 working pressure in accordance with 2.9.2.3, Part II "Survey Schedule and Scope" of the Rules for the Classification Surveys of Ships in Service; the testing shall be reflected in the Report on Survey signed by the chief engineer.

16.5.2.3 Internal survey of boiler's furnace/fire side shall be performed by the ship crew at least twice a year.

16.5.2.4 During annual survey, the documentation on performed internal surveys and photos of boiler's components subject to internal survey shall be submitted to the RS surveyor, who reviews the submitted materials and performs the boiler external examination in accordance with 2.9.1, Part II "Survey Schedule and Scope" of the Rules for the Classification Surveys of Ships in Service. If the boiler internal survey (internal examination) documents are drawn up improperly or there are reasonable doubts regarding reliability of the photos submitted, the RS surveyor is entitled to require repeated boiler internal survey in his presence.

16.5.2.5 During annual survey of the ship, the documentation on boiler and feed water monitoring along with results of annual boiler water analysis shall be submitted to the RS surveyor in accordance with 16.4.2.6.

17 REQUIREMENTS FOR SHIPS EQUIPPED WITH HULL STRENGTH AND STABILITY MONITORING SYSTEMS

17.1 GENERAL PROVISIONS

17.1.1 The ships equipped with automated hull strength and/or current stability monitoring system (hereinafter referred to as "HMS") compliant with the requirements of this Section are assigned the distinguishing mark **HMS** added to the character of classification. The information on completeness and features of the system in compliance with the symbols given in 17.2 shall be indicated in brackets.

17.1.2 This Section establishes the minimum requirements to the monitoring system necessary for assignment of the distinguishing mark to the class notation pursuant to 17.2.

17.1.3 The strength and stability monitoring system is intended for informing the ship's crew on loads exerted on the ship and changes in stability during the service and loading/unloading operations in a port.

The hull monitoring system is intended for supplying auxiliary information to the master but shall not substitute for the master's own judgement and shall not detract from the master's responsibility related to the decisions to be taken during the ship service.

17.2 DISTINGUISHING MARK IN THE CLASS NOTATION

17.2.1 For ships equipped with a monitoring system complying with the requirements of this Section, the distinguishing mark shall be added to the class notation specifying the system completeness:

.1 **HMS(STR)** — system is intended for monitoring of strength parameters;

.2 **HMS(STAB)** — system is intended for monitoring of stability parameters;

.3 **HMS(STR-STAB)** — system is intended for monitoring of strength and stability parameters.

17.2.2 Where the system is fitted with additional features, the distinguishing mark shall be specified as **HMS(…)+…**, and the following additional feature symbols shall be added after brackets:

.1 **BS** — availability of connection to the ballast, heel and trim systems of the ship;

.2 **C** — availability of connection to the onboard computer software for calculation of ship's strength and stability;

.3 **DD** — availability of directional data link ensuring monitoring data transfer to the shore;

.4 **DM** — availability of mutual data link ensuring monitoring data transfer to the shore and control of monitoring system from the shore;

.5 **N** — availability of connection to GPS/GLONASS receivers, log, echo sounder and indication of received data on the monitoring system display;

.6 **RPM** — availability of connection to the ship system for propeller shaft(s) speed measurement and recording;

.7 **SI** — availability of connection to the ship radar ice display with transfer of current ice condition data, their recording in the database and indication on the monitoring system display;

.8 **SW** — availability of connection to the ship weather station with transfer of current sea state parameters, their recording in the database and indication on the monitoring system display;

.9 **TS** — availability of connection to the ship system for the propeller shaft(s) torque measurement and recording;

.10 **ThS** — availability of connection to the ship system for measurement and recording of thrust along the propeller shaft(s) fore-aft axis;

.11 **TVS** — availability of connection to the ship system for measurement and recording of radial and longitudinal vibration displacements of the propeller shaft(s);

.12 **W** — availability of connection to the ship weather station with transfer of current apparent and true wind speed and direction, and sea state parameters including data indication on the monitoring system display.

17.3 TERMS AND DEFINITIONS

Definitions and explanations concerning the general terminology of the Rules are given in Part I "Classification".

For the purpose of this section the following definitions and explanations have been adopted.

After perpendicular means the after perpendicular as defined in Part II "Hull".

Calibration of a measuring instrument means a set of operations performed for determination and verification of actual values of metrological characteristics and/or suitability for purpose of a measuring instrument not subject to state metrological control and supervision.

Forward perpendicular means the forward perpendicular as defined in Part II "Hull".

Intermediate waterline means the waterline determined as the arithmetic mean position between draughts corresponding to the ice loadline and ballast waterline. The ice loadline and ballast waterline shall be determined in accordance with 3.10.1.3.2, Part II "Hull".

Length L means the length as defined in Part II "Hull".

Local deformation means changes in shape and sizes of individual structural members of the ship's hull (framing members and plating connected thereto) caused by external effects. Such changes are characterized by tension or compression, and/or bending, and/or shear of the structure in general and/or its parts.

Midship section means the midship section as defined in Part II "Hull".

Solid state drive means a nonmechanical storage device based on storage integrated circuits.

Upper deck means the upper deck as defined in Part II "Hull".

17.4 SURVEY SCOPE

17.4.1 General provisions pertaining to the procedure of surveys, as well as the requirements for the technical documentation submitted to the Register for review and approval are specified in General Regulations for the Classification and Other Activity and in Part I "Classification".

17.4.2 The Register performs review of technical documentation for the monitoring system and survey of the system during installation and service.

17.4.3 Testing of the monitoring system shall be carried out under the RS supervision according to test programmes approved by the Register.

17.4.4 When changes affecting main parameters or internal ship subdivision are introduced in the ship design, or approved documentation on stability and/or strength is amended, the approval of the monitoring system becomes invalid. Upon introduction of required changes the system shall be submitted for repeated review.

17.5 TECHNICAL DOCUMENTATION

17.5.1 Prior to installation of the system on board the ship, the following technical documentation for the monitoring systems shall be submitted to the Register for review (upon the positive review results the documents shall be stamped "Approved" (A), "Agreed" (AG) or "For information" (FI)):

.1 technical description (AG);

.2 schematic diagram (AG);

.3 function block diagram (AG);

.4 list of measuring channels (AG);

.5 arrangement plan with indication of measuring instrument locations, cable laying and hardware installation (A);

.6 general electrical diagram (AG);

.7 schematic circuit diagram (AG);

.8 permissible values of parameters used for monitoring in sensor location points (AG);

.9 technical description of software, including procedure for calculation of parameters used for monitoring, based on results of measurements (AG);

.10 monitoring system operating manual (AG);

.11 maintenance instruction manual including calibration procedure (AG);

.12 installation drawings (A) (to be reviewed by the RS Branch Office performing technical supervision of the system installation at the stage of mounting);

.13 installation, commissioning and adjustment instruction (AG) (to be reviewed by the RS Branch Office performing technical supervision of the system installation at the stage of mounting);

.14 programme of periodical surveys of the system in service (A).

17.5.2 For the monitoring system having connection with other systems, the following technical documentation shall be additionally submitted:

.1 schematic diagram of monitoring system connection with other systems (AG);

.2 diagram of hardware arrangement and cable routing for monitoring system connection with other systems (A);

.3 schematic circuit diagram for monitoring system hardware intended for connection with other systems (AG).

17.5.3 Where a computer model of ship is used for the monitoring system calculations, the model shall be approved in compliance with 12.2.4.1 to 12.2.4.3, Part II "Technical Documentation" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

17.5.4 Along with the technical documentation, the reports of previous tests may be submitted, as well as the available certificates confirming the compliance of hardware and software components used in the monitoring system with the requirements of RS rules.

17.5.5 The following technical documents shall be permanently available on board every ship equipped with the monitoring system:

.1 monitoring system operating manual;

.2 maintenance instruction manual including calibration procedure;

.3 list of measuring channels;

.4 schematic diagram;

.5 function block diagram;

.6 arrangement plan with indication of measuring instrument locations, cable laying and hardware installation;

.7 general electrical diagram;

.8 schematic circuit diagram;

.9 monitoring system record book;

.10 programme of periodical surveys.

17.5.6 Where the monitoring system has connection with other systems, the following technical documentation shall be additionally available on board:

.1 schematic diagram of connection system;

.2 arrangement diagram of connecting unit hardware, cable routing and wireless local link antennas;

.3 schematic circuit diagram of connection system.

17.5.7 The technical documentation of the monitoring system available on board shall be drawn up in working language of the ship's crew. Where the ship is engaged in international voyages, the documentation shall be translated into English.

17.6 GENERAL REQUIREMENTS

17.6.1 The monitoring system shall ensure:

.1 on-line collection and processing of measurement results;

.2 on-line monitoring of variations of the parameters which are indicative of the ship's strength and/or stability state;

.3 calculation of parameters used for monitoring based on measurement results;

.4 on-line sorting of parameters by hazard levels;

.5 preservation and visualization for results of processing of measurements, calculations and sorting of parameters by hazard levels;

.6 generation of alarms and warning messages based on results of parameters sorting by hazard levels;

.7 data import/export between the monitoring system and other ship equipment (where provided by system design version);

.8 transmission of monitoring data to the shore (where provided by system design version);

.9 configuring of operating modes of the monitoring system and calibration of measuring components;

.10 self-diagnostics of components;

.11 preservation of measurement, processing and calculation data in case of power failure and automatic resumption of normal operation upon power supply return;

.12 continuous round-the-clock operation.

17.6.2 The hardware shall ensure reliable operation in marine conditions and meet the requirements specified in Part XV "Automation".

17.6.3 Hardware components located in the spaces with the vibration level in excess of values specified in Part XV "Automation" shall be designed to ensure reliable operation in such conditions or shall be installed on appropriate shock absorbers.

17.6.4 The protection degree of hardware shall be at least as specified in 2.4.4, Part XI "Electrical Equipment".

17.6.5 Hardware components located on open decks and in cargo hold spaces shall be protected against accidental mechanical damage.

17.6.6 The requirements for marking of the instruments shall be determined in the technical documentation for products.

17.6.7 Hardware components of the monitoring system shall meet the requirements for:

.1 electrical safety specified in Part XI "Electrical Equipment";

.2 electromagnetic compatibility specified in 2.2, Part XI "Electrical Equipment".

17.6.8 The software shall be protected against unintended and unauthorized access.

17.6.9 Automatic control of software functioning and user warning in case of its malfunctions shall be provided in the monitoring system.

17.7 COMPLETENESS

17.7.1 The type and minimum number of measuring components within the monitoring system shall be specified depending on the ship type, its particulars, area of navigation and system features.

17.7.2 The minimum list of the values to be measured when the system is intended for strength monitoring is given in Table 17.7.2.

17.7.3 Where the system intended for strength monitoring is installed on board the ice class ships, the values given in Table 17.7.3 shall be additionally measured.

17.7.4 Where the system is intended for stability monitoring, the ship shall be equipped with a dynamic displacement measurement device with 6 degrees of freedom for measurement of angular motions, angular rates of heel, trim, yaw and vertical, transverse and longitudinal displacements and accelerations. The device shall be installed at midship both on port and starboard, and at after and forward perpendiculars.

17.7.5 The control areas shown in Figs. 17.7.3-1 — 17.7.3-7 and in Table 17.7.3 are approximate.

Actual points for installation of sensors shall be specified at the stage of monitoring system development depending on structural particulars of the ship, possibility for sensor installation and cable route laying.

17.7.6 The minimum configuration of equipment, to which the monitoring system shall be connected for distinguishing marks specified in 17.2.2 to be added to the class notation is given in Table 17.7.6.

Table 17.7.2

List of values to be measured by system intended for strength monitoring

Parameter	Area of installation	Measuring instrument	Type of ship	Remark
1	2	3	4	5
Vertical impact acceleration	At forward perpendicular	Single-axis accelerometer	All ships	Area of installation: not exceeding $0{,}01L$ from forward perpendicular
Longitudinal bending of hull	At midship on port and starboard at upper deck	Single-axis long base linear surface strain sensor	All ships	For multi-hull ships: at cross-structure between hulls at midship on port/starboard
	At intersection of midship section and ship centreline on inner side of bottom		**Container ship**, **Timber carrier**, ships without descriptive notation in class notation	Applicable to ships $L \geq 200$ m. Area of installation on double bottom ships: on inside of inner bottom
	At distance of $L/4$ from midship section forward and aft on port and starboard at upper deck		**Bulk carrier**, **Ore carrier**, **Bilge water removing ship**, **Chemical tanker**, **Gas carrier**, **Oil recovery ship**, **Oil tanker**, **Oil/bulk carrier**, **Oil/ore carrier**, **Oil/bulk/ore carrier**, **Tanker**, **FPSO**, **FSO**, **Container ship**, **Timber carrier**, **Ro-ro ship**, **Ro-ro passenger ship**,	Applicable to ships with descriptive notation **Ro-ro ship** and **Ro-ro passenger ship** $L \geq 200$ m, **Fishing vessel** $L \geq 100$ m and for ships with other descriptive notations listed in column 4, $L \geq 300$ m

1	2	3	4	5
			Fishing vessel, ships without descriptive notation in class notation, except for multi-hull ships	
Transverse bending of hull	At forward perpendicular at upper deck	Single-axis long base linear surface strain sensor	**Bulk carrier**, **Ore carrier**	Applicable to ships with large deck opening $L \geq 150$ m. Area of installation: not exceeding $0{,}01L$ from forward perpendicular
	In way of forward part of cargo area at upper deck in centreline		**Bilge water removing ship**, **Chemical tanker**, **Gas carrier**, **Oil recovery ship**, **Oil tanker**, **Oil/bulk carrier**, **Oil/ore carrier**, **Oil/bulk/ore carrier**, **Tanker**, **FPSO**, **FSO**	Applicable to ships $L \geq 150$ m
	At midship on port and starboard at upper deck		**Container ship**, **Timber carrier**, ships without descriptive notation in class notation	Applicable to ships with large deck opening $L \geq 200$ m
Vertical linear acceleration	At forward perpendicular	Single-axis accelerometer	**Container ship**, **Timber carrier**, ships without descriptive notation in class notation	Applicable to ships $L \geq 200$ m. Area of installation: not exceeding $0{,}01L$ from forward perpendicular
			Ro-ro ship, **Ro-ro passenger ship**	Applicable to ships with descriptive notation **Ro-ro passenger ship** $L \geq 100$ m. Area of installation: not exceeding $0{,}01L$ from forward perpendicular
Vertical, transverse and longitudinal linear accelerations	In forward and aft sections of cross-structure in ship centreline	Three-axis accelerometer	Multi-hull ships	
1. One accelerometer may be installed for two kinds of measurements, when the amplitude and frequency ranges of the accelerometer and other parameters comply with the requirements for both kinds of measurements. 2. A dynamic displacement measurement device may be used instead of accelerometer. It is permitted not to install accelerometer, when the amplitude and frequency ranges of the dynamic displacement measurement device and other parameters comply with the requirements of both kinds of measurements.				

Table 17.7.3

List of values to be measured by system intended for strength monitoring installed on board of ice class ships

Parameter to be measured	Control area	Measuring instrument	Remark
1	2	3	4
Local deformations (bending/shear, tension/ compression)	Bow region. Port/starboard in stem area in spans of nearest primary transverse members (frames); orientation based on ice loadline, ballast waterline and intermediate waterline[1] levels (Fig. 17.7.3-1) — 3 control points per each member span	Short base linear strain sensor	
	Bow region. Port/starboard in area corresponding to the maximum values of the shape factor[2] determined in compliance with 3.10.3, Part II "Hull" in frame spans; orientation based on ice loadline, ballast waterline and intermediate waterline levels (Fig. 17.7.3-2) — 3 control points per each member span		
	Midbody region. Port/starboard in spans of the following frames: 1. Nearest to the midlength of the midbody region. 2. Nearest to the coordinate of 1/4 of length of the midbody region forward from the boundary of the midbody and stern regions. 3. Nearest to the coordinate of 1/4 of length of the midbody region aft from the boundary of the bow region; orientation based on ice loadline, ballast waterline and intermediate waterline levels (Fig. 17.7.3-4) — 3 control points per each member span.		Installation of sensors in control points 1 and 2 only for ships $L \geq 200$ m
	Stern region. Port/starboard in frame spans in sternframe area. Areas corresponding to the maximum ice loads; orientation based on ice loadline, ballast waterline and intermediate waterline levels (Fig. 17.7.3-5) — 3 control points per each member span		For ships having distinguishing mark **DAS** in class notation
Vertical, transverse and longitudinal impact accelerations	Bow region. Port/starboard in stem region in spans of nearest primary transverse members (frames); orientation based on ice loadline, ballast waterline and intermediate waterline levels (Fig. 17.7.3-1) — 1 control point per each member span	Three-axis impact accelerometer	
	Bow region. Port/starboard in area corresponding to the maximum values of the shape factor (refer to 3.10.3, Part II "Hull") in frame spans; orientation based on ice loadline, ballast waterline and intermediate waterline levels (Fig. 17.7.3-2) — 1 control point per each member span		
	Bow region. Port/starboard in frame spans in compliance with Fig. 17.7.3-3 — 1 control point per each span		
	Bow region. Port/starboard in spans of bottom stringers (Fig. 17.7.3-6) — 1 control point per each span		
	Stern region. Port/starboard in frame spans in sternframe area. Regions corresponding to the maximum ice loads; orientation based on ice loadline, ballast waterline and intermediate		For ships having distinguishing mark **DAS** in class notation

1	2	3	4
	waterline levels (Fig. 17.7.3-5) — 1 control point per each span		
	Stern region. Port/starboard in spans of bottom stringers nearest to mid-length of stern region and to line passing at the distance of 1/4 of ship's breadth in parallel to ship centreline (Fig. 17.7.3-7) — 1 control point per each span		For ships having distinguishing mark **DAS** in the class notation
Vertical impact acceleration	At forward perpendicular	Single-axis accelerometer	For ice class ships **Icebreaker6**, **Icebreaker7**, **Icebreaker8**, **Icebreaker9**
Longitudinal bending of hull	At midship on port and starboard	Single-axis long base linear surface strain sensor	
Angular motions and angular rates of heel, trim, yaw. Vertical, transverse and longitudinal displacements and accelerations	At midship on port and starboard. At forward and after perpendiculars	Device for measurement of dynamic displacements with 6 degrees of freedom	
[1] The applicate of the intermediate waterline is determined as the arithmetic mean between the draughts corresponding to the ice loadline and ballast waterline. [2] In accordance with 3.10.3.2.1, Part II "Hull".			

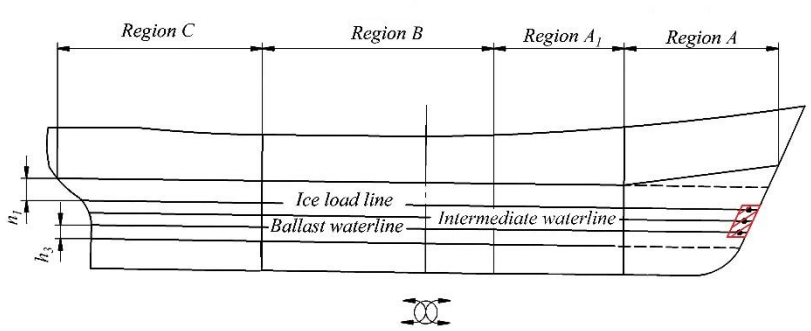


Fig. 17.7.3-1
Diagram showing control points for local deformations in region A in stem area

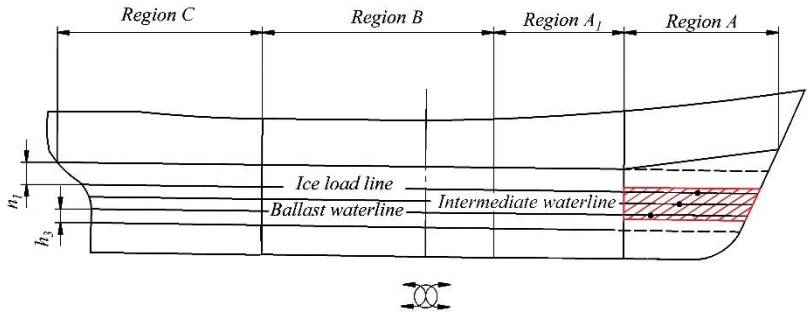


Fig. 17.7.3-2
Diagram showing control points for local deformations in region A in area corresponding to maximum values of shape factors

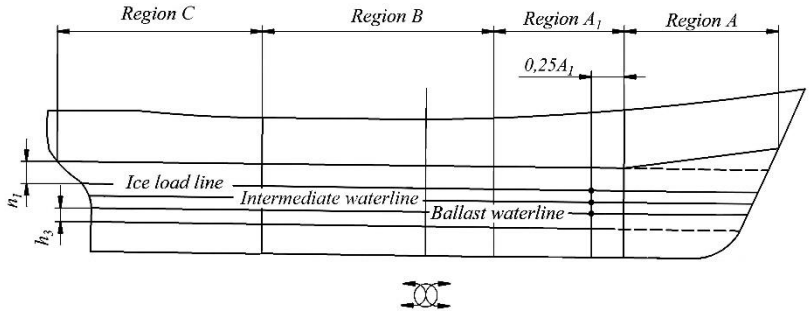


Fig. 17.7.3-3
Diagram showing control points for local deformations in region A_1

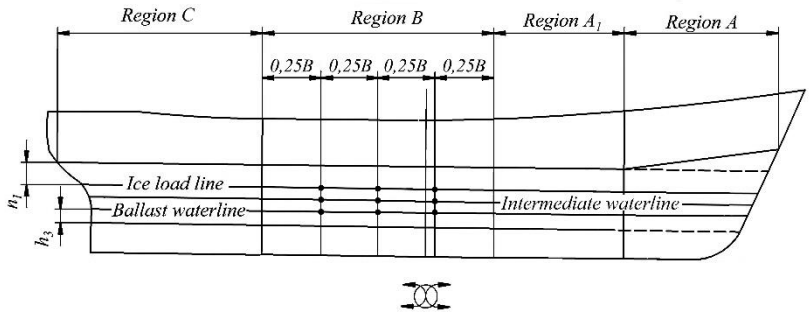


Fig. 17.7.3-4
Diagram showing control points for local deformations in region B

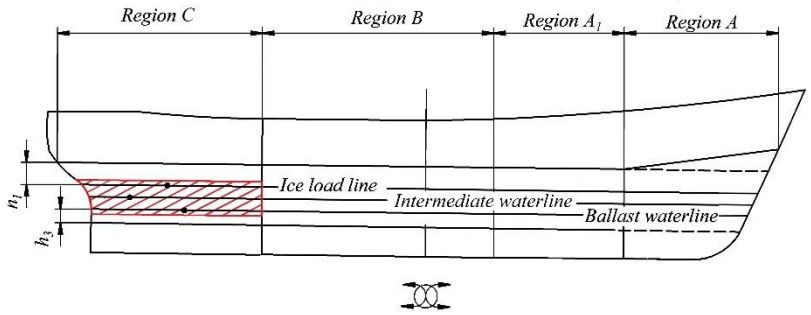


Fig. 17.7.3-5
Diagram showing control points for local deformations in region C

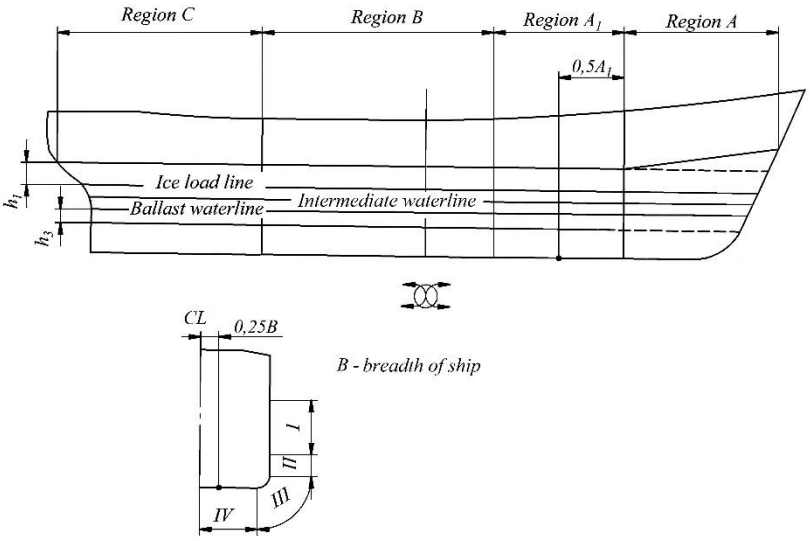


Fig. 17.7.3-6
Diagram showing control points for local deformations in region A_1 in bottom area

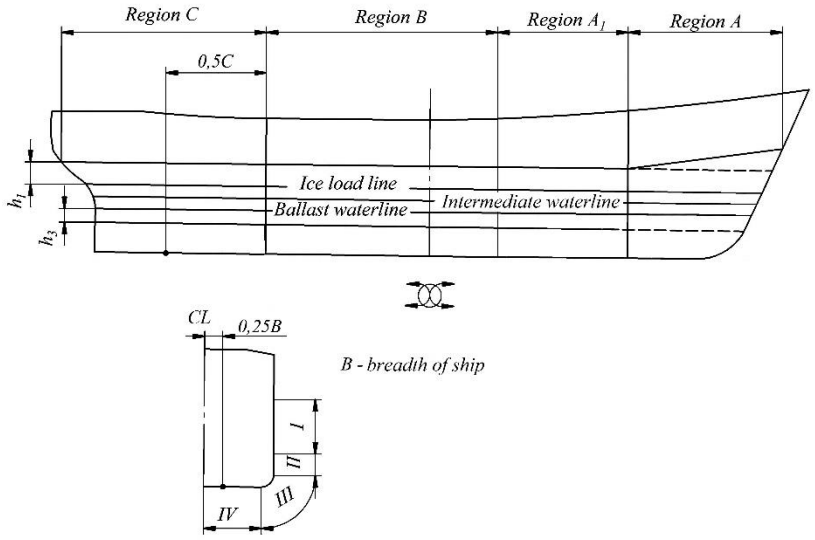


Fig. 17.7.3-7
Diagram showing control points for local deformations in region C in bottom area

Table 17.7.6

Minimum list of equipment to which the monitoring system shall communicate

Designation of system functions (Z)	Equipment to which the monitoring system is connected
BS	Ballast, heel and trim systems of the ship
C	Onboard computer software for ship strength and stability calculations
N	Receiver of global navigation satellite systems GPS/GLONASS, log, echo sounder
RPM	Propeller shaft speed sensor
SI	Radar ice display
SW	Weather station including sensors for sea state parameters
TS	Propeller shaft torque sensor
ThS	Record of thrust along propeller shaft fore-aft axis
TVS	Sensor for radial and longitudinal vibration displacements of propeller shaft
W	Weather station including sensors for sea state and wind parameters

17.8 MEASURING CHANNELS AND MEASURING COMPONENTS

17.8.1 All measuring components being part of the monitoring system shall be calibrated in compliance with the requirements and instructions of the manufacturer.

17.8.2 Measuring components based on different operating principles may be used in measuring channels.

17.8.3 The design of measuring components shall rule out influence of the following factors on measurement accuracy:

.1 ambient temperature during operation, with additional or alternative provision for automatic thermal compensation within the design ambient temperature range, but at least from minus 25 °C to plus 45 °C for measuring components installed on open decks and in open hold spaces and from 0 °C to plus 45 °C for measuring components installed in closed spaces;

.2 external influence of general low-frequency ship vibration;

.3 local deformations in the mounting pad area.

17.8.4 The design of measuring components installed on open decks of ice class ships shall ensure icing protection.

17.8.5 The measuring components installed in hazardous areas and spaces shall comply with the requirements specified in 2.9 and 2.10, Part XI "Electrical equipment" of the Rules for the Classification and Construction of Sea-Going Ships.

17.8.6 Measuring channels for ship's hull deformations.

17.8.6.1 The design of the measuring component for longitudinal and transverse bending shall balance out any effects on the results of bending, shear and local deformation measurements at the measurement area.

17.8.6.2 The measuring component shall ensure continuous measurement of multiple changes of the base length of the control section of hull structure.

17.8.6.3 The value of the base length of the measuring component for longitudinal and transverse bending shall be taken based on the design values of the maximum permissible ship's hull deformation in the control area.

The maximum permissible hull deformation shall be determined based on the strength provision as per 1.4 and 3.1.4.1 (where applicable), Part II "Hull" taking into consideration the actual section modulus of the hull in way of the sensor location and shall be specified in the documentation required by 17.5.1.10.

17.8.6.4 The detection limit of the measuring component shall be at least 0,1 μm/m.

17.8.6.5 The measuring channels of longitudinal and transverse bending of the ship's hull shall ensure:

.1 measurement error not exceeding ±1 μm/m or 5 % of the measurement range, whichever is less;

.2 performance capacity from 0,01 Hz to 5 Hz (except for the measuring channels of mid-base sensors installed in the forward perpendicular area);

.3 sampling rate at least 15 Hz (except for the measuring channels of mid-base sensors installed in the area of forward perpendicular coordinate).

17.8.6.6 The measuring channels of the mid-base sensors installed in the forward perpendicular area shall ensure performance capacity from 0,01 Hz to 100 Hz and sampling rate at least 300 Hz.

17.8.6.7 The measuring channels of the ship's hull local deformations shall ensure:

.1 measurement error not exceeding ±1 μm/m or 5 % of the measurement range, whichever is less;

.2 performance capacity from 0,01 Hz to 500 Hz;

.3 sampling rate at least 1 kHz.

17.8.7 Measuring channels for accelerations.

17.8.7.1 Measuring channels of vertical, longitudinal and transverse linear accelerations shall ensure continuous measurement of accelerations:

.1 in amplitude dynamic range ±5*g*[1];

.2 with error not exceeding ±0,02*g*;

.3 with performance capacity from 0,01 Hz to 50 Hz;

.4 with sampling rate at least 200 Hz.

17.8.7.2 The measuring components of vertical, longitudinal and transverse linear accelerations shall comply with the shock resistance requirements within the peak value range of at least ±15*g*.

17.8.7.3 The measuring channels of vertical impact accelerations measured in the forward perpendicular area shall ensure measurement of accelerations:

.1 in amplitude dynamic range at least ±2000*g*;

.2 with error not exceeding ±1 % of the measurement range;

.3 with performance capacity from 0,04 Hz to 1 kHz;

.4 with sampling rate at least 2 kHz.

17.8.7.4 The measuring components of vertical impact accelerations measured in the forward perpendicular area shall comply with the shock resistance requirements within the peak value range of at least ±5000*g*.

17.8.7.5 The measuring channels of vertical, longitudinal and transverse linear impact accelerations measured at frame spacings of ice class ships shall ensure measurement of accelerations:

.1 in amplitude dynamic range ±20*g***;**

.2 with error not exceeding ±0,02*g*;

.3 with performance capacity from 0,01 Hz to 500 Hz;

.4 with sampling rate at least 1 kHz.

17.8.7.6 The measuring components of accelerations caused by ice loads shall comply with the shock resistance requirements within the peak value range of at least ±50*g*.

17.8.7.7 The converter of the measuring component shall include a filter minimizing "zero offset" and a filter for elimination of electromagnetic interference.

17.8.7.8 The converters being part of acceleration measuring channels shall include a computation component ensuring continuous conversion of measured values of linear accelerations to respective values of linear displacements and velocities with the conversion error not exceeding ±0,01 %.

17.8.8 Measuring channels for angular and linear displacements.

17.8.8.1 The measuring channels of angular and linear displacements shall ensure continuous simultaneous measurement of the following angular motions, angular rates of heel, trim, yaw, linear vertical, transverse and longitudinal displacements:

.1 heel and trim angular motions:

.1.1 within range of at least ±90°;

.1.2 with error not exceeding ±0,02°;

.1.3 with sensitivity of at least 0,001°;

.2 yaw angular motions:

.2.1 within range of at least ±180°;

.2.2 with error not exceeding ±0,02°;

.2.3 with sensitivity of at least 0,001°;

.3 heel, trim and yaw angular velocities:

.3.1 within range of at least ±150°/s;

.3.2 with error not exceeding ±0,02°/s;

.3.3 with resolution of at least 0,01°/s.

[1]g — gravity acceleration, 9,81 m/s^2

.4 linear vertical, transverse and longitudinal displacements:

.4.1 within range of at least ±50 m;

.4.2 with error not exceeding ±5 cm or 5 % of the measurement range, whichever is less.

17.8.8.2 The measuring channels of angular and linear displacements shall ensure the following measurements:

.1 within periods of angular and vertical displacements from 1 s to 40 s;

.2 with performance capacity from 0,01 Hz to 50 Hz;

.3 with sampling rate of at least 200 Hz.

17.8.8.3 The design of the measuring component shall comply with the shock resistance requirements within the peak value range of at least ±500*g*.

17.8.8.4 The converters being part of measuring channels of angular and linear displacements shall ensure continuous conversion of the measured values with the conversion error not exceeding ±0,01 %.

17.8.9 Requirements for converters.

17.8.9.1 The measurements synchronization value ensured by the converters used in the measuring channels of the monitoring system shall be at least 0,001.

17.8.9.2 The converters being part of the measuring channels for longitudinal and transverse bending (except for mid-base sensors installed in the area of the forward perpendicular coordinate) shall ensure filtration of low-frequency components corresponding to the lower limit of the operational frequency range and shall be based on the analog-to-digital converters (ADC) with at least 12 effective bits.

17.8.9.3 The converters being part of the measuring channels of mid-base strain sensors installed in the area of the forward perpendicular coordinate, local deformation sensors and accelerometers shall:

.1 be based on sigma-delta ADCs with at least 24 effective bits;

.2 ensure filtration of low-frequency components of the initial output signal corresponding to the lower limit of the operational frequency range;

.3 contain an anti-aliasing filter of analog signals to exclude the spectrum aliasing in the dynamic ranges of the low-frequency region;

.4 ensure automatic setting to the actual frequency range of input signal.

17.8.9.4 The converters being part of the measuring channels (except for the channels of the devices of inertial dynamic displacement measuring modules) and ensuring the above functions may be partially and/or completely combined in individual electronic multi-channel modules (assemblies) for control of multiple type measurement processes, collection and processing of measurement data.

17.8.9.5 Electronic multi-channel modules shall ensure:

.1 autonomous control (adjustment) for each measuring channel of each measuring component;

.2 reception of upper level digital control commands and their conversion, transmission of return signals on status of execution of control commands, including duplexing while transferring test signals of measuring channel self-diagnostics;

.3 parallel generation and reception of analog "input/output" signals from the measurement sensors;

.4 parallel processing of analog signals from the measurement sensors and digitization of these signals;

.5 parallel digital transmission of measurement data;

.6 measurement synchronization for all enabled measuring channels.

17.8.10 The protection degree of measuring components shall be at least as specified in 2.4.4, Part XI "Electrical Equipment".

17.9 COMPUTATION COMPONENTS

17.9.1 The computation component software shall ensure processing of measurement data and automatic generation of the database for monitoring data results.

17.9.2 The speed of the system components shall timely feed the user information taking into consideration the operating conditions of the ship and the requirements of this Section.

17.9.3 The time frame and number of observations to be recorded which are adopted for measurement processing shall be representative and sufficient taking into consideration the operating conditions of the ship.

17.9.4 Accuracy of computation shall comply with the requirements for accuracy of respective measuring channels.

17.9.5 The processing results shall be stored and visualized in tabular form based on 30 minute periods with reference to the unified time scale.

17.9.6 The system intended for monitoring of ship's strength shall ensure calculation of stress values due to bending moments based on the measurement data, and comparison of the obtained results with the permissible ones being specified based on the approved hull documentation.

Permissible stresses shall be determined based on the permissible design bending moment and torque (if applicable) affecting the ship's hull.

The permissible stresses shall be determined with regard to reduction of hull section modulus determined in compliance with 2.2 of Annex 2 "Instructions for Determination of the Technical Condition and Repair of the Hulls of Sea-Going Ships" to the Rules for the Classification Surveys of Ships in Service, where such reduction was made.

17.9.7 The system intended for monitoring of ship's strength installed on ice class ships shall ensure calculation of values for stresses in ship structures fitted with the sensors, due to local loads, based on the measurement data, and comparison of the obtained results with the permissible ones as specified in the approved hull documentation.

The permissible stresses of the structure shall be determined based on the values of permissible local load acting on the structure as specified in documentation.

17.9.8 The system intended for monitoring of ship stability shall ensure calculation of at least transverse metacentric height and its comparison to the permissible values. It is recommended to include in the system the possibility of calculating all the applicable stability criteria, as well as their comparison to the permissible values.

When the stability monitoring is performed only based on the transverse metacentric height, the applicable values shall be determined based on the stability curve as required by 4.1.8, Appendix I to Part IV "Stability", from the approved Stability Booklet.

17.9.9 During the tests performed upon installation of the monitoring system on board the ship in the presence of the RS surveyor, the error of the calculation results shall be checked. The check shall be performed based on comparing the parameters calculated by the monitoring system to the reference values.

17.9.9.1 The calculation results of the system intended for monitoring of ship strength shall have deviations from the reference values of stresses originating under influence of bending moment, not exceeding ±10 % or ±10 MPa, whichever is greater.

The value as given in the documentation of the monitoring system determined for the loading case used during the tests shall be the reference value.

17.9.9.2 The calculation results of the system intended for monitoring of ship stability shall have deviations from the reference values not exceeding:

longitudinal centre of gravity of ship: ±1 % of ship's length or ±0,5 m, whichever is greater;

transverse centre of gravity of ship: ±0,5 % of ship's breadth or ±0,05 m, whichever is greater;

vertical centre of gravity of ship: ±1 % or ±0,05 m, whichever is greater;

transverse metacentric height : ±1 % or ± 0,05 m, whichever is greater.

The value given in the approved Stability Booklet is used as the reference one.

17.9.10 The calculation results shall be sorted by hazard levels based on the following conditions:

healthy state — arithmetic mean value of absolute peaks over the period less than 60 % of the maximum permissible value;

pre-hazard — arithmetic mean value of absolute peaks over the period greater than or equal to 60 %, but less than 80 % of the maximum permissible value;

hazard — arithmetic mean value of absolute peaks over the period greater than or equal to 80 %, but less than 100 % of the maximum permissible value;

emergency — arithmetic mean value of absolute peaks over the period greater than or equal to 100 % of the maximum permissible value.

17.9.11 The updating time for results of sorting shall not exceed 10 seconds.

17.9.12 The calculation results shall be stored and displayed using appropriate color indication with addition of percentage values for each parameter relative to the maximum permissible value.

The duration of the monitoring data storage shall comply with 17.10.3.3 and 17.10.3.4.

17.9.13 The indication colours shall change depending on the hazard level.

17.10 AUXILIARY COMPONENTS

17.10.1 The monitoring system shall include the following auxiliary components:
display device;
data storage device;
control device;
electric power source.

17.10.2 Display device.

17.10.2.1 Visualization of the monitoring results shall be available on the monitor display located at the workstation of the monitoring system operator in the wheelhouse of the navigation bridge of the ship.

17.10.2.2 The displays being part of the system shall have a diagonal of at least 23 inches and comply with the requirements of 7.7.3, Part XV "Automation".

17.10.2.3 Presentation of data, text information, symbols and graphic information shall ensure clear legibility in any light conditions that may be encountered at the navigation bridge in day time, in half light and in night time (using supplementary illumination, where necessary).

17.10.2.4 Font and its size selected for display of alphanumeric data shall ensure easy reading of the information by the operator.

17.10.2.5 Text information shall be simple, understandable and minimized in terms of volume.

17.10.2.6 Clear explanations shall be given in operating documentation for all symbols used for display of information.

17.10.2.7 Flashing display of data displaying is permitted for alarms only.

17.10.2.8 The following basic information shall be visualized:
location of sensors on board the ship in graphical form;
results of calculation of the required parameters in percentage relative to the maximum permissible design value per each sensor;
current status of system functioning;
current data and time in the following format: hours, minutes, seconds.

17.10.2.9 When the monitoring system is connected with other systems, the basic imported data shall be displayed: ship's positioning coordinates, speed, course, wind speed and direction, sea state parameters, ice conditions, loading condition of the ship, basic trim and stability data (applicate of the gravity centre, metacentric height, draught), etc.

17.10.2.10 The following extended information shall be visualized:
schematic diagram of the system indicating the actual functioning state of the system in the form of light/colour-coded indication;
current data and time in the following format: hours, minutes, seconds.

17.10.2.11 The examples of display screens shall be given in the monitoring system operating manual.

17.10.3 Data storage device.

17.10.3.1 The data storage device shall ensure:

.1 storage and automatic and manual output of the results of measurement data processing and data on actuation of the alarm system;

.2 output of data on the maximum permissible design values of the parameters in compliance with the conditions of ship's loading and operational conditions;

.3 transmission of measurement processing results from the monitoring system to the voyage data recorder;

.4 transmission of measurement processing results to the shore (where provided by the monitoring system design version).

17.10.3.2 The data storage device shall:

.1 have sufficient memory capacity for the storage of the total data volume within the time period specified in 17.10.3.3;

.2 have the speed corresponding to the data processing rate of the computing device;

.3 provide for substitution of solid-state drives and connection of external USB drives not being part of the system;

.4 provide for creation of backup files of information data on external devices;

.5 be protected against power failures with provision for saving of all information data sets in case of complete power failure and data reproduction upon power recovery;

17.10.3.3 The data storage device shall ensure recording and storage of the monitoring data on board the ship:

.1 for at least 24 hours on a continuous basis;

.2 for at least 30 days using a set of mass storage devices and/or external USB drives.

When the scheduled voyage time exceeds 30 days, the set of mass storage devices shall be formed based on the provision of recording and saving the monitoring data on board the ship during the entire voyage.

17.10.3.4 Duration of data storage ashore shall be specified by the shipowner. The minimum data storage period ashore shall be 1 year.

17.10.4 Control device.

17.10.4.1 The control device shall consist of the following:

supervisory computer (processing unit) being part of the workstation of the monitoring system operator together with keyboard and integrated trackball located in the wheelhouse of the navigation bridge of the ship;

time synchronization electronic module.

17.10.4.2 The control device shall make it possible for the operator of the workstation of the monitoring system to:

supply power and send "on/off" commands to all components of the monitoring system;

adjust the monitoring system in compliance with the conditions of ship's loading, where necessary;

adjust the monitoring system in compliance with the operating conditions of the ship, where necessary;

adjust the measuring channel configuration;

start the test programmes;

represent and display the processed data of any time series with information on them stored in the storage device, without blocking continuous network traffic of information received via measuring channels;

control the alarm system.

17.10.4.3 The control device shall ensure automatic self-checking of the monitoring system and make it possible to keep track of the system status by detecting and indicating the following conditions:

failure to supply power to any component of the monitoring system;

computer network shut-off or hang-up and/or malfunction of the electronic programmable components;

interruption of data entry via a measuring channel;

measurement results beyond the adjusted range of the measuring channel.

17.10.4.4 The time synchronization electronic module of the control device shall communicate with the receiver of the radio navigation system/systems of ship navigation equipment complex.

The time synchronization electronic module shall ensure synchronization for:

.1 measurements via all measuring channels with timing cycle mismatching not exceeding 0,001 s;

.2 parallel-serial computing and logical operations and measurement data processing operations with timing cycle mismatching not exceeding 0,01 s.

17.10.4.5 The control device may be based on the electronic modules and general purpose protocols using IEEE 802.1 standards, including IEEE 802.1AS PTP (precision time protocol) and IEEE 802.1Qav (queuing and forwarding protocol) standards.

17.10.4.6 The hardware of the control device shall have storage capacity and speed ensuring execution of the control algorithm implementing all functional options in compliance with the requirements for timing cycles.

17.10.5 Electric power sources.

17.10.5.1 The power for all equipment of the monitoring system shall be supplied from the ship primary electrical power source.

17.10.5.2 All devices of the monitoring system shall be supplied via separate feeders from one common board of the monitoring system.

The switchboard of the monitoring system shall be supplied form the main switchboard.

17.10.5.3 Where the current and voltage parameters for individual hardware items of the monitoring system shall be different from those of the ship electric mains, the power for these items may be supplied from other additional switchboards fed via separate feeders.

17.10.5.4 The power for the converters shall be supplied from the same electric power sources as for the measuring components and other hardware being the sources of input signals received for conversion.

17.10.5.5 The switchboards shall be equipped with switches and fuses or current-limiting circuit breakers in outgoing lines to each type of the system hardware.

17.10.5.6 The consumers not related to the system shall not be connected to the system board.

17.10.5.7 Where connection with other types of ship equipment is implemented by the monitoring system design version, de-energization of the system shall not impair the functioning of this equipment.

17.10.5.8 Arrangement of electrical equipment of the system, cable network laying and connection to the ship electric power system shall be carried out in compliance with the requirements specified in Part XI "Electrical equipment".

17.11 INTERCONNECTION COMPONENTS

17.11.1 The design of the interconnection components of the system shall ensure noise resistance, data transmission rates, redundancy for normal functioning of the system in compliance with the technical requirements of the manufacturer.

17.11.2 The system components shall be interconnected via the common local information and interswitch communications forming a set of interconnection components.

17.11.3 The interconnection components shall ensure transmission of control and monitoring information via two independent communication channels.

17.11.4 Where the wire communication channels are used, they shall meet the requirements of Part XI "Electrical equipment".

17.11.5 The interconnection components (cable line connectors) installed on open deck, in open cargo holds, in shafting space shall have the degree of protection at least as specified in 2.4.4, Part XI "Electrical equipment".

The interconnection components installed on the frame webs or transverse web frames in the ballast tanks of tankers shall have the degree of protection at least as specified in 2.4.4, Part XI "Electrical equipment".

The interconnection components (repeater units, switches/routers, etc.) installed in the closed service spaces of the ship except for the above mentioned shall have the degree of protection at least as specified in 2.4.4, Part XI "Electrical equipment".

17.12 ALARM SYSTEM

17.12.1 General requirements.

17.12.1.1 The alarm annunciator being part of the monitoring system as its component part, is intended for urgent notification of the watch crew in the wheelhouse of the navigation bridge on any situations related to deviations of the normal operation of the ship detected by the monitoring system.

17.12.1.2 The alarm system shall meet the requirements specified in 3.2.24.3 and 3.2.24.5, Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships.

17.13 CONNECTION OF MONITORING SYSTEM WITH OTHER SHIP EQUIPMENT

17.13.1 The monitoring system shall be connected with the ship's universal time system and voyage data recorder being parts of the ship's complex of navigational equipment.

17.13.2 Connection of the monitoring system with other ship systems shall not affect the performance of these systems, and failure or malfunctions of the monitoring system shall not result in failure or malfunctions of the ship systems linked with the monitoring system.

Failure or malfunctions of the systems linked with the monitoring system shall not result in failure or malfunctions of the monitoring system.

Failures or faults of communication with one system shall not affect the functioning of communications with other systems.

17.13.3 Electronic interconnection units, including appropriate software, and cable communications links are the components for connection of the monitoring system with ship equipment.

17.13.4 Schematic diagram of the monitoring system connection with ship equipment and functioning status of components of such connection shall be displayed on the visualization components.

17.13.5 All connections of the monitoring system with the navigational equipment of the ship shall be performed in compliance with the International standard for digital interfaces for navigational equipment, IEC 61162.

17.13.6 To introduce the symbols of additional functions **DD** and/or **DM** in the class notation, the connection of the monitoring system with the ship's complex of telecommunication equipment shall be available.

The system for transmission of information data via "ship-shore-ship" channel shall ensure integrity, confidentiality and accessibility of the transmitted data.

17.14 INSTALLATION

17.14.1 Installation and testing of the monitoring system on board the ship shall be carried out under the technical supervision of the Register according to the RS-approved technical documentation.

17.14.2 The requirements for installation of measuring components depending on their physical principle of operation and design features shall be specified in the set of installation drawings and in the installation instruction.

17.14.3 During the installation of the strain sensors, the following requirements shall be met:

.1 sensors shall be fixed directly to the structural member of the ship's hull. Use of any intermediate components between the mounting pad on the structural member and the sensor is not permitted;

.2 surface of the mounting pad on which the sensors are installed shall be prepared and free of paint or any other protective coatings, rust, grease of other contaminations;

.3 surface of the mounting pad shall be flat, free of indentions, scratches, scoring or any other mechanical damage (permissible conditions of out-of-flatness and roughness of the mounting pad surface shall be specified in the set of installation drawings);

.4 no welding seams shall be present in the mounting pad area;

.5 it is permitted to install the strain sensors by means of permanent or detachable mechanical joining to the structural member of the ship's hull.

The joint design shall ensure its strength under the loads during the deformation of ship's hull structure.

Use of arc welding for installation of the strain sensors is not permitted.

Welding technology shall ensure the minimum residual stresses and deformations in the welded connection area.

The joint design and technology shall ensure a gap between the joining surfaces of the sensor and the mounting pad not exceeding 0,1 mm.

17.14.4 After the sensor installation, the protective coatings of the ship's hull structural member used prior to installation in the installation points shall be completely restored.

17.14.5 During the installation of accelerometers and devices for measurement of dynamic displacements, the following requirements shall be met:

.1 mounting pad in the installation point shall have sufficient stiffness and strength to introduce the minimum distortions in the measured motions of the structure;

.2 surface of the mounting pad shall be flat, shall have no indentions, scratches, scoring or any other mechanical damage; the surface shall be prepared and free of paint or any other protective coatings, rust, grease of other contaminations;

.3 prior to the installation, the sensitive axes of the accelerometer and/or dynamic displacement measurement device shall be marked (requirements for accuracy of positional relationship between the sensitive axes and measurement directions shall be established in the set of installation drawings);

.4 special paste shall be used to ensure tight contact between the device and mounting pad;

.5 use of various additional arrangements for installation of accelerometers and/or dynamic displacement measurement devices shall be avoided. Where used, the adapters shall have minimum inertial effect. If the mounting adapter is of a shaped type, natural frequency and oscillation moduli of this fixture shall be first identified.

17.14.6 The sensor outgoing cables in the points of sensor installation shall be rigidly fixed. Other requirements for cable laying are specified in 17.11.

17.14.7 All hardware of the monitoring system installed on board shall be grounded to the ship's hull.

17.14.8 Calibration.

17.14.8.1 During the monitoring system installation, the adjustment and calibration of the system shall be performed in the condition of ship's loading ensuring the minimum possible effect of bending moment from the cargo to the ship.

17.14.8.2 All sensors and converters being part of the measuring channels shall be calibrated and have a documentary evidence containing the information on calibration results.

During the calibration of sensors, the strain-stress state of the hull at the time of installation shall be considered with account of actual bending moments.

17.14.8.3 Where necessary, check of the monitoring system adjustment and re-calibration of the measuring channels shall be performed at least once a year.

17.14.8.4 All results of the initial and periodical calibrations of each measuring channel shall be recorded in the monitoring system record book stored on board the ship.

17.14.9 The monitoring system installation instruction shall specify the procedure and requirements for dismounting of measuring components for periodical verification.

Upon reinstallation the measuring components shall be recalibrated and appropriate entries shall be made in the monitoring system record book.

17.14.10 Types of maintenance, works frequency, nomenclature and procedure shall be established by the system designer in the technical documentation.

17.14.11 The maintenance results shall be recorded in the monitoring system record book.

17.15 TESTING

17.15.1 Upon installation on board prior to commissioning the monitoring system shall be tested.

17.15.2 All tests shall be carried out according to RS-approved programmes in the presence of the RS surveyor.

17.15.3 When the system design version provides for its connection with other types of ship equipment, all tests shall be performed according to the programmes containing the appropriate types of tests for verification of the operability of data export/import channels and lack of influence of the system connection with other systems on the operability and performance of the ship equipment.

17.15.4 The testing of the monitoring system onboard the ship under construction shall be performed at the stage of construction completion.

The testing of the monitoring system on board the ship in service shall be performed in the loaded condition of the ship where the moments affecting the ship (cargo, waves) are prevented to the maximum which enables the most accurate comparison of the stress values measured by the system to the reference values determined for the load case under which the tests are performed. It is recommended to perform such testing with a ship in ballast condition in the port.

17.15.5 The testing shall be performed after refinement and testing of software, adjustment of the system, including loading of the initial data sets.

17.15.6 The testing shall be performed for check and verification of:

operability of the system on board the ship;

compliance with electrical safety requirements;

availability of documentary evidence of the measuring component calibration;

execution of all functional options provided in all functioning modes;

operability of all functional interconnections between the system components;

system response to emergency situations or entry of incorrect information to the system;

provision of the required processing speed of computing and logical operations;

detection of necessity to carry out system modifications.

17.15.7 The test programme shall include:

description of the monitoring system;

description of components being part of the system including software;

description of interconnections between components;

description of the list of submitted documentation;

list of interconnections of components to be checked, functions and parameters to be tested;

sequencing, conditions, procedure and methods of testing, including software and equipment intended for performance of tests;

list and description of tests;

description of methods for processing of testing results;

description of test criteria.

17.15.8 The software testing programme is an integral part of the monitoring system test programme and shall include the following:

description and configuration of software;

description of interconnections of software modules;

description of software requirements;

procedure and means used for testing;

description of test methods including list and description of needed tests;

description of test criteria.

17.15.9 Any deviations detected during testing shall be eliminated. Upon elimination of deviations, the testing shall be repeated in the required scope.

17.15.10 Satisfactory results of tests, no deviations identified by the Register during testing are the basis for introduction of the distinguishing mark in the class notation.

17.16 POSSIBILITY OF RETAINMENT OF DISTINGUISHING MARK HMS IN SERVICE

17.16.1 During the annual, intermediate and renewal survey on board the ship in the presence of RS surveyor, the check of the monitoring system shall be performed.

The extent of the surveys and the procedure for documentation of results are specified in the Rules for the Classification Surveys of Ships in Service.

18 INDOOR HYGIENE AND SANITARY CONDITIONS

18.1 INDOOR CLIMATE

18.1.1 General.

Ships complying with the indoor climate requirements of this Chapter may be assigned the distinguishing mark **COMF(C)** added to the character of classification.

18.1.2 Definitions.

Air supply quantity means total amount of supplied air to any given space, which may consist of a percentage re-circulated return air in addition to the fresh air supply quantity.

Air velocity means measured mean absolute velocity of air mass in motion.

Fresh air supply quantity means quantity of fresh/outside air per person supplied to a space, expressed in l/s or m^3/h.

Indoor climate means indoor ambient temperature, temperature gradient, air velocity, humidity and carbon dioxide concentration used as parameters for indoor climate.

Relative humidity means ratio of the partial pressure of water vapor in air to the equilibrium pressure of saturated vapors at a specified temperature.

Vertical gradient means vertical air temperature difference.

18.1.3 Documentation.

In addition to documentation specified in Section 3, Part I "Classification" the following documentation shall be submitted (A – for approval, FI – for information):

.1 heat balance calculation (FI);

.2 program of mooring and sea trials (A) (to be approved by the RS Branch Office for supervision during construction);

.3 measurement report (FI).

18.1.4 Requirements for on board climate.

18.1.4.1 Measurements.

.1 for ships with less than 100 cabins and the accommodation restricted to a separate section in the aftship, midship or in the foreship a full set of measurements applicable to climate parameters shall be taken in the following minimum number of cabins (*n* = number of cabins):

for $n < 10$ − measurements in all cabins;

for $10 \leq n \leq 40$ − measurements in at least 10 cabins;

for $n \geq 41$ − measurements in at least 25 % of all cabins.

The cabins to be measured shall be evenly distributed amongst the cabins on each deck or in each respective fire zone.

.2 for ships with more than 100 cabins distributed over a major portion of the ship, e.g. passenger ships, a full set of measurements shall be taken in at least 10 % of the cabins in each fire zone containing cabins on each deck. The cabins to be measured shall be evenly distributed amongst the cabins on each deck or in each respective fire zone;

.3 climate parameters shall be measured in a representative number of public spaces on board. The measuring positions shall be selected such as to give a representative description of the climate in the public spaces on board the ship.

18.1.4.2 Air temperature.

18.1.4.2.1 Band width between 20 °C to 24 °C at outside temperature ≤ 15 °C and between 24 °C to 28 °C at outside temperature ≥ 40 °C shall be provided.

18.1.4.2.2 Air temperature in a designated space shall be measured at the geometrical centre of the location. For larger spaces the temperature shall be measured in a representative number of positions in the occupancy zone.

18.1.4.2.3 Individual space temperature control is required.

18.1.4.3 Relative humidity.

18.1.4.3.1 Heating, Ventilation and Air Conditioning (HVAC) system shall provide and maintain a relative humidity within a range from at least 20 % to 60 % maximum.

18.1.4.3.2 Air relative humidity value is determined based on documentation and shall not be generally verified through measurements.

18.1.4.4 Enclosed space vertical gradient.

18.1.4.4.1 Vertical gradient shall be maintained within 3 °C.

18.1.4.4.2 Vertical temperature difference in all designated spaces shall be measured in the geometric centre of the occupancy zone at the following distances above the floor: 0,2 m, 1,0 m and 1,8 m. For larger spaces, measurements shall be taken in representative positions.

18.1.4.5 Air velocity.

18.1.4.5.1 Mean air velocities shall not exceed 0,35 m/s at the measurement position in the space.

18.1.4.5.2 Mean air velocity shall be measured at the geometric centre of the space. However, the surveyor may request alterations of the measurement position based on survey results. Typical alteration may be to carry out the measurement at the most commonly occupied position in the space in question.

18.1.4.6 Air exchange rate.

18.1.4.6.1 Air exchange rate for cabins, public spaces, wheelhouse and control stations shall be at least 6 complete air changes per hour.

18.1.5 Requirements for HVAC system.

18.1.5.1 General.

18.1.5.1.1 Individual space temperature control is required.

18.1.5.1.2 In case of system failure, a controlled climate in cabins, hospitals and messrooms shall be restored after maximum 12 h. If different failures, not related to each other, occur simultaneously, the required restoring time shall be increased by 12 h.

18.1.5.1.3 Minimum level of ventilation in hospitals and machinery control rooms shall be provided during a system failure by means of separate forced ventilation. Regulation of the fans shall be located in the respective spaces. This ventilation shall maintain the temperature below 35 ºC and above 15 ºC.

18.1.5.1.4 It shall be possible to examine, clean or replace air ducts, central air handling units, air filters, dust collectors, heat exchangers, re-heaters and air terminals at regular work intervals.

18.2 NOISE LEVEL IN SHIP'S SPACES

18.2.1 General.

18.2.1.1 If ships comply with the requirements of this Chapter for noise level in all passenger and crew spaces, the distinguishing mark **COMF(N – 1** or **2**, or **3)** may be added to the character of classification, where grades **1**, **2**, **3** indicate the noise comfort level in ship's spaces (with grade **1** corresponding to the most comfortable level).

18.2.1.2 The requirements of this Chapter do not apply to:

.1 dynamically supported craft;
.2 high-speed craft;
.3 fishing vessels;
.4 pipe-laying vessels and pipe-laying barges;
.5 mobile offshore drilling units and fixed offshore platforms;
.6 pleasure craft;
.7 auxiliary ships of war;
.8 pile driving vessels;
.9 dredgers.

18.2.2 Definitions.

For the purpose of this Chapter the following definitions have been adopted.

Apparent weighted sound reduction index R'_w means a single number value, in dB, which describes the overall sound insulation performance in situ of walls, doors or floors provides (refer to ISO 717-1:1996, as amended).

Passenger public spaces:

.1 Type A means closed rooms where noise is generally high (e.g. discotheques);

.2 Type B means closed rooms where noise is moderately high (e.g. restaurants, bars, cinemas, casinos, lounges, fitness rooms, gymnasiums and other closed sport areas);

.3 Type C means closed rooms where noise is relatively low (e.g. lecture rooms, libraries, theatres);

.4 Type D means closed rooms used for passages which do not require very low background noise (e.g. halls, atriums, shops, corridors, staircases).

A-weighted sound pressure level or noise level means the quantity measured by a sound level meter in which the frequency response is weighted according to the A-weighting curve (refer to IEC 61672-1).

A-weighted equivalent continuous sound level A, $L_{Aeq}\ (T)$ means A-weighted sound pressure level of a continuous steady sound that, within a measurement time interval T, has the same mean square sound pressure as a sound under consideration which varies with time (refer to IEC 31672-1).

18.2.3 Documentation.

In addition to technical documentation specified in Section 3, Part I "Classification", a measurement program shall be submitted to the RS Branch Office carrying out technical supervision during construction of a ship for approval. Measurement results shall be submitted to the RS Branch Office for information.

18.2.4 Measurements.

18.2.4.1 Noise level measurement and equipment calibration shall be carried out considering the requirements of ISO 2923, IEC 61672-1, IEC 61260 and IEC 60942.

18.2.4.2 Sound insulation measurement shall be carried out considering the requirements of ISO 16283-1.

18.2.4.3 Measuring equipment shall be verified at least every 2 years by a competent laboratory accredited according to ISO 17025 (2005), as amended.

The instrumentation shall be calibrated in situ before the tests and verified after. The deviation shall not exceed 0,5 dB.

18.2.4.4 The nominal noise level is evaluated with A, $L_{Aeq}(T)$ value with T at least 15 s. Results shall be given in global values calculated in octave bands 31,5 Hz – 8 kHz.

18.2.4.5 The criterion of sound insulation shall be expressed in terms of apparent weighted sound reduction index R'_w measured according to ISO 16283-1 and then calculated in accordance with the method specified in ISO 717-1.

18.2.4.6 A tolerance on noise levels may be accepted but shall not exceed the following maximum values:

.1 3 dB(A) for 18 % of all measured cabins and 5 dB(A) for 2 % of all measured cabins (with a minimum of 1 cabin);

.2 3 dB(A) for 25 % of measuring points and 5 dB(A) for 5 % of measuring points in other spaces;

.3 1 dB for 20 % of apparent weighted sound reduction indexes R'_w and 2 dB for 10 % of apparent weighted sound reduction indexes.

18.2.4.7 Operating conditions at sea trials for noise level measurements shall comply with 3.3 and 3.5 of IMO resolution MSC.337(91).

18.2.4.8 List of measuring points shall be prepared according to 18.2.3 prior to the tests and include at least the following conditions:

.1 noise level measurements in spaces at sea trials;

.2 apparent weighted sound reduction index measurements in spaces at sea trials.

18.2.4.9 Measurement positions shall comply with 3.10 – 3.14 of IMO resolution MSC.337(91). For spaces exceeding 20 m^2, noise measurements shall be performed for every 20 m^2.

18.2.4.10 For passenger spaces, the measuring points alongside the length of the ship are divided in two regions:

.1 from the aft part of the ship to the front bulkhead of the machinery casing, measurements shall be carried out for 35 % of cabins, as a minimum, and all public spaces and open decks. For large public spaces (lounges, restaurants, etc.) measurements shall be carried out in different locations, each measuring point covering at least 50 m^2 of the space area;

.2 the front bulkhead of the casing to the fore end of the ship, the measurements shall be carried out for 15 % of cabins, as a minimum, and all public spaces and open decks. For large public spaces (lounges, restaurants, etc.) measurements shall be carried out in different locations, each measuring point covering at least 100 m^2 of the space area.

18.2.5 Permissible noise levels and requirements for sound insulation.

18.2.5.1 Maximum permissible noise levels in the crew accommodations shall not exceed the values specified in Table 18.2.5.1.

Table 18.2.5.1

Noise level requirements for crew accommodations

Location	A-weighted equivalent continuous sound level A, $L_{Aeq}(T)$, in dB(A)		
	Grade 1	Grade 2	Grade 3
Wheelhouse	60	63	65
Radio room[1]	55	57	60
Cabins	52	55	60
Offices	57	60	65
Public spaces, mess rooms	57	60	65
Hospital	56	58	60
Main machinery control room and switchboard room continuously manned at sea[2]	70	73	75
Open recreation areas[3,4]	70	73	75
Galleys[2]	70	73	75
Workshops other than those forming part of machinery spaces[2]	85	85	85

Location	A-weighted equivalent continuous sound level A, $L_{Aeq}(T)$, in dB(A)		
	Grade 1	Grade 2	Grade 3
Staircases and corridors in crew areas	70	73	75

[1] Equipment switched on but not emitting.
[2] Equipment switched on but not processing.
[3] Measurement carried out with a windscreen microphone protection.
[4] A tolerance of 5 dB(A) may be accepted for measurements at less than 3 m from ventilation inlet/outlet.

18.2.5.2 Between two adjacent crew accommodation spaces, the apparent weighted sound reduction index R'_w shall not be less than the values specified in Table 18.2.5.2. Measurements shall be performed in situ, ship at quay or at anchorage.

Table 18.2.5.2

Apparent weighted sound reduction index R'_w, in dB

Location	Grade 1	Grade 2	Grade 3
Cabin to cabin	37	35	32
Corridor to cabin	35	32	30
Stairs to cabin	35	32	30
Public spaces to cabin	45	44	42

18.2.5.3 Maximum permissible noise levels in passenger spaces shall not exceed the values specified in Table 18.2.5.3.

Table 18.2.5.3

Noise level requirements for passenger spaces

Location	A-weighted equivalent continuous sound level A, $L_{Aeq}(T)$, in dB(A)		
	Grade 1	Grade 2	Grade 3
Passenger cabins of higher comfort class[1]	45	47	50
Standard passenger cabins[1]	49	52	55
Restaurants, cafeterias and public spaces of Type B	55	57	60
Shops, corridors, public spaces of Type D	60	63	65
Public spaces of Type A	65	68	72
Public spaces of Type C	53	56	59
Open recreation areas (swimming pools, sport areas, etc.)[2,3]	65	70	75
Beauty parlours, barber shops, etc.[4]	53	56	59

[1] Granting of the comfort grade to passenger cabins is the shipowner's prerogative right.
[2] Measurement shall be carried out with a windscreen microphone protection.
[3] A tolerance of 5 dB(A) may be accepted for measurements at less than 3 m from ventilation inlet/outlet.
[4] Equipment is not processing.

18.2.5.4 For passenger spaces, the apparent weighted sound reduction index R'_w shall not be less than the values specified in Table 18.2.5.4. Measurements shall be performed in situ, ship at quay or at anchorage.

Table 18.2.5.4

Apparent weighted sound reduction index R'_w, in dB

Location	Grade 1	Grade 2	Grade 3
Cabin to cabin	41	38	36
Corridor to cabin	38	36	34
Stairs to cabin	48	45	45
Public spaces to cabin	53	50	48
Discotheque to cabin or cinema hall	64	62	60

18.3 SANITARY VIBRATION LEVEL IN SHIP'S SPACES

18.3.1 General.

18.3.1.1 If ships comply with the requirements of this Chapter for sanitary vibration level in all passenger and crew spaces, the distinguishing mark **COMF(V – 1** or **2**, or **3)** may be added to the character of classification, where grades **1**, **2**, **3** indicate permissible sanitary vibration comfort level in ship's spaces (with grade **1** corresponding to the most comfortable level).

18.3.1.2 The criterion of vibration shall be expressed in terms of overall frequency-weighted r.m.s. value of vibration velocity, in mm/s, in the frequency range 1 – 80 Hz, determined in accordance with ISO 6954.

18.3.1.3 The requirements of this Chapter do not apply to:

.1 dynamically supported craft;
.2 high-speed craft;
.3 fishing vessels;
.4 pipe-laying vessels and pipe-laying barges;
.5 mobile offshore drilling units and fixed offshore platforms;
.6 pleasure craft;
.7 auxiliary ships of war;
.8 pile driving vessels;
.9 dredgers.

18.2.3 Definitions.

For the purpose of this Chapter the following definition has been adopted.

Passenger public spaces:

.1 Type A means closed rooms where vibration is generally high (e.g. discotheques);

.2 Type B means closed rooms where vibration is moderately high (e.g. restaurants, bars, cinemas, casinos, lounges, fitness rooms, gymnasiums and other closed sport areas);

.3 Type C means closed rooms where vibration is relatively low (e.g. lecture rooms, libraries, theatres);

.4 Type D means closed rooms used for passages which do not require very low background noise (e.g. halls, atriums, shops, corridors, staircases).

18.3.3 Documentation.

In addition to technical documentation specified in Section 3, Part I "Classification", a measurement program shall be submitted to the RS Branch Office carrying out technical supervision during construction of a ship for approval. Measurement results shall be submitted to the RS Branch Office for information.

18.3.4 Measurements.

18.3.4.1 Sanitary vibration level measurement in spaces shall be carried out considering the requirements of ISO 6954.

18.3.4.2 Measurements shall be taken in vertical direction. In cabins, offices or other small spaces, measurements shall be taken in the centre of a space. For larger spaces, increased number of measuring points may be required. Vibrations shall be measured in all accommodation and public spaces (cabins, mess rooms, offices) in the wheelhouse, main machinery control room, workshops and other spaces specified in Tables 18.3.5.1 and 18.3.5.2 (if any).

18.3.4.3 For passenger spaces, the measuring points alongside the length of the ship are divided in two regions:

.1 from the aft part of the ship to the front bulkhead of the machinery casing, measurements shall be carried out for 20 % of cabins, as a minimum, and all public spaces and open decks. For large public spaces (lounges, restaurants, etc.) measurements shall be carried out in different locations, each measuring point covering at least 80 m^2 of the space area;

.2 the front bulkhead of the casing to the fore end of the ship, the measurements shall be carried out for 10 % of cabins, as a minimum, and all public spaces and open decks. For large public spaces (lounges, restaurants, etc.) measurements shall be carried out in different locations, each measuring point covering at least 150 m^2 of the space area.

18.3.4.4 A tolerance on vibration levels shall not exceed 0,3 mm/s for 20 % of the measurement points for overall frequency-weighted r.m.s. value of vibration velocity.

18.3.5 Permissible vibration levels.

18.3.5.1 Maximum permissible vibration levels in crew accommodations shall not exceed the values specified in Table 18.3.5.1.

Table 18.3.5.1

Vibration levels requirements in crew accommodations

Location	Overall frequency-weighted r.m.s. value of vibration velocity, in mm/s, in the frequency range 1 – 80 Hz		
	Permissible vibration level 1	Permissible vibration level 2	Permissible vibration level 3
Wheelhouse	2,8	3,0	3,2
Radio room			
Cabins	2,8	3,0	3,2
Offices	3,0	3,5	4,0
Public spaces, mess rooms	3,0	3,2	3,5
Hospital	2,8	3,0	3,2
Main machinery control room or switchboard room continuously manned at sea	4,0	4,5	5,0
Open recreation areas	–	–	–
Galleys	5,0	5,5	6,0
Workshops			
Staircases and corridors in crew areas	5,0	5,5	6,0

18.3.5.2 Maximum permissible vibration levels in passenger spaces shall not exceed the values specified in Table 18.3.5.2.

Table 18.3.5.2

Vibration level requirements for passenger spaces

Location	Overall frequency-weighted r.m.s. value of vibration velocity, in mm/s, in the frequency range 1 – 80 Hz		
	Permissible vibration level 1	Permissible vibration level 2	Permissible vibration level 3
Passenger cabins of higher comfort class[1]	1,7	2,0	2,2
Standard passenger cabins[1]	2,0	2,5	3,0
Restaurants, cafeterias and public spaces of Type B	2,2	2,5	3,0
Shops, corridors, public spaces of Type D	4,0	4,5	5,0
Public spaces of Type A			
Public spaces of Type C	2,0	2,5	3,0
Open recreation areas (swimming pools, sport areas, etc.)	3,0	3,5	4,0
Beauty parlours, barber shops, etc.[2]	2,0	2,5	3,0

[1] Granting of the comfort grade to passenger cabins is the shipowner's prerogative right.
[2] Equipment is not processing.

19 REQUIREMENTS FOR HULL ICE-STRENGTHENING STRUCTURES OF SHIPS INTENDED FOR STERN-FIRST OPERATION

19.1 APPLICATION

19.1.1 Ships complying with the requirements of this Section, may be assigned the distinguishing mark **DAS (‹ice class mark›)** added to the character of classification in accordance with 2.2.3.3.5, Part I "Classification".

19.2 REQUIREMENTS FOR HULL STRUCTURE

19.2.1 The requirements of this Chapter apply to the ships operating stern first in ice, and are additional to the requirements of Chapter 3.10, Part II "Hull".

19.2.2 Regions of ice strengthening.

19.2.2.1 There are ice strengthening regions lengthwise as follows:

for ships designed for both bow- and stern- first ice operation:

forward region – A;

intermediate region – A_1;

midship region – B;

aft region – C;

for ships designed for stern-first ice operation only:

forward region – A;

midship region – B;

aft region – C.

19.2.2.2 There are ice strengthening regions transversely as follows:

region of alternating draughts and similar regions – I;

region from the lower edge of region I to the upper edge of bilge strake – II;

bilge strake – III;

region from the lower edge of bilge strake where the shell is inclined 7° from horizontal, to the centre line – IV.

For ships designed for stern-first operation only, the position of the forward, midship and aft regions of ice strengthening are set relative to the borderline of the flat side of hull:

forward region – from the stem to a line at a distance of L_3 aft from the forward boundary of the flat side of hull;

midship region – from the aft boundary of the forward region to a line at a distance of L_3 forward from the aft boundary of the flat side of hull;

aft region – from the aft boundary of the midship region to the sternframe.

Ice belt extension in the forward region of the bottom is regulated by parameter L_2, which is equal to a distance from point *A* to the point of intersection of the base line with the vertical line that defines the bow region boundary at the level of the lower limit of the ice belt.

These requirements shall be complied with both at the upper and lower service waterlines.

19.2.2.3 The length of ice strengthening regions of ice class ships shall be determined according to Fig. 19.2.2.3 and Table 3.10.1.3.2, Part II "Hull".

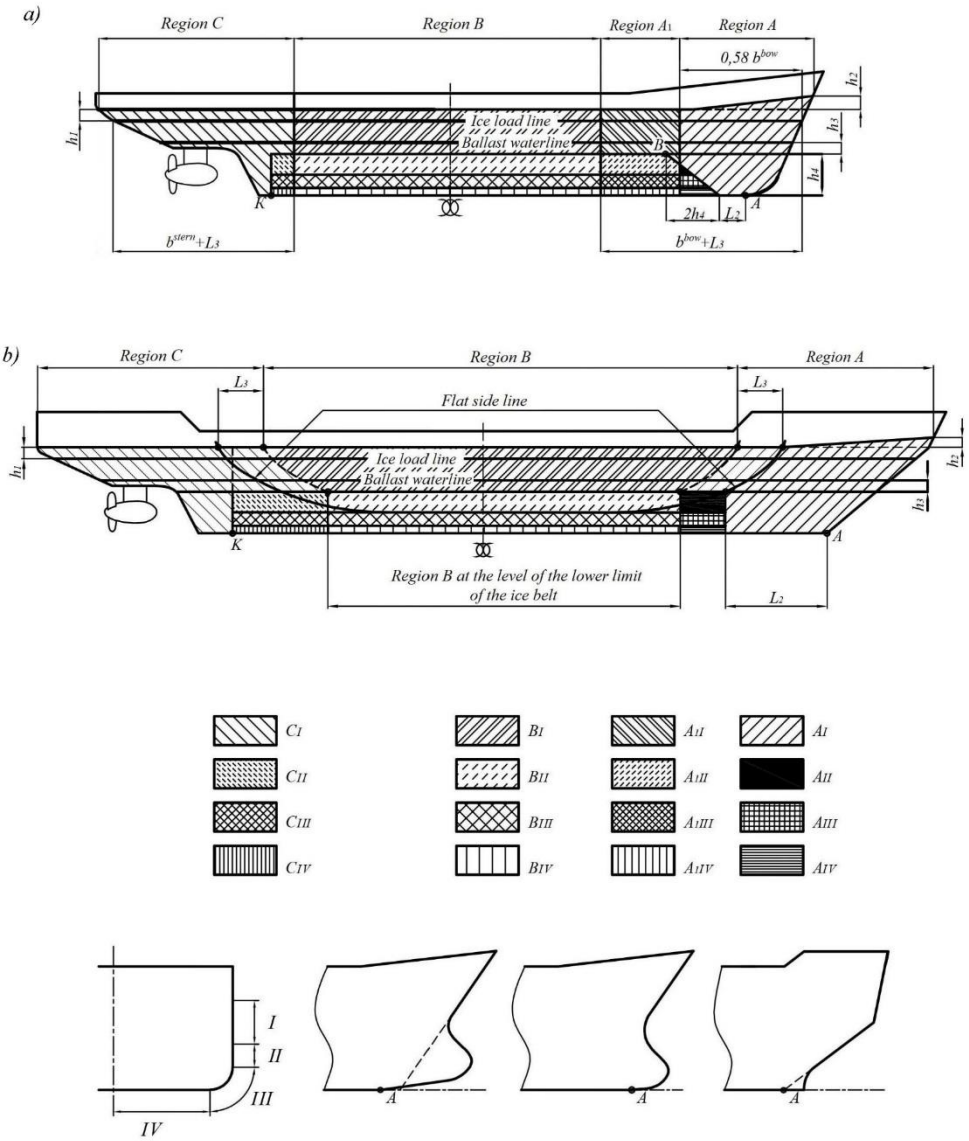


Fig. 19.2.2.3
Regions of ice strengthening of ice class ships:
a) ships designed for both bow- and stern- first ice operation;
b) ships designed for stern-first ice operation only;

b^{bow} = distance from the point of the ice load line and stem intersection to the section where the ice load line is the widest, but no greater than $0{,}4L$;

b^{stern} = distance from the point of the ice load line and sternframe intersection to the section where the ice load line is the widest, but no greater than $0{,}2L$;

position of point *K* is defined as a point located at a distance of at least five standard spacings (refer to 1.1.3, Part II "Hull") forward of the fore point of the skeg

19.2.2.4 For the Arctic double acting ships occasionally involved in icebreaking operations with ice class mark **Icebreaker6** or **Icebreaker7** in the class notation when operating stern first, the length of ice strengthening regions shall be determined according to Fig. 19.2.2.4 and Table 19.2.2.4.

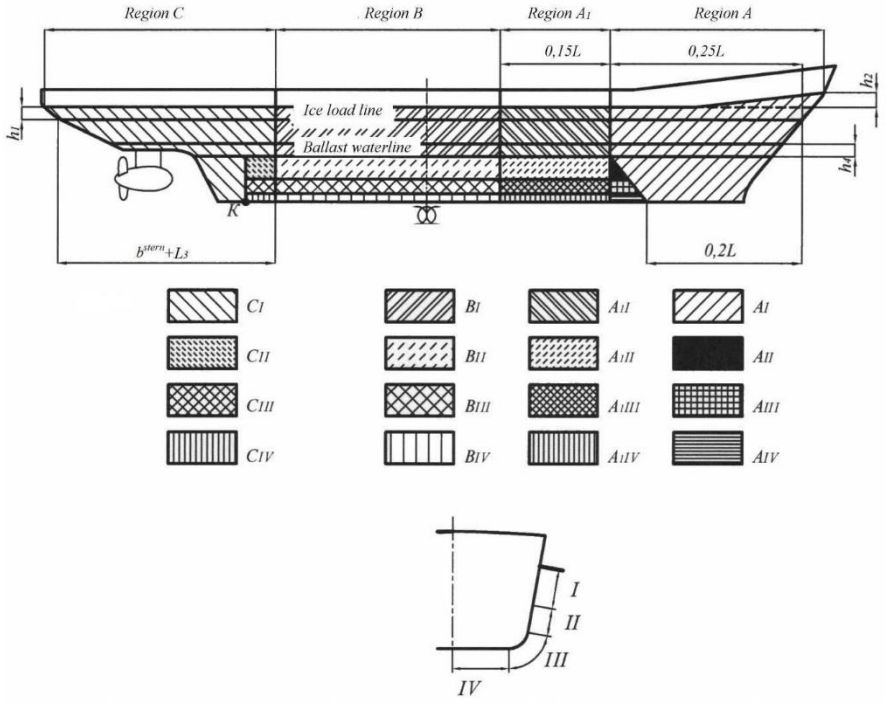


Fig. 19.2.2.4
Regions of ice strengthening of Arctic double acting ships with ice class mark **Icebreaker6** or **Icebreaker7** in the class notation when operating stern first:
b^{stern} = distance from the point of the ice load line and sternframe intersection to the section where the ice load line is the widest, but not greater than $0{,}2L$

Table 19.2.2.4

Parameter		Ice class	
		Icebreaker7	**Icebreaker6**
h_1, in m	at $B \leq 20$ m	0,75	
	at $B > 20$ m	$\frac{0{,}5B + 8}{24}$	
h_2, in m		1,4	1,1
h_3, in m		$1{,}6 + 1{,}6h_1 \geq 2{,}8$	$0{,}4 + 1{,}6h_1 \geq 1{,}6$
L_3, in m		$0{,}06L$	$0{,}05L$

19.2.2.5 Proceeding from the ice class, the requirements of this Section apply to the regions of ice strengthening marked with "+" in Table 19.2.2.5-1 (for ships designed for both bow- and stern- first ice operation) and Table 19.2.2.5-2 (for ships designed for stern-first ice operation only). For the purpose of Tables 19.2.2.5-1 and 19.2.2.5-2, the absence of mark "+" means that the particular region of ice strengthening is not covered by the requirements of this Section.

Table 19.2.2.5-1

Ice class	Vertical regioning															
	I				II				III				IV			
	Horizontal regioning															
	A	A_1	B	C	A	A_1	B	C	A	A_1	B	C	A	A_1	B	C
Icebreaker7 Arc9, Arc8	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Arc7	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+

Ice class	Vertical regioning															
	I				II				III				IV			
	Horizontal regioning															
	A	A_1	B	C	A	A_1	B	C	A	A_1	B	C	A	A_1	B	C
Icebreaker6 Arc6	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+
Arc5	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+
Arc4	+	+	+	+	+	+	+	+	+	+		+	+	+		+
Ice3	+		+	+	+			+								
Ice2	+		+	+												
Ice1	+			+												

Table 19.2.2.5-2

Ice class	Vertical regioning											
	I			II			III			IV		
	Horizontal regioning											
	A	B	C	A	B	C	A	B	C	A	B	C
Arc9, Arc8	+	+	+	+	+	+	+	+	+	+		+
Arc7	+	+	+	++	+	+	+	+	+	+		+
Arc6	+	+	+	+	+	+		+	+			+
Arc5	+	+	+		+	+			+			
Arc4	+	+	+			+						
Ice3	+	+	+									
Ice2	+	+	+									
Ice1			+	+	+	+	+	+	+	+	+	

19.2.3 Structure.

19.2.3.1 Aft end structure.

19.2.3.1.1 To increase stiffness of the aft-end structures, reduce the length of the stern overhang and protect the podded propulsion units against the effects of ice in the stern counter area, it is recommended that the skeg be installed on the centerline.

The lower surface of the skeg shall coincide with the flat bottom. Lengthwise, the skeg shall be consistent with the location of the transverse bulkheads of the aft end.

The framing system of the skeg structures shall be selected proceeding from the condition that the stern counter bottom is consistent with the structural layout.

Given the longitudinal framing of the stern counter bottom, vertical diaphragms are installed inside the skeg that are located in line with the transverse bottom framing of the stern counter, as well as in line with the transverse bulkheads.

Structures of diaphragms, bulkheads and platforms shall comply with the requirements of 3.10.2.4, Part II "Hull".

19.2.3.1.2 The bearing tub of the podded propulsion unit shall have a stiffened thickened flange for the bolted connection to the flange of the azimuth thruster.

The structure of the tub and reinforcements shall provide access to the bolting of the azimuth thruster.

The reinforcements of the bearing tub shall be braced to the reinforced floors and the double-bottom stringers. Additionally installed bottom stringers shall be in line with the bulkhead stiffeners of the transverse bulkheads that confine the azimuth thruster compartment and smoothly change into the longitudinal strength members along a length of 3-4 spacings beyond the compartment. The reinforced floors shall be supported by the frames and longitudinal bulkhead stiffeners that are reinforced in height to the nearest deck or platform.

19.2.4 Ice load.

19.2.4.1 Angles of waterline inclinations at the aft end are determined according to Fig. 19.2.4.1:

when one podded propulsion unit installed as for the fore end according to 3.10.1.2.1, Part II "Hull";

when two/three podded propulsion units installed as for the waterline areas located alongside of the propulsion unit centerline.

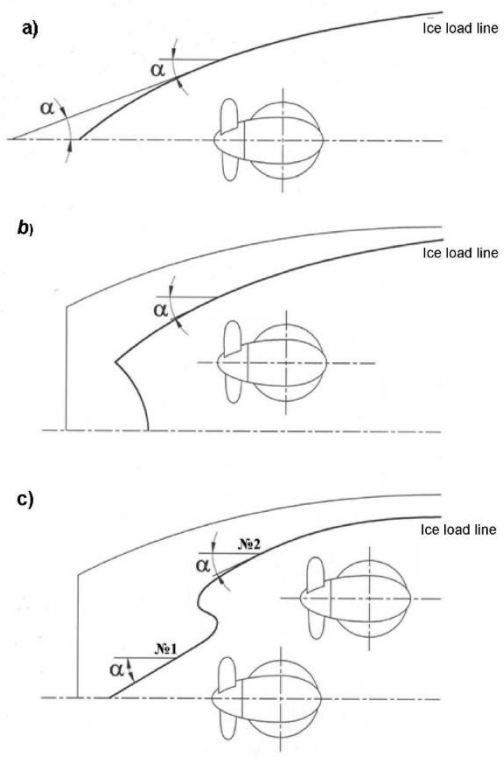


Fig. 19.2.4.1
Determination of waterline inclination angles at the aft end:
a) single podded propulsion unit installation; *b*) twin podded propulsion unit installation; *c*) triple podded propulsion unit installation

19.2.4.2 Ice pressure.

19.2.4.2.1 In region AI:

for ships designed for both bow- and stern- first ice operation:

in accordance with 3.10.3.2.1, Part II "Hull";

for ships designed for stern-first ice operation only:

for ice classes **Ice2**, **Ice3**, **Arc4**, **Arc5**, **Arc6**:

$$p_{\mathrm{AI}} = a_4 p_{\mathrm{BI}} \qquad (19.2.4.2.1\text{-}1)$$

where a_4 = factor to be taken from Table 3.10.3.2.1, Part II "Hull";
p_{BI} = ice pressure in region BI (refer to 19.2.4.2.2);

for ships of ice classes **Arc7**, **Arc8**, **Arc9**:

$$p_{\mathrm{AI}} = 0{,}75 p_{\mathrm{CI}} \qquad (19.2.4.2.2\text{-}2)$$

where p_{CI} = ice pressure in region CI (refer to 19.2.4.2.3).

19.2.4.2.2 In regions A_1I and BI, in accordance with 3.10.3.2.2 and 3.10.3.2.3, Part II "Hull" accordingly. When the ice class in case of bow-first operation differs from that in case of stern-first operation, factor a_3 shall correspond to a higher ice class.

19.2.4.2.3 In region CI:

$$p_{\text{CI}} = 2100 a_1 \nu_m \sqrt[6]{\frac{\Delta}{1000}} \qquad (19.2.4.2.3)$$

where a_1 = factor to be taken from Table 3.10.3.2.1 Part II "Hull" depending on the ice class;
ν_m = value of the shape factor ν, which is the maximum one for the region, as determined at sections within $x = 0; 0{,}025L; 0{,}05L; 0{,}075L$, etc. from the aft boundary of the design ice waterline by the following formula:

$$\nu = f_\nu(b_0^\nu + b_1^\nu \frac{x}{L} + b_2^\nu \alpha + b_3^\nu \beta')$$

where b_i^ν = factors to be taken from Table 19.2.4.2.3 depending on the number of podded propulsion units.

Table 19.2.4.2.3

	b_0^ν	b_1^ν	b_2^ν	b_3^ν
One podded propulsion unit	0,8731	0,1537	0,0011	–0,0012
Two podded propulsion units	0,8721	0,2090	0,0009	–0,0011
Three podded propulsion units, area No. 1 (Fig. 19.2.4.1)	0,8265	0,2474	0,0011	0,0004
Three podded propulsion units, area No. 2 (Fig. 19.2.4.1)	0,8660	–0,1016	0,0010	–0,0007

19.2.4.2.4 In regions II, III and IV, the ice pressure is determined as a part of the ice pressure in region I at the appropriate section of the ship length:

$$p_{kl} = a_{kl} p_k \qquad (19.2.4.2.4)$$

where k = A, A_1, B, C;
l = II, III, IV;
a_{kl} = factor to be taken from Table 19.2.4.2.4.

Table 19.2.4.2.4

Ice class	Horizontal regioning								
	forward and intermediate regions (A, A_1)			midship region (B)			aft region (C)		
	Vertical regioning								
	II	III	IV	II	III	IV	II	III	IV
Ice3	0,4	–	–	–	–	–	0,4	–	–
Arc4	0,5	0,4	0,35	0,4	–	–	0,5	0,4	0,35
Arc5	0,65	0,65	0,45	0,5	0,4	–	0,65	0,65	0,45
Arc6	0,65	0,65	0,5	0,5	0,45	–	0,65	0,65	0,5
Arc7	0,65	0,65	0,5	0,5	0,45	–	0,65	0,65	0,5
Arc8	0,7	0,65	0,5	0,55	0,45	0,25	0,7	0,65	0,5
Arc9	0,4	–	–	–	–	–	0,4	–	–

19.2.4.3 Vertical distribution of ice pressure.
19.2.4.3.1 In regions AI, AII, AIII, AIV:
for ships designed for both bow- and stern- first ice operation:
in accordance with 3.10.3.3.1, Part II "Hull";
for ships designed for stern-first ice operation only:
for ice classes **Ice2**, **Ice3**, **Arc4**, **Arc5**, **Arc6**:

$$b_{\mathrm{A}} = 0{,}8 b_{\mathrm{B}} \qquad (19.2.4.3.1\text{-}1)$$

where b_{B} = refer to 3.10.3.3.3;

for ships of ice classes **Arc7**, **Arc8**, **Arc9**:

$$b_{\mathrm{A}} = b_{\mathrm{C}} \qquad (19.2.4.3.1\text{-}2)$$

where b_{C} = refer to 3.10.3.3.4.

19.2.4.3.2 In regions A_1I, A_1II, A_1III and A_1IV, in accordance with 3.10.3.3.2, Part II "Hull", and in regions BI, BII, BIII and BIV, in accordance with 3.10.3.3.3, Part II "Hull".
19.2.4.3.3 In regions CI, CII, CIII, CIV:

$$b_C = C_1 \, k_\Delta \, u_m \qquad (19.2.4.3.3)$$

where C_1 and k_Δ = factors to be taken from 3.10.3.3.1, Part II "Hull";
u_m = value of the shape factor u, which is the maximum one for the region, as determined at sections within $x = 0;\ 0{,}025L;\ 0{,}05L;\ 0{,}075L$, etc. from the aft boundary of the design ice waterline by the following formula:

$$u = f_u(b_0^u + b_1^u \frac{x}{L} + b_2^u \alpha + b_3^u \beta' + b_4^u \frac{x}{L} \beta' + b_5^u \alpha \beta')$$

where b_i^u = factors to be taken from Table 19.2.4.3.3 depending on a number of podded propulsion units.

Table 19.2.4.3.3

	b_0^u	b_1^u	b_2^u	b_3^u	b_4^u	b_5^u
One podded propulsion unit	0,6445	1,0425	0,0035	0,0010	–0,0201	–0,0001
Two podded propulsion units	0,6584	0,8894	0,0036	0,0005	–0,0128	–0,0001
Three podded propulsion units, area No. 1 (Fig. 19.2.4.1)	0,6075	1,3355	0,0037	0,0025	–0,0225	–0,0001
Three podded propulsion units, area No. 2 (Fig. 19.2.4.1)	0,6021	1,3103	0,0040	0,0024	–0,0368	–0,0001

19.2.4.4 Horizontal distribution of ice pressure.
19.2.4.4.1 In regions AI, AII, AIII, AIV:
for ships designed for both bow- and stern- first ice operation:
in accordance with 3.10.3.4.1, Part II "Hull";
for ships designed for stern-first ice operation only:

$$l_{\mathrm{A}}^{\mathrm{H}} = 6 b_{\mathrm{A}} \geq 3{,}5\sqrt{k_\Delta} \qquad (19.2.4.4.1)$$

where b_{A} = vertical distribution of ice pressure in accordance with 19.2.4.3.1-1 or 19.2.4.3.1-2.

19.2.4.4.2 In regions A_1I, A_1II, A_1III and A_1IV, in accordance with 3.10.3.3.2, Part II "Hull", and in regions BI, BII, BIII and BIV, in accordance with 3.10.3.3.3, Part II "Hull".

19.2.4.4.3 In regions CI, CII, CIII, CIV:

$$l_{\mathrm{C}}^{\mathrm{H}} = 11{,}3\sqrt{b_{\mathrm{C}} \sin \beta_m^{\mathrm{C}}} \geq 3{,}5\sqrt{k_\Delta} \qquad (19.2.4.4.3)$$

where b_C = vertical distribution of ice pressure in accordance with 19.2.4.3.3;
β_m^{C} = angle β in the design section of region C, for which the u parameter is maximum.

19.2.4.5 Ice pressure for Arctic ships of ice classes **Icebreaker6** and **Icebreaker7**.

19.2.4.5.1 In regions AI, A_1I, BI ice pressure is determined according to 3.10.3.5.1 and 3.10.3.5.2, Part II "Hull". Value of $p_{\mathrm{AI}}^{\mathrm{o}}$ is determined in accordance with 19.2.4.2.1.

19.2.4.5.2 In region CI, ice pressure is determined according to 3.10.3.5.2, Part II "Hull".

19.2.4.5.3 In regions II, III, IV ice pressure is determined according to 3.10.3.4.1, Part II "Hull":

$$p_{mn} = a_{mn} p_{m\mathrm{I}} \qquad (19.2.4.5.3)$$

where a_{mn}, m, n = refer to 3.10.3.5.3, Part II "Hull".

19.2.4.6 As far as Arctic ships of ice classes **Icebreaker6** and **Icebreaker7** are concerned, the vertical distribution of ice pressure in regions A, A_1 and B shall be adopted equal for all regions and shall be determined in accordance with 3.10.3.3.1, Part II "Hull" as for the forward region of the ship whose ice class number coincides with the ice class number of the icebreaker. In region C, the vertical distribution of ice pressure shall be determined in accordance with 19.2.4.3.3 as for the aft region of the ship whose ice class number coincides with the ice class number of the icebreaker.

19.2.4.7 As far as Arctic ships of ice classes **Icebreaker6** and **Icebreaker7** are concerned, the horizontal distribution of ice pressure in regions A, A_1 and B shall be adopted equal for all regions and shall be determined in accordance with 3.10.3.4.1, Part II "Hull" as for the forward region of the ship whose ice class number coincides with the ice class number of the icebreaker. In region C, the horizontal distribution of ice pressure shall be determined in accordance with 19.2.4.4.3 as for the aft region of the ship whose ice class number coincides with the ice class number of the icebreaker.

19.2.5 Scantlings of ice-strengthening structures.

19.2.5.1 Scantlings of ice strengthening structures shall be determined based on the requirements of 3.10.4, Part II "Hull" for the ice load parameters determined according to the calculation procedure in 19.2.4.

19.2.5.2 Scantlings of skeg and stern counter shall be determined based on the dependencies in 3.10.4, Part II "Hull" for hull structures (shell plating, conventional and web frames, framing members and plate structures) using the ice load parameters determined according to calculation procedure in 19.2.4.

19.3 SUBDIVISION

19.3.1 For the purpose of damage trim and stability calculations of the ships of ice classes **Arc4 — Arc9** with the distinguishing mark **DAS** in the class notation, the longitudinal extent 0,045L_{ice} shall be assumed for ice damage in the forward and aft part of the hull, if the centre of damage lies within 0,4L_{ice} from the forward and aft perpendiculars, respectively, and 0,015L_{ice} in other areas.

20 REQUIREMENTS FOR SHIPS FITTED FOR LONG-TERM OPERATION WITHOUT DRY-DOCKING AND DESIGNED IN SUCH A WAY AS TO PROVIDE THE POSSIBILITY OF IN-WATER SURVEY

20.1 GENERAL PROVISIONS AND SCOPE OF APPLICATION

20.1.1 For ships constructed in compliance with the requirements of this Section, the distinguishing mark **UWILD** or **UWILD-S** is added to the character of classification in accordance with 2.2.47, Part I "Classification". The assignment of the distinguishing mark is not mandatory and may be performed at the shipowner's discretion. These requirements are applied to berth-connected ships designed in such a way as to provide the possibility to replace surveys of the outside of the ship's bottom in dry dock with alternative survey methods (such ships include floating oil/gas storages, floating power plants, etc.). In some cases, application of this mark may require agreement with the Flag State Maritime Administration (depending on MA requirements as well as when the ship is covered by SOLAS).

20.1.2 The conditions for in-water survey are specified in 2.5, Part II "Survey Schedule and Scope" of the Rules for the Classification Surveys of Ships in Service.

20.2 TECHNICAL DOCUMENTATION

20.2.1 In addition to 3.2, Part I "Classification", the scope of the plan approval documentation for a ship under construction to be submitted shall include the following documents (A – for approval, AG – for agreement, FI – for information):

.1 technical background containing substantiation of the possibility of the ship operation without drydocking throughout the planned service life, periodical examinations of the shell plating from inside ensuring free passage for RS surveyor along ship's structures in all directions during surveys (AG);

.2 manual on means of access to structures from inside and outside, including description of procedures (with the use of divers and other technical means) for installation and securing of temporary blanks required for maintenance and survey of bottom and side valves, closing devices or other structures under water providing free access (A);

.3 installation drawings for bottom and side valves and on board means ensuring maintenance of these valves without dry-docking (A);

.4 data on coatings used for anticorrosive protection of the inside and the outside of the bottom and side plating of ship's underwater part (FI) with confirmation based on the hull coating manufacturer's guarantee that the coatings applied onto ship's bottom have been designed to remain in undamaged condition within the particular period of time (ship service period or possible operation period without dry-docking shall be specified), and that the coating will remain effective within the specified period (the submitted document shall be agreed upon with the coating manufacturer). The information shall be submitted as part of the specification of protective coatings required in compliance with 3.2.2.20, Part I "Classification";

.5 if applicable, information on installation of anode protection, instructions on the renewal of the installed anodes in the ship outer hull afloat (the submitted document shall be agreed upon with the coating manufacturer as regards compatibility);

.6 if applicable, cathodic protection specification as well as its installation scheme (the submitted document shall be agreed upon with the coating manufacturer as regards compatibility);

.7 draft programme for in-water survey, including with the use of underwater television, which takes into account the structural particulars of a ship (A). The draft programme shall define and substantiate periods of in-water survey using underwater television if they differ from those specified in 2.5, Part II "Survey Schedule and Scope" of the Rules for the Classification Surveys of Ships in Service (to be approved by the RS Branch Office carrying out technical supervision during construction).

20.3 TECHNICAL REQUIREMENTS

20.3.1 The distinguishing mark **UWILD** or **UWILD-S** may be assigned to the ships complying with the following requirements.

20.3.1.1 The ship shall comply with the requirements for the distinguishing mark denoting the ship's fitness for in-water survey, specified in Section 12, and shall have the distinguishing mark **IWS** in the class notation.

20.3.1.2 The ship shall have the descriptive notation **Berth-connected ship (G)**, or **(S)**, or **(W)**. For operation conditions **Berth-connected ship (S)** and **(W)**, a distance from the outer bottom plating to the sea-bed ensuring safe divers' operations shall be provided at the ship's anchorage location.

20.3.1.3 Additional requirements for distinguishing marks **UWILD** and **UWILD-S**.

20.3.1.3.1 Ship spaces shall be designed in such a way as to provide the possibility of performing periodical examinations of the shell plating from inside (i.e. internal examinations). Protective coating shall be applied onto the ship spaces. Effectiveness and service period of the protective coating shall be determined by the shipowner and agreed with the manufacturer. Permanent means of access shall be provided in such spaces, enabling a throughout examination of the shell plating from inside without using any additional portable arrangements. Openings in hull structures (floors, longitudinal girders, bulkheads, etc.) shall ensure free passage for RS surveyor in all directions during surveys.

20.3.1.3.2 Corrosion protection for the underwater hull shell plating shall be ensured by using anticorrosive coating together with electrochemical protection. Effectiveness and service period of such protection shall be determined by the shipowner.

20.3.1.3.3 Means shall be provided enabling necessary maintenance, repair or replacement of any ship's bottom and side valves without dry-docking. This may require the use of separate external blanks for each valve as well as watertight means of closing for sea chests or special water intake shafts.

Temporary closing devices and blanks for maintenance of bottom and side valves on the shell plating below the waterline may be installed by divers.

20.3.1.3.4 Compliance with the requirements specified in 4.3.1, Part VIII "Systems and Piping" is not mandatory. However, the following shall be provided: measures for prevention of brash and broken ice penetration into inlets, blowing with compressed air or steam or backwash of gratings, cooling system recirculation towards suction arrangements and heating of bottom and side valves installed above the waterline.

20.3.1.3.5 If the ship is provided with a through trunk (or shaft), inside of which all the discharge and inlet valves are installed, provision shall be made for its closure and draining for operations with bottom and side valves. If submersible pumps are used in such a shaft without bottom and side valves, closure and draining of the shaft may not be provided but the submersible pumps shall be retrievable for maintenance.

20.3.1.3.6 Only for a berth-connected ship with the mark **UWILD-S** all systems and mechanisms using temporarily isolated bottom and side valves shall remain operational using redundancy of isolated components of sea water systems. In such case the possibility of performing any types of maintenance and surveys shall be provided without interrupting the ship's normal operation for the intended purpose.

20.3.1.4 Possibility of retainment of distinguishing mark **UWILD** or **UWILD-S** in service.

20.3.1.4.1 The in-water survey shall be performed in due dates in compliance with the applicable requirements of Section 9, Part II "Carrying out Classification Surveys of Ships" of the Guidelines on Technical Supervision of Ships in Service and Annex 1 thereto with account of the RS-approved draft programme for in-water survey using underwater television (refer to 20.2.1.7).

20.3.1.4.2 If the ship's anchorage location and/or move method need to be changed, the matter relating to the retainment of the mark **UWILD** or **UWILD-S** in the class notation shall be agreed upon with the Register in each particular case.

20.3.1.4.3 For operation conditions **Berth-connected ship (S)** and **(W)**, a distance from the bottom shell plating to the sea-bed ensuring safe divers' operations shall be provided at the ship's anchorage location.

20.3.1.4.4 In case of detection of defects that are recognized as not complying with the RS requirements, the possibility for repair afloat of any hull structure in the underwater part shall be provided using the RS-approved technology under RS supervision. If a repair afloat is not technically feasible, it shall be carried out by dry-docking.

21 REQUIREMENTS FOR SHIPS AND OFFSHORE INSTALLATIONS EQUIPPED WITH POSITION-KEEPING/POSITION MOORING SYSTEMS

21.1 GENERAL PROVISIONS AND SCOPE OF APPLICATION

21.1.1 Ships and offshore installations equipped with the position-keeping system/automated control system for power equipment of position mooring or thruster assisted position mooring systems are assigned with one of the following distinguishing marks:

.1 POSIMOOR-FIX — for ships and offshore installations equipped with the position-keeping system and complying with the requirements of Section 4 "Position-Keeping Systems and Components Thereof", Part III "Equipment, Arrangements and Outfit of MODU/FOP" of the Rules for the Classification, Construction and Equipment of MODU/FOP or Section 4 "Position-Keeping Systems", Part III "Equipment, Arrangements and Outfit" (Classification and Construction of Floating Offshore Oil-and-Gas Production Units (FPU)) of the Rules for the Classification, Construction and Equipment of Floating Offshore Oil-and-Gas Production Units (FPU), as applicable;

.2 POSIMOOR — for ships and offshore installations equipped with the automated control system for power equipment of position mooring systems and complying, in addition to 21.1.1.1, with the requirements specified in 9.1 — 9.3, Part XV "Automation" of these Rules or Section 8, Part XIV "Automation" of the Rules for the Classification, Construction and Equipment of MODU/FOP or Section 8, Part XV "Automation" of the Rules for the Classification, Construction and Equipment of Floating Offshore Oil-and-Gas Production Units (FPU), as applicable;

.3 POSIMOOR-TA — for ships and offshore installations, equipped with the automated control system for power equipment of thruster assisted position mooring systems and complying, in addition to 21.1.1.1 and 21.1.1.1.2, with the requirements specified in 9.4 and applicable requirements of Section 8, Part XV "Automation" of these Rules or Sections 7 and 8, Part XIV "Automation" of the Rules for the Classification, Construction and Equipment of MODU/FOP or Sections 8 and 9, Part XV "Automation" of the Rules for the Classification, Construction and Equipment of Floating Offshore Oil-and-Gas Production Units (FPU), as applicable**.**

21.2 TECHNICAL DOCUMENTATION

21.2.1 To assign the distinguishing marks according to 21.1, the technical documentation in the scope specified in Section 4, Part I "Classification" (as applicable) and Section 4, Part III "Equipment, Arrangements and Outfit of MODU/FOP" of the Rules for the Classification, Construction and Equipment of MODU/FOP shall be submitted to the Register for review and approval (agreement).

21.2.2 Arrangements, equipment and component parts of the position-keeping/position mooring systems, which belong to the items of the RS technical supervision, shall have RS certificates.

21.3 SURVEYS

21.3.1 The arrangements and equipment which are part of the position-keeping/position mooring systems shall be installed under the RS surveyor supervision according to the RS-approved documentation.

21.3.2 Upon completion of positioning on a site, the arrangements and equipment are subject to testing under the RS surveyor supervision in the scope prescribed by Section 4, Part III "Equipment, Arrangements and Outfit of MODU/FOP" of the Rules for the Classification, Construction and Equipment of MODU/FOP.

21.3.3 The position-keeping/position mooring systems of the ships and offshore installations in service, which are assigned the distinguishing marks **POSIMOOR-FIX**, **POSIMOOR** or **POSIMOOR-TA**, are subject to periodical surveys according to the applicable requirements of 19.2, Part III "Additional Surveys of Ships Depending on Their Purpose and Hull Material" of the Rules for the Classification Surveys of Ships in Service.

22 ADDITIONAL REQUIREMENTS FOR MONITORING OF CRITICAL STRUCTURAL AREAS

22.1 The ships covered by the IACS Common Structural Rules for Bulk Carriers and Oil Tankers may be assigned the distinguishing mark **CON-M** added to the character of classification in accordance with 2.2.49, Part I "Classification". The assignment of the distinguishing mark is not mandatory and may be performed at the shipowner's discretion.

22.2 Critical structural areas are locations which have been identified from calculations to require monitoring or from the service history of similar or sister ships to be sensitive to cracking, waviness, buckling or corrosion, which may impair the structural integrity of the ship.

22.3 Technical requirements.

22.3.1 To assign the distinguishing mark **CON-M**, the critical structural areas monitoring plan (hereinafter referred to as Construction Monitoring Plan, refer to 3.2.2.24 or 3.4.1.16, Part I "Classification") shall be submitted to the Register prior to the commencement of ship construction. The plan is subject to review for compliance with 22.3.2 taking into account the shipbuilding quality standards for the hull structure agreed during the kick-off meeting according to the Guidelines on Technical Supervision of Ships under Construction, as well the Ship Structure Access Manual approved by the Register, which contains the full list of critical areas/locations identified by the designer as the result of the strength and fatigue design assessment of the project.

22.3.2 The Construction Monitoring Plan shall include at least the following:

.1 description of the method for determination of critical areas (references to the results of calculations within the ship's design or service history of similar or sister ships may be made in the description of the method);

.2 appropriate structural plans with the critical locations marked;

.3 summary table of critical areas with information on each critical location inside the critical area, namely:

designation of the critical area/location;

position (space, frame No., starboard/portside);

type of structural joint, to which the location belongs, e.g., "Upper hopper knuckle";

assembly stage to be controlled (block construction/pre-erection/erection);

remarks;

.4 control procedures, including, but not limited to:

verification of alignment for elements of structure;

applied non-destructive testing methods;

.5 details of joint type, including installation (assembling) tolerances, as well as methods for improvement of structural fatigue life such as degree of weld toe burr grinding;

.6 remedial measures;

.7 sample forms of shipyard reporting on inspections of critical areas.

22.3.3 The Construction Monitoring Plan approved by the Register shall be included in the Ship Construction File (SCF) and used for surveys during construction in accordance with Section 2 of the Guidelines on Technical Supervision of Ships under Construction.

22.3.4 Information on critical areas may be used during subsequent surveys of the ship in service for periodic inspection of such areas, if necessary.

Russian Maritime Register of Shipping

Rules for the Classification and Construction of Sea-Going Ships
Part XVII
Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships

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