RUSSIAN MARITIME REGISTER OF SHIPPING

Version: 01.07.2024

# 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

ND No. 2-020101-174-E

St. Petersburg

# RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS (PART XVII)

The present version of Part XVII "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships" of the Rules for the Classification and Construction of Sea-Going Ships of Russian Maritime Register of Shipping (RS, the Register) has been approved in accordance with the established approval procedure and comes into force on 1 July 2024.

The present version is based on the version dated 1 January 2024 and Rule Change Notices No. 24-126872, and No. 24-132693 taking into account the amendments and additions developed immediately before publication (refer to the Revision History).

**REVISION HISTORY**[1]

| Item | Description | | Remarks |
|---|---|---|---|
| Para 10.1.1 | The reference to the Finnish-Swedish Ice Class Rules specifies the year of issue of the updated version of these Rules | | Editorial amendment of 25.09.2024 |
| Para 10.4.3 | For the users' convenience, the formulas for calculating the values of $C_1$ and $C_2$ have been numbered (10.4.3-3) and (10.4.3-4), accordingly | | Editorial amendment of 25.09.2024 |
| Formula 10.4.3-3 | As was | As is | Editorial amendment of 25.09.2024 |
| | $C_1 = f_1 \frac{BL_{PAR}}{2(T/B)+1} + (1+0{,}021\varphi_1)(f_2B + f_3L_{BOW} + f_4L_{BOW})$ | $C_1 = f_1 \frac{BL_{PAR}}{2(T/B)+1} + (1+0{,}021\varphi_1)(f_2B + f_3L_{BOW} + f_4BL_{BOW})$ | |

[1] With the exception of amendments and additions introduced by Rule Change Notices (RCN), as well as of misprints and omissions.

# 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.

Note. 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".

Table 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 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 extension of ice strengthening region shall be determined in compliance with Fig. 1.2.2.1.

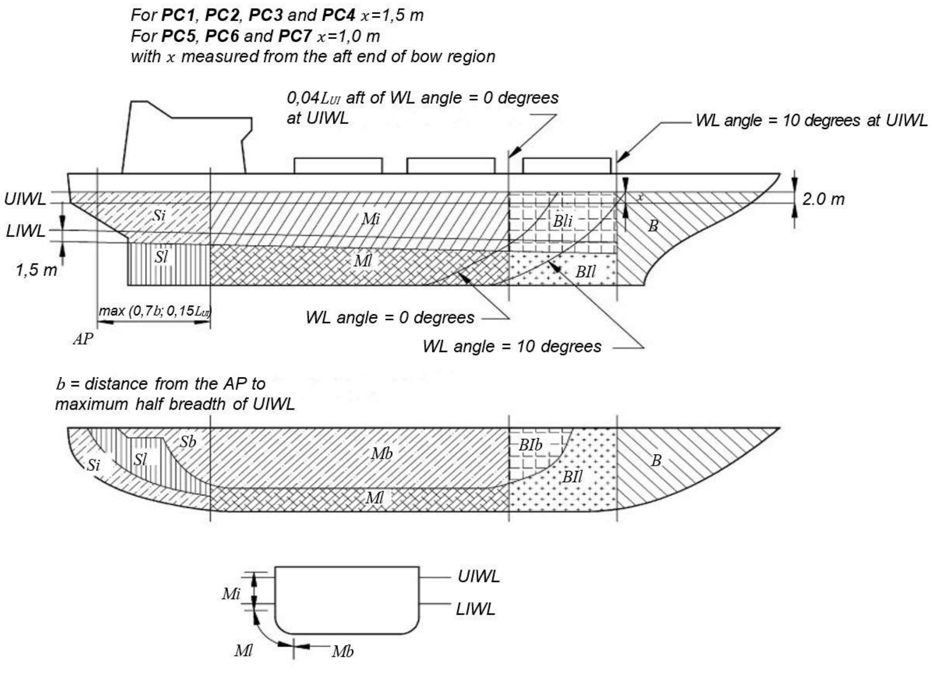



Fig. 1.2.2.1
Hull area extents

**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 0,04$L_{UI}$ 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 $f_{a_i}$:

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

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

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

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

force $F$, in MN:

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

load patch aspect ratio $AR$:

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

line load $Q$, in MN/m:

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

pressure $P$, in MPa:

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

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;
$\alpha$ = waterline angle, in deg. (refer to Fig. 1.2.3.2.1);
$\beta'$ = 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, $f_{a_i}$:

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

force $F$, in MN:

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

line load $Q$, in MN/m:

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

pressure $P$, in kPa:

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

where $i$ = sub-region considered;
$\alpha$ = 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.

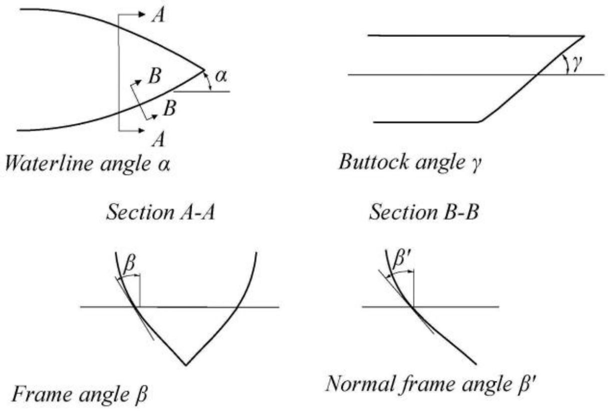



Fig. 1.2.3.2.1
Definition of hull angles

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.;
$\mathrm{tg}\beta = \mathrm{tg}\alpha/\mathrm{tg}\gamma$;
$\mathrm{tg}\beta' = \mathrm{tg}\beta \cdot \cos\alpha$.

**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:

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

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

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:

$$w_{Bow} = F_{Bow}/Q_{Bow}; \tag{1.2.3.3-1}$$

$$b_{Bow} = Q_{Bow}/P_{Bow} \tag{1.2.3.3-2}$$

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:

$$w_{NonBow} = F_{NonBow}/Q_{NonBow}; \tag{1.2.3.3.2-1}$$

$$b_{NonBow} = w_{NonBow}/3{,}6 \tag{1.2.3.3.2-2}$$

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:

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

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;<br>side longitudinals;<br>web frames | | $PPF_s = 1{,}0$ if $S_w \geq 0{,}5w$<br>$PPF_s = 2{,}0 - 2{,}0 \cdot S_w/w$ if $S_w < 0{,}5w$ |
| where $s$ = frame or longitudinal spacing, in m;<br>$S_w$ = web frame spacing, in m;<br>$w$ = 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 |
| 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

$$t = t_{net} + t_s \qquad (1.2.4.1)$$

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

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

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

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

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

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

where $\Omega$ = 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;
$\sigma_y$ = 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.

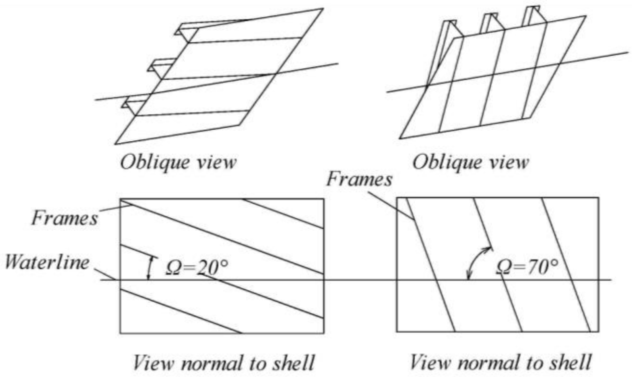



Fig. 1.2.4.2
Shell framing angle Ω

**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);
$\varphi_w$ = smallest angle between shell plate and stiffener web, measured at the midspan of the stiffener (refer to Fig. 1.2.5.7). The angle $\varphi_w$ may be taken as 90 deg., provided the smallest angle is not less than 75 deg.

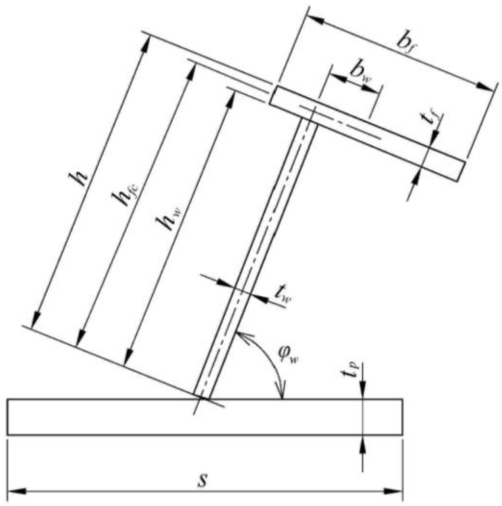



Fig. 1.2.5.7
Stiffener geometry

**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 $\varphi_w$ 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 $\Omega$ 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 $B_{Ib}$, $M_b$ 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 cm², as defined in 1.2.5.7, shall comply with the following condition: $A_w \geq A_t$, where

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

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;
$\sigma_y$ = minimum upper yield stress of the material, in N/mm².

**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 cm³, 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.

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

where $AF$, $PPF$, $P_{avg}$, $LL$, $b$, $s$, $a$ and $\sigma_y$ 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 cm²;
$A_w$ = effective net shear area of transverse frame (calculated according to 1.2.5.7), in cm²;
$k_w = 1/\left(1 + 2A_{fn}/A_w\right)$, 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 cm³;
$z_p = \left(b_f t_{fn}^2/4 + b_{eff} t_{pn}^2/4\right)/1000$;
$b_f$ = 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

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

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;
$\sigma_y$ = 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

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

where $AF$, $PPF_s$ $P_{avg}$, $b_1$, $a$ and $\sigma_y$ 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:

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

for bulb, tee and angle sections:

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

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

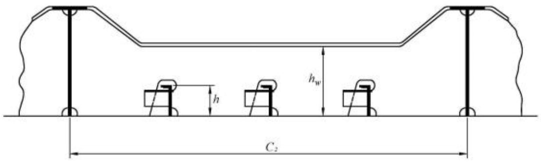



Fig. 1.2.9.2
Parameter definition for web stiffening

**1.2.9.3** In addition, the following shall be satisfied:

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

where $\sigma_y$ = 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:

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

where $t_{fn}$ = net thickness of flange, in mm;
$\sigma_y$ = 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.

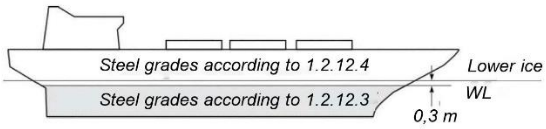



Fig. 1.2.12.3
Steel grade requirements for submerged and weather exposed shell plating

**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[1]**

| 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 |
| $t \le 10$ | B | AH | B | AH | B | AH | B | AH | E | EH | E | EH | B | AH |
| $10 < t \le 15$ | B | AH | B | AH | D | DH | B | AH | E | EH | E | EH | D | DH |
| $15 < t \le 20$ | D | DH | B | AH | D | DH | B | AH | E | EH | E | EH | D | DH |
| $20 < t \le 25$ | D | DH | B | AH | D | DH | B | AH | E | EH | E | EH | D | DH |
| $25 < t \le 30$ | D | DH | B | AH | E | EH[2] | D | DH | E | EH | E | EH | E | EH |
| $30 < t \le 35$ | D | DH | B | AH | E | EH | D | DH | E | EH | E | EH | E | EH |
| $35 < t \le 40$ | D | DH | D | DH | E | EH | D | DH | - | FH | E | EH | E | EH |
| $40 < t \le 45$ | E | EH | D | DH | E | EH | D | DH | - | FH | E | EH | E | EH |
| $45 < t \le 50$ | E | EH | D | DH | E | EH | D | DH | - | FH | - | 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 $\gamma_{stem}$ 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 ($\alpha_{stem}$ < 80°), $e_b$ = 1 and the above simplifies to:

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

$K_h$ = $0{,}01 A_{wp}$, 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;
$\gamma_{stem}$ = 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);
$\alpha_{stem}$ = 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.

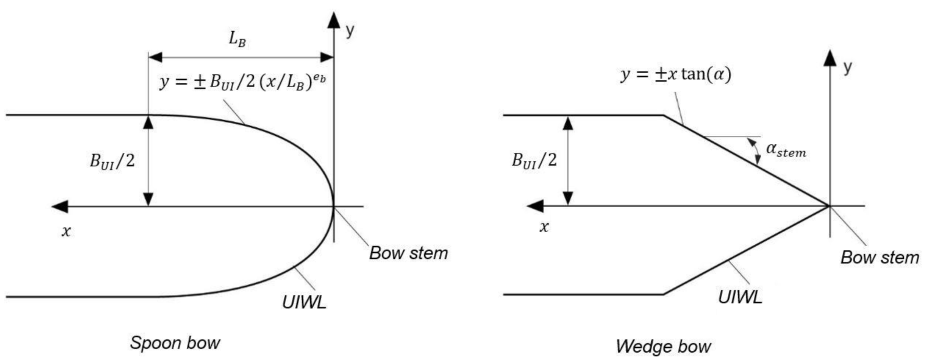



Fig. 1.2.13.2.1-1
Bow shape definition

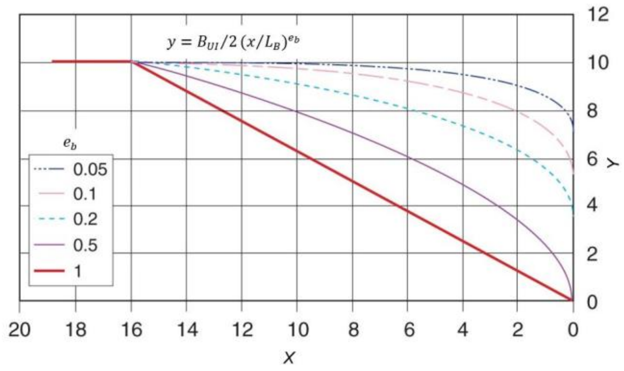



Fig. 1.2.13.2.1-2
Illustration of $e_b$ effect on the bow shape for $B_{UI} = 20$ and $L_b = 16$

**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

$$F_I = C_f F_{IB} \tag{1.2.13.3.1}$$

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

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

where $L_{UI}$ = ship length measured on UIWL according to 1.2.1.2;
$\gamma_{stem}$ = 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 – 2,8$x/L_{UI}$ in sections 0,7 < $x/L_{UI}$ < 0,95;
$C_m$ = 0,3 in section $x/L_{UI}$ = 0,95;
$C_m$ = 6,0 – 6,0$x/L_{UI}$ 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 $\sigma_a$ 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 $\sigma_y/\sigma_u \le 0{,}7$ | Permissible stress when $\sigma_y/\sigma_u > 0{,}7$ |
|---|---|---|---|
| Tension | $\sigma_a$ | $\eta\sigma_y$ | $\eta 0{,}41(\sigma_u + \sigma_y)$ |
| Shear | $\tau_a$ | $\eta\sigma_y/3^{0{,}5}$ | $\eta 0{,}41(\sigma_u + \sigma_y)/3^{0{,}3}$ |
| Buckling | $\sigma_a$ | $\sigma_c$ for plating and for web plating of stiffeners $\sigma_c/1{,}1$ for stiffeners | |
| | $\tau_a$ | $\tau_c$ | |

where $\sigma_a$ = applied vertical bending stress, in N/mm$^2$;
$\tau_a$ = applied vertical shear stress, in N/mm$^2$;
$\sigma_y$ = minimum upper yield stress of the material, in N/mm$^2$;
$\sigma_u$ = ultimate tensile strength of material, in N/mm$^2$;
$\sigma_c$ = critical buckling stress in compression, according to 1.6.5.3, Part II "Hull", in N/mm$^2$;
$\tau_c$ = critical buckling stress in shear, according to 1.6.5.3, Part II "Hull", in N/mm$^2$;
$\eta$ = 0,8.
$\eta$ = 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;
$\sigma_y$ = minimum upper yield stress of outer shell material, in N/mm$^2$;
$\sigma_{y1}$ = 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** Hull supporting structures for equipment and machinery located in way of ice strengthening region.

**1.2.16.1.1** Hull supporting structures for azimuth thrusters.

**1.2.16.1.1.1** The supporting structures for azimuth thrusters shall withstand loads transmitted to them from azimuth thrusters. Scantlings of supporting structures shall be checked using direct calculation methods. This shall include a check that there are no stresses exceeding the allowable stresses and a buckling strength check.

**1.2.16.1.1.2** When finite element analysis is used, the design model shall include all structures of thruster compartment including bulkheads forming its boundaries as well as framing at least up to the first deck above the thruster compartment. The size of the model shall be sufficient to avoid the effect of boundary conditions.

**1.2.16.1.1.3** When carrying out direct calculations, the following permanent loads shall be taken into account:

gravitational force;

buoyancy force;

maximum load determined from orientation of the thruster to the maximum angle at which the azimuth thruster can be oriented on each side when the ship navigates at its maximum speed;

lateral pressure calculated for all possible thruster orientations up to the maximum rotation angle on each side when the ship navigates at its maximum speed. The design lateral pressure is defined as the greatest pressure taken from obtained values for all possible orientations of the azimuth thruster on each side when the ship navigates at its maximum speed. The total force acting on the propulsion system is calculated by integrating the lateral pressure on the external surface of the azimuth thruster;

maximum loads calculated for the crash stop of the ship obtained through inversion of the propeller rotation;

maximum loads calculated for the crash stop of the ship obtained through a 180° rotation of the pod.

**1.2.16.1.1.4** Loads.

Ice loads are calculated in accordance with 6.2.2 and 6.2.3 of the Rules for Active Means of Polar Class Ships' Steering.

**1.2.16.1.1.5** Allowable stresses.

When making calculations, the following criterion shall be met:

$$\sigma_{VM} \le 1{,}25\ \sigma_{ALL}$$

where $\sigma_{VM}$ = Von Mises equivalent stress, in MPa;
$\sigma_{ALL} = 65/\eta$ – allowable stress, in MPa;
$\eta$ = factor indicating application of steel mechanical properties determined in accordance with 1.1.4.3, Part II "Hull" of these Rules.

For design cases related to the crash stop of the ship, the following criterion shall be met:

$$\sigma_{VM} \le \sigma_{CRASH}$$

where $\sigma_{CRASH} = 1{,}25\sigma_{ALL}$.

When models with fine mesh (size of a finite element is approximately equal to 50 mm x 50 mm) are used for calculation, the following criteria shall be met:

$\sigma_{VM} \leq 1{,}53\ \sigma_{CRASH}$ – for elements not adjacent to welds;
$\sigma_{VM} \leq 1{,}34\ \sigma_{CRASH}$ – for elements adjacent to welds.

Where the criteria are not met, the $\sigma_{VM}$ values may be assumed taking into account their location and particulars of the design model. Such possibility is determined in each particular case.

**1.2.16.2** Structures in way of cut-outs.

The loads carried by a member in way of cut-outs shall not cause buckling. 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 behaviour 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 | | |
|---|---|---|---|---|---|---|
| | $\delta_x$ | $\delta_y$ | $\delta_z$ | $\theta_x$ | $\theta_y$ | $\theta_z$ |
| 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 behaviour 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 modelled 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;

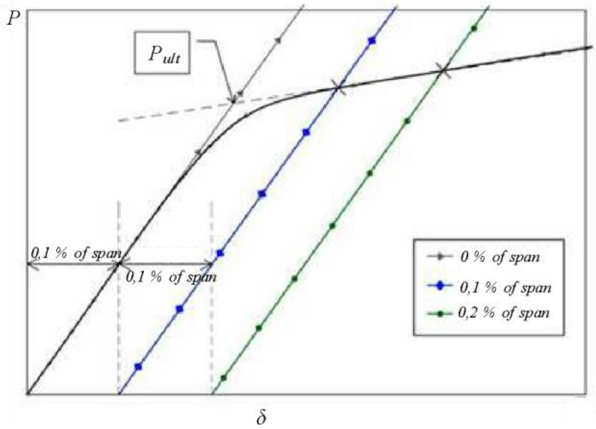
load patch centroid is located at the midspan of the central load carrying stringer of the grillage.

**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 behaviour, 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 REQUIREMENTS FOR MACHINERY OF POLAR CLASS SHIPS

**1.3.1 Application.**
The requirements of this Chapter apply to main propulsion, steering gear, emergency and auxiliary systems essential for the safety of the ship and the crew.
The ice descriptions for polar class ships are provided in chapter 1.1.
The requirements herein are additional to those applicable for ships without an ice class assigned.
**1.3.2 General.**
**1.3.2.1** The documentation submitted to the Register in accordance with Section 3, Part I "Classification" shall contain the following information with regard to the requirements of this Chapter:
**.1** details of the intended environmental operational conditions and the required ice strengthening for the machinery, if different from ship's polar class;
**.2** detailed drawings and descriptions of the main propulsion, steering, emergency and auxiliary machinery and information on the essential main propulsion load control functions. The descriptions shall include operational limitations;
**.3** description detailing where main, emergency and auxiliary systems are located and how they are protected to prevent problems from freezing, ice and snow accumulation 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** Systems, subject to damage by freezing, shall be drainable.
**1.3.2.2.2** Ships classed **PC1** to **PC5** inclusive shall have means provided to ensure sufficient ship operation in the case of propeller damage including the Controllable Pitch (CP) mechanism. Sufficient ship operation means that the ship shall be able to reach safe haven (safe location) where repairs can be undertaken. This may be achieved either by a temporary repair at sea, or by towing, assuming assistance is available, which has to be approved by the Register.
**1.3.2.2.3** Means shall be provided to free a stuck propeller by turning it in reverse direction. This shall also be possible for a propulsion plant intended for unidirectional rotation.
**1.3.2.2.4** The propeller shall be fully submerged at the ships LIWL.
**1.3.3 Materials.**
Materials shall be of an approved ductile material. Ferritic nodular cast iron may be used for parts other than bolts. For nodular cast iron an averaged impact energy value of 10 J at testing temperature is regarded as equivalent to the Charpy V test requirements defined below.
**1.3.3.1** Materials exposed to sea water.
Materials exposed to sea water, such as propeller blades, propeller hubs and cast thruster bodies shall have an elongation not less than 15 % on a test specimen according to requirements of 2.2.2 of Part XIII "Materials".
Charpy V-notch impact testing (determination of impact energy $KV$ for sharply-notched specimen) shall be carried out for materials other than bronze and austenitic steel. The tests shall be carried out on three specimens at minus 10 °C, and the average energy value shall be not less than 20 J. However, Charpy V impact test requirements of 3.7 of Part XIII "Materials" or 3.12 of Part XIII "Materials" as applicable for ships with a polar class notation, shall also be applied to ships covered by this Chapter.
**1.3.3.2** Materials exposed to sea water temperature.
Charpy V-notch impact testing shall be carried out for materials other than bronze and austenitic steel. The tests shall be carried out on three specimens at minus 10 °C, and the average energy value shall be not less than 20 J. However, the Charpy V impact test

requirements of 3.7 of Part XIII "Materials" as applicable for ships with a polar class notation, shall also be applied to ships covered by this Chapter.

This requirement applies to components such as but not limited to blade bolts, CP-mechanisms, shaft bolts, propeller shaft, strut-pod connecting bolts, etc. This requirement does not apply to surface hardened components, such as bearings and gear teeth or sea water cooling lines (heat exchangers, pipes, valves, fittings, etc.). For a definition of structural boundaries exposed to sea water temperature refer to Fig. 1.2.12.3.

**1.3.3.3** Materials exposed to low air temperature.

Materials of exposed machinery and foundations shall be manufactured from steel or other approved ductile material. An average impact energy value of 20 J taken from three Charpy V tests shall be obtained at 10 °C below the lowest design temperature. Charpy V impact tests are not required for bronze and austenitic steel.

This requirement does not apply to surface hardened components, such as bearings and gear teeth. For a definition of structural boundaries exposed to air temperature refer to Fig. 1.2.12.3.

**1.3.4 Definitions.**

**1.3.4.1** Definition of symbols.

Table 1.3.4.1

| Symbol | Unit | Definition |
|---|---|---|
| $c$ | m | Chord length of the blade section |
| $c_{0,7}$ | m | Chord length of the blade section at 0,7$R$ propeller radius |
| $CP$ | — | Controllable pitch |
| $d$ | m | Propeller hub external diameter (at propeller plane) |
| $d_{pin}$ | mm | Diameter of shear pin |
| $D$ | m | Propeller diameter |
| $D_{limit}$ | m | Limit value for the propeller diameter |
| $EAR$ | — | Expanded blade area ratio |
| $F_b$ | kN | Maximum backward blade force for the ship’s service life (negative sign) |
| $F_{ex}$ | kN | Ultimate blade load resulting from blade failure through plastic bending |
| $F_f$ | kN | Maximum forward blade force for the ship’s service life (positive sign) |
| $F_{ice}$ | kN | Ice load |
| $(F_{ice})_{\max}$ | kN | Maximum ice load for the ship's service life |
| $FP$ | — | Fixed pitch |
| $h_0$ | m | Depth of the propeller centreline from lower ice waterline (LIWL) |
| $H_{ice}$ | m | Ice block dimension for propeller load definition |
| $I$ | kgm$^2$ | Equivalent mass moment of inertia of all parts on engine side of component under consideration |
| $I_t$ | kgm$^2$ | Equivalent mass moment of inertia of the whole propulsion system |
| $k$ | — | Shape parameter for Weibull distribution |
| $LIWL$ | — | Lower ice waterline |
| $m$ | — | Slope for S-N curve in log/log scale |
| $M_{BL}$ | kNm | Blade bending moment |
| $MCR$ | — | Maximum continuous rating |
| $n$ | rev/s | Propeller rotational speed |

| Symbol | Unit | Definition |
|---|---|---|
| $n_n$ | rev/s | Nominal rotational propeller speed at $MCR$, in free running open water conditions |
| $N$ | — | Number of ice load cycles |
| $N_{class}$ | — | Reference number of ice impacts per propeller revolution per a polar class |
| $N_{ice}$ | — | Total number of load cycles on propeller blade for the ship's service life |
| $N_R$ | — | Reference number of loads for equivalent fatigue stress ($10^8$ cycles) |
| $N_Q$ | — | Number of propeller revolution during a milling sequence |
| $P_{0,7}$ | m | Propeller pitch at 0.7 $R$ radius |
| $P_{0,7b}$ | m | Propeller pitch at 0,7 $R$ radius at MCR in bollard condition |
| $P_{0,7n}$ | m | Propeller pitch at 0,7 $R$ radius at MCR in free running condition |
| $PCD$ | mm | Pitch circle diameter |
| $Q(\varphi)$ | kNm | Torque |
| $Q_{A\max}$ | kNm | Maximum response torque amplitude as a simulation result |
| $Q_{e\max}$ | kNm | Maximum engine torque |
| $Q_F(\varphi)$ | kNm | Ice torque excitation for frequency domain calculations |
| $Q_{fr}$ | kNm | Friction torque in pitching mechanism, reduction of spindle torque |
| $Q_{\max}$ | kNm | Maximum torque on a propeller due to propeller-to-ice interaction |
| $Q_{motor}$ | kNm | Electric motor peak torque |
| $Q_n$ | kNm | Nominal torque at MCR in free running condition |
| $Q_r(t)$ | kNm | Response torque along the propeller shaft line |
| $Q_{peak}$ | kNm | Maximum of the response torque $Q_r(t)$ |
| $Q_{sex}$ | kNm | Extreme spindle torque corresponding to the blade failure load $F_{ex}$ |
| $Q_{s\max}$ | kNm | Maximum blade spindle torque for the ship's service life |
| $Q_{vib}$ | kNm | Vibratory torque at considered component, taken from frequency domain open water TVC |
| $r$ | m | Blade section radius |
| $R$ | m | Propeller radius |
| $S$ | — | Safety factor |
| $S_{fat}$ | — | Safety factor for fatigue |
| $S_{ice}$ | — | Ice strength index for blade ice force |
| $t$ | m | Maximum blade section thickness |
| $T$ | kN | Hydrodynamic propeller thrust in bollard condition |
| $T_b$ | kN | Maximum backward propeller ice thrust for the ship's service life |
| $T_f$ | kN | Maximum forward propeller ice thrust for the ship’s service life |
| $T_{k\max}$ | kNm | Maximum torque capacity of flexible coupling |
| $T_{k\max1}$ | kNm | $T_{k\max}$ at $N$ = $5\cdot10^4$ load cycles |
| $T_{k\max2}$ | kNm | $T_{k\max}$ at $N$ = 1 load cycle |
| $T_{kv}$ | kNm | Vibratory torque amplitude at $N$ = $10^6$ load cycles |
| $T_n$ | kN | Nominal propeller thrust at MCR in free running condition |
| $T_r$ | kN | Maximum response thrust along the shaft line |
| $TVC$ | — | Torsional vibration calculation |

| Symbol | Unit | Definition |
|---|---|---|
| $\Delta T_{k\max}$ | kNm | Maximum range of $T_{k\max}$ at $N$ = 5·10⁴ load cycles |
| $Z$ | — | Number of propeller blades |
| $z_{pin}$ | | Number of shear pins |
| $\alpha_i$ | deg | Duration of propeller blade/ice interaction expressed in rotation angle |
| $\gamma_\varepsilon$ | — | Reduction factor for fatigue; scatter and test specimen size effect |
| $\gamma_v$ | — | Reduction factor for fatigue; variable amplitude loading effect |
| $\gamma_m$ | — | Reduction factor for fatigue; mean stress effect |
| $\rho$ | — | Reduction factor for fatigue correlating the maximum stress amplitude to the equivalent fatigue stress for $10^8$ stress cycles |
| $\sigma_{0,2}$ | MPa | Proof yield strength of material at 0,2 % plastic strain |
| $\sigma_{exp}$ | MPa | Mean fatigue strength of blade material at $10^8$ cycles to failure in sea water |
| $\sigma_{fat}$ | MPa | Equivalent fatigue ice load stress amplitude for $10^8$ stress cycles |
| $\sigma_{fl}$ | MPa | Characteristic fatigue strength for blade material |
| $\sigma_{ref1}$ | MPa | Reference stress, equal to $\sigma_{ref1} = 0{,}6\ \sigma_{0,2} + 0{,}4\ \sigma_u$ |
| $\sigma_{ref2}$ | MPa | Reference stress, equal to $\sigma_{ref2} = \mathrm{Min}(0{,}7\ \sigma_u, 0{,}6\ \sigma_{0,2} + 0{,}4\ \sigma_u)$ |
| $\sigma_{st}$ | MPa | Maximum stress, resulting from $F_b$ or $F_f$ |
| $\sigma_u$ | MPa | Ultimate tensile strength for blade material |
| $(\sigma_{ice})_A(N)$ | MPa | Blade stress amplitude distribution |
| $(\sigma_{ice})_{A\max}$ | MPa | Maximum ice load stress amplitude at the considered location on the blade |
| $(\sigma_{ice})_{b\max}$ | MPa | Principal stress caused by the maximum backward propeller ice load |
| $(\sigma_{ice})_{f\max}$ | MPa | Principal stress caused by the maximum forward propeller ice load |
| $\sigma_{mean}$ | MPa | Mean stress |

**1.3.4.2** Definition of loads.

Table 1.3.4.2

| | Definition | Use of the load in design process |
|---|---|---|
| $F_b$ | The maximum lifetime backward force on a propeller blade resulting from propeller-to-ice interaction, including hydrodynamic loads on that blade. The direction of the force is perpendicular to 0.7 $R$ chord line (refer to Fig. 1.3.4.2) | Design force for strength calculation of the propeller blade |
| $F_f$ | The maximum lifetime forward force on a propeller blade resulting from propeller-to-ice interaction, including hydrodynamic loads on that blade. The direction of the force is perpendicular to 0,7 $R$ chord line | Design force for strength calculation of the propeller blade |
| $Q_{s\max}$ | The maximum lifetime spindle torque on a propeller blade resulting from propeller-to-ice interaction, including hydrodynamic loads on that blade | When 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 |

| | Definition | Use of the load in design process |
|---|---|---|
| $T_b$ | The maximum lifetime thrust on propeller (all blades) resulting from propeller-to-ice interaction. The direction of the thrust is the propeller shaft direction and the force is opposite to the hydrodynamic thrust | Used for estimating of the response thrust $T_r$.<br>$T_b$ can be used as an estimate of excitation in axial vibration calculations. However, axial vibration calculations are not required by the rules |
| $T_f$ | The maximum lifetime thrust on propeller (all blades) resulting from propeller-to-ice interaction. The direction of the thrust is the propeller shaft direction acting in the direction of hydrodynamic thrust | Used for estimating of the response thrust $T_r$.<br>$T_f$ can be used as an estimate of excitation in axial vibration calculations. However, axial vibration calculations are not required by the rules |
| $Q_{\max}$ | The maximum ice-induced torque resulting from propeller-to-ice interaction on one propeller blade, including hydrodynamic loads on that blade | Used for estimating of the response torque ($Q_r$) 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 that is needed to cause total failure of the blade so that plastic hinge appear in the root area. The force is acting on 0,8 $R$ | Blade failure load is used to dimension the blade bolts, pitch control mechanism, propeller shaft, propeller shaft bearing and trust bearing. The objective shall guarantee that total propeller blade failure does not lead to damage to other components |
| $Q_{sex}$ | Maximum spindle torque resulting from blade failure load | Used to ensure pyramid strength principle for the pitching mechanism |
| $Q_r$ | Maximum response torque along the propeller shaft line, with account for the dynamic behaviour 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, with account for the dynamic behaviour of the shaft line for ice excitation (axial vibration) and hydrodynamic mean thrust on propeller | Design thrust for propeller shaft line components |

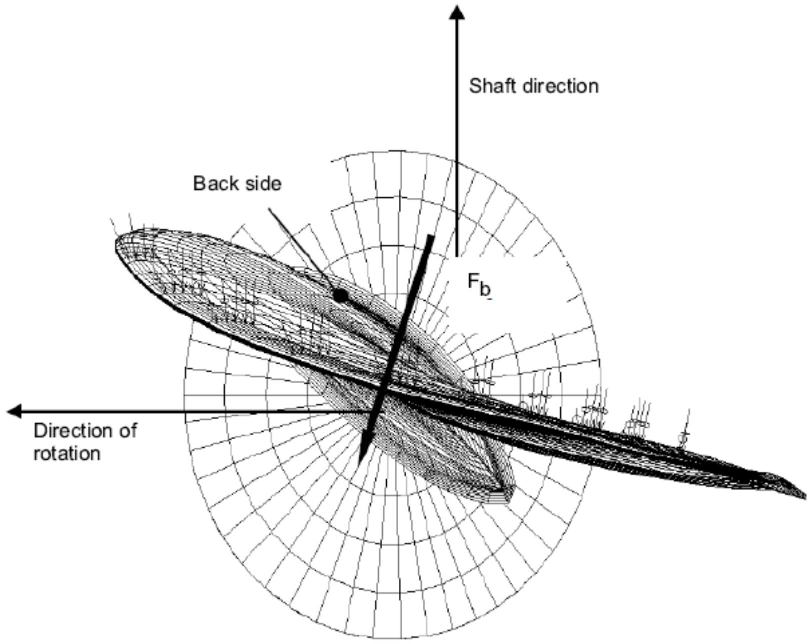



Fig. 1.3.4.2
Direction of the backward blade force resultant taken perpendicular to chord line at radius 0,7 $R$.
Ice contact pressure at the leading edge is shown with small arrows

**1.3.5 Design ice loads.**

**1.3.5.1** General.

**1.3.5.1.1** 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-mounted propellers shall be agreed with the Register.

**1.3.5.1.2** The given loads are expected, single occurrence, maximum values for the whole ship's service life for normal operational conditions, including loads resulting from directional change of rotation where applicable. These loads do not cover off-design operational conditions, for example when a stopped propeller is dragged through ice.

**1.3.5.1.3** These requirements also cover loads due to propeller ice interaction for azimuthing and fixed thrusters with geared transmission or an integrated electric motor ("geared and podded propulsors"). However, the load models of the regulations do not include propeller-to-ice interaction loads when ice enters the propeller of a turned azimuthing thruster from the side (radially) or loads when ice blocks hit on the propeller hub of a pulling propeller. Ice loads resulting from ice impacts on the body of thrusters shall be estimated on a case-by-case basis, considering provisions of Section 6 of the Rules for Active Means of Polar Class Ships' Steering.

**1.3.5.1.4** The loads given in 1.3.5.3 are total loads including ice-induced loads and hydrodynamic loads (unless otherwise stated) during ice interaction and shall be applied separately (unless otherwise stated) and are intended for component strength calculations only.

$F_b$ 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-to-ice interaction phenomena, which do not act simultaneously. Hence, they shall be applied separately.

**1.3.5.2** Polar class factors.

The dimensions of the considered design ice block are $H_{ice} \times 2 \cdot H_{ice} \times 3 \cdot H_{ice}$. The design ice block and ice strength index $S_{ice}$ are used for the estimation of the propeller-to-ice loads. Both $H_{ice}$ and $S_{ice}$ are defined for each polar class in Table 1.3.5.2.

Table 1.3.5.2

**Design polar-class factors**

| Polar class | **PC1** | **PC2** | **PC3** | **PC4** | **PC5** | **PC6** | **PC7** |
|---|---|---|---|---|---|---|---|
| $H_{ice}$, in m | 4,00 | 3,50 | 3,00 | 2,50 | 2,00 | 1,75 | 1,50 |
| $S_{ice}$ | 1,20 | 1,10 | 1,10 | 1,10 | 1,10 | 1,00 | 1,00 |

**1.3.5.3** Propeller-to-ice interaction loads.

**1.3.5.3.1** Maximum backward blade force $F_b$ for open propellers.

The maximum backward blade force $F_b$, in kN, for open propellers is equal to:

when $D < D_{limit}$: $$F_b = 27S_{ice}(nD)^{0,7}\left(\frac{EAR}{Z}\right)^{0,3} D^2, \qquad (1.3.5.3.1\text{-}1)$$

when $D \geq D_{limit}$: $$F_b = 23S_{ice}(nD)^{0,7} \cdot \left(\frac{EAR}{Z}\right)^{0,3} (H_{ice})^{1,4} D, \qquad (1.3.5.3.1\text{-}2)$$

where $D_{limit}$ = $0,85\ (H_{ice})^{1,4}$, in m;

$n$ = nominal rotational speed at MCR in free running open water condition_in rps, taken as follows:

$n = n_n$ for CP propellers;

$n = 0,85n_n$ for FP propellers.

For ships with the additional notation **Icebreaker**, the above stated backward blade force $F_b$ shall be multiplied by a factor of 1,1.

**1.3.5.3.2** Maximum forward blade force $F_f$ for open propellers.

The maximum forward blade force $F_f$, in kN, for open propellers is equal to:

when $D < D_{limit}$: $$F_f = 250\frac{EAR}{Z}D^2, \qquad (1.3.5.3.2\text{-}1)$$

when $D \geq D_{limit}$: $$F_f = 500\frac{1}{1-\frac{d}{D}}H_{ice}\frac{EAR}{Z}D, \qquad (1.3.5.3.2\text{-}2)$$

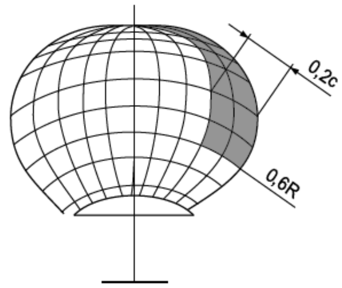
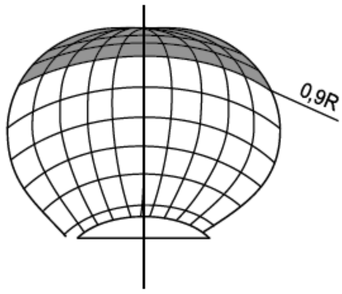
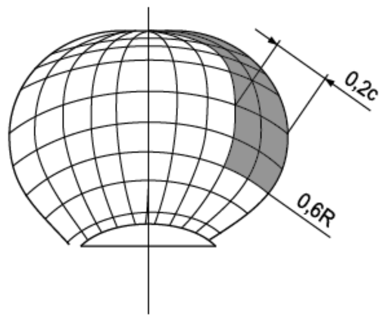
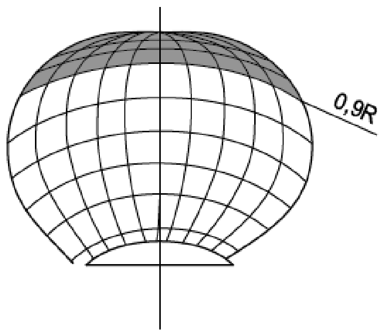
where $D_{limit} = \frac{2}{1-\frac{d}{D}}H_{ice}$.

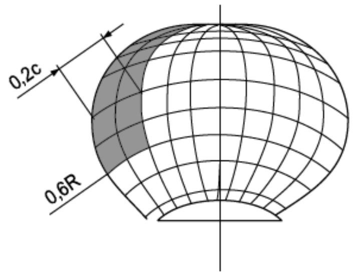
**1.3.5.3.3** Loaded area on the blade for open propellers.

Load cases 1 to 4 given in Table 1.3.5.3.3 shall be verified for both the CP and FP propellers. In order to obtain blade ice loads for a reversing propeller, load case 5 shall also be checked for propellers where reversing is possible.

Table 1.3.5.3.3

**Loaded areas and load case definition for open propeller**

| Load case No. | Force | Loaded area | Right handed propeller blade seen from behind |
|---|---|---|---|
| 1 | $F_b$ | Uniform pressure applied on the back of the blade (suction side) to an area from 0,6$\cdot R$ to the tip and from the leading edge to 0,2 times the chord length |   |
| 2 | $0,5F_b$ | Uniform pressure applied on the back of the blade (suction side) on the propeller tip area outside of 0,9$\cdot R$ radius |   |
| 3 | $F_f$ | Uniform pressure applied on the blade face (pressure side) to an area from 0,6$\cdot R$ to the tip and from the leading edge to 0,2 times the chord length |   |
| 4 | $0,5F_f$ | Uniform pressure applied on propeller face (pressure side) on the propeller tip area outside 0,9$\cdot R$ radius |   |

| Load case No. | Force | Loaded area | Right handed propeller blade seen from behind |
|---|---|---|---|
| 5 | $0{,}6\ \mathrm{Max}(F_b, F_f)$ | Uniform pressure applied on propeller face (pressure side) to an area from 0,6·$R$ to the tip and from the trailing edge to 0,2 times the chord length |   |

**1.3.5.3.4** Maximum backward blade force $F_b$ for ducted propellers.

The maximum backward blade force $F_b$, in kN, for ducted propellers is equal to:

when $D < D_{limit}$: $$F_b = 9{,}5\, S_{ice} (nD)^{0,7} \left(\frac{EAR}{Z}\right)^{0,3} D^2, \qquad (1.3.5.3.4\text{-}1)$$

when $D \geq D_{limit}$: $$F_b = 66\, S_{ice} (nD)^{0,7} \left(\frac{EAR}{Z}\right)^{0,3} (H_{ice})^{1,4} D^{0,6}, \qquad (1.3.5.3.4\text{-}2)$$

where $D_{limit}$ = $4 \cdot H_{ice}$ , in m;
$n$ = nominal rotational speed at MCR in free running open water condition in rps, taken as follows:
$n = n_n$ for CP propellers;
$n = 0{,}85 n_n$ for FP propellers.

For ships with the additional notation **Icebreaker**, the above stated backward blade force $F_b$ shall be multiplied by a factor of 1.1.

**1.3.5.3.5** Maximum forward blade force $F_f$ for ducted propellers.

The maximum forward blade force $F_f$, in kN, for ducted propellers is equal to:

when $D \leq D_{limit}$: $$F_f = 250 \frac{EAR}{Z} D^2, \qquad (1.3.5.3.5\text{-}1)$$

when $D > D_{limit}$: $$F_f = 500 \frac{1}{1 - \frac{d}{D}} H_{ice} \frac{EAR}{Z} D, \qquad (1.3.5.3.5\text{-}2)$$

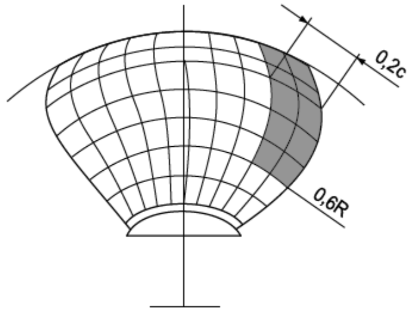
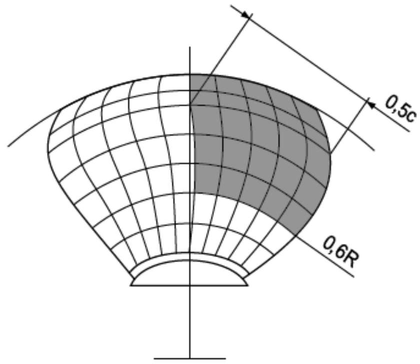
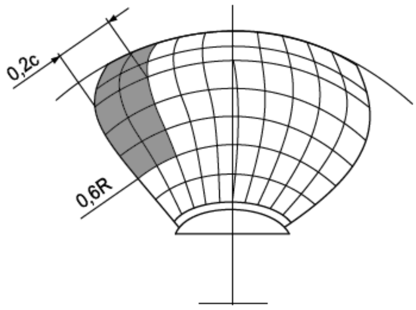
where $D_{limit} = \frac{2}{1 - \frac{d}{D}} H_{ice}$.

**1.3.5.3.6** Loaded area on the blade for ducted propellers.

Load cases 1 and 3 given in Table 1.3.5.3.6 shall be verified for all propellers. In order to obtain blade ice loads for a reversing propeller, the load case 5 shall also be covered for propellers where reversing is possible.

Table 1.3.5.3.6

**Loaded areas and load case definition for ducted propeller**

| Load case No. | Force | Loaded area | Right handed propeller blade seen from behind |
|---|---|---|---|
| 1 | $F_b$ | Uniform pressure applied on the back of the blade (suction side) to an area from 0,6·$R$ to the tip and from the leading edge to 0,2 times the chord length |   |
| 3 | $F_f$ | Uniform pressure applied on the blade face (pressure side) to an area from 0,6·$R$ to the tip and from the leading edge to 0,5 times the chord length |   |
| 5 | 0,6 $\mathrm{Max}(F_b, F_f)$ | Uniform pressure applied on propeller face (pressure side) to an area from 0,6·$R$ to the tip and from the trailing edge to 0,2 times the chord length |   |

**1.3.5.3.7** Maximum blade spindle torque $Q_{s\max}$ for open and ducted propeller.

The spindle torque $Q_{s\max}$ around the axis of the blade fitting shall be calculated both for the maximum backward blade force $F_b$ and forward blade force $F_f$, which are applied as per Table 1.3.5.3.3 and Table 1.3.5.3.6.

If the above method gives a value which is less than the default value given by the formula below, in kNm, the default value shall be used.

$$Q_{s\max-Def} = 0{,}25 \cdot F \cdot c_{0,7}, \qquad (1.3.5.3.7\text{-}1)$$

where $F = \mathrm{Max}[|F_b|, |F_f|]$. (1.3.5.3.7-2)

**1.3.5.3.8** Load distributions (spectra) for blade loads.

The Weibull-type distribution, probability that $F_{ice}$ exceeds $(F_{ice})_{\max}$, as given in Fig. 1.3.5.3.8, is used for the fatigue design of the blade.

$$P\left[\frac{F_{ice}}{(F_{ice})_{\max}} \geq \frac{F}{(F_{ice})_{\max}}\right] = e^{-\left(\frac{F}{(F_{ice})_{\max}}\right)^{k} \ln(N_{ice})}, \qquad (1.3.5.3.8\text{-}1)$$

where $k$ = shape parameter of the spectrum;
$N_{ice}$ = number of load cycles in the spectrum, as defined in 1.3.5.3.9;
$F_{ice}$ = random variable for ice loads on the blade, such as $0 \le F_{ice} \le (F_{ice})_{\max}$.

The resulting blade stress amplitude distribution is given by the following formula:

$$(\sigma_{ice})_A(N) = (\sigma_{ice})_{A_{\max}} \left(1 - \frac{\log(N)}{\log(N_{ice})}\right)^{1/k}, \tag{1.3.5.3.8-2}$$

where $(\sigma_{ice})_{A_{\max}}$ = maximum ice load stress amplitude at the considered location on the blade, in MPa, as given by:

$$(\sigma_{ice})_{A_{\max}} = \frac{(\sigma_{ice})_{f\max} - (\sigma_{ice})_{b\max}}{2};$$

$k$ = shape parameter for the ice force distribution to be taken as:
for open propeller $k$ = 0,75;
for ducted propeller $k$ = 1,0.

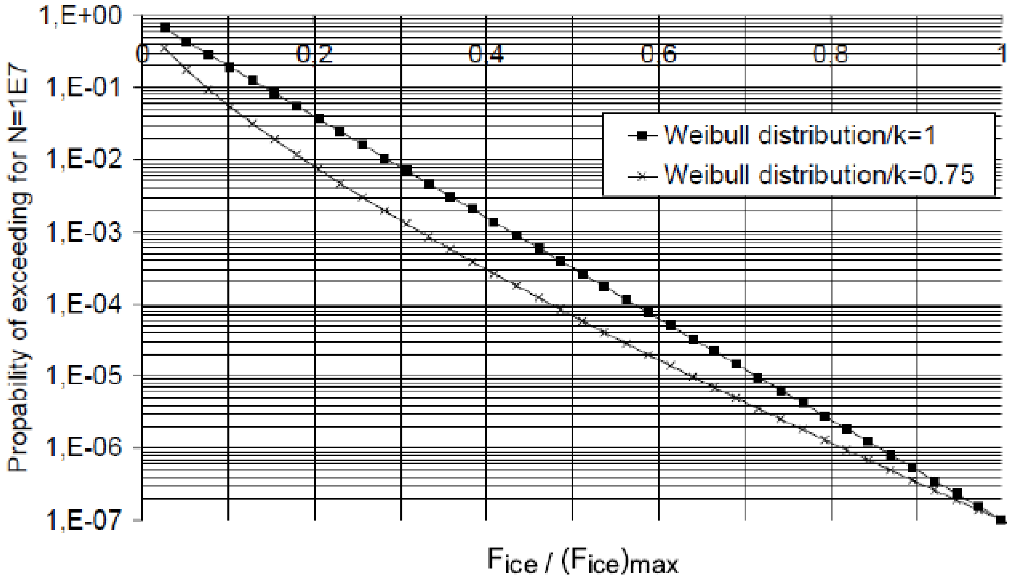



Fig. 1.3.5.3.8
Weibull-type distribution for fatigue design

**1.3.5.3.9** Number of ice loads.
The number of load cycles, $N_{ice}$, used in the load spectrum per blade is given by the following formula:

$$N_{ice} = k_1 k_2 N_{class} n, \tag{1.3.5.3.9}$$

where $k_1$ = coefficient defined as:
$k_1$ = 1 for centre propeller;
$k_1$ = 2 for wing propeller;
$k_1$ = 3 for pulling propeller, wing and centre;
$k_2$ = coefficient defined as:
$k_2 = 0{,}8 - f$ for $f < 0$;
$k_2 = 0{,}8 - 0{,}4f$ for $0 \le f \le 1$;
$k_2 = 0{,}6 - 0{,}2f$ for $1 < f \le 2{,}5$;
$k_2 = 0{,}1$ for $f > 2{,}5$;

$f$ = coefficient taken equal to $f = \frac{h_0 - H_{ice}}{D/2} - 1$;
when $h_0$ is unknown, $h_0 = D/2$;
$N_{class}$ = reference number of impacts per propeller revolution for each polar class taken according to Table 1.3.5.3.9.

For components that are subject to loads resulting from propeller-to-ice interaction with all the propeller blades, the number of load cycles, $N_{ice}$, shall be multiplied by the number of propeller blades, $Z$.

Table 1.3.5.3.9

**Reference number of impacts**

| Polar class | **PC1** | **PC2** | **PC3** | **PC4** | **PC5** | **PC6** | **PC7** |
|---|---|---|---|---|---|---|---|
| $N_{class}$ | $21 \cdot 10^6$ | $17 \cdot 10^6$ | $15 \cdot 10^6$ | $13 \cdot 10^6$ | $11 \cdot 10^6$ | $9 \cdot 10^6$ | $6 \cdot 10^6$ |

**1.3.5.4** Blade failure load for both open and ducted propellers.

**1.3.5.4.1** Bending force $F_{ex}$.

The minimum load required resulting in blade failure through plastic bending shall be calculated iteratively along the radius of the blade from blade root to 0,5 $R$ using the following formula with the ultimate load assumed to be acting at 0,8 $R$ in the weakest direction.

$$F_{ex} = \frac{0{,}3ct^2}{0{,}8D - 2r} \sigma_{ref1} 10^3, \qquad (1.3.5.4.1)$$

where $F_{ex}$ = blade failure load, in kN;
$c$ = chord length of the considered blade section, in m;
$c, t, r$ = values as defined in Symbols taken at the cylindrical root section of the blade, i.e. at the weakest section outside the root fillet located typically at the termination of the fillet into the blade profile;
$\sigma_{ref1} = 0{,}6 \cdot \sigma_{0{,}2} + 0{,}4 \cdot \sigma_u$ in [MPa],
where $\sigma_u$ (minimum ultimate tensile strength to be specified on the drawing) and $\sigma_{0{,}2}$ (minimum yield or 0,2 % proof strength to be specified on the drawing) are representative values for the blade material.

Register may approve alternative means of failure load calculation by means of an appropriate stress analysis reflecting the non-linear plastic material behaviour of the actual blade. A blade is regarded as having failed, if the tip is bent by more than 10 % of the propeller diameter.

**1.3.5.4.2** Spindle torque $Q_{sex}$.

The force that causes blade failure typically reduces when moving from the propeller centre towards the leading and trailing edges. The maximum spindle torque occurs at a certain distance from the blade centre of rotation.

The maximum spindle torque, $Q_{sex}$, due to a blade failure load acting at 0,8 $R$ is defined either by an appropriate stress analysis or with the following formula:

$$Q_{sex} = \mathrm{Max}(c_{LE0{,}8}; 0{,}8 \cdot c_{TE0{,}8}) \cdot C_{spex} \cdot F_{ex}, \qquad (1.3.5.4.2)$$

where $c_{LE0{,}8}$ = leading edge portion of the chord length at 0,8·$R$;
$c_{TE0{,}8}$ = trailing edge portion of the chord length at 0,8·$R$;
$C_{spex}$ = coefficient defined by the following formula without being less than 0,3:
$C_{spex} = C_{sp} \cdot C_{fex}$,
where $C_{sp}$ = non-dimensional parameter with account for the spindle arm equal to 0,7;
$C_{fex}$ = non-dimensional parameter with account for the reduction of blade failure force at the location of maximum spindle torque, taken as:
$C_{fex} = 1 - \left(4 \cdot \frac{EAR}{Z}\right)^3$.

Figure 1.3.5.4.2 illustrates the spindle torque values due to blade failure loads across the whole chord length.

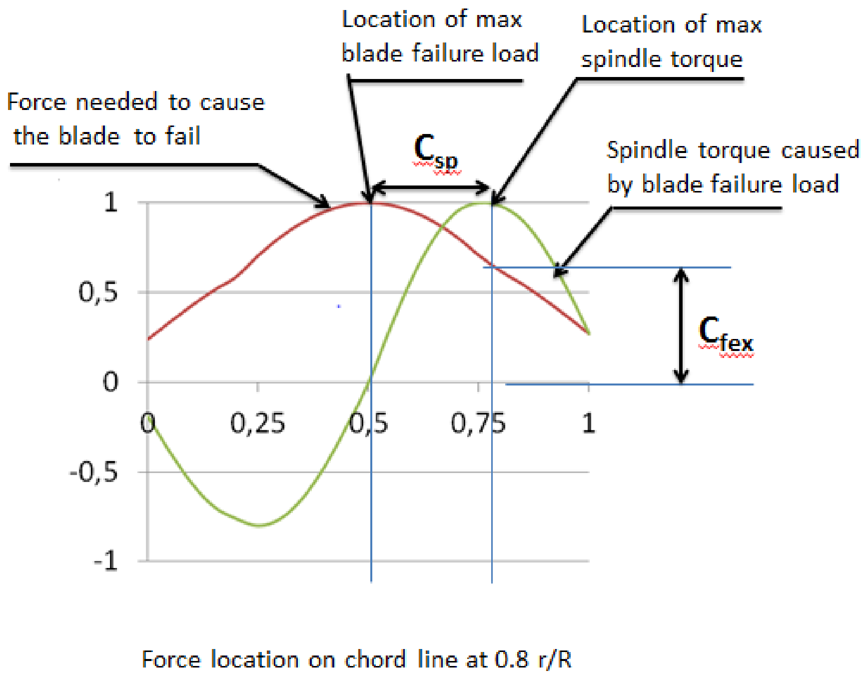



Fig. 1.3.5.4.2
Force location on chord line at 0,8 $r/R$. Schematic figure showing the blade failure load and the related spindle torque when the force acts at different location on the chord line at radius 0,8 $R$

**1.3.5.5** Axial design loads acting on open and ducted propellers.
**1.3.5.5.1** Maximum ice thrust acting on open and ducted propellers.
The maximum forward and backward ice thrusts, $T_f$ and $T_b$, in kN, acting on open or ducted propellers are given by the following formula:

$$T_f = 1{,}1 \cdot F_f, \quad (1.3.5.5.1\text{-}1)$$
$$T_b = 1{,}1 \cdot F_b. \quad (1.3.5.5.1\text{-}2)$$

However, the attention is drawn that the load models within this Chapter do not include propeller-to-ice interaction loads where an ice block hits the propeller hub of a pulling propeller.
**1.3.5.5.2** Design thrust along the propulsion shaft line for open and ducted propellers.
The design thrust along the propeller shaft line, $T_r$, in kN, shall be calculated with the following formulae. The greater value of the forward and backward directional loads shall be taken as the design load for both directions. Factors 2,2 and 1,5 take into account the dynamic magnification resulting from axial vibration.

In forward direction:

$$T_r = T + 2{,}2 \cdot T_f; \quad (1.3.5.5.2\text{-}1)$$

in backward direction:

$$T_r = 1{,}5 \cdot T_b, \quad (1.3.5.5.2\text{-}2)$$

where $T$ = hydrodynamic bollard thrust, in kN.

When the hydrodynamic bollard thrust is unknown, $T$ shall be taken from Table 1.3.5.5.2.

Table 1.3.5.5.2

**Guidance for hydrodynamic bollard thrust values**

| Propeller type | | $T^1$ |
|---|---|---|
| CP propellers | Open | 1,25 $T_n$ |
| | Ducted | 1,1 $T_n$ |
| FP propellers driven by turbine or electrical motor | | $T_n$ |
| FP propellers driven by diesel engine | Open | 0,85 $T_n$ |
| | Ducted | 0,75 $T_n$ |
| [1] $T_n$ — the nominal propeller thrust at MCR in the free running open water condition | | |

For pulling type propellers, ice interaction loads on propeller hub shall be considered in addition to the above and to be submitted to the Register for consideration.

**1.3.5.6** Torsional design loads acting on open and ducted propellers.

**1.3.5.6.1** Design ice torque on propellers.

The design ice torque, $Q_{\max}$, in kNm, acting on propellers is equal to:

when $D < D_{limit}$:

$$Q_{\max} = k_{prop} \cdot \left(1 - \frac{d}{D}\right) \cdot \left(\frac{P_{0,7}}{D}\right)^{0,16} \cdot (nD)^{0,17} \cdot D^3; \qquad (1.3.5.6.1\text{-}1)$$

when $D \geq D_{limit}$:

$$Q_{\max} = 1,9 \cdot k_{prop} \cdot \left(1 - \frac{d}{D}\right) \cdot H_{ice}^{1,1} \cdot \left(\frac{P_{0,7}}{D}\right)^{0,16} \cdot (nD)^{0,17} \cdot D^{1,9}, \qquad (1.3.5.6.1\text{-}2)$$

where $D_{limit}$ = 1,8 $H_{ice}$;

$k_{prop}$ = coefficient depending on the propeller type and taken as:

$k_{prop} = k_{open}$ for open propeller;

$k_{prop} = k_{ducted}$ for ducted propeller;

$k_{open}$ = coefficient taken as:

$k_{open} = 14,7$ for **PC1** to **PC5**;

$k_{open} = 10,9$ for **PC6** and **PC7**;

$k_{ducted}$ = coefficient taken as:

$k_{ducted} = 10,4$ for **PC1** to **PC5**;

$k_{ducted} = 7,7$ for **PC6** and **PC7**;

$n$ = rotational propeller speed in bollard condition, in rps;

If unknown, $n$ shall be taken from Table 1.3.5.6.1.

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 0,7 $P_{0,7n}$ where $P_{0,7n}$ is the propeller pitch at MCR in free running condition.

Table 1.3.5.6.1

**Guidance for rotational propeller speed $n$**

| Propeller type | $n$ |
|---|---|
| CP propellers | $n_n$ |
| FP propellers driven by turbine or electrical motor | $n_n$ |
| FP propellers driven by diesel engine | 0,85 $n_n$ |

**1.3.5.6.2** Ice torque excitation for open and ducted propellers.

The given excitations are used to estimate the maximum torque likely to be experienced once during the service life of the ship. The following load cases are intended to reflect the operational loads on the propulsion system when the propeller interacts with ice and the corresponding reaction of the complete system. The ice impact and system response cause 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.

Diesel engine plants without an elastic coupling shall be calculated at the least favourable phase angle for ice versus engine excitation, when calculated in time domain. The engine firing pulses shall be included in the calculations and their standard steady state harmonics can be used. A phase angle between ice and gas force excitation does not need to be regarded in frequency domain analysis. Misfiring does not need to be considered.

If there is a blade order resonance just above MCR speed, calculations shall cover the rotational speeds up to 105 % of MCR speed.

Refer also to guidelines for calculations given in 1.3.5.7.

**1.3.5.6.2.1** Excitation for the time domain calculation.

The propeller ice torque excitation for shaft line transient dynamic analysis (time domain) is defined as 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 defined as:

when φ rotates from 0 to $\alpha_i$ plus integer revolutions:

$$Q(\varphi) = C_q \cdot Q_{\max} \cdot \sin\left(\varphi \frac{180}{\alpha_i}\right), \qquad (1.3.5.6.2.1\text{-}1)$$

when φ rotates from $\alpha_i$ to 360 plus integer revolutions:

$$Q(\varphi) = 0, \qquad (1.3.5.6.2.1\text{-}2)$$

where $\varphi$ = rotation angle, in deg, starting when the first ice impact occurs;
$C_q$ = parameter given in Table 1.3.5.6.2.1;
$\alpha_i$ = duration of propeller blade/ice interaction expressed in propeller rotation angle, given in Table 1.3.5.6.2.1, in deg.

The total ice torque is obtained by summing the torque of single blades, with account for the phase shift $360/Z$, in deg.

At the beginning and at the end of the milling sequence (within calculated duration), linear ramp functions shall be used to increase $C_q$ to its maximum within one propeller revolution and vice versa to decrease it to zero.

The number of propeller revolutions during a milling sequence shall be obtained from the formula:

$$N_q = 2 \cdot H_{ice}, \qquad (1.3.5.6.2.1\text{-}3)$$

with $Z \cdot N_Q$ = number of impacts for blade order excitation.

An illustration of all excitation cases for different blade numbers is given in the Appendix.

The dynamic simulation shall be performed for all excitation cases starting at MCR nominal, MCR bollard condition and just above all resonance speeds (1st engine and 1st blade harmonic), so that the resonant vibration responses can be obtained. For a fixed pitch propeller plant the dynamic simulation is also to cover bollard pull condition with a corresponding speed assuming maximum possible output of the engine.

If a speed drop occurs down to stand still of the main engine, it 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 applied. The excitation shall follow the shaft speed, if a speed drop occurs.

Table 1.3.5.6.2.1

**Ice impact magnification and duration factors for different blade numbers**

| Torque excitation | Propeller-to-ice interaction | $C_q$ | $\alpha_i$, in deg | | | |
|---|---|---|---|---|---|---|
| | | | $Z = 3$ | $Z = 4$ | $Z = 5$ | $Z = 6$ |
| Case 1 | Single ice block | 0,75 | 90 | 90 | 72 | 60 |
| Case 2 | Single ice block | 1,00 | 135 | 135 | 135 | 135 |
| Case 3 | Two ice blocks (phase shift 360/(2·Z) deg.) | 0,50 | 45 | 45 | 36 | 30 |
| Case 4 | Single ice block | 0,50 | 45 | 45 | 36 | 30 |

**1.3.5.6.2.2** Frequency domain excitation.

For frequency domain calculations the following torque excitation, $Q_F(\varphi)$, may be used. The excitation has been derived so that the time domain half sine impact sequences have been assumed to be continuous and the Fourier series components for blade order and twice the blade order components have been derived. The frequency domain analysis is generally considered as conservative compared to the time domain simulation provided there is a first blade order resonance in the considered speed range.

$$Q_F(\varphi) = Q_{\max}\left[C_{q0} + C_{q1} \cdot \sin(Z \cdot E_0 \cdot \varphi + \alpha_1) + C_{q2} \cdot \sin(2 \cdot Z \cdot E_0 \cdot \varphi + \alpha_2)\right], \qquad (1.3.5.6.2.2\text{-}1)$$

where $C_{q1}$ = mean torque component given in Table 1.3.5.6.2.2;
$C_{q0}$ = first blade order excitation amplitude given in Table 1.3.5.6.2.2;
$C_{q2}$ = second blade order excitation amplitude given in Table 1.3.5.6.2.2;
$\varphi$ = rotation angle, in deg;
$\alpha_1$, $\alpha_2$ = phase angles of excitation component given in Table 1.3.5.6.2.2;
$Z$ = number of blades.

Torsional vibration responses shall be calculated for all excitation cases.

The results of the relevant excitation cases at the most critical rotational speeds shall be used in the following way:

The highest response torque (between the various lumped masses in the system) is in the following referred to as peak torque $Q_{peak}$.

The highest torque amplitude during a sequence of impacts shall be determined as half of the range from max to min torque and is referred to as $Q_{A\max}$, that can be determined, in kNm, by the following formula:

$$Q_{A\max} = \frac{\mathrm{Max}[Q_r(time)] - \mathrm{Min}[Q_r(time)]}{2}. \qquad (1.3.5.6.2.2\text{-}2)$$

An illustration of $Q_{A\max}$ is given in Fig. 1.3.5.6.2.2.

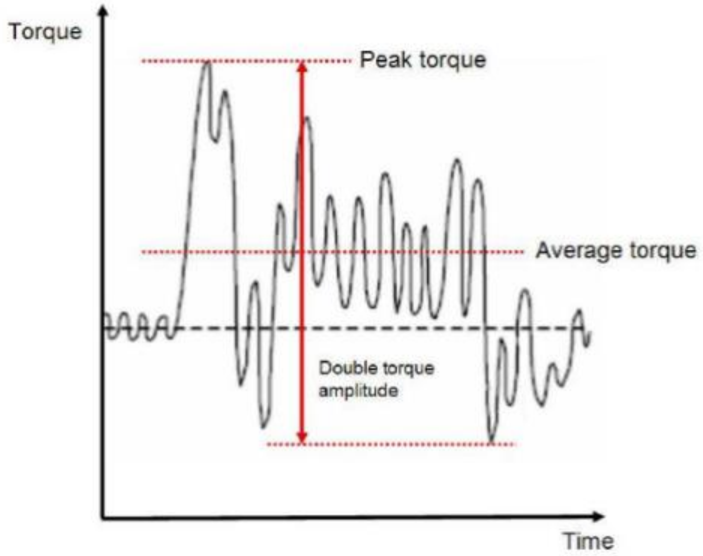



Fig. 1.3.5.6.2.2
Interpretation of different torques in a measured curve, as example

Table 1.3.5.6.2.2

**Coefficients for simplified excitation torque estimation**

| No. of blades, $Z$ | Excitation Case | $C_{q0}$ | $C_{q1}$ | $\alpha_1$ | $C_{q2}$ | $\alpha_2$ | $E_0$ |
|---|---|---|---|---|---|---|---|
| 3 | 1 | 0,3750 | 0,375 | -90 | 0,0000 | 0 | 1 |
| | 2 | 0,7000 | 0,330 | -90 | 0,0500 | -45 | 1 |
| | 3 | 0,2500 | 0,250 | -90 | 0,0000 | 0 | 2 |
| | 4 | 0,2000 | 0,250 | 0 | 0,0500 | -90 | 1 |
| 4 | 1 | 0,4500 | 0,360 | -90 | 0,0600 | -90 | 1 |
| | 2 | 0,9375 | 0,000 | -90 | 0,0625 | -90 | 1 |
| | 3 | 0,2500 | 0,251 | -90 | 0,0000 | 0 | 2 |
| | 4 | 0,2000 | 0,250 | 0 | 0,0500 | -90 | 1 |
| 5 | 1 | 0,4500 | 0,360 | -90 | 0,0600 | -90 | 1 |
| | 2 | 1,1900 | 0,170 | -90 | 0,0200 | -90 | 1 |
| | 3 | 0,3000 | 0,250 | -90 | 0,0480 | -90 | 2 |
| | 4 | 0,2000 | 0,250 | 0 | 0,0500 | -90 | 1 |
| 6 | 1 | 0,4500 | 0,375 | -90 | 0,0500 | -90 | 1 |
| | 2 | 1,4350 | 0,100 | -90 | 0,0000 | 0 | 1 |
| | 3 | 0,3000 | 0,250 | -90 | 0,0480 | -90 | 2 |
| | 4 | 0,2000 | 0,250 | 0 | 0,0500 | -90 | 1 |

**1.3.5.6.3** Design torque along shaft line.

**1.3.5.6.3.1** If there is no relevant first order propeller torsional resonance in the range 20 % of $n_n$ above and 20 % below the maximum operating speed in bollard condition (refer to Table 1.3.5.6.1.), the following estimation of the maximum response torque $Q_r$, in kNm, can be used to calculate the design torque along the propeller shaft line:

For directly coupled two stroke diesel engines without flexible coupling:

$$Q_r = Q_{e\max} + Q_{vib} + Q_{\max} \cdot \frac{I}{I_t}; \qquad (1.3.5.6.3.1\text{-}1)$$

for all other plants:

$$Q_r = Q_{e\max} + Q_{\max} \cdot \frac{I}{I_t}, \qquad (1.3.5.6.2.2\text{-}2)$$

where $I$ = equivalent mass moment of inertia of all parts on engine side of component under consideration;
$I_t$ = equivalent mass moment of inertia of the whole propulsion system;
$Q_{e\max}$ = maximum torque, in kNm.

If $Q_{e\max}$, is not known, it shall be taken as follows:
$Q_{e\max} = Q_{motor}$ for propellers driven by electric motor, where $Q_{motor}$ is the electric motor peak torque, in kNm,
$Q_{e\max} = Q_n$ for CP propellers not driven by electric motor,
$Q_{e\max} = Q_n$ for FP propellers driven by turbine,
$Q_{e\max} = 0{,}75\ Q_n$ for FP propellers driven by diesel engine.

All the torques and the inertia moments shall be reduced to the rotation speed of the component being examined.

**1.3.5.6.3.2** If there is a first blade order torsional resonance in the range 20 % of $n_n$ above and 20 % below the maximum operating speed (bollard condition), the design torque $Q_r$ of the shaft component shall be determined by means of a dynamic torsional vibration analysis of the entire propulsion line in the time domain or alternatively in the frequency domain. It is then assumed that the plant is sufficiently designed to avoid harmful operation in barred speed range.

**1.3.5.7** Guideline for torsional vibration calculation.

The aim of torsional vibration calculations is to estimate the torsional loads for individual shaft line components over the life time in order to determine scantlings for safe operation. The model can be taken from the normal lumped mass elastic torsional vibration model (frequency domain) including the damping. Standard harmonics may be used to consider the gas forces. The engine torque - speed curve of the actual plant shall be applied.

For time domain analysis the model shall include the ice excitation at propeller, the mean torques provided by the prime mover and the hydrodynamic mean torque produced by the propeller as well as any other relevant excitations. The calculations shall cover the variation of phase between the ice excitation and prime mover excitation. This is extremely relevant for propulsion lines with direct driven combustion engines.

For frequency domain calculations the load shall be estimated as a Fourier component analysis of the continuous sequence of half sine load peaks. The first and second order blade components shall be used for excitation. The calculation shall cover the whole relevant shaft speed range. The analysis of the responses at the relevant torsional vibration resonances may be performed for open water (without ice excitation) and ice excitation separately. The resulting maximum torque can be obtained for directly coupled plants by the following superposition:

$$Q_{peak} = Q_{e\max} + Q_{opw} + Q_{ice}, \text{ kNm}, \tag{1.3.5.7}$$

where $Q_{e\max}$ = the maximum engine torque at considered rotational speed;
$Q_{opw}$ = is the maximum open water response of engine excitation at considered shaft speed and determined by frequency domain analysis;
$Q_{ice}$ = is the calculated torque using frequency domain analysis for the relevant shaft speeds, ice excitation cases 1 — 4, resulting in the maximum response torque due to ice excitation.

**1.3.6 Design.**

**1.3.6.1** Design principle.

The propulsion line shall be designed according to the pyramid strength principle in terms of its strength. This means that the loss of the propeller blade shall not cause any significant damage to other propeller shaft line components.

The propulsion line components shall withstand maximum and fatigue operational loads with the relevant safety margin. The loads do not need to be considered for shaft alignment or other calculations of normal operational conditions.

**1.3.6.2** Fatigue design in general.

The design loads shall be based on the ice excitation and where necessary (shafting) dynamic analysis, described as a sequence of blade impacts (refer to 1.3.5.6.2.1). The shaft response torque shall be determined according to 1.3.5.6.3.

The propulsion line components shall be designed so as to prevent accumulated fatigue failure when considering the relevant loads using the linear elastic Miner's rule as defined below:

$$D = \sum_{j=1}^{k} \frac{n_j}{N_j} \leq 1, \qquad (1.3.6.2)$$

where $D$ = Miner's damage sum;
$k$ = number of stress levels;
$N_j$ = number of load cycles to failure of the individual stress level class, $j$ from 1 to $k$;
$n_j$ = accumulated number of load cycles of the case under consideration, per class, $j$ from 1 to $k$.

N o t e. The stress distribution shall be divided into a frequency load spectrum having min. 10 stress blocks (every 10 % of the load). The maximum allowable load is limited to $\sigma_{ref2}$ for propeller blades and yield strength for all other components. The load distribution (spectrum) shall be in accordance with the Weibull distribution.

**1.3.6.3** Propeller blades.

**1.3.6.3.1** Calculation of blade stresses due to static loads.

The blade stresses, i.e. equivalent and principal stresses, shall be calculated for the design loads given in 1.3.5.3. Finite element analysis (FEA) shall be used for stress analysis as part of the final approval for all propeller blades.

The von Mises stresses, $\sigma_{st}$, in MPa, shall comply with acceptability criterion given in 1.3.6.3.2.

Alternatively, the following simplified equation can be used in estimating the blade stresses for all propellers in the root area ($r/R < 0{,}5$) for final approval:

$$\sigma_{st} = C_1 \cdot \frac{M_{BL}}{100ct^2}, \qquad (1.3.6.3.1)$$

where $C_1$ = ratio between the actual stress and the one obtained from beam theory. If $C_1$ is not available, $C_1 = 1{,}6$;
$M_{BL}$ = bending moment applied on the blade taken equal to:
$M_{BL} = \left(0{,}75 - \frac{r}{R}\right) \cdot R \cdot F$, for relative radius $r/R < 0{,}5$,
where $F = \mathrm{Max}[F_b;\ F_t]$.

**1.3.6.3.2** Acceptability criterion for static loads.

The following criterion for calculated blade stresses shall be fulfilled:

$$\sigma_{st} \leq \frac{\sigma_{ref2}}{1{,}3}, \qquad (1.3.6.3.2)$$

where $\sigma_{st}$ = calculated stress for the design loads, in MPa.

If finite element analysis is used in estimating the stresses, von Mises stresses shall be used.

**1.3.6.3.3** Fatigue design of propeller blade.

**1.3.6.3.3.1** General.

For materials with a two slope S-N curve (refer to Fig. 1.3.6.3.3.1-1), the fatigue calculations defined in this rule are not required if the following criterion is fulfilled:

$$\sigma_{\exp} \geq B_1 \cdot \sigma_{ref2}{}^{B_2} \cdot \log(N_{ice})^{B_3}, \qquad (1.3.6.3.3.1\text{-}1)$$

where $B_1, B_2, B_3$ = coefficients defined according to Table 1.3.6.3.3.1:

Table 1.3.6.3.3.1

| Coefficient | Open propeller | Ducted propeller |
|---|---|---|
| **$B_1$** | 0,00328 | 0,00223 |
| **$B_2$** | 1,0076 | 1,0071 |
| **$B_3$** | 2,101 | 2,471 |

Where the above criterion is not fulfilled the fatigue requirements defined below shall be applied:

the fatigue design of the propeller blade is based on an estimated load distribution for the service life of the ship and the S-N curve for the blade material;

an equivalent stress $\sigma_{fat}$ that produces the same fatigue damage as the expected load distribution shall be calculated according to Miner's rule;

the acceptability criterion for fatigue shall be fulfilled as given in this requirement;

the equivalent stress is normalised for $10^8$ cycles.

The blade stresses at various selected load levels for fatigue analysis shall be taken proportional to the stresses calculated for maximum loads given in 1.3.5.3.

The peak principal stresses $\sigma_f$ and $\sigma_b$ are determined from $F_f$ and $F_b$ using FEA.

The peak stress range $\Delta\sigma_{\max}$, in MPa, is given by the following formula:

$$\Delta\sigma_{\max} = 2\sigma_{A\max} = \left|(\sigma_{ice})_{f\max}\right| + \left|(\sigma_{ice})_{b\max}\right|, \qquad (1.3.6.3.3.1\text{-}2)$$

where $\Delta\sigma_{\max}$ = peak stress range, in MPa;
$\sigma_{A\max}$ = maximum stress amplitude, in MPa, determined on the basis of load cases 1 and 3, 2 and 4.

The load spectrum for backward loads is normally expected to have a lower number of cycles than the load spectrum for forward loads. Taking this into account in a fatigue analysis introduces complications that are not justified considering all uncertainties involved.

For the calculation of equivalent stress, two types of S-N curves are available:

two slope S-N curve (slopes 4.5 and 10), refer to Fig. 1.3.6.3.3.1-1;

one slope S-N curve (the slope can be chosen), refer to Fig. 1.3.6.3.3.1-2.

The type of the S-N-curve shall be selected to correspond with the material properties of the blade. If the S-N-curve is not known the two slope S-N curve shall be used.

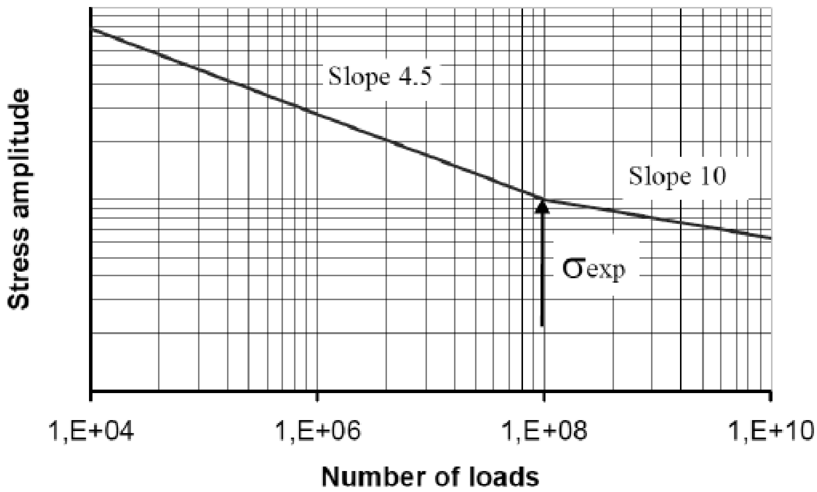



Fig. 1.3.6.3.3.1-1
Two-slope S-N curve

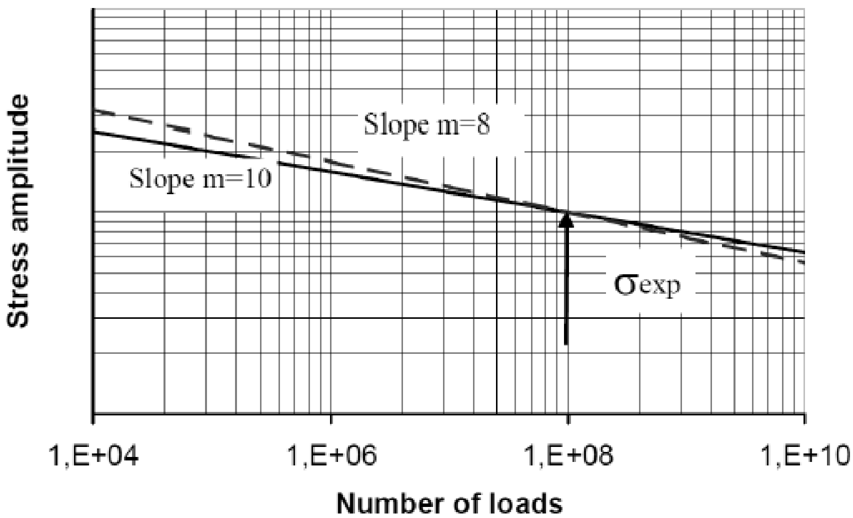



Fig.1.3.6.3.3.1-2
Constant-slope S-N curve

**1.3.6.3.3.2** Equivalent fatigue stress.

The equivalent fatigue stress, in MPa, for $10^8$ cycles which produces the same fatigue damage as the load distribution is given by the following formula:

$$\sigma_{fat} = \rho(\sigma_{ice})_{\max}, \quad (1.3.6.3.3.2\text{-}1)$$

where $(\sigma_{ice})_{\max}$ = value of the principal stress amplitudes resulting from design forward and backward blade forces at the location being studied, in MPa, taken equal to:

$(\sigma_{ice})_{\max} = 0{,}5\left[(\sigma_{ice})_{f\max} - (\sigma_{ice})_{b\max}\right]$.

In the calculation of $(\sigma_{ice})_{\max}$, case 1 and case 3 or case 2 and case 4 are considered as pairs for $(\sigma_{ice})_{fmax}$ and $(\sigma_{ice})_{b\max}$ calculations. Case 5 is excluded from the fatigue analysis.

$(\sigma_{ice})_{f\max}$ = principal stress resulting from forward load, in MPa;
$(\sigma_{ice})_{b\max}$ = principal stress resulting from backward load, in MPa.

ρ = parameter related to S-N curve, taken as follows:

**.1** for two-slope S-N curve:

the error of the following method to determine ρ is sufficiently small, if the number of load cycles $N_{ice}$ is within the range $5 \times 10^6 \le N_{ice} \le 10^8$;

parameter ρ relates the maximum ice load to the distribution of ice loads according to the regression formula:

$$\rho = C_1 \cdot (\sigma_{ice})_{\max}{}^{C_2} \cdot \sigma_{fl}{}^{C_3} \cdot \log(N_{ice})^{C_4}, \qquad (1.3.6.3.3.2\text{-}2)$$

where $\sigma_{fl}$ = blade material fatigue strength at $10^8$ load cycles, in MPa, given as: $\sigma_{fl} = \gamma_{\varepsilon 1} \cdot \gamma_{\varepsilon 2} \cdot \gamma_v \cdot \gamma_m \cdot \sigma_{exp}$ (refer to 1.3.6.3.3.3 for the parameters used in the formula);

$C_1$, $C_2$, $C_3$, $C_4$ = coefficients given in Table 1.3.6.3.3.2-1;

**.2** for constant-slope S-N curve:

for materials with a constant-slope S-N curve ρ shall be calculated from the following formula:

$$\rho = \left(G \cdot \frac{N_{ice}}{N_r}\right)^{1/m} [\ln(N_{ice})]^{-1/k}, \qquad (1.3.6.3.3.2\text{-}3)$$

where $k$ = shape parameter of the Weibull distribution:
for ducted propellers: $k = 1{,}0$;
for open propellers: $k = 0{,}75$;

$N_{ice}$ = number of load cycles to be taken between $5 \times 10^6$ and $10^8$;

$N_r$ = reference number of load cycles, $N_r = 10^8$;

$G$ = parameter defined in Table 1.3.6.3.3.2-2. Linear interpolation may be used to calculate the value of $G$ for intermediate values of $m/k$ ratios.

Table 1.3.6.3.3.2-1

**Coefficients $C_1$, $C_2$, $C_3$, and $C_4$**

| | $C_1$ | $C_2$ | $C_3$ | $C_4$ |
|---|---|---|---|---|
| Open propeller | 0,000747 | 0,0645 | −0,0565 | 2,220 |
| Ducted propeller | 0,000534 | 0,0533 | −0,0459 | 2,584 |

Table 1.3.6.3.3.2-2

**$G$ parameter as a function of $m/k$**

| $m/k$ | 3 | 3,5 | 4 | 4,5 | 5 | 5,5 | 6 | 6,5 |
|---|---|---|---|---|---|---|---|---|
| $G$ | 6 | 11,6 | 24 | 52,3 | 120 | 287,9 | 720 | 1871 |
| $m/k$ | 7 | 7,5 | 8 | 8,5 | 9 | 9.5 | 10 | |
| $G$ | 5040 | 14034 | 40320 | 119292 | 362880 | $1{,}133 \cdot 10^6$ | $3{,}623 \cdot 10^6$ | |

N o t e. A more general method of determining the equivalent fatigue stress of propeller blades is described in 1.3.6.5, where the principal stresses are considered according to 1.3.5.3 using the Miner's rule. For a total number of load blocks $n_{bl} > 100$, both methods deliver the same result. Therefore, they are regarded as equivalent.

**1.3.6.3.3.3** Acceptability criterion for fatigue.

The equivalent fatigue stress, $\sigma_{fat}$, in MPa, at all locations on the blade shall fulfil the following acceptability criterion:

$$\sigma_{fat} \le \frac{\sigma_{fl}}{1{,}5}, \qquad (1.3.6.3.3.3)$$

where $\sigma_{fat}$ = fatigue strength, in MPa, corresponding to the fatigue limit at $10^8$ load cycles;

$\sigma_{fl}$ = blade material fatigue strength at $10^8$ load cycles, in MPa, given as:

$\sigma_{fl} = \gamma_{\varepsilon 1} \cdot \gamma_{\varepsilon 2} \cdot \gamma_v \cdot \gamma_m \cdot \sigma_{exp}$,

where $\gamma_{\varepsilon 1}$ = reduction factor due to scatter, equal to one standard deviation; if the actual value is not known, $\gamma_{\varepsilon 1}$ = 0,85;
$\gamma_{\varepsilon 2}$ = geometrical size factor for test specimen size effect given as:
$\gamma_{\varepsilon 2} = 1 - a \cdot \ln\left(\frac{t}{0{,}025}\right)$,
where: $a = 0{,}10$ for bronze and brass;
$a = 0{,}05$ for stainless steel;
$t =$ maximum blade thickness at the considered point, in m;
$\gamma_v$ = reduction factor for variable amplitude loading; if the actual value is not known, $\gamma_v$ = 0,75;
$\gamma_m$ = reduction factor for mean stress, given as:
$\gamma_m = 1 - \left(1{,}4 \cdot \frac{\sigma_{mean}}{\sigma_u}\right)^{0{,}75}$; if the actual value is not known, $\gamma_m$ = 0,75;
$\sigma_{exp}$ = mean fatigue strength of the blade material at $10^8$ cycles to failure in seawater. $\sigma_{exp}$ provided in Table 1.3.6.3.3.3 has been defined from the results of constant amplitude loading fatigue tests at $10^7$ load cycles and 50 % survival probability and has been extended to $10^8$ load cycles.

Fatigue strength values and correction factors other than those given in Table 1.3.6.3.3.3 may be used, provided the values are determined under conditions approved by the Register.

The characteristics of the S-N curve are based on two slopes, the first slope is equal to 4,5 from 1000 to $10^8$ load cycles; the second slope is equal to 10 over $10^8$ load cycles.

The maximum allowable stress for one or low number of cycles is limited to $\sigma_{ref2}/S$, with $S = 1{,}3$ for static loads.

Table 1.3.6.3.3.3

**Mean fatigue strength $\sigma_{exp}$ for different material types at $10^8$ load cycles and stress ratio $R = -1$ with a survival probability of 50 %**

| Bronze and brass | $\sigma_{exp}$, MPa | Stainless steel | $\sigma_{exp}$, MPa |
|---|---|---|---|
| Mn-Bronze, CU1 (high tensile brass) | 84 | Ferritic (12Cr 1Ni) | 144[1] |
| Mn-Ni-Bronze, CU2 (high tensile brass) | 84 | Martensitic (13Cr 4Ni/13Cr 6Ni) | 156 |
| Ni-Al-Bronze, CU3 | 120 | Martensitic (16Cr 5Ni) | 168 |
| Mn-Al-Bronze, CU4 | 113 | Austenitic (19Cr 10Ni) | 132 |
| [1] This value may be used provided a perfect galvanic protection is active. Otherwise, a reduction of about 30 MPa shall be applied. | | | |

**1.3.6.4** Blade bolts and pitch control mechanism.

**1.3.6.4.1** General.

The blade bolts, pitch control mechanism, and the fitting of the propeller to the propeller shaft shall be designed to withstand the maximum static and fatigue design loads (as applicable), as defined in 1.3.5.3 and 1.3.6.3.

The safety factor $S$, against yielding due to static loads and against fatigue shall be greater than 1,5, if not stated otherwise. The safety factor $S$ for loads, resulting from propeller blade failure as defined in 1.3.5.4 shall be greater than 1,0 against yielding.

Provided that calculated stresses duly considering local stress concentrations are less than yield strength, or maximum of $0{,}7\ \sigma_u$ of respective materials, detailed fatigue analysis is not required. In all other cases components shall be analysed for cumulative fatigue. An approach similar to that used for shafting assessment may be applied (refer to 1.3.6.5).

**1.3.6.4.2** Blade bolts design.

Blade bolts shall withstand the following bending moment, in kNm, considered around a tangent on bolt pitch circle, or any other relevant axis for non-circular joints, parallel to considered root section:

$$M_{bolt} = S \cdot F_{ex}\left(0{,}8 \cdot \frac{D}{2} - r_{bolt}\right), \tag{1.3.6.4.2-1}$$

where $r_{bolt}$ = radius from the shaft centreline to the blade bolt plane, in m;
$S$ = safety factor taken as $S = 1$;
$F_{ex}$ = bending force, in kN, given in 1.3.5.4.1.

Blade bolt pre-tension shall be sufficient to avoid separation between mating surfaces when the maximum forward and backward ice loads defined in 1.3.5.3 (open and ducted propellers respectively) are applied. For conventional arrangements, the blade bolts effective diameter $d_{bb}$, in mm, may be obtained by the following formula:

$$d_{bb} = 41\sqrt{\frac{F_{ex} \cdot (0{,}8D - d) \cdot S \cdot \alpha}{\sigma_{0,2} \cdot Z_{bb} \cdot PCD}}, \tag{1.3.6.4.2-2}$$

where $d_{bb}$ = effective diameter of blade bolt in way of thread, in mm;
$S$ = safety factor taken as $S = 1$;
$z_{bb}$ = number of blade bolts;
$\alpha$ = coefficient taken equal to:
$\alpha = 1{,}6$ for torque guided tightening;
$\alpha = 1{,}3$ for elongation guided;
$\alpha = 1{,}2$ for angle guided;
$\alpha = 1{,}1$ for elongated by other additional means.
Other value of $\alpha$ may be used, provided evidence is demonstrated to the Register.

**1.3.6.4.3 Pitch control mechanism.**

Separate means, e.g. dowel pins, shall be provided in order to withstand the spindle torque resulting from blade failure $Q_{sex}$ (refer to 1.3.5.4.2) or ice interaction $Q_{smax}$ (refer to 1.3.5.3.7), whichever is greater. Other components of the pitch control mechanism shall not be damaged by the maximum spindle torques ($Q_{smax}$, $Q_{sex}$). One third of the spindle torque is assumed to be consumed by friction, if not otherwise documented through further analysis.

The diameter of fitted pins $d_{fp}$, in mm, between the blade and blade carrier can be determined as follows:

$$d_{fp} = 66\sqrt{\frac{Q_s - Q_{fr}}{PCD \cdot Z_{pin} \cdot \sigma_{0,2}}}, \tag{1.3.6.4.3-1}$$

where $Q_s$ = spindle torque, in kNm, equal to:
$Q_s = \mathrm{Max}(S \cdot Q_{smax}; S \cdot Q_{sex})$;
where:
$S = 1{,}3$ for $Q_{smax}$;
$S = 1{,}0$ for $Q_{sex}$
$Q_{fr}$ = friction between connected surfaces, $Q_{fr} = 0{,}33\,Q_s$.
Alternative values of $Q_{fr}$ according to reaction forces due to $F_{ex}$, or $F_f$, $F_b$ whichever is relevant, utilising a friction coefficient equal to 0,15 may be used, provided they are approved by the Register.

The stress in the actuating pin can be estimated by

$$Q_{vMises} = \sqrt{\left(\frac{\left(F \cdot \frac{h_{pin}}{2}\right)}{\frac{\pi \cdot d_{pin}{}^{3}}{32}}\right)^{2} + 3 \cdot \left(\frac{F}{\frac{\pi}{4} \cdot d_{pin}{}^{2}}\right)^{2}}, \qquad (1.3.6.4.3\text{-}2)$$

where:

$F = \frac{Q_s - Q_{fr}}{l_m}$, in kN;

$l_m$ = distance from the pitching centre of the blade to the pin axis, in m;

$h_{pin}$ = height of actuating pin, in mm;

$d_{pin}$ = diameter of actuating pin, in mm;

$Q_{fr}$ = friction torque in blade bearings acting on the blade palm and caused by the reaction forces due to $F_{ex}$, or $F_f$, $F_b$ whichever is relevant, taken $Q_{fr} = 0{,}33\ Q_s$.

The blade failure spindle torque $Q_{sex}$ shall not lead to any consequential damage.

Fatigue strength shall be considered for parts transmitting the spindle torque from the blade to a servo system considering the ice spindle torque acting on one blade. The maximum amplitude $Q_{samax}$ is defined as:

$$Q_{samax} = \frac{Q_{sb} + Q_{sf}}{2}, \qquad (1.3.6.4.3\text{-}3)$$

where $Q_{sb}$ = spindle torque due to $|F_b|$, in kNm;
$Q_{sf}$ = spindle torque due to $|F_f|$, in kNm.

**1.3.6.4.4** Servo pressure.
The design pressure for the servo system shall be taken as the pressure caused by $Q_{smax}$, or $Q_{sex}$ when not protected by relief valves on the hydraulic actuator side, reduced by relevant friction losses in bearings caused by the respective ice loads. The design pressure is in any case not to be less than relief valve set pressure.

**1.3.6.5** Propulsion line components.
The ultimate load resulting from total blade failure $F_{ex}$ as defined in 1.3.5.4 consists of combined axial and bending load components, wherever this is significant. The minimum safety factor against yielding shall be 1,0 for all shaft line components.

The shafts and shafting components, such as bearings, couplings and flanges shall be designed to withstand the operational propeller-to-ice interaction loads as given in 1.3.3.2.

The given loads are not intended to be used for shaft alignment calculation.

Cumulative fatigue calculations shall be conducted according to the Miner's rule. A fatigue calculation is not necessary, if the maximum stress is below fatigue strength at $10^8$ load cycles.

The torque, $Q_{A\max}$, and thrust amplitude distribution (spectrum), $Q_A(N)$, in the propulsion line shall be taken as (because Weibull exponent $k = 1$):

$$Q_A(N) = Q_{A\max} \cdot \left[1 - \frac{\log N}{\log(Z \cdot N_{ice})}\right], \qquad (1.3.6.5\text{-}1)$$

where $Z \cdot N_{ice}$ = number of load cycles in the load spectrum.

The ratio $Q_{A\max}/Q_A(N)$ is illustrated by the example in Fig. 1.3.6.5-1.

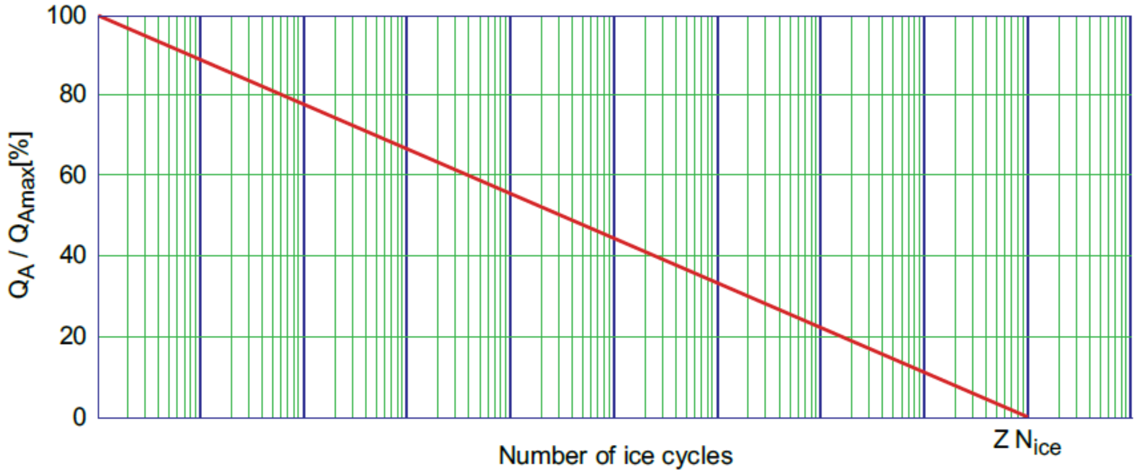



Fig.1.3.6.5-1
Cumulative torque distribution

The Weibull exponent shall be considered as $k$ = 1.0 for both open and ducted propeller torque and bending forces. The load distribution is an accumulated load spectrum, and the load spectrum shall be divided into a minimum of ten load blocks when using the Miner summation method.

The load spectrum used counts the number of cycles for 100 % load to be the number of cycles above the next step, e.g. 90 % load. This ensures that the calculation is on the conservative side. Consequently, the fewer stress blocks used the more conservative the calculated safety margin.

The load spectrum is divided into $N_{bl}$ load blocks for the Miner summation method. The following formula can be used for calculation of the number of cycles for each load block (refer to Fig. 1.3.6.5-2).

$$n_i = {N_{ice}}^{1-\left(1-\frac{i}{Nbl}\right)^k} - \sum_{j=2}^{i} n_{j-1}, \quad (1.3.6.5\text{-}2)$$

where $i$ = single load block $i$;
$N_{bl}$ = number of load blocks.

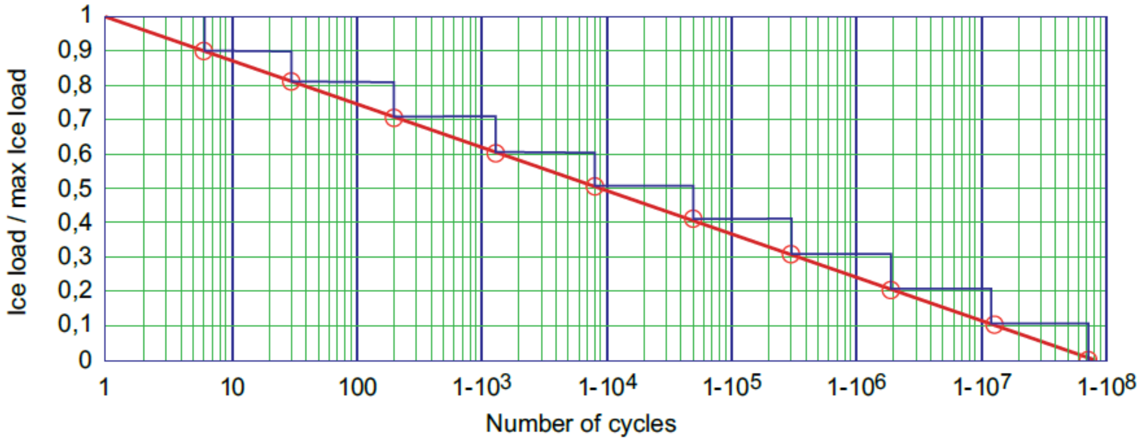



Fig.1.3.6.5-2
Example of ice load distribution (spectrum) for the shafting with Weibull exponent $k = 1$

**1.3.6.5.1** Propeller fitting to the shaft.

**1.3.6.5.1.1** Keyless cone mounting.

The friction capacity at 0 °C shall correspond at least to 2 times the highest value of the peak torque, $Q_{peak}$, as determined in 1.3.5.6 without exceeding the permissible hub stresses.

The minimum surface pressure $p_0$ at 0 °C shall be determined as:

$$p_0 = \frac{2 \cdot S \cdot Q_{peak}}{\pi \cdot \mu \cdot D_S^2 \cdot L \cdot 10^3}, \qquad (1.3.6.5.1.1)$$

where $\mu$ = friction coefficient taken as:

$\mu = 0{,}15$ for steel-steel friction;

$\mu = 0{,}13$ for steel-bronze friction.

These friction coefficients may be increased by 0,04 if glycerine is used in wet mounting.

$D_S$ = shrinkage diameter at the mid-length of the taper, in m;

$L$ = effective length of taper, in m;

$S$ = safety factor, equal to 2,0.

The contact pressure corresponding to the actual pull-up length and to the ambient temperature during the propeller fitting shall guarantee that the required safety factor will be fulfilled in ice operating conditions.

**1.3.6.5.1.2** Key mounting.

Key mounting is not permitted.

**1.3.6.5.1.3** Flange mounting.

The flange thickness shall be at least 25 % of the required aft end shaft diameter.

Any additional stress raisers such as recesses for bolt heads shall not interfere with the flange fillet unless the flange thickness is increased correspondingly.

The flange fillet radius shall be at least 10 % of the required shaft diameter.

The diameter of shear pins, $d_{pin}$, in mm, shall be determined as follows:

$$d_{pin} = 66\sqrt{\frac{Q_{peak} \cdot S}{PCD \cdot Z_{pin} \cdot \sigma_{0,2}}}, \qquad (1.3.6.5.1.3\text{-}1)$$

where $z_{pin}$ = number of shear pins;

$S$ = safety factor taken as $S = 1{,}3$.

The bolts shall be designed so that the blade failure load $F_{ex}$ (refer to 1.3.5.4) in backward direction does not cause yielding of the bolts. The flange bolt diameter is determined as:

$$d_b = 41\sqrt{\frac{F_{ex} \cdot \left(\frac{0{,}8 \cdot D}{PCD} + 1\right) \cdot \alpha}{\sigma_{0,2} \cdot Z_b}}, \qquad (1.3.6.5.1.3\text{-}2)$$

where $\alpha$ = coefficient taken equal to:

$\alpha = 1{,}6$ for torque guided tightening;

$\alpha = 1{,}3$ for elongation guided;

$\alpha = 1{,}2$ for angle guided;

$\alpha = 1{,}1$ for elongated by other additional means.

Other $\alpha$ values may be used, if evidence is demonstrated to the Register;

$d_b$ = flange bolt diameter, in mm;

$z_b$ = number of flange bolts.

**1.3.6.5.2** Propeller shaft.

The design of the propeller shaft shall fulfil the following.

**1.3.6.5.2.1** The blade failure load $F_{ex}$ (refer to 1.3.5.4) applied parallel to the shaft (forward or backwards) shall not cause yielding. The bending moment need not to be combined with any other loads. The diameter in way of the aft stern tube bearing, $d_{pastb}$, in mm, shall not be less than:

$$d_{pastb} = 160\sqrt{\frac{F_{ex}\cdot D}{\sigma_{0,2}\cdot\left[1-\left(\frac{d_i}{d_p}\right)^4\right]}}, \qquad (1.3.6.5.2.1)$$

where $d_p$ = propeller shaft diameter, in mm;
$d_i$ = propeller shaft inner diameter, in mm.

Forward from the aft stern tube bearing the shaft diameter may be reduced based on direct calculation of the actual bending moment, or by the assumption that the bending moment caused by $F_{ex}$ is linearly reduced to 25 % at the next bearing and in front of this linearly to zero at third bearing.

Bending due to maximum blade forces $F_b$ and $F_f$ have been disregarded since the resulting stress levels are much lower than the stresses caused by the blade failure load.

**1.3.6.5.2.2** The stresses due to the peak torque $Q_{peak}$ shall have a minimum safety factor equal to 1,5 against yielding in plain sections and to 1,0 in way of stress concentrations in order to avoid bent shafts.

Minimum diameter of the plain and notched shafts are defined as follows, in mm:

for the plain shaft:

$$d_p = 210\sqrt{\frac{Q_{peak}\cdot S}{\sigma_{0,2}\cdot\left[1-\left(\frac{d_i}{d}\right)^4\right]}}, \qquad (1.3.6.5.2.2\text{-}1)$$

for the notched shaft:

$$d_p = 210\sqrt{\frac{Q_{peak}\cdot S\cdot\alpha_t}{\sigma_{0,2}\cdot\left[1-\left(\frac{d_i}{d}\right)^4\right]}}, \qquad (1.3.6.5.2.2\text{-}2)$$

where $\alpha_t$ = local stress concentration factor in torsion.

In any case, the actual notched shaft diameter shall not be less than the required plain shaft diameter.

**1.3.6.5.2.3** The torque amplitudes (refer to 1.3.5.6.3) with the corresponding number of load cycles shall be used in an accumulated fatigue evaluation where the fatigue safety factor is $S_{fat} = 1{,}5$. If the plant has high engine excited torsional vibrations (e.g. direct coupled 2-stroke engines), this shall also be considered.

**1.3.6.5.2.4** The fatigue strengths $\sigma_F$ and $\tau_F$ (3 $10^6$ cycles) of shaft materials may be assessed on the basis of the material's yield or 0,2 % proof strength as:

$$\sigma_F = 0{,}436\cdot\sigma_{0,2} + 77 = \sqrt{3}\cdot\tau_F. \qquad (1.3.6.5.2.4)$$

This formula is valid for small polished specimens (no notch) and reversed stresses.

The high cycle fatigue (HCF) shall be assessed based on the above fatigue strengths, notch factors (i.e. geometrical stress concentration factors and notch sensitivity), size factors, mean stress influence and the required safety factor of 1,6 at 3 $10^6$ cycles increasing to 1,8 at $10^9$ cycles.

The low cycle fatigue (LCF) representing $10^4$ cycles shall be based on the smaller value of yield or 0,7 of tensile strength/√3. The criterion utilises a safety factor of 1,25.

The LCF and HCF as given above represent the upper and lower knees in a stress-cycle diagram. Since the required safety factors are included in these values, a Miner sum of unity is acceptable.

**1.3.6.5.3** Intermediate shafts.

The design of intermediate shafts shall fulfil the requirements of 1.3.6.5.2.2 — 1.3.6.5.2.4.

**1.3.6.5.4** Shaft connections.

**1.3.6.5.4.1** Shrink fit couplings (keyless).

The requirements in 1.3.6.5.1.1 apply with a safety factor $S$ equal to 1,8 ($S = 1{,}8$).

**1.3.6.5.4.2** Key mounting.

Key mounting is not permitted.

**1.3.6.5.4.3** Flange mounting.

The flange thickness shall be at least 20 % of the required shaft diameter.

Any additional stress raisers such as recesses for bolt heads shall not interfere with the flange fillet unless the flange thickness is increased correspondingly.

The flange fillet radius shall be at least 8 % of the shaft diameter.

The diameter of ream fitted (light press fit) bolts shall be chosen so that the peak torque is transmitted with a safety factor of 1,9. This accounts for a pre-stress. Pins shall transmit the peak torque with a safety factor of 1,5 against yielding (refer to $d_{pin}$ in 1.3.6.5.1.3).

The bolts shall be designed so that the blade failure load (refer to 1.3.5.4) in backward direction does not cause yielding.

**1.3.6.5.4.4** Splined shaft connections.

Splined shaft connections can be applied where no axial or bending loads occur. A safety factor of $S = 1{,}5$ against allowable contact and shear stress resulting from $Q_{peak}$ shall be applied.

**1.3.6.5.5** Gear transmissions.

**.1** Shafts.

Shafts in gear transmissions shall meet the same safety level as intermediate shafts, but where relevant, bending stresses and torsional stresses shall be combined (e.g. by von Mises for static loads).Maximum permissible deflection in order to maintain sufficient tooth contact pattern shall be considered for the relevant parts of the gear shafts.

**.2** Gearing.

The gearing shall fulfil following three acceptance criteria:

tooth root stresses;

pitting of flanks;

scuffing.

In addition to above 3 criteria subsurface fatigue need to be considered.

Common for all criteria is the influence of load distribution over the face width. All relevant parameters shall be considered, such as elastic deflections (of mesh, shafts and gear bodies), accuracy tolerances, helix modifications, and working positions in bearings (especially for twin input single output gears).

The load spectrum (refer to 1.3.6.5) shall be applied in such a way that the numbers of load cycles for the output wheel are multiplied by a factor equal to the number of pinions on the wheel divided by the number of propeller blades, $Z$. For pinions and wheels operating at higher speeds the numbers of load cycles are found by multiplication with the gear ratios. The peak torque ($Q_{peak}$) shall also be considered during calculations.

Cylindrical gears can be assessed on the basis of the international standard ISO 6336 series (i.e. ISO 6336-1:2019, ISO 6336-2:2019, ISO 6336-3:2019, ISO 6336-4:2019, ISO 6336-5:2016 and ISO 6336-6:2019), provided that "method B" is used. Bevel gears can be assessed on the basis of the international standard ISO 10300 series (i.e. ISO 10300-1:2014, ISO 10300-2:2014 and ISO 10300-3:2014).

Tooth root safety shall be assessed against the peak torque, torque amplitudes (with the pertinent average torque) as well as the ordinary loads (open water free running) by means of accumulated fatigue analyses. The resulting factor of safety shall be at least 1,5.

The safety against pitting shall be assessed in the same way as tooth root stresses, but with a minimum resulting safety factor of 1,2 (refer to ISO 6336-1:2019, ISO 6336-2:2019 and ISO 6336-6:2019).

The scuffing safety (refer to ISO/TR 13989-1:2000 and ISO/TR 13989-2:2000) based on the peak torque shall be at least 1.2 when the FZG class of the oil, as defined in ISO 14635-1:2000, is assumed one stage below specification.

The safety against subsurface fatigue of flanks for surface hardened gears (oblique fracture from active flank to opposite root) shall be assessed at the discretion of Register. (It shall be noted that high overloads can initiate subsurface fatigue cracks that may lead to a premature failure. In lieu of analyses UT inspection intervals may be used).

**.3** Gear wheel shaft connections.

The torque capacity shall be at least 1,8 times the highest peak torque $Q_{peak}$ (at considered rotational speed) without exceeding the permissible hub stresses of 80 % yield.

**1.3.6.5.6** Clutches.

Clutches shall have a static friction torque of at least 1,3 times the peak torque $Q_{peak}$ and dynamic friction torque of 2/3 of the static.

Emergency operation of clutch after failure of e.g. operating pressure shall be made possible within reasonably short time. If this is arranged by bolts, it shall be on the engine side of the clutch in order to ensure access to all bolts by turning the engine.

**1.3.6.5.7** Elastic couplings.

A separation margin of at least 20 % is required between the peak torque $Q_{peak}$ and the torque $T_{k\max}$:

$$Q_{peak} < 0{,}8 \cdot T_{kmax}(N = 1). \quad (1.3.6.5.7\text{-}1)$$

A separation margin of at least 20 % is required between the maximum response torque $Q_{peak}$ (refer to Fig. 1.3.5.6.2.2) and the torque where any mechanical twist limitation and/or the permissible maximum torque of the elastic coupling, valid for at least a single load cycle ($N = 1$), is reached.

A sufficient fatigue strength shall be demonstrated at design torque level $Q_r(N = x)$ and $Q_A(N = x)$. This may be demonstrated by interpolation in a Weibull torque distribution (similar to Fig. 1.3.6.5-1):

$$\frac{Q_r(N=x)}{Q_r(N=1)} = 1 - \frac{\log x}{\log(Z \cdot N_{ice})}, \quad (1.3.6.5.7\text{-}2)$$

$$\frac{Q_A(N=x)}{Q_A(N=1)} = 1 - \frac{\log x}{\log(Z \cdot N_{ice})}, \quad (1.3.6.5.7\text{-}3)$$

respectively,

where $Q_r(N = 1)$ = torque level corresponding to $Q_{peak}$, in kNm;

$Q_A(N = 1)$: torque level corresponding to $Q_{A\max}$, in kNm;

$Q_r(N = 5 \times 10^4) \cdot S < T_{k\max}(N = 5 \times 10^4)$,

$Q_r(N = 1 \times 10^6) \cdot S < T_{KV}$,

$Q_A(N = 5 \times 10^4) \cdot S < \Delta T_{\max}(N = 5 \times 10^4)$,

$S$ = general safety factor for fatigue, equal to 1,5 ($S = 1{,}5$).

The torque amplitude (or range, Δ) shall not lead to fatigue cracking, i.e. exceeding the permissible vibratory torque. The permissible torque is obtained by interpolation in a Weibull torque distribution where $T_{k\max1}$ and $\Delta T_{k\max}$ refer to 5 10$^4$ cycles and $T_{KV}$ to 10$^6$ cycles respectively.

$T_{k\max1} \geq Q_r$ at $5 \times 10^4$ load cycles. (1.3.6.5.7-4)

Refer to illustration of $T_{k\max1}$, $\Delta T_{k\max}$ and $T_{KV}$ = f (time) in Figs. 1.3.6.5.6.7-1, 1.3.6.5.6.7-2, and 1.3.6.5.6.7-3, respectively.

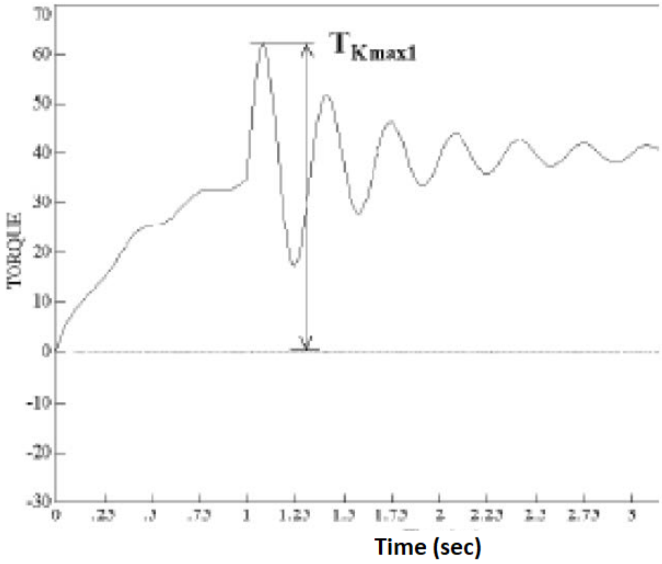



Fig. 1.3.6.5.6.7-1
$T_{k\max1}$

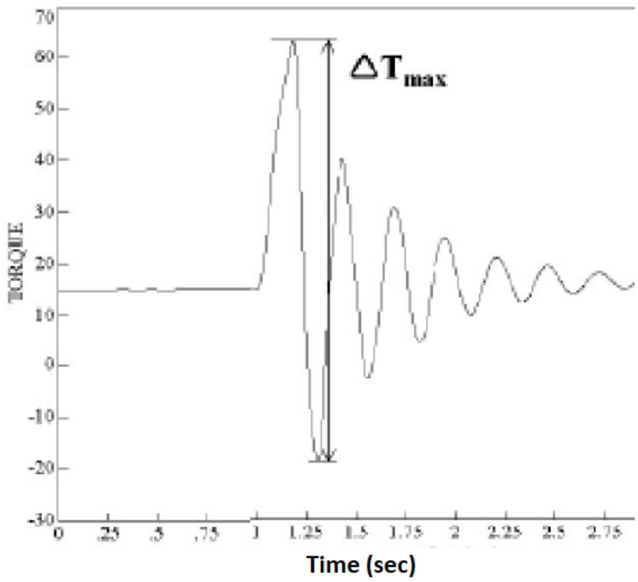



Fig. 1.3.6.5.6.7-2
$\Delta T_{k\max}$

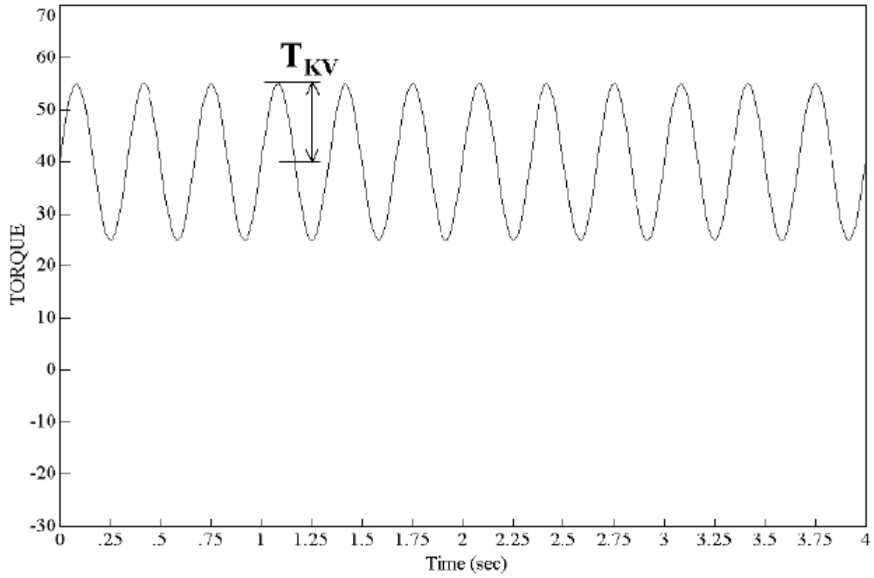



Fig. 1.3.6.5.6.7-3.
$T_{KV}$ = f (time)

**1.3.6.5.8** Crankshafts.

Special considerations apply for plants with large inertia (e.g. flywheel, tuning wheel or PTO) in the non-driving end front of the engine (opposite to main power take off).

**1.3.6.5.9** Bearings.

The aft stern tube bearing as well as the next shaft line bearing shall withstand $F_{ex}$ as given in 1.3.5.4, in such a way that the ship can maintain operational capability. Rolling bearings shall have an $L_{10a}$ lifetime of at least 40000 hours according to ISO 281:2007. Thrust bearings and their housings shall be designed to withstand with a safety factor $SS = 1{,}0$ the maximum response thrust 1.3.5.5 and the axial force resulting from the blade failure load $F_{ex}$ in 1.3.5.4. For the purpose of calculation, except for $F_{ex}$, the shafts are assumed to rotate at rated speed. For pulling propellers special consideration shall be given to loads from ice interaction on the propeller hub.

**1.3.6.5.10** Seals.

Seals shall prevent egress of pollutants and be suitable for the operating temperatures. Contingency plans for preventing the egress of pollutants under failure conditions shall be documented.

Seals installed shall be suitable for the intended application. The manufacturer shall provide for consideration an information on operating experience under similar conditions and/or test results.

**1.3.6.6** Azimuthing main propulsors.

In addition to the above requirements, special consideration shall be given to those loading cases which are extraordinary for propulsion units when compared with conventional propellers. The estimation of load cases shall reflect the way the thrusters are intended to operate on the specific ship. In this respect, for example, the loads caused by the impacts of ice blocks on the propeller hub of a pulling propeller shall be considered. Furthermore, loads resulting from the thrusters operating at 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 loss of a blade shall be considered for the propeller blade orientation which causes the maximum load on the component being studied. Typically, top-down blade orientation places the maximum bending loads on the thruster body.

Azimuth thrusters shall also be designed for estimated loads caused by thruster body-to-ice interaction considering the provisions of Section 6 of the Rules for Active Means of Polar Class Ships' Steering. The thruster body shall withstand the loads arising due to an impact on the thruster body by an ice block of the maximum size specified in 1.3.5.2, when the ship is at a typical ice operating speed. In addition, the design situation in which an ice sheet glides along the ship's hull and presses against the thruster body shall be considered. The thickness of such sheet shall be taken as the thickness of the maximum-size ice block entering the propeller, as defined in 1.3.5.2.

**1.3.7 Prime movers.**

**1.3.7.1** Propulsion engines.

Engines shall be capable of being started and running the propeller in bollard condition. Propulsion plants with CP propeller shall be capable being operated even when the CP system is at full pitch as limited by mechanical stoppers.

**1.3.7.2** Starting arrangements.

The capacity of the air receivers shall be sufficient to provide, without recharging, 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 one (1) hour, except for ships with polar classes **PC1** — **PC6**, if its propulsion engine has to be reversed for going astern, in which case the compressor shall be able to charge the receivers in half an hour.

**1.3.7.3** Emergency power units.

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

Emergency power units shall be equipped with starting devices with a stored energy capability of at least three consecutive starts at the above-mentioned temperature. The source of stored energy shall be protected to preclude critical depletion by the automatic starting system, unless a second independent mean 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.

**1.3.8 Equipment fastening loading accelerations.**

**1.3.8.1** General.

Essential equipment and supports shall be suitable for the accelerations as indicated in the following paragraphs. Accelerations shall be considered as acting independently.

**1.3.8.2** Longitudinal impact accelerations, $a_l$.

The maximum longitudinal impact acceleration at any point along the hull girder, in m/s$^2$, is defined as:

$$a_1 = \frac{F_{IB}}{\Delta} \cdot \left(1{,}1 \cdot \tan(\gamma + \varphi) + 7 \cdot \frac{H}{L}\right), \qquad (1.3.8.2)$$

where $F_{IB}$ = vertical design ice force, in kN;
$\Delta$ = displacement, in t;
$\gamma$ = bow stem angle at waterline, in deg;
$\varphi$ = maximum friction angle between steel and ice, normally taken as 10 deg, $\varphi$ = 10;
$H$ = distance from the water line to the point being considered, in m;
$L$ = ship length between perpendiculars, in m.

**1.3.8.3** Vertical impact acceleration, $a_v$.
The combined vertical impact acceleration at any point along the hull girder, in m/s$^2$, is defined as:

$$a_v = 2{,}5 \cdot \frac{F_{IB} \cdot F_X}{\Delta}, \qquad (1.3.8.3)$$

Coefficient $F_x$ is taken as:
$F_x$ = 1,3 at FP;
$F_x$ = 0,2 at midship perpendicular;
$F_x$ = 0,4 at AP;
$F_x$ = 1,3 at AP for ships conducting ice breaking astern.
Intermediate values are obtained by linear interpolation.

**1.3.8.4** Transverse impact acceleration, $a_t$.
The combined transverse impact acceleration at any point along hull girder, in m/s$^2$, is defined as:

$$a_t = 3 \cdot \frac{F_i \cdot F_X}{\Delta}, \qquad (1.3.8.4)$$

$F_i$ = total design ice force normal to shell plating in the bow area due to oblique ice impact, in kN, as defined in 1.2.3.2.1.
$F_x$ is coefficient taken as:
$F_x$ = 1,5 at FP;
$F_x$ = 0,25 at midship perpendicular;
$F_x$ = 0,5 at AP;
$F_x$ = 1,5 at AP for ships conducting ice breaking astern;
Intermediate values are obtained by linear interpolation.

**1.3.9 Auxiliary systems.**
**1.3.9.1** 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.
**1.3.9.2** Means shall be provided to prevent damage to tanks containing liquids due to freezing.
**1.3.9.3** Vent pipes, intake and discharge pipes and associated systems shall be designed to prevent blockage due to freezing or ice and snow accumulation.
**1.3.10 Sea inlets and cooling water systems.**
**1.3.10.1** Cooling water systems for machinery that is essential for the propulsion and safety of a ship, including sea chest inlets, shall be designed for the environmental conditions applicable to the ship's polar class.
**1.3.10.2** At least two sea chests shall be arranged as ice boxes (sea chests for water intake in severe ice conditions) for polar classes **PC1** — **PC5**. The calculated volume for each of the ice boxes shall be at least 1 m$^3$ for every 750 kW of the totally installed power. For polar classes **PC6** and **PC7**, there shall be at least one ice box located preferably near centre line.
**1.3.10.3** Ice boxes shall be designed for an effective separation of ice and venting of air.
**1.3.10.4** Sea inlet valves shall be secured directly to the ice boxes. The valve shall be a full-bore type.
**1.3.10.5** Ice boxes and sea bays shall have vent pipes and shall have shut off valves connected directly to the shell.
**1.3.10.6** Means shall be provided to prevent freezing of sea bays, ice boxes, ship side valves and fittings above the load water line.

**1.3.10.7** 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.

**1.3.10.8** 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.

**1.3.10.9** 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. The means of clearing shall be of a type using low pressure steam. Clearing pipes shall be provided with screw-down type non-return valves.

**1.3.11 Ballast tanks.**

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.

**1.3.12 Ventilation systems.**

**1.3.12.1** The air intakes for machinery and accommodation ventilation shall be located on both sides of the ship at locations where manual de-icing is possible. Anti-icing protection of the air inlets may be accepted as an equivalent solution to location on both sides of the ship and manual de-icing at the Register's discretion. Notwithstanding the above, multiple air intakes shall be provided for the emergency generating set and shall be as far apart as possible.

**1.3.12.2** The temperature of the inlet air shall be suitable for the safe operation of the machinery; and the thermal comfort in the accommodation.

Accommodation and ventilation air intakes shall be provided with means of heating, if needed.

**1.3.13 Steering systems.**

**1.3.13.1** Rudder stops shall be provided. The design ice force on rudder shall be transmitted to the rudder stops without damage to the steering system. An ice knife shall, in general, be fitted to protect the rudder in centre position. The ice knife shall extend below the ballast waterline (BWL). Design forces shall be determined according to 1.2.15.

**1.3.13.2** The rudder actuator shall comply with the following requirements 1.3.13.2.1 and 1.3.13.2.2.

**1.3.13.2.1** The rudder actuator shall be designed for a holding torque obtained by multiplying the open water torque resulting from the application of SOLAS-74 Reg. II-1/29.3.2 (considering however a maximum speed of 18 knots) by the following factors:

Table 1.3.13.2.1

| Polar class | **PC1** | **PC2** | **PC3** | **PC4** | **PC5** | **PC6** | **PC7** |
|---|---|---|---|---|---|---|---|
| Factor | 5 | 5 | 3 | 3 | 3 | 1,5 | 1,5 |

**1.3.13.2.2** The design pressure for calculations to determine the scantlings of the rudder actuator shall be at least 1,25 times the maximum working pressure corresponding to the holding torque defined in 1.3.13.2.1 (according to SOLAS-74 Reg. II-1/29.2.2).

**1.3.13.3** The rudder actuator shall be protected by torque relief arrangements, assuming the following turning speeds [deg/s] without an undue pressure rise (Table 1.3.13.3).

Table 1.3.13.3

**Steering gear turning speeds for polar class ships**

| Polar class | **PC1** and **PC2** | **PC3** to **PC5** | **PC6** and **PC7** |
|---|---|---|---|
| Turning speed [deg/s] | 10 | 7,5 | 6 |

If the rudder and actuator design can withstand such rapid loads, this special relief arrangement is not necessary and a conventional one may be used instead.

**1.3.13.4** Additionally for icebreakers, fast-acting torque relief arrangements shall be fitted in order to provide effective protection of the rudder actuator in case of the rudder being pushed rapidly hard over against the stops.

For hydraulically operated steering gear, the fast-acting torque relief arrangement shall be so designed that the pressure cannot exceed 115 % of the set pressure of the safety valves when the rudder is being forced to move at the speed indicated in Table 1.3.13.4, also when with account for the oil viscosity at the lowest expected ambient temperature in the steering gear compartment.

For alternative steering systems the fast-acting torque relief arrangement shall demonstrate an equivalent degree of protection to that required for hydraulically operated arrangements.

The turning speeds to be assumed for each icebreaker's polar class are shown in Table 1.3.13.4 below.

Table 1.3.13.4

**Steering gear turning speeds for icebreakers**

| Polar class | **PC1** and **PC2** | **PC3** to **PC5** | **PC6** and **PC7** |
|---|---|---|---|
| Turning speed [deg/s] | 40 | 20 | 15 |

The fast-acting torque relief arrangement shall be designed so to ensure the ship's steering capacity to be promptly regained.

**1.3.14 Alternative design.**

**1.3.14.1** General.

As an alternative, a comprehensive design study may be submitted to the Register and may be requested for validation as per an agreed test programme.

*APPENDIX*

## ILLUSTRATION OF EXCITATION CASES FOR DIFFERENT BLADE NUMBERS

The illustrations in Figures 1 and 2 show the excitation torque for all torsional load cases given in this Chapter (refer to 1.3.6.3.3.2) for different blade numbers ($Z$). The curves have been made using data for **PC7** ($Hice$=1,5).

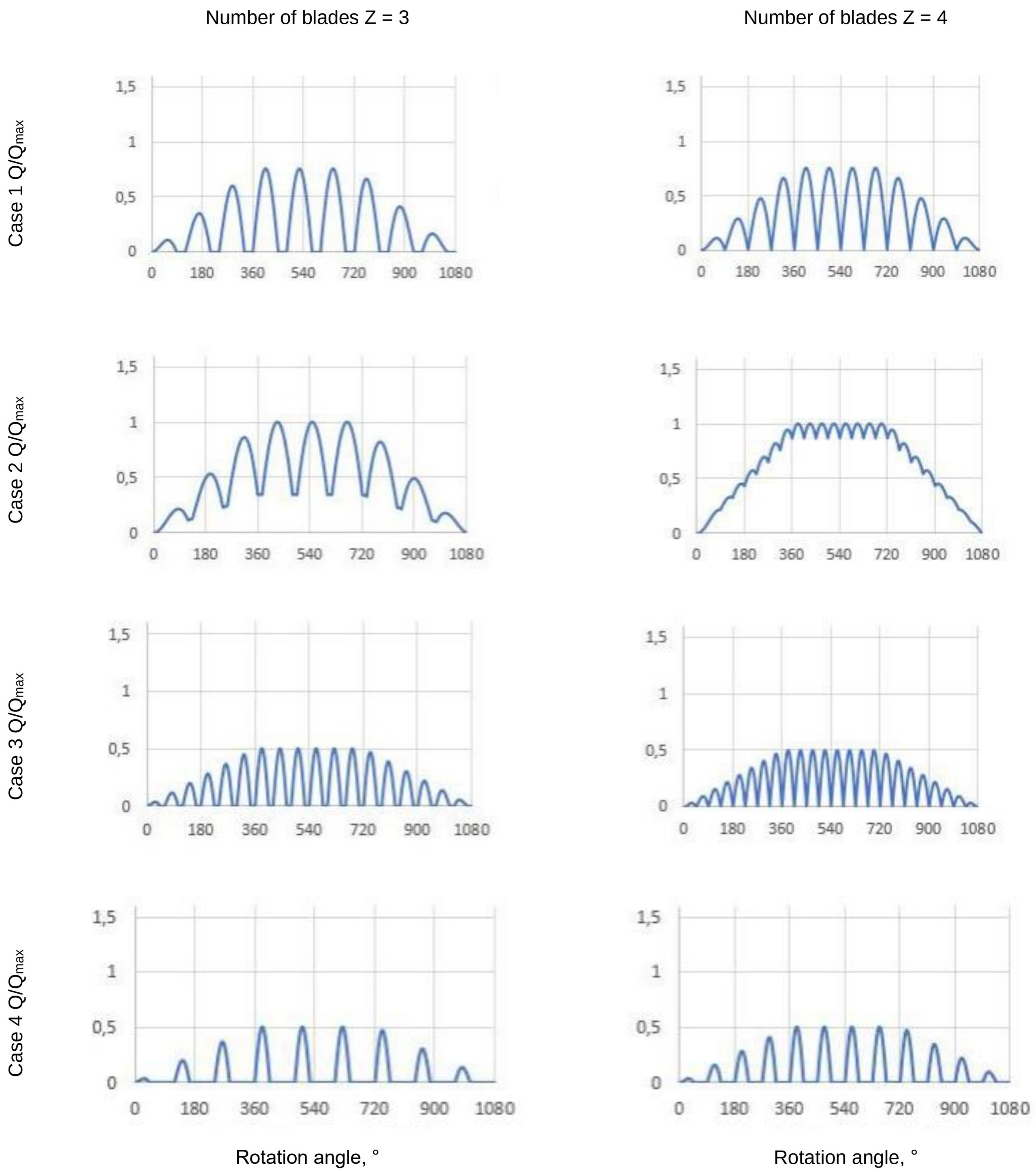



Fig. 1

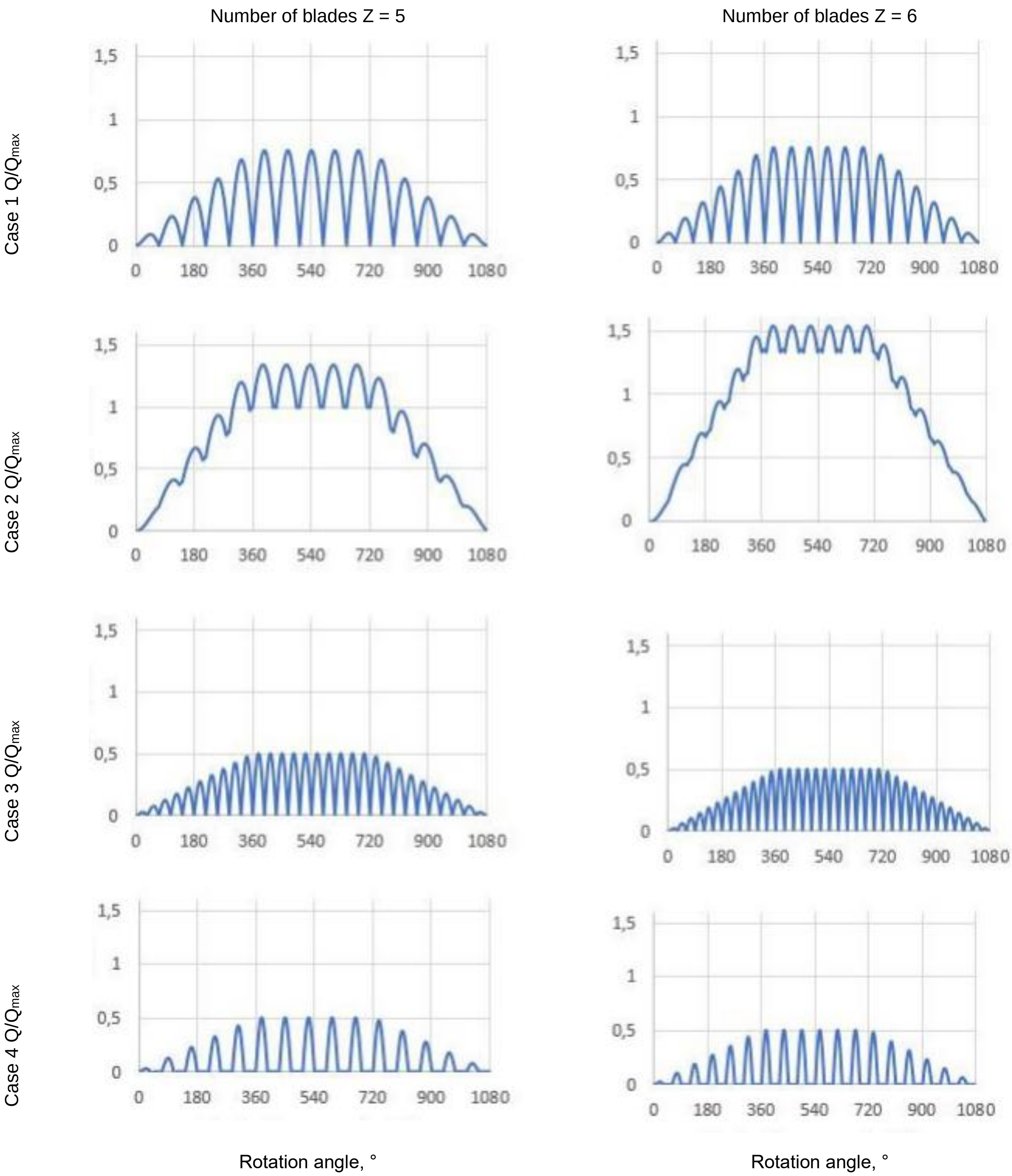

Number of blades Z = 5
Number of blades Z = 6
Case 1 Q/Qmax
Case 2 Q/Qmax
Case 3 Q/Qmax
Case 4 Q/Qmax
0
0,5
1
1,5
0
180
360
540
720
900
1080
Rotation angle, °
Rotation angle, °

Fig. 2

# 2 TECHNICAL REQUIREMENTS FOR ESCORT TUGS

## 2.1 GENERAL

**2.1.1 Scope of application.**

**2.1.1.1** The requirements 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; escort test speed $V$, in knots; manoeuvring time $t$, in s.

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

Escort test speed $V$ means the speed, in knots, of the assisted ship.

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 $t$ means a minimum manoeuvring time, in s, from position of the tug on one side of the assisted ship giving the maximum transverse steering force to mirror position on the other side of the assisted ship.

Maximum steering pull of the tug $F_S$ 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 (refer to Fig. 2.1.2).

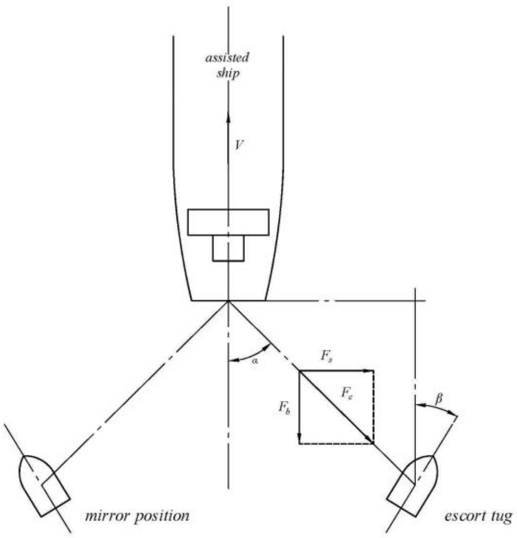



Fig. 2.1.2
Typical working mode of the escort tug
$F_S$ = steering pull; $F_b$ = braking force; $F_t$ = towing line tension; α = towing line angle; β = oblique angle;
$V$ = speed of the assisted ship

**2.1.3 Technical documentation.**

**2.1.3.1** The following technical documentation shall be submitted to the Register for review:

**.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;

**.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.

**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 $\theta_e$ 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 $\theta_e$ 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 $\theta_d$ (refer to Fig. 2.2.2.3.3-2);

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

$\theta_d$ = 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;

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

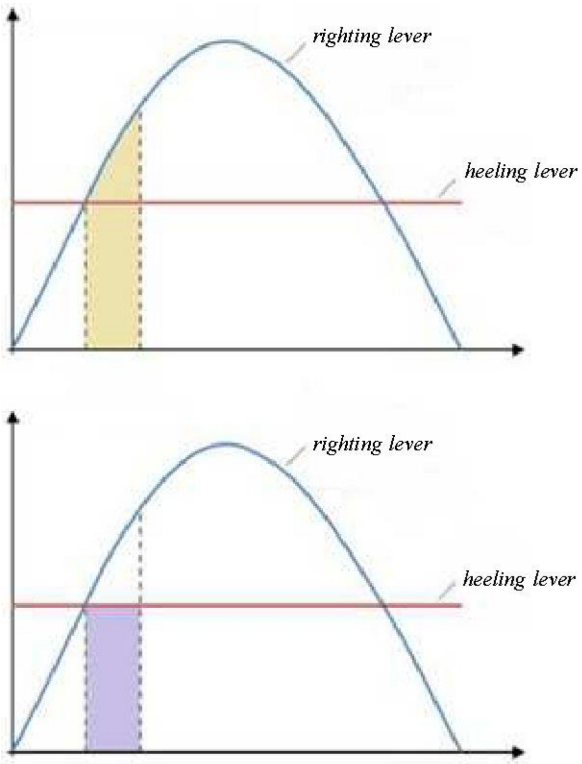



Fig. 2.2.2.3.3-1

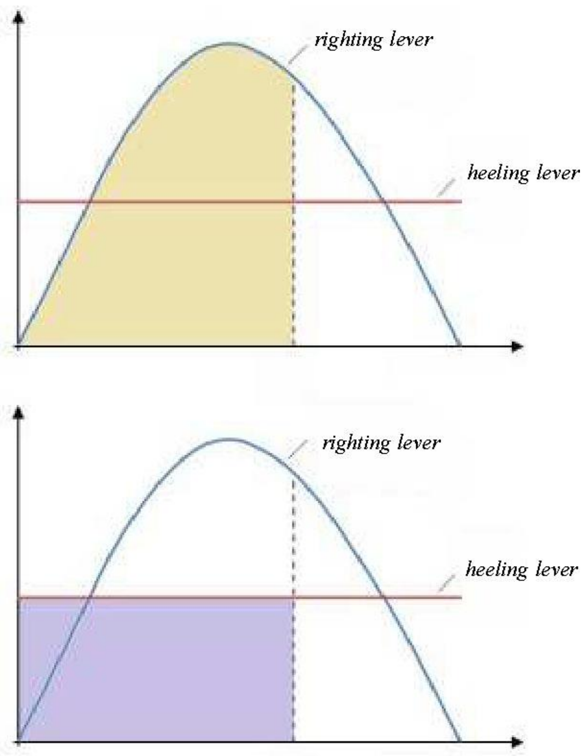



Fig. 2.2.2.3.3-2

**2.2.2.4** A minimum freeboard at stern measured on centreline 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.

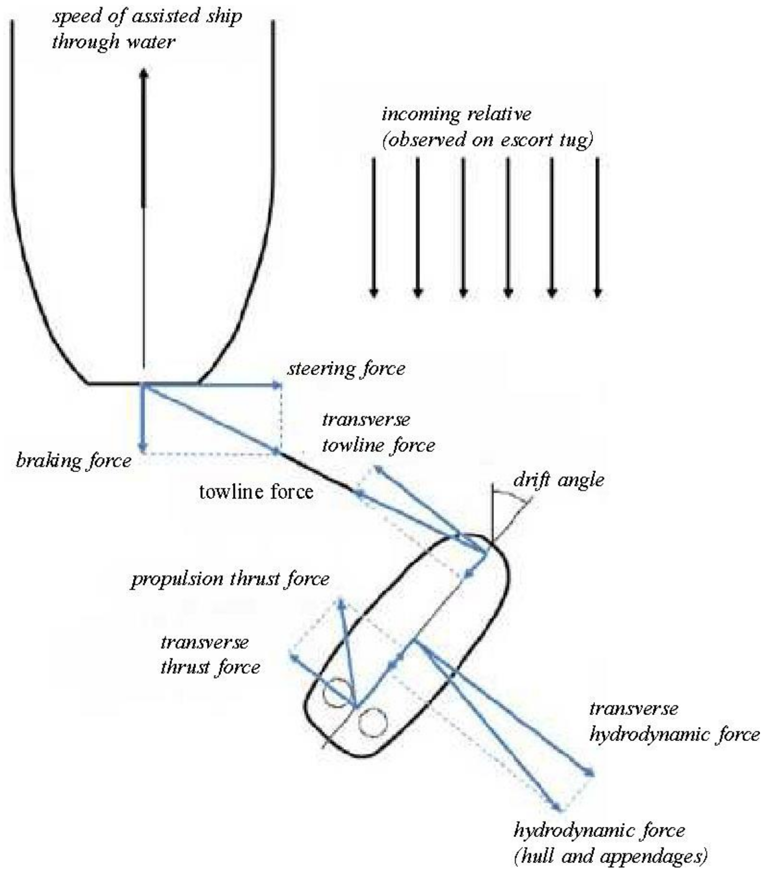



Fig. 2.2.2.5.1

**2.2.2.5.2** At design stage, the values of steering force, breaking force and heeling lever may be determined by model test or calculation. On completion of the tug's construction, the values 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.

**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** The full scale trials are performed to specify the preliminary values of the escort characteristics adopted at the design stage.

If the escort characteristics are determined in accordance with the procedure approved by the Register, the full scale trials may not be performed.

**2.3.2 Plan of full scale trials.**

**2.3.2.1** The following shall be submitted to surveyor to the Register prior to the full scale trials:

plan of the trials;

calculation of tug's stability during escort service;

preliminary calculation of the ship's escort characteristics.

**2.3.2.2** The plan of full scale trials shall stipulate determination of escort characteristics at the speed of the assisted ship of 8 and/or 10 knots (refer to Fig. 2.1.2).

**2.3.2.3** The plan shall include a list of measuring instruments, description of mandatory manoeuvres, a towing arrangement scheme for escort service, design and safe working loads of strong points of the tug and assisted ship.

**2.3.3 Procedure of trials.**

**2.3.3.1** 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.

**2.3.3.2** The trials shall be carried out in weather conditions that deliver reliable results (recommended limitation of wind force is 10 m/s, sea state 2), with the load of the tug equal to 50 — 10 % of provisions. Velocity of current in the area of the trials, if any, shall be measured both upstream and downstream.

**2.3.3.3** The assisted ship shall maintain the heading and speed during the necessary tug manoeuvring.

**2.3.3.4** The following data shall be recorded continuously in real time mode during trials:

**.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** angle of the towing line from the centreline 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 of towing line and the maximum towing line angle from the centreline 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 full scale trials shall contain records of the parameters measured and calculation of the steering pull value taking into account the time of the tug's transfer to the mirror position.

The results of the full scale trials shall be executed as the report and submitted to the Register for review. Based on the positive results of the review, the Register representative signs and stamps the front page of the record with the surveyor's seal.

**2.4.2** The Stability Booklet shall be drawn up with regard to refined escort characteristics.

**2.4.3** Upon satisfactory results of the review of the Stability Booklet, the descriptive notation **Escort tug** is added to the character of classification in the Classification Certificate (form 3.1.2), and the following entry shall be made in the column "Other characteristics": "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** 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;

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

**.6** 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: | | |
| 3.6.4 Prevention of pollution at ship recycling | – | × |

## 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, IMO circular 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.340(77) |

**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 3.5.3.7.1));

**.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 3.5.3.9.3 — 3.5.3.9.5 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** Sewage Management Plan and procedure for sewage record keeping;

**.13** sewage system diagram and sanitary and domestic waste waters system diagram;

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

**.15** 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;

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

**.17** 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 fulfil 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 SOx 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.340(77)) 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 < 4000.

**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 signalling if refrigerant is found outside refrigerating system;

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

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 circular 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 circular 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 product 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 fuel and oil bunkering.

**3.5.3.3.1** Oil tankers, chemical tankers and NLS tankers shall have fitted 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 direct 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.

Direct gravity drainage may be used during cargo operations where cargo spills may occur, and shall not be used under normal conditions when at sea. For direct gravity drainage, each pipe of deck system shall be arranged with a manually operated valve opened only during cargo operations, as well as an automatic scupper or non-disconnectable drainage arrangement preventing vapour discharge to the atmosphere.

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

The trays shall have the following minimum dimensions:

tray length shall be so that the cargo manifold does not extend beyond forward and aft ends of the tray;

width is 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 is 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 spill trays or coamings shall be designed to allow the removal of accumulated water with the aid of drain plugs or other means. The capacity of spill trays/coamings in the areas for reception and delivery of petroleum products shall be not less than 60 l on ships of less than 1800 gross tonnage and not less than 140 l on ships of 1800 gross tonnage and above. For other areas, it shall be not less than 30 l on ships of less than 1800 gross tonnage and on fishing vessels of any gross tonnage, and not less than 60 l on ships of 1800 gross tonnage and above, except for fishing vessels. The height of the spill trays/coamings shall not be less than 100 mm.

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 drainage 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 by supplying at least 0,15 — 0,20 $m^3/h$ of air per 1 $m^3$ of the tank volume, through a perforated pipe fitted in the lower part of 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 3.4.4.12 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** 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).

**3.5.3.7.2** 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.

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

**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 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** Ships with an aggregate fuel oil tanks capacity 600 m$^3$ and over and deadweight of 5000 t 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.

**3.5.3.9.3** 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. However, if it is not practicable to provide structural protection taking into account the type and purpose of the ship, alternatively to this requirement, the ships shall comply with the accidental oil fuel outflow performance standard according to regulation 12A.11 of Annex I to MARPOL 73/78.

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

**3.5.3.9.5** 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. 3.5.3.9.5).

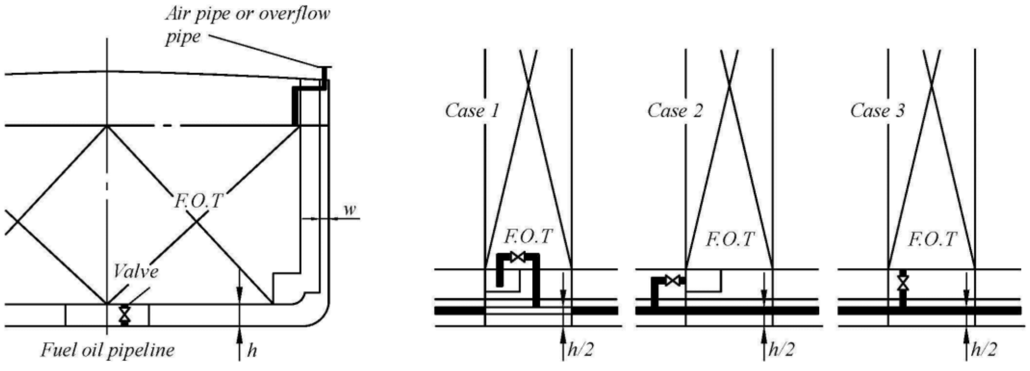



Fig. 3.5.3.9.5

Symbols:

*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 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 < 2000, 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 fuel and oil bunkering.

**3.6.3.3.1** Oil tankers, chemical tankers and NLS tankers shall have fitted means and arrangements to reduce the possibility of oil or NLS spill on deck 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 restricted by coamings on the open deck in the areas of receiving fuel and oil manifolds positioned outside the bunkering station areas shall be fitted with a system for collection of the spilled fuel and oil with its accumulation in a dedicated tank.

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

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 and, where applicable, 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, except that the alternative for structural protection of tanks specified in 3.5.3.9.3 shall not apply to ships of ice class **Arc4** and higher or equivalent class.

**3.6.3.9.2** For ships of ice class specified in 3.6.3.9.1 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** For ships of ice class specified in 3.6.3.9.1, 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 Prevention of pollution at ship recycling.**

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 shall carry onboard Certificate on Inventory of Hazardous Materials or Statement of Compliance, as applicable. Other ships shall carry onboard Statement on Inventory of Hazardous Materials in accordance with the requirements of the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009. The documents mentioned above shall be drawn up according to the requirements in 3.4.3.6.

**3.6.5 Environmental responsibilities.**

The requirements of 3.5.4 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 or the requirements of SOLAS-74 Chapter III, whichever is applicable.

**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 condensation 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** Ship stability under icing shall be checked in accordance with 2.4 of Part IV "Stability".

**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 of Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships or by regulation V/22 of SOLAS-74 (whichever is applicable) 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 an 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 manoeuvrability 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 centreline. Where two fairleads are fitted they shall be arranged symmetrically on each side of ship's centreline 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, the 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 VIII "Systems and Piping", Part XI "Electrical Equipment" of the Rules for the Classification and Construction of Sea-Going Ships and Part V "Navigational 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 refuelling 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 skids 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, as well as to ships without ice class assigned, 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** When the Rules contain no additional provisions, the design temperature of hull structures is determined in terms of minimum average daily air temperature $T_A$ as per 1.2.3.2 of Part II "Hull", in this case, the temperature $T_A$ shall not be assumed more than 13 °C above the design ambient temperature.

**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.

## 7.4 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 7.11.7.
**7.4.1.3** Materials of castings for manufacture of anchor hawse pipe shall meet the requirements of 7.11.4.
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 7.11.4.
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 7.11.4.
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 7.11.7.
**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 4.2.3.5.
**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 7.11.1 — 7.11.6.
**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** A ship, which is involved in ice escort shall be equipped with a manually operated flashing red light visible from astern to indicate when the ship is stopped. 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 MACHINERY INSTALLATIONS

**7.5.1** The requirements for availability of necessary propulsion starting energy to restore the propulsion within 30 min of black out/dead ship condition, specified in 2.1.6 of Part VII "Machinery Installations", shall be met provided the ship is at design ambient temperature during this period.

**7.5.2** 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.

**7.5.3** 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.

**7.5.4** At least two auxiliary boilers are recommended to be provided onboard the ships operating at the design ambient temperature below –40 °C.

## 7.6 SYSTEMS AND PIPING

**7.6.1 Fittings, formed components, expansion joints.**

**7.6.1.1** 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 7.11.1 — 7.11.6.

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 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.

**7.6.1.2** 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.

**7.6.1.3** Side fittings installed above the load waterline shall meet the requirements of 4.3.1.2 of "Systems and Piping".

**7.6.2 Ballast and sewage systems.**

**7.6.2.1** Ballast system shall meet the requirements of 8.3.2, Part VIII "Systems and Piping".

**7.6.2.2** Discharge pipeline of ballast system shall be provided with heating.

**7.6.2.3** 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.

**7.6.2.4** Hydraulic liquids used as working media for ballast pumps driving and remotely controlled fittings shall be suitable for use at design ambient temperature.

**7.6.2.5** Sewage holding tanks and pipelines leading thereto shall be located in heated spaces or provided with heating.

**7.6.3 Fire-fighting systems and outfit.**

**7.6.3.1** 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.

**7.6.3.2** 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.

**7.6.3.3** A foam concentrate for foam fire extinguishing system shall be approved by the Register and be stored in the space with positive temperature.

**7.6.3.4** 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.

**7.6.3.5** 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.

**7.6.3.6** 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".

**7.6.3.7** 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.

**7.6.4 Systems of tankers and combination carriers.**

**7.6.4.1** Cargo system.

**7.6.4.1.1** 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.

**7.6.4.1.2** Hydraulic liquids used as working media for ballast pumps driving and remotely controlled fittings shall be suitable for use at design ambient temperature.

**7.6.4.1.3** 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.

**7.6.4.2** Bow loading system.

**7.6.4.2.1** Materials of components of the bow loading system shall meet the requirements of 7.11.1 — 7.11.6.

**7.6.4.2.2** Hydraulic liquids and lubricating oils shall be suitable for use at design ambient temperature.

**7.6.4.2.3** 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.

**7.6.4.3** Inert gas system.

**7.6.4.3.1** Sea water supply pipeline for deck water seal, a gas scrubber and other equipment of inert gas system shall be fitted with heating.

**7.6.5 Ventilation system.**

**7.6.5.1** 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.

## 7.7 DECK MACHINERY

**7.7.1** Materials used for manufacture of deck machinery components shall comply with the requirements of 7.11.1 — 7.11.6.

**7.7.2** 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.

**7.7.3** Hydraulic liquids and lubricating oils shall be suitable for use at design ambient temperature.

## 7.8 LIFE-SAVING APPLIANCES

**7.8.1 General requirements for life-saving appliances.**

**7.8.1.1** Life-saving appliances shall comply with the requirements of LSA Code; at that, they shall be in the operating condition when stored at design ambient temperature.

**7.8.1.2** 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.

**7.8.1.3** Life-saving appliances intended for ships with distinguishing marks **WINTERIZATION(–40)** and **WINTERIZATION(–50)** shall be marked **W(–40)** and **W(–50)** accordingly.

**7.8.1.4** Sufficient emergency rations for the maximum expected time of rescue shall be provided onboard.

**7.8.2 Lifeboats.**

**7.8.2.1** Lifeboats shall be of an enclosed type and shall comply with the following additional requirements with regard to chapter 4.6 of the LSA Code:

**.1** a lifeboat shall provide accommodation for a specified number of persons in warm clothes with personal survival kits stipulated by 7.8.6.2;

**.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 Appendix 3, Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships for RS Nomenclature Codes 04230000MK or 04230001MK; the 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.

**7.8.3 Rescue boats.**

**7.8.3.1** Rescue boats shall comply with the following additional requirements with regard to chapter 5.1 of the LSA Code:

**.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 Appendix 3, Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships for RS Nomenclature Codes 04230000МК or 04230001МК; apparatus shall be operable at appropriate design ambient temperature.

**7.8.4 Liferafts.**

**7.8.4.1** Liferafts shall comply with the following additional requirements with regard to chapter 4.2 of the LSA Code:

**.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.

**7.8.5 Launching appliances of lifeboats, rescue boats and liferafts.**

**7.8.5.1** Launching appliances of lifeboats, rescue boats and liferafts shall comply with the following additional requirements with regard to chapter 6.1 of the LSA Code:

**.1** materials used for their manufacture shall comply with the requirements of 7.11.1 — 7.11.6;

**.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.

**7.8.6 Group and personal survival kits.**

**7.8.6.1** In addition to the equipment listed in LSA Code, both the 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 7.8.6.2 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 7.8.6.4 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.

**7.8.6.2** 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 2.5, LSA Code — 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 or with 1.5, regulation III/32 SOLAS-74 taking into account the requirements of Section 19 of the Guidelines on the Application of Provisions of Chapter III of the International Convention for the Safety of Life at Sea (SOLAS-74), whichever is applicable;

**.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".

**7.8.6.3** In addition to the equipment listed in 7.8.6.2, 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.

**7.8.6.4** 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 7.8.6.2, without immersion suit as specified in 7.8.6.2.3.
**7.8.6.5** In addition to the equipment listed in 7.8.6.4, 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.
**7.8.6.6** It is recommended to provide air mattresses included in a group survival kit with a self-inflation system.
**7.8.6.7** 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.

## 7.9 CARGO GEAR

**7.9.1 Cargo handling gear.**

**7.9.1.1** 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 7.11.1 — 7.11.6.

Design ambient temperature is assumed as design temperature of the structure.

**7.9.1.2** 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.

**7.9.1.3** Necessary means for cold start of machinery of cargo handling gear at design ambient temperature shall be provided.

**7.9.1.4** For hydraulic and electro-hydraulic cargo handling gear, heating of hydraulic liquid shall be provided.

**7.9.1.5** Hydraulic liquids and lubricating oils shall be suitable for use at design ambient temperature.

**7.9.1.6** 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.

**7.9.2 Devices for cargo securing on open decks.**

**7.9.2.1** Materials of devices for securing cargo on open decks, including guides for fastening of deck containers shall meet the requirements of 7.11.1 — 7.11.4.

**7.9.2.2** 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.

## 7.10 ELECTRICAL, RADIO AND NAVIGATIONAL EQUIPMENT

**7.10.1 Installation of cables.**

**7.10.1.1** Cables to be installed on the open decks and in the open unheated spaces shall be tested for cold endurance according to 10.7.14.9 of 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 working temperature in the chamber equal to the design ambient temperature.

**7.10.1.2** 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.

**7.10.1.3** Materials for manufacture of cable fastening parts (hangers, cable boxes, pipes) and cable sealing shall meet the requirements of 7.11.1 — 7.11.4.

**7.10.1.4** Means shall be provided to protect cable installed on open decks from mechanical damage at manual ice removal.

**7.10.2 Equipment.**

**7.10.2.1** 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.

**7.10.2.2** All electrical equipment intended for installation on the open decks and in the open unheated spaces shall be tested for cold endurance according to the requirements of IEC 60068-2-1:2007 (Test A) at the working temperature in the chamber equal to the design ambient temperature.

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.

**7.10.2.3** 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 equal to 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.

**7.10.2.4** 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 equal to 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.

**7.10.3 Lighting and signal means.**

**7.10.3.1** Ships shall be equipped with at least two suitable searchlights which shall be controllable from conning positions.

**7.10.3.2** Searchlights specified in 7.10.3.1 shall be installed to provide, as far as practicable, all-round illumination suitable for mooring, astern manoeuvres and emergency towing.

**7.10.3.3** Searchlights specified in 7.10.3.1 shall be designed so as to prevent icing or shall be provided with heating.

**7.10.4 Electrical heating appliances.**

**7.10.4.1** 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.

**7.10.4.2** Heating appliances capacity fitted in the above spaces shall provide positive temperature in these spaces at design ambient temperature.

**7.10.4.3** 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".

**7.10.4.4** 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.

## 7.11 MATERIALS

**7.11.1** 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.

**7.11.2** If the hull structural steel rolled products selected for hull structural members exceed 50 mm in thickness or if design temperature of hull structures is below −60 °C, the use of hull structural steel marked with index "Arc" is recommended.

**7.11.3** 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.

**7.11.4** 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".

**7.11.5** 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.

**7.11.6** 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.

**7.11.6.1** 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.

**7.11.7** 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 shall be equal to –20 °C.

## 7.12 TESTS

**7.12.1** 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.

## 7.13 RECORDS

**7.13.1** 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 or Failure Mode and Effect Analysis (FMEA) of the propulsion plant components based on the failure tree or the equivalent risk analysis;

**.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 of 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 of Part VI "Fire Protection".

When independent engine rooms and the sections of main switchboard are located above the damage waterline as defined in 1.2.1 of Part V "Subdivision", it is allowed to divide the rooms with a longitudinal bulkhead of "A-60" class fire integrity.

**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 of 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 of Part VI "Fire Protection".

When independent engine rooms and the sections of main switchboard are located above the damage waterline as defined in 1.2.1 of Part V "Subdivision", it is allowed to divide the rooms with a longitudinal bulkhead of "A-60" class fire integrity.

**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.

S e c o n d a r y  b a r r i e r 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.

S o u r c e  o f  r e l e a s e 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.

I G F  C o d e means the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels.

**9.1.4** In addition to the technical documentation specified in Section 3 of Part I "Classification", the following technical data and ship documents confirming fulfilment of the Rules shall be submitted to the Register (A — for approval; AG — for agreement, FI — for information taking into account 8.2 of Part II "Technical Documentation" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships):

**.1** drawings of fuel tanks arrangement with their distances from side plating and the bottom specified (A);

**.2** drawings of supports and other structures to ensure fastening and limiting shifting of fuel tanks (A);

**.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 (AG);

**.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 (A), calculations of stresses in piping containing gas fuel at a temperature below –110 °C (AG);

**.5** drawings of safety and vacuum safety valves of fuel storage tanks (A);

**.6** drawings and descriptions of all systems and arrangements for the measurement of fuel amount and characteristics, and for gas detection (A);

**.7** diagrams of gas fuel pressure and temperature control and regulating systems (A);

**.8** drawings (A) and calculations of bilge and ballast systems in gas-hazardous spaces (AG);

**.9** diagrams (A) and calculations of gas-dangerous spaces ventilation (AG);

**.10** diagrams (A) and calculations of gas-freeing system (AG);

**.11** circuit diagrams of electric drives and control systems for fuel preparation plants, ventilation of hazardous spaces and airlocks (A);

**.12** circuit diagrams of electric measurement and alarm systems for equipment related to the use of gas fuel (A);

**.13** general arrangement drawings of electrical equipment related to the use of gas fuel (A);

**.14** drawings of cable laying in hazardous spaces and areas (A);

**.15** drawings of earthing for electrical equipment, cables, piping located in gas-dangerous spaces (A);

**.16** block diagram for all intrinsically safe circuits, including data for verification of the compatibility between the barrier and the field components (A);

**.17** list of non-certified safe electrical equipment to be disconnected by the safety system, installed in ESD protected machinery spaces, in spaces isolated from hazardous area by airlock (AG);

**.18** 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 (A, AG or FI, as applicable);

**.19** data on the properties of gas fuel intended for the use on board the ship (FI);

**.20** 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 (AG);

**.21** 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 (A, AG or FI, as applicable);

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 (A, AG or FI, as applicable).

When the standard cylinders are used, the calculation of permissible pressure shall be submitted (AG);

**.22** Inspection/survey plan for the liquefied gas fuel containment system (A).

**.23** Fuel Handling Manual (AG).

[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 or with 1.4, regulation III/31 SOLAS-74 taking into account the requirements of Section 18 of the Guidelines on the Application of Provisions of Chapter III of the International Convention for the Safety of Life at Sea (SOLAS-74), whichever is applicable.

**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$^3$ ≤ $V_c$ < 30000 m$^3$ – 0,8 + $V_c$/25000 m; and

**.4.2.4** for $V_c$ ≥ 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 9.1.4.20.

**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 and tank connection spaces, 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 9.10.6.2 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 or with 1.4, regulation III/31 SOLAS-74 taking into account the requirements of Section 18 of the Guidelines on the Application of Provisions of Chapter III of the International Convention for the Safety of Life at Sea (SOLAS-74), whichever is applicable.

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 9.10.6.2 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 9.10.6.2.

**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 9.10.6.2 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** Gaseous 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.

**9.5.4.12** Liquefied fuel pipes passing outside the machinery spaces shall be protected by a secondary enclosure able to contain leakages. This requirement may be omitted for pipes in a fuel preparation room or a tank connection space.

Detection of leaks in the space between the secondary enclosure and the piping shall be provided by a gas detection system in accordance with 9.10.4 using sensors suitable for monitoring the leak media or by means of temperature and/or pressure monitoring systems.

The secondary enclosure shall be able to withstand the maximum pressure that may build up in the enclosure in case of leakage from the liquefied gas fuel piping. For this purpose, the secondary enclosure may be arranged with a pressure relief system that prevents the enclosure from being subjected to pressures above their design pressures.

**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.

Gas fuel piping enclosed in external pipes or ducts, shall, as far as practicable, use a minimum of flange connection. There shall be no single flange or other components of piping system, where one single failure itself may result in a gas leak into surrounding area causing danger to the persons on board, the environment or the ship.

A single common flange with two sealing systems may be using at the fuel connection to the gas consumers including gas combustion unit (GCU), boilers and components of the engine, such as gas regulating units.

**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 systems unless designed to accommodate the worst-case overpressure due to ignited gas leaks or justified by the safety concept of the engine. A detailed evaluation of the potential for unburnt gas in the exhaust system is to be undertaken covering the complete system from the cylinders up to the open end. This detailed evaluation shall be reflected in the safety concept of the engine.

**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, provided that the type C tank is not located directly above machinery spaces of category A or other rooms with high fire risk specified below, and the minimum distance to the A-60 boundary from the outer shell of the type C tank or the boundary of the tank connection space, if any, is not less than 900 mm.

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 with respect to their structural fire protection and protection of a fixed fire- extinguishing system complying with the requirements of 3.1.2 of Part VI "Fire Protection" taking into account necessary concentrations/application rate required for extinguishing gas fires. The requirements for escape routes from machinery spaces of category A shall not apply to these spaces.

**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** A drain well in each space for tank connections of an independent LNG tank shall be provided with level indicators and temperature indicating devices. As a result of temperature sensor activation, the master 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.

The automatic shutdown of submersible fuel pumps may be accomplished by sensing low pump discharge pressure, low motor current, or low-liquid level.

**9.10.2.6** FST hold spaces and interbarrier spaces without open connection to the atmosphere shall be provided with pressure indicators.

**9.10.2.7** Except for fuel storage tanks of type C supplied with vacuum insulation system and pressure build-up fuel discharge unit, fuel tanks shall be provided with devices to measure and indicate the temperature of the fuel in at least three locations: the bottom and middle of the tank as well as the top of the tank below the highest allowable liquid level.

**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 %;
$\rho_R$ = relative density of fuel at the reference temperature; and
$\rho_L$ = 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 signalling that 95 % of the design pressure has been reached.

**9.10.3.5** Liquefied gas fuel tanks shall be fitted with high liquid level alarms operating independently of other liquid level indicators and giving an audible and visual warning when activated.

**9.10.3.6** An additional sensor shall be provided that operates independently of the high tank liquid level alarm and automatically closes the master gas valve of the tank in a manner that will both avoid excessive liquid pressure in the bunkering line and prevent the fuel tank from becoming liquid full.

**9.10.3.7** Where arrangements are provided for overriding the overflow control system, they shall be such that inadvertent operation is prevented. When this override is operated continuous visual indication is to be provided at the navigation bridge, continuously manned central control station or onboard safety centre.

**9.10.4 Gas leaks control in spaces.**

**9.10.4.1** All enclosed and semi-enclosed gas-dangerous spaces, except for fuel storage hold spaces of independent tanks of type C, as well as ventilation inlets to accommodation and machinery spaces if required based on the risk assessment 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 9.10.6.2) 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** The gas detection equipment shall be of a type approved (by the Register) and comply with IEC 60079-29-1:2016. Audible and visible alarms from the gas detection equipment shall be located on the navigation bridge or in the continuously manned central control station. Gas detection shall be continuous without delay.

**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.

**9.10.6 Safety system functions.**

**9.10.6.1** Gas compressors, pumps and fuel supply shall be arranged for manual remote emergency stop from the following locations as applicable:

navigation bridge;
cargo control room;
onboard safety centre;
engine control room;

fire control station;
adjacent to the exit of fuel preparation rooms.
The gas compressors shall also be arranged for manual local emergency stop.

**9.10.6.2** Where gas-fuel leakage is found and in case of system failure, the safety system shall automatically activate regulating functions stated in Table 9.10.6.2.

Table 9.10.6.2

| 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 | x | | | Except for fuel storage hold spaces for type C independent tanks |
| Gas detection by two detectors[1] in gas fuel tank storage room above 40 % LEL | x | x | | Except for fuel storage hold spaces for type C independent tanks |
| Gas detection in tank connection space above 20 % LEL | x | | | |
| Gas detection by two detectors[1] in tank connection space above 40 % LEL | x | x | | |
| Fire detection in gas fuel tank storage room | x | x | | |
| Bilge well high level in tank connection space | x | | | |
| Bilge well low temperature in tank connection space | x | x | | |
| Gas detection in the duct between gas fuel tank and machinery space containing gas consumers above 20 % LEL | x | | | |
| Gas detection by two detectors[1] in the duct between gas fuel tank and machinery space containing gas consumers above 40 % LEL | x | x[2] | x[2] | |
| Gas detection in fuel preparation room above 20 % LEL | x | | | |
| Gas detection by one of two detectors[1] in fuel preparation room above 40 % LEL | x | x[2] | | |
| Gas detection in gas compressor room above 20 % LEL | x | | | |
| Gas detection by one of two detectors[1] in gas compressor room above 40 % LEL | x | x[2] | | |
| Gas detection in the duct inside machinery space containing gas consumers above 30 % LEL | x | | | 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 60 % LEL | x | | x[3] | If double pipes are provided for gas supply to consumers |
| Gas detection in machinery space containing gas consumers above 20 % LEL | x | | | Gas detectors are required for protection of gas-dangerous machinery spaces only |

| Monitored parameter | Alarm | Automatic closure of master gas fuel valve[7] | Automatic shutdown of gas supply to consumers in machinery space | Notes |
|---|---|---|---|---|
| Gas detection by one of two detectors[1] in machinery space containing gas consumers above 40% LEL | x | | x | 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] | x | | x[2,4] | |
| Loss of ventilation in the duct inside machinery space containing gas consumers[6] | x | | x[3,4] | If double pipes are provided for gas supply to consumers |
| Loss of ventilation in machinery space containing gas consumers | x | | x | For protection of gas-dangerous machinery spaces only |
| Fire detection in machinery space containing gas consumers | x | | x | |
| Abnormal gas pressure in gas supply pipe | x | | x[4] | |
| Failure in valve control system | x | | x[5] | Time delay as found necessary |
| Automatic shutdown of engine (engine failure) | x | | x[5] | |
| Emergency shutdown of engine (manually or by operator) | x | | x | |

[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.

**9.10.6.3** Monitored parameters of the fuel installation using gases or low-flashpoint fuels, measuring points, limiting values of parameters and types of automatic protection and indication shall be found in Table 9.10.6.3.

Table 9.10.6.3

| Nos. | Monitored parameter | Indication, alarm | Automatic protection |
|---|---|---|---|
| **1** | **Fuel storage system** | | |
| **1.1** | Fuel level in fuel storage tank | ●↑↓ | ■[1] |
| **1.2** | Pressure in tank where fuel is stored as liquefied gas | ●↑↓[2] | – |
| **1.3** | Submersible fuel pump, low liquid level in tank | ↓ | ☐ |
| **1.4** | Submersible fuel pump, low motor current | ↓ | ☐ |
| **1.5** | Submersible fuel pump, discharge pressure in discharge line | ↓ | ☐ |
| **1.6** | Temperature of fuel in tank | ● | – |
| **1.7** | Pressure in fuel storage hold space without open connection to the atmosphere | ● | – |
| **1.8** | Pressure in interbarrier space without open connection to the atmosphere | ● | – |
| **2** | **Fuel supply system** | | |
| **2.1** | Fuel pump, discharge pressure in discharge line | ● | – |
| **2.2** | Bunker line, pressure in liquid fuel line | ● | – |
| **2.3** | Bunker line, pressure in gas vapour line | ● | – |
| **2.4** | Gas pressure at heat exchanger outlet | ●↑↓ | – |
| **2.5** | Gas temperature at heat exchanger outlet | ●↓ | – |
| **2.6** | Heating medium temperature at heat exchanger outlet | ↓ | – |
| **2.7** | Heating medium flow in heat exchanger | ↓ | – |
| **2.8** | Heating medium expansion tank for fuel heating system, level of heating medium in tank | ↓ | – |
| **3** | **Compressors** | | |
| **3.1** | Gas compressor, suction pressure | ↓ | × |
| **3.2** | Gas compressor, discharge pressure | ●↑↓ | × |
| **3.3** | Gas compressor, discharge temperature | ↑ | × |
| **3.4** | Lubricating oil pressure | ↓ | × |
| **3.5** | Lubricating oil temperature | ↑ | × |
| **3.6** | Rotor displacement or vibration[3] | ↑ | × |
| **3.7** | Bearing temperature[3] | ↑ | × |
| **3.8** | Temperature of bulkhead shaft glands and bearings | ●↑ | – |
| **4** | **Spaces, gas monitoring devices** | | |
| **4.1** | Airlock, more than one door moved from closed position | ○ | – |
| **4.2** | Airlock, gas concentration in space | ↑ | – |
| **4.3** | Bunkering station, gas concentration in space (if required) | ↑ | – |
| **4.4** | Heating medium expansion tank for fuel heating system, gas concentration in tank | ↑ | – |
| **4.5** | $O_2$ concentration in $N_2$ generation and storage space | ↓ | – |

Symbols:
● — remote indication;
↑ — alarm for high value;
↓ — alarm for low value;
○ — alarm;
☐ — pump shutdown;
■ — automatic closure of master valve of fuel tank;
× — compressor shutdown.

[1]Three independent devices for indication, alarm and closure of master valve.
[2]Low-pressure alarm if vacuum protection is required.
[3] For centrifugal compressors.

## 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 ship shall be provided with operational procedures including a suitably detailed Fuel Handling Manual containing at least the following data:

**.1** overall operation of the ship from dry-dock to dry-dock, including procedures for system cool down and warm up, bunkering and, where appropriate, discharging, sampling, inerting and gas freeing;

**.2** temperature and pressure control during bunkering, alarm and safety systems;

**.3** system limitations, cool down rates and maximum fuel storage tank temperatures prior to bunkering, including minimum fuel temperatures, maximum tank pressures, transfer rates, filling limits and sloshing limitations;

**.4** operation of inert gas systems;

**.5** firefighting and emergency procedures: operation and maintenance of fire extinguishing systems and use of extinguishing media;

**.6** specific fuel properties and special equipment needed for the safe handling of the particular fuel;

**.7** fixed and portable gas detection operation and maintenance of equipment;

**.8** emergency shutdown and emergency release systems, where fitted; and

**.9** a description of the procedural actions to take in an emergency situation, such as leakage, fire or potential fuel stratification in fuel storage tank resulting in rollover.

**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, 2021 and apply to the ships operating in the Baltic Sea area in winter and water areas of other seas with similar ice conditions.

**10.1.2 Design temperature of ambient air.**

When selecting steel grades for hull structures, the minimum design temperature of ambient air $T_A$ shall not exceed −30 °C.

N o t e . The limitation of the design temperature is based on the document "Guidelines for the application of the 2017 Finnish-Swedish Ice Class Rules", 8 January 2019.

## 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 $\Delta$ = 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.;

$\varphi_1$ — the rake of the stem at the centreline, in deg. $\varphi_1$ = 90° for a ship with a bulbous bow;

$\varphi_2$ — 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.

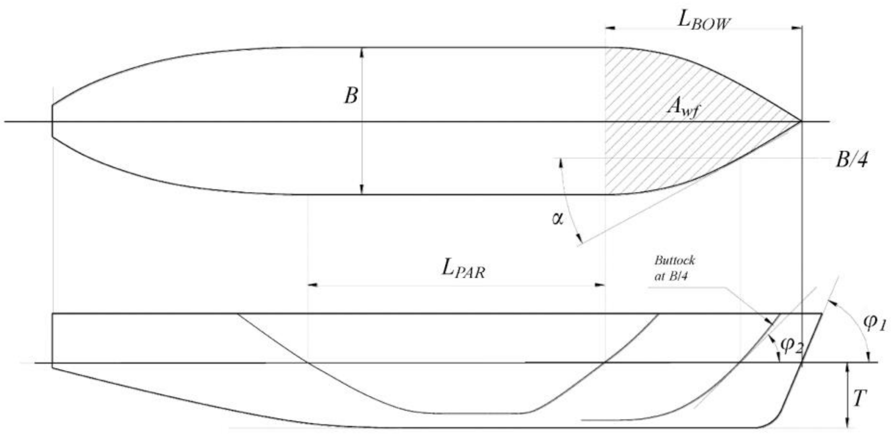



Fig. 10.4.1.1
Determination of the geometric quantities of the hull

**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 |

$$R_{CH} = C_1 + C_2 + C_3 C_\mu (H_F + H_M)^2 (B + C_\psi H_F) + C_4 L_{PAR} H_F^2 + C_5 \left(\frac{LT}{B^2}\right)^3 \frac{A_{wf}}{L}, \qquad (10.4.3\text{-}2)$$

where $C_\mu$ = 0,15cosφ$_2$ + sinψsinα, $C_\mu$ shall be taken equal or larger than 0,45;
$C_\psi$ = 0,047ψ – 2,115, and $C_\psi$ = 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**.

$$C_1 = f_1 \frac{B L_{PAR}}{2(T/B)+1} + (1 + 0{,}021\varphi_1)(f_2 B + f_3 L_{BOW} + f_4 B L_{BOW}) \qquad (10.4.3\text{-}3)$$

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**.

$$C_2 = (1 + 0{,}063\varphi_1)(g_1 + g_2 B) + g_3 (1 + 1{,}2\frac{T}{B})\frac{B^2}{\sqrt{L}} \qquad (10.4.3\text{-}4)$$

for ice class **IA Super**;
$g_1$ = 1530 N;
$g_2$ = 170 N/m;
$g_3$ = 400 N/m$^{1,5}$;
$C_3$ = 845 kg/(m$^2$s$^2$);
$C_4$ = 42 kg/(m$^2$s$^2$);
$C_5$ = 825 kg/s$^2$.

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.

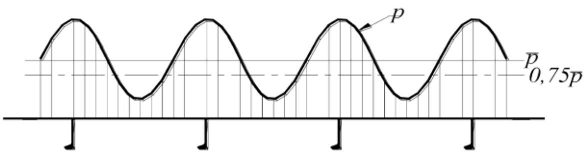



Fig. 10.5.1-1
Ice load distribution on a ship's side

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 1,8$p$ 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, 0,5$h_0$ 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 $\sigma_y$. When the direct calculation is using beam theory, the allowable shear stress is not to be larger than 0,9$\tau_y$, 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".

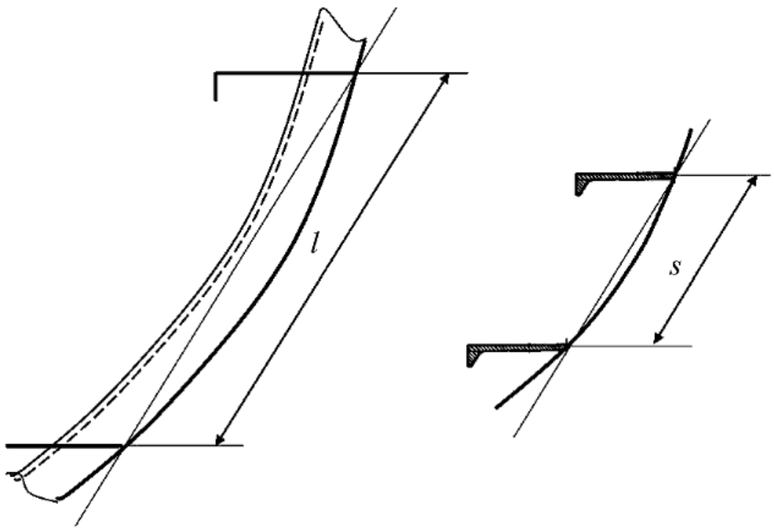



Fig. 10.5.1-2
Definition of the frame span (left) and frame spacing (right) for curved members

**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 centreline. 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 centreline. 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".

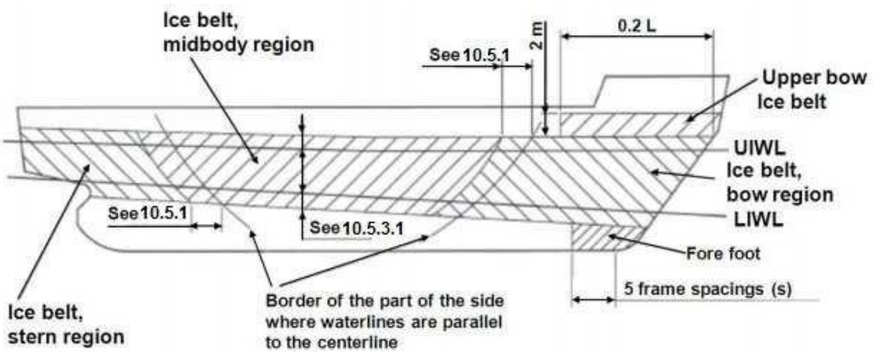



Fig. 10.5.1.1
Ice strengthened regions of the hull

### 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 Table10.5.2.1:

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:

$$p = c_d c_p c_a p_0, \text{ in MPa} \quad (10.5.2.2)$$

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 Table10.5.2.2-1:

Table 10.5.2.2-1

| | Region | | | |
|---|---|---|---|---|
| | bow | | midbody and stern | |
| | $k \le 12$ | $k > 12$ | $k \le 12$ | $k > 12$ |
| $a$ | 30 | 6 | 8 | 2 |
| $b$ | 230 | 518 | 214 | 286 |

$\Delta$ = 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:

$$c_a = \sqrt{l_0/l_a},\ 0{,}35 \ge c_a \ge 1{,}0$$

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;

$p_{pl}$ = 0,75$p$, 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;

$\sigma_y$ = yield stress of the material, in MPa, for which the following values shall be used:

$\sigma_y$ = 235 MPa for normal-strength hull structural steel;

$\sigma_y$ = 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 2 mm shall be indicated in hull structural drawing. A special entry shall be made in the Classification Certificate of such ships (refer to 2.4.1, 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 or a 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:

$$Z = \frac{pshl}{m_t \sigma_y} \times 10^6. \qquad (10.5.4.2.1\text{-}1)$$

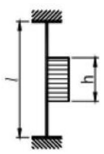
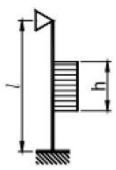
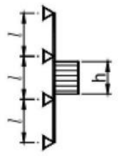
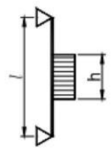
The effective shear area is calculated from the formula

$$A = \frac{\sqrt{3} f_3 phs}{2\sigma_y} \times 10^4, \text{ in cm}^2 \qquad (10.5.4.2.1\text{-}2)$$

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;
$\sigma_y$ = 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:

$$Z = \frac{f_4 p h l^2}{m \sigma_y} 10^6 \qquad (10.5.4.3.1\text{-}1)$$

and effective shear area of a longitudinal frame, in cm$^2$, shall be not less than determined by the following formula:

$$A = \frac{\sqrt{3} f_4 f_5 p h l}{2 \sigma_y} 10^4 \text{, in cm}^2\text{,} \qquad (10.5.4.3.1\text{-}2)$$

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;
$\sigma_y$ = 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 $\sigma_y$ 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

$$Z=\frac{f_6 f_7 p h l^2}{m\sigma_y}10^6\text{, in cm}^3. \tag{10.5.5.1-1}$$

The effective shear area shall be taken not less than determined by the formula

$$A=\frac{\sqrt{3}f_6 f_7 f_8 p h l}{2\sigma_y}\times 10^4\text{, in cm}^2 \tag{10.5.5.1-2}$$

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;
$\sigma_y$ = 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

$$Z = \frac{f_9 f_{10} p h l^2}{m \sigma_y}(1 - h_s/l_s)10^6, \text{ in cm}^3. \qquad (10.5.5.2\text{-}1)$$

The effective shear area shall be taken not less than determined by the formula

$$A = \frac{\sqrt{3} f_9 f_{10} f_{11} p h l}{2\sigma_y}(1 - h_s/l_s)10^4, \text{ in cm}^2, \qquad (10.5.5.2\text{-}2)$$

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;
$\sigma_y$ = 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:

$$F = f_{12} p h S, \text{ in MN} \qquad (10.5.6.1)$$

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

$$A = \frac{\sqrt{3}\alpha f_{13} Q}{2\sigma_y} 10^4, \text{ in cm}^2, \qquad (10.5.6.2\text{-}1)$$

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;
$\alpha$ = refer to Table 10.5.6.2;
$\sigma_y$ = 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 $M = 0{,}193Fl$;
$\gamma$ = 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.

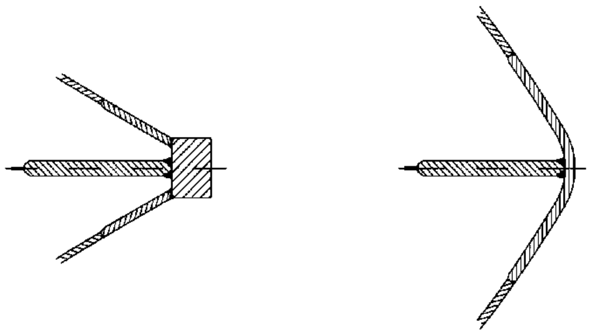


Fig. 10.5.7.1
Examples of suitable stems

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 azimuth 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 $r$ = 0,7$R$, 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 $r$ = 0,7$R$, in m.

$P_{0,7n}$ — propeller pitch at radius $r$ = 0,7$R$ at MCR in free running condition, in m.

$P_{0,7b}$ — propeller pitch at radius $r$ = 0,7$R$ 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.
$Q_{s\max}$ — 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.
$\alpha_1$ — phase angle of propeller ice torque for blade order excitation component, in deg.
$\alpha_2$ — phase angle of propeller ice torque for twice-the-blade order excitation component, in deg.
$\gamma_v$ — reduction factor for fatigue; variable amplitude loading effect.
$\gamma_m$ — reduction factor for fatigue; mean stress effect.
$\rho$ — 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.
$\sigma_{exp}$ — mean fatigue strength of blade material at $10^8$ cycles to failure in sea water, in MPa.
$\sigma_{fat}$ — equivalent fatigue ice load stress amplitude for $10^8$ stress cycles, in MPa.
$\sigma_{fl}$ — characteristic fatigue strength for blade material, in MPa.
$\sigma_u$ — 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.
$\sigma_{st}$ — 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.<br>The direction of the force is perpendicular to 0,7$R$ 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.<br>The direction of the force is perpendicular to 0,7$R$ chord line. | Design force for calculation of strength of the propeller blade. |
| $Q_{smax}$ | 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.<br>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.<br>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 0,8$R$. 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 0,8$R$ 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 behaviour 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 behaviour 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.

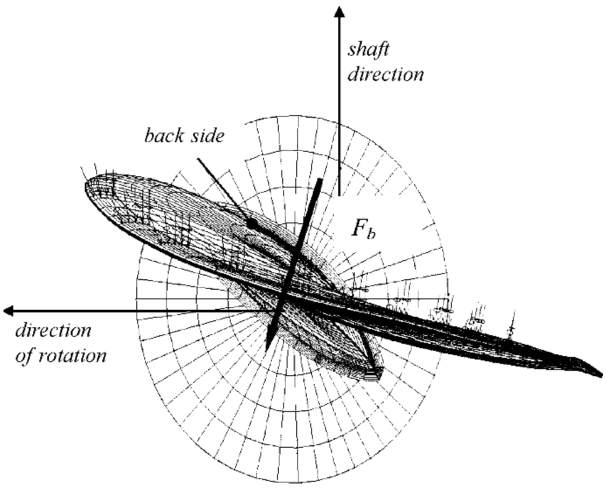



Fig. 10.7.2
Direction of force $F_b$.
Ice contact pressure at leading edge is shown with small arrows

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 °C. For nodular cast iron, average impact energy of 10 J at –10 °C 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 °C. 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 °C.

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.

$$F_b = 27[nD]^{0,7}\left[\frac{EAR}{Z}\right]^{0,3} D^2, \text{ in kN, when } D \le D_{limit}; \qquad (10.7.5.1.1\text{-}1)$$

$$F_b = 27[nD]^{0,7}\left[\frac{EAR}{Z}\right]^{0,3} DH_{ice}^{1,4}, \text{ in kN, when } D > D_{limit} \qquad (10.7.5.1.1\text{-}2)$$

where $D_{limit}$ = 0,85 $H_{ice}^{1,4}$, in m;
$n$ = $n_n$ for a CP propeller;
$n$ = 0,85$n_n$ for a FP propeller.

**10.7.5.1.2** Force $F_f$ for open propellers.

$$F_f = 250\left[\frac{EAR}{Z}\right] D^2, \text{ in kN, when } D \le D_{limit}; \qquad (10.7.5.1.2\text{-}1)$$

$$F_f = 500\left[\frac{EAR}{Z}\right] D \frac{1}{\left(1-\frac{d}{D}\right)} H_{ice}, \text{ in kN, when } D > D_{limit} \qquad (10.7.5.1.2\text{-}2)$$

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

**10.7.5.1.3** 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.

$$F_b = 9{,}5[nD]^{0,7}\left[\frac{EAR}{Z}\right]^{0,3} D^2, \text{ in kN, when } D \le D_{limit}; \qquad (10.7.5.1.4\text{-}1)$$

$$F_b = 66[nD]^{0,7}\left[\frac{EAR}{Z}\right]^{0,3} D^{0,6}H_{ice}^{1,4}, \text{ in kN, when } D > D_{limit} \qquad (10.7.5.1.4\text{-}2)$$

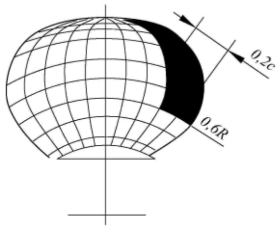
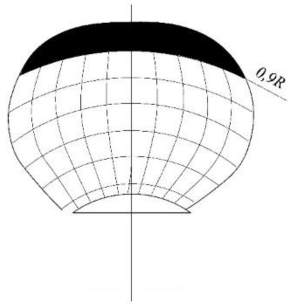
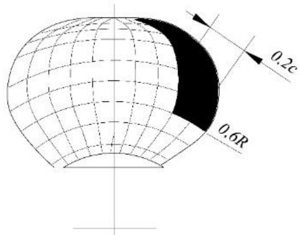
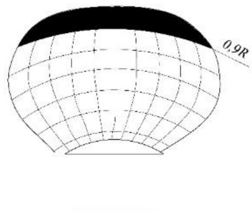
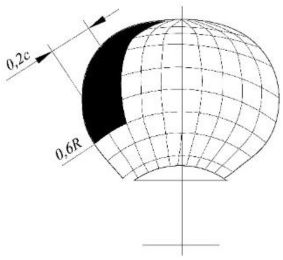
where $D_{limit}$ = 4$H_{ice}$ , in m;
$n$ = $n_n$ for a CP propeller;
$n$ = 0,85$n_n$ for a FP propeller.

**10.7.5.1.5** Maximum forward blade ice force $F_f$ for ducted propellers.

$$F_f = 250\left[\frac{EAR}{Z}\right] D^2, \text{ in kN, when } D \le D_{limit}; \qquad (10.7.5.1.5\text{-}1)$$

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 0,6$R$ 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 0,9$R$ radius |  |
| Load case 3 | $F_f$ | Uniform pressure applied on the blade face (pressure side) to an area from 0,6$R$ 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 0,9$R$ 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 0,6$R$ to the tip and from the trailing edge to 0,2 times the chord length |  |

$$F_f = 500\left[\frac{EAR}{Z}\right] D \frac{1}{\left(1-\frac{d}{D}\right)} H_{ice}, \text{ in kN, when } D > D_{limit} \qquad (10.7.5.1.2\text{-}2)$$

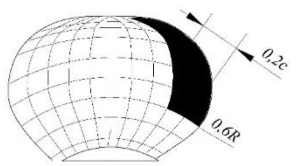
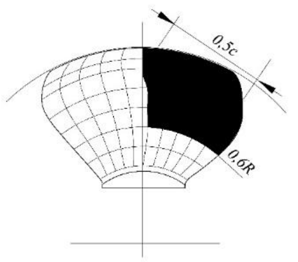
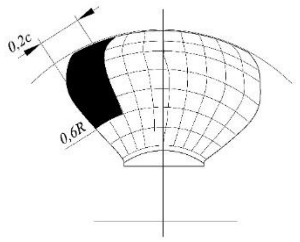
where $D_{limit} = \frac{2}{\left(1-\frac{d}{D}\right)} H_{ice}$, in m.

**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 0,6$R$ 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 0,6$R$ 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 0,6$R$ 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:

$$Q_{s\max} = 0{,}25 F c_{0,7}, \text{ in kNm} \tag{10.7.5.1.7}$$

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.

$$P\left(\frac{F_{ice}}{(F_{ice})_{\max}} \geq \frac{F}{(F_{ice})_{\max}}\right) = \exp\left(-\left(\frac{F}{(F_{ice})_{\max}}\right)^k \ln N_{ice}\right) \tag{10.7.5.1.8}$$

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 < $F_{ice}$ < $(F_{ice})_{\max}$.

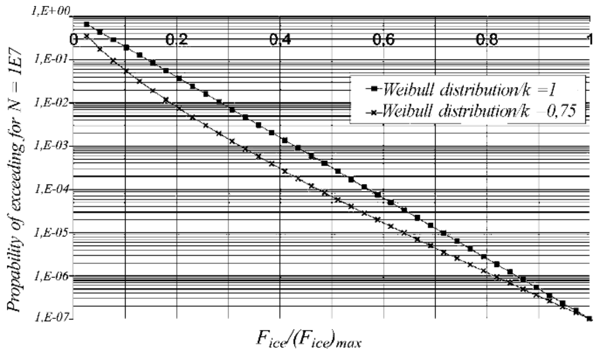



Fig. 10.7.5.1.8
The Weibull-type distribution

**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 $T_b$:

$$T_f = 1{,}1 F_f, \text{ in kN}; \qquad (10.7.5.2.1\text{-}1)$$

$T_b = 1{,}1F_b$, 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.

$$Q_{\max} = 10{,}9\left[1-\frac{d}{D}\right]\left[\frac{P_{0,7}}{D}\right]^{0,16}(nD)^{0,17}D^3\text{, in kNm, when } D \le D_{limit};$$

$$Q_{\max} = 20{,}7\left[1-\frac{d}{D}\right]\left[\frac{P_{0,7}}{D}\right]^{0,16}(nD)^{0,17}D^{1,9}H_{ice}^{1,1}\text{, in kNm, when } D > D_{limit}$$

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.

$$Q_{\max} = 7{,}7\left[1-\frac{d}{D}\right]\left[\frac{P_{0,7}}{D}\right]^{0,16}(nD)^{0,17}D^3\text{, in kNm, when } D \le D_{limit};$$

$$Q_{\max} = 14{,}6\left[1-\frac{d}{D}\right]\left[\frac{P_{0,7}}{D}\right]^{0,16}(nD)^{0,17}D^{1,9}H_{ice}^{1,1}\text{, in kNm, when } D > D_{limit}$$

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 | 0,75$Q_n$ |
| *$Q_{motor}$ = 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;

$\varphi$ – rotation angle from when the first impact occurs. Parameters $C_q$ and $\alpha_i$ are specified in Table 10.7.5.3.4.1;

$\alpha_i$ = duration of propeller blade/ice interaction expressed in terms of the propeller rotation angle (refer to Fig. 10.7.5.3.4.1-1).

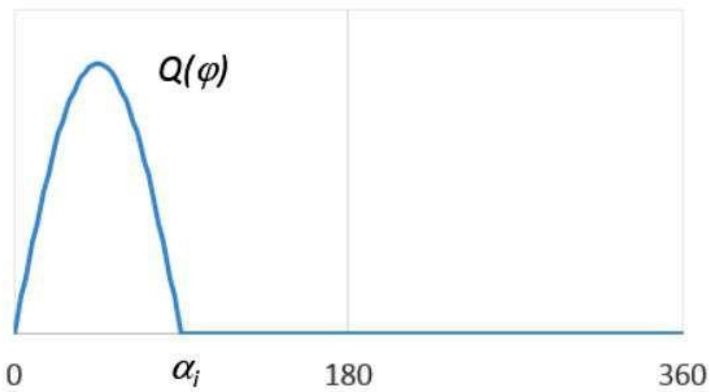



Fig. 10.7.5.3.4.1-1
Ice torque due to a single blade ice impact as a function of the propeller rotation angle.

Table 10.7.5.3.4.1

| Torque excitation | Propeller/ice interaction | $C_q$ | $\alpha_i$, 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.

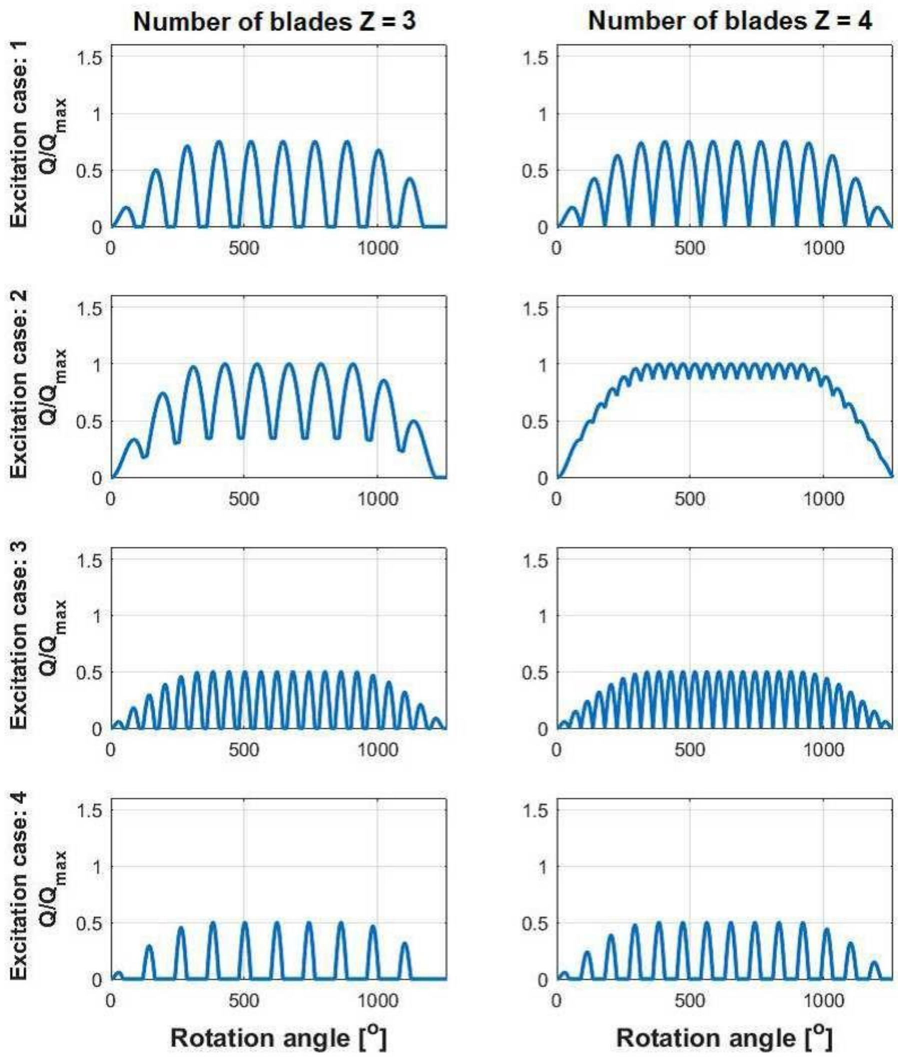



Fig. 10.7.5.3.4.1-2
Propeller ice torque excitation for propellers with 3 and 4 blades

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:

$$Q_{peak} = Q_{\text{emax}} + Q_{rtd}$$

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.

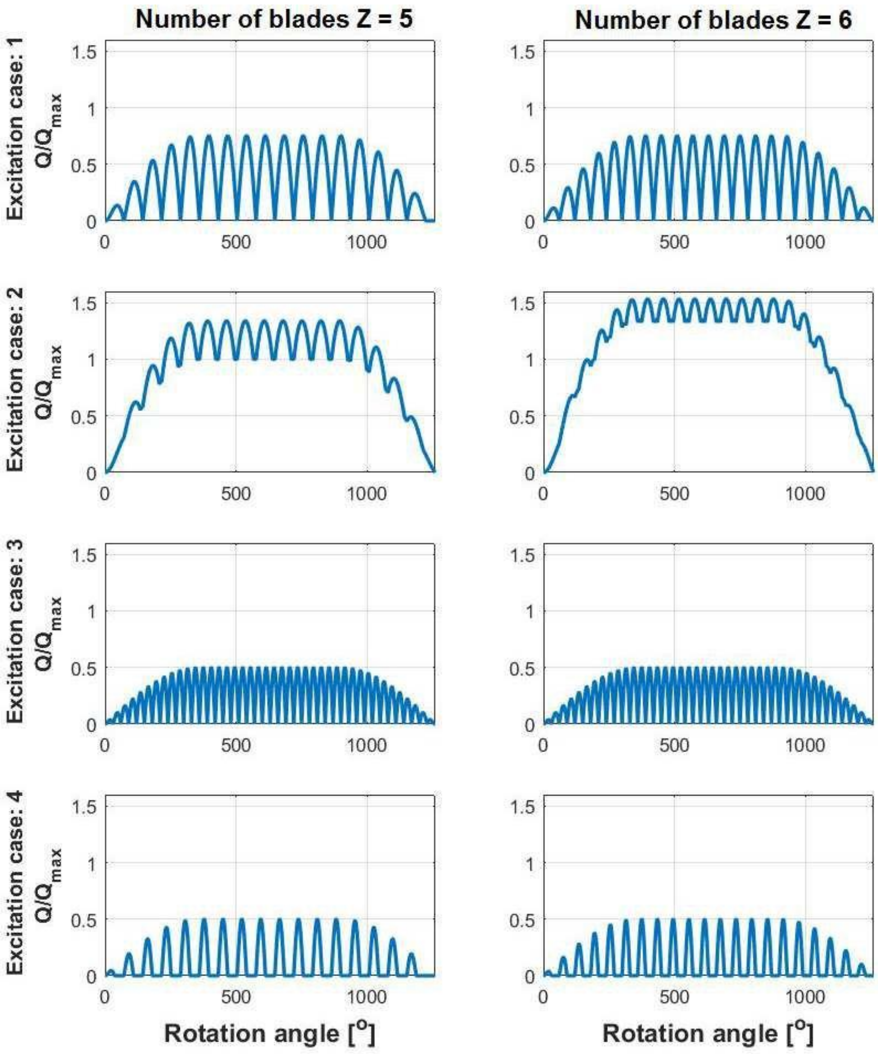



Fig. 10.7.5.3.4.1-3
Propeller ice torque excitation for propellers with 5 and 6 blades

The design torque for the frequency domain excitation case shall be obtained using the formula:

$$Q_{peak} = Q_{e\max} + Q_{vib} + (Q_{\max}^{n} C_{q0}) I_e / I_t + Q_{rf1} + Q_{rf2}$$

where $Q_{\max}^{n}$ = 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 | $C_{q0}$ | $C_{q1}$ | $\alpha_1$ | $C_{q2}$ | $\alpha_2$ | $E_0$ |
|---|---|---|---|---|---|---|
| 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.

$$Q_{sex} = \max(C_{LE0,8}; 0,8C_{TE0,8})\, C_{spex}F_{ex}, \text{ in kNm;}$$

$$C_{spex} = 0,7(1-(4EAR/Z)^3)$$

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 0,8$R$
$C_{TE0,8}$ = the trailing edge portion of the chord length at 0,8$R$.

The spindle torque values due to blade failure loads across the entire chord length are shown in Fig. 10.7.5.4.2.

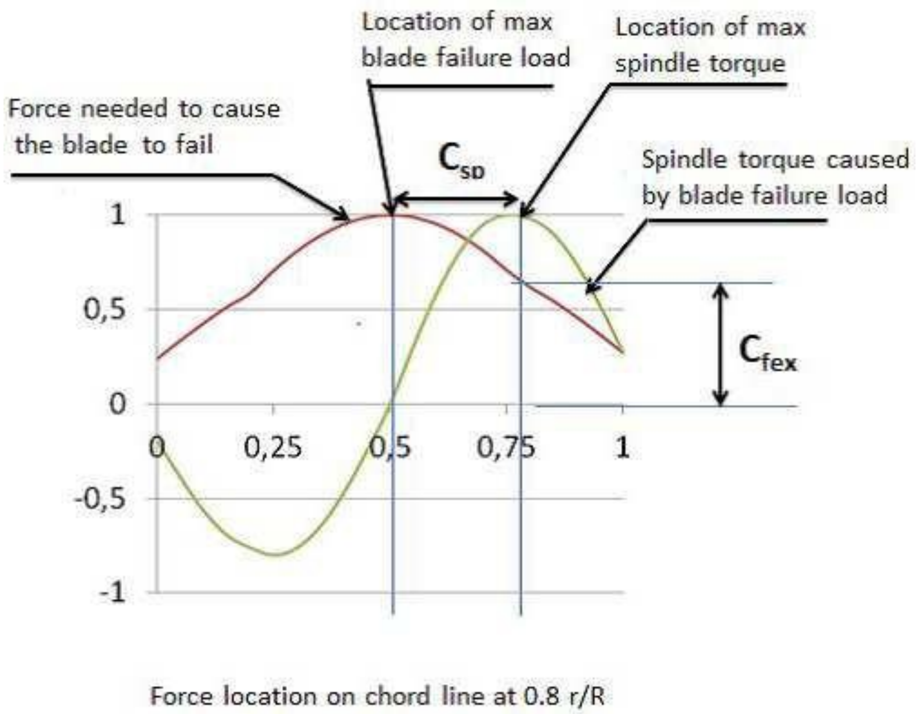



Fig. 10.7.5.4.2
Blade failure load and the related spindle torque when the force acts at a different location on the chord line at radius 0,8$R$

**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.

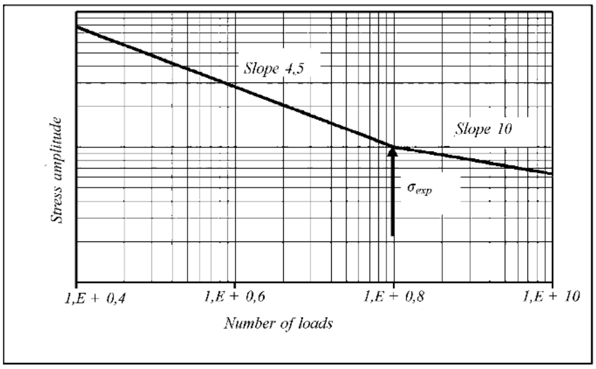



Fig. 10.7.6.2.3-1
Two-slope *SN*-curve

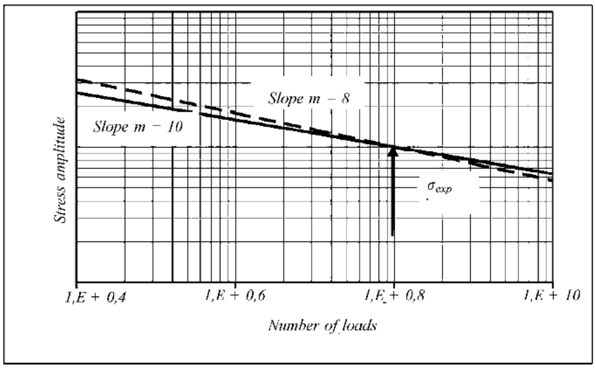



Fig. 10.7.6.2.3-2
Constant-slope *SN*-curve

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:

$$\sigma_{fat} = \rho(\sigma_{ice})_{\max} \tag{10.7.6.2.3.1}$$

where $(\sigma_{ice})_{\max} = 0{,}5\big((\sigma_{ice})_{f\max} - (\sigma_{ice})_{b\max}\big)$.

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

$$\rho = C_1(\sigma_{ice})_{\max}^{C_2}\sigma_{fl}^{C_3}\log(N_{ice})^{C_4} \tag{10.7.6.2.3.2}$$

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: $\gamma_\varepsilon$ = 0,67, $\gamma_\nu$ = 0,75 and $\gamma_m$ = 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

$$\rho = \left(G\frac{N_{ice}}{N_R}\right)^{1/m}(\ln(N_{ice}))^{-1/k} \tag{10.7.6.2.3.3}$$

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 $\sigma_{fl} = \gamma_{\epsilon 1} \gamma_{\epsilon 2} \gamma_{\nu} \gamma_{m} \sigma_{exp}$.

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, $\gamma_{\nu}$ = 0,75 and $\gamma_{m}$ = 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** Azimuth main thrusters.

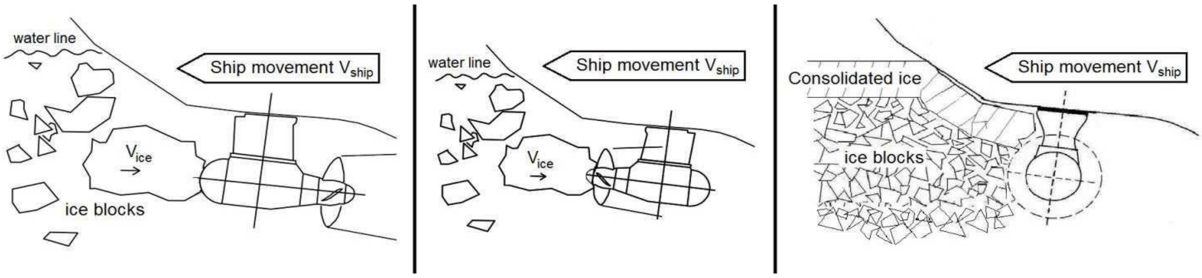
**10.7.6.5.1** Design principle.

In addition to the above requirements for propeller blade dimensioning, azimuth main 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

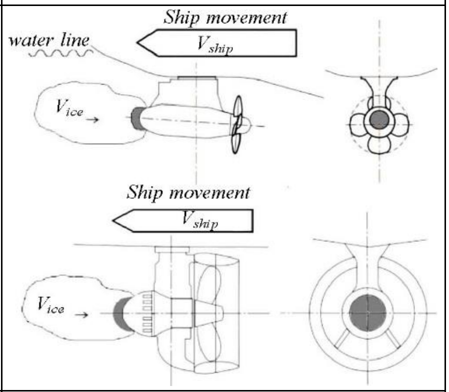
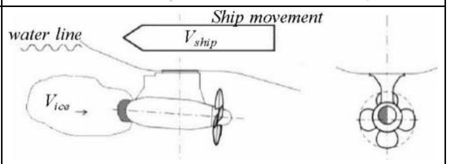
The steering mechanism, the fitting of the unit, and the body of the thruster shall be designed to withstand the plastic bending of a blade without damage. The loss of a blade shall be taken into account for the propeller blade orientation causing the maximum load on the component being studied. Top-down blade orientation typically places the maximum bending loads on the thruster body.

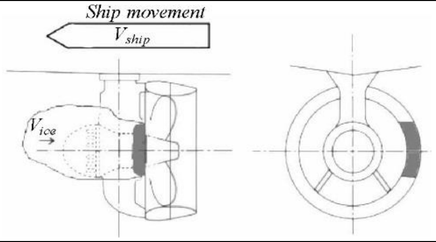
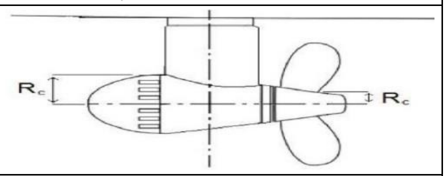
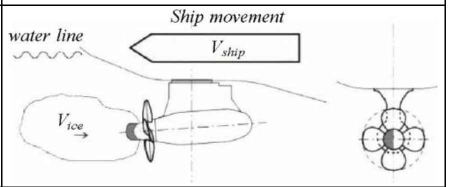
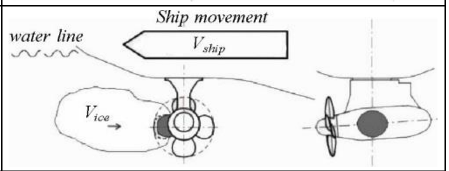
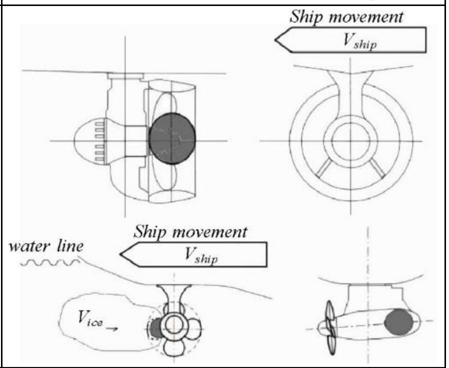
**10.7.6.5.2** Extreme ice impact loads.

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<br>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<br>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<br>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<br>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<br>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<br>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<br>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.

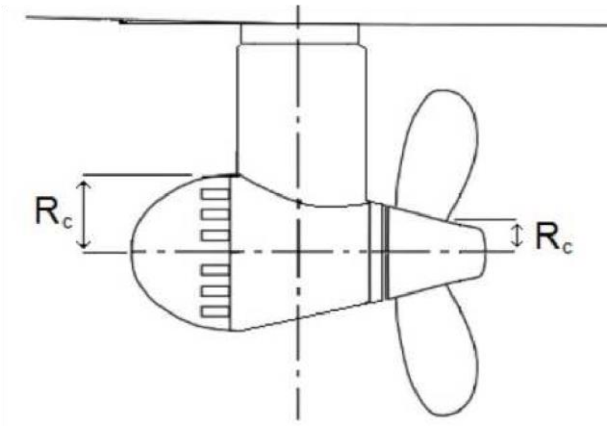



Fig. 10.7.6.5.2
Dimensions used for *Rc*

$C_{DMI}$ 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 centreline 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 centreline 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.

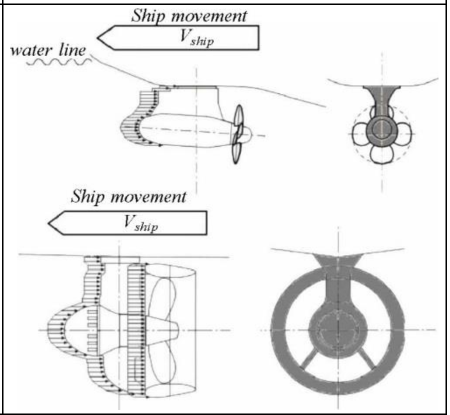
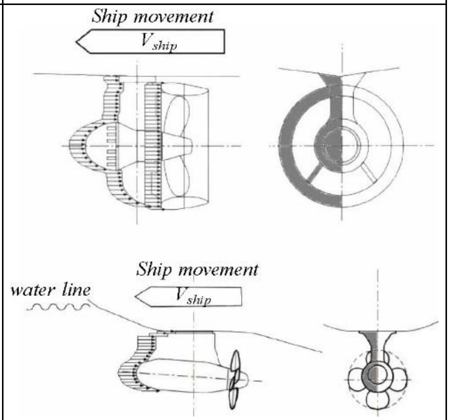
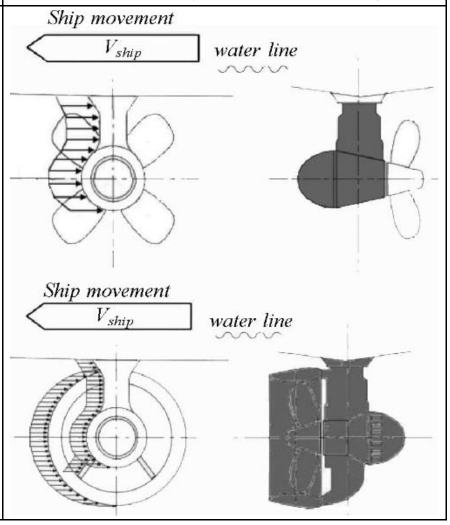
The stresses on the thruster shall be calculated for the extreme once-in-a-lifetime loads described in 10.7.6.5. The nominal von Mises stresses on the thruster body shall have a safety margin of 1,3 against the yielding strength of the material. At areas of local stress concentrations, stresses shall 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.

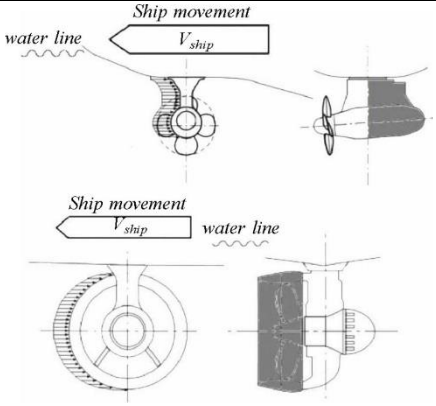
**10.7.6.5.5** Thruster body global vibration.

Evaluating the global vibratory behaviour 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<br>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<br>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<br>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<br>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 |   |

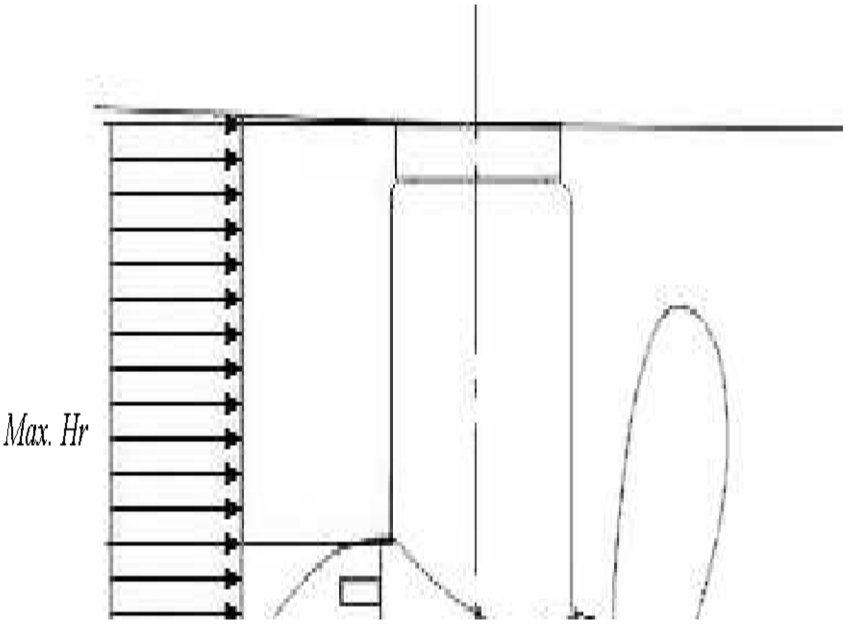



Fig. 10.7.6.5.3
The reduction of the contact area by the maximum ridge thickness.

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 the 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.

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.

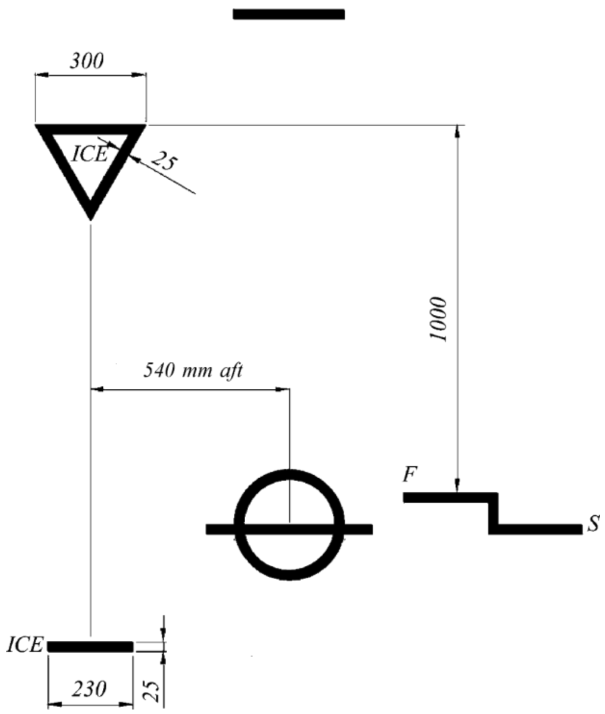



Fig.
Ice class draught marking

## 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.**

LNG bunkering station 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.

LNG bunkering control room 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.

Emergency shutdown system (ESD) 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.

Bunkering connections 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).

Emergency release coupling (ERC) 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** additional cargo transfer equipment (including transfer loading arms, bunkering booms, transfer hoses, adaptors, reducers, spool pieces and transfer hose reels) installed in different locations around the ship, shall comply, where applicable, with the requirements in 3.3.1.4, 3.3.1.5, 3.4.1 and 3.4.3 of Part V "Fire Protection" and 3.23.7.2 of Part VI "Systems and Piping" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk for fire detection and fire protection in the cargo area (ESD system functionality and fusible elements (refer to 3.17.4, Part VI "Systems and Piping" of that Rules), water-spray system and dry chemical powder fire-extinguishing system protection, drip trays), including hull protection from low temperatures;

**.4** 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 fuelled 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.

**12.1.2** 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.

**12.1.3** The requirements for arrangement and carrying out of an in-water survey are specified in Section 9 of Part II "Carrying Out Classification Surveys of Ships" of the Guidelines on Technical Supervision of Ships in Service.

## 12.2 TECHNICAL DOCUMENTATION

In-water survey plan, containing the following items (as applicable), shall be submitted to the Register for approval in the scope of plan approval documentation for a ship under construction:

arrangements plan of ship side valves and shell openings in the underwater hull;

stem and sternpost plan;

bilge keels plan;

rudder and fittings plan;

propeller plan, including the means used for identifying each blade;

arrangement of anodes and impressed current system;

procedure for measurement of clearances for rudder stock bearing and pintles (refer to 12.3.5);

procedure for afloat measurement of propeller shaft bearing sagging;

procedure for measurement of clearances for AMSS;

drawings of the marking on the side and bottom plating to identify the tanks, ship side valves, bottom plugs, echo sounders, speed log transducer, and other equipment, abbreviation table (refer to 12.3.6).

Aforesaid documentation approved by the Register shall be kept on board and shall be available to RS surveyor and other responsible personnel during an in-water survey.

## 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 ADDITIONAL REQUIREMENTS FOR SHIPS OF SPECIAL TYPES

## 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 AND SALVAGE SHIPS, AS WELL AS SHIPS CARRYING EQUIPMENT FOR FIRE FIGHTING ABOARD OTHER SHIPS

**13.2.1 General.**

**13.2.1.1** For ships intended to carry out rescue and standby services and complying with the requirements of 13.2.2 — 13.2.10, the descriptive notation **Standby vessel** may be assigned.

**13.2.1.2** For ships intended to carry out rescue services and complying as a minimum with the requirements of 13.2.3 (except for 13.2.3.1 — 13.2.3.3, 13.2.3.11), 13.2.4, 13.2.5 and 13.2.10, the descriptive notation **Salvage ship** may be assigned.

**13.2.1.3** Ships carrying equipment for firefighting aboard other ships and complying with the requirements of 7.2.1.10 and 9.2.12, Part III "Equipment, Arrangements and Outfit", 3.13.1 of Part IV "Stability", 5.1.2 and 6.6 of Part VI "Fire Protection", 7.1.10 and 13.7.7 of Part VIII "Systems and Piping" (as applicable) may be assigned one of the following distinguishing marks: **FF1, FF2, FF3, FF1WS, FF2WS, FF3WS**.

**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 (refer to 13.2.4.1.1).

**13.2.3.11** 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** Standby vessels and salvage ships taking into account their purpose and particulars of their structure shall be provided with additional life-saving appliances:

**.1** cargo handling gears installed onboard the ship shall be provided with nets, baskets or cradles to lift persons from the water and these nets, baskets and cradles as well as cargo handling gears shall comply with the requirements of 5.8 of the Rules for the Cargo Handling Gear of Sea-Going Ships;

**.2** irrespective of the length of the ship and the area of navigation, the ship shall be equipped with the line-throwing appliances having projectiles in accordance with the requirements of regulation III/34 SOLAS-74;

**.3** ship shall be equipped with gears for towing of liferafts and rescue boats, which number and list shall be decided by the shipowner. Specified additional gears, if subject to technical supervision, shall have documents required in accordance with Section 5 of Part I "General Regulations for Technical Supervision" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships;

**.4** ship shall be equipped with at least one fast rescue boat complying with the requirements of 5.1.4, LSA Code. The emergency source of power of launching appliances of the fast rescue boat shall provide operation of the launching appliances for at least 4 h;

**.5** ship shall be additionally equipped with lifejackets complying with the requirements of section 2.2 of the LSA Code, provided for 25 % of the number of survivors for which the ship is intended to carry. The number of survivors for which the ship is intended to carry shall be recorded in section "Other characteristics" of the Classification Certificate.

**13.2.5 Survivors' spaces.**

**13.2.5.1** The ship's documentation shall specify the number of survivors. 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.

**13.2.5.4** Upon agreement with the Register, the number of spaces may be revised subject to the justification provided by the designer/shipowner, taking into account the following: spaces provided for shelter of the survivors shall be enclosed and provided with heat, light and ventilation. If it is justified that it is impossible to allot additional spaces, survivors may be lodged in crew accommodations, except for sanitary areas, galleys, berths for the master and two crew members, the radio room (if any) and the wheelhouse.

**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, FI — 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 (FI).

**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) (FI);

**.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 (FI);

**.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 quick release system in operational and dead ship conditions (FI);

**.2** strength calculation (AG);

**.3** assembly drawings and general view (A).

**13.3.2.5** For stern rollers:

**.1** design criteria, including design loads (FI);

**.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 (FI).

**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 $\Delta_2$ 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 $HL_\theta$, 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

$\mathrm{arctg}(y/(h \cdot \sin\alpha))$;

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;

$\Delta_2$ = displacement of a vessel, including action of the vertical loads added $F_v$, at the centreline in the stern of the vessel.

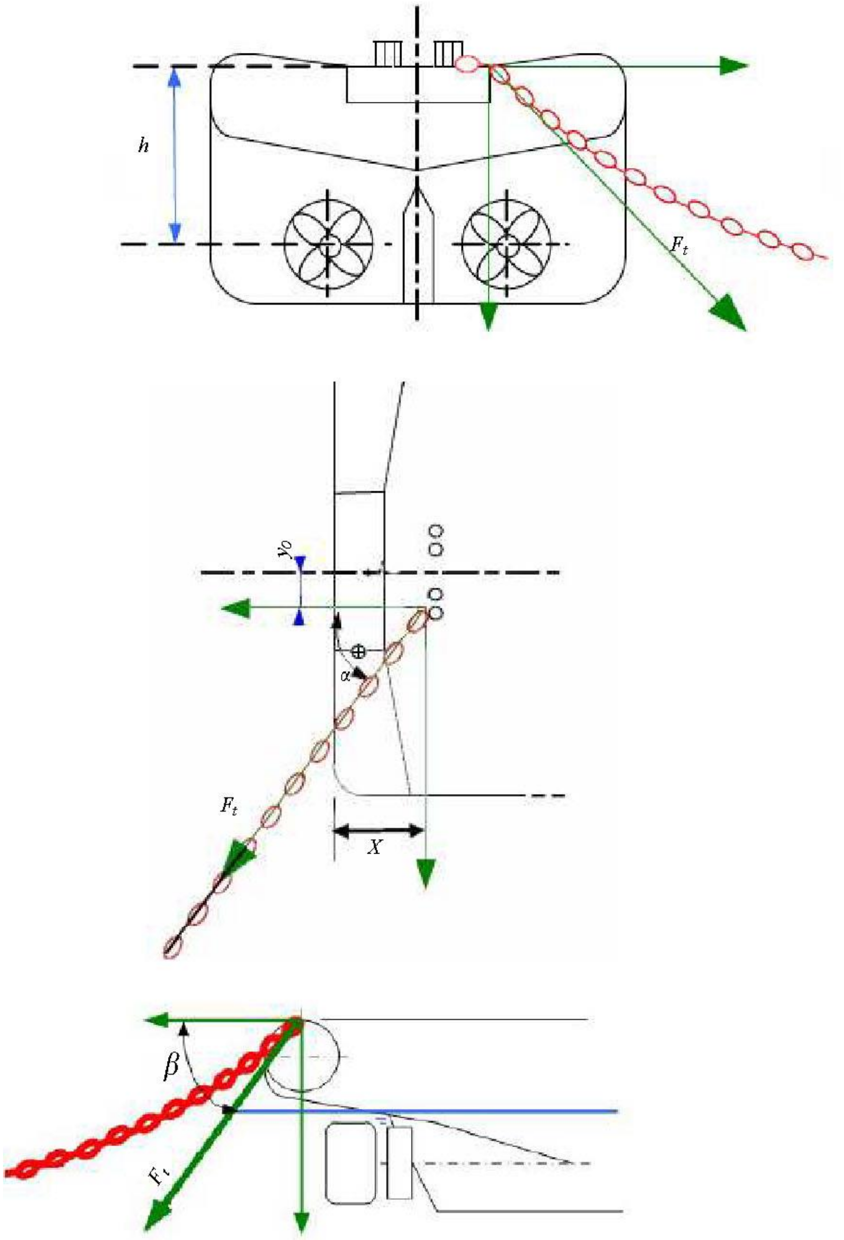



Fig. 13.3.5.4
Diagram showing the positions of angles α and β and distances $h$, $x$ and $y$.
$F_t$ shows the vector of the applied tow line tension

**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 centreline, 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**.

## 13.4 PILOT SHIPS

**13.4.1 General.**

For ships intended for transportation and safe embarkation/disembarkation of pilots from one board to another and complying with the requirements of this Chapter, a descriptive notation **Pilot ship** may be added to the character of classification.

**13.4.2 Basic requirements.**

**13.4.2.1** The pilot ships shall have a roll period $T$, in s, not less than:

9 s with displacement ≥ 250 t;

6 s with displacement < 250 t.

The roll period $T$ shall be determined by the formula given in the explication to formula 2.1.5.1 in Part IV "Stability".

**13.4.2.2** Those pilot ships whose intrinsic characteristics do not ensure these parameters shall be fitted with devices to reduce the amount of roll (anti-rolling devices, stabilisers, bilge keels, etc.).

**13.4.2.3** The stability of pilot ships shall comply with the requirements specified in Part IV "Stability" for stability of cargo ships.

**13.4.3 Design, equipment and supply.**

**13.4.3.1** In addition to the radio communication facilities required by Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships, all pilot ships shall be equipped with fixed or portable VHF radio sets ensuring communication with the ships being served and pilot stations via international channels. Pilot ships shall be fitted with a main and stand-by VHF radio set.

**13.4.3.2** Pilot ships intended for operation in cold climactic conditions shall be equipped with:

**.1** efficient means to prevent icing of deckhouse windows, the radar and radio aerials and the platform for transfer and disembarkation of a pilot;

**.2** radars having the smallest possible skip area, two radars — main and stand-by — being recommended for ships;

**.3** searchlights with anti-fog light filters.

**13.4.3.4** The anchor gear elements of pilot ships shall have increased strength due to the fact that the chain diameter shall be 10 % greater than that required by Part III "Equipment, Arrangements and Outfit".

**13.4.3.5** The design of mechanized pilot hoists shall ensure their efficient and safe usage in conditions of vibration, rolling and hydrometeorological factors acceptable for the operation of the ship.

The hoist shall be located as near the mid-section as possible, and in such a manner that the platform (cabin) is visible from the navigation bridge when transferring a pilot.

**13.4.3.6** To provide a view from the deckhouse of the pilot ship when transferring a pilot, the deckhouse ceiling shall be fitted with the scuttles to ensure that the platform (cabin) with the pilot is continuously in the field of vision of the person responsible for transferring the pilot to the ship being served.

**13.4.3.7** To transmit commands and signals, pilot ships shall be fitted with loudspeakers providing sufficient audibility forward, aft and along the sides.

**13.4.3.8** When determining the composition of life-saving appliances, the pilots simultaneously aboard the ship shall be assumed to be members of the crew.

**13.4.3.9** Pilot ships shall have manoeuvrability to function under adverse sea-and-wind conditions, taking into account the established operational limitations. For this purpose, it is recommended that they be equipped with two-shaft propulsion plants with controllable pitch propellers, diesel-electric plants capable of dead slow speed, steering nozzles or azimuth thrusters.

**13.4.3.10** To permit mooring to high freeboard ships, pilot ships shall be fitted with fairleads of such a design as to permit deflection of the mooring rope in a direction close to vertical.

The places of installation of fairleads shall be selected so that the tension of the mooring rope does not create a heeling moment dangerous for pilot ship stability.

**13.4.3.11** To ensure the pilot's safety during transfer and disembarkation at sea, the foredeck of pilot ships shall be as free from equipment as possible, and shall have a non-skid coating.

The hand-rail fitted on the deck at the area of disembarkation of a pilot, if any, shall be as close to the centre-plane as possible. When fitted along the sides, the hand-rail shall be kept sufficiently away from the sides to ensure the safety of the pilot when the boat is alist, and be within the extended reach of the pilot whilst he still holds the boarding ladder with his other hand.

The foredeck area shall be sufficient for disembarkation of the pilot from an accommodation ladder or from the hoist platform.

**13.4.3.12** For safe movement of the pilot along the ship, a passage not less than 600 mm wide shall be provided on both sides with a hand-rail on the superstructure wall.

**13.4.3.13** All pilot ships shall be fitted with fenders and side fenders which efficiently cushion the blows against the hull of the merchant ship.

**13.4.3.14** The place from which the transfer of the pilot is carried out shall be illuminated in such a manner that the light does not dazzle the pilot, the ship receiving the pilot or the members of the crew operating the hoisting/lowering device.

**13.4.3.15** In addition to the signal means specified by the International Regulations for Preventing Collisions at sea (RPCS-72) and Part III "Signal Means" of the Rules for the Equipment of Sea-Going Ships, pilot ships shall carry unified navigation lights and shapes by day indicating: "Make lee side, watch us". When the pilot is aboard by day, the ship shall carry the flag "H" of the International Code of Signals meaning: "I have a pilot on board".

**13.4.3.16** Where signal means required by national regulations and different from those specified in 13.4.3.15 are arranged on the ship, their operation shall not interfere with the signal means specified in 13.4.3.15.

**13.4.4 Painting.**

**13.4.4.1** Requirements for ship's hull painting.

Depending on the area of the pilot ship available for the identification marking, and in order to make the most effective use of the outside painting, two versions of painting are specified:

for ships with a freeboard amidships of 1 m and more: hull — yellow-orange, superstructure (deckhouse) — white (Figs. 13.4.4.1-1 and 13.4.4.1-2);

for ships with a freeboard amidships less than 1 m: hull and superstructure (deckhouse) — yellow-orange (Fig. 13.4.4.1-3).

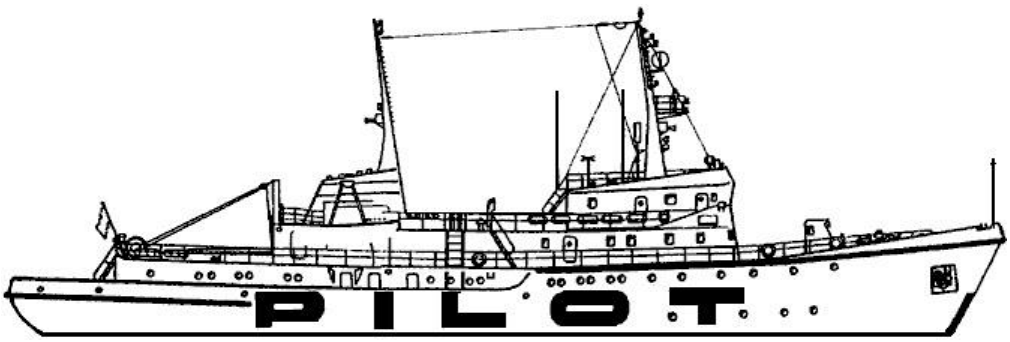



Fig. 13.4.4.1-1

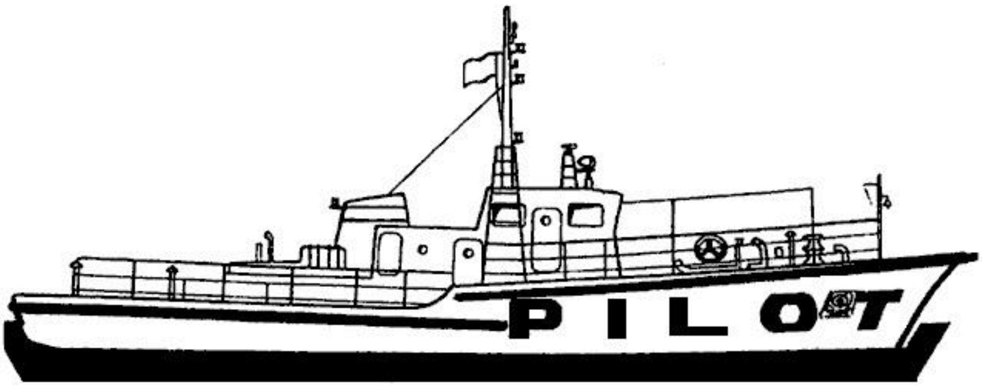



Fig. 13.4.4.1-2

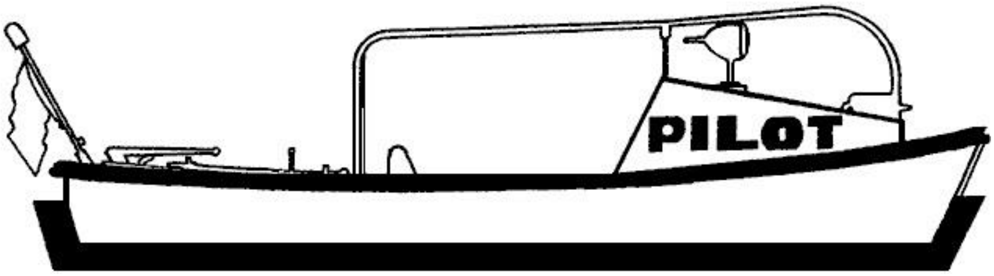



Fig. 13.4.4.1-3

**13.4.4.2** Requirements for colour.

To paint the surfaces yellow-orange, paints of a light, saturated, pure yellow-orange tint shall be used. Red-orange tints are not permitted. Colour standards are determined by national/international standards.

**13.4.5 Identification inscriptions.**

**13.4.5.1** Pilot ships shall carry an identification inscription "PILOT" in black.

**13.4.5.2** The inscription "PILOT" on pilot ships with a freeboard of 1 m or more shall be made on both sides of the hull (Figs. 13.4.4.1-1 and 13.4.4.1-2). The height of the letters shall be not less than half of the freeboard amidships. It is recommended that this inscription also be made on the front bulkhead of the superstructure in letters not less than 250 mm high.

**13.4.5.3** The inscription "PILOT" on pilot ships with a freeboard of less than 1 m shall be made on the deckhouse walls or on special boards on the superstructure on both sides (Fig. 13.4.4.1-3). The height of letters shall be not less than 250 mm.

In case of small dimensions or taking into account design features of the pilot ship, the inscription may be made on the deckhouse roof. If there is not enough space to place the word "PILOT" on the deckhouse roof, a black circle with a letter "P" in white, the base of which points to the bow of the ship, shall be used instead.

# 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:

$\Delta_N$ = 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);

$\Delta d$ = change of midship mean draft relative to level $d_N$ corresponding to design displacement $\Delta N$, in m;

$\psi_0$ = design trim angle of the ship, in deg. (positive nose-up trim);

$\psi_N$ = design sea bed slope angle along the ship, in deg.;

$\psi_S$ = operating trim angle of the ship, in deg.;

$\psi_{ON}$ = 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;

$\beta_k$ = deadrise angle, in deg.;

$h_k$ = design height of external structural protection below the keel line, in m;

$\upsilon_N$ = 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.

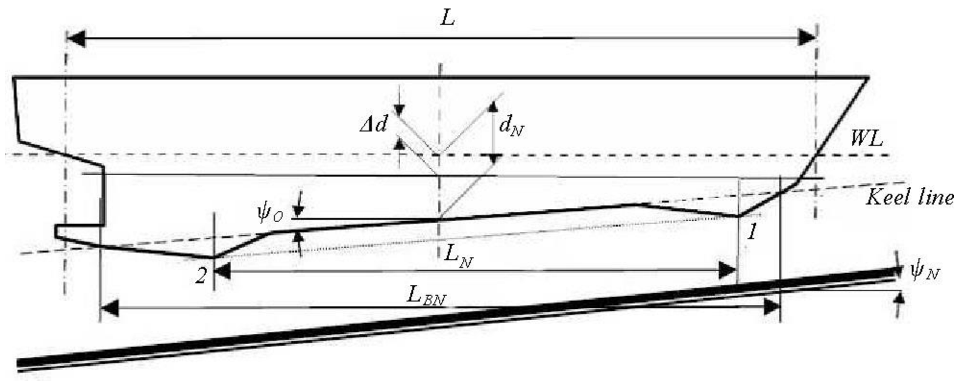



Fig. 15.2.2.1

**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.

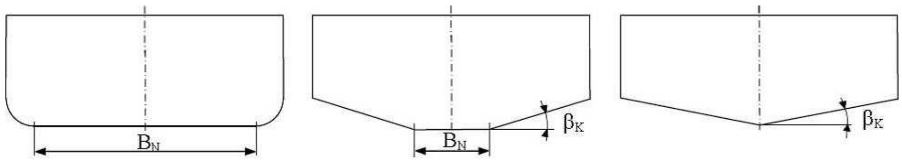



Fig. 15.2.3.1

**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:

$$L_A = 0{,}3L(1 + 0{,}175\psi_0) - 20h_k \geq 2L_3, \text{ but not more than } 0{,}3L \quad (15.2.4.2\text{-}1)$$

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.

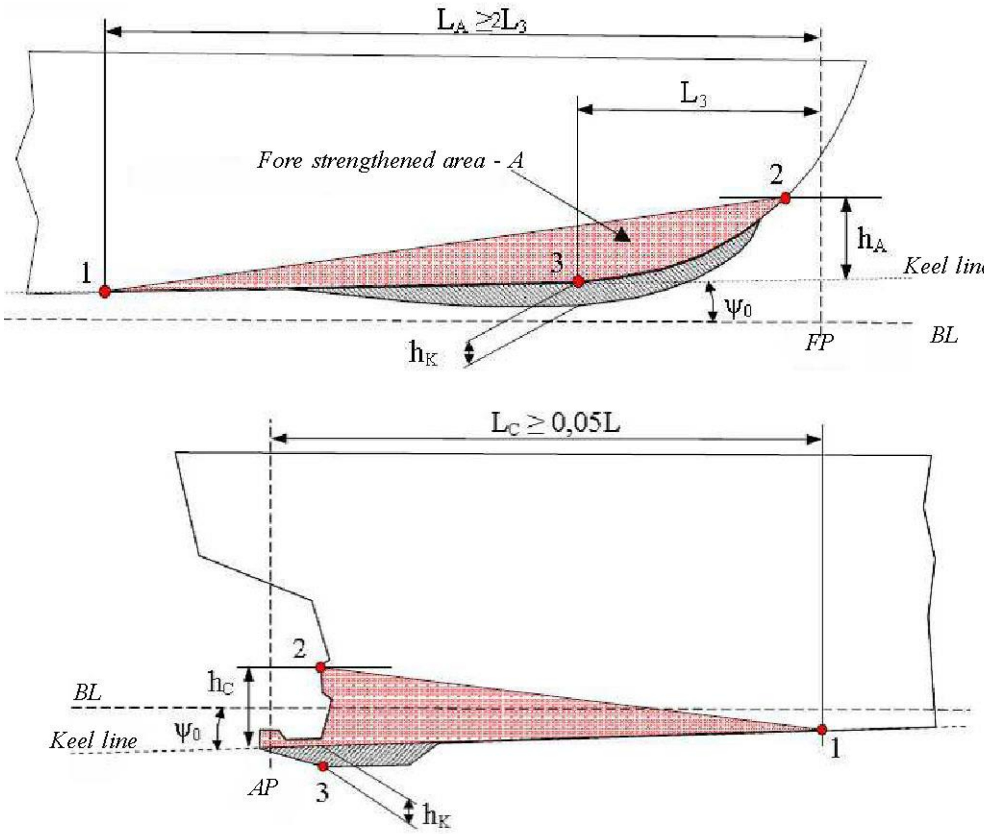



Fig. 15.2.4.2
*1* – point of distance from perpendicular; *2* – upper boundary;
*3* – point to determine the height of external structural protection

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 $\psi$ = design trim angle at rolling in the place of grounding, in rad; if no exact data is available, $\psi$ 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 following formula:

$$h_C = (0{,}5B - B_k) \cdot \mathrm{tg}\,\theta - h_k \leq h_{AN} \quad (15.2.4.2\text{-}5)$$

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;
$\theta$ = design heel angle at rolling in the place of grounding, in rad; if no exact data is available, $\theta$ 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 not more than 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.

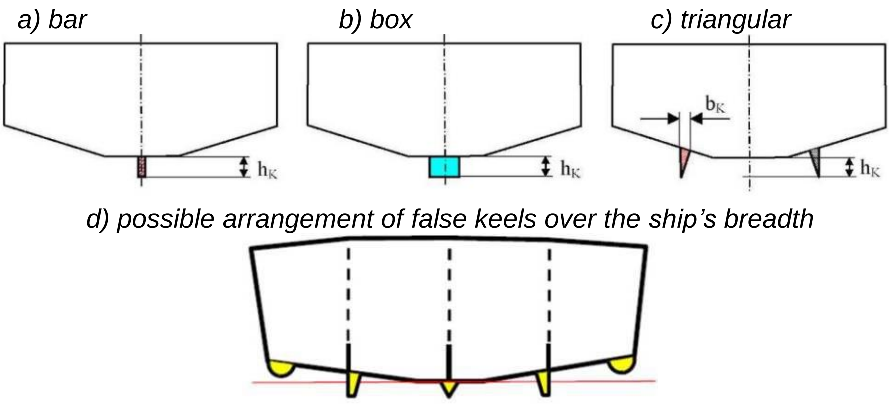



Fig. 15.2.5.7

**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

$$p_i = 10d_N(1 + 0{,}8/(A_i)^{1/2}), \tag{15.2.6.1}$$

where $d_N$ = refer to 15.2.2;
$A_i$ = calculated area of the member strain zone, in m².

**15.2.6.2** The required total area of contact with the seabed in case of full ship hull baring $A_N^{\min}$, in m², shall be at least

$$A_N^{\min} = g\Delta_N/R_0 \tag{15.2.6.2-1}$$

where $R_0$ = design nominal resistance of ground, in kPa, at least

$$R_0 > 10\Delta d. \tag{15.2.6.2-2}$$

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

$$Q_{OS} = k_\varphi R_N^n \frac{L_{OS}}{L_{BN}} \tag{15.2.6.3-1}$$

where $k_\varphi$ = 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:

$$R_N^n = g\Delta_N \frac{\Delta d}{d_N} \cdot \frac{\alpha}{C_b}. \tag{15.2.6.3-2}$$

For full baring conditions:

$$R_N^n = g\Delta_N \tag{15.2.6.3-3}$$

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.

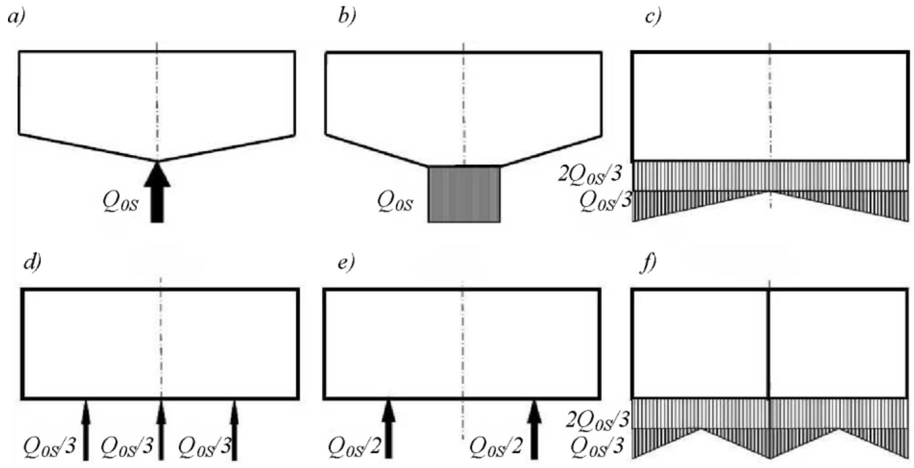



Fig. 15.2.6.3:
*a* – deadrise; *b* – flat-deadrise; *c* – flat; *d* – with three false keels;
*e* – with two false keels; *f* – flat with one longitudinal bulkhead at *CL*

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:

$$R_N^m = g\Delta_N\left[\frac{\mathrm{tg}(\psi_S-\psi_0-\psi_S-\psi_{ON})}{6}\frac{L}{d_N}\right] + R_{ON}. \quad (15.2.6.3\text{-}4)$$

For ships with the distinguishing mark **NAABSA1** $R_{ON}$ = 0 and $\psi_{ON}$=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:

$$M_N = 0{,}315\Delta_N L; \quad (15.2.6.4.3\text{-}1)$$

$$N_N = -1{,}03\Delta_N. \quad (15.2.6.4.3\text{-}2)$$

For partial hull baring of ships with the distinguishing mark **NAABSA1**, the obtained values can be reduced by replacing $\Delta_N$ 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**:

$$M_N = -0{,}363\Delta_N L; \quad (15.2.6.4.4\text{-}1)$$

$N_N = 2{,}45\Delta_N$. (15.2.6.4.4-2)

**15.2.6.4.5** In case of action of end force, including bow impact of ships with the distinguishing mark **NAABSA2**:

$M_N = -0{,}629\Delta_N L$; (15.2.6.4.5-1)

$N_N = 3{,}27\Delta_N$. (15.2.6.4.5-2)

**15.2.6.4.6** In case of action of end force, including bow or stern impact of ships with the distinguishing mark **NAABSA3**:

$M_N = -0{,}921\Delta_N L$; (15.2.6.4.6-1)

$N_N = 4{,}09\Delta_N$. (15.2.6.4.6-2)

**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 following formula:

$$W_{LM}(bot) = 1{,}1 \cdot \frac{|0{,}92M_N + M_{SW}|}{R_{eH}} \cdot 10^3 \quad (15.2.7.1)$$

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:

$$s = 15{,}8ak_\alpha\sqrt{\frac{k_p p}{k_\sigma R_{eH}}} \cdot m_n^{-1}, \quad (15.2.8.1)$$

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 $A_i = a \times b$;
$k_\sigma$ – 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:

$$s = \frac{10{,}6}{R_{eH}} \cdot pb \tag{15.2.8.2}$$

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:

$$W_0 = \frac{1000 k_p p a l^2}{m k_\sigma R_{eH}} k_\alpha k_k m_n^{-1} \tag{15.2.8.4}$$

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;
$k_\sigma$ = $0{,}95 - 0{,}42L/100$ – for bottom longitudinal girders in the midship strengthened area;
$k_\sigma$ = 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

$$f_c = \frac{5 k_p p a l (1 - \alpha/2)}{0{,}57 m_n k_\sigma R_{eH}} \tag{15.2.8.6}$$

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; |
| $k_\sigma$ | = | $0{,}95 - 0{,}42L/100$ for longitudinal beams of bottom framing in the midship strengthened area; |
| $k_\sigma$ | = | 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 2.4.4.9, 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 $k_\sigma$=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 $k_\sigma$=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

**15.3.1** 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 6.1.6, LSA Code.

## 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 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.

Monitoring 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.

Boiler water means water inside the boiler and all its components.

Feed water means water supplied by feed water pumps to the steam boiler to generate steam; it is a mixture of condensate and make-up water.

Make-up 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.

Condensate means water generated in the condensate and feed water system upon the waste steam condensation.

Distillate 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 analysed 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 2.10.3, 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 2.10.2.3, 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 2.10.2.1, 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 |

<table>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td></td><td></td><td></td><td>Fishing vessel, ships without descriptive notation in class notation, except for multi-hull ships</td><td></td></tr>
<tr><td rowspan="3">Transverse bending of hull</td><td>At forward perpendicular at upper deck</td><td rowspan="3">Single-axis long base linear surface strain sensor</td><td>Bulk carrier,<br>Ore carrier</td><td>Applicable to ships with large deck opening $L \geq 150$ m. Area of installation: not exceeding $0{,}01L$ from forward perpendicular</td></tr>
<tr><td>In way of forward part of cargo area at upper deck in centreline</td><td>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</td><td>Applicable to ships $L \geq 150$ m</td></tr>
<tr><td>At midship on port and starboard at upper deck</td><td>Container ship, Timber carrier, ships without descriptive notation in class notation</td><td>Applicable to ships with large deck opening $L \geq 200$ m</td></tr>
<tr><td rowspan="2">Vertical linear acceleration</td><td rowspan="2">At forward perpendicular</td><td rowspan="2">Single-axis accelerometer</td><td>Container ship, Timber carrier, ships without descriptive notation in class notation</td><td>Applicable to ships $L \geq 200$ m. Area of installation: not exceeding $0{,}01L$ from forward perpendicular</td></tr>
<tr><td>Ro-ro ship,<br>Ro-ro passenger ship</td><td>Applicable to ships with descriptive notation Ro-ro passenger ship $L \geq 100$ m. Area of installation: not exceeding $0{,}01L$ from forward perpendicular</td></tr>
<tr><td>Vertical, transverse and longitudinal linear accelerations</td><td>In forward and aft sections of cross-structure in ship centreline</td><td>Three-axis accelerometer</td><td>Multi-hull ships</td><td></td></tr>
<tr><td colspan="5">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.<br>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.</td></tr>
</table>

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:<br>1. Nearest to the midlength of the midbody region.<br>2. Nearest to the coordinate of 1/4 of length of the midbody region forward from the boundary of the midbody and stern regions.<br>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". | | | |

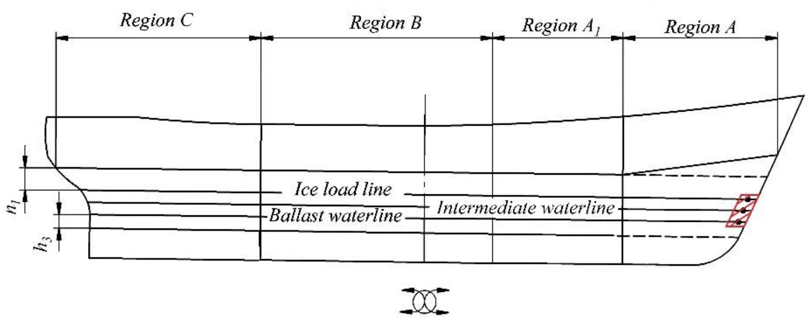



Fig. 17.7.3-1
Diagram showing control points for local deformations in region A in stem area

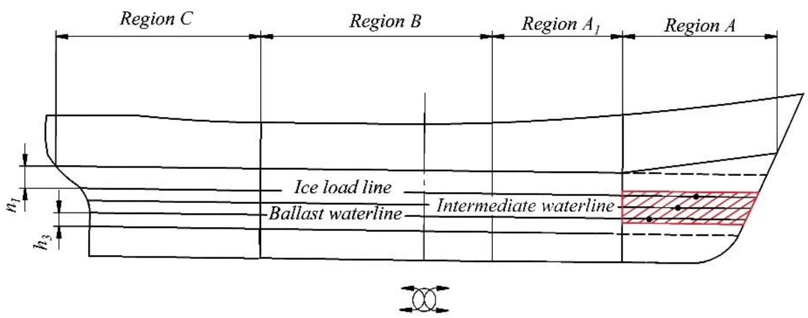



Fig. 17.7.3-2
Diagram showing control points for local deformations in region A in area corresponding to maximum values of shape factors

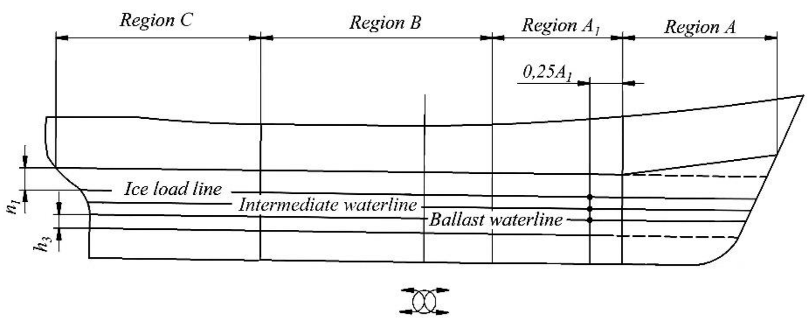



Fig. 17.7.3-3
Diagram showing control points for local deformations in region $A_1$

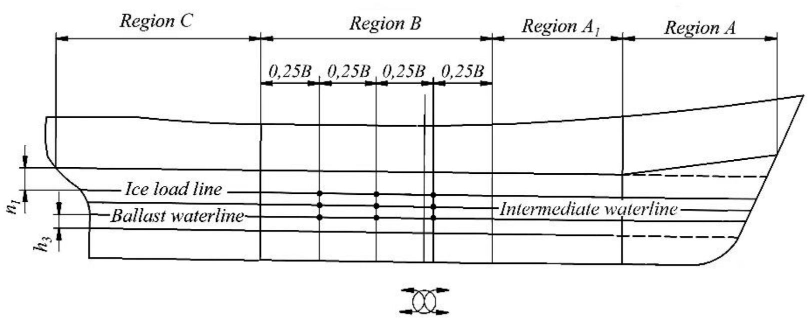



Fig. 17.7.3-4
Diagram showing control points for local deformations in region B

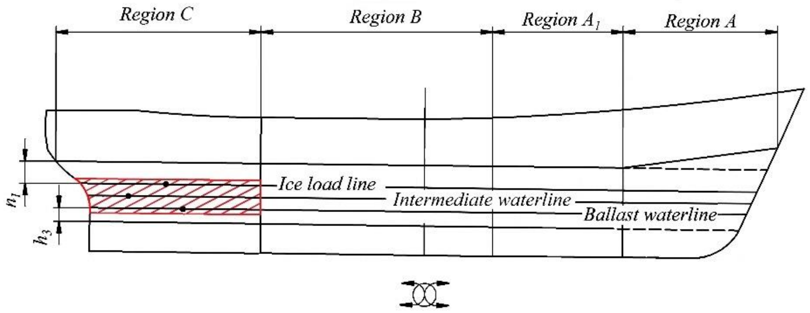



Fig. 17.7.3-5
Diagram showing control points for local deformations in region C

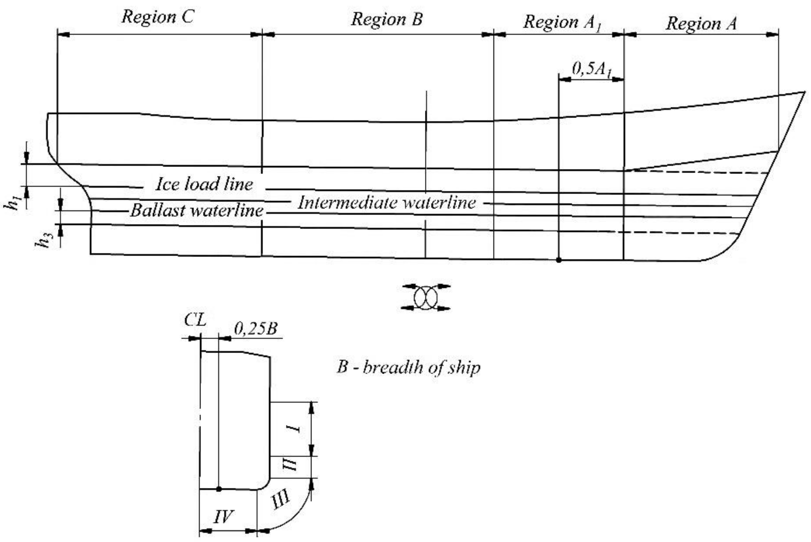



Fig. 17.7.3-6
Diagram showing control points for local deformations in region $A_1$ in bottom area

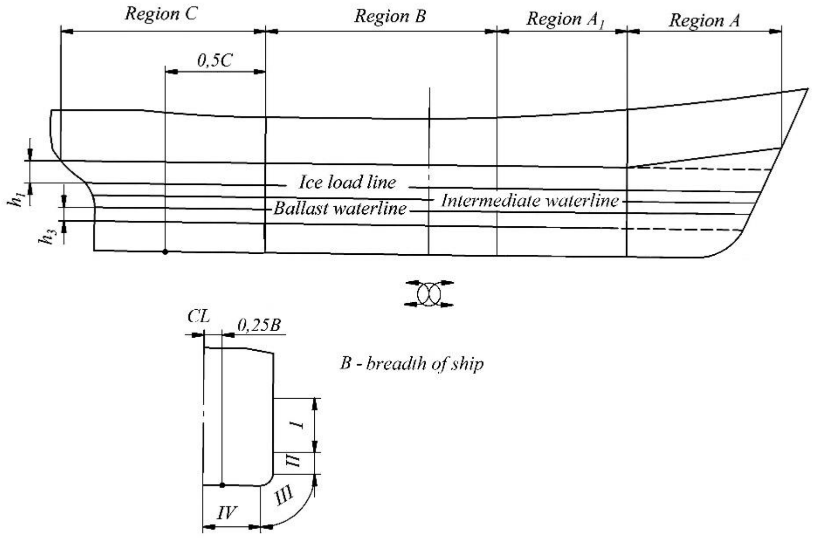



Fig. 17.7.3-7
Diagram showing control points for local deformations in region C in bottom area

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 colour 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 Modules A and C, Annex to IMO resolution MSC.302(87).

### 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.

The requirements of this Chapter apply to ship's passenger and crew spaces including accommodation spaces (cabins, corridors, offices, hospitals, lounges, mess rooms, shopping rooms, sanitary spaces, games, recreation and entertainment rooms, and other similar spaces), navigation bridge, main machinery control room and other spaces where the continuous or prolonged presence of persons is required for normal operational conditions.

**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** Depending on the outside temperature, temperature conditions in ship's spaces shall be provided in accordance with Table 18.1.4.2.1.

Table 18.1.4.2.1

| Outside temperature, $T_{out}$, °C | Inside temperature, $T_{in}$, °C | |
|---|---|---|
| | minimum | maximum |
| 15 and less | 20 | 24 |
| more than 15°C, but less than 40°C | 0,16$T_{out}$+17,6 | 0,16$T_{out}$+21,6 |
| 40 and more | 24 | 28 |

**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, irrespective of gross tonnage, not engaged on international voyages, comply with the requirements of this Chapter for noise level in all passenger and crew spaces, with account of 18.2.1.2 and 18.2.1.3, the distinguishing mark **COMF(N – 1** or **2**, or **3**) may be added to the character of classification, where **1**, **2**, **3** indicate the noise comfort level in ship's spaces (with 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 (non-commercial use);
**.7** auxiliary ships of war;
**.8** pile driving vessels;
**.9** dredgers;
**.10** floating cranes;
**.11** ships not propelled by mechanical means.

**18.2.1.3** If ships of 1600 gross tonnage and upwards engaged on international voyages, with account of 18.2.1.2, comply with the requirements of this Chapter for noise level in passenger and crew spaces (refer also to Notes), the distinguishing mark **COMF(N – S)** shall be mandatorily added to the character of classification, where "**S**" means compliance of the noise comfort level with the requirements of SOLAS-74.

N o t e s : 1. Taking into account SOLAS-74 regulation II-1/3-12, as amended, ships of 1600 gross tonnage and upwards engaged on international voyages shall comply with the requirements of the Code on Noise Levels on Board Ships, adopted by IMO resolution MSC.337(91) as may be amended (hereinafter referred to as "the Code").

The requirements of the Code are not intended to apply to passenger cabins and other passenger spaces, except in so far as they are work spaces and are covered by the provisions of the Code.

2. In case of repairs, alterations and modifications of a major character and outfitting related thereto of existing ships (ships that are not new in relation to the scope of application of SOLAS-74 regulation II-1/3-12), it shall be ensured that areas, in which changes have been made, meet the requirements of the Code for new ships, insofar as the ship's flag Maritime Administration (MA) deems reasonable and practicable.

3. The Code covers only noise sources related to the ship such as machinery and propulsion but does not include wind/wave/ice noise, alarms, public address systems, etc.

4. Dispensations from certain requirements may in special circumstances be granted by the ship's flag MA, if it is documented that compliance will not be possible despite relevant and reasonable technical noise reduction measures. Such dispensations shall not include cabins, unless exceptional circumstances prevail.

5. For ships designed for and employed on voyages of short duration, or on other services involving short periods of operation of the ship, to the satisfaction of the flag MA, requirements of 4.2.3 and 4.2.4 of the Code may be applied only with the ship in the port condition, provided that the periods under such conditions are adequate for seafarers' rest and recreation.

**18.2.1.4** Where the ship's flag MA has established instructions governing the measurement of noise level on board ships, other than those given in this Chapter and the Code, the ship's flag MA instructions shall apply.

**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.**

**18.2.3.1** In addition to technical documentation specified in Section 3 of 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 prior to the commencement of the sea trials.

On completion of the construction of the ship, but before a ship is put into service, measurement of noise levels in all spaces specified in the measurement program taking into account 18.2.5 or 18.2.6 (as applicable) shall take place under the operating conditions at sea trials and in port (refer to 3.3 and 3.4 of the Code). Measurement results shall be submitted to the RS Branch Office for information in the form of a noise survey report.

**18.2.3.2** A noise survey report shall be made for each ship. The report shall comprise information on the noise levels in the various spaces on board. The report shall show the reading at each specified measuring point. The points shall be marked on a general arrangement plan, or on accommodation drawings attached to the report, or shall otherwise be identified. The recommended format for noise survey reports is set out in Appendix 1 to the Code. The noise survey report shall confirm the effectiveness of noise reduction measures and shall always be carried on board and be accessible for the crew.

**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, 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 the Code.

**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 the Code. 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 on board ships specified in 18.2.1.1.**

**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) | | |
|---|---|---|---|
| | Noise comfort level 1 | Noise comfort level 2 | Noise comfort level 3 |
| Wheel house | 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 rooms 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[2,5] | 85 | 85 | 85 |
| 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.

[5] "Workshops other than those forming part of machinery spaces" are enclosed workshops that are separated from the engine room with bulkheads, which may include access doors of the equivalent acoustic insulating properties as the bulkhead. Workbenches and workstations located inside the machinery space are not to be considered as workshops other than those forming part of machinery spaces.

**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 |

**18.2.6 Permissible noise levels and requirements for sound insulation on board ships specified in 18.2.1.3.**

**18.2.6.1** Maximum permissible noise levels in the crew accommodations shall not exceed the values specified in Table 18.2.6.1.

Table 18.2.6.1

**Noise level requirements for crew accommodations**

| Location | A-weighted equivalent continuous sound level A, $L_{Aeq}(T)$, in dB(A) | |
|---|---|---|
| | Noise comfort level **S** | |
| | 1600 ≤ GT< 10000 | GT ≥ 10000 |
| Work spaces | | |
| Machinery spaces[1] | 110 | 110 |
| Main machinery control room and switchboard rooms continuously manned at sea[2] | 75 | 75 |
| Workshops other than those forming part of machinery spaces[3] | 85 | 85 |
| Non-specified work spaces[3] (other work areas) | 85 | 85 |
| Navigation spaces | | |
| Look-out posts, incl. navigating bridge wings[4] and windows | 70 | 70 |
| Navigating bridge and wheelhouse | 65 | 65 |
| Radar room | 65 | 65 |
| Radio rooms[5] | 60 | 60 |
| Accommodation spaces | | |
| Cabins and hospitals[6] | 60 | 55 |
| Offices | 65 | 60 |
| Public spaces, mess rooms | 65 | 60 |
| Open recreation areas[7, 8] | 75 | 75 |
| Recreation rooms | 65 | 60 |
| Service spaces | | |
| Galleys[2] | 75 | |
| Serveries and pantries | 75 | 75 |
| Normally unoccupied spaces | | |
| Spaces referred to in 3.14 of the Code | 90 | 90 |

GT — gross tonnage.
The limits specified in this Table shall be regarded as maximum levels and not as desirable levels. Where reasonably practicable, it is desirable for the noise level to be lower than the maximum levels specified.
Personnel entering spaces with nominal noise levels greater than 85 dB(A) shall be required to wear hearing protectors while in those spaces (refer to Section 5 of the Code).
The limit of 110 dB(A) assumes that hearing protectors are used giving protection that meets the requirements for hearing protectors in Section 7 of the Code.

[1] If the maximum noise levels are exceeded when machinery is operating (only permitted if dispensation is granted in accordance with 1.3.6 of the Code), stay shall be limited to very short periods or not allowed at all. The area shall be marked according to 7.4 of the Code.

[2] Equipment switched on but not processing.

[3] "Workshops other than those forming part of machinery spaces" are enclosed workshops that are separated from the engine room with bulkheads, which may include access doors of the equivalent acoustic insulating properties as the bulkhead. Workbenches and workstations located inside the machinery space are not to be considered as workshops other than those forming part of machinery spaces (refer also to IACS UI SC296 (May 2022), the document is available on the IACS website (www.iacs.org.uk), and IMO circular MSC.1/Circ.1654). The permissible noise level limit for workshops, which are forming part of machinery space, shall be as for the machinery space: 110 dB(A).

[4] Reference is made to the "Recommendation on methods of measuring noise levels at listening posts" (IMO resolution A.343(IX)) which also applies.

[5] Equipment switched on but not emitting.

[6] Treatment rooms with beds.

[7] Measurement carried out with a windscreen microphone protection.

[8] A tolerance of 5 dB(A) may be accepted for measurements at less than 3 m from ventilation inlet/outlet.

**18.2.6.2** Between two adjacent crew accommodation spaces, the apparent weighted sound reduction index $R'_w$ shall not be less than the values specified in Table 18.2.6.2 with a tolerance of up to 3 dB. Measurements shall be performed in situ, ship at quay or at anchorage. The airborne sound insulation properties shall be determined by laboratory tests in accordance with ISO 10140-2:2010, to the satisfaction of the ship's flag MA.

Table 18.2.6.2

**Apparent weighted sound reduction index $R'_w$, in dB**

| Location | Noise comfort level **S** |
|---|---|
| Cabin to cabin | 35 |
| Corridor to cabin | 30 |
| Stairs to cabin/cabin to cabin with communicating door | 30 |
| Messrooms, recreation rooms, public spaces and entertainment areas to cabins or hospitals | 45 |
| Note. Field measurements shall be performed according to ISO 140-4:1998. When the area of the materials tested is <10 m$^2$, a minimum value of 10 m$^2$ shall be considered for the calculation of the $R'_w$ index. | |

**18.2.7 Measures for noise abatement on board ships**.

**18.2.7.1** Design measures for noise abatement.

In the design phase, it is recommended to calculate expected noise levels in spaces likely to have noise levels over those specified in 18.2.6.1 and to assign the necessary design measures for abatement of noise level in the space.

The appropriateness of these measures on a ship shall be determined for each ship (or series of ships) by the designer or shipyard, taking into account the structural features of the ship and the technical feasibility of their implementation.

The following design measures for reduction of noise levels can be considered effective.

**18.2.7.1.1** Isolation of sources of noise.

Where practicable, any engines or machinery producing noise levels in excess of the limits set out in 18.2.6.1 shall be installed in spaces which do not require continuous operator attendance.

Accommodation spaces shall be sited both horizontally and vertically as far away as is practicable from sources of noise such as propellers and propulsion machinery.

Machinery casings shall, where practicable, be arranged outside superstructures and deckhouses containing accommodation spaces. Where this is not feasible, passageways are recommended to be arranged between the casings and accommodation spaces.

Accommodation spaces shall not be placed in deckhouses, and they are not recommended to be placed in superstructures extending from side to side.

Accommodation spaces, if structurally possible, shall be separated from machinery spaces by service spaces (e.g. showers, toilets, storerooms).

If suitable partitions, baffles or bulkheads are installed to prevent the spread of sound, it is important that these be of the correct location in relation to the source of sound and of the correct construction to take into account the frequency of the sound to be attenuated. Good seamanship shall also be taken into account when locating such structures.

Where a machinery space is being divided into noisy (not continually manned) and less noisy (capable of being continually manned) spaces, it is preferable to have complete separation.

It may be advisable to provide sound absorbing insulation on bulkheads and decks in rooms where necessary.

**18.2.7.1.2** Exhaust and air intake silencing.

Exhaust and air intake devices of machinery spaces shall be located away from continually manned locations. Silencers, noise-cancelling structures or equipment shall be installed where necessary.

Air ducts in accommodation areas as well as ventilation casing walls are recommended to be insulated with sound absorbing insulation in order to reduce structure-borne noise. Flexible or resilient connections to decks and bulkheads are recommended for mounting air ducts in the crew recreation and accommodation areas.

**18.2.7.1.3** Machinery enclosure.

In continuously manned machinery spaces or spaces where seafarers might reasonably be expected to spend lengthy periods of time on maintenance or overhaul work, and where separation as detailed in 18.2.7.1.1 is structurally impossible, consideration shall be given to the fitting of sound insulating enclosures or partial enclosures to engines or machinery producing sound pressure levels in excess of the limits set out in 18.2.6.1. When sound insulating enclosures are fitted, they shall entirely enclose the noise source.

**18.2.7.1.4** Enclosure of the operator in machinery spaces.

It is recommended that a sound reducing control room be installed in the machinery spaces for continuous watchkeeping in the machinery space.

**18.2.7.1.5** Noise reduction in accommodation spaces.

To reduce noise levels in accommodation spaces, when designing a ship, consideration shall be given to installing deckhouses on resilient mountings or other structures that eliminate the transmission of vibration to the deckhouse from the main hull.

Flexible or resilient connections to decks and bulkheads are recommended for mounting of lining systems within crew recreation and accommodation spaces.

The use of "floating floor" systems in all crew recreation and accommodation spaces is recommended.

The provision of curtains to side scuttles and windows and the use of carpets over plating also assist in absorbing noise.

**18.2.7.1.6** Inspection and maintenance.

Machinery and associated working spaces shall be periodically inspected as part of the onboard safety management system with respect to any noise control/reduction features.

**18.2.7.1.7** Vibration isolation.

Where necessary, engines and machinery, hydraulic units, fans, pumps, etc., shall be supported on resilient mountings.

When sound insulating enclosures are fitted as specified in 18.2.7.1.3, such engines and machinery shall be installed on resilient mountings, and it is also recommended that all pipe and cable connections to them be made with flexible or vibration-absorbing connections.

**18.2.7.2** Personal hearing protection equipment.

In spaces where the noise level is less than 85 dB(A), personal hearing protection equipment with an attenuation of at least 25 dB(A) shall be provided.

In spaces where the noise level is 85 to 110 dB(A), personal hearing protection equipment with an attenuation of at least 25 dB(A) shall be provided.

In spaces where the noise level is greater than 110 dB(A), personal hearing protection equipment with an attenuation of 25 to 35 dB(A) shall be provided.

Personal hearing protection equipment is a passive means of protection and its presence cannot be considered as an effective measure to reduce the negative impact of noise on humans.

**18.2.7.3 Warning signs and information notices.**

Where the noise level in spaces is greater than 85 dB(A), entrances to such spaces shall carry warning signs and information notices in the working language of the ship crew. If equipment with a noise level greater than 85 dB(A) is only installed in a portion of the space, such warning signs and information notices shall be located at its installation place at eye level, and visible from each direction of access to this equipment.

The following are examples of information notices:

| | |
|---|---|
| 80 — 85 dB(A) | "HIGH NOISE LEVEL — USE HEARING PROTECTORS" |
| 85 — 110 dB(A) | "DANGEROUS NOISE LEVEL — USE OF HEARING PROTECTORS MANDATORY" |
| 110 — 115 dB(A) | "CAUTION! DANGEROUS NOISE LEVEL — USE OF HEARING PROTECTORS MANDATORY. SHORT STAY ONLY" |
| above 115 dB(A) | "CAUTION! CRITICAL NOISE LEVEL — USE OF HEARING PROTECTORS MANDATORY. NO STAY LONGER THAN 10 MINUTES" |

## 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.

**18.3.2 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<br>Radio room | 2,8 | 3,0 | 3,2 |
| 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<br>Workshops | 5,0 | 5,5 | 6,0 |
| 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<br>Public spaces of Type A | 4,0 | 4,5 | 5,0 |
| 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 DOUBLE ACTING SHIPS

### 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".

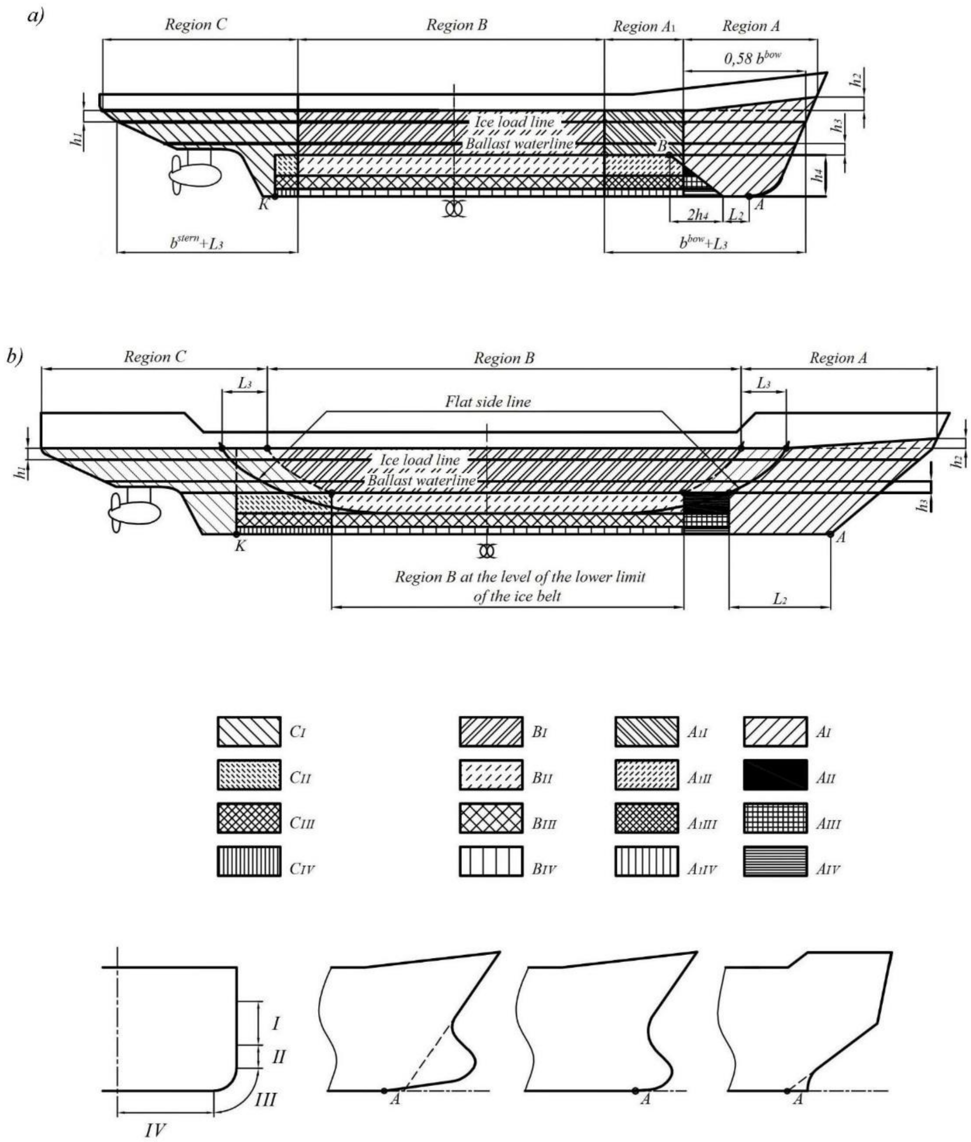



Fig. 19.2.2.3
Regions of ice strengthening of ice class ships:
*a*) ships designed for both bow- and stern- first ice operation;
*b*) ships designed for stern-first ice operation only;

$b^{bow}$ = 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.

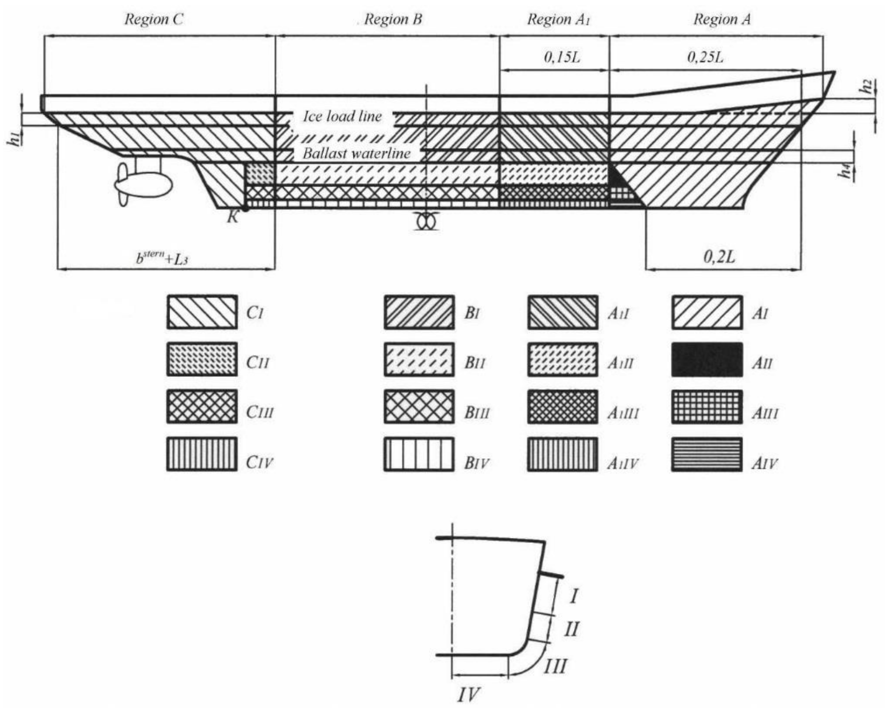



Fig. 19.2.2.4
Regions of ice strengthening of Arctic double acting ships with ice class mark **Icebreaker6** or **Icebreaker7** in the class notation when operating stern first:

$b^{stern}$ = 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 $B \le 20$ m | 0,75 | |
| | at $B > 20$ m | $\frac{0{,}5B + 8}{24}$ | |
| $h_2$, in m | | 1,4 | 1,1 |
| $h_3$, in m | | $1{,}6 + 1{,}6h_1 \ge 2{,}8$ | $0{,}4 + 1{,}6h_1 \ge 1{,}6$ |
| $L_3$, 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** | + | + | + | + | + | + | + | + | + | + | + | + | + | + | | + |
| **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 azimuth thrusters against the effects of ice in the stern counter area, it is recommended that the skeg be installed on the centreline.

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 azimuth thruster shall have a stiffened thickened flange for the bolted connection to the flange of the thruster body.

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 azimuth thruster installed as for the fore end according to 3.10.1.2.1, Part II "Hull";

when two/three azimuth thrusters installed as for the waterline areas located alongside of the thruster centreline.

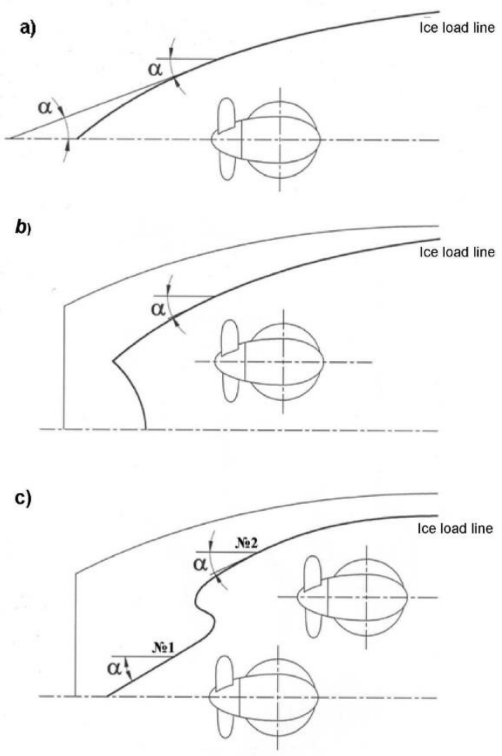



Fig. 19.2.4.1
Determination of waterline inclination angles at the aft end:
*a*) single azimuth thruster installation; *b*) twin azimuth thruster installation; *c*) triple azimuth thruster installation

**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**:

$$p_{\mathrm{AI}} = a_4 p_{\mathrm{BI}} \quad (19.2.4.2.1\text{-}1)$$

where $a_4$ = factor to be taken from Table 3.10.3.2.1, Part II "Hull";
$p_{\mathrm{BI}}$ = ice pressure in region BI (refer to 19.2.4.2.2);

for ships of ice classes **Arc7**, **Arc8**, **Arc9**:

$$p_{\mathrm{AI}} = 0{,}75 p_{\mathrm{CI}} \quad (19.2.4.2.2\text{-}2)$$

where $p_{\mathrm{CI}}$ = ice pressure in region CI (refer to 19.2.4.2.3).

**19.2.4.2.2** In regions A$_1$I 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:

$$p_{\mathrm{CI}} = 2100 a_1 v_m \sqrt[6]{\frac{\Delta}{1000}} \qquad (19.2.4.2.3)$$

where $a_1$ = factor to be taken from Table 3.10.3.2.1 Part II "Hull" depending on the ice class;
$v_m$ = value of the shape factor $v$, 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:

$$v = f_v(b_0^v + b_1^v \frac{x}{L} + b_2^v \alpha + b_3^v \beta')$$

where $b_i^v$ = factors to be taken from Table 19.2.4.2.3 depending on the number of azimuth thrusters.

Table 19.2.4.2.3

| | $b_0^v$ | $b_1^v$ | $b_2^v$ | $b_3^v$ |
|---|---|---|---|---|
| One azimuth thruster | 0,8731 | 0,1537 | 0,0011 | –0,0012 |
| Two azimuth thrusters | 0,8721 | 0,2090 | 0,0009 | –0,0011 |
| Three azimuth thrusters, area No. 1 (Fig. 19.2.4.1) | 0,8265 | 0,2474 | 0,0011 | 0,0004 |
| Three azimuth thrusters, 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** | 0,7 | 0,65 | 0,5 | 0,55 | 0,45 | 0,3 | 0,7 | 0,65 | 0,5 |

**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 $b_{\mathrm{B}}$ = 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 $b_{\mathrm{C}}$ = refer to 3.10.3.3.4.

**19.2.4.3.2** In regions $\mathrm{A_1I}$, $\mathrm{A_1II}$, $\mathrm{A_1III}$ and $\mathrm{A_1IV}$, 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 $k_\Delta$ = 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:

$$u = f_u\left(b_0^u + b_1^u \frac{x}{L} + b_2^u \alpha + b_3^u \beta' + b_4^u \frac{x}{L} \beta' + b_5^u \alpha\beta'\right)$$

where $b_i^u$ = factors to be taken from Table 19.2.4.3.3 depending on a number of azimuth thrusters.

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 azimuth thruster | 0,6445 | 1,0425 | 0,0035 | 0,0010 | –0,0201 | –0,0001 |
| Two azimuth thrusters | 0,6584 | 0,8894 | 0,0036 | 0,0005 | –0,0128 | –0,0001 |
| Three azimuth thrusters, area No. 1 (Fig. 19.2.4.1) | 0,6075 | 1,3355 | 0,0037 | 0,0025 | –0,0225 | –0,0001 |
| Three azimuth thrusters, 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 $b_{\mathrm{A}}$ = 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 $\mathrm{A_1I}$, $\mathrm{A_1II}$, $\mathrm{A_1III}$ and $\mathrm{A_1IV}$, 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;
$\beta_m^{\mathrm{C}}$ = 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, $A_1$I, 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.

**19.2.4.8** Consideration of interaction between ice and an azimuth thruster (determination of global ice loads).

**19.2.4.8.1** The passaging of a ship through a wide channel made by an icebreaker in hummocked ice is taken as the basic design mode of the ship’s operation to specify the global ice loads (a load due to impact with an ice block and a load due to a contact between the azimuth thruster and a ridge keel).

The design parameters of an ice feature to specify the global ice loads on the azimuth thruster due to impact with an ice block are given in Table 19.2.4.8.1-1, and those due to a contact between the thruster and an ice ridge — in Table 19.2.4.8.1-2. The maximum of the values for the below calculated cases is taken as the design load.

Table 19.2.4.8.1-1

| Ice Class notation | $H_{con}$, m | $H_{ch}$, m | $\sigma_v$, MPa | $\sigma_H$, MPa | $l_d$, m | $b_d$, m | $H_d$, m | $m_d$, kg |
|---|---|---|---|---|---|---|---|---|
| **Arc4** | 1,8 | 1,6 | 11,5 | 9,5 | 2,3 | 3,8 | 1,8 | 7315 |
| **Arc5** | 2 | 1,9 | 12,5 | 10 | 3,2 | 5,4 | 2 | 16070 |
| **Arc6** | 2,6 | 2,5 | 13 | 10,5 | 3,6 | 5,7 | 2,7 | 25763 |
| **Arc7** **Arc8** **Arc9** | 4,5 | 4,0 | 14 | 11,5 | 6,22 | 10,44 | 4,8 | 144938 |

where $H_{con}$ — design thickness of the ridge consolidated layer, m;
$H_{ch}$ — design thickness of ice packed in the channel, m;
$\sigma_v$ — design ice strength due to coaxial compression under vertical loading, MPa;
$\sigma_H$ — design ice strength due to uniaxial compression under horizontal loading, MPa;
$l_d$ — design length of an ice block;
$b_d$ — design width of an ice block, m;
$H_d$ — design thickness of an ice block, m;
$m_d$ — weight of an ice block, kg

Table 19.2.4.8.1-2

| Ice Class notation | Design depth of a ridge keel $H_{keel}$, m | Design thickness of ice packed in the channel $H_{ch}$, m |
|---|---|---|
| **Arc4** | 11 | 1,9 |
| **Arc5** | 11,8 | 2,3 |
| **Arc6** | 12 | 2,7 |
| **Arc7** **Arc8** **Arc9** | 15,5 | 4,0 |

**19.2.4.8.2** For double acting ships, the design speed of interaction between the thruster and an ice feature is determined for the stern-first and the bow-first operation modes. In the stern-first operation, the design speed of interaction with an ice feature, $V_{ice}$, m/s, is taken equal to the design ship speed in ice, $V$, m/s, in accordance with the ship's specifications, but shall be no less than 5 knots. The design speed can be taken based on the results of model tests, but shall be no less than 5 knots.

**19.2.4.8.3** A point in the buttock plane at a distance of $3B/8$ from the centreline is taken as the design point of a contact between the ship's aft end and the ice cover to specify the dimensions of ice blocks. This buttock corresponds to the entry angles of the ice waterline, $\alpha$, $\varphi_2$ (see Fig. 19.2.4.8.3 to determine the angles).

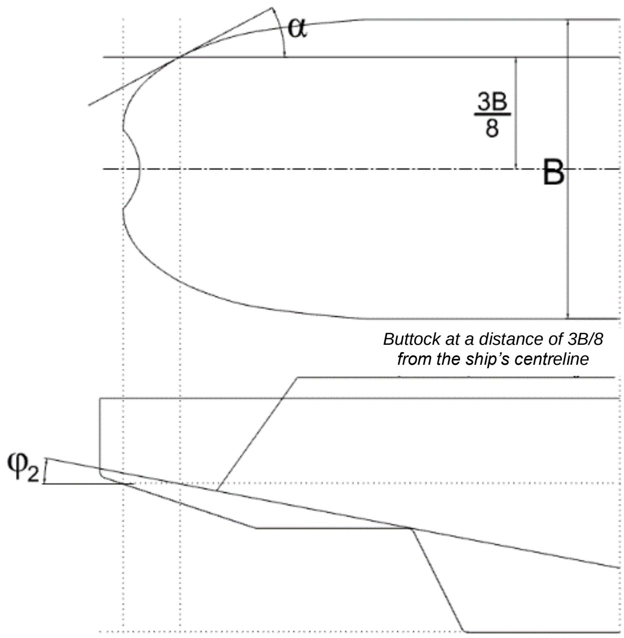



Fig. 19.2.4.8.3
Values for angles α, $\varphi_2$

**19.2.4.8.4** Width of an ice block, $b_{block}$, is calculated by the formula:

$$b_{block} = \frac{10H_{con}}{k_{dyn}}, \qquad (19.2.4.8.4\text{-}1)$$

where $k_{dyn}$ — the dynamic factor to define the dynamic magnification of the ice cover failure load and a decrease in the characteristic dimensions of ice blocks depending on the loading rate:

$$k_{dyn} = \frac{1}{\left(0{,}13031+0{,}45717\cdot exp\left(\frac{-Fr(H_{con})}{0.0595777}\right)+0.41251\cdot exp\left(\frac{-Fr(H_{con})}{0.256}\right)\right)}, \qquad (19.2.4.8.4\text{-}2)$$

where $Fr(H_{con}) = \frac{V \sin\alpha \operatorname{tg}(90-\beta_1)}{\sqrt{gH_{con}}}$. (19.2.4.8.4-3)

Length of an ice block, $l_{block}$, is calculated by the formula:

$$l_{block} = 0.5\, b_{block}/\operatorname{tg}\alpha. \qquad (19.2.4.8.4\text{-}4)$$

**19.2.4.8.5** To specify the ice force due to impact with an ice block, the following values are taken as the design length $l_d$ and the design width $b_d$ of an ice block:

$l_d = \min(b_{block}; l_{block})$;

$b_d = \max(b_{block}; l_{block})$.

**19.2.4.8.6** Weight of an ice block, $m_d$, kg, is calculated by the formula:

$$m_d = 930k_{fb} \cdot b_d \cdot l_d \cdot H_d,$$

where $k_{fb} = 0.5$ — the shape factor of an ice block;
$H_d = H_{con}$ — the design thickness of an ice block.

**19.2.4.8.7** The global load due to impact with an ice block.
**19.2.4.8.7.1** The longitudinal ice force acting on the propeller cone of a pulling thruster and the pod cone of a pushing thruster, $F_{cl}$, MN, is calculated by the formula:

$$F_{cl} = 3.14 \cdot R_c^2 \cdot p_0 \left(2\bar{l} - (\bar{l})^2\right) \cdot k_{form}(\bar{l}) \cdot k_{dyn}, \quad (19.2.4.8.7.1\text{-}1)$$

where $R_c$ — radius of the cone, m;
$p_0 = 2.4\sigma_v^{0,6}$ — average local pressure, MPa;
$\sigma_v$ — ice strength in uniaxial compression under vertical loading, see Table 19.2.4.8.1-1, MPa;
$\bar{l}$ — non-dimensional distance of the cone penetration into ice, see Fig. 19.2.4.8.7.1;

$$\bar{l} = 0.44\left(\frac{m_d v_{ice}^2}{R_c^3 p_0 \cdot 10^6}\right)^{0.6}, \quad (19.2.4.8.7.1\text{-}2)$$

where $m_d$ — weight of an ice block, kg, in accordance with 19.2.4.8.6;
$V_{ice}$ — speed of interaction with an ice feature in accordance with 19.2.4.8.2;

$k_{form}(\bar{l})$ — the shape factor;

$$k_{form}(\bar{l}) = -0.1525\bar{l}^3 + 0.402\bar{l}^2 - 0.3897\bar{l} + 1; \quad (19.2.4.8.7.1\text{-}3)$$

$k_{dyn} = 1.2$ — the dynamic magnification factor.

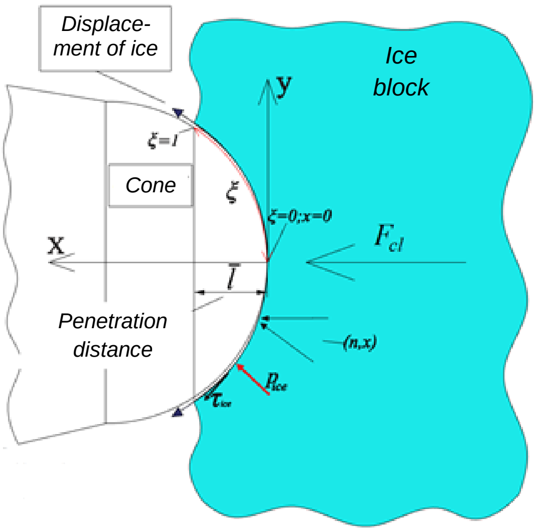



Fig. 19.2.4.8.7.1
Interaction pattern between the propeller cone of a pulling thruster and the pod cone of a pushing thruster

**19.2.4.8.7.2** The longitudinal ice force acting on the thruster strut due to impact with an ice block, $F_{sl}$, MN, is calculated by the formula:

$$F_{sl} = b \cdot l_{ice} \cdot k_{scale}(l_{ice}) \cdot k_{form}(\bar{l}) \cdot p_0, \qquad (19.2.4.8.7.2\text{-}1)$$

where $l_{ice}$— the contact height, m, calculated as follows:

$$l_{ice} = \begin{cases} H_d, at\ \Delta z \geq H_d \\ \Delta z,\ \ at\ \Delta z < H_d \end{cases}, \qquad (19.2.4.8.7.2\text{-}2)$$

where $H_d$ — the design thickness of an ice block, see 19.2.4.8.6;
$\Delta z$ — height of the thruster strut, see Fig. 19.2.4.8.7.4;

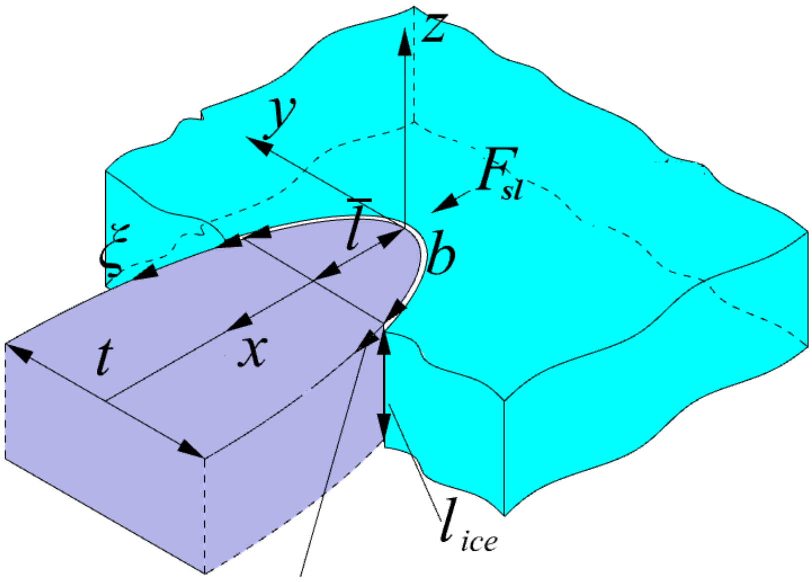



Fig. 19.2.4.8.7.2
Interaction pattern between the thruster strut and an ice block

$k_{scale}(l_{ice})$ — the ice strength scale factor due to the non-simultaneity of the ice failure;

$$k_{scale}(l_{ice}) = 0.7853 \cdot exp\left[-\frac{l_{ice}}{1{,}99}\right] + 0.2146; \qquad (19.2.4.8.7.2\text{-}3)$$

$p_0$— the average local pressure, MPa;

$$p_0 = 2.4 \cdot \sigma_H{}^{0.6}, \qquad (19.2.4.8.7.2\text{-}4)$$

where $\sigma_H$ — the uniaxial compression ice strength under horizontal loading, see Table 19.2.4.8.1-1;

$k_{form}(\bar{l})$ — the shape factor;

$$k_{form}(\bar{l}) = -0.1525\bar{l}^{-3} + 0.402\bar{l}^{-2} - 0.3897\bar{l} + 1,$$

where $\bar{l}$ — the non-dimensional depth of the thruster strut penetration into ice, see Fig. 19.2.4.8.7.2;

$$\bar{l} = 1.0864 \cdot \left[\frac{\frac{m_d \cdot V_{ice}^2}{2}}{l_{ice} \cdot t^2 \cdot p_0 \cdot 10^6 \cdot k_{scale}(l_{ice})}\right]^{0.65}, \qquad (19.2.4.8.7.2\text{-}5)$$

where $m_d$ — weight of an ice block, kg, see 19.2.4.8.6;
$V_{ice}$ — speed of interaction between the nozzle and an ice block, m/s, see 19.2.4.8.2;
$t$ — the nozzle characteristic dimension, m, see Fig. 19.2.4.8.7.2;

$b$ — the contact area in the plane of the profile cross-section, m, see Fig. 19.2.4.8.7.2;

$$b = 2\arccos(1 - \bar{l}) \cdot (t/2). \qquad (19.2.4.8.7.2\text{-}6)$$

**19.2.4.8.7.3** The longitudinal ice force acting on the thruster nozzle due to impact with an ice block, $F_{nl}$, MN, is calculated by the formula:

$$F_{nl} = b \cdot l_{ice} \cdot k_{scale}(l_{ice}) \cdot k_{form}(\bar{l}) \cdot p_0 \cdot k_{dyn}, \qquad (19.2.4.8.7.3\text{-}1)$$

where $l_{ice}$ — the contact length of an ice block along the nozzle leading edge, m;

$$l_{ice} = 2\arccos(1 - \bar{\delta}_{ice}) \cdot R, \qquad (19.2.4.8.7.3\text{-}2)$$

where $R$ — the nozzle radius, m, see Fig. 19.2.4.8.7.3;

$\bar{\delta}_{ice}$ — the non-dimensional contact height;

$$\bar{\delta}_{ice} = \delta_{ice}/R_n; \qquad (19.2.4.8.7.3\text{-}3)$$

$$\delta_{ice} = \begin{cases} H_d, at\ H_d < (R - R_{hub}); \\ R - R_{hub}\ at\ H_d \geq (R - R_{hub}), \end{cases} \qquad (19.2.4.8.7.3\text{-}4)$$

where $H_d$ — the design thickness of an ice block, see 19.2.4.8.1;

$R_{hub}$ — the hub radius;

$k_{scale}(l_{ice})$ — the ice strength scale factor due to non-simultaneity of the ice failure;

$$k_{scale}(l_{ice}) = 0.7853 \cdot exp\left[-\frac{l_{ice}}{1.99}\right] + 0.2146; \qquad (19.2.4.8.7.3\text{-}5)$$

$p_0$ — the average local pressure (the bearing strength), MPa;

$$p_0 = 2.4 \cdot \sigma_H^{0.6}, \qquad (19.2.4.8.7.3\text{-}6)$$

where $\sigma_H$ - the uniaxial compression ice strength under horizontal loading, see Table 19.2.4.8.1-1;

$k_{form}(\bar{l})$ — the shape factor;

$$k_{form}(\bar{l}) = -0.1525\bar{l}^3 + 0.402\bar{l}^2 - 0.3897\bar{l} + 1. \qquad (19.2.4.8.7.3\text{-}7)$$

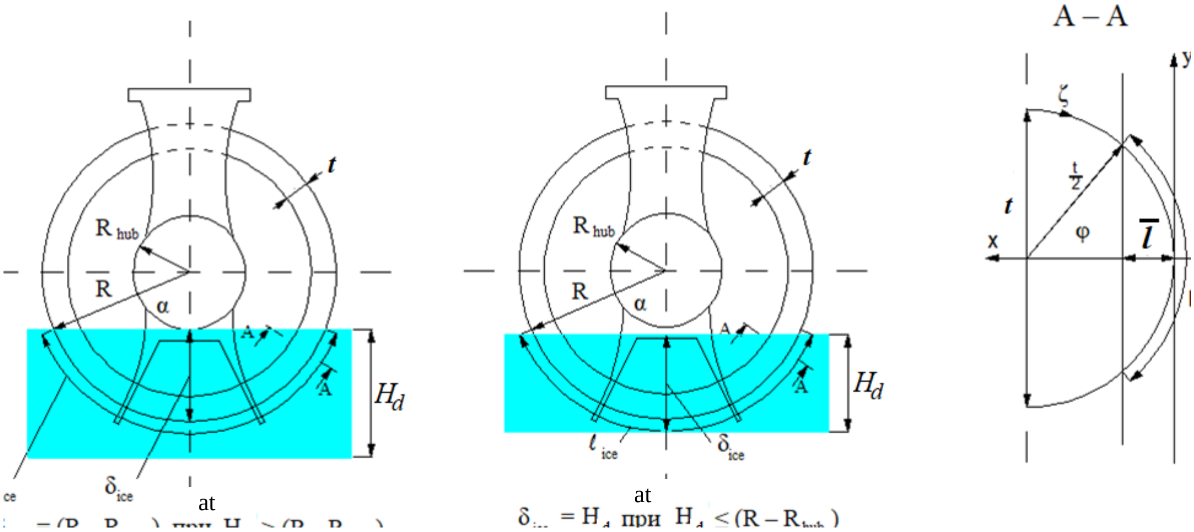



Fig. 19.2.4.8.7.3
Interaction pattern between ice and the nozzle

$\bar{l}$ — the non-dimensional depth of ice block penetration into the nozzle, see Fig. 19.2.4.8.7.3;

$$\bar{l} = 1.0864 \cdot \left[\frac{(m_d \cdot V_{ice}{}^2)/2}{\arccos(1-\bar{\delta}_{ice}) \cdot R \cdot t^2 \cdot p_0 \cdot 10^6 \cdot k_{scale}(l_{ice})}\right]^{0.65}, \qquad (19.2.4.8.7.3\text{-}8)$$

where $t$ — the nozzle characteristic dimension;
$m_d$ — weight of an ice block, kg, see 19.2.4.8.6;
$V_{ice}$ — speed of interaction between the nozzle and an ice block, m/s, see 19.2.4.8.2;

$b$ — the contact area in the plane of the profile cross-section, m, see Fig. 19.2.4.8.7.3;

$$b = 2\arccos(1-\bar{l}) \cdot (t/2); \qquad (19.2.4.8.7.3\text{-}9)$$

$k_{dyn} = 1.2$ — the dynamic magnification factor.

**19.2.4.8.7.4** The longitudinal ice force acting on the thruster strut due to milling, $F_{sc}$, MN, is calculated by the formula

$$F_{cs} = p_0 \cdot l_{ice} \cdot k_{scale}(l_{ice}) \cdot k_{form} \cdot t, \qquad (19.2.4.8.7.4\text{-}1)$$

where $t$ — the strut characteristic transverse dimension, m, see Fig. 19.2.4.8.7.2;
$k_{form}$= 0.7 — the shape factor;
$l_{ice}$ — the contact height, see Fig. 19.2.4.8.7.2, calculated by the formula:

$$l_{ice} = \begin{cases} at\Delta z \geq H_d \\ \Delta z, \ \Delta z < H_d \end{cases}, \qquad (19.2.4.8.7.4\text{-}2)$$

where $H_d$— the design thickness of an ice block, see 19.2.4.8.1;

$k_{scale}(l_{ice})$ — the ice strength scale factor;

$$k_{scale}(l_{ice}) = 0{,}7853 \cdot \exp\left[-\frac{l_{ice}}{1{,}99}\right] + 0{,}2146; \qquad (19.2.4.8.7.4\text{-}3)$$

$p_0 = 2{,}4 \cdot \sigma_H{}^{0{,}6}$ — the average local pressure (the bearing strength), MPa.

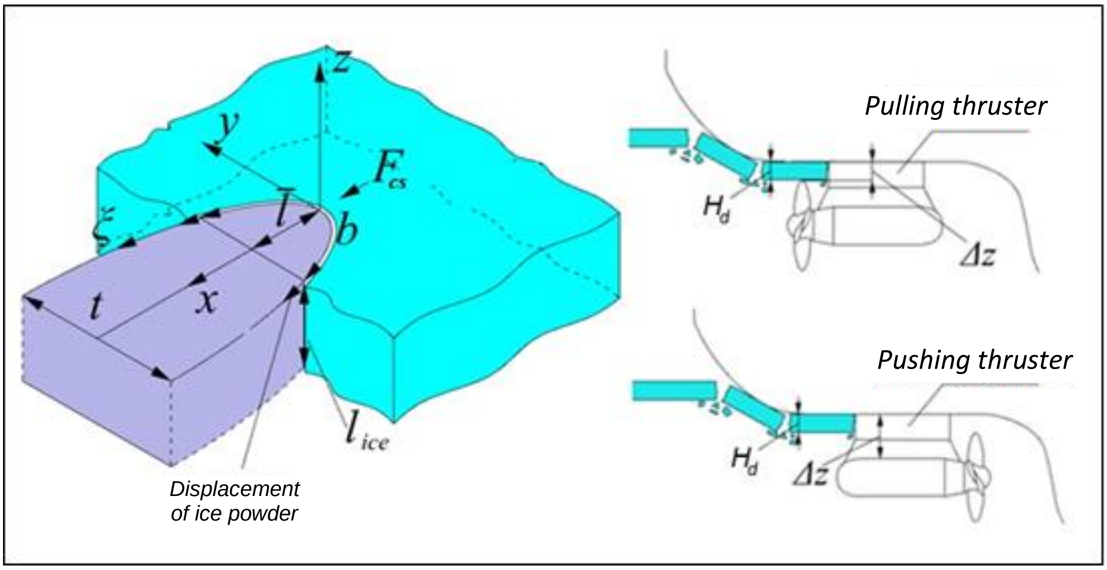



Fig. 19.2.4.8.7.4
Interaction pattern between the thruster strut and an ice block

**19.2.4.8.7.5** The transversal ice force acting on the strut, $F_{st}$, MN, is calculated by the formula:

$$F_{st} = \omega \cdot b_{ice} \cdot p_0 \cdot k_{scale}(\omega), \tag{19.2.4.8.7.5-1}$$

where $\omega = b_d \cdot \bar{l}$ — width of contact area, m;

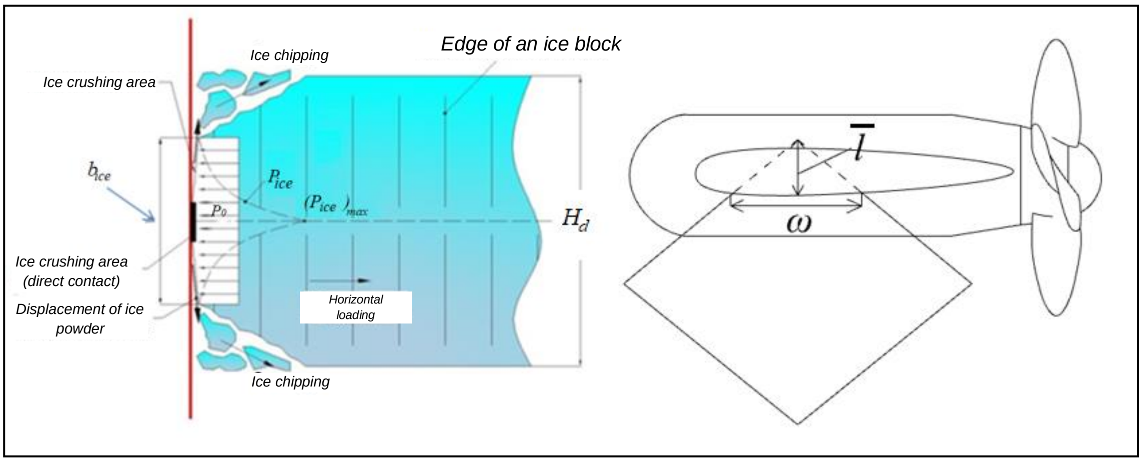



Fig. 19.2.4.8.7.5
Interaction pattern between the thruster strut and an ice block

$\bar{l}$ — the non-dimensional penetration distance, see Fig. 19.2.4.8.7.5;

$$\bar{l} = C_2 \cdot f^2 + C_1 \cdot f + C_0; \tag{19.2.4.8.7.5-2}$$

$$C_2 = -19.849 \cdot b_d - 420.7; \tag{19.2.4.8.7.5-3}$$

$$C_1 = 0.439 \cdot b_d + 13.906; \tag{19.2.4.8.7.5-4}$$

$$C_0 = -0.0003 \cdot b_d + 0.0287; \quad (19.2.4.8.7.5\text{-}5)$$

$$f = 1.273 \left(\frac{\rho_{ice} \cdot k_{fb}}{k_{split} \cdot p_0 \cdot 10^6}\right) V_{ice}{}^2, \quad (19.2.4.8.7.5\text{-}6)$$

where $\rho_{ice} = 930\ kg/m^3$ — the ice density;
$k_{fb} = 0.5$ — the ice block shape factor;
$k_{split} = 0.4$ — the chipping factor to take into account a decrease in the contact height due to the ice chipping;
$p_0$ — the average local pressure (the bearing strength), MPa;

$$p_0 = 2.4 \cdot \sigma_H{}^{0.6}; \quad (19.2.4.8.7.5\text{-}7)$$

$V_{ice}$ — speed of interaction with an ice feature in accordance with 19.2.4.8.2;

$b_{ice}$ — height of the contact area, m;

$$b_{ice} = k_{split} \cdot H_d, \quad (19.2.4.8.7.5\text{-}8)$$

где $H_d$ — the ice block design thickness, see 19.2.4.8.1;

$k_{scale}(\omega)$ — the ice strength scale factor;

**19.2.4.8.7.6** The transversal ice force acting on the thruster pod (nozzle) due to impact with an ice block, $F_{pnt}$, MN, is calculated by the formula:

$$F_{pnt} = 0.65 \cdot \omega \cdot b_{ice} \cdot p_0 \cdot k_{scale}(b_{ice}) \cdot k_{dyn}, \quad (19.2.4.8.7.6\text{-}1)$$

where $\omega$ — width of the contact area, m;

$$\omega = 2 \cdot \bar{l} \cdot R \cdot \frac{b_d}{l_d}, \quad (19.2.4.8.7.6\text{-}2)$$

where $R$ — the pod (nozzle) radius, m;
$b_d, l_d$ — the ice block design dimensions, m, see 19.2.4.8.1;
$\bar{l}$ — non-dimensional distance of an ice block penetration into the pod (nozzle), see Fig. 19.2.4.8.7.6;

$$\bar{l} = a\psi^b; \quad (19.2.4.8.7.6\text{-}3)$$

$$\psi = 0{,}245 \left(\frac{l_d{}^2 H_d}{R^3}\right)\left(\frac{\rho_{ice} \cdot k_{fb}}{p_0 \cdot 10^6}\right) V_{ice}{}^2, \quad (19.2.4.8.7.6\text{-}4)$$

where $\rho_{ice} = 930\ kg/m^3$ — the ice density;
$V_{ice}$ — speed of interaction with an ice feature in accordance with 19.2.4.8.2;
$H_d$ — the ice block design thickness, see 19.2.4.8.1;
$p_0$ — the average local pressure (the bearing strength), MPa;

$$p_0 = 2.4 \cdot \sigma_H{}^{0.6}; \quad (19.2.4.8.7.6\text{-}5)$$

$b_{ice}$ — height of the contact area;

$$b_{ice} = 2R \sin(\arccos(1 - \bar{l})); \quad (19.2.4.8.7.6\text{-}8)$$

$k_{scale}(b_{ice})$ — the ice strength scale factor;

$$k_{scale}(b_{ice}) = 0.7853 \cdot \exp\left[-\frac{b_{ice}}{1{,}99}\right] + 0.2146; \quad (19.2.4.8.7.6\text{-}9)$$

$k_{dyn} = 1.2$ — the dynamic magnification factor.

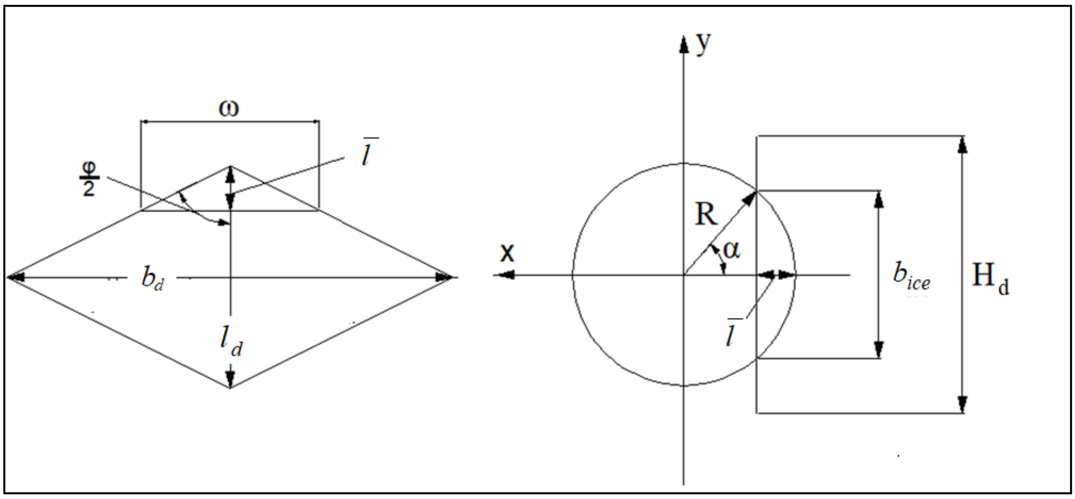



Fig. 19.2.4.8.7.6
Interaction pattern between the thruster pod (nozzle) and an ice block

**19.2.4.8.7.7** The total transversal ice force acting on the thruster due the strut and the pod (nozzle) impact with an ice block, $F_{tt}$, MN, is calculated by the formula:

$$F_{tt} = k_{red} \cdot (F_{st} + F_{pnt}), \qquad (19.2.4.8.7.7)$$

where $k_{red} = 0.7$ — the reduction factor of the total transverse load due to the non-simultaneous implementation of the maximum values of the load components (the effect of non-simultaneous failure);
$F_{st}$ — the transversal ice force acting on the thruster strut, MN, see 19.2.4.8.7.5;
$F_{pnt}$ — the transversal ice force acting on the thruster pod (nozzle), MN, see 19.2.4.8.7.6.

**19.2.4.8.8** Load due to a contact with a ridge keel.

**19.2.4.8.8.1** The transversal ice force acting on the thruster pod (nozzle) due to a contact with a ridge keel, $F_{kt}$, MN, is calculated by the formula:

$$F_{kt} = S \cdot p_{keel} \cdot V_{ice}^{0.66}, \qquad (19.2.4.8.8.1\text{-}1)$$

where $V_{ice}$ — speed of interaction with an ice feature in accordance with 19.2.4.8.2;
$S$ — total area of the thruster side projection, m$^2$;
$p_{keel}$ — the normal shear stress in a ridge keel, MPa;

$$p_{keel} = 0.0149 \cdot H_{keel} + 0.0397, \qquad (19.2.4.8.8.1\text{-}2)$$

where $H_{keel}$ — the design depth of a ridge keel, see Table 19.2.4.8.1-2.

**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 0,045$L_{ice}$ shall be assumed for ice damage in the forward and aft part of the hull, if the centre of damage lies within 0,4$L_{ice}$ from the forward and aft perpendiculars, respectively, and 0,015$L_{ice}$ in other areas.

## 19.4 REQUIREMENTS FOR DESIGN OF STERN FACING CONNING POSITION, COMPOSITION, LOCATION AND CONFIGURATION OF RADIO, NAVIGATIONAL, ELECTRICAL AND AUTOMATION EQUIPMENT OF DOUBLE ACTING SHIPS

**19.4.1 Application.**

The requirements of this Chapter are applicable to the design of the stern facing conning position, location and configuration of radio, navigational, electrical and automation equipment of the ships intended to operate in ice going stern first.

**19.4.2 Definitions and explanations.**

Stern facing conning position means an area from which the navigation and control of the ship is exercised during extended periods of operation stern first in ice.

**19.4.3 Requirements for design of the stern facing conning position.**

**19.4.3.1** A stern facing conning position with a workstation for navigation and maneuvering and a workstation for traffic surveillance and monitoring is required for any ship intending to operate stern first in ice.

**19.4.3.2** The stern facing conning position may be located in one common space with the main conning position or in a separate space (with access provided through doors, corridors, stairways, etc.) on the navigation bridge deck or another deck.

**19.4.3.3** The main and stern facing conning positions may be configured in different ways, provided the stern facing conning position is equipped with all instrumentation and controls required for the safety of navigation.

**19.4.3.4** The field of vision from the stern facing conning position shall meet the requirements specified in 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.9, and, to the extent practically possible, 3.2.7, Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships, but at least 90 deg. on either side relative to the centre line, considering stern first operation of the ship.

**19.4.3.5** The space for the stern facing conning position shall meet the requirements specified in 3.2.5, 3.2.11, 3.2.12, 3.2.13 and 3.2.14, Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships considering stern first operation of the ship.

**19.4.4 Requirements for composition of stern facing conning position equipment.**

The following minimum set of equipment with technical characteristics meeting the requirements of the relevant parts of the RS Rules shall be installed at the stern facing conning position considering stern first operation of the ship:

**.1** radar operating in 9 GHz frequency band. The antennas and transceivers may be used jointly with the radar installed at the main conning position;

**.2** radar operating in 3 GHz frequency band. The antennas and transceivers may be used jointly with the radar installed at the main conning position;

**.3** electronic chart display and information system (ECDIS) with back-up arrangements;

**.4** radar ice display;

**.5** display of radio navigation system receiver;

**.6** gyrocompass steering repeater;

**.7** rate-of-turn indicator (for ships of gross tonnage 50000 and above);

**.8** log repeater;

**.9** bottom speed log repeater (for ships of gross tonnage 50000 and above);

**.10** echo sounder repeaters;

**.11** microphone(s) of the voyage data recorder;

**.12** bridge navigational watch alarm system (BNWAS). The BNWAS of the main conning position may be used if an interlock is provided for preventing simultaneous use of devices for signal acknowledgement and reset of the BNWAS to the initial state, installed at the main and stern facing conning positions;

**.13** sound reception system;

**.14** VHF radio installation;

**.15** distress panel and distress alarm panel in case the stern facing conning position is not in the same space as the main conning position;

**.16** NAVTEX receiver in case the stern facing conning position is not in the same space as the main conning position. Alternatively, equipment may be used which is capable of displaying the maritime safety information (MSI) received by the main NAVTEX receiver;

**.17** enhanced group calling (EGC) receiver in case the stern facing conning position is not in the same space as the main conning position. Alternatively, equipment may be used which is capable of displaying the MSI received by the main EGC receiver;

**.18** controls for propulsion systems in accordance with 3.1 and 7.3, Part VII "Machinery Installations".

To ensure commonality in ship control when operating in different modes (stern first or bow first), the direction of setting of the controls (joystick, handwheel, remote automated control unit handles, etc.) for the main machinery, propellers and steering arrangements located at the stern facing conning position shall match the direction of setting of the controls for the main machinery, propellers and steering arrangements located at the forward facing conning position;

**.19** control panel for navigation lights and the light, which shall meet the requirements specified in 7.4.6 (ship's stop light), for the stern first operation mode.

Two sets of the above navigation lights and ship's stop lights shall be provided: a set for the bow first navigation and a set for stern first navigation. An interlock for preventing simultaneous use of the both sets of navigation lights and ship's stop lights shall be provided;

**.20** control panel for searchlights used to illuminate ice situation in front of the aft part of the ship.

The dedicated searchlights for stern first operation or the same searchlights (when operating bow first or stern first) may be used. In the latter case, the searchlights shall have no rotation restrictions for illumination when operating bow first or stern first, and no obstructions for illumination (funnel, masts, etc.);

**.21** control panel for heating, wipers and window washing of the stern facing conning position;

**.22** buttons for actuation of ship's whistle and day signalling lamp;

**.23** means for activation of general alarm system;

**.24** alarm and monitoring system devices and indication devices in accordance with 2.4, Part XV "Automation";

**.25** indicating unit of fire detection system;

**.26** sound-powered telephones, voice communication facilities, two-way loud-speaking communication facilities, automatic telephone systems or mobile phones of a local network installed on board the ship shall meet the requirements specified in 7.2.3, Part XI "Electrical Equipment".

**19.4.5** When the control is exercised from the stern facing conning position, the equipment located in this position shall process and display navigational information taking into account the stern first movement and ship control under this mode of operation.

The following instructions for processing and displaying information at the stern facing conning position shall be used:

**.1** inverted (relative to display of data when moving bow first) heading data shall be displayed on all repeaters and used for output to the equipment installed at the stern facing conning position;

**.2** inverted speed data shall be displayed on all repeaters and used for output to the equipment installed at the stern facing conning position (while the speed in COG/SOG format shall not be inverted);

**.3** radar presentation shall be inverted relative to the bow;

**.4** inverted relative wind speed and direction data (if any) shall be displayed on all repeaters and used for output to the equipment installed at the stern facing conning position;

**.5** the sound reception panel shall display origin directions of received sounds inverted relative to the bow;

**.6** for ECDIS and radar additional indication of stern first operation mode is recommended. The ship symbol is recommended to be oriented per inverted heading value.

**19.4.6 General requirements.**

**19.4.6.1** The location of the radar antennas shall provide scanning aft of the ship without blind sectors in an arc of the horizon of 225° (straight aft to the directions of 22,5° after the beam to either side).

**19.4.6.2** Indication of the ship operation mode (bow first or stern first) shall be easy to understand and displayed on the equipment where necessary.

**19.4.6.3** The following shall be provided for the azimuth thruster control system:

selection of conning position (bow/stern first). The changeover of control from one conning position to another shall be confirmed by assuming control at the other conning position;

an interlock for preventing simultaneous ship control from the main and stern facing conning positions;

indication of selected ship operation mode at all conning stations, local control stations of the main machinery and main machinery control room (if any).

**19.4.6.4** Location of the group alert block to be arranged in the navigation bridge (wheelhouse) in accordance with 2.4.1.4, Part XV "Automation" shall provide clear visibility and audibility of alert signals from the forward and stern facing conning positions. Where it is impossible to arrange the group alert block so as to fulfil the above requirement, separate group alert blocks shall be provided for the stern and forward facing conning positions.

# 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** description of means of access to structures from inside and outside (may be drawn up in the form of a manual on means of access), 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 (FI);

**.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. Means of access shall be provided in such spaces, enabling a throughout examination of the shell plating from inside. 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 the Rules for the Classification and Construction of MODU or Section 4 "Position-Keeping Systems", Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Floating Offshore Oil-and-Gas Product 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 and Construction of MODU or Section 8, Part XV "Automation" of the Rules for the Classification and Construction of Floating Offshore Oil-and-Gas Product 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 21.1.1.2, 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 and Construction of MODU or Sections 8 and 9, Part XV "Automation" of the Rules for the Classification and Construction of Floating Offshore Oil-and-Gas Product 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 the Rules for the Classification and Construction of MODU 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 the Rules for the Classification and Construction of MODU.

**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 Common Structural Rules for Bulk Carriers and Oil Tankers shall have the distinguishing mark **CON-M** added to the character of classification, provided the provisions of this Section and the applicable provisions of the Guidelines on Technical Supervision of Ships under Construction are met.

**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.

# 23 REQUIREMENTS FOR SHIPS EQUIPPED TO USE METHANOL/ETHANOL AS FUEL

## 23.1 GENERAL

**23.1.1 Application.**

The requirements of this Section apply to ships equipped to use methanol and ethanol as fuel. In addition to the requirements of this Section, the ship shall comply with requirements of the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code).

Where the ship is a chemical tanker and uses cargo as fuel, the requirements of this Section related to arrangement of fuel tanks on board the ship do not apply to cargo tanks which shall be located in compliance with the requirements of the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code) and the Rules for the Classification and Construction of Chemical Tankers.

For ships equipped to use methanol and ethanol as fuel in compliance with the requirements of this Section, the distinguishing mark **LFLFS (Me)** or **LFLFS (Et)** (Low Flashpoint Liquid Fuelled Ship, (Methanol) or (Ethanol)) is added to the character of classification.

**23.1.2 Definitions.**

In addition to the below mentioned, the definitions specified in 1.2 of Part VI "Fire Protection", 9.1.3 of this Part and in the IGF Code are applicable to the requirements of this Section.

*Independent tanks* are self-supporting tanks, do not form part of the ship's hull and are not essential to the hull strength.

*Integral tanks* are fuel-containment envelope tanks which form part of the ship's hull and which may be stressed in the same manner and by the same loads which stress the contiguous hull structure.

*Single fuel engine* means, for the purpose of this Section, a heat engine capable of operating only on methyl/ethyl alcohol, and not able to switch over to operation on any other type of fuel.

*Dual fuel engine* means, for the purpose of this Section, a heat engine designed to operate on methanol/ethanol and conventional fuel, either simultaneously or separately.

*Conventional fuel* means liquid petroleum-derived fuel which complies with the requirements specified in 1.1.2 of Part VII "Machinery Installations".

*Pilot oil fuel* means conventional fuel fed to the dual fuel engine cylinder for self-ignition as per conventional diesel cycle ensuring an ignition source for methanol/ethanol.

*Tank connection space* means a space surrounding all tank valves and connections required for methanol/ethanol tank with such connections in enclosed spaces.

*Fuel storage hold space* means the space where an independent methanol/ethanol tank is located. If tank connections are located in the fuel storage hold space, such fuel storage hold space shall also be considered as tank connection space.

*Portable tank* means an independent tank being able to be easily removed from ship and installed on board ship and easily connected and disconnected from ship systems.

**23.1.3 Technical documentation.**

In addition to the technical documentation specified in Section 3 of Part I "Classification", the technical documents and ship data specified in this Section shall be submitted. In case of review based on plan approval documentation and in case of conversion of ships, the technical documentation shall be submitted in full scope specified in 23.1.3.1 — 23.1.3.16.

In case of two-stage review, at the technical design stage the technical documentation shall be submitted as per 23.1.3.1 — 23.1.3.2, 23.1.3.8 — 23.1.3.9, 23.1.3.13 — 23.1.3.16. The technical documentation as per 23.1.3.4 — 23.1.3.5, 23.1.3.10 — 23.1.3.12 shall be submitted at the detailed design stage. As regards 23.1.3.3, 23.1.3.6 and 23.1.3.7, the diagrams shall be submitted during the technical design review, and the drawings shall be submitted at the stage of detailed design review.

The letter identification (A — Approved, AG — Agreed) in 23.1.3.1 — 23.1.3.16 means the documentation review results which are documented by stamping in compliance with 8.2 of Part II "Technical Documentation" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

**.1** drawing of fuel tanks arrangement with indication of distance from bottom and side plating to methanol/ethanol fuel tanks (A);

**.2** drawing of supports and other structures to ensure fastening and limiting shifting of methanol/ethanol fuel tanks (A);

**.3** drawings and diagrams of systems and piping for methanol/ethanol specifying such assemblies as compensators, flange joints, stop and control valves and fittings, drawings of quick-closing arrangements of the fuel system, diagrams of fuel preparation systems (A);

**.4** drawings of safety and vacuum valves of fuel tanks, where available (A);

**.5** installation drawings of arrangements for measurement of fuel amount and characteristics, and for leakage detection (A);

**.6** diagrams and calculations of gas-dangerous spaces ventilation (A);

**.7** diagrams and calculations of gas-freeing system and inert gas system, drawings and calculations of bilge and ballast systems in cargo area, pump rooms, cofferdams, pipe tunnels and hold spaces (A);

**.8** electrical diagrams for connection of drives and control systems for fuel preparation plants, ventilation of hazardous spaces and airlocks (A);

**.9** electrical circuit diagrams for measurement and alarm systems for equipment related to the use of methanol/ethanol (A);

**.10** arrangement drawings of electrical equipment related to the use of methanol/ethanol (A);

**.11** drawings of cable laying in hazardous and gas-dangerous spaces and areas (A);

**.12** drawings of earthing for electrical equipment, cables, piping located in gas-dangerous spaces (A);

**.13** arrangement of hazardous areas diagram specifying the layout of methanol/ethanol 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 (A);

**.14** analysis of risks related to the use and storage of methanol/ethanol and possible consequences of its leakages. The analysis shall consider the risks of damage of hull structural members and failure of any equipment after accident related to the use of methanol/ethanol. The results of risk analysis shall be taken into account in the ship's operational documentation (AG);

**.15** diagram of fire-protection water spray system, including piping, valves, nozzles and fittings, as well as diagram of dry powder fire extinguishing system and foam fire extinguishing system, their operating manuals and capacity calculation (A);

**.16** description and plan of monitoring, control and alarm systems (A).

## 23.2 GENERAL REQUIREMENTS FOR SHIP STRUCTURE

**23.2.1 Onboard location of fuel storage tanks.**

**23.2.1.1** Tanks containing methanol/ethanol shall not be located within accommodation spaces and machinery spaces of category A or be adjacent to them.

**23.2.1.2** Fuel tanks containing methanol/ethanol shall be located abaft the collision bulkhead and forward of the afterpeak bulkhead and at the distance of at least 800 mm from the side shell. Storage of fuel in integral tanks bound by shell plating below the waterline is accepted.

**23.2.1.3** Fuel tanks containing methyl/ethyl alcohol which are located on open decks shall be protected against mechanical damage.

**23.2.1.4** Fuel tanks containing methyl/ethyl alcohol which are located on open decks shall be surrounded by coamings and spills shall be collected in a dedicated holding tank.

**23.2.2 Drip trays.**

**23.2.2.1** Drip trays shall be fitted where leakage and spill may occur, in particular, in way of single wall pipe connections.

**23.2.2.2** Each drip tray shall have sufficient capacity to ensure that the maximum amount of spill can be handled.

**23.2.2.3** Each drip tray shall be provided with means to safely drain methanol/ethanol spills or transfer spills to a dedicated holding tank. Means for preventing backflow from the tank shall be provided.

**23.2.2.4** Drip trays for leakage of less than 10 litres may be provided with means for manual emptying, other trays shall be self-drained by means of scupper pipes.

**23.2.2.5** The holding tank shall be equipped with a level indicator and high level alarm. The tank shall be inerted at all times during normal operation.

**23.2.3 Machinery spaces.**

**23.2.3.1** A single failure within the fuel system shall not lead to release of methanol/ethanol into the machinery space.

**23.2.3.2** Methanol/ethanol piping within machinery space boundaries shall be enclosed in gas and liquid tight outer pipes or ducts in accordance with 23.5.4.3.

**23.2.4 Requirements for bilge systems.**

**23.2.4.1** Bilge systems installed in areas where methyl/ethyl alcohol may be present shall be segregated from the bilge systems of spaces where methyl alcohol or ethyl alcohol cannot be present.

**23.2.4.2** One or more holding tanks for collecting drainage and any possible leakage of methyl/ethyl alcohol from fuel pumps, valves or from double walled inner pipes located in enclosed spaces shall be provided. Means shall be provided for safely transferring contaminated liquids to onshore reception facilities.

**23.2.5 Requirements for arrangement of entrances and other openings in enclosed spaces.**

**23.2.5.1** Direct access shall not be permitted from a non-hazardous area to a hazardous area. Where such openings are necessary for operational reasons, an airlock complying with the requirements of 23.2.6 shall be provided.

**23.2.5.2** Fuel preparation spaces shall have independent access direct from open deck. Where a separate access from open deck is not practicable, an airlock complying with the requirements of 23.2.6 shall be provided.

**23.2.5.3** Tanks for storage of methanol/ethanol and surrounding cofferdams shall normally have suitable access from the open deck, where practicable, for gas freeing, cleaning, maintenance and inspection. Where it is not possible to provide a separate access from the open deck for fuel tanks or cofferdams, an access from a space not connected with accommodations and service spaces, control stations or machinery spaces of category A in any way shall be provided and shall meet the following:

**.1** be fitted with an independent extraction ventilation system, providing a minimum of 6 air changes per hour, a low oxygen alarm and a vapour detection alarm;

**.2** have sufficient open area around the fuel tank hatch for efficient rescue operations and evacuation of injured persons.

**23.2.5.4** The area around independent fuel tanks shall be sufficient to carry out maintenance, inspections, evacuation of injured persons and rescue operations.

**23.2.6 Requirements for airlocks.**

**23.2.6.1** The airlocks shall comply with the requirements of 9.2.7.

**23.2.7 Requirements for location and protection of fuel piping.**

**23.2.7.1** Fuel pipes shall not be located less than 800 mm from the ship's side.

**23.2.7.2** Fuel piping shall not be led directly through accommodation spaces, service spaces, and control stations.

**23.2.7.3** Fuel pipes led through ro-ro spaces, special category spaces and on open decks shall be protected against mechanical damage.

**23.2.8** Methanol fuel piping shall comply with the following:

**.1** methanol fuel piping that passes through enclosed spaces in the ship shall be enclosed in an outer pipe or duct that is gas and liquid tight towards the surrounding spaces with the fuel contained in the inner pipe. Such double walled piping is not required in cofferdams surrounding fuel tanks, fuel preparation spaces or spaces containing independent fuel tanks, however, electrical equipment located in such enclosed spaces shall be explosion-proof;

**.2** pipes shall be self-draining to suitable fuel or collecting tanks in normal conditions of operation.

## 23.3 DESIGN OF TANKS FOR METHYL/ETHYL FUEL

**23.3.1 Requirements for integral fuel storage tanks.**

**23.3.1.1** On ships other than tankers for the carriage of methanol/ethanol, fuel storage tanks shall be surrounded by protective cofferdams, except of those tanks with walls bound by other fuel tanks containing methanol/ethanol, pump room, fuel preparation space and shell plating below the waterline. On tankers carrying methanol/ethanol, methanol/ethanol tanks may be adjacent to the cargo tanks.

**23.3.2 Requirements for independent tanks.**

**23.3.2.1** Independent tanks may be accepted on open decks or in a fuel storage space.

**23.3.2.2** Independent tanks shall be fitted with:

**.1** mechanical protection of the tanks depending on location and damage hazard during cargo operations;

**.2** if located on an open deck, drip tray arrangements for leak containment and water spray systems for emergency cooling.

**23.3.2.3** Independent fuel tanks shall be secured to the ship's structure. The arrangement for supporting and fixing the tanks shall be designed for the maximum expected static, dynamic and accidental loads as well as the maximum expected values of acceleration, taking into account the ship characteristics and the position of the tanks.

**23.3.3 Requirements for portable tanks.**

**23.3.3.1** Portable methanol and ethanol tanks shall comply with the requirements of 9.3.4.

**23.3.3.2** When a portable tank is connected to the ship's fuel piping system, the following shall be met:

**.1** each portable tank shall be capable of being remotely isolated from fuel system at any time from a readily accessible position;

**.2** isolation of one tank shall not impair the operability of the remaining portable tanks.

**23.3.4 Venting and gas freeing systems for methanol/ethanol fuel tanks.**

**23.3.4.1** The methanol/ethanol fuel tanks shall be fitted with a controlled fixed tank venting system to enable safe gas freeing and fuel filling. The formation of gas pockets during the filling and gas freeing operations shall be avoided by considering the arrangement of tank structure and location of gas freeing inlets and outlets.

**23.3.4.2** Pressure and vacuum relief valves shall be fitted to each fuel tank to limit the pressure or vacuum in the tank. The tank venting system may consist of individual vents from each fuel tank or the vents from each individual fuel tank may be connected to a common header. Design and arrangement shall prevent flame propagation into the fuel containment system. If pressure relief valves of the high velocity type are fitted to the end of the vent pipes, they shall comply with the requirements of IMO circular MSC/Circ.677, as amended. If pressure relief valves are fitted in the vent line, the vent outlet shall be fitted with a flame arrestor complying with the requirements of IMO circular MSC/Circ.677, as amended.

**23.3.4.3** Shut-off valves shall not be arranged either upstream or downstream of the pressure relief valves. Bypass valves may be provided. For temporary tank segregation purposes (maintenance) shut-off valves in common vent lines may be accepted if a secondary independent over/underpressure protection is provided to all tanks as per 23.3.4.4.

**23.3.4.4** The controlled venting system shall consist of the main (primary) and auxiliary (secondary) means allowing relief of fuel vapour to prevent overpressure or vacuum. Pressure sensors fitted in each fuel tank, and connected to an alarm system, may be accepted in lieu of the secondary redundancy requirement for pressure relief. The opening pressure of the pressure relief valves shall not be lower than 0,007 MPa below atmospheric pressure.

**23.3.4.5** Pressure relief valves shall be of a type which allows the functioning of the valve to be easily checked. Piping of pressure relief valves shall vent to a safe location on open deck.

**23.3.4.6** The fuel tank vent system shall be sized to permit bunkering at a design loading rate without over-pressurizing the fuel tank.

**23.3.4.7** The fuel tank vent system shall be connected to the highest point of each tank and vent lines shall be self-draining under all normal operating conditions.

**23.3.4.8** Fuel tank vent outlets shall be situated:

**.1** not less than 3 m above the open deck or gangway if located within 4 m from such gangways;

**.2** at a horizontal distance of at least 10 m from the nearest air intake or opening to accommodation, service and machinery spaces and ignition sources. The vapour discharge shall be directed upwards in the form of unimpeded jets.

**23.3.4.9** Outlets from fuel tank vent pipes shall be provided with flame arrestors of a type approved by the Register. Due attention shall be paid in the design and position of the pressure relief valves of vent pipes to preclude blocking due to icing. Provision for inspection and cleaning shall be arranged.

## 23.4 FUEL CONSUMERS ON BOARD SHIP

**23.4.1 General requirements for internal combustion engines.**

**23.4.1.1** Engine components containing methyl/ethyl alcohol fuel shall be effectively sealed. A single failure in the fuel supply system shall not lead to a leakage of fuel into the non-hazardous area of the machinery space.

**23.4.1.2** Means shall be provided to monitor and detect poor combustion or misfiring. In the event that it is detected, continued operation may be allowed, provided that the 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.

**23.4.1.3** For engines where the space below the piston is in direct communication with the crankcase, a detailed evaluation regarding the hazard potential of methanol/ethanol accumulation in the crankcase shall be carried out and operational documents shall indicate the procedure for such a situation.

**23.4.2 Dual fuel engines.**

**23.4.2.1** In case of shutoff of the methyl/ethyl alcohol supply, the engines shall be capable of continuous operation by conventional fuel only, without interruption.

**23.4.2.2** An automatic system shall be fitted to change over from methyl/ethyl alcohol fuel operation to conventional 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 methyl/ethyl alcohol firing, the engine shall automatically change to conventional fuel mode. There shall always be the possibility for manual changeover.

**23.4.2.3** In case of a normal stop or an emergency stop, the methanol/ethanol supply shall be shut off not later than the pilot oil fuel. It shall not be possible to shut off the pilot oil fuel without first or simultaneously closing the methanol supply to each cylinder or to the complete engine.

**23.4.3 Single-fuel engines for operation on methanol only.**

**23.4.3.1** In case of a normal stop or an emergency shutdown, the 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 fuel supply to each cylinder or to the complete engine.

**23.4.3.2** Power installations with one engine operating only on methanol may be accepted, when the risk assessment results are submitted which demonstrate the equivalent level of reliability as compared with the conventional oil fuel engine.

## 23.5 FUEL SYSTEM

**23.5.1 General requirements for fuel piping.**

**23.5.1.1** The walls thickness of pipes in the cargo piping system shall be in accordance with the requirements in 2.3 of Part VIII "Systems and Piping".

**23.5.1.2** All fuel piping and independent fuel tanks shall be electrically continuous and earthed to the ship's hull. Electrical earthing shall be maintained across all gasketed pipe joints and hose connections. Electrical resistance between any piping section and the hull shall be maximum 1 MOhm.

**23.5.1.3** Filling lines to fuel tanks shall be arranged to minimize the possibility for static electricity by reducing the free fall into the fuel tank to a minimum during tank filling.

**23.5.1.4** The arrangement and installation of fuel piping shall provide the necessary flexibility to maintain the integrity of the piping system in the actual service situations, taking potential for fatigue into account. Expansion bellows shall not be used.

**23.5.1.5** Due consideration shall be taken with respect to the corrosive nature of fuel when selecting materials.

**23.5.2 Piping fabrication and joining details.**

**23.5.2.1** In addition to the requirements of this Section, during fabrication of fuel system pipelines and selection of connections, requirements specified in 1.3 of Part VI "Systems and Piping" of the Rules for the Classification and Construction of Chemical Tankers shall be complied with.

The inner piping, where an outer pipe or a duct is required, shall be butt-welded. Welded joints shall be 100 % radiographed. Flange connections in this piping may only be permitted within the tank connection space and fuel preparation spaces.

**23.5.2.2** The annular space in the double walled fuel piping shall be segregated at the engine-room bulkhead; this implies that there shall be no common ducting between the engine-room and other spaces.

**23.5.2.3** Heat expansion of pipes shall normally be allowed for by the provision of expansion loops or bends in the piping systems.

**23.5.3 Methanol/ethanol bunkering station.**

**23.5.3.1** 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.

**23.5.3.2** Closed or semi-enclosed bunkering stations shall be surrounded by gas- and liquid-tight boundaries against adjacent enclosed spaces.

**23.5.3.3** Bunkering lines shall not be led directly through accommodation, control stations or service spaces. Bunkering lines passing through non-hazardous areas shall be double walled or located in ventilated gastight ducts.

**23.5.3.4** Arrangements shall be made for safe management of fuel spills. Coamings and/or drip trays shall be provided below the bunkering connections together with a means of safely collecting and storing spills of methanol. This could be a drain to a dedicated holding tank equipped with a level indicator and alarm. Where coamings or drip trays are subject to rainwater, provision shall be made to drain rainwater overboard.

**23.5.3.5** Showers and eye wash stations for emergency usage shall be located in close proximity to areas where the possibility for accidental contact with fuel exists. The emergency showers and eye wash stations shall be operable under all ambient conditions.

**23.5.3.6** Bunkering hoses carried permanently on board the ship shall comply with the requirements specified in 1.8 of Part VI "Systems and Piping" of the Rules for the Classification and Construction of Chemical Tankers.

**23.5.3.7** Means shall be provided for draining any fuel from the bunkering hoses upon completion of operation. Means shall be provided for safe storage of hoses carried on board the ship. Hoses shall be stored on the open deck or in a storage room with an independent extraction ventilation system, providing a minimum of six air changes per hour.

**23.5.3.8** 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.

**23.5.3.9** Means shall be provided for draining any fuel from the bunkering pipes upon completion of operation.

**23.5.3.10** Bunkering lines shall be arranged for inerting and gas freeing. When not engaged in bunkering, the bunkering lines shall be free of gas, unless the decision of not gas freeing is approved and the consequences are evaluated by a person in charge.

**23.5.3.11** A ship-shore link (SSL) or an equivalent means for automatic and manual ESD communication to the bunkering source shall be fitted.

**23.5.3.12** In the bunkering line, as close to the connection point as possible, there shall be a manually operated stop valve and a remotely operated shutdown valve arranged in series. Alternatively, a combined manually operated and remote valve may be provided. It shall be possible to operate this remotely operated valve from the bunkering control station and/or from another safe location.

**23.5.3.13** The bunkering control station shall not be used for any other purpose. Where bunkering lines are arranged with a cross-over, suitable isolation arrangements shall be provided to ensure that fuel cannot be transferred inadvertently to the ship side not in use for bunkering.

**23.5.3.14** Risk assessment of bunkering shall be carried out, and the results thereof shall be stated in a document "Risk assessment related to use and storage of methanol/ethanol and potential consequences of leakage". Such assessment shall be aimed at the review of bunkering equipment and operating procedures thereof in order to:

**.1** identify causes and effects for safety of potential fuel emissions at connection, preparation and disconnection of bunkering equipment, as well as during the fuel transfer;

**.2** establish safety precautions to ensure safe bunkering to minimize the causes and effects of failures.

The study shall be performed in accordance with a recognized standard (e.g. ISO 31010 "Risk management. Risk assessment techniques") which is based on risk assessment, considering the applicable appendices thereto.

**23.5.3.15** Bunkering shall be controlled from a safe location, where, as a minimum, the information showing instrument readings, such as fuel level in the tanks and methanol pressure in supply piping, as well as overfill alarms and automatic shutdown of methanol/ethanol supply shall be indicated at this location.

**23.5.3.16** If the pressure in the annular spaces of the double walled bunkering lines or air pressure in the ventilated air ducts is decreased, the alarm system shall activate audible and visual alarm at the bunkering control stations.

**23.5.3.17** The ship shall be fitted with an emergency shutdown of bunkering (ESD) capable of operating both from the ship and control station of the facility.

Quick and safe shutdown of both bunkering supply and ship methanol/ethanol supply system shall be provided without liquid spill or vapour emission.

**23.5.3.18** Fuel tanks shall be filled up to maximum 98 % of the total capacity.

**23.5.4 Methanol/ethanol supply to consumers.**

**23.5.4.1** The methanol/ethanol fuel piping system shall be separate from all other piping systems of the ship.

For chemical tankers carrying methanol/ethanol and using cargo as fuel, the fuel system shall be separate from cargo piping system.

For single fuel installations the fuel supply system shall be arranged with full redundancy all the way from the fuel tanks to the fuel consumers.

**23.5.4.2** The piping and their joints shall be so arranged that any damage of fuel piping cannot lead to an uncontrolled release of fuel. The number of fuel piping joints shall be kept to a minimum necessary for mounting of valves and equipment of the fuel system.

**23.5.4.3** All methanol/ethanol supply piping in the enclosed spaces including the machinery spaces shall be enclosed within gas and liquid tight outer pipes or ducts complying with one of the following requirements:

**.1** the annular space between inner and outer pipe shall have mechanical ventilation of underpressure type with a capacity of minimum 30 air changes per hour and be ventilated to open air. Appropriate means for detecting leakage of methanol/ethanol into the annular space shall be provided. The double wall enclosure shall be connected to a suitable draining tank allowing the collection and the detection of any possible leakage;

**.2** the annular space shall be inerted. Appropriate means of detecting leakage of methanol/ethanol into the annular space shall be provided. Suitable alarms shall be provided to indicate a loss of inert gas pressure between the pipes.

**23.5.4.4** The outer pipe in the double walled fuel pipes shall be dimensioned for a design pressure not less than the maximum working pressure of the fuel pipes. As an alternative the calculated maximum built-up pressure in the duct in the case of an inner pipe rupture may be used for dimensioning of the duct.

**23.5.4.5** Fuel piping to every consumer shall be provided with the means of purging the piping after the master fuel valve. Purging shall be conducted automatically in the methanol supply system at closing of the master fuel valve.

**23.5.4.6** For installations with a single engine for transfer of power to the propeller, the arrangements shall be such that in case of fuel supply stop a standby fuel supply system is provided. Dual fuel engines shall be capable of continuous operation on conventional fuel without using methanol/ethanol.

**23.5.5 Safety of fuel supply systems.**

**23.5.5.1** All fuel piping shall be arranged for gas freeing and inerting.

**23.5.5.2** 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.

**23.5.5.3** The main fuel supply line to each consumer or set of consumers shall be equipped with a manually operated shut-off valve and an automatically operated master fuel valve for methanol/ethanol supply. The valves shall be situated in the part of the piping that is outside the machinery space containing methanol/ethanol consumers. The master methanol/ethanol supply valve shall automatically shut off the fuel supply when the safety system as required in Table 23.9.1.1.2 is activated.

**23.5.5.4** Means of manual emergency shutdown of fuel supply to the consumers or set of consumers shall be provided on the primary and secondary escape routes from the compartment where methanol/ethanol consumers are located, at a location outside consumer space, outside the fuel preparation space and at the bridge. The activation device shall be arranged as a physical button, duly marked and protected against inadvertent operation and operable under emergency lighting.

The fuel supply line to each consumer shall be provided with a remotely operated shut-off valve.

**23.5.5.5** There shall be one manually operated shut-off valve in the fuel line to each consumer to ensure safe isolation during maintenance.

**23.5.5.6** When pipes penetrate the fuel tank below the top of the tank a remotely operated shut-off valve shall be fitted to the fuel tank bulkhead. When the fuel tank is adjacent to a fuel preparation space, the valve may be fitted on the tank bulkhead on the fuel preparation space side.

**23.5.6 Requirements for fuel preparation spaces and pumps.**

**23.5.6.1** All equipment containing fuel intended for its preparation and supply to consumers shall be located in a particular space which shall comply with the following requirements:

**.1** fuel preparation spaces shall be located outside ship's machinery spaces of category A or other spaces of high fire hazard;

**.2** fuel preparation space shall be gas and liquid tight to surrounding enclosed spaces.

**23.5.6.2** Hydraulically powered pumps that are submerged in fuel tanks shall be arranged with double barriers preventing the hydraulic system serving the pumps from being directly exposed to fuel. The double barrier shall be arranged for detection and drainage of eventual fuel leakage.

**23.5.6.3** All pumps in the fuel system shall be protected against running dry.

**23.5.6.4** All pumps which are capable of developing a pressure exceeding the design pressure of the system shall be provided with relief valves. Each relief valve shall be in closed circuit, i.e. arranged to discharge back to the piping on the suction side of the pump and to effectively limit the pump discharge pressure to the design pressure of the system.

## 23.6 REQUIREMENTS FOR FIRE PROTECTION

**23.6.1 General.**

**23.6.1.1** Fire protection shall comply with the requirements of this Section in addition to Part VI "Fire Protection" depending on the purpose of the ship.

**23.6.2 Structural fire protection.**

**23.6.2.1** Any boundary of accommodation spaces, service spaces, control stations, escape routes, machinery spaces facing methyl/ethyl fuel storage tanks on the open deck, shall have A-60 fire integrity and shall be extended to the lower boundary of the wheelhouse deck. Methyl/ethyl fuel storage tanks shall be isolated from the cargo and be located in accordance with the requirements of the International Maritime Dangerous Goods Code (IMDG Code) for the class 3 package.

**23.6.2.2** For the purposes of fire protection, fuel preparation spaces shall be regarded as machinery space of category A. Should the space have boundaries towards other machinery spaces of category A, accommodation, control station or cargo areas, these boundaries shall not be less than A-60.

**23.6.2.3** The boundaries of spaces for storage of methyl/ethyl alcohol tanks shall be separated from the machinery spaces of category A and other rooms with high fire risks by a cofferdam of at least 600 mm, with insulation of not less than A-60 class. They may be separated from other spaces with low fire risks by A-0 fire structures.

**23.6.2.4** Methyl/ethyl fuel pipes led through open ro-ro spaces on open deck shall be provided with special guards to prevent vehicle collision damage. Fire insulation of such pipelines shall be considered by the Register in each particular case.

**23.6.2.5** Where more than one machinery space is arranged on board the ship, they shall be separated by class A-60 divisions.

**23.6.2.6** Any space containing equipment for the fuel preparation shall be regarded as a machinery space of category A and provided with a fixed fire extinguishing system complying with the requirements set out in 3.1.2 of Part VI "Fire Protection" taking into account necessary concentrations/application rate of fire extinguishing substance required for extinguishing gas fires.

**23.6.2.7** The bunkering station shall be separated by A-60 class divisions towards machinery spaces of category A, accommodation, 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 similar spaces where the insulation standard may be reduced to class A-0.

**23.6.2.8** Fuel hold space shall not be used for arrangement and storage of other equipment.

**23.6.2.9** The bunkering space shall be separated from the machinery spaces of category A, accommodation, control stations and high fire risk spaces by A-60 class divisions. Fire resistance of structures separating this space from tanks, voids, auxiliary machinery spaces of little or no fire risk, sanitary and similar spaces may be reduced to class A-0.

**23.6.3 Water fire main system.**

**23.6.3.1** The water fire main system shall comply with the requirements set out in 3.2 of Part VI "Fire Protection" with due regard to the purpose of the ship.

**23.6.3.2** 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.

**23.6.3.3** Where methyl/ethyl alcohol storage tanks 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.

**23.6.4 Water spray system.**

**23.6.4.1** 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, CCRs, 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.

**23.6.4.2** The system shall be designed to cover all areas specified in 23.6.4.1 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.

**23.6.4.3** 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.

**23.6.4.4** 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.

**23.6.4.5** 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.

**23.6.4.6** 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.

**23.6.5 Foam fire extinguishing system and special provisions of fire protection.**

**23.6.5.1** Where a fuel storage tanks is located on open deck, there shall be a fixed fire-fighting system of alcohol-resistant foam type (AR/AFFF), as set out in Chapter 17 of the IBC Code and the applicable requirements of Chapter 14 of the International Code for Fire Safety Systems (FSS Code).

**23.6.5.2** The alcohol-resistant foam type fire-fighting system shall cover the area below the fuel storage tank where a spill of fuel could be expected to spread.

**23.6.5.3** The bunker station shall have a fixed fire extinguishing system of alcohol resistant foam type and a portable dry chemical powder extinguisher, located near the entrance of the bunkering station.

**23.6.5.4** Where FSTs are located on open deck, there shall be a fixed water spray system for diluting eventual spills and fire prevention. The system shall cover exposed parts of FST.

**23.6.5.5** A fixed fire detection and fire alarm system complying with FSS Code shall be provided for all compartments containing the alcohol fuel system.

**23.6.5.6** Suitable detectors shall be selected based on the fire characteristics of the fuel. Smoke detectors shall be used in combination with detectors which can more effectively detect methyl/ethyl alcohol fires.

**23.6.6 Provision for fire extinguishing of machinery space and fuel preparation space.**

**23.6.6.1** Machinery space and fuel preparation space where methyl/ethyl alcohol-fuelled engines or fuel pumps are arranged shall be protected by an approved fixed fire extinguishing system in accordance with regulation II-2/10 of SOLAS-74, as amended, and the FSS Code. In addition, the fire extinguishing medium used shall be suitable for the extinguishing of methyl alcohol fires.

**23.6.6.2** An alcohol-resistant foam system covering the whole space area, the FST top and area under the floor plates shall be arranged for machinery space of category A and fuel preparation space.

**23.6.7 Fire-fighting outfit.**

**23.6.7.1** 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.

**23.6.7.2** The machinery space where alcohol (methanol/ethanol) is used as fuel shall be provided with two portable dry chemical powder extinguishers of at least 5 kg capacity each, located at the entrance.

## 23.7 VENTILATION

**23.7.1 General.**

**23.7.1.1** Ventilation inlets and outlets for spaces required to be fitted with mechanical ventilation in compliance with this Section, shall be located such that according to the International Convention on Load Lines they will not be required to have closing appliances.

**23.7.1.2** 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.

**23.7.1.3** 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.

**23.7.1.4** Design of ventilation fans serving spaces containing fuel vapours shall comply with the requirements of 9.8.1.3.

**23.7.1.5** Ventilation system shall be of a mechanical exhaust type with inlets located such as to avoid accumulation of vapour from leaked methyl/ethyl alcohol leak in the space.

**23.7.1.6** 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.

**23.7.1.7** Air outlets from non-hazardous spaces shall be located outside hazardous areas.

**23.7.1.8** 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.

**23.7.1.9** 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.

**23.7.1.10** Non-hazardous spaces with entry openings to a hazardous area shall be arranged with an airlock 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.

**23.7.1.11** Double bottoms, cofferdams, duct keels, pipe tunnels, hold spaces and other spaces where methyl/ethyl fuel may accumulate shall be capable of being ventilated to ensure a safe environment when entry into the spaces is necessary.

**23.7.2 Ventilation of fuel preparation spaces.**

**23.7.2.1** Fuel preparation spaces shall be provided with an effective mechanical forced ventilation system of extraction type. During normal operation the ventilation shall be at least 30 air changes per hour.

**23.7.2.2** 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.

**23.7.2.3** Ventilation systems for fuel preparation rooms shall be in operation when pumps or any other equipment for fuel treatment are working.

**23.7.3 Requirements for ventilation of bunkering stations.**

**23.7.3.1** Ventilation of bunkering stations shall be provided as specified in 9.8.5.

**23.7.4 Requirements for ventilation of ducts and double pipes.**

**23.7.4.1** 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.

**23.7.4.2** The ventilation system for double wall piping and ducts shall be independent of all other ventilation systems.

**23.7.4.3** 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.

**23.7.4.4** Ventilation inlets shall be so located that to be arranged at least at the height of 3 m above the main deck and at the distance of at least 3 m from the nearest air inlets, openings for the enclosed spaces and possible ignition sources.

**23.7.4.5** Ventilation shall be so arranged that it shall be operated each time when methyl/ethyl fuel is available in the piping.

**23.7.4.6** Continuous vapour detection shall be arranged in the ventilation system, and fuel supply to the machinery space shall be shut-off in case of methanol/ethanol vapour leak is detected.

**23.7.4.7** When the required air flow is not maintained by the exhaust ventilation system, the master fuel valve shall be automatically closed.

**23.7.4.8** Materials, design and strength of outer protective pipes or air ducts and mechanical ventilation systems shall be capable of withstanding an instantaneous outburst and expansion of methanol under pressure in case of a failure of methanol/ethanol piping internal structure.

**23.7.4.9** The number of flange connections of outer protective pipes or air ducts shall be kept to a minimum.

**23.7.4.10** Outer protective pipes or air ducts shall be tested by the maximum working pressure of the internal pipe.

**23.7.4.11** Ventilation system shall be operable at all expected ambient temperatures.

## 23.8 INERTING AND ATMOSPHERE CONTROL

**23.8.1 General requirements for inert gas system.**

**23.8.1.1** All fuel tanks shall be inerted during normal operation. The system shall be so designed that to eliminate the possibility of a flammable mixture atmosphere existing in the fuel tank during any operations and gas freeing utilizing an inerting medium.

**23.8.1.2** Cofferdams shall be arranged either for purging or filling with water through a non-permanent connection. Emptying the cofferdams shall be done by a separate drainage system.

**23.8.1.3** To prevent the return of flammable liquid and vapour to the inert gas system, 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 inside hazardous spaces.

**23.8.1.4** Where the connections of the inert gas piping systems to fuel tanks are non-permanent, two non-return valves may substitute the valves required in 23.8.1.3.

**23.8.1.5** Blanking arrangements shall be fitted in the inert gas supply line to individual tanks. The position of the blanking arrangements shall be immediately obvious to personnel entering the tank. Blanking shall be via removable spool piece.

**23.8.1.6** The arrangements for gas freeing and ventilation of fuel tanks shall be such as to minimize the hazards of the dispersal of flammable vapours to the atmosphere and ignition of gas mixture in the tank. The ventilation system for fuel tanks shall be exclusively for ventilating and gas freeing purposes. Connection between fuel tank ventilation system and fuel preparation space will not be accepted.

**23.8.1.7** Gas freeing operations shall be carried out such that vapour is initially discharged in one of the following ways:

**.1** through outlets at least 3 m above the deck level with a vertical efflux velocity of at least 30 m/s maintained during the gas freeing operation;

**.2** through outlets at least 3 m above the deck level with a vertical efflux velocity of at least 20 m/s which are protected by suitable devices to prevent the passage of flame; or

**.3** through outlets underwater.

**23.8.2 Inert gas production and storage on board.**

**23.8.2.1** Inert gas shall be available permanently on board in order to achieve at least one trip from port to port considering maximum consumption of fuel expected and maximum length of trip expected, and to keep tanks inerted during two weeks in harbour with minimum port consumption of fuel.

**23.8.2.2** An inert gas production plant and/or adequate inert gas storage capacities capable of being filled externally to the ship shall be used to achieve the availability target defined in 23.8.2.1.

**23.8.2.3** Fluid used for inerting shall not modify the characteristics of the fuel.

**23.8.2.4** 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.

The system shall be designed to ensure that if the oxygen content exceeds 5 % by volume at the generator output the inert gas shall be automatically vented to atmosphere.

**23.8.2.5** The system shall be able to maintain an atmosphere with an oxygen content not exceeding 8 % by volume in any part of any fuel tank.

**23.8.2.6** The inert gas generator or inert gas storage facilities may be installed in a separate space outside of the engine room. This space shall be fitted with an independent extraction ventilation system, providing a minimum of 6 air changes per hour. If the oxygen content is below 19 % in the separate space, an alarm shall be given. A minimum of two oxygen sensors shall be provided in each space. Visual and audible alarms shall be placed at each entrance to the inert gas room.

**23.8.2.7** Inert gas pipelines shall only be laid through well ventilated spaces. Pipelines in enclosed spaces shall:

**.1** have only a minimum of flange connections as needed for fitting of valves;

**.2** be as short as possible.

**23.8.2.8** Inert gas utilized for gas freeing of fuel tanks may be provided externally to the ship.

## 23.9 MONITORING, CONTROL AND SAFETY SYSTEMS

**23.9.1 General.**

**23.9.1.1** The control, monitoring and safety systems shall be so arranged that to meet the following functional requirements in order to ensure safe and effective use of methyl/ethyl alcohol as fuel on board ships:

**.1** there is not an unacceptable loss of power in the event of a single failure of monitoring, control and safety systems;

**.2** a fuel safety system shall be arranged to close down the fuel supply system automatically, upon failure in systems as described in Table 23.9.1.1.2;

**.3** the safety functions shall be arranged in a dedicated fuel safety system that is independent of the fuel control system in order to avoid possible common cause failures; this includes power supplies and input and output signal;

**.4** the safety systems including the field instrumentation shall be arranged to avoid spurious shutdown, e.g. as a result of a faulty vapour detector or a wire break in a sensor loop;

**.5** where two independent fuel supply systems are required to meet the provisions, each system shall be fitted with its own set of independent fuel control and safety systems.

**23.9.1.2** Suitable instrumentation devices shall be fitted to allow a local and a remote reading of essential parameters to ensure safe management of the whole fuel equipment including bunkering.

**23.9.1.3** Liquid leakage detection shall be installed in the protective cofferdams surrounding the fuel tanks, in ducts around fuel pipes, in fuel preparation spaces, and in other enclosed spaces containing single walled fuel piping or other fuel equipment.

**23.9.1.4** The annular space in a double walled piping system shall be monitored for leakages and the monitoring system shall be connected to an alarm system. Any leakage detected shall lead to shutdown of the affected fuel supply line in accordance with Table 23.9.1.1.2.

**23.9.1.5** At least one bilge well with a level indicator shall be provided for each enclosed space, where independent storage tanks are located. A high-level bilge alarm shall be provided. The leakage detection system shall trigger an alarm and the safety functions in accordance with Table 23.9.1.1.2.

**23.9.1.6** A monitoring system, equivalent to that intended for permanently installed tanks, shall be provided for portable fuel tanks.

**23.9.2 Bunkering and fuel tank monitoring systems.**

**23.9.2.1** Level indicators.

Each fuel tank shall be fitted with closed level gauging devices enabling continuous level reading. Where it is not possible to arrange the required maintenance of such device while the fuel tank is in service, two level gauging devices shall be installed.

**23.9.2.2** Overflow control.

**.1** each fuel tank shall be fitted with a visual and audible high-level alarm. This shall be able to be function tested from the outside of the tank and can be common with the level gauging system (configured as an alarm on the gauging transmitter), but shall be independent of the high-high-level alarm;

**.2** an additional sensor (high-high-level) operating independently of the high liquid level alarm shall automatically actuate a shut-off valve to avoid excessive liquid pressure in the bunkering line and prevent the tank from becoming liquid full;

**.3** the high and high-high-level alarm for the fuel tanks shall be visual and audible at the location at which gas freeing by water filling of the fuel tanks is controlled, given that water filling is the preferred method for gas freeing.

**23.9.2.3** Bunkering control.

**23.9.2.3.1** Bunkering control shall be from a safe remote location. At this safe remote location:

**.1** tank level shall be capable of being monitored;

**.2** the remote-control valves shall be capable of being operated from this location, as required by 23.5.3.12. Closing of the bunkering shutdown valves shall be possible from the control location for bunkering and from another safe location;

**.3** overfill alarms and automatic shutdown shall also be indicated at this location.

**23.9.2.3.2** If the ventilation in the ducting enclosure or annular spaces of the double walled bunkering lines stops, an audible and visual alarm shall be activated at the bunkering control location.

**23.9.2.3.3** If fuel leakage is detected in ducting enclosure or the annular spaces of the double walled bunkering lines, an audible and visual alarm and emergency shutdown of the bunkering valve shall automatically be activated.

**23.9.3 Engine monitoring.**

**23.9.3.1** In addition to the instrumentation provided in accordance with Part XV "Automation", indicators for operating condition of engines operated on methanol/ethanol shall be fitted on the navigation bridge and the engine control room.

**23.9.4 Methanol/ethanol vapour detection.**

**23.9.4.1** Permanently installed methanol/ethanol vapour detectors shall be fitted in:

**.1** ventilated annular spaces of the double walled fuel pipes;

**.2** machinery spaces containing methyl/ethyl fuel consumers or fuel equipment;

**.3** methyl/ethyl fuel preparation spaces;

**.4** enclosed or semi-enclosed spaces containing methyl/ethyl fuel piping or other fuel equipment without outer pipes or ducting;

**.5** enclosed or semi-enclosed spaces where methyl/ethyl alcohol vapours may accumulate;

**.6** closed fuel storage hold spaces and cofferdams surrounding fuel tanks;

**.7** airlocks;

**.8** ventilation inlets to accommodation and machinery spaces, if required, based on the risk assessment.

**23.9.4.2** Methanol/ethanol vapour detection system shall be designed, installed and tested in accordance with the requirements of current national or international standards, e.g. IEC 60079-29-1:2016.

**23.9.4.3** The number and placement of methanol/ethanol vapour detectors in each space shall be specially considered in each case taking into account the size, layout and ventilation of the space. Gas dispersal analysis or a physical smoke test shall be used to find the best arrangement.

**23.9.4.4** An audible and visible alarm shall be activated at a fuel vapour concentration of 20 % of the lower explosion limit (LEL). The safety system shall be activated at 40 % of LEL at two detectors.

**23.9.4.5** For ventilated ducts and annular spaces around double walled fuel pipes in the machinery spaces containing methyl/ethyl alcohol consumers, the alarm limit shall be set to 20 % of LEL. The safety system shall be activated at 40 % of LEL at two detectors.

**23.9.4.6** Audible and visible alarms from the fuel vapour detection equipment shall be located on the navigation bridge, in the continuously manned central control station, at the control location for bunkering or in safety centre.

**23.9.5 Fire detection.**

**23.9.5.1** Fire detection in machinery space containing methyl/ethyl alcohol engines and fuel storage hold spaces shall give audible and visual alarms on the navigation bridge and in a continuously manned central control station or safety centre.

**23.9.6 Ventilation performance.**

**23.9.6.1** Any loss of the required ventilating capacity shall give an audible and visual alarm on the navigation bridge, and in a continuously manned central control station or safety centre.

**23.9.7 Safety functions of fuel supply systems.**

**23.9.7.1** If the fuel supply is shut off due to activation of an automatic shut-off valve, the fuel supply shall not be opened until the reason for the disconnection is ascertained and the necessary precautions taken. A readily visible notice giving instruction to this effect shall be placed at the operating station for the shut-off valves in the fuel supply lines.

**23.9.7.2** If a fuel leak leading to a fuel supply shutdown occurs, the fuel supply shall not be operated until the leak has been found and dealt with. Instructions to this effect shall be placed in a prominent position in the machinery space.

**23.9.7.3** A caution placard or signboard shall be permanently fitted in the machinery space containing methyl/ethyl-fuelled engines stating that heavy lifting, implying danger of damage to the fuel pipes, shall not be done when the engine is running on methyl/ethyl fuel.

**23.9.7.4** Pumps and methyl/ethyl fuel supply shall be arranged for manual remote emergency stop from the following locations as applicable:

**.1** navigation bridge;
**.2** cargo control room;
**.3** onboard safety centre;
**.4** central control station;
**.5** fire control station;
**.6** adjacent to the exit of fuel preparation space.

Table 23.9.1.1.2

**Safety system of methyl/ethyl alcohol supply to engines**

| Monitored parameter | Alarm | Automatic closure of master fuel valve of tank required by 23.5.5.2 | Automatic shutdown of fuel supply to consumers in machinery space (refer to 23.5.5.3) | Automatic shut-down of valve required by 23.5.3.12 | Notes |
|---|---|---|---|---|---|
| High level in tank (95 %) | X | | | X | Refer to 23.9.2.2.1 |
| High-high level in tank (98 %) | X | | | X | Refer to 23.9.2.2.1 and 23.9.2.3.1 |
| Loss of ventilation in the annular space of the double walled bunkering lines | X | | | X | Refer to 23.9.2.3.2 |
| Vapour detection in the annular space of the double walled bunkering lines | X | | | X | Refer to 23.9.2.3.3 |
| Loss of ventilation in ventilated areas | X | | | | Refer to 23.9.6 |
| Manual shutdown | | | | X | Refer to 23.9.2.3.1 |

| Monitored parameter | Alarm | Automatic closure of master fuel valve of tank required by 23.5.5.2 | Automatic shutdown of fuel supply to consumers in machinery space (refer to 23.5.5.3) | Automatic shut-down of valve required by 23.5.3.12 | Notes |
|---|---|---|---|---|---|
| Methyl/ethyl alcohol leakage detection in the annular space of the double walled bunkering lines | X | | | X | Refer to 23.9.2.3.3 |
| Vapour detection in ducts around fuel pipes | X | | | | Refer to 23.9.4.1.1 |
| Vapour detection in cofferdams surrounding fuel tanks. One detector giving above 20 % of LEL | X | | | | Refer to 23.9.4.5 |
| Vapour detection in airlock | X | | | | Refer to 23.9.4.1.7 |
| Vapour detection in cofferdams surrounding fuel tanks. Two detectors giving above 40 % of LEL | X | X | | X | Refer to 23.9.4.1.6 |
| Vapour detection in ducts around double walled pipes, 20 % of LEL | X | | | | Refer to 23.9.4.5 |
| Vapour detection in ducts around double walled pipes, 40 % of LEL | X | X | X | | Refer to 23.9.4.4. Two detectors giving 40 % of LEL prior to valve shut-down. |
| Liquid leak detection in annular space of double walled pipes | X | X | X | | Refer to 23.9.1.4 |
| Liquid leak detection in engine room | X | X | | | Refer to 23.9.1.3 |
| Liquid leak detection in fuel preparation space | X | X | | | Refer to 23.9.1.3 |
| Liquid leakage detection in protective cofferdams surrounding fuel tanks | X | | | | Refer to 23.9.1.3 |

## 23.10 ELECTRICAL EQUIPMENT

**23.10.1 General.**

**23.10.1.1** Electrical equipment shall comply with the applicable requirements of IEC 60092:2018 series or other equivalent standards.

**23.10.1.2** Electrical equipment or wiring shall not be installed in gas-dangerous spaces or zones unless essential for operational purposes or safety enhancement.

**23.10.1.3** Where electrical equipment is installed in gas-dangerous spaces, it shall be selected, installed and maintained in accordance with the applicable IEC standards or other equivalent standards.

**23.10.1.4** The lighting system in gas-dangerous spaces and areas shall be divided between at least two branch circuits and be supplied from different switchboards. Switches and protective devices of the lighting system in gas-dangerous spaces and areas shall interrupt all phases and shall be located in a non-hazardous space or area.

**23.10.1.5** All onboard electrical equipment shall be safely earthed to the ship's hull.

**23.10.2 Classification of hazardous zones, spaces and areas.**

**23.10.2.1** Classification of hazardous zones is given in 23.10.2.2 — 23.10.2.4. In cases where the prescriptive provisions in 23.10.2.2 — 23.10.2.4 are deemed to be inappropriate, area classification according to IEC 60079-10 and IEC 60092-502 shall be applied.

**23.10.2.2** Zone 0: the internal areas of methanol/ethanol storage tanks, fuel pipelines, pipelines from safety valves of fuel storage tanks and any venting pipelines from equipment containing methanol/ethanol.

**23.10.2.3** Zone 1:

**.1** cofferdams and other spaces surrounding the fuel tanks;

**.2** fuel preparation spaces;

**.3** areas on open deck, or semi-enclosed spaces on deck, within 3 m of any methyl/ethyl fuel tank outlet, vapour outlet, bunker manifold valve, other methyl/ethyl fuel valve, any methyl/ethyl fuel pipe flange, methyl/ethyl fuel preparation space ventilation outlets;

**.4** areas on open deck or semi-enclosed spaces on deck in the vicinity of the fuel tank outlets, within a vertical cylinder of unlimited height and 6 m radius centred upon the centre of the outlet and within a hemisphere of 6 m radius below the outlet;

**.5** areas on open deck or semi-enclosed spaces on deck, within 1,5 m of fuel preparation space entrances, fuel preparation space ventilation openings and other openings into zone 1 spaces;

**.6** areas on the open deck within coamings surrounding methyl/ethyl fuel bunker manifold valves and 3 m beyond these, up to a height of 2,4 m above the deck;

**.7** enclosed or semi-enclosed spaces in which pipes containing methyl/ethyl fuel are located, e.g. ducts around methyl/ethyl fuel pipes, semi-enclosed bunkering stations; and

**.8** a space protected by an airlock is considered as a non-hazardous area during normal operation, but will require equipment to operate following loss of differential pressure between the protected space and the hazardous area to be certified as suitable for zone 1.

**23.10.2.4** Zone 2:

**.1** areas 4 m beyond the cylinder and beyond the sphere defined in 23.10.2.3.4;

**.2** areas within 1,5 m surrounding other open or semi-enclosed spaces of zone 1 defined in 23.10.2.3; and

**.3** airlocks.

## 23.11 PERSONNEL PROTECTION

**23.11.1 Protective equipment.**

**23.11.1.1** For the protection of crew members who are engaged in bunkering operations, the ship shall have on board protective clothing and outfit consisting of the following:

**.1** large aprons;
**.2** special gloves with long sleeves;
**.3** protective footwear;
**.4** coveralls made of chemically resistant material;
**.5** tight-fitting goggles or face shields.

**23.11.1.2** Protective clothing and outfit shall cover and protect all skin and all body parts. For each crew member engaged in bunkering operations, 1 set of protective clothing and outfit shall be provided (there shall be at least 6 sets in total).

**23.11.1.3** Work clothes and protective equipment shall be kept in easily accessible places in special lockers.

Such equipment shall not be located in the accommodation area, except for new, unused equipment and equipment that was not in use after relocation and arrangement. Used protective clothes and equipment shall be kept in a stowage space located away from accommodation spaces.

**23.11.1.4** Protective equipment shall be used in any operation, which may entail danger to personnel.

**23.11.2 Safety equipment for methanol operations.**

**23.11.2.1** On ships using methanol as fuel, there shall be available at least two complete sets of equipment to ensure safety of the crew members while entering a compartment with fuel vapour and operating in it for 20 minutes.

**23.11.2.2** One complete set of safety equipment shall consist of the following:

**.1** one self-contained air-breathing apparatus;
**.2** protective clothing, boots, gloves and tight-fitting goggles;
**.3** fire-proof lifeline with a belt resistant to methanol;
**.4** explosion-proof lamp.

## 24 REQUIREMENTS FOR SHIPS CARRYING CONTAINERS AND FOR GENERAL CARGO SHIPS WITH PARTIALLY OR COMPLETELY HATCHCOVERLESS CARGO HOLDS

### 24.1 GENERAL PROVISIONS AND SCOPE OF APPLICATION

**24.1.1** The requirements for the distinguishing mark **Open cargo hatch** are based on the provisions of IMO circular MSC/Circ.608/rev.1 "Interim Guidelines for Open-top Containerships", adopted on 5 July 1994.

The application of the provisions of this Section and the IMO circular mentioned above for any sea voyage shall be agreed with the Register and the Flag State Maritime Administration, including agreement on the possibility of drawing up and issuing an exemption certificate in accordance with the International Convention on Load Lines (application to MA is required only for ships, to which the provisions of the International Convention on Load Lines are applicable).

**24.1.2** The distinguishing mark **Open cargo hatch** may be inserted into the class notation of:

container ships and ships equipped for the carriage of containers designed such that one or more cargo holds are not fitted with hatch covers; or

general cargo ships where the cargo hatches may be completely or partially open or where the hatch covers are temporarily removed during sea voyage, and complying with the provisions of IMO circular MSC/Circ.608/rev.1 "Interim Guidelines for Open-top Containerships", adopted on 5 July 1994, taking into account the provisions of this Section.

## 24.2 DEFINITIONS

**24.2.1** The definitions in this Section are additional to those specified in 1.1 of Part I "Classification", Part IV "Stability", Part V "Subdivision", in 1.2 of the Load Line Rules for Sea-Going Ships.

Maximum sustained speed is defined as the maximum service speed taking into account speed loss due to resistance increase in regular waves. Voluntary speed loss in waves is not taken into consideration.

Minimum ship manoeuvring speed is defined to be the minimum speed which maintains directional control and is consistent with the operating characteristics of the ship.

Green water is large mass of sea water other than spray shipped aboard the ship under normal operational conditions.

### 24.3 TECHNICAL DOCUMENTATION

**24.3.1** To assess compliance with the provisions of this Section, the following documentation shall be submitted to the Register (AG — for agreement, taking into account 8.2 of Part II "Technical Documentation" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships):

**.1** Assessment of seaworthiness and ingress of green water (AG), containing, as a minimum, a report with the results of:

computational modelling of motions in regular and irregular waves and ingress of green water;

model tests of seaworthiness and ingress of green water in the ship model basin (model tests shall comply with 24.4), documentation of the process of carrying out model experiments shall be accompanied by a video recording to be attached to the report;

freeboard calculation.

**.2** Analysis of the conformity of the means for cargo hold bilge dewatering with the requirements of IMO circular MSC/Circ.608/rev.1 (AG);

**.3** stability and damage stability calculations taking into account the possible flooding of cargo holds (AG);

**.4** calculations of general longitudinal and local strength of the hull taking into account the possible flooding of cargo holds (AG).

### 24.4 PROCEDURE OF MODEL TESTS

**24.4.1** The model tests shall be carried out in long-crested, irregular waves. The Pierson-Moskovitz, JONSWAP, Bretschneider wave spectrum generated for the purpose of these experiments shall have a significant wave height of approximately 11 m with 3 % probability of exceeding level, at the most unfavourable realistic wave period as determined by calculation or previous testing experience.

For ships of restricted service, model tests may be carried in waves with a height corresponding to the limit set out for the given area of navigation in accordance with 2.2.5 of Part I "Classification".

**24.4.2** For ships operating in restricted areas of navigation, in agreement with the Register and if necessary with the MA, other spectra may be allowed for model tests.

**24.4.3** The effect of wind generated spray need not be simulated during the tests.

**24.4.4** The model experiments shall be carried out for at least the following wave directions:

**.1** following seas (0°/360°);

**.2** stern-quartering seas (45°/315°);

**.3** beam seas (90°/270°);

**.4** bow-quartering seas (135°/225°);

**.5** head seas (180°).

**24.4.5** The model tests shall be carried out for at least the following speeds:

**.1** maximum sustained speed in head seas and quarter head seas;

**.2** minimum ship manoeuvring speed in following seas and in quarter following seas;

**.3** zero ship speed (dead ship condition) in beam seas.

**24.4.6** The Register may require additional tests if necessary.

**24.4.7** The model tests shall be carried out with an unrestrained model without the necessity to change course and the time period of each experiment shall correspond to at least one hour real time.

**24.4.8** The loading condition used for the tests shall correspond to the maximum loaded draught with level trim. If operational trim values or trim values from damage stability calculations differ substantially from level trim, additional trim values shall be included in the model test programme.

**24.4.9** The KG value selected for the model shall correspond to the value most likely to be encountered during the ship's service. If KG values which may be expected during the operation of the ship differ substantially from this selected KG value, additional KG values shall be included in the model test programme.

**24.4.10** In running tests, the cargo holds open during sea voyage shall be simulated as having no cargo. Cargoes shall not be used as a means to prevent shipping of water into an empty hold when they are located on the deck or near the coaming of an open hold. Tarpaulin covers for the open holds shall not be simulated in the model tests.

**24.4.11** In additional to the usual parameters measured (ship motions, ship speed, relative motions, rudder angles, etc.) the volume of water entering open cargo holds shall be measured for each experiment. The water taken aboard the model shall be removed after each test run so that the metacentric height, moment of inertia and displacement are not disturbed by any accumulation of water during the test programme.

**24.4.12** Where freeing ports are fitted, the adequacy of the discharge rates from cargo hold freeing ports shall be evaluated at a draught which corresponds to the condition of the ship fully loaded with cargo and open holds flooded to the static equilibrium level with freeing ports open. A hold permeability index of 0,7 shall be assumed.

**24.4.13** A report shall be drawn up on the results of the tests. In the conclusion to the report, in addition to the measurement results and their processing, the following shall also be reflected:

**.1** maximum hourly rate of ingress of green water into each cargo hold determined from model testing;

**.2** evaluation of the adequacy of the discharge rates from freeing ports (if they are fitted);

**.3** freeboard calculation taking into account 24.5.

## 24.5 FREEBOARD

**24.5.1** A conventional freeboard and minimum bow height shall be calculated assuming that hatch covers are fitted.

**24.5.2** The freeboard shall be such that the maximum hourly rate of ingress of green water in each open hold determined from model testing, $Q$, in m$^3$/h, does not exceed the value determined by the following formula:

$$Q = S_h \cdot 0.4 \qquad (24.5.2)$$

where $S_h$ = cargo hatch area, in m$^2$.

**24.5.3** The freeboard and minimum bow height assigned to the ship shall not be less than those corresponding to the model test conditions.

**24.5.4** Seasonal load lines are not applicable if corresponding seasonal freeboards (assuming hatch covers fitted) are less than the freeboard for which the model tests were satisfactorily carried out.

## 24.6 STRENGTH

**24.6.1** The general and local strength of the hull shall be sufficient in the intact flooded condition of the hold, while:

structural members of container ships and ships with a wide deck opening shall comply with the requirements of 3.1 of Part II "Hull";

structural members of other types of ships shall comply with the applicable requirements of Sections 1 and 2 of Part II "Hull".

## 24.7 STABILITY

**24.7.1** When determining the flooding angle, the cargo hold freeing ports are not taken into account, provided that they comply with the requirements of this Section.

**24.7.2** With all open holds completely filled with water (permeability of 0,70 for holds) to the level of the top of the hatch coaming or, in the case of a ship fitted with cargo hold freeing ports, to the level of those ports, the stability of the fully laden ship shall meet the survival criteria with factor $s_i$ = 1 determined in accordance with 2.5 of Part V "Subdivision".

**24.7.3** For the condition with flooded holds for a container ship, the free surfaces may be determined based on the assumption that the holds are empty. The correction to metacentric height and righting levers shall be made on the basis of real flooding.

The correction to the metacentric height and righting levers may be determined in another way if the designer submits the relevant calculations to the Register for agreement.

**24.7.4** Intermediate conditions of hold flooding shall be considered in the stability calculations if they may lead to more severe consequences.

## 24.8 DAMAGE STABILITY

**24.8.1** The coamings of open holds shall be considered as downflooding areas in the damage stability calculations.

## 24.9 HOLD BILGE DEWATERING SYSTEM AND FREEING PORTS

**24.9.1** The cargo hold bilge pumping system shall have a required capacity to pump:
**.1** maximum hourly rate of green water shipped in cargo holds as established by the model testing;
**.2** amount equal to rainfall of 100 mm/hour penetrated through the total area of the gaps between the panels of weathertight covers or regardless of the installation of tarpaulin covers;
**.3** amount of green water shipped in holds measured during the model tests for the dead ship condition in beam seas, multiplied by safety factor 2;
**.4** 133 % of the amount of water required for fire-fighting purposes in the largest hold;
**.5** amount of water equal to the required capacity of the bilge system for ships with equivalent closed hold as per 7.1.6 and 7.2.2 of Part VIII "Systems and Piping";
whichever is the greater.
**24.9.2** The pumping of hold bilges shall be possible by at least three bilge pumps complying with the requirements in Section 7 of Part VIII "Systems and Piping".
**24.9.3** At least one of these pumps shall have a capacity of not less than the required capacity as defined in 24.9.1 and shall be dedicated to bilge and ballast service only. It shall be located in such a way that it will not be affected by a fire or other casualty to the space containing the pumps required in 24.9.4 or the space containing the main source of power and shall be supplied from the emergency switchboard complying with the requirements in 9.4 of Part XI "Electrical Equipment".
**24.9.4** The combined output of at least two pumps shall not be less than the required capacity as defined in 24.9.1. These pumps shall be supplied from the main source of electrical power required in accordance with Section 3 of Part XI "Electrical Equipment" or any other source of power independent of the emergency switchboard required in accordance with 9.4 of Part XI "Electrical Equipment".
**24.9.5** The bilge pumping system, including the piping system, shall incorporate sufficient redundancy features so that the system will be fully operational and capable of dewatering the hold spaces at the required capacity in the event of failure of any one system component.
**24.9.6** The bilge pumping system shall be arranged to be effective within the limiting angles of inclination specified in 2.1.2.2 of Part XI "Electrical Equipment" and bilge wells shall be readily accessible for cleaning.
**24.9.7** All open cargo holds shall be fitted with high bilge level alarms. The alarms shall annunciate in the machinery spaces and the control locations and be independent of bilge pump controls.
**24.9.8** If the loss of suction prevents the proper functioning of the bilge system, special measures to prevent this shall be considered, as for instance, the installation of level indicators.
**24.9.9** Open cargo hold drain wells shall be designed to ensure unobstructed discharge of water and easy access for cleaning under all conditions.
**24.9.10** Freeing ports shall be fitted on both sides of cargo hold, subject to the following:
**.1** number, size and location of the freeing ports on each side of cargo holds shall be sufficient to prevent the accumulation of water above the level defined in 24.4.12;
**.2** two efficient means of closure to prevent the accidental ingress of water shall be provided. Such means shall be operated from the freeboard deck. For ice-class ships, measures shall be taken to prevent freezing of water in freeing ports in addition to the requirements set out in 4.3.1.2 of Part VIII "Systems and Piping".

## 24.10 FIRE PROTECTION

**24.10.1** Hatchcoverless cargo holds of container ships and ships equipped for the carriage of containers shall be protected by a fixed water spray system. The system shall be capable of spraying water into the cargo hold from deck level downward. The system shall be designed and arranged to take account of the specific hold and container configuration[1].

**24.10.2** The water spray system shall be able to effectively contain a fire in the container bay of origin. The spray system shall be subdivided, with each subdivision to consist of a ring-line at deck level in an open cargo hold around a container bay.

**24.10.3** The water spray system shall be capable of spraying the outer vertical boundaries of each container bay in an open cargo hold and of cooling the adjacent structure. The uniform application density shall be not less than 1.1 l/min/m$^2$. At least one dedicated fire extinguishing pump for the hold water spray system with a capacity to serve all container bays in any one open-top container hold simultaneously shall be provided. The pump(s) shall be installed outside the open-top area. The availability of water to the water spray system shall be at least 50 % of the total capacity, with adequate spray patterns in the open-top container hold, and with any one pump inoperable. For the case of a single dedicated water spray pump this may be accomplished by an interconnection on the weather deck connecting the water spray system to an alternative source of water.

**24.10.4** Whenever a fire detection alarm system is required in the open hold area, it shall be designed and arranged to take account of the specific hold and container configuration and ventilation arrangement.

**24.10.5** Multipurpose general dry cargo ships shall comply with the requirements set out in 6.7 of Part VI "Fire Protection".

---

[1] Container positions in bays, rows and tiers on a container ship are numbered according to ISO 9711-1:1990.

## 24.11 DANGEROUS GOODS

**24.11.1** Dangerous goods for which "on deck only" stowage is specified in the IMDG Code, shall not be carried in or vertically above hatchcoverless container holds.

**24.11.2** In addition to the provisions of 24.11.1, containers with dangerous goods extending more than 1 m above the top of the watertight upper boundary around a hold without hatch cover (open-top container hold) and containing liquids, gases or vapours heavier than air and for which “on deck only" stowage is specified, shall not be carried within one container space[1] horizontally from the boundary of the container holds without hatch covers.

**24.11.3** Dangerous goods other than those described in 24.11.1 shall not be carried in or vertically above container holds without hatch covers unless such holds are in full compliance with the requirements specified in 7.2 of Part VI "Fire Protection", applicable to enclosed container cargo spaces, as appropriate for the cargo carried.

**24.11.4** Containers with dangerous goods extending more than 1 m above the top of the watertight upper boundary around a container hold without hatch covers shall not be carried within one container space, horizontally from the boundary of the hold unless that hold is in full compliance with the requirements specified in 7.2 of Part VI "Fire Protection", applicable to enclosed container cargo spaces, as appropriate for the cargo carried.

---

[1] Container space means a distance of not less than 6 m fore and aft or not less than 2,4 m athwartships.

## 24.12 STOWAGE AND SEGREGATION OF DANGEROUS GOODS

**24.12.1** Stowage and segregation of containers on board container ships without hatch covers shall be carried out in accordance with Table 7.4.3.3 of the IMDG Code.

## 24.13 INSPECTIONS

**24.13.1** The operability and condition of the hold bilge dewatering system and freeing port (if they are fitted) on ships with the distinguishing mark **Open cargo hatch** shall be inspected by the crew on a monthly basis and recorded in the ship's log for annual check by the surveyor to the Register and/or flag MA.

## 25 ADDITIONAL REQUIREMENTS FOR SEMI-SUBMERSIBLE (DOCKLIFT) SHIPS AND SHIPS CARRYING HEAVY AND/OR BULKY CARGOS

### 25.1 GENERAL PROVISIONS AND SCOPE OF APPLICATION

**25.1.1** Provisions of this Section cover semi-submersible (docklift) ships as well as ships carrying heavy and/or bulky cargoes.

**25.1.2** The descriptive notation **Heavy cargo carrier** may be added to the character of classification of ships designed for the carriage of heavy, bulky cargoes. Depending on the method of cargo carriage, the following distinguishing marks are added in brackets after the descriptive notation:

on deck — **(Deck)**;

on hatch covers of cargo holds — **(Hatch cover**);

in cargo holds — **(Hold)**.

For distinguishing marks in brackets, the design uniformly distributed static load for the relevant structure, in t/m$^2$, shall be additionally indicated.

Distinguishing marks specifying method of cargo carriage may be concatenated within one pair of brackets, for example: **(Deck-t/m$^2$, Hold-t/m$^2$)**.

At the request of the shipowner, the descriptive notation **Project** may be added before the descriptive notation **Heavy cargo carrier** for ships intended for the carriage of project (non-standard) heavy cargoes.

**25.1.3** The descriptive notation **Heavy cargo carrier (Deck-t/m$^2$)** is mandatory for semi-submersible (docklift) ships with descriptive notation **Semi-submersible (Docklift) ship**.

**25.1.4** Descriptive notation **Heavy cargo carrier** or **Heavy cargo carrier Semi-submersible (Docklift) ship** may be assigned to ships provided the applicable provisions of this Section as well as applicable provisions of these Rules are met.

**25.1.5** For semi-submersible (docklift) ships, requirements of the Flag State Maritime Administration (if any) shall be taken into account, including agreement on the necessity of drawing up and issuing an exemption certificate for the load line in accordance with the International Convention on Load Lines (request to MA is needed only for ships covered by the provisions of the International Convention on Load Lines).

## 25.2 DEFINITIONS

**25.2.1** Definitions of terms used in this Section are given in the relevant Parts of these Rules.

## 25.3 TECHNICAL DOCUMENTATION

**25.3.1** In addition to the documentation listed in Section 3 of Part I "Classification", the following documentation shall be submitted to the Register to assess fulfilment of provisions of this Section:

**.1** Cargo Securing Manual (A) developed in compliance with IMO resolution A.714(17) as amended by IMO circulars MSC/Circ.664, MSC/Circ.691, MSC/Circ.740, MSC/Circ.812, MSC/Circ.1026, MSC.1/Circ.1352, MSC.1/Circ.1352/Rev.1;

**.2** only for semi-submersible (docklift) ships:

power supply and control system diagrams of the ballast system;

description of the draught gauging system;

description of the ballast tanks level gauging system.

## 25.4 TECHNICAL REQUIREMENTS

In addition to the applicable requirements of these Rules, semi-submersible (docklift) ships and ships designed for the carriage of heavy/bulky cargoes shall meet the requirements of this Section.

**25.4.1 Hull structure of ships designed for the carriage of heavy/bulky cargoes.**

**25.4.1.1** The hull structure and strength of ships designed for the carriage of heavy/bulky cargoes shall meet the requirements of Part II "Hull".

**25.4.1.2** When calculating strength as regards the requirement of 1.3.4 in Part II "Hull", the minimum recommended design load on deck shall be 5 t/m$^2$ (the product of cargo density and applicable design cargo height).

**25.4.1.3** The design load on hull structures of a ship carrying heavy/bulky cargoes shall be specified in the ship's technical documentation.

**25.4.1.4** When calculating strength of ro-ro ships as regards the requirement of 3.2.3.9 in Part II "Hull", the value ($pc + pd$) shall not be less than 6,3 kPa (0,64 t/m$^2$).

**25.4.1.5** When calculating strength of deck framing members, it is necessary to consider the requirement of 3.6.5.5 in Part II "Hull".

**25.4.2 Hull structure of semi-submersible (docklift) ships.**

The hull structure of semi-submersible (docklift) ships shall comply with the applicable requirements of 3.6 and 3.12 in Part II "Hull".

**25.4.3 Stability of semi-submersible (docklift) ships.**

**25.4.3.1** Loading conditions.

**.1** The stability in maximum submerged condition shall be checked under the following loading conditions:

without cargo on the deck;

with cargo on the deck.

**.2** The stability of semi-submersible (docklift) ships shall be checked during submersion and emersion. This check shall be performed for such a number of intermediate stages that allows to confirm the safety of ship.

**.3** Buoyancy of deck cargo shall be taken into account during the check.

**25.4.3.2** Stability criteria.

Trim and stability of the ship shall comply with the following criteria:

**.1** corrected initial metacentric height shall be not less than 0,3 m;

**.2** extent of positive part of righting lever curve shall be not less than 15°;

**.3** maximum righting lever shall be not less than 0,1 m within 15° from static heeling angle;

**.4** angle where the maximum of righting level curve $\theta_{\max}$ occurs shall be not less than 10°;

**.5** distance from the waterline to openings without watertight closures through which the ship may be flooded, shall be not less than 1 m or such that angle of down-flooding is not less than 5°, whichever is the greater.

**25.4.4 Subdivision of semi-submersible (docklift) ships.**

**25.4.4.1** Subdivision is considered to be in compliance with the requirements of this Part if in case of damage to the extent specified in 25.4.4.2 and 25.4.4.3, located between any adjacent watertight bulkheads, damage trim and stability comply with the criteria given in 25.4.4.4.

**25.4.4.2** The following extent of side damage shall be assumed when performing damage trim and stability calculations:

**.1** longitudinal extent: 5 m;

**.2** transverse extent measured inboard of ship side perpendicular to the centreline: 0,76 m;

**.3** vertical extent: from open deck upwards without limit.

**25.4.4.3** The following extent of open deck damage shall be assumed when performing damage trim and stability calculations:

**.1** longitudinal extent: 5 m;
**.2** transverse extent: 5 m;
**.3** vertical extent: 0,76 m.
**25.4.4.4** Damage trim and stability criteria.
**.1** damage waterline in the final stage of flooding shall be below any opening without watertight closures through which progressive flooding may take place;
**.2** static heeling angle shall not exceed 15°;
**.3** extent of positive part of righting lever curve shall be not less than 7°;
**.4** maximum righting lever shall be not less than 0,05 m within the positive portion of the curve.

**25.4.5 Reserve buoyancy of semi-submersible (docklift) ships.**

**25.4.5.1** The watertight ship's volume above the waterline shall be not less than 4,5 % of its total volume.

The watertight volume of the fore end and aft end structures above the waterline considered separately shall be not less than 1,5 % of the total ship's volume.

**25.4.5.2** The criterion given in 25.4.5.1 may be dispensed with in the case if, in the event of flooding of any one watertight compartments, the following criteria are met:
**.1** heeling angle in the final stage of flooding does not exceed 25°;
**.2** all submersed openings are fitted with watertight closures;
**.3** extent of positive part of righting lever curve shall be not less than 7°.

**25.4.6 Ship's arrangements.**

Closures of semi-submergible (docklift) ships:
**.1** on no account shall the side scuttles be fitted in the outer wall sides of semi-submersible (docklift) ships so that their sills are below the margin line. In the boundary bulkheads of the semi-submersible (docklift) ships installation of the side scuttles is not permitted;
**.2** in the sides of the semi-submersible (docklift) ships the side scuttles, the sills of which are above the margin line by less than 300 mm or 0,025 times the ship's breadth, whichever is the greater, shall be of heavy type, fitted with hinged inside deadlights, and of non-opening type;
**.3** openings that may be flooded during submersion shall be fitted with watertight closures and have strength equal to that of the bulkhead where they are installed. Watertightness shall be ensured by two independent means to maintain the watertight integrity if one of means fails.

The fitting of an inner door or hatch of equivalent strength and watertightness is an acceptable arrangement. A leakage detection device shall be provided in the compartment between two doors. Drainage of this compartment controlled by a readily accessible shut-off valve shall be arranged. The outer door shall open outwards.

Closures may be weathertight if they have a distance above the final submersion waterline of not less than 1 m or at a distance corresponding to a heeling angle of 5 degrees, whichever is greater.

Openings which shall remain open during submersion, such as the engine room air intakes, shall be fitted with remote operated quick-closing appliances.

**25.4.7 Machinery installations.**

Semi-submersible (docklift) ships shall comply with the requirements set out in 3.2.9, 3.3.4 of Part VII "Machinery Installations".

**25.4.8 Systems and piping.**

**25.4.8.1** Ballast control and monitoring systems for semi-submersible (docklift) ships.

**.1** General.

**.1.1** Provisions shall be made for a central ballast control station containing all means necessary to perform submersion/emersion operations. The central ballast control station shall be located above the maximum submerged draught and in a space not within the assumed extent of damage.

**.1.2** Any equipment on the hull and submitted to the sea pressure shall withstand the pressure due to the maximum submerged draught.

**.1.3** Ballast tanks used for cargo handling operations shall be equipped with two independent remote level gauging systems that shall ensure continuous level measurement in each tank.

**.2** Ballast system.

**.2.1** The Failure Mode and Effect Analysis (FMEA) shall be performed regarding the ballast system, including its control and monitoring systems.

**.2.2** Failure modes.

The ballast system shall be so designed as to comply with the safety principles specified in 25.4.8.1.2.4 in the following operation modes:

normal conditions, refer to 25.4.8.1.2.3.1;

degraded conditions, refer to 25.4.8.1.2.3.2;

emergency conditions, refer to 25.4.8.1.2.3.3.

**.2.3** Operation modes.

**.2.3.1** Normal ballast functions.

The normal ballast functions mode means the operation of system for the intended purpose with design parameters, functioning of control and monitoring systems allowing to perform ballasting of ship regarding submersion/emersion operations.

**.2.3.2** Degraded (faulty) ballast functions.

The degraded ballast functions mode is operation of the ballast system together with control and monitoring systems in case of a single failure on any active component of these systems as specified in 25.4.8.1.2.4. System functions that shall remain available in conditions of degraded functions shall be specified by the shipowner during FMEA.

**.2.3.3** Emergency ballast functions.

The emergency ballast functions mode is operation of the system by using those components of the ballast system, control and monitoring systems that remain available and continue their functioning in case of main power source failure. System functions that shall remain available in emergency conditions shall be specified by the shipowner during FMEA.

**.2.3.4** Active component of the system.

Active component of the system means any component of the ballast system, control and monitoring systems which is not a pipe, an electrical cable, a manually controlled valve or a tank. Active components include the machinery items (pumps, remote controlled valves, filters, etc.) and the control system items (gauges, sensors, switchboards).

**.2.4** Safety principles.

**.2.4.1** Any single failure on an active component in the ballast system shall not lead to unintended flooding of any compartment or to a situation where the degraded ballast functions are not met. Thus, duplicate of components of the ballast control system may be required.

**.2.4.2** Failure of the main source of electrical power shall not lead to emergency flooding or unintended filling of any tank, uncontrolled ballast overflow between the tanks as well as to a situation where the emergency ballast functions are not met.

**.2.5** Air pipes.

**.2.5.1** Air pipe shall be connected to the highest point of the ballast tank. During ballast operations the possibility of air pockets in ballast tanks shall be taken into account. If the system requires operational restrictions (i.e. no trim by the bow or the stern when submersing), this shall be specifically noted in the operating manual.

**.2.5.2** Installation of valves on ballast tank air pipes is allowed, subject to the following conditions:

when designing the lay-out of the air pipe system and of the control systems for the valves installed on them, both the risk of flooding and pressurisation in a tank shall be taken into account;

an interlock system is provided between the tank filling pumps and air pipes.

**.2.6** Overflow pipes.

**.2.6.1** Overflow during ballast operations shall be performed through the overflow pipes. Ballast tank air pipes may be simultaneously of an overflow design. The maximum pressurisation in a ballast tank during overflow shall be calculated based on capacity of the largest ballast pump. The value of pressurisation in the ballast tank at overflow shall be checked during mooring trials.

**.2.6.2** A sensor triggered on overflow shall be provided on the overflow or air pipe.

**.2.6.3** Overflow mode need not be considered provided that the following alarms are fitted:

high level alarm or overflow alarm;

high-high level alarm at maximum 98 % level with automatic shut-down of ballast pumps.

**.2.7** Valves and actuators.

Every ballast tank shall be provided with isolating shut-off valves for filling and/or emptying purposes. The valves shall be able to be operated from the central ballast control station.

An emergency system shall be provided to operate the isolating ballast valves. The isolating ballast tank valves shall be closed in case of loss of power.

The operating time shall be determined for remotely-controlled valves. The operating time of remotely-controlled valves shall be long enough to avoid any water hammering in the valve and pipe.

**.2.8** Pressurized ballast tanks.

Where compressed air systems are used to fill or empty the ballast tanks, adequate means to control and to mitigate the risks of overpressure shall be provided. A description of the air pressure system shall be submitted.

**.2.9** Control systems.

**.2.9.1** The central ballast control station shall include the following control systems:

ballast pump control system;

ballast pump status-indicating system;

ballast valves control system;

ballast valves position-indicating system;

ballast tank level indicating and monitoring system;

draught, heel and trim indicating system;

power availability indicating system (main and emergency);

ballast system hydraulic/pneumatic pressure-indicating system;

permanently installed means of communication, independent of the unit's main source of electrical power, between the control station and those spaces containing the ballast pumps and valves or their manual controls, or other spaces that may contain equipment necessary for the operation of the ballast system.

**.3** Ballast water and sediments treatment systems.

The ballast water treatment system shall comply with the requirements of 8.7 in Part VIII "Systems and Piping".

**25.4.8.2** Drainage system.

Drainage system of semi-submersible (docklift) ships shall comply with the requirements in 7.13 of Part VIII "Systems and Piping".

# 26 ADDITIONAL REQUIREMENTS FOR SEA COASTAL SHIPS IN RESTRICTED AREAS RN(SCI) AND RN(SCII)

## 26.1 GENERAL

**26.1.1 Application.**

The requirements of this Section apply to sea coastal ships (hereinafter referred to as "ships") flying the flag of the Russian Federation not engaged on international voyages, with restrictions specified in 2.2.5.4 of Part I "Classification".

**26.1.2 Technical documentation.**

**26.1.2.1** The requirements for the scope of submitted technical documentation are specified in Section 3 of Part I "Classification".

In order to establish other restrictions on the area and conditions of navigation than those specified in 2.2.5.4 of Part I "Classification", the following shall be submitted to the Register for review and approval (A):

**.1** Design justifications taking into account the wind and wave conditions in particular restricted sea areas.

## 26.2 TECHNICAL REQUIREMENTS

In addition to the applicable requirements of these Rules the ships of areas of navigation **RN(SCI)** and **RN(SCII)** shall comply with the requirements of this Section.

**26.2.1 Hull.**

**26.2.1.1** General.

Requirements of 26.2.1 apply to steel ships of welded construction, from 12 to 140 m in length.

**26.2.1.2** Requirements for hull structures.

**26.2.1.2.1** The requirements of 1.1.4.6, 1.4.1.1, 1.4.1.2, 1.4.5.3, 1.6.4.6, 1.6.5.1, 1.6.5.2, 2.2.2.1, 2.4.4.6, 2.6.5.2, 2.10.4.1, 2.10.4.2, 2.10.4.6, 3.6.1.2 of Part II "Hull" apply to ships of areas of navigation **RN(SCI)** and **RN(SCII)** as ships of area of navigation **R3**.

**26.2.1.2.2** The requirements in 1.3.1.5 of Part II "Hull" apply to ships of areas of navigation **RN(SCI)** and **RN(SCII)** taking into account the reduction factor $\varphi_r$, obtained from Table 26.2.1.2.2.

Table 26.2.1.2.2

| Area of navigation | $\varphi_r$ |
|---|---|
| **RN(SCI)** | 0,81–0,18 $L\cdot10^{-2}$ |
| **RN(SCII)** | 0,70–0,18 $L\cdot10^{-2}$ |

**26.2.1.2.3** The requirements in 1.4.4.3 of Part II "Hull" apply to ships of areas of navigation **RN(SCI)** and **RN(SCII)** taking into account the reduction factor $\varphi$, obtained from Table 26.2.1.2.3.

Table 26.2.1.2.3

| Area of navigation | $\varphi$ |
|---|---|
| **RN(SCI)** | 0,66–0,21 $L\cdot10^{-2}$ |
| **RN(SCII)** | 0,55–0,19 $L\cdot10^{-2}$ |

**26.2.2 Equipment, arrangements and outfit.**

**26.2.2.1** Rudder and steering gear.

**26.2.2.1.1** General.

Definitions and explanations given in this Section are specified in Part II "Hull" and Part III "Equipment, Arrangements and Outfit".

**26.2.2.1.1.1** The requirements of this para apply to steering gears with rudders (ordinary, balanced, semi-balanced) and nozzles (turning, non-turning) as well as thrusters, steering means of steerable propellers, waterjet and vertical-axis propellers.

**26.2.2.1.1.2** All self-propelled ships shall be equipped with a steering gear. Non-self-propelled ships intended for towing by rope shall be equipped with fixed stabilizers.

Stabilizers may be omitted in non-self-propelled ships intended for navigation only by pushing.

**26.2.2.1.1.3** In case of failure in main drive or main power source of the steering engine, the time of transition to the standby drive or the time of power supply pause shall not exceed 5 s.

**26.2.2.1.2** Rudder and nozzle.

**26.2.2.1.2.1** The rudder blade and the nozzle shall be made of steel with carbon content not more than 0,22 %.

Construction of the nozzle may be either welded or cast-welded.

**26.2.2.1.2.2** The plate thickness of streamlined rudder blade casing $t$, in mm, shall be not less than determined by formula:

$$t = sa\sqrt{p/R_{eH}} + \Delta s, \qquad (26.2.2.1.2.2)$$

where $s = 32{,}6 - 7{,}56\left({}^{a}/_{b}\right)^{2}$

$a$ = distance between horizontal stiffeners or vertical diaphragms, whichever is less, in m;
$b$ = distance between horizontal stiffeners or vertical diaphragms, whichever is the greater, in m;
$p$ = design pressure on a rudder blade plating, in kPa, determined in accordance with 26.2.2.1.2.3;
$R_{eH}$ = the yield stress of the rudder plating material, in MPa;
$\Delta s$ = 0,6 – corrosion allowance, in mm.

**26.2.2.1.2.3** Design pressure on a rudder blade plating, $p$, in kPa, shall be taken equal to the greater value of pressures on the pressure ($p_{ps}$) and suction ($p_{ss}$) sides of the rudder profile:

for a plating area falling into the propeller jet and located within 0,35 the rudder blade width from its leading edge:

$$\left.\begin{aligned} p_{ps} &= 0{,}5(1{,}706C_T + 1{,}538)\rho V_A^2 + 9{,}81T \\ p_{ss} &= 0{,}5(5{,}505C_T + 6{,}093)\rho V_A^2 \end{aligned}\right\}; \qquad (26.2.2.1.2.3\text{-}1)$$

for a plating area falling into the propeller jet and located within 0,65 the rudder blade width from its trailing edge:

$$\left.\begin{aligned} p_{ps} &= 0{,}5(0{,}734C_T + 0{,}662)\rho V_A^2 + 9{,}81T \\ p_{ss} &= 0{,}5(2{,}369C_T + 2{,}622)\rho V_A^2 \end{aligned}\right\}; \qquad (26.2.2.1.2.3\text{-}2)$$

for a plating area not falling into the propeller jet and located within 0,35 the rudder blade width from its leading edge:

$$\left.\begin{aligned} p_{ps} &= 0{,}5\rho V_A^2 + 9{,}81T \\ p_{ss} &= 2{,}5\rho V_A^2 \end{aligned}\right\}; \qquad (26.2.2.1.2.3\text{-}3)$$

for a plating area not falling into the propeller jet and located within 0,65 the rudder blade width from its trailing edge:

$$\left.\begin{aligned} p_{ps} &= 0{,}25\rho V_A^2 + 9{,}81T \\ p_{ss} &= 1{,}25\rho V_A^2 \end{aligned}\right\}, \qquad (26.2.2.1.2.3\text{-}4)$$

where $C_T = {}^{8T_p}/_{(\rho V_A^2 \pi D^2)}$ — propeller loading factor;

$T_p$ = propeller thrust, in kN;
ρ = water density, in t/m$^3$;
$V_A = V(1 - W_T)$ – propulsion and steering system inflow velocity, in m/s;
$V$ = design speed of a ship in loaded condition (for pushers — together with the convoy), in m/s;
$W_T$ = wake factor for straight motion of the ship by calculation of propulsion ability;
$D$ = propeller diameter, in m;
$T$ = ship draught, in m.

Pressure $p_{ss}$ shall not be taken to be more than 96,9 kPa.

Jet diameter is taken to be equal to propeller diameter.

**26.2.2.1.2.4** In order to prevent resonance, natural oscillation frequencies of the first tone of the rudder plating plates shall exceed the propeller blade frequency which is the product of a number of propeller blades by shaft revolution frequency by at least 50 %.

Natural oscillation frequencies of the first tone of the rudder plating plates shall be determined in accordance with requirements of 26.2.2.1.2.4.1 and 26.2.2.1.2.4.2 as for the plate washed by liquid from one side.

**.1** Natural oscillation frequency $N$, in Hz, of the first tone of the rudder plating plates supported by webs and not supported by framing or stiffeners shall be determined by the following formula:

$$N = \pi(1 + a^2/b^2)\sqrt{t^2\mathrm{E}/[12\rho(1 - \mu^2)]}/(2a^2) \qquad (26.2.2.1.2.4.1)$$

where $a$ = short side of the plate, in m;
$b$ = long side of the plate, in m;
$t$ = plate thickness, in m;
$E$ = Young's modulus of plate material, in Pa;
$\rho$ = density of plate material, in kg/m$^3$;
$\mu$ = Poisson ratio of plate materials.

**.2** Natural oscillation frequency $N^*$, in Hz, of the plate taking into account added-liquid mass shall be determined by the following formula:

$$N^* = N/\sqrt{k_a} \qquad (26.2.2.1.2.4.2)$$

where $N$ = refer to 26.2.2.1.2.4.1;
$k_a = 1 + \alpha\rho_l a/(\rho t)$
$\rho_l$ = liquid density, in kg/m$^3$;
$\rho$ = density of plate material, in kg/m$^3$;
$\alpha$ = factor determined depending on ratio between plate sides according to Table 26.2.2.1.2.4;
$t$ = plate thickness, in m.

Table 26.2.2.1.2.4

**Factor α**

| $a/b$, $c/l$ | α | $a/b$, $c/l$ | α |
|---|---|---|---|
| 0,1 | 0,76 | 0,6 | 0,51 |
| 0,2 | 0,71 | 0,7 | 0,47 |
| 0,3 | 0,65 | 0,8 | 0,45 |
| 0,4 | 0,61 | 0,9 | 0,43 |
| 0,5 | 0,55 | 1,0 | 0,42 |

**26.2.2.1.2.5** The edge plate thickness of the rudder blade and stabilizer shall be not less than the shell thickness determined according to 26.2.2.1.2.2.

**26.2.2.1.2.6** The plate thickness of lamellar rudder blade casing $t_{lrb}$, in mm, shall be not less than determined by formula:

$$t_{lrb} = k \cdot d_0 + 4 \qquad (26.2.2.1.2.6)$$

where $k$ = factor taken equal for ships of areas of navigation:
**RN(SCI)** 0,080
**RN(SCII)** 0,055
$d_0$ = rudder stock diameter, in mm, determined according to 26.2.2.1.3.1 or 26.2.2.1.3.3 at $R_{eH}$ = 260 MPa.

**26.2.2.1.2.7** The minimum thickness of hollow nozzle shell and the stabilizer casing plates $t_1$, in mm, shall be not less than determined by formula:

$$t_1 = k_1 \cdot d_o + 4, \qquad (26.2.2.1.2.7\text{-}1)$$

where $k_1$ = factor taken equal for ships of areas of navigation:

**RN(SCI)** 0,025

**RN(SCII)** 0,020

$d_0$ = rudder stock diameter, in mm, determined according to 26.2.2.1.3.1 or 26.2.2.1.3.3 at $R_{eH}$ = 260 MPa.

The minimum thickness of nozzle internal plating $t_2$, in mm, shall be not less than determined by formula:

$$t_2 = 1{,}25 \cdot t_1 \qquad (26.2.2.1.2.7\text{-}2)$$

**26.2.2.1.2.8** Inner plating of the hollow nozzle in the middle part shall have a strengthened belt, in mm, with thickness not less than determined by formula:

$$t_3 = 2 \cdot t_2 \qquad (26.2.2.1.2.7\text{-}3)$$

Plates of the strengthened belt are recommended to be made of stainless steel.

**26.2.2.1.2.9** The plating thickness of streamlined rudder blade, hollow nozzle and its stabilizer shall be not less than shell plating thickness of the ship's aft extremity.

**26.2.2.1.2.10** The plating thickness of the rudder blade and the nozzle with stabilizer for ships with ice strengthening shall be increased by 20 % as compared with that determined in accordance with 26.2.2.1.2.2, 26.2.2.1.2.3, 26.2.2.1.2.5 — 26.2.2.1.2.9.

**26.2.2.1.2.11** The plating of the rudder blade and the stabilizer shall be strengthened from the inside by vertical stiffeners and horizontal diaphragms.

**26.2.2.1.2.12** The nozzle plating shall be strengthened from the inside by longitudinal stiffeners and circular diaphragms.

At least four longitudinal diaphragms uniformly distributed along the circumference of the nozzle shall be provided.

**26.2.2.1.2.13** Stiffener and diaphragm thickness shall be not less than plate thickness of streamlined rudder (stabilizer) or the nozzle shell plating.

**26.2.2.1.2.14** Cut-outs shall be provided in stiffeners and diaphragms.

**26.2.2.1.2.15** Plugs made of anti-corrosion material shall be provided in the rudder blade edge plates, in the lowermost and the uppermost points of the nozzle.

**26.2.2.1.2.16** The rudder blade and the nozzle shall not protrude beyond the ship overall dimensions. When it is impracticable, protective arrangements shall be provided (housings, crinolines).

**26.2.2.1.2.17** The rudder and the nozzle shall be so located as to prevent their damage due to stroke on ground when ship sails with the maximum design stern trim.

N o t e. The rudder and the nozzle intended for work on shallow water shall be designed with the lower support.

**26.2.2.1.2.18** The plating thickness of fixed stabilizer installed instead of the rudder shall be determined in accordance with the requirements of 26.2.2.1.2.2, 26.2.2.1.2.3, 26.2.2.1.2.5, 26.2.2.1.2.9, 26.2.2.1.2.10. The design of fixed stabilizer shall meet the requirements of 26.2.2.1.2.11 — 26.2.2.1.2.14, 26.2.2.1.2.16.

**26.2.2.1.3** Rudder stock and rudder piece.

**26.2.2.1.3.1** The diameter of the rudder stock and the steering nozzle in the area of lower supporting bearing shall be proved by the calculation carried out in accordance with requirements of this Section. Hydrodynamic loads, bending moments, shear forces and support reaction forces acting in the stock – rudder system shall be calculated in accordance with Appendix 1.

**26.2.2.1.3.2** The full ahead speed shall be taken as the design speed: for self-propelled ships — not less than 3,5 m/s, and for non-self-propelled ships — not less than 3,0 m/s.

The design astern speed shall be taken not less than 60 % of the design ahead speed.

**26.2.2.1.3.3** If there are no hydrodynamic calculations, the rudder stock diameter, in mm, in the area of lower supporting bearing shall be not less than determined by formulas:

for suspended rudder (refer to Fig. 26.2.2.1.3.3-1)

$$d_0' = 46{,}2\sqrt[3]{k_2\sqrt{M_{torque}^2 + M_b^2}/(9{,}81\cdot 10^{-3}R_{eH})}, \quad (26.2.2.1.3.3\text{-}1)$$

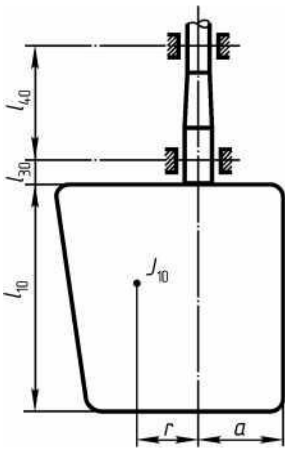



Fig. 26.2.2.1.3.3-1
Calculation method for suspended rudder

for rudder with lower support on sternframe heel (refer to Fig. 26.2.2.1.3.3-2)

$$d_0'' = 46{,}2\sqrt[3]{k_2R\sqrt{r^2 + 0{,}029l_{10}^2}/(9{,}81\cdot 10^{-3}R_{eH})} \quad (26.2.2.1.3.3\text{-}2)$$

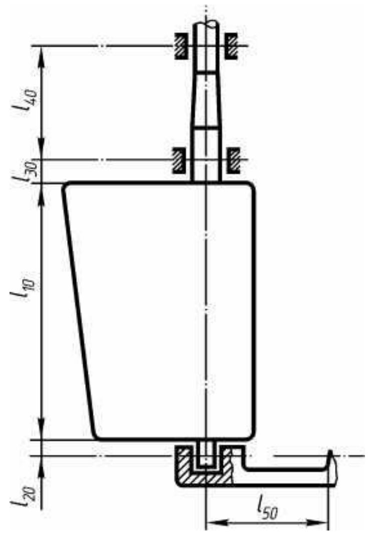



Fig. 26.2.2.1.3.3-2
Calculation method for rudder with lower support on sternframe heel

for rudder with pins on sternframe hinges

$$d_0''' = 46{,}2\sqrt[3]{k_2 M_{torque}^2/(9{,}81 \cdot 10^{-3} R_{eH})} \qquad (26.2.2.1.3.3\text{-}3)$$

where $k_2$ = safety factor of the rudder stock material taken equal to 2,5.
$M_{\mathrm{torque}}$ = torque calculated by the following formula, in kN·m;

$$M_{\mathrm{torque}} = R \cdot r \qquad (26.2.2.1.3.3\text{-}4)$$

where $R$ = resultant force on a rudder calculated by the following formula, in kN,

$$R = 9{,}81 \cdot 10^{-3} c \cdot \xi \cdot A \cdot v^2; \qquad (26.2.2.1.3.3\text{-}5)$$

c = coefficient determined by the formula

$c = \sqrt{13{,}87 + 22{,}025\lambda}$;
$\lambda$ = relative elongation of the rudder blade determined by one of the following formulae:

$$\lambda = l_{10}/b;\ \lambda = l_{10}^2/A;\ \lambda = A/b^2;$$

$\xi$ = factor taken equal for rudders located:
within the propeller jet 1,0
beyond the propeller jet 0,9
$A$ = the rudder blade area, in m$^2$;
$v$ = design speed of a ship in loaded condition, in km/h;
$r$ = distance between the application point of an assumed design load and the rudder blade rotation axis at the level of its centre of gravity, in m, determined by the following formula:

$$r = b \cdot [0{,}33 + 1{,}5(A_1/A)^2] - a, \qquad (26.2.2.1.3.3\text{-}6)$$

$b$ = width of the rudder blade, in m;
$A_1$ = part of the rudder blade area forward of the rotation axis, in m$^2$;
$a$ = distance between the rotation axis and the leading edge of the rudder blade edge at the level of the centre of gravity of its area, in m;
$M_b$, kN·m = bending moment determined by the formula

$$M_b = R \cdot (0{,}5 \cdot l_{10} + l_{30}); \qquad (26.2.2.1.3.3\text{-}7)$$

$l_{10}$ = height of the rudder blade, in m;
$l_{20}$ = distance between the lower edge of rudder blade plating and the support on sternframe heel, in m;
$l_{30}$ = distance between the upper edge of rudder blade plating and the lower bearing of the rudder stock, in m;
$R_{eH}$ = yield point of the rudder stock material, in MPa.

**26.2.2.1.3.4** Minimum permissible external diameter of hollow rudder stock, in mm, is determined by the following formula:

$$d_{outer} = \alpha \cdot d_0, \quad (26.2.2.1.3.4)$$

where α = coefficient taken from Table 26.2.2.1.3.4 depending on the set ratio of the rudder stock wall thickness to the external diameter ($\delta/d_{outer}$);

Table 26.2.2.1.3.4

**Coefficient α**

| $\delta/d_{outer}$ | α | $\delta/d_{outer}$ | α |
|---|---|---|---|
| 0,50 | 1,00 | 0,15 | 1,10 |
| 0,25 | 1,02 | 0,10 | 1,20 |
| 0,20 | 1,05 | 0,08 | 1,26 |

$d_0$ = rudder stock diameter determined according to 26.2.2.1.3.1 or 26.2.2.1.3.3, in mm.

**26.2.2.1.3.5** Permissible stresses shall be taken according to Table 26.2.2.1.3.5 while calculating the steering gear element dimensions.

Table 26.2.2.1.3.5

**Permissible stresses for calculation of steering gear element dimensions**

| Kind of stressed state | Permissible stress in portions of the material yield point $R_{eH}$ for ships of areas of navigation **RN(SCI)** and **RN(SCII)** |
|---|---|
| Torsion and shear | 0,30 |
| Bending and bending with torsion | 0,45 |
| Tension and compression (bearing strain) | 0,75 |

**26.2.2.1.3.6** The rudder stock strength shall be checked for maximum forces induced by steering engines in case of rudder or nozzle seizure.

In this case, the design stresses shall not exceed 0,8$R_{eH}$ or 0,67 $R_m$, where $R_m$ is tensile strength of rudder stock material.

**26.2.2.1.3.7** For ships intended for navigation in broken ice the diameters of the rudder stock design cross-sections calculated in accordance with 26.2.2.1.3.1 and 26.2.2.1.3.3, shall be increased by 15 %.

**26.2.2.1.3.8** Rudder stocks and rudder pieces may be forged or welded.

Cast-welded and cast-forged-welded constructions are permissible, with the diameter of cast part of the rudder stock being increased by 15 % as compared with the design diameter of forged rudder stock.

For ships less than 25 m in length the rudder stocks and rudder pieces may be made of rolled steel.

**26.2.2.1.3.9** The rudder piece cross-section area in the upper part shall be equal to the rudder stock cross-section area. The rudder piece cross-section area below the upper edge of the rudder blade may be smoothly reduced down to 50 % of cross-section area in the upper part.

Connection of the rudder stock with the rudder blade or steerable nozzle shall be equal in strength to the rudder stock.

**26.2.2.1.3.10** Streamlined hollow rudders may have no rudder piece.

In this case the constructions substituting the rudder piece are continuous vertical diaphragms of the rudder blade with adjacent plating of rectangular or tubular cross-section as shown in Fig. 26.2.2.1.3.10.

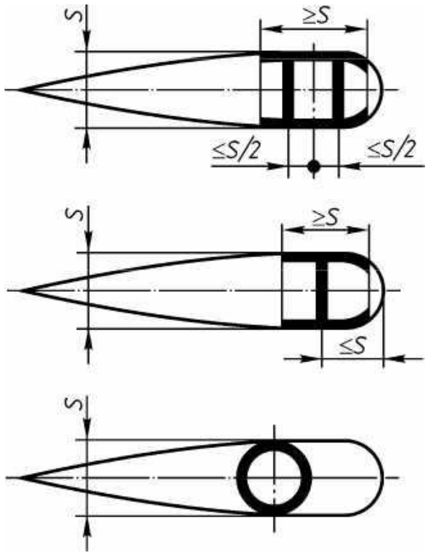



Fig. 26.2.2.1.3.10
Distance for installation of diaphragms for balanced and non-balanced rudders

Balanced rudders shall be fitted with two diaphragms at a distance not exceeding a half of maximum dimension $s$ along the rudder blade width from the rotation axis (refer to Fig. 26.2.2.1.3.10), and non-balanced rudders — one diaphragm at a distance not exceeding the dimension $s$ from the leading edge of the rudder. A diameter of the tube substituting the rudder piece is taken to be equal to $s$ along the rudder blade width. A thickness of the diaphragms, adjacent shell plating and the tube wall shall be increased as compared to the plating thickness calculated by the formula (26.2.2.1.2.2) at least twice.

A width of thickened plates of the shell plating shall be not less than maximum thickness of the rudder blade profile.

**26.2.2.1.3.11** The rudder blade or steerable nozzle with the rudder stock shall be connected by means of a horizontal flange or other structure (conic, stirrup, etc.) which ensures the required connection properties.

For ships with a length of 10 m and less with manual steering drive the connection of the rudder stock with the rudder blade may be welded.

**26.2.2.1.3.12** Connecting bolts (studs) shall be tightly fitted. The number of tightly fitted bolts shall be at least two for keyed joints. Minimum permissible total cross-section area, in mm$^2$, of all bolts is determined by the following formula:

$$F_{\Sigma} = 0{,}3 \cdot d_0^2 \qquad (26.2.2.1.3.12)$$

where $d_0$ = rudder stock diameter determined according to 26.2.2.1.3.1 or 26.2.2.1.3.3, in mm.

**26.2.2.1.3.13** Fastening joints of the rudder stock and the rudder blade or steerable nozzle shall be reliably locked to prevent spontaneous unscrewing.

**26.2.2.1.3.14** The distance from the edge of bolt hole to the outer edge of connecting flange shall be not less than $0{,}65 \cdot d_b$, where $d_b$ is the bolt diameter.

**26.2.2.1.3.15** Flange thickness shall be not less than the connecting bolt diameter.

**26.2.2.1.3.16** A radius of the fillet at the junction of the rudder stock with the flange shall be not less than $0{,}12 \cdot d_0$, (for $d_0$ refer to 26.2.2.1.3.12).

**26.2.2.1.3.17** For conic connection of the rudder stock with the rudder blade or the nozzle the length of cone shall be not less than 1,5 the rudder stock diameter, and the conicity — not more than 1:10. The conic part of the rudder stock shall change into the cylindrical part without a shoulder.

A key shall be placed in the conic connection which dimensions shall be calculated for the case of maximum hydrodynamic torque transfer acting on the rudder stock or steerable nozzle. The key slot shall have ski-shaped exits.

**26.2.2.1.3.18** Plain bearings or rolling bearings may serve as the rudder stock supports.

Plain bearing sleeve height $h_{bush}$, in mm, shall be determined by the following formula:

$$h_{bush} = 1000 \cdot B_{\text{н}}/(p \cdot d_1) \qquad (26.2.2.1.3.18)$$

where $B_{\text{н}}$ = assumed reaction of the rudder stock support while calculating the rudder stock – rudder piece bar for bending determined according to 26.2.2.1.3.19, in kN;
$p$ = permissible contact pressure for bearing materials taken from Table 26.2.2.1.3.18, in MPa;

Table 26.2.2.1.3.18

**Permissible contact pressure for bearing materials**

| Materials | Permissible contact pressure $p$, in MPa, during | |
|---|---|---|
| | water lubrication | oil lubrication |
| Steel against bronze | 6,85 | – |
| Steel against babbit | – | 4,41 |
| Steel or bronze against lignum vitae | 2,36 | – |
| Steel or bronze against synthetic materials or rubber | Subject to technical justification | |

$d_1$ = diameter of the rudder stock in the support (including facing, if any), in mm.

In any case, the rudder stock bearing sleeve supporting surface height shall be not less than 0,8 $d_1$.

**26.2.2.1.3.19** Minimum assumed design reaction, in kN, from the rudder stock side shall be determined by the following formula:

For suspended rudder

$$\boldsymbol{B}_{\text{H}} = \boldsymbol{R} \cdot (\mathbf{0,5} \cdot \boldsymbol{l}_{\mathbf{10}} + \boldsymbol{l}_{\mathbf{30}} + \boldsymbol{l}_{\mathbf{40}})/\boldsymbol{l}_{\mathbf{40}}; \qquad (26.2.2.1.3.19\text{-}1)$$

for the rudder with lower support

$$B_{\text{H}} = 0{,}549 \cdot R. \qquad (26.2.2.1.3.19\text{-}2)$$

where $R, l_{10}, l_{30}, l_{40}$ shall be taken in accordance with 26.2.2.1.3.3.

**26.2.2.1.3.20** Standard rolling bearings may be used for the rudder stock supports provided their reliable lubrication and protection against water is ensured.

The rudder stock sealings shall be designed to prevent leakage of lubricants from supporting units of bearings.

**26.2.2.1.3.21** Measures shall be taken to prevent axial displacement of the rudder stock or steerable nozzle while designing the rudder stock bearings.

**26.2.2.1.3.22** The rudder trunk shall be so designed as to prevent the ingress of sea water into the ship's hull.

Glands situated above the load waterline shall be accessible for inspection and service afloat.

**26.2.2.1.3.23** The elements of the rudder trunk subject to loads of rudder stock or steerable nozzle shall be sized so that the occurring stresses do not exceed 0,35 $R_{eH}$.

**26.2.2.1.3.24** The height of the hubs of loose segment racks and auxiliary tillers shall not be less than 0,8 of the diameter of the rudder stock head.

The hub external diameter shall be not less than 1,6 times the diameter of the rudder stock head.

**26.2.2.1.3.25** The split hubs shall be fastened with at least two bolts on each side and have two keys. The keys shall be arranged at an angle of 90° to the split joints plane.

**26.2.2.1.3.26** The connection of the steering engine or gear with the elements coupled with the rudder stock shall eliminate the possibility of breakdown on the steering gear when the rudder stock is shifted in the axial direction by not more than 0,1 times the rudder stock diameter.

**26.2.2.1.4** Steering gears.

**26.2.2.1.4.1** Steering devices available with steering gears.

**26.2.2.1.4.1.1** The ship rudder shall be fitted with two gears: main gear and standby gear.

**26.2.2.1.4.1.2** A standby gear may be omitted in ships with several rudders or nozzles driven by separately controlled engine.

**26.2.2.1.4.1.3** Main and standby steering gears shall be so arranged that any one of them can work despite the damage of the other. It is allowed to have common parts of a power drive to the rudder stock (tiller, quadrant, cylinder block).

**26.2.2.1.4.1.4** The main steering gear control system shall be independent of the standby steering gear control system. It is allowed to have common steering wheel or control handle.

**26.2.2.1.4.1.5** The main and standby gears may be manually controlled. In this cases, requirements of 26.2.2.1.4.3.1 — 26.2.2.1.4.3.4 shall be met. In all other cases the steering gear shall be driven from the power source.

**26.2.2.1.4.1.6** The standby steering gear shall provide the rudder or steerable nozzle being put over to the same maximum angle as the main steering gear.

**26.2.2.1.4.1.7** Rope for steering line pilotage shall be flexible, galvanized, cross-twisted and unravelling.

**26.2.2.1.4.1.8** Main and standby steering gear control stations shall be fitted with rudder (steerable nozzle) position indicators.

**26.2.2.1.4.1.9** If main and standby gears are hydraulic, each of them shall have a pump with independent motor and the drive pipelines shall be laid apart as far as practicable.

**26.2.2.1.4.1.10** If main and standby gears are electric, their supply and control systems shall be independent of each other. Each of these two gears shall have its own electric motor.

**26.2.2.1.4.2** Power of steering gear.

**26.2.2.1.4.2.1** The power of the main steering gear shall be sufficient to put the rudder stock (steerable nozzles) over to the angle from 35° of either side to 35° of the other side in not longer than 30 s at maximum ahead service speed and the draught corresponding to the load waterline.

**26.2.2.1.4.2.2** The power of the standby steering drive shall be sufficient to put the rudder stock (steerable nozzles) over to the angle from 20° of either side to 20° of the other side in not longer than 60 s at ahead speed equal to 0,6 times the maximum one and the draught corresponding to the load waterline.

**26.2.2.1.4.2.3** The steering gear power units shall permit a torque overload of at least 1,5 times the rated torque for a period of 1 min.

**26.2.2.1.4.3** Hand-operated and standby steering gears.

**26.2.2.1.4.3.1** The main hand-operated steering gear shall be of self-braking design or be fitted with an automatic brake.

The main hand-operated steering gear shall meet the requirements of 26.2.2.1.4.2.1 when handled by one man with a force of not over 120 N applied to the steering wheel handles and with not more than 25 revolutions per one wheel turn.

**26.2.2.1.4.3.2** The standby hand-operated steering gear shall be of self-braking design or shall have a locking device.

The standby hand-operated steering gear shall comply with the requirements of 26.2.2.1.4.2.2 when operating with a force on the handle not more than 160 N per each operator with not more than 25 revolutions per one wheel turn.

**26.2.2.1.4.3.3** The standby steering gear shall be independent of the main steering gear and shall act directly on the rudder stock if possible.

**26.2.2.1.4.3.4** The steering wheels of the main and standby hand-operated non-self-braking gears shall have external rims.

**26.2.2.1.4.4** Mechanical steering gear with remote control.

**26.2.2.1.4.4.1** Chain cables, pull rods and galvanized steel ropes which are included in the steering line convoy pilotage shall be fitted with devices for taking slack of a rope; moreover, tightening springs shall be fitted on each side in the steering line pilotage.

**26.2.2.1.4.4.2** Rudder indicators (supports, transmissions, joints, couplings) shall be designed so as to prevent seizure or damage of their parts due to the hull deformation because of cargo movement or waves.

**26.2.2.1.4.4.3** Transmissions of mechanical steering gears of oil tankers intended for transportation, pumping and storage of liquids with a flash point of 60 °C and below shall be led above the deck in chutes or ducts. Construction of rubbing units and parts of these drives shall prevent spark formation.

**26.2.2.1.4.5** Protection against overload and reverse rotation.

**26.2.2.1.4.5.1** For the hand-operated steering gear it is sufficient to provide the gear with buffer springs instead of the protection against overload.

When the hand-operated steering gear is used as a standby gear, overload protection need not be fitted.

**26.2.2.2** Anchor arrangement.

**26.2.2.2.1** General.

**26.2.2.2.1.1** This Section covers standards of anchor equipment and anchor chain cables, as well as requirements for the machinery and elements of anchor arrangements.

**26.2.2.2.1.2** Every ship shall be equipped with an anchor arrangement for holding the ship at the place when she is anchored.

**26.2.2.2.1.3** Anchor equipment of floating cranes, oil-transfer stations shall be substantiated in a ship design depending on nature and features of her service.

The required conditions (depth, current speed, wind speed), at which anchoring of any of the above ship types shall be provided, are assigned by the design specification.

**26.2.2.2.1.4** The requirements of the present Section apply to normal holding power anchors.

When using high holding power anchors their weight shall be taken in accordance with GOST 25496.

Sizes of chains are determined in accordance with 26.2.2.2.3.6 — 26.2.2.2.3.9 for a weight of an anchor calculated in accordance with 26.2.2.2.3.1.

**26.2.2.2.1.5** Cable chain lockers of oil tankers (when located in dangerous spaces and areas) shall be tight and be fitted with arrangements for water filling.

**26.2.2.2.2** Equipment number.
**26.2.2.2.2.1** Equipment number $N_{eq}$ is calculated by the following formula:

$$N_{eq} = L \cdot (B + D) + k \sum_{i=1}^{n} (l_i h_i) \qquad (26.2.2.2.2.1)$$

where $L$, $B$, $D$ = design dimensions of the ship in accordance with 1.1.3 of Part II "Hull", in m;
$l_i$ = length of separate superstructures and deckhouses, in m;
$h_i$ = average height of separate superstructures and deckhouses, in m.
$k$ = coefficient assumed equal to 1,0 for ships with the total length of superstructures and deckhouses, located on all decks, exceeding a half of the ship's length and 0,5 for ships with the total length being in the range of 0,25 to 0,5 of the ship's length. The superstructures and deckhouses may be neglected for calculation of equipment number at the total length of the superstructures and deckhouses less than 0,25 of the ship's length.

**26.2.2.2.2.2** Equipment number of catamaran-type ships shall be determined by the following formula:

$$N_{eq} = 2L(B_{hull} + d) + (L + B_{ship})(D - d) + k \sum_{i=1}^{n} (l_i h_i) \qquad (26.2.2.2.2.2)$$

where $B_{hull}$ = breadth of one hull body, in m;
$B_{ship}$ = breadth of the ship, in m;
$D$ = side depth, in m;
$d$ = load draught, in m.

**26.2.2.2.2.3** For ships carrying cargoes on deck parameter $\sum_{i=1}^{n}(l_i h_i)$ in the formula (26.2.2.2.2.1) shall be calculated by multiplication of the side projection length of cargo stowed on the deck together with cargo limiting structures by its average height, and coefficient $k$ shall be assumed equal to 0,5 for ships intended for transportation of bulk cargoes only, and 1,0 — for transportation of other deck cargoes.
**26.2.2.2.3** Anchor, anchor chain and wire rope outfit.
**26.2.2.2.3.1** Total weight of bow anchors $\sum m_{anch}$ with normal holding power (refer to 26.2.2.2.1.4) for self-propelled, non-self-propelled and towing displacement ships shall be determined by the following formula:

$$\sum m_{\mathrm{anch}} = k_1 k_2 N_{eq} \qquad (26.2.2.2.3.1)$$

where $N_{eq}$ = equipment number;
$k_1$ = coefficient which accounts for forces acting on the ship when anchored to be taken based on data or determined by formulas given in Table 26.2.2.2.3.1-1;

Table 26.2.2.2.3.1-1

**Coefficient $k_1$**

| Area of navigation | for self-propelled and non-self-propelled ships | | for tugboats | |
|---|---|---|---|---|
| | $N_{eq}$, m² | $k_1$ | $N_{eq}$, m² | $k_1$ |
| **RN(SCI)** | $50 \le N_{eq} < 200$ | $k_1 = 1{,}5$ | — | $k_1 = 1{,}342 + 0{,}5/\left[1 + (N_{eq}/287)^{3{,}861}\right]$ |
| | $200 \le N_{eq} < 2000$ | $k_1 = 1{,}245 + 1{,}127 \cdot \exp\left(-\frac{N_{eq}}{206{,}917}\right)$ | | |
| | $2000 \le N_{eq} < 5200$ | $k_1 = 1{,}147 + 32{,}154 \cdot \exp(-\frac{N_{eq}}{388{,}564})$ | | |
| **RN(SCII)** | <2000 | $k_1 = 1{,}0$ | $50 \le N_{eq} < 100$ | $k_1 = 1{,}5$ |
| | ≥2000 | $k_1 = k_1 = 0{,}844 + 295/N_{eq}$ | $100 \le N_{eq} < 1600$ | $k_1 = 0{,}8 + 3{,}169/\ln(N_{eq})$ |

$k_2$ = coefficient which accounts for requirements for anchor equipment due to navigation area category to be taken based on data or determined by formulas given in Table 26.2.2.2.3.1-2.

Table 26.2.2.2.3.1-2

**Coefficient $k_2$**

| Area of navigation | Value of $k_2$ (at $N_{eq}$ m$^2$) | |
|---|---|---|
| | for self-propelled and non-self-propelled ships | for tugboats |
| **RN(SCI)** | 1,025 | 1,160 |
| **RN(SCII)** | at $50 \le N_{eq} < 100$ and $N_{eq} \ge 700$ $k_2 = 1{,}0$ | at $50 \le N_{eq} < 100$ $k_2 = 1{,}0$ |
| | at $100 \le N_{eq} < 700$ $k_2 = 1{,}0 + 49{,}98/N_{eq}$ | at $100 \le N_{eq} \le 1600$ $k_2 = 0{,}9 + 2{,}515/\sqrt{N_{eq}}$ |

The calculated values of $\sum m_{anch}$, in kg, are rounded to the nearest greater value of weight $M_{anch}$ of the anchor of dimension-type series regulated by normative document according to which the chain is manufactured.

One bow anchor shall be available onboard the ships of the following classes at $N_{eq}$ not exceeding:

| | $N_{eq}$, not exceeding |
|---|---|
| **RN(SCII)** | 100 |
| **RN(SCI)** | 75 |

Otherwise the ships shall be equipped with two bow anchors.

**26.2.2.2.3.2** Dredgers may be fitted with one bowing anchor of a weight equal to at least one half of a total weight determined in accordance with 26.2.2.2.3.1. On self-propelled dredgers anchor arrangement shall be fitted in the bow end and on non-self-propelled dredgers — in the extremity which is opposite to that where the main dredger working arrangement is fitted (dredging pipe, bucket ladder, etc.).

**26.2.2.2.3.3** Stern anchor arrangements of ships other than self-propelled ships (refer to 26.2.2.2.3.4), are installed at shipowners' discretion.

Where bow anchor arrangement cannot be located in ships with a length less than 25 m, such ships may be fitted with stern anchor arrangement only.

**26.2.2.2.3.4** Self-propelled ships with equipment number of 1000 m$^2$ (refer to 26.2.2.2.2) and over shall be fitted with the stern anchor arrangement in addition to the bow anchor arrangement, when:

**.1** navigation area of those ships includes areas without current or with a low current rate. Weight of the stern anchor for such ships shall be not less than 0,25 of total mass of bow anchors;

**.2** navigation area of those ships includes numerous fairway sections which do not allow the ship for turning to come to bow anchors against the current due to its breadth. The stern anchor weight in this case shall be at least 0,4 of the total weight of bow anchors;

**26.2.2.2.3.5** Weight of each of two installed bow anchors shall be equal to a half of a total weight of bow anchors $\Sigma m_{anch}$. The weight of one anchor (starboard anchor) may be taken equal up to 0,6 $\Sigma m_{anch}$ with respective reduction of the weight of another anchor.

**26.2.2.2.3.6** Length $L_{anch}$ of the anchor chain of one bow anchor is determined as follows.

**.1** The approximate total length of bow anchor chains is calculated by the following formula:

$$l_{\Sigma} = a / \left[ b + c \ln N_{eq} ) / N_{eq} \right] \qquad (26.2.2.2.3.6)$$

where $a$ = coefficient equal to 1;
$b$ and $c$ = coefficients to be taken from Table 26.2.2.2.3.6.

Table 26.2.2.2.3.6

**Coefficients $b$ and $c$**

| Type of a ship | Area of navigation | $b \cdot 10^2$ | $c$ |
|---|---|---|---|
| Self-propelled | **RN(SCI)** | 0,275 | 0,172 |
| | **RN(SCII)** | 0,364 | 0,229 |
| Non-self-propelled | **RN(SCI)** | 0,305 | 0,172 |
| | **RN(SCII)** | 0,417 | 0,233 |
| Tugboat | **RN(SCI)** | 0,240 | 0,180 |
| | **RN(SCII)** | 0,303 | 0,231 |

**.2** Obtained value $l_\Sigma$ shall be rounded for ships equipped with two bow anchors (refer to 26.2.2.2.3.1) to the nearest greater value $l_\Sigma$, multiple of shot length (25 m), and for ships equipped with one bow anchor to the nearest value $l_\Sigma$ from the range of 25, 30, 40, 50, 60 and 75 m.

For ships of areas of navigation **RN(SCI)** and **RN(SCII)** with equipment number of 1000 m$^2$ and over except tugboats, the total length of anchor chains shall be increased by one shot length.

**.3** If total length of anchor chains of two bow anchors is characterized with even number of shots, then chain length of one bow anchor $L_{anch}$ is taken equal to one half of $l$.

If total length of anchor chains of two bow anchors is characterized with odd number of shots, then length of one of chains shall be taken one shot more and connected to a heavier anchor if anchors are different in weight.

The anchor chain cable length for self-propelled ships equipped with stern anchor arrangement in addition to bow anchor arrangement shall be at least 75 % of the shorter chain length of the bow anchors.

**26.2.2.2.3.7** Anchor chain diameter shall be determined as follows.

**.1** the approximate value $k_{str}$ of anchor chain diameter is calculated:

for stud link anchor chains, in mm:

$$k_{str} = c + d \cdot M_{anch} + eM_{anch}^2 + f/M_{anch} \qquad (26.2.2.2.3.7\text{-}1)$$

where $M_{anch}$ = weight of an anchor to be fitted on the ship (refer to 26.2.2.2.3.1), for which the anchor chain is intended, in kg;

$c, d, e$ and $f$ = coefficients to be taken from Table 26.2.2.2.3.7 for stud link anchor chains;

Table 26.2.2.2.3.7

**Coefficients $c$, $d$, $e$ and $f$**

| Coefficient | Value of coefficient for ships of areas of navigation **RN(SCI)** and **RN(SCII)** for the chain strength category | |
|---|---|---|
| | 1 | 2 |
| $c$ | 17,890 | 17,939 |
| $d$ | 0,0196 | 0,0139 |
| $e$ $10^6$ | -2,541 | -1,361 |
| $f$ | -1560,571 | -1884,867 |

for studless anchor chains, in mm:

$$k_{str} = a_1 + b_1 M_{anch}/\ln(M_{anch}) \qquad (26.2.2.2.3.7\text{-}2)$$

where $a_1 = 6{,}197, b_1 = 0{,}253$.

**.2** the appropriate values of anchor chain diameter shall be rounded to the nearest value from dimension-type range of diameters regulated by the normative document in accordance with which the chain is manufactured.

**.3** if the anchor chain diameter calculated according to Formula (26.2.2.2.3.7-1) exceeds the value for ships of restricted area of navigation **R3-RSN**, determined in accordance with 3.1.3 of Part III "Equipment, Arrangements and Outfit", it is allowed to apply the anchor chain with a diameter determined in accordance with 3.1.3 of Part III "Equipment, Arrangements and Outfit" for ships of restricted area of navigation **R3-RSN**.

**26.2.2.2.3.8** When using cast chain cables instead of welded ones, their diameter may be reduced by 12 %.

**26.2.2.2.3.9** On non-self-propelled technical and auxiliary fleet vessels equipped with bow winches which ensure rope slippage at loose drum anchor, chain cables of a diameter up to 31 mm may be replaced with steel wire ropes. In both cases the requirements shall be met:

**.1** ropes shall be flexible and of the same strength as the chain cable of the required diameter, their length shall be at least 20 % greater than that of the anchor chain to be replaced;

**.2** steel wire ropes shall be galvanized and hemp ropes shall be tarred;

**.3** the rope shall be connected to the anchor by means of a chain cable section of the same strength as the rope and of a length sufficient for stowing the anchor for sea by means of chain stopper. The chain cable section is not required, if a design of the anchor arrangement provides other stopper device for securing the raised anchor.

**26.2.2.2.3.10** For ships of area of navigation **RN(SCI)** with equipment number of 1000 $m^2$ and over engaged in coastal navigation of the Kara Sea, weight of anchors determined in accordance with 26.2.2.2.3.1 shall be increased by 20 % and length of anchor chain cables determined in accordance with 26.2.2.2.3.6 — by 25 %.

**26.2.2.2.4** Securing attachments for anchors, anchor chain cables and ropes.

**26.2.2.2.4.1** Two stoppers shall be provided for each anchor chain cable: one for securing the chain cable at anchorage and the other one for securing the raised anchor. An anchor hoisting gear brake may be used as the stopper device for securing the chain cable at anchorage.

Cam, friction or chain anchor stoppers shall be used for securing of raised anchor. For Matrosov anchors up to 25 kg and Hall anchors up to 50 kg, one stopper device is permissible ensuring riding the ship at anchor. Bollards and cleats may be used as stoppers.

**26.2.2.2.4.2** Inboard shots of anchor chains or bitter ends of ropes shall be securely attached to the hull and fitted with detachable joints in order to enable releasing of these ends from easily accessible place at tight chain cable or rope.

Attachment elements of the chain cables and ropes connection and of their detachable joints shall be of the same strength as the chain cable or the rope.

The capacity of chain lockers shall be sufficient for free arrangement of the whole anchor chain.

In ships less than 25 m in length bitter ends of synthetic or hemp ropes need not be fitted with detachable joints.

**26.2.2.2.4.3** Anchor hawses and their location shall comply with the following requirements:

**.1** inner hawse pipe diameter shall not be less than 10 chain cable diameters and the wall thickness shall not be less than 0,4 of the chain cable diameter;

**.2** easy entering of the anchor shank into the hawse pipe and easy taking off the hawse pipe when the chain cable is released due to the gravity force shall be provided;

**.3** bend of the chain cable when passing through the stopper and the hawse pipe shall be minimal. If the small bend is not practicable, lead roll may be fitted.

**26.2.2.2.5** Anchor machinery.

**26.2.2.2.5.1** General.

**26.2.2.2.5.1.1** When dropping and hoisting the anchors having a weight of 50 kg and over as well as holding the ship at anchorage a capstan or windlass shall be provided. When anchor weight is 150 kg and over that machinery shall be fitted with chain sprockets.

**26.2.2.2.5.1.2** When chains are replaced by ropes, anchor winches may be used. Towing winches may be used as anchor hoisting gear.

**26.2.2.2.5.2** Remote-controlled anchor release device.

**26.2.2.2.5.2.1** In self-propelled ships over 60 m in length intended for carriage of inflammable liquids, the hoisting gear brake of bow starboard anchor shall be fitted with a remote-controlled anchor release device. The remote-controlled release device shall prevent from spontaneous anchor release.

**26.2.2.2.5.2.2** The remote-controlled anchor release device shall provide the following:

**.1** control from the wheelhouse of release of the bow starboard anchor as well as indication of the released chain cable;

**.2** stopping the anchor chain from the wheelhouse at any released chain cable;

**.3** the duration of the anchor release of max. 15 s from the moment of actuation of the anchor release remote control.

**26.2.2.2.5.2.3** Stoppers and other anchor equipment for which remote control is provided shall also be fitted with means of local manual control.

**26.2.2.2.5.2.4** Anchor appliances and the associated means of local manual control shall be designed to ensure normal operation of anchor arrangement in the event of failure of separate elements or the whole remote control system.

**26.2.2.3** Mooring arrangement.

**26.2.2.3.1** General.

**26.2.2.3.1.1** Every ship shall be fitted with mooring arrangements for warping to shore or floating berths structures and reliable attachment of the ship to them.

**26.2.2.3.1.2** Selection of number, type of machinery and elements of the mooring arrangements, and also their arrangement on board shall be carried out by a designer in accordance with design features and the ship purpose subject to the requirements of this Section.

**26.2.2.3.2** Mooring equipment.

**26.2.2.3.2.1** Mooring bollards shall be made of steel or cast iron. Small ships equipped only with natural fibre or synthetic fibre ropes are permitted to use bollards made of light alloys.

**26.2.2.3.2.2** The outside diameter of the bollard column shall be not less than 10 diameters of the steel wire rope or not less than one circumference of the natural or synthetic fibre rope.

**26.2.2.3.2.3** Bollards shall be installed on foundations which shall be fixed on the deck and be attached to the ship framing. It is allowed to weld bollards to strengthened plates of the deck flooring. No side bollards welded to the deck flooring are allowed in cargo ships.

**26.2.2.3.2.4** Bollards, mooring chocks and other elements of mooring equipment as well as their foundations shall be so designed that stresses in the elements do not exceed 0,95 times the yield point of their material due to acting of force equal to the breaking strength of the mooring rope for which they are intended.

**26.2.2.3.2.5** Mooring bollards located in dangerous spaces and areas, shall be installed on foundations designed so as to provide natural air circulation under the bollards.

**26.2.2.3.2.6** Hull structures in way of the mooring equipment installation shall be supported by ordinary framing or stiffeners.

**26.2.2.3.2.7** For hauling mooring ropes the mooring machinery may be used (mooring capstans, mooring winches, etc.) or other deck machinery (windlasses, cargo winches, etc.) fitted with mooring drums.

**26.2.2.3.3** Mooring ropes.
**26.2.2.3.3.1** Mooring ropes may be made of steel, natural fibres or synthetic fibres.
**26.2.2.3.3.2** Breaking load $F_{\mathrm{br}}$, in kN, of the mooring rope shall be not less than:
for ships with equipment number of 100 to 1000 m$^2$

$$F_{br} = 0{,}147 \cdot N_{eq} + 24{,}5; \qquad (26.2.2.3.3.2\text{-}1)$$

for ships with equipment number more than 1000

$$F_{br} = 171 + 3{,}92 \cdot 10^{-2}\,(N_{eq} - 1000) \qquad (26.2.2.3.3.2\text{-}2)$$

where $N_{eq}$ = equipment number calculated in accordance with 26.2.2.2.2.

**26.2.2.3.3.3** Number and length of mooring ropes shall be selected depending on the ship type and operating conditions. However, there shall be at least three mooring ropes on the ship:
length of the first rope shall be at least $L$ + 20 but max. 100 m, where L is the length of a ship, in m, in accordance with 1.1.3 of Part II "Hull";
length of the second rope shall be at least two thirds the length of the first rope;
length of the third rope shall be at least one third the length of the first rope.
For ships with length $L$ less than 20 m, the third rope is not required.
**26.2.2.3.3.4** Steel wire mooring ropes shall not be used or stored in dangerous spaces and areas.
**26.2.2.4** Towing arrangement.
**26.2.2.4.1** General.
**26.2.2.4.1.1** Towing arrangement of tugs shall include:
**.1** at least two devices for towing rope securing: the main device and the reserve one. Towing rope may be also secured by means of:
towing winch and towing hook;
towing hook and towing bollards or bitts;
towing winch and towing bollards or bitts;
**.2** towing rope;
**.3** towing arches and other rope guides;
**.4** towing rope limiters.

Notes: 1. Towing hooks may be used instead of towing bollards or bitts, and towing winch — instead of towing hook.
2. Where two towing winches of the same type or two towing hooks of the same type are installed in a tug, one of them is considered as the main and another — as the reserve one.

**26.2.2.4.1.2** Tugboats shall be fitted with automatic towing winches with a towing rope at least 500 meters long.
**26.2.2.4.1.3** Ships of all other types with main engines with output over 300 kW, with towing arrangements and not equipped with towing winches, shall be fitted with arrangements for hauling and laying of towing ropes.
**26.2.2.4.1.4** Number and arrangement of towing bollards, bitts, mooring chocks, guiding blocks, stops shall correspond to the design features and general arrangement of the main towing equipment (winches, hooks).
**26.2.2.4.1.5** Every self-propelled and non-self-propelled ship shall be fitted with arrangement allowing its towing, including the following equipment:
**.1** two towing bollards or bitts situated in the fore and after parts of the ship;
**.2** towing hawses for passing the towing ropes through the bulwarks.

**26.2.2.4.1.6** Floating cranes, technical and auxiliary fleet vessels and other ships with transom extremities shall be fitted with two pairs of bollards or bitts installed in the fore or aft end of the ship on either side.

**26.2.2.4.1.7** It is allowed to replace towing hawses with roller fairleads or guiding bollards.

**26.2.2.4.2** Towing hooks.

**26.2.2.4.2.1** A ship may be fitted with standard folding towing hooks of opened and closed types, with spring shock absorbers and without them, with mechanical and hydraulic locks.

Hooks of non-folding type may be used as the main means for securing of the towing rope on towed ships and as reserve means in tugs.

**26.2.2.4.2.2** All carrying elements of the towing hook and parts securing it to the hull shall be designed for the breaking load of the towing rope taken by calculation. Stresses in these shall not exceed 0,95 the yield point of the material.

**26.2.2.4.2.3** Load at which the shock absorber spring is compressed against the stop shall be not less than 1,3 times the nominal traction on the hook.

**26.2.2.4.2.4** The cramp irons of the towing hooks shall be solid-forged.

**26.2.2.4.2.5** Prior to installation on board the ship, the towing hooks shall be tested by test load equal to doubled design tractive force on the hook determined for ships in mooring mode.

**26.2.2.4.2.6** Attachment of the towing hook to the ship structures shall be of such design that at any possible towing angles the hook is not subject to the bending forces in the horizontal plane and does not touch any hull structures within the set angle of side stops, directly or by the rope thimble.

**26.2.2.4.2.7** When in non-working position, the towing hook shall be stowed for sea.

**26.2.2.4.2.8** Towing rope release shall be possible from two stations:

**.1** from the wheelhouse (remote control);

**.2** from the local station located in the immediate vicinity of the towing hook in a safe area.

**26.2.2.4.2.9** Towing rope releasing arrangement shall operate in the range of loads on the hook from zero to the breaking load at any possible rope deviation from the centreline.

**26.2.2.4.3** Towing equipment.

**26.2.2.4.3.1** Bollards, bitts, rope locks.

**26.2.2.4.3.1.1** Bollards, bitts and towing arrangement machinery shall be installed on foundations which shall be fixed on the deck and connected with the hull framing.

Deck shall be strengthened in way of installation of the foundations.

Bollards located in dangerous spaces and areas of the second category of explosion risk shall be installed on foundations so designed as to provide natural air circulation under the bollards.

**26.2.2.4.3.1.2** The outside diameter of the bollard or bitt column shall be not less than 10 diameters of the steel wire rope or not less than one circumference of the natural fibre rope.

**26.2.2.4.3.1.3** Rope locks shall be designed so as to withstand a load equal to a half of design tractive force on the hook.

**26.2.2.4.3.2** Towing arches.

**26.2.2.4.3.2.1** In the after part of tugs in way of possible displacement of the towing rope towing arches shall be installed in the transverse direction of the ship from side to side or other structures guiding the rope. The number of towing arches shall be determined for each tug depending on the length of its after part.

**26.2.2.4.3.2.2** The height of the towing arches and protective rails shall ensure the safe work and movement of the crew in way of possible displacement of the towing rope.

**26.2.2.4.3.2.3** The towing arches, supporting counterforts and other parts of the towing arrangement being touched by the towing rope shall be made of pipes or other proper profile with the rounding radius not less than the towing rope diameter.

**26.2.2.4.3.3** Towing rope limiters.

**26.2.2.4.3.3.1** In all ships equipped with the towing arrangement the side limiters of towing rope shall be fitted.

**26.2.2.4.3.3.2** The side limiters of the towing rope shall be designed to take the load equal to the breaking load of the towing rope. Stresses in carrying elements of the limiters and also in the fastenings securing them to the ship's hull or other structures shall not exceed 0,95 times the yield point of the material.

**26.2.2.4.4** Towing ropes.

**26.2.2.4.4.1** Strength characteristics of the towing ropes shall be determined depending on the design tractive force on the hook in the mooring mode established by hydrodynamic calculation agreed by the Register or by prototype and the results of trials of lead ships. If such calculations are not performed or a prototype is not available, the tractive force on the hook $F$, in kN, shall be assumed not less than the value calculated by the following formula:

$$F = 0{,}16 \cdot P_e \qquad (26.2.2.4.4.1)$$

where $P_e$= the total output of main engines, in kW.

**26.2.2.4.4.2** Minimum permissible breaking load, in kN, of the rope as a whole used for towing on the hook shall be not less than determined by the following formula:

$$F_0 = k \cdot F \, , \qquad (26.2.2.4.4.2)$$

where $F$ = design tractive force on the hook, in kN;
k = safety factor equal to:

| | |
|---|---|
| for design tractive factor on the hook up to 120 kN | 5 |
| for design tractive force on the hook of 120 kN and more | 4 |
| for ropes of automatic towing winches | 3 |
| for ropes of natural and synthetic fibres | 6 |

**26.2.2.4.4.3** The length of the towing rope is selected depending on the area of navigation.

**26.2.2.4.4.4** Ropes must be untwistable in all cases. Wires shall be galvanized.

**26.2.2.4.4.5** Manila ropes with increased strength may be used as the towing ropes. It is allowed to use three-rowed, ordinary and special tarred hemp ropes, and also ropes made of synthetic fibres — three-rowed, with circumference up to 200 mm.

**26.2.2.4.4.6** Each rope shall be provided with a splice from one end, either with a thimble or without it, or a mark (on one end or both ends). A splice without thimble is allowed only when the towing rope is being fixed on the columns of a bollard or a bitt.

**26.2.2.4.4.7** No steel towing ropes may be used or stowed in dangerous spaces and areas.

**26.2.2.5** Signal masts.

**26.2.2.5.1** General.

**26.2.2.5.1.1** General provisions and requirements for signal masts are specified in Section 6 of Part III "Equipment, Arrangements and Outfit".

**26.2.2.6** Openings in hull, superstructures and deckhouses and their closing appliances.

**26.2.2.6.1** Height of coamings from the upper surface of deck plating of cargo and other hatches located on the freeboard deck and not protected by superstructures or deckhouses shall be not less than that specified in Table 26.2.2.6.1.

Table 26.2.2.6.1

**Hatch coaming heights**

| Area of navigation | Minimum height, in mm, of the hatch coamings | |
|---|---|---|
| | cargo | other* |
| **RN(SCI)** | 400 | 300 |
| **RN(SCII)** | 300 | 250 |

* Other hatches include trunks, access holes, non-cargo holds, outer exits to the superstructures and wheelhouses, awnings.

The coaming height of hatches in passenger ships where passengers are located in the hull compartments not closed by a deck or superstructure, shall be not less than the coaming height on open cargo ships.

**26.2.2.6.2** Where the hatches are located inside the superstructures fitted with the closures as specified in this Chapter, the height of the hatch coamings may be taken as 75 mm for the ships of areas of navigation **RN(SCI)** and **RN(SCII)**.

**26.2.2.6.3** Cargo and other hatches located on the open areas of the freeboard deck for the closed ships shall be fitted with watertight closures,

**26.2.2.6.4** Closures of the cargo hatches for the ships of area of navigation **RN(SCI)** shall be rated for loading by the cargo weight which is assumed to be stowed on those closures. Herewith, the minimum specific load on cargo hatches depending on the ship's length shall be assumed as linearly increased from 4,90 kPa at the ship's length 24 m up to 9,81 kPa at the ship's length 100 m. For the ships of less than 24 m and more than 100 m in length the specified weight load shall be taken as not dependent on the ship's length and equal to the above limit values of 4,90 kPa and 9,81 kPa accordingly.

**26.2.2.6.5** Cargo hatchway covers and closures of other hatches and openings on open parts on the weather deck, air-locks, entrances and other openings in the superstructure on the main deck of ships of area of navigation **RN(SCII)** shall be rated for the weight loads from the cargo which is assumed to be stowed on those covers. The minimum specific load on the cargo hatch covers depending on the ship's length shall be assumed as linearly increased from 2,45 kPa at the ship's length of 24 m up to 5,40 kPa at the ship's length of 100 m. For the ships less than 24 m and more 100 m in length the specific weight load shall be taken as not dependent on the ship's length and equal to the above limit values of 2,45 kPa and 5,40 kPa accordingly.

**26.2.2.6.6** Ventilation heads located on the open parts of the freeboard deck shall have strong steel coaming with the height being not less than that required for coamings of the cargo hatches. Ventilation openings on all the ships shall be fitted with tight closures. Coamings of portable ventilation heads shall be fitted with covers or similar closing means.

**26.2.2.6.7** All outer doors and windows of the superstructures, wheelhouses and air-locks located on the freeboard deck shall be watertight.

Doors of the closed spaces (e. g., storerooms, boatswain's stores) located on the freeboard, forecastle and poop decks, may be weathertight.

**26.2.2.6.8** Scuttles in superstructures and wheelhouses of the first and second tiers located outside the areas and structures, in the outer shell plating below the freeboard deck, in frontal bulkheads of closed superstructures and wheelhouses of the first tier as well as in frontal bulkheads of closed superstructures and wheelhouses of the second tier on 0,25 of the ship's length from the forward perpendicular shall be supplied with permanently attached deadlights and the thickness of glass shall be at least 8 mm at clear diameter of 250 mm or less and at least 12 mm at clear diameter of 350 mm or more. Clear diameter shall not exceed 400 mm.

**26.2.2.6.9** On ships of area of navigation **RN(SCI)**, the side scuttles located in spaces below the freeboard deck shall be fitted with permanently attached deadlights; here, the scuttle glass thickness shall be at least 8 mm at a clear diameter up to 250 mm inclusive and at least 12 mm at a clear diameter of 350 mm and more. However, the clear diameter shall not exceed 450 mm. For intermediate clear diameters the glass thickness is determined by linear interpolation.

The lower edge of side scuttles shall be clear of the maximum draught line on at least 150 mm.

Side scuttles of passenger ships of area of navigation **RN(SCI)** located less than 2,5 % of the ship's breadth apart from the maximum draught line shall be dead.

On ships of area of navigation **RN(SCI)**, in the superstructures located on the freeboard deck and extended from side to side, the scuttles shall be fitted with deadlights. In superstructure spaces located on the freeboard deck and not being extended to the sides may be fitted with watertight windows with heavy glass (at least 10 mm).

On the passenger ships, the scuttles located in the spaces below the freeboard deck, except rescue scuttles, shall be dead (non-opening) or shall have a structure allowing to open them only by the crew members. The scuttles, except for the non-opening ones, located below the freeboard deck, including rescue scuttles, shall be provided with an automatic alarm of their open position given at the wheelhouse.

**26.2.2.6.10** On oil tankers and flush deck ships all openings in the freeboard deck shall be fitted with strong watertight closures.

**26.2.2.7** Arrangement and equipment of spaces. Other arrangements and equipment.

**26.2.2.7.1** General.

**26.2.2.7.1.1** Requirements of this Section apply to arrangement and equipment of accommodation and service spaces for the crew and passengers, wheelhouse, dry cargo holds, to passageways, doors, ladders and rescue manhole-scuttles.

**26.2.2.7.2** Passageways, doors, ladders.

**26.2.2.7.2.1** The breadth of passageways shall not be less than:

**.1** 0,8 m in main corridors of common passenger spaces, corridors of passenger accommodation and public spaces as well as deck passages of passenger ships leading to muster stations;

**.2** 0,6 m on decks between the bulwark and the wheelhouse for ships with power below 590 kW, or less than 25 m in length, or with a gross tonnage below 300 t, and 0,7 m for ships with greater power, length or gross tonnage values;

**.3** 0,7 m in the crew accommodation corridors;

**.4** 0,6 m in corridors of spaces in ships less than 25 m in length;

**.5** 0,5 m in corridors of spaces on dynamically supported craft less than 25 m in length;

**.6** 0,5 m on decks in places of installation of bollards, stanchions, hatchways.

**26.2.2.7.2.2** Doors of superstructures and wheelhouses leading to the open deck shall be designed to open outwards.

Doors of public spaces (saloons, messrooms) shall be designed to open outwards or to either side. Cabin doors shall open inwards and be fitted with detachable panels of 0,4 × 0,5 m in their lower part. On the passenger cabin doors from the inner sides of those panels there shall be provided the inscriptions "Means of escape — knock out in case of emergency".

Where cabins are fitted with rescue manhole-scuttles or opening windows with clear dimensions of at least 400 mm, detachable panels need not be fitted.

**26.2.2.7.2.3** Passenger spaces located in superstructures of second and third tiers shall be fitted with at least two ladders located at the opposite ends of the superstructures.

**26.2.2.7.2.4** In hold passenger spaces with a number of passengers less than 20 persons one ladder per each space may be provided.

**26.2.2.7.2.5** When a number of passengers in the hold passenger space is 20 persons and more, there shall be two ladders located at the opposite ends of the space with one of them giving access to an open deck outside the deck structures as far as practicable.

**26.2.2.7.2.6** When a number of passengers in the hold passenger space is from 20 to 50 persons inclusive, emergency ladder may be replaced by vertical ladder.

**26.2.2.7.2.7** In addition to exits from hold spaces specified in 26.2.2.7.2.4 — 26.2.2.7.2.6, each space shall be fitted with rescue scuttles with one scuttle at each side according to 26.2.2.7.3.

**26.2.2.7.2.8** Hold crew accommodation spaces for 20 persons and more shall be provided with at least two ladders located at the opposite ends of the space and giving access to the main deck; one of them (emergency ladder) shall be led to an open deck outside the deck structures or through insulated steel enclosure in the superstructure which provides safe exit to an open part of the main deck or deck overboard extension in the event of fire. Emergency ladder may be replaced by vertical ladder.

**26.2.2.7.2.9** Where hold spaces are intended for accommodation of 10 to 20 crew members and there is an exit giving access to an open deck, additional ladder need not be fitted provided that rescue scuttles are fitted at the side opposite to the main exit, with one scuttle at each side of the ship.

**26.2.2.7.2.10** Where hold spaces are intended for accommodation of less than 10 crew members and there is an exit giving access to the open deck, additional ladder or rescue scuttles need not be fitted.

**26.2.2.7.2.11** The ladders shall be arranged to provide free access of escape. Before entering/leaving a ladder as well as places where the next ladder builds on previous one shall be provided with free areas of a lengths not less than 0,8 m — for outer ladders and 0,6 m — for inner and vertical ladders, and a breadth not less than ladder breadth. The areas shall not have transverse coamings or shoulders. Angle of ladder slope to horizontal plain shall not exceed 50° — for accommodation and service spaces, and 55° — on decks and in machinery spaces. In order to access to equipment located in rooms and compartments of a ship the ladders with slope angle of 60° may be installed, and in periodically unattended machinery spaces where the ladders are difficult to install the vertical ladder may be used.

**26.2.2.7.2.12** Intermediate areas stated in 26.2.2.7.2.11 shall be arranged if the ladder length, in mm, exceeds, for:

| | |
|---|---|
| inclined ladder | 4000 |
| vertical ladder | 9000 |

**26.2.2.7.2.13** Ladder breadth for a number of passengers of 50 and less in the given space shall be at least 0,8 m. Ladder breadth shall be increased by 5 cm per each 10 passengers in excess of 50 persons. In crew spaces the ladder breadth shall be at least 0,8 m and in ships up to 25 m in length — not less than 0,65 m.

In ships of a length up to 25 m the ladder breadth may be decreased to 0,5 m if the requirement of this para is not technically feasible.

**26.2.2.7.2.14** Ladders with more than three steps shall be equipped with handrails or guardrail.

**26.2.2.7.3** Scuttles.

**26.2.2.7.3.1** The side scuttles shall be arranged to meet the requirements of 26.2.2.6.8 and 26.2.2.6.9.

No scuttles are allowed in spaces intended for cargo carriage.

**26.2.2.7.3.2** In hold spaces intended for passengers and crew as well as in engine room rescue scuttles shall be provided with a clear breadth of 400 mm.

N o t e . Rescue scuttles are required only in ships where a freeboard height is sufficient for its free arrangement.

**26.2.2.7.3.3** In hold spaces intended for passengers and crew rescue scuttles shall be located in common cabins or in corridors with one scuttle at each side of the ship.

**26.2.2.7.3.4** In the machinery spaces one rescue scuttle shall be provided at each side of a ship. Where a door is arranged in the bulkhead separating the machinery space and the boiler room, at least one scuttle shall be provided in each of the spaces being located at the opposite ends of the space.

**26.2.2.7.3.5** Where an emergency exit is provided in the hold space for passengers or crew as well as in the machinery space which gives access directly to the open main deck, rescue scuttles need not be fitted.

**26.2.2.7.3.6** Lower edges of rescue scuttles shall not be located below the lower edges of ordinary side portholes.

**26.2.2.7.3.7** Free access shall be provided to rescue scuttles. Hand irons shall be fitted in sides to facilitate the access to scuttles.

**26.2.2.7.3.8** Frames of rescue scuttles shall be painted red and shall bear relevant inscriptions. Location indicators of rescue scuttles shall be placed on visible places.

**26.2.2.7.4** Accommodation and service spaces.

**26.2.2.7.4.1** Accommodation spaces and galleys as well as canteens used as recreation spaces may be located in the vicinity of tanks with fuel or above them only when a horizontal cofferdam at least 600 mm high or a vertical cofferdam of breadth equal to the spacing is provided.

Cofferdams shall be equipped with ventilation independent of the ventilation of accommodation spaces.

No cutouts for manholes or other cutouts are allowed in decks and bulkheads in way of the above spaces.

**26.2.2.7.4.2** Above the emergency exits there shall be provided illuminated inscriptions "Emergency exit".

**26.2.2.7.5** Halls and spaces for multimedia presentations.

**26.2.2.7.5**.1 Halls and spaces equipped for multimedia presentations, film exhibition, etc. on passenger ships shall be fitted with exits giving access directly to an open deck with one exit per 50 spectators, but at least two exits at the opposite ends of the space. Each exit shall be fitted with a door which opens outwards; minimum breadth of the door and the passage shall be not less than 1,1 m.

Above each exit there shall be provided illuminated inscriptions "Exit" or "Emergency exit".

**26.2.2.8** Railing, handrails, gangways, companionways.

**26.2.2.8.1** General.

**26.2.2.8.1.1** Along the perimeter of open decks, bridges and superstructures as well as around the open areas and workplaces located at a height over 0,5 m, the bulwark and guard rails shall be provided. Openings and doorways in decks, sides, bulkheads, bulwark shall be provided with railings preventing the possible fall or injury of people while operating a ship.

**26.2.2.8.1.2** Fixed railings (coamings, bulwark, rails and guard rails) with regard to type, purpose and operating conditions of a ship shall eliminate the risk of man-overboard, falls into machinery space trunk, opening in deck, from bridge wings, from maintenance area, from other workplaces.

In order to protect passengers and crew against overboard risk, ships are fitted with handrails, gangways, companionways in addition to the fixed railings.

Companion hatchways and other openings in decks, bulkheads, sides shall be equipped with movable or removable railings.

**26.2.2.8.1.3** The railings shall withstand loads arising during operation. Connections and fittings of railings shall be so designed that they are not reduced by vibration. Structural provisions shall be taken to prevent loss of fittings (bolts, nuts, pins).

**26.2.2.8.1.4** Height of bulwark or guard rail along a perimeter of decks and bridges as well as around the open areas located at a height more than 0,5 m above the deck shall be not less than 1100 mm, and the railings height inside rooms and compartments shall not be less than 1000 mm. Guard rail on the upper awnings may be omitted.

For ships less than 20 m in length the height of a bulwark or a guard rail may be reduced, but shall be not less than 900 mm when relevant grounds of adequate protection of the crew and passengers are submitted to the Register.

**26.2.2.8.1.5** Bulwark or guard rail shall be fitted on all open decks of the hull, superstructures and wheelhouses. On self-propelled ships up to 10 m in length handrail may be fitted along the perimeter of a superstructure or a deck.

**26.2.2.8.1.6** On passenger ships of areas of navigation **RN(SCI)** and **RN(SCII)** railings on decks accessible for passengers shall be made as solid bulwark or guard rail with protective mesh screen.

**26.2.2.8.1.7** In areas where bollards and fairleads are installed, the guard rail or bulwark shall not have parts that require change of their position when operating with mooring lines.

**26.2.2.8.1.8** In places where gangways are handled, the doors or removable, telescopic, hinged and similar types of railings shall be provided.

**26.2.2.8.1.9** Removable railings shall have special safety hooks, design of which provides quick installation and easy removal of railings and prevents spontaneous release under the weight of falling person.

**26.2.2.8.1.10** Decks of ferries and other ships intended for transportation of wheeled vehicles shall be fenced by fender beams with a height of at least 0,45 m.

**26.2.2.8.2** Bulwark.

**26.2.2.8.2.1** Exit cutouts in the bulwark shall have folding doors which open inwards, or a removable railing.

**26.2.2.8.3** Guard rail.

**26.2.2.8.3.1** The distance between guard rail stanchions shall not exceed three spacings.

**26.2.2.8.3.2** The guard rail of 1100 mm high shall be four-row, of 1000 mm high — three-row. The lower rail shall be located not higher than 230 mm above the deck. The distance between other rails shall not exceed 380 mm. The guard rail of decks accessible for passengers shall be fitted with protective screens. Side of screen cell shall not exceed 100 mm.

**26.2.2.8.3.3** On non-self-propelled ships of areas of navigation **RN(SCI)** и **RN(SCII)** handrail shall be provided in way of superstructures and wheelhouses, and on non-attended ships — in way of forecastle and poop.

On flush deck barges without cargo bunker in the area of cargo platform a waist bar shall be installed.

On flush deck barges being unloaded by inclination or capsizing method a guard rail may be dispensed with provided that through passage is provided under the deck.

**26.2.2.8.3.4** The upper edge of the waist bar shall be raised above the deck for at least 100 mm. The waist bar shall not impede water drainage from the deck.

**26.2.2.8.3.5** In places of interruption of the bulwark and the guard rail (the deck machinery area, ladder flights, etc.) removable chain rails shall be provided.

**26.2.2.8.3.6** Clearances (gaps) between guard rails as well as between railings and other structures of a ship shall not exceed 150 mm.

**26.2.2.8.3.7** Design of removable rigid or flexible guard rails shall provide their quick removal. In case of flexible guard rails (chain, rope) the possibility to tighten rails shall be provided.

**26.2.2.8.3.8** In people passages, the chain railings may be used only. Length of such railing (distance between stays) shall not exceed one meter. The maximum sagging of chain guard rail shall not exceed 40 mm.

**26.2.2.8.4** Handrails, gangways, companionways.

**26.2.2.8.4.1** Ladders shall be fitted with railings and handrails of a height not less than required by the Rules.

**26.2.2.8.4.2** Where a passage is provided along the deck extension, handrails shall be fitted on outer walls of the superstructures.

**26.2.2.8.4.3** On oil tankers of areas of navigation **RN(SCI)** and **RN(SCII)** between separate accommodation spaces and service spaces as well as in order to provide the crew with safe access to the fore part of the ship in any operating conditions gangways shall be provided raised above the deck. The gangways shall:

**.1** be at least 1 m wide and be located in way of the centre line;

**.2** be fitted with handrails at least 1,1 m high with stanchions not more than three spacings apart;

**.3** have side entries from the deck not more than 40 m apart from each other.

When the open deck is extended for more than 70 m, shelters of practicable design shall be arranged along the entire length of the gangways at intervals not more than 45 m apart from each other.

Each shelter shall be sufficient for at least one person and shall protect him/her against bad weather.

*APPENDIX 1 (mandatory)*

## Calculation Method for Hydrodynamic Loads, Bending Moments, Shear Forces and Support Reaction Forces Acting in the Stock - Rudder System

**1.** This Appendix establishes the method for accounting for a non-uniform nature of hydrodynamic load distribution over the height of ship's rudders and calculation methods for bending moments, shear forces and support reaction forces acting in the stock - rudder system.

**2.** Hydrodynamic loads (resultant of hydrodynamic forces and torque) acting on the rudder shall be determined based on experimental or calculation results for all possible range of rudder angles.

**3.** When calculating hydrodynamic forces acting on the rudder within the propeller jet or steerable nozzle, the effects of the ship's hull and propeller jet shall be taken into account.

**4.** When determining hydrodynamic forces acting on the rudder within the propeller jet or steerable nozzle experimentally, the compliance between load factors for model and full-scale propeller shall be ensured

$$C_T = {}^{8T_p}\Big/_{(\rho V_A^2 \pi D^2)} \qquad (4)$$

where $T_p$ = propeller thrust, in kN;
$\rho$ = water density, in t/m$^3$;
$V_A$ = propulsion and steering system inflow velocity, in m/s;
$V_A = V(1 - W_T)$
$V$ = design speed of a ship in loaded condition (for pushers — together with the convoy), in m/s;
$W_T$ = wake factor for straight motion of the ship by calculation of propulsion ability;
$D$ = propeller diameter, in m.

**5.** Bending moments, shear forces and support reaction forces acting in the stock-rudder system shall be calculated according to methods shown in Figs. 5-1 — 5-3.

Calculation shall be performed for such combination of hydrodynamic loads when the stock is subject to maximum equivalent stresses defined in accordance with 1.5.1 of Part III "Equipment, Arrangements and Outfit".

Maximum unit load intensity $q$, in kN, shall be calculated by the following formula:

$$q = R/\{l_{10}[(0{,}45D/l_{10} - 0{,}975)f + 0{,}95]\} \qquad (5\text{-}1)$$

where $D$ = propeller diameter, in m;
$l_{10} — l_{60}$ = lengths of steering gear elements (refer to Figs. 5-1 — 5-3), in m;
$R$ = resultant force on a rudder, in kN;
$f$ = coefficient considering non-uniformity of load distribution for suspended rudders and rudders with support on sternframe heel determined by Table 5 depending on load factor $C_T$ and relative height of the part of the rudder protruding from the jet $(l_{10} - D)/l_{10}$.

Table 5

**Coefficient considering non-uniformity of load distribution $f$**

| $(l_{10} - D)/l_{10}$ | $f$ at $C_T$ | | | | |
|---|---|---|---|---|---|
| | 0 | 2 | 6 | 12 | >25 |
| 0 | 0,000 | 0,133 | 0,196 | 0,226 | 0,256 |
| 0,1 | 0,000 | 0,226 | 0,326 | 0,373 | 0,418 |
| 0,2 | 0,000 | 0,315 | 0,447 | 0,506 | 0,561 |
| 0,3 | 0,000 | 0,435 | 0,597 | 0,664 | 0,722 |
| 0,4 | 0,000 | 0,540 | 0,715 | 0,779 | 0,827 |
| 0,5 | 0,000 | 0,631 | 0,801 | 0,850 | 0,876 |
| 0,6 | 0,000 | 0,707 | 0,856 | 0,879 | 0,880 |

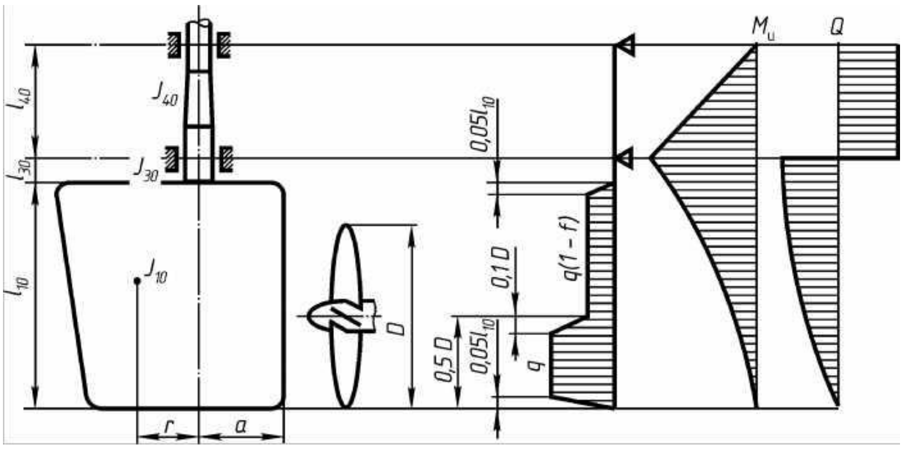



Fig. 5-1
Calculation method for moments, forces and reaction forces acting in the stock — suspended rudder system

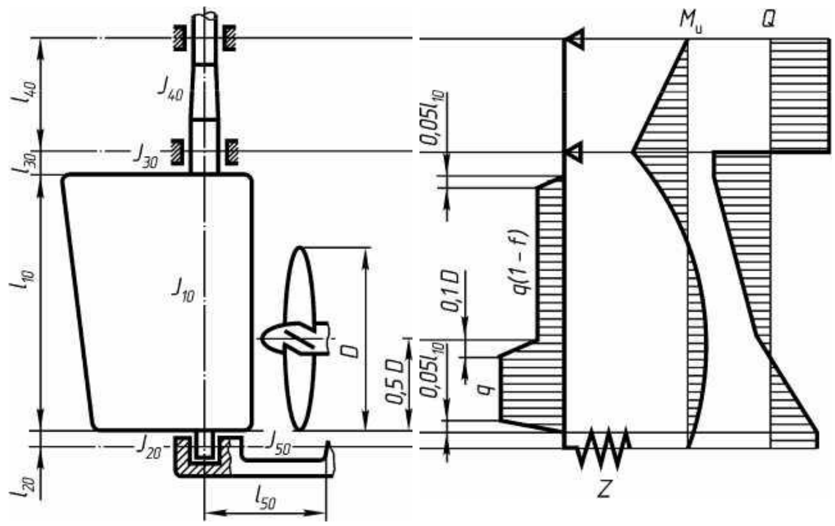



Fig. 5-2
Calculation method for moments, forces and reaction forces acting in the system of stock and rudder with lower support on sternframe heel

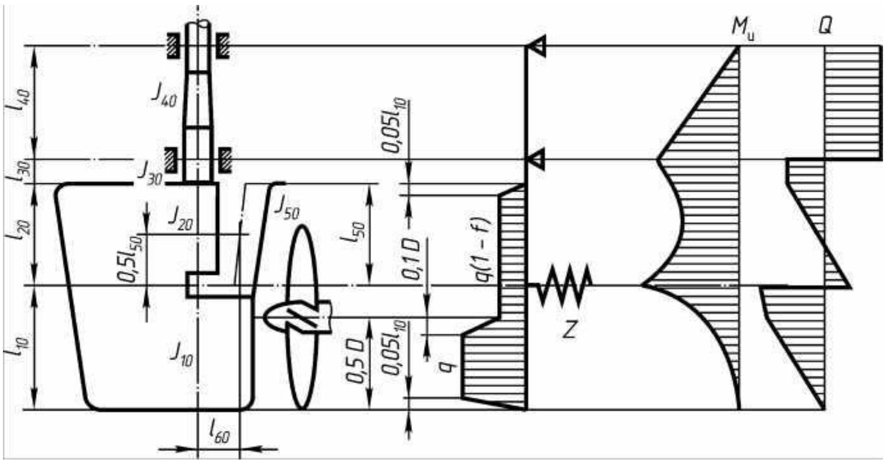



Fig. 5-3
Calculation method for moments, forces and reaction forces acting in the system of stock and rudder with pins on sternframe hinges

For semi-suspended rudders, totally or partially falling into the propeller jet when the ship is moving ahead at $(l_{10} - D)/l_{10} < 0,4$ coefficient considering non-uniformity of load distribution shall be taken

$$f = -1{,}625[(l_{10} - D)/l_{10}]^2 + 1{,}275\,(l_{10} - D)/l_{10} + 0{,}65 \qquad (5\text{-}2)$$

For rudders totally beyond the propeller jet, $f$ is taken equal to 0.

Jet diameter is taken equal to propeller diameter.

For rudders downstream of the propeller, for the astern motion of the ship $f$ is taken equal to 0.

Support rigidity factor $Z$, in kN/m, shall be determined as follows:

for support on sternframe heel

$$Z = 1/u_b; \qquad (5\text{-}3)$$

for support in the rudder horn

$$Z = 1/(u_b + u_5 + u_t) \qquad (5\text{-}4)$$

where $u_b$ = displacement of the support due to bending when the force of 1 kN is applied to the support centre:
$u_b = l_{50}^5 \cdot 10^3/(3EJ_{50})$;
$u_5$ = displacement of the support due to shear when the force of 1 kN is applied to the support centre:
$u_5 = l_{50} \cdot 10^3/(GF)$;
$u_t$ = displacement of the support due to horn torsion when the force of 1 kN is applied to the support centre:
$u_t = l_{50} l_{60}^2 \cdot 10^3/(GJ_t)$;
$E$ = Young's modulus of the horn and sternframe heel material, in MPa;
$G$ = shear modulus of horn material, in MPa;
$F$ = average cross-sectional area of the rudder horn, in m$^2$;
$J_t$ = average polar moment of inertia of cross-sectional area of the rudder horn, in m$^4$;
$J_{10} — J_{50}$ = moments of inertia of appropriate sections of steering gear elements, in m$^4$.

Where a bending moment applied to the rudder stock is determined experimentally, the idealized law of load distribution over height as shown in Figs. 5-1 — 5-3 may be neglected.

**6.** When the lateral force from the steering drive is transmitted to the rudder stock, this force and corresponding bending moments shall be taken into account when stock strength is calculated.

**7.** When calculating the height of the plain bearing sleeve, assumed design reaction from the rudder stock bearing $b_h$, in kN, for suspended rudder and rudder with lower support on sternframe heel shall be not less than determined by the following formula:

$$B_{low} = [R(\eta l_{10} + l_{30} + l_{40}) - B_{str}(l_{10} + l_{20} + l_{30} + l_{40})]/l_{40}; \quad (7)$$

where η = non-dimensional arm of bending moment (Table 7).

Table 7

**Non-dimensional arm of bending moment η**

| $(l_{10} - D)/l_{10}$ | η at $C_T$ | | | | |
|---|---|---|---|---|---|
| | 0 | 2 | 6 | 12 | >25 |
| 0,0 | 0,50 | 0,52 | 0,53 | 0,54 | 0,54 |
| 0,1 | 0,50 | 0,54 | 0,55 | 0,56 | 0,57 |
| 0,2 | 0,50 | 0,55 | 0,58 | 0,59 | 0,60 |
| 0,3 | 0,50 | 0,57 | 0,61 | 0,63 | 0,65 |
| 0,4 | 0,50 | 0,60 | 0,64 | 0,67 | 0,69 |
| 0,5 | 0,50 | 0,62 | 0,68 | 0,71 | 0,74 |
| 0,6 | 0,50 | 0,64 | 0,71 | 0,75 | 0,78 |

$B_{str}$ shall be taken in accordance with 8, for suspended rudders, $B_{str}$ = 0.

Element lengths $l_{10}, l_{30}, l_{40}$ shall be determined in accordance with Figs. 5-1 and 5-2.

For the rudders with lower support on sternframe heel, calculation for η = 0,5 shall be additionally performed.

**8.** Reaction force in the sternframe heel, in kN, shall be determined by formula (8), where $R$ is a yield point of the stock material, in MPa.

$$B_{str} = \frac{R(\eta l_{10}+l_{30})^3\left\{1+1,5\frac{l_{10}-\eta l_{10}+l_{20}}{\eta l_{10}+l_{30}}+l_{40}J_{10}\left(1+\frac{l_{10}-\eta l_{10}+l_{20}}{\eta l_{10}+l_{30}}\right)/[J_{40}(\eta l_{10}+l_{30})]\right\}}{\frac{J_{10}l_{10}^3}{J_{50}}+(l_{10}+l_{20}+l_{30})^3+\frac{l_{40}J_{10}(l_{10}+l_{20}+l_{30})^2}{J_{40}}} \quad (8)$$

**26.2.3 Stability, subdivision, freeboard.**

**26.2.3.1** Stability.

The requirements for stability specified in this Section shall apply instead of requirements in 2.1, 2.2 and 2.3 of Part IV "Stability".

Definitions and explanations specified in this Section are given in Part IV "Stability".

**26.2.3.1.1** Stability criteria $K$.

**26.2.3.1.1.1** The ship stability is considered sufficient by the criterion $K$, when it withstands dynamically applied wind pressure, i.e. the following condition is met:

$$K \geq \frac{M_{al}}{M_h}, \quad (26.2.3.1.1.1)$$

where $M_h$ = heeling moment due to dynamic wind pressure, in t·m, determined according to 26.2.3.1.1.2;
$M_{al}$ = allowable moment, in t·m, determined in accordance with 26.2.3.1.1.4.

**26.2.3.1.1.2** The heeling moment applied to a ship due to the dynamic wind pressure, in t·m, is calculated by the following formula:

$$M_h = 0{,}001 p_v A_v z_h / g \qquad (26.2.3.1.1.2)$$

where $p_v$ = wind pressure, in Pa, determined in accordance with 26.2.3.1.1.3;
$z_h$ = heeling lever arm, in m, determined in accordance with 26.2.3.1.1.4;
$A_v$ = windage area, in m$^2$, determined in accordance with 1.4.6 of Part IV "Stability".

**26.2.3.1.1.3** The wind pressure $p_v$, in Pa, shall be taken from Table 26.2.3.1.1.3.

Table 26.2.3.1.1.3

| Distance from the windage centre to the plane of the waterline of floatation, m | Wind pressure $p_v$, Pa, for ships of area of navigation | |
|---|---|---|
| | Restricted **RN(SCI)** | Restricted **RN(SCII)** |
| 0.5 | 177 | 157 |
| 1.0 | 196 | 177 |
| 1.5 | 216 | 196 |
| 2.0 | 235 | 216 |
| 2.5 | 255 | 235 |
| 3.0 | 265 | 245 |
| 4.0 | 284 | 265 |
| 5.0 | 304 | 284 |
| 6.0 | 324 | 304 |

**26.2.3.1.1.4** The heeling lever arm $z$, in m, is calculated by the following formula:

$$z_h = z + a_1 a_2 T \qquad (26.2.3.1.1.4)$$

where $z$ = distance from the windage centre to the plane of the waterline of floatation, in m;
$a_1, a_2$ = coefficients determined in accordance with 26.2.3.1.1.5;
$T$ = ship draught, in m.

**26.2.3.1.1.5** Values of coefficients $a_1$ and $a_2$ are determined in accordance with Tables 26.2.3.1.1.5-1 and 26.2.3.1.1.5-2.

Table 26.2.3.1.1.5-1

| $B/d$ | $a_1$ |
|---|---|
| ≤2,5 | 0,40 |
| 3,0 | 0,41 |
| 4,0 | 0,46 |
| 5,0 | 0,60 |
| 6,0 | 0,81 |
| 7,0 | 1,00 |
| 8,0 | 1,20 |
| 9,0 | 1,28 |
| ≥10 | 1,30 |

Table 26.2.3.1.1.5-2

| $z_g/B$ | $a_2$ |
|---|---|
| 0,15 | 0,66 |
| 0,20 | 0,58 |
| 0,25 | 0,46 |
| 0,30 | 0,34 |
| 0,35 | 0,22 |
| 0,40 | 0,10 |
| >0,45 | 0 |

**26.2.3.1.1.6** The allowable moment $M_{all}$ , in t·m, is determined by the allowable heeling angle.

**26.2.3.1.1.7** The allowable heeling angle $\theta_{al}$ shall be taken equal to either the capsizing angle $\theta_{cap}$ or the angle of down-flooding $\theta_f$, whichever is less.

**26.2.3.1.1.8** In order to determine the moment $M_{all}$ the value of rolling amplitude, $\theta_m$, calculated in accordance with the requirements of 26.2.3.1.1.12 — 26.2.3.1.1.18 is plotted to the left from the point of origin (Figs. 26.2.3.1.1.9 and 26.2.3.1.1.10) and corresponding point $A$ is fixed in the left leg of the curve.

**26.2.3.1.1.9** For determination of the allowable moment $M_{all1}$ corresponding to the capsizing angle $\theta_{cap}$, tangent line $AK$ to the right leg of the curve of arms is drawn from the point $A$ (refer to Fig. 26.2.3.1.1.9).

An abscissa of the point of contact $K$ defines the capsizing angle. Further, a line parallel to abscissa axis is drawn via the point $A$, and segment $AB$ equal to 1 rad (57,3°) is laid.

A perpendicular is conducted from point $B$ up to intersecting tangent line $AK$ in a point $E$.

Segment $BE$ presents the numerical value of the arm $l_{al1}$, of the allowable moment corresponding to the capsizing angle. The allowable moment $M_{al1}$, in t·m, is calculated by the following formula:

$$M_{al1} = \Delta \cdot l_{al1} \quad (26.2.3.1.1.9)$$

where $\Delta$ = ship displacement, in t;

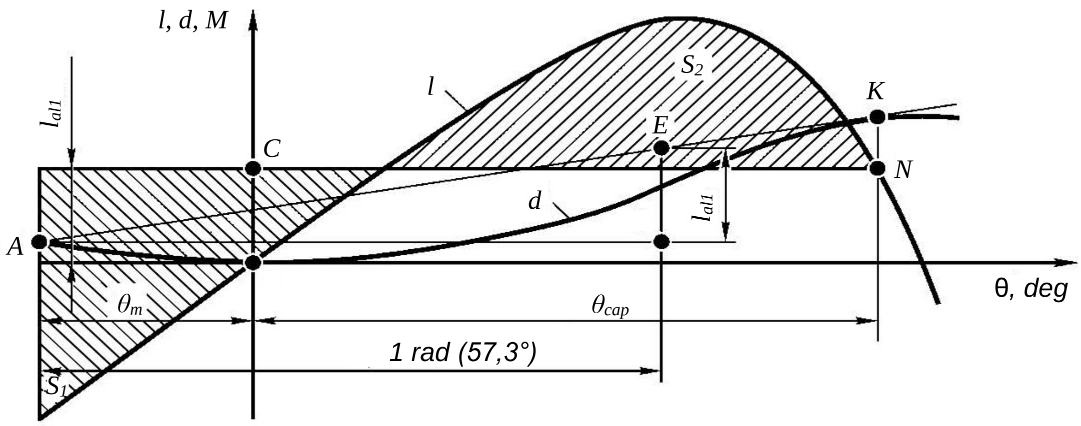



Fig. 26.2.3.1.1.9

**26.2.3.1.1.10** For determination of allowable moment $M_{al2}$ corresponding to the angle of down-flooding $\theta_f$, a value of the angle of down-flooding $\theta_f$ is plotted on the curve's X axis (refer to Fig. 26.2.3.1.1.10) and a perpendicular is drawn from the obtained point up to intersecting the curve of arms in a point $F$.

Further plotting on the curve are performed by the same way as stated in 26.2.3.1.1.9, except that instead of the tangent line to the curve, a secant line $AF$ is conducted to intersecting, in point $E$ with perpendicular $BE$, constructed to segment $AB$ equal to 1 radian.

The segment $BE$ is equal to the arm $l_{al2}$ of the allowable moment corresponding to the angle of down-flooding. The allowable moment $M_{al2}$, in t·m, is calculated by the following formula:

$$M_{al2} = \Delta \cdot l_{al2} \tag{26.2.3.1.1.10}$$

where Δ = ship displacement, in t;

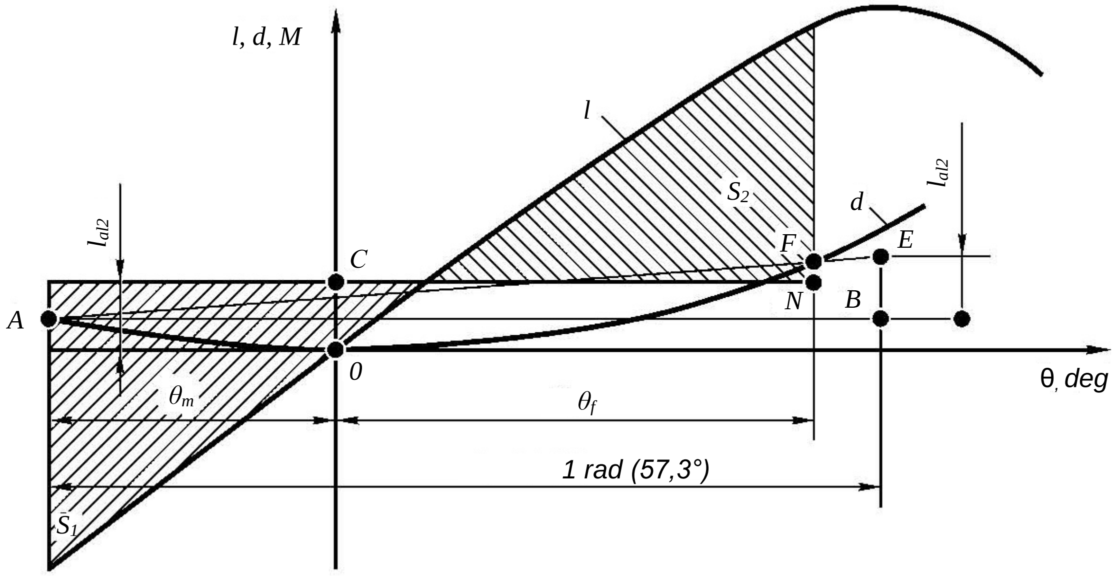



Fig. 26.2.3.1.1.10

**26.2.3.1.1.11** The arms $l_{al1}$ and $l_{al2}$ of the allowable moment may be determined according to the static stability curve as a result of plotting shown on Figs. 26.2.3.1.1.9 and 26.2.3.1.1.10, formed based on equality of areas $S_1$ and $S_2$.

Segments $OC$ shown on Figs. 26.2.3.1.1.9 and 26.2.3.1.1.10 represents arms $l_{al1}$ and $l_{al2}$ accordingly.

**26.2.3.1.1.12** Rolling amplitudes $\theta_m$, in deg, for ships with a rounded bilge and without bilge keels or bar keel shall be taken from Table 26.2.3.1.1.12 depending on frequency $m$, in s$^{-1}$, calculated by the formula

$$m = m_1 m_2 m_3 \tag{26.2.3.1.1.12}$$

where $m_1, m_2, m_3$ = coefficients determined in accordance with 26.2.3.1.1.14 — 26.2.3.1.1.15;

Table 26.2.3.1.1.12

| $m$, in s$^{-1}$ | Rolling amplitude $\theta_m$, in deg, for ships of the area of navigation | |
|---|---|---|
| | **RN(SCI)** | **RN(SCII)** |
| 0,40 | 14° | 9° |
| 0,60 | 18° | 10° |
| 0,80 | 24° | 13° |
| 1,00 | 28° | 17° |

| $m$, in s[-1] | Rolling amplitude $\theta_m$, in deg, for ships of the area of navigation | |
|---|---|---|
| | **RN(SCI)** | **RN(SCII)** |
| 1,20 | 30° | 20° |
| 1,40 | 31° | 23° |
| 1,60 | 31° | 24° |
| ≥1,80 | 31° | 24° |

**26.2.3.1.1.13** For the ships with sharp bilges the rolling amplitude shall be taken equal to 0,75 of the values taken from Table 26.2.3.1.1.12.

**26.2.3.1.1.14** The coefficient $m_1$ shall be determined by the following formula:

$$m_1 = {}^{m_0}\!\Big/\!\sqrt{h_0}, \qquad (26.2.3.1.1.14)$$

where $h_0$ = non-corrected metacentric height, in m;

$m_0$ = coefficient taken from Table 26.2.3.1.1.14 depending on parameter $n_1$, determined by the formula;

$$n_1 = {}^{h_0 B}\!\Big/\!(z_g \sqrt[3]{V})$$

where $B$ = breadth at the waterline, in m;

$z_g$ = vertical centre of gravity;

$V$ = ship's volume displacement, in m[3].

Table 26.2.3.1.1.14

| $n_1$ | $m_0$ |
|---|---|
| ≤0,10 | 0,42 |
| 0,15 | 0,52 |
| 0,25 | 0,78 |
| 0,50 | 1,38 |
| 0,75 | 1,94 |
| 1,00 | 2,40 |
| 1,50 | 3,00 |
| 2,00 | 3,30 |
| 2,50 | 3,50 |
| ≥3,00 | 3,60 |

**26.2.3.1.1.15** The values of coefficients $m_2$ and $m_3$ are determined according to Tables 26.2.3.1.1.15-1 and 26.2.3.1.1.15-2.

Table 26.2.3.1.1.15-1

| $B/d$ | $m_2$ |
|---|---|
| ≤2,50 | 1,00 |
| 3,00 | 0,90 |
| 3,50 | 0,81 |
| 4,00 | 0,78 |
| 5,00 | 0,81 |
| 6,00 | 0,87 |
| 7,00 | 0,92 |
| 8,00 | 0,96 |
| 9,00 | 0,99 |
| ≥10,00 | 1,00 |

Table 26.2.3.1.1.15-2

| δ | $m_3$ |
|---|---|
| ≤0,45 | 1,00 |
| 0,50 | 0,95 |
| 0,55 | 0,86 |
| 0,60 | 0,77 |
| 0,65 | 0,72 |
| 0,70 | 0,69 |
| 0,75 | 0,67 |
| ≥0,80 | 0,66 |

**26.2.3.1.1.16** Rolling amplitude $\theta'_m$, in deg, for the ships with bilge keels and/or bar keel is determined by the following formula:

$$\theta'_m = k\theta_m, \quad (26.2.3.1.1.16)$$

where $\theta_m$ = rolling amplitude for ship without keels determined according to 26.2.3.1.1.12 — 26.2.3.1.1.13;
$k$ = coefficient determined in accordance with Table 26.2.3.1.1.16 depending on parameter $q$ calculated by the formula

$$q = r\alpha\sqrt{B}$$

where $B$ = ship's breadth at the waterline, in m;
α = waterplane coefficient for waterline;
$r$ = coefficient determined according to 26.2.3.1.1.17.

Table 26.2.3.1.1.16

| $q$ | $k$ |
|---|---|
| 0 | 1,00 |
| 1,00 | 0,95 |
| 2,00 | 0,85 |
| 3,00 | 0,77 |
| 4,00 | 0,72 |
| 5,00 | 0,68 |
| 6,00 | 0,65 |
| 7,00 | 0,63 |
| ≥8,00 | 0,62 |

**26.2.3.1.1.17** The coefficient $r$ shall be determined by the following formula:

$$r = (r_1 + r_2)r_3 \quad (26.2.3.1.1.17)$$

where $r_1, r_2, r_3$ = coefficients determined in accordance with 26.2.3.1.1.18.

**26.2.3.1.1.18** The coefficient $r_1$ shall be adopted from Table 26.2.3.1.1.18-1 proceeding from the $100A_k/L_{wl}B$ ratio in which $A_k$ denotes the total area, in m$^2$, of bilge keels or the lateral projected area of the bar keel, or the sum of both areas.

Table 26.2.3.1.1.18-1

| $100A_k/L_{wl}B$ | 0,70 | 1,0 | 1,5 | 2,0 | 2,5 | 3,0 | 3,5 | ≥4,0 |
|---|---|---|---|---|---|---|---|---|
| $r_1$ | 0,14 | 0,24 | 0,44 | 0,68 | 0,94 | 1,20 | 1,48 | 1,66 |

The coefficients $r_2$ and $r_3$ shall be taken from Tables 26.2.3.1.1.18-2 and 26.2.3.1.1.18-3.

Table 26.2.3.1.1.18-2

| $\delta$ | $r_2$ |
|---|---|
| ≤0,45 | 0 |
| 0,50 | 0,06 |
| 0,55 | 0,18 |
| 0,60 | 0,35 |
| 0,65 | 0,51 |
| 0,70 | 0,65 |
| 0,75 | 0,71 |
| 0,80 | 0,68 |
| ≥0,85 | 0,64 |

Table 26.2.3.1.1.18-3

| $B/d$ | $r_3$ |
|---|---|
| ≤2,50 | 1,40 |
| 3,00 | 1,48 |
| 4,00 | 1,58 |
| 5,00 | 1,83 |
| 6,00 | 2,00 |
| 7,00 | 2,13 |
| 8,00 | 2,34 |
| 9,00 | 2,50 |
| ≥10,0 | 2,60 |

**26.2.3.1.2** The righting level curve for ships of the restricted area of navigation **RN(SCI)** shall satisfy the following criteria:

**.1** the righting lever shall be not less than 0,25 m for ships with $L \le 80$ m and 0,20 m for ships with $L \ge 105$ m at an angle of heel greater than 25°. For intermediate values of $L$, the lever value shall be obtained by linear interpolation;

**.2** the angle of vanishing of the righting lever curve $\theta_v$ and the angle of down-flooding $\theta_f$ shall be not less than 50°.

**26.2.3.1.3** For all cargo ships with windage centre of 2 m above the waterline, stability shall be checked as per the following condition

$$M_w < M_{al} \tag{26.2.3.1.3}$$

where $M_w$ = heeling moment due to static effect of wind, in kN·m, determined according to 26.2.3.1.4;
$M_{al}$ = allowable moment, in kN·m, determined according to the static stability curve depending on the value of angle $\theta_{al}$, taken equal to $0{,}8\theta_f$ or open deck edge entrance angle, whichever is less.

**26.2.3.1.4** The heeling moment due to static effect of wind $M_w$, in kN·m, is determined by the following formula:

$$M_w = 0{,}001pA_v(z - a_3d) \tag{26.2.3.1.4}$$

where $p$ = static wind pressure, in Pa, which shall be taken equal to 0,47 of the wind pressure determined according to Table 26.2.3.1.1.3;
$A_v$ = windage area, in m$^2$, determined in accordance with 1.4.6 of Part IV "Stability";
$z$ = height of the centre of windage above the base plane;
$a_3$ = factor determined according to Table 26.2.3.1.4;
$d$ = draught of a ship, in m.

Table 26.2.3.1.4

| $B/d$ | $a_3$ |
|---|---|
| ≤2,50 | 0,73 |
| 3,00 | 0,50 |
| 4,00 | -0,27 |
| 5,00 | -1,27 |
| 6,00 | -2,33 |
| 7,00 | -3,38 |
| 9,00 | -5,40 |
| 8,00 | -4,45 |
| ≥10,00 | -6,00 |

**26.2.3.1.5** For cargo ships where the parameter $P_e/V$ in which $P_e$ is a power, in kW, and $V$ is ship displacement, in m$^3$, exceeds 0,735, the stability on turn shall be checked, i.e. the condition shall be met

$$M_c < M_{al} \tag{26.2.3.1.5}$$

where $M_c$ = heeling moment, in kN·m, applied to a ship at turn determined according to 26.2.3.1.6;
$M_{al}$ = allowable moment, in kN·m, determined according to the static stability curve depending on the angle $\theta_{al}$, taken equal to deck entrance angle or entrance angle of waterline laying 75 mm below the edges of free-flooding openings, whichever is less.

**26.2.3.1.6** The heeling moment applied to a ship on account of turning $M_c$, in kN·m, shall be calculated by the following formula:

$$M_c = 0{,}2\frac{v^2 \cdot \Delta}{L_{wl}}\left(z_g - \frac{a_3 \cdot d}{2}\right) \tag{26.2.3.1.6}$$

where $v_0$ = ship's speed before entering the turn taken equal to 0,8 of full ahead speed on a straight course, in m/s;
$\Delta$ = displacement, in t;
$L_{wl}$ = length of ship on the waterline, in m;
$a_3$ = factor determined according to Table 26.2.3.1.4.

**26.2.3.2** Subdivision.

Definitions and explanations specified in this Section are given in Part V "Subdivision".

**26.2.3.2.1** Forepeak, afterpeak and engine room on all the ships shall be enclosed by watertight bulkheads.

**26.2.3.2.2** For floodability calculations, the dimensions of the side and bottom damages shall be taken according to 26.2.3.2.3 and 26.2.3.2.4. A rectangular parallelepiped is assumed as a form of damage.

**26.2.3.2.3** The dimensions of the hull side damages shall be taken as follows:

**.1** length of damage: 4 % of the ship's length $L$;

**.2** transverse extent measured from the inner surface of the outer plating at right angles to the centre plane: 0,075 $B$ or 0,9 m whichever is less;

**.3** vertical extent: from the base line upwards without limit.

**26.2.3.2.4** The following extent of bottom damage shall be assumed:

**.1** length of damage: 4 % of the ship's length $L$;

**.2** transverse extent: 0,1 $B$;

**.3** vertical extent: from the base plane 0,05 $B$ or 0,8 m whichever is less.

**26.2.3.2.5** When ship's damage of extent less than specified in 26.2.3.2.3 and 26.2.3.2.4, may worsen damage trim and/or damage stability, this variant of damage shall be considered when making checking floodability calculations.

**26.2.3.2.6** If the distance between two adjacent transverse watertight bulkheads is less than the dimensions of the damage specified in 26.2.3.2.3 and 26.2.3.2.4, then the respective compartment shall be added to any of the adjacent compartments at the discretion of the designer during the damage stability check. In this case for all compartments of the hull the damage mid-length shall be assumed at the compartment mid-length. The forepeak and afterpeak shall be considered as separate compartments.

**26.2.3.2.7** In checking floodability calculations the design volume of flooded compartments shall be taken with due consideration of volume permeability coefficient of each room of the compartment which shall be taken for all ships as equal to:

| | |
|---|---|
| double-side and double-bottom compartments, ballast tanks, empty non-refrigerated holds, free under-deck compartments of flush deck ships | 0,98 |
| accommodation and passenger spaces, dry forepeak and afterpeak compartments, spaces occupied by empty vehicles | 0,95 |
| empty refrigerated holds | 0,93 |
| engine rooms of medium and large ships ($L$ > 40 m) | 0,85 |
| engine rooms of small ships ($L$ < 40 m) | 0,80 |
| spaces occupied by general cargoes, ship's stores | 0,60 |
| holds occupied by cargoes in bulk, including coal | 0,55 |
| holds occupied by timber cargo | 0,35 |
| holds occupied by flour or cement in bags | 0,25 |

**26.2.3.2.8** For compartments that include spaces of different purpose, the volume permeability coefficient shall be calculated by the following formula:

$$k_v = k_{vi} V_i / \sum V_i,$$

where $V_i$ = total theoretical volume of separate rooms in the compartment;
$k_{vi}$ = volume permeability coefficient taken with due regard of the purpose of those rooms.

**26.2.3.2.9** The surface permeability coefficients $k_s$ used when calculating the areas, static moments and inertia moments of the lost waterline area in flooded compartment for the purpose of taking into account the cargo, machinery, equipment etc., in way of the damaged waterline, shall generally be adopted equal to volume permeability coefficients in accordance with 26.2.3.2.7. For rooms not occupied by cargo, machinery and equipment in way of the damaged waterline, the surface permeability coefficients shall be adopted equal to the arithmetic mean of unity and the volume permeability coefficient.

**26.2.3.2.10** The requirements of the Rules for floodability of ships shall be considered met, if at flooding the compartments specified in 26.2.3.2.11:

**.1** margin line is not immersed;

**.2** lower edges of free-flooding openings through which overboard water may spread to non-damaged compartments are located before righting above the damage waterline at least:

for passenger ships, crew boats, special purpose ships and non-passenger ships carrying organized groups of people with a length of ≥ 25 m — 0,3 m;

for ships of area of navigation **RN(SCI)** except those specified above, as well as passenger ships, crew boats, special purpose ships and non-passenger ships carrying organized groups of people not more than 12 persons with a length of < 25 m — 0,15 m;

for other ships — 0,075 m.

**.3** heeling angles before and after righting do not exceed the values specified in 26.2.3.2.16 and 26.2.3.2.17;

**.4** damage stability complies with the requirements of 26.2.3.2.18 and 26.2.3.2.19.

**26.2.3.2.11** The requirements for floodability shall be provided at flooding:

**.1** the forepeak and afterpeak individually;

**.2** each compartment individually — for passenger ships and ships carrying organized groups of people and specific personnel more than 12 persons; ice breakers; self-propelled flush deck ships; manned reinforced concrete ships of 25 m in length and over;

**.3** the forepeak and afterpeak individually in one hull or both hulls, for catamarans;

**.4** the forepeak and afterpeak individually in one skeg and in both skegs simultaneously, for skeg type hovercraft;

**.5** each two adjacent compartments adjoining to the board or transom, for all unmanned reinforced concrete ships of 25 m in length and over;

**.6** each compartment individually in the dredge cut area, for bucket dredges.

**26.2.3.2.12** At floodability calculations, flooding of the machinery space shall be taken into account irrespective of the requirement on providing floodability at flooding the machinery space.

**26.2.3.2.13** When designing ships, the damage waterline and damage stability shall be checked by calculations at flooding of each compartment individually with submitting the calculations to the Register. The calculation results shall be stated in the Information on Damage Stability.

**26.2.3.2.14** When checking the ship's floodability at flooding the compartments, the parameters of damage trim and stability shall be determined by constant displacement method.

**26.2.3.2.15** For passenger ships, damage stability shall be checked on the assumption that all the passengers are crowding on the uppermost decks they are permitted to be. The distribution of passengers shall be assumed according to 3.1.6 — 3.1.8 of Part IV "Stability".

**26.2.3.2.16** In the final stage of unsymmetrical flooding before the righting measures, the heeling angle shall not exceed:

for passenger ships 15°;
for non-passenger ships 20°.

**26.2.3.2.17** For unsymmetrical flooding after the righting measures, the heeling angle shall not exceed:

for passenger ships 7°;
for non-passenger ships 12°.

**26.2.3.2.18** Transverse metacentric height determined by the constant displacement method shall be at least 0,05 m in the final stage of flooding for stable equilibrium state at symmetrical flooding and for non-inclined position at unsymmetrical flooding, before appropriate measures to increase the metacentric height are taken.

**26.2.3.2.19** The static stability curve of a damaged ship shall have a sufficient positive lever arm section. In the final stage of flooding and after righting, for all the ships other than non-self-propelled flush deck ships, the following shall be provided:

**.1** the maximum lever arm of the static stability curve of not less than 0,1 m;

**.2** the length of the positive arm section of the damage stability curve to the angle of down-flooding is at least 30° at symmetrical flooding and at least 20° at unsymmetrical flooding.

For non-self-propelled flush deck ships, these norms are recommended.

**26.2.3.2.20** Calculations to conform compliance with the requirements for damage trim and stability shall be performed for such a number of loading conditions to be encountered in service and being the most unfavourable from the point of view of trim and stability, that, proceeding from those calculations, one could assure that in all other cases the damaged ship would be in a better condition as regards damage trim and stability established by these Rules. Besides, the following shall be considered: the actual configuration of damaged compartments, type of covers, whether longitudinal bulkheads and partitions are provided sufficiently watertight as to render the flow of water through the ship completely or temporarily impossible.

**26.2.3.3** Freeboard and load line.

**26.2.3.3.1** Freeboard height for ships with sheer taken according to Table 26.2.3.3.10 and coaming heights taken according to Table 26.2.2.6.1 shall be set according to Tables 26.2.3.3.1-1 and 26.2.3.3.1-2.

In this case the tabular values are increased by 1/48 of the respective draught in fresh water.

Table 26.2.3.3.1-1

**Tabular freeboard height for self-propelled and non-self-propelled ships except for tankers and flush deck ships**

| Ship length, in m | Freeboard height $H_{fb}$, in mm | |
|---|---|---|
| | **RN(SCII)** | **RN(SCI)** |
| ≤30 | 85 | 140 |
| 40 | 100 | 160 |
| 50 | 115 | 180 |
| 60 | 130 | 200 |
| 70 | 150 | 235 |
| 80 | 170 | 270 |
| 90 | 190 | 305 |
| 100 | 210 | 340 |
| 110 | 230 | 375 |
| 120 | 260 | 410 |
| ≥130 | 290 | 450 |

Table 26.2.3.3.1-2

**Tabular freeboard height for tankers and flush deck ships**

| Ship length, in m | Freeboard height $H_{fb}$, in mm | |
|---|---|---|
| | **RN(SCII)** | **RN(SCI)** |
| ≤30 | 60 | 110 |
| 40 | 70 | 125 |
| 50 | 80 | 140 |
| 60 | 90 | 155 |
| 70 | 100 | 170 |

| | | |
|---|---|---|
| 80 | 120 | 200 |
| 90 | 140 | 230 |
| 100 | 160 | 260 |
| 110 | 180 | 290 |
| 120 | 200 | 325 |
| ≥130 | 220 | 360 |

**26.2.3.3.2** Minimum freeboard is determined by increasing the tabular freeboard determined according to 26.2.3.3.1 by the following corrections in accordance with the maximum values specified in 26.2.3.3.3.

**26.2.3.3.3** The freeboard height as obtained from Tables 26.2.3.3.1-1 and 26.2.3.3.1-2, shall be corrected as follows:

**.1** for the ships with the $B/T$ < 4,5, the tabular freeboard height, in mm, shall be increased by the correction value calculated by the following formula:

$$\Delta H_{B/T} = 0{,}49L(4{,}5 - B/T); \qquad (26.2.3.3.3.1)$$

**.2** for the ships with block coefficient δ > 0,75, the tabular freeboard height, in mm, shall be increased by the correction value calculated by the following formula:

$$\Delta H_{\delta} = (18{,}2L + 17(4{,}5 - \frac{B}{T})) \cdot (\delta - 0{,}75). \qquad (26.2.3.3.3.2)$$

If $B/T$ ≥ 4,5, in the formula (26.2.3.3.3.2) the $B/T$ ratio shall be taken equal to 4,5;

**.3** for the ships with the length to breadth ratio $L/B$ < 5,5, the tabular freeboard height, in mm, shall be increased by the correction value calculated by the following formula:

$$\Delta H_{L/B} = 2{,}71L(5{,}5 - \frac{L}{B}) \qquad (26.2.3.3.3.3)$$

**26.2.3.3.4** If the sheer or dimensions of the forecastle and poop are different from the values specified in 26.2.3.3.10 and 26.2.3.3.11, the freeboard height shall be increased by a value that provides compliance with two following conditions:

**.1** buoyancy reserve shall be not less than that determined for the ships with sheer specified according to 26.2.3.3.10 or with forecastle and poop;

**.2** static moments of volumes, which result from the extended freeboard height relative to the midship plane, shall be not less than static moments of volumes for the ships with sheer determined according to 26.2.3.3.10 or with forecastle and poop.

**26.2.3.3.5** If the coaming height is less than that specified in the requirements in 26.2.2, the minimum freeboard height shall be increased by the difference between the tabular and the actual coaming heights.

The minimum height of coaming of hatches located on the open decks shall be at least 100 mm.

Decrease of the freeboard height as compared with the value stated in 26.2.3.3.2 due to the increase of the coaming height is not allowed.

The coaming's heights of other hatches may be less than tabular heights without correction of the freeboard height, if the hatch covers comply with the requirements in 26.2.2.

**26.2.3.3.6** The cargo platform guard of the flush deck ship shall be designed to prevent washing of the bulk cargo. The sum of the guard height and the freeboard height shall be at least one half of the wave height corresponding to the basin category where the ship operates.

**26.2.3.3.7** For dredgers the freeboard height shall be determined in a similar manner as for the closed ships.

**26.2.3.3.8** For the cargo ships loaded by hydromechanization means, the freeboard height shall be calculated in a similar manner as for the tankers. While substantiating the possibility of transporting other types of cargo on these ships the freeboard height shall be assigned as for the open ships.

**26.2.3.3.9** On ships of area of navigation **RN(SCI)**, with the freeboard height to the forecastle deck in the fore perpendicular area (and in absence of the forecastle, to the freeboard deck) less than the sum of the minimum freeboard height amidships and sheer, the ordinate values of which are specified in this Section, it is recommended to fit the bulwark in the bow.

**26.2.3.3.10** The sheer line of ships without forecastle and poop shall be taken as a broken line with ordinates on fore and aft perpendiculars taken according to Table 26.2.3.3.10, and ordinates at points located 0,15 of the ship's length apart from the fore perpendicular and 0,07 of the ship's length apart from the aft perpendicular being equal to 0.

The sheer ordinates shall be measured from a horizontal line coinciding with the upper edge of the deck line.

Table 26.2.3.3.10

**Sheer ordinate values**

| Ship length, in m | Sheer ordinates, in mm | | | |
|---|---|---|---|---|
| | **RN(SCI)** | | **RN(SCII)** | |
| | Bow | Stern | Bow | Stern |
| ≤30 | 1000 | 500 | 550 | 275 |
| 40 | 1000 | 500 | 600 | 300 |
| 60 | 1000 | 500 | 700 | 350 |
| 80 | 1000 | 500 | 800 | 400 |
| 100 | 1100 | 550 | 900 | 475 |
| 120 | 1200 | 600 | 1050 | 525 |
| 130 | 1300 | 650 | 1100 | 550 |

Note. Sheer ordinates for the tankers are taken according to this Table with lowering the area of navigation, i.e. for the ships of area of navigation **RN(SCI)** ordinates of the ships of area of navigation **RN(SCII)** are taken.

**26.2.3.3.11** The sheer specified in 26.2.3.3.10 is not required, if the following conditions are met:

**.1** the forecastle height above the deck shall be at least: for the ships of area of navigation **RN(SCI)** — 1000 mm, for the ships of area of navigation **RN(SCII)** — 900 mm;

**.2** the forecastle length not less than 0,07 of the ship's length;

**.3** the poop height above the deck not less than one half of the forecastle height;

**.4** the poop length not less than 0,03 of the ship's length but not less than 2 m.

The ships of area of navigation **RN(SCI)** with sheer without forecastle, a bulwark with a length equal to the length of the forecastle determined according to 26.2.3.3.11.2 shall be fitted in the forward end.

Ships without sheer and poop at stern shall be fitted with a bulwark of the same length, but not less than 2 m.

**26.2.3.3.12** Load line mark and marks applied together with the load line mark for ships with the assigned freeboard (minimum and greater than minimum) shall be marked in accordance with 2.1.2 and 2.1.3 of the Load Line Rules for Sea-Going Ships.

**26.2.3.3.13** Outlet openings of piping when located in sides below the freeboard deck shall be arranged according to the requirements of 26.2.6.

**26.2.3.3.14** Covers on sea chests and ice boxes shall be watertight.

The upper edge of openings of the specified items shall be above the maximum draught line not less than by 150 mm.

**26.2.3.3.15** All openings in the freeboard deck on oil tankers and flush deck ships shall be fitted with strong watertight covers.

**26.2.4 Fire protection.**

**26.2.4.1** The ships of areas of navigation **RN(SCI)** and **RN(SCII)** shall meet the requirements of Part VI "Fire Protection".

**26.2.5 Machinery Installations.**

**26.2.5.1** General.

The requirements of this Section apply to ship's machinery installations, equipment of machinery spaces, shafting lines, propellers, machinery condition monitoring systems, spare parts and active means of the ship's steering in accordance with the requirements of Part VII "Machinery Installations", including requirements applicable to river-sea navigation ships, in so much as applicable and sufficient, unless provided otherwise.

**26.2.5.2** Applied fuel.

On the specified ships the following types of fuel may be used:

**.1** liquid fuel with closed-cup vapour flash point not less than 60 °C;

**.2** liquid fuel with closed-cup vapour flash point not less than 40 °C — in order to provide operation of generator driving motors, being part of emergency power supply sources, as well as to provide operation of main and auxiliary engines and boilers of different purposes installed on ships the operation of which is allowed in restricted areas with climate conditions under which the temperature in the spaces where the fuel is stored and used is at least 10 °C lower that the vapour flash point. In such cases measures shall be taken to provide temperature monitoring and control in the above spaces;

**.3** gasoline to provide operation of main engines (inboard and outboard) of small craft and rescue boats, as well as for portable fire and bilge pumps for all ships except for oil tankers and ships carrying flammable products.

**26.2.5.3** Control devices and stations. Means of communication.

Control devices and stations and means of communication shall comply with the requirements of Section 3 in Part VII "Machinery Installations" except for 3.3.1 on obligatory installation of engine-room telegraph for communication between the navigation bridge and the position in the machinery space or in the control room, from which the speed and direction of thrust of the propellers are normally controlled (for ships having the automation mark in the class notation and length less than 25 m).

**26.2.5.4** Machinery spaces, arrangement of machinery and equipment.

Machinery spaces, as well as arrangement of machinery and equipment shall comply with the requirements of Section 4 in Part VII "Machinery Installations", and in this case:

**.1** main and auxiliary engines, units and equipment shall be so arranged as to provide passageways from the control stations and servicing flats to the means of escape from the machinery spaces. The width of passageway shall be not less than 600 mm over the whole length. The width of passageway may be reduced locally to 500 mm;

**.2** in hydrofoil craft, hovercraft and displacement ships of a length less than 25 m, the width of passageways shall be at least 400 mm;

**.3** each machinery space, shafting tunnels and each space where main switchboards are installed (for example, main machinery control room) shall be provided with at least two means of escape, one of which may lead to the adjacent space which has an independent escape route. One of the escapes shall lead directly to the open deck. The means of escape shall be as widely separated as possible. Ladder trunks, where vertical ladders for escape routes are arranged, shall have clear dimensions not less than 600 × 600 mm;

**.4** if two adjacent machinery spaces communicate through doors and each of them has only one means of escape to the open deck, these means of escape shall be located at the opposite sides;

**.5** cargo pump rooms in oil tankers shall have at least one means of escape leading directly to the open deck;

**.6** the second means of escape may be omitted:

from machinery spaces with an area not exceeding 25 $m^2$, where the existing escape route does not lead to the adjacent machinery or accommodation space;

in ships of less than 25 m in length;

from auxiliary spaces without risk of fire and being enclosed inside the machinery space which has two means of escape;

from enclosed central control stations where main switchboards are not located;

from spaces containing no fuel oil fired engines or incinerators.

**26.2.6 Systems and piping.**

**26.2.6.1** For ships having distinguishing marks **RN(SCI)** and **RN(SCII)** in the class notation the requirements of Part VIII "Systems and Piping" shall apply to the extent applicable for ships of the restricted area of navigation **R3**.

**26.2.6.2** The requirements in 7.1.2 — 7.1.5 of Part VIII "Systems and Piping" for the ships of areas of navigation **RN(SCI)** and **RN(SCII)** shall not apply. The bilge system of passenger ships having distinguishing marks **RN(SCI)** and **RN(SCII)** in the class notation shall be provided with at least 3 bilge pumps.

**26.2.6.3** The requirements in 8.7 of Part VIII "Systems and Piping" shall not apply to the ships of areas of navigation **RN(SCI)** and **RN(SCII)**, if they are not engaged on the international voyages.

**26.2.6.4** The requirements in 12.2.4 of Part VIII "Systems and Piping" may be waived as regards the installation of fixed fire extinguishing systems in the galley ventilation duct for ships of areas of navigation **RN(SCI)** and **RN(SCII)**, if they are not engaged on international voyages.

**26.2.6.5** A standby fuel pump required by 13.1.1 of Part VIII "Systems and Piping" may be replaced by a hand pump for ships of areas of navigation **RN(SCI)** and **RN(SCII)**.

**26.2.6.6** The requirements in 13.3.5.1 and 13.3.5.3 of Part VIII "Systems and Piping" shall not apply to the ships of areas of navigation **RN(SCI)** and **RN(SCII)**.

**26.2.7 Machinery.**

**26.2.7.1** Internal combustion engines.

**26.2.7.1.1** The internal combustion engines shall comply with the requirements of Section 2 in Part IX "Machinery".

**26.2.7.1.2** If calculation of the crankshaft is performed according to the procedure other than that specified in 2.4 of Part IX "Machinery", the safety factors shall not be less than required by 2.4.

**26.2.7.1.3** Gasoline engines and engines operating on different grades of fuels may be installed in compliance with the requirements of 26.2.7.1.4 and 26.2.7.1.5.

**26.2.7.1.4** Gasoline engines.

**26.2.7.1.4.1** Gasoline engines may be used:

as main and auxiliary engines on ships of 20 m in length and less, except for oil tankers and ships carrying dangerous cargoes;

as main engines on rescue boats provided the fuel tanks are protected against fire and explosion;

as drive engines for mobile fire and bilge pumps on all ships except for oil tankers and ships carrying dangerous goods.

**26.2.7.1.4.2** Engines in open ships shall be covered by protective housings. Protective housings made of inflammable materials shall have lining from the inside made of steel roofing on the layer of mineral insulating material.

In enclosed ships all wooden parts in the machinery space shall have sheeting made of steel roofing on the layer of mineral insulating material.

**26.2.7.1.4.3** Watertight floors shall be installed in front of the engine and beyond it. Hand pump or motor-driven pump drainage shall be provided in the places of engine installation in enclosed machinery spaces separated by floors as well as in spaces where oil tanks are situated.

**26.2.7.1.4.4** Carburettor and engine fuel pumps shall be installed so as to avoid flame ingress from carburettor on fuel pump.

**26.2.7.1.4.5** Suction pipes of carburettors shall be led outside the removable housings and be raised over it for at least 500 mm. Suction pipes on the ends shall be fitted with heads with flame arresters.

**26.2.7.1.4.6** Carburettor suction pipe inlet shall be located not less than 300 mm above the cylinder heads and provided with flame screens, where engines are installed in enclosed spaces. If there are no suction pipes, flame arresters shall be mounted at carburettor air inlet.

**26.2.7.1.4.7** A gasoline tank shall be installed in a compartment (enclosure) isolated from the internal combustion engine compartment in ships with continuous deck. These compartments (enclosures) shall be equipped with natural ventilation for gasoline vapour removal.

**26.2.7.1.4.8** Protective housings of the engines, machinery spaces, compartments with fuel tanks shall have plenum-exhaust ventilation.

Ventilation tubes of these compartments shall not be connected with each other.

Ventilation tubes from the engine housings and tubes removing gas from the fuel tanks shall be equipped with flame arresters.

**26.2.7.1.4.9** Air pipes from the gasoline tank and from the compartment shall be separate, their outlet holes shall be apart from each other as far as possible and shall be fitted with ejecting heads with flame arresters.

**26.2.7.1.4.10** Closed motor spaces shall have ventilation which provides removal of accumulated gasoline vapours before the engine start.

**26.2.7.1.4.11** Fuel tanks and oil pipelines shall be made of metal resistant to corrosion caused by influence of fuel environment.

**26.2.7.1.4.12** For the purpose of fuel tank filling fill-in branch pipes shall be led out to the deck, which shall prevent the fuel ingress inside the hull.

**26.2.7.1.4.13** No tubular glass fuel level indicators shall be installed on fuel tanks.

**26.2.7.1.4.14** Electric indicator of gasoline level in the tank shall be of explosion-proof type.

**26.2.7.1.4.15** It is not allowed to provide devices for sediment discharge in the fuel tanks. When such device is used, self-locking valves shall be additionally provided with thread plug on the outlet end and a drip tray shall be placed under the tank.

**26.2.7.1.4.16** A locking device shall be installed on the fuel pipeline directly before the engine which shall allow locking the pipeline from the ship control station.

Fuel pipelines shall be protected against mechanical damage and be located so as they can be inspected throughout the length. The pipes shall be connected by hard-brazed nipples with coupling nuts.

**26.2.7.1.4.17** Gasoline pipeline joints shall be free of gaskets. The gasoline pipeline shall be mounted in easily accessible places and protected against damage.

For installation of engines on shock absorbers it is allowed to use gasoline pipeline flexible joints made of gasoline-proof and fire-proof materials.

**26.2.7.1.4.18** All units of the fuel system shall be placed on the opposite side relatively to the exhaust manifold.

**26.2.7.1.4.19** In the motor spaces, accumulators shall be installed only in a closed box on the side opposite to the carburettor or fuel injecting equipment. Exhaust ventilation shall be provided.

Accumulators shall not be located under the fuel tanks.

**26.2.7.1.4.20** Exhaust manifold and connecting branch pipes shall have water cooling.

**26.2.7.1.5** Additional requirements for engines which are permitted to operate on different grades of fuels.

**26.2.7.1.5.1** For dual-fuel internal combustion engines the requirements in Section 9 of Part VII "Machinery Installations" shall apply.

**26.2.7.1.5.2** The engines can operate on fuel oil meeting the requirements of 26.2.5.2 which substitutes for the corresponding types of the specification fuel listed in the technical documentation of the manufacturer or is produced (extracted) by means of non-conventional sources and types of primary energy (alternative fuel), or is a mixture of alternative and specification fuel with properties differing from the specification fuel, provided the engine characteristics during operation on this fuel in all operating conditions, including variable conditions, which do not differ from the certificate ones.

**26.2.7.1.5.3** A possibility to switch promptly to the specification fuel oil for fuel fired engines as specified in 26.2.7.1.5.1 shall be provided. In the process of such transfer the engine output shall not drop by more than 20%.

**26.2.7.1.5.4** When the fuel specified in 26.2.7.1.5.1 is used in the engine, the safety valves shall be fitted in the crankcases and the under-piston cavities of the engine near each crankthrow. The design and actuation pressure of safety valves depend on the properties of fuel-air mixture produced in the crankcase and on the engine output at the moment of transfer from one grade of fuel to another one.

**26.2.7.1.5.5** When the fuel specified in 26.2.7.1.5.1 with saturated vapours pressure exceeding 25 kPa at 40 °C is used, the devices (sensors or other similar devices) measuring concentration of vapours of the specified fuel flowing through the sealings shall be fitted in the crankcases and under-piston cavities.

**26.2.7.2** Steam turbines.

Steam turbines shall comply with the requirements in Section 3 of Part IX "Machinery".

**26.2.7.3** Gears, disengaging and elastic couplings.

Gears, disengaging and elastic couplings shall comply with the requirements in Section 4 of Part IX "Machinery".

**26.2.7.4** Auxiliary machinery.

Auxiliary machinery shall comply with the requirements in Section 5 of Part IX "Machinery".

**26.2.7.5** Deck machinery.

Deck machinery shall comply with the requirements in Section 6 of Part IX "Machinery".

**26.2.7.6** Hydraulic drives.

Hydraulic drives shall comply with the requirements in Section 7 of Part IX "Machinery".

**26.2.7.7** Gas turbines.

Gas turbines shall comply with the requirements in Section 8 of Part IX "Machinery".

**26.2.8 Boilers, heat exchangers and pressure vessels.**

**26.2.8.1** All requirements of Part X "Boilers, Heat Exchangers and Pressure Vessels" to the extent applicable for ships of the area of navigation **R3** shall apply to the ships of areas of navigation **RN(SCI)** and **RN(SCII)**.

**26.2.9 Refrigerating plants.**

**26.2.9.1** All requirements of Part XII "Refrigerating Plants" to the extent applicable for ships of the area of navigation **R3** shall apply to the ships of areas of navigation **RN(SCI)** and **RN(SCII)**.

**26.2.10 Electrical equipment.**

**26.2.10.1** The electrical equipment on ships shall comply with the requirements specified in Sections 1 and 2 of Part XI "Electrical Equipment". In this case for machinery and devices on ships, except for machinery and devices of essential services, it is allowed to use the electrical equipment (of general commercial type) not fully complying with the requirements in 2.1.3.1 of Part XI "Electrical Equipment".

**26.2.10.2** The main source of electrical power shall comply with the requirements in Section 3 of Part XI "Electrical Equipment". In this case on ships (except for passenger ships) with a low power electrical installation as the main source of electrical power, only one generator with an independent prime mover or accumulator batteries may be installed and for ships (except for passenger ones) of less than 300 gross tonnage with a low power electrical installation, only one transformer may be installed.

**26.2.10.3** Electrical power distribution systems shall comply with the requirements in Section 4 of Part XI "Electrical Equipment". The supply feeder of anchor gear may be connected to the distribution board of cargo winches or to another distribution board provided the boards are supplied directly from the main distribution board and adequate protection is available.

**26.2.10.4** Electric drives for shipboard mechanisms and equipment, lighting, internal communication and signalling, protective devices shall comply with the requirements in Sections 5, 6, 7 and 8 respectively of Part XI "Electrical Equipment".

**26.2.10.5** Emergency electrical installations shall comply with the requirements in Section 9 of Part XI "Electrical Equipment". Emergency sources in ships of 300 gross tonnage and above shall ensure the supply of the consumers specified in 9.3.1 of Part XI "Electrical Equipment" during at least 12 hours and in ships of less than 300 gross tonnage, during at least 3 hours.

**26.2.10.6** Electrical machines, transformers, power semiconductor units shall comply with the requirements in Sections 10, 11 and 12 respectively of Part XI "Electrical Equipment".

**26.2.10.7** Accumulators.

**26.2.10.7.1** Accumulators shall comply with the requirements in 13.1 — 13.6, 13.7.2 and 13.7.3.1 of Part XI "Electrical Equipment".

**26.2.10.7.2** In a ship equipped with electrically-started internal combustion engines, irrespective of the number of such engines, not less than one starter battery shall be permanently installed for starting each of the main and auxiliary engines. A starter battery shall be charged only from the appurtenant generator.

**26.2.10.8** Electrical apparatus and accessories, electrical cooking and heating appliances, cables and wires, electric propulsion plants shall comply with the requirements in Sections 14, 15, 16 and 17 respectively of Part XI "Electrical Equipment".

**26.2.10.9** Electrical equipment for a voltage in excess of 1000 V up to 15 kV shall comply with the requirements in Section 18 of Part XI "Electrical Equipment".

**26.2.10.10** Electrical equipment depending on the purpose of a ship shall comply with the requirements of respective Chapters in Section 20 of Part XI "Electrical Equipment". In this case, on passenger ships the emergency sources shall ensure simultaneous supply of the consumers specified in 20.1.2.1 of Part XI "Electrical Equipment" during at least 12 hours.

**26.2.10.11** Electrical equipment of refrigerating plants shall comply with the requirements in Section 21 of Part XI "Electrical Equipment".

**26.2.10.12** Spare parts shall comply with the requirements in Section 22 of Part XI "Electrical Equipment".

**26.2.10.13** Electrical equipment of ship's electric power system with electrical distribution for direct current shall comply with the requirements in Section 23 of Part XI "Electrical Equipment".

**26.2.10.14** Valve-type generator sets, composite (hybrid) propulsive systems, static sources of electrical power shall comply with the requirements in Sections 24, 25 and 26 respectively of Part XI "Electrical Equipment".

**26.2.11 Automation.**

**26.2.11.1** Automation equipment of ships of areas of navigation **RN(SCI)** and **RN(SCII)** as regards the general provisions, design of automation systems, automation components and control devices, as well as supply of automation systems shall comply with the applicable requirements in Sections 1 — 3, 7 — 9 of Part XV "Automation".

**26.2.12 Life-saving appliances.**

**26.2.12.1** Outfit of ships of classes **RN(SCI)** and **RN(SCII)** shall comply with the requirements of Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships as for ships of the area of navigation **R3**.

**26.2.13 Radio equipment.**

**26.2.13.1** Radio equipment of ships of areas or navigation **RN(SCI)** and **RN(SCII)** shall comply with the applicable requirements of Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships.

**26.2.13.2** Each ship engaged in voyages on inland waterways of the Russian Federation, in addition to the requirements of 26.2.13.1, shall be equipped with:

**.1** main VHF radiotelephone station (300,025 MHz — 300,500 MHz);

**.2** operational VHF radiotelephone station (300,025 — 300,500 MHz; 336,025 — 336,500 MHz). It is required for passenger ships, ships having the length of 25 m and above, ships with the main engines output of 367 kW and above;

**.3** portable VHF radiotelephone station (300,025 to 300,225 MHz) — 2 sets;

**.4** public address system.

The type of the VHF radiotelephone station shall be determined by the shipowner based on the system of communications established in the ship's operational area.

**26.2.14 Navigational equipment.**

**26.2.14.1** Navigational equipment for ships of areas of navigation **RN(SCI)** and **RN(SCII)** shall comply with the applicable requirements of Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships.

**26.2.14.2** An additional radar station meeting the following requirements shall be provided on ships engaged in voyages on inland waterways of the Russian Federation.

**26.2.14.2.1** The display unit of the radar installed on board ship with the aerial height above sea level being equal to 10 m shall be capable of giving clear presentation of various objects within the ranges (in kilometres) given below:

| Object | Dimension | Range, in km |
|---|---|---|
| Shore of height | 60 m | 32 |
| | 6 m | 13 |
| Ship of gross tonnage | 5000 | 13 |
| | 20 | 4 |
| Buoy with reflecting surface of | 10 $m^2$ | 4 |

The display of all objects shall remain visible when the ship is rolling or pitching up to ±10°.

**26.2.14.2.2** Basic performance parameters of the shipboard radar with the aerial height of 7 m above sea level shall not be worse than those specified in Table 26.2.14.2.2.

Table 26.2.14.2.2

| Basic performance parameters | Value |
|---|---|
| Minimum radar detection range, in m | 15 |
| Range resolution on dials 0,4 to 1,2 km, in m | 15 |
| Range resolution on the rest dials in relation to the maximum value of the range dial established, in % | 1 |
| Accuracy in range measuring, in m | 10 |
| Bearing resolution, in deg | 1,0 |
| Accuracy in measuring bearings, in deg | 1,0 |
| Accuracy in course indication, in deg | 0,5 |

The equipment performance shall not deteriorate when the ship is rolling and pitching up to ±10.

**26.2.14.2.3** The display shall have an effective diameter of at least:

180 mm for ships from 300 to 1600 gross tonnage;

250 mm for ships from 1600 gross tonnage and over.

The display unit of the radar shall be provided with six range scales from 400 m to 5000 m. In this regard there shall be indicated not less than four fixed electronic range rings and a variable electronic marker range with a numeric read-out of range in meters (kilometres) on each range scale.

The variable electronic marker range shall enable the range of an object to be measured with an error not more than 10 m on range scales of 0,4 to 2,0 km and 0,8 % of the range of the following scale established.

**26.2.14.2.4** It shall be possible that brightness of the fixed electronic range rings and a variable electronic marker be varied until they are fully removed from the display.

**26.2.14.2.5** The display unit of the radar shall be fitted with the electronic or mechanical device for taking bearings of the detected objects.

**26.2.14.2.6** In radar, provision shall be made for clockwise, continuous and automatic scan through 360° of azimuth. The scan rate shall be not less than 18 r.p.m. The aerial shall operate satisfactorily in relative wind speeds up to 50 m/s.

**26.2.14.2.7** It shall be possible to off-set the radar origin to any display point for a distance of at least 0,5 of the display radius.

**26.2.14.2.8** The radar display provided with two sets of range scales, in meters (kilometres) and miles, shall have the means of switching-over and the relevant indication of a measurement unit chosen for range measuring.

**26.2.14.3** An additional radar station is not required if ships are equipped with a radar station which fully meets the requirements of 26.2.14.2 and all applicable requirements of Appendix 1 to Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships.

**26.2.15 Signal means.**

**26.2.15.1** Outfit of ships of classes **RN(SCI)** and **RN(SCII)** shall comply with the requirements of Part III "Signal Means" of the Rules for the Equipment of Sea-Going Ships, including requirements applicable to river-sea navigation ships.

## 27 REQUIREMENTS FOR TANKERS EQUIPPED WITH AN EFFECTIVE CARGO TANK WASHING SYSTEM

**27.1 General provisions and application.**

**27.1.1** The tankers with descriptive notation **Chemical tanker** and/or **Oil tanker**, and combination carriers (**Oil/bulk/ore carrier** or **Oil/bulk carrier** or **Oil/ore carrier**) equipped with an effective cargo tank washing system that meets the requirements set out in 9.12 of Part VIII "Systems and Piping" and the requirements of this Section, may be assigned the distinguishing mark **ETW** (Effective Tank Washing).

**27.2 Definitions and explanations.**

Shadow area means the surface of a cargo tank which cannot be effectively treated by permanently installed washing machines of the cargo tank washing system.

**27.3 Technical requirements.**

**27.3.1** An effective cargo tank washing system shall meet the following requirements:

**.1** cargo tank washing heater shall continuously provide a minimum system temperature of 85 °C with the system capacity sufficient for washing the largest cargo tank. The heater capacity shall be based on a seawater temperature of 0 °C;

**.2** permanently installed washing machines shall give the minimum coverage of 96 % of the surface of each cargo tank. The shadow area shall be no more than 4 % of the surface of the cargo tank. When calculating the shadow areas, 70 % of the permanently installed washing machine jet length at normal operating pressure shall be taken into account. Shadow areas shall include any areas not directly exposed to the jets from the washing machines or exposed at an angle of less than 10°. Cargo and stripping pipelines and pumps located in the cargo tank as well as any pipes passing through the tanks shall be taken into account when determining shadow areas. Heating coils, ladders, ladder platforms of grating type, handrails shall not be taken into account when calculating the shadow areas;

**.3** portable washing machines enabling washing of cargo tanks in shadow areas and necessary openings, equipment and instructions for washing any parts of shadow areas using portable washing machines shall be provided. The use of portable washing machines for tanks cleaning shall be carried out without need for cargo tank entry;

**.4** cargo tank washing system shall have detailed operating instructions for personnel.

**27.3.2** The design of cargo tanks shall meet the following requirements:

**.1** cargo tanks shall be designed with smooth inner surfaces and shall be equipped with bilge wells for effective stripping;

**.2** horizontal surfaces (other than the tank upper deck), stiffeners and brackets where cargo residue may accumulate are not acceptable or such structures shall be arranged for self-drainage under normal conditions of trim and heel (including aft trim). Any shadow area created by such structures shall be included in the shadow area calculations and shall be taken into account when developing procedures for washing using portable machines without tank entry;

**.3** bulkheads may be corrugated but the horizontal corrugations shall not have an angle in excess of 65° related to the vertical plane.

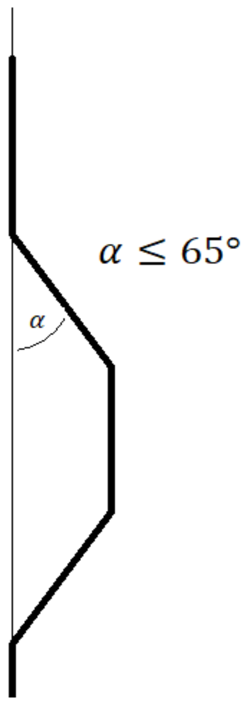



Fig. 27.3.2.3

**27.4 Technical documentation.**

The following technical documentation (A — stamped as "Approved", AG — stamped as "Agreed", FI — stamped as "For information") shall be submitted to the Register for review as part of the technical design or plan approval documentation:

**.1** cargo tanks arrangement and capacity diagram with indication of distance from the side and bottom shell to the tanks, including information on the materials used and coverings (A);

**.2** effective cargo tank washing system diagram with indication of technical and operational characteristics of the system equipment (A);

**.3** shadow diagrams of the washing system for each cargo tank (may be included in the system diagram) (A);

**.4** cargo system diagram (A);

**.5** manual on operation of effective cargo tank washing system for the crew (AG);

**.6** technical characteristics of permanently installed and portable washing machines (FI).

## 28 ADDITIONAL REQUIREMENTS FOR SHIPS WITH DISTINGUISHING MARK OMBO IN THE CLASS NOTATION

**28.1 Application.**
The requirements of this Section apply to ships with distinguishing mark **OMBO** in the class notation irrespective of gross tonnage and ship purpose.
A ship with distinguishing mark **OMBO** is a ship equipped to enable one man bridge operation under normal conditions.
Normal conditions for ships with distinguishing mark **OMBO** mean a situation when all systems and equipment on the navigation bridge operate within design limits, and environmental conditions and traffic do not cause excessive workload to the officer of the watch.
**28.2 Requirements for navigation bridge of ships with distinguishing mark OMBO.**
**28.2.1** Design of the navigation bridge shall comply with the requirements in 3.2 of Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships.
**28.2.2** Navigation bridge visibility shall comply with the requirements in 3.2.3 — 3.2.14 of Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships.
**28.2.3** The main conning position of the ship shall be arranged in a way to enable the ship's control and manoeuvring, and a proper lookout by one person under normal operating conditions.
**28.3 Equipment of a ship with distinguishing mark OMBO.**
**28.3.1** The navigational equipment of a ship with distinguishing mark **OMBO** shall comprise the following equipment:
**.1** two radars; one of them shall operate within X-band (3 cm);
**.2** automatic radar plotting aids (ARPA);
**.3** heading or track control system;
**.4** two independent receivers of the electronic position fixing systems operating in ship's service area;
**.5** electronic chart display and information system (ECDIS);
**.6** voyage data recorder (VDR);
.7 automatic identification system (AIS);
**.8** sound reception system;
**.9** magnetic compass;
**.10** gyrocompass;
**.11** log;
**.12** echo sounder;
and on the navigation bridge:
**.13** propulsion plant remote control system;
.14 whistle control device;
**.15** window wipe and wash control device;
**.16** main workstation console lighting control device;
**.17** steering gear pump selector/control switches;
**.18** internal communication system;
**.19** radio equipment in accordance with area of navigation;
**.20** wheelhouse heating/cooling control system;
**.21** weather station display unit showing, as a minimum, wind direction and speed;
**.22** bridge navigational watch alarm system (BNWAS) with a function of urgent calling the back-up officer and/or ship's master.
**28.3.2** Where equipment is interconnected through a computer network, failure of this network shall not prevent individual equipment from performing their functions.

**28.3.3** The alarm/warning and communication system (AWCS) shall be provided on the navigation bridge of the ships with distinguishing mark **OMBO** which generates audible and visual alarms in the following cases:

**.1** the ship's approach to the pre-set minimum depth under a keel;

**.2** detection of a dangerous target;

**.3** deviation from a pre-set course and/or track;

**.4** an approach to the next waypoint (when following a pre-set track);

**.5** a gyrocompass malfunction;

**.6** a sharp drop below a permissible level or failure of power supply for navigational equipment;

**.7** a malfunction of the bridge navigational watch alarm system;

**.8** failure of navigation lights.

The device to acknowledge AWCS signals shall be easily accessible from the workstation for navigating and manoeuvring.

Any AWCS signal shall be automatically transferred to the master, back-up officer and to the public rooms, if not acknowledged on the bridge by the watch officer within 30 s. The alarm/warning transfer shall be operated through a fixed system. The acknowledging of alarms/warnings shall only be possible from the bridge.

Under all operational conditions a watch officer shall have a possibility to call the master and back-up officer to the bridge.

**28.3.4** The navigation bridge of the ship with distinguishing mark **OMBO** shall have priority in the service telephone communication system.

# 29 REQUIREMENTS FOR CONTAINER SHIPS AND OTHER SHIPS OF 500 GROSS TONNAGE AND OVER DESIGNED FOR CARRIAGE OF CONTAINERS AND FITTED WITH ADDITIONAL FIRE-FIGHTING MEANS

## 29.1 GENERAL

**29.1.1 Application.**

**29.1.1.1** The requirements of this Section apply to ships whose special equipment ensures effective fire protection in way of cargo holds and container stowage decks, and supplement the requirements stipulated in Part VI "Fire Protection", Part VIII "Systems and Piping" and in this Part.

**29.1.1.2** For ships with descriptive notation **Container ship** or distinguishing mark **CONT (deck)**, or **CONT (cargo hold(s) No.)**, or **CONT (deck) (cargo hold(s) No.)** in the class notation, one of the following distinguishing marks may be added to the character of classification:

**ACFP(P)** (Additional Cargo Fire Protection (Portable)) — the ship is fitted with portable equipment and additional fire-fighting outfit intended for firefighting in way of cargo holds and container stowage decks;

**ACFP(S)** (Additional Cargo Fire Protection (Stationary)) — the ship is fitted with additional equipment, fire-fighting outfit and systems which constitute an extensive set of fire-fighting means in way of cargo holds and container stowage decks;

**ACFP(S,F)** (where **F** means flooding) — the ship, alongside being fitted with additional equipment, fire-fighting outfit and systems which constitute an extensive set of fire-fighting means in way of cargo holds and container stowage decks, is designed considering possible flooding of a cargo hold in case of fire.

**29.1.2 Technical documentation.**

**29.1.2.1** In order to assign the distinguishing mark **ACFP(P)** to a ship, the following technical documentation shall be submitted to the Register as part of the technical design or plan approval documentation (A — stamped as "Approved", AG — stamped as "Agreed"):

**.1** arrangement diagrams of fire-fighting equipment (considering 29.2.1) (A);

**.2** list of fire-fighting equipment (considering 29.2.1) (AG).

**29.1.2.2** In order to assign the distinguishing mark **ACFP(S)** or **ACFP(S,F)** to a ship, the following technical documentation shall be submitted to the Register as part of the technical design or plan approval documentation:

**.1** arrangement diagrams of fire-fighting equipment (considering 29.2.1) (A);

**.2** list of fire-fighting equipment (considering 29.2.1) (AG);

**.3** diagrams of ventilation systems showing the location of fire dampers, closures of ventilation ducts and ventilation openings in cargo holds (A);

**.4** diagram of fire alarm system (A);

**.5** calculations of fire extinguishing and flooding systems (AG);

**.6** diagrams of fire extinguishing and flooding systems (A);

**.7** cargo hold flooding control booklet (AG);

**.8** stability and damage stability calculations showing that the ship complies with the requirements set out in Sections 2 and 3 of Part V "Subdivision" taking into account possible flooding of cargo holds (AG);

**.9** calculations of longitudinal and local strength of ship hull showing that the ship complies with the requirements in 3.1 of Part II "Hull" and Part XVIII "Additional Requirements for Structures of Container Ships and Ships, Dedicated Primarily to Carry their Load in Containers", taking into account possible flooding of cargo holds (AG);

**.10** functional diagram of alarm and monitoring system activated when water is detected in the hold and upon reaching the design water level at flooding (A).

## 29.2 TECHNICAL REQUIREMENTS FOR ASSIGNMENT OF DISTINGUISHING MARKS ACFP(P), ACFP(S), ACFP(S,F)

### 29.2.1 General requirements.

**29.2.1.1** Ships having the distinguishing mark **ACFP(P)**, **ACFP(S)** or **ACFP(S,F)** in the class notation shall be fitted with additional systems and items of fire-fighting outfit in accordance with Tables 29.2.1.1-1 and 29.2.1.1-2.

Special fire extinguishing systems shall be controlled and monitored from the control station. The control station may be a part of the navigation bridge or fire control station.

Table 29.2.1.1-1

| Additional equipment | Distinguishing mark in the class notation | | |
|---|---|---|---|
| | **ACFP(P)** | **ACFP(S)** | **ACFP(S,F)** |
| Additional requirements for water fire main system | – | +[1] | +[1] |
| Flooding system for cargo holds | – | – | +[2] |
| Water-spraying system | – | +[3] | +[3] |
| Ventilation system | – | +[4] | +[4] |
| Fire detection and alarm system | – | +[5] | +[5] |

[1] Refer to 29.2.2.
[2] Refer to 29.2.4.
[3] Refer to 29.2.5.
[4] Refer to 29.2.6.
[5] Refer to 29.2.7.

Table 29.2.1.1-2

| Additional equipment | Distinguishing mark in the class notation | |
|---|---|---|
| | **ACFP(P)** | **ACFP(S)/ACFP(S,F)** |
| Water mist lance | +[1] | +[1] |
| Fire-fighting outfit | +[2] | +[2] |
| Thermal imaging camera for fire patrols | +[3] | +[3] |
| Fixed water monitors | – | +[4] |
| Air compressor | +[5] | +[5] |

[1] Refer to 29.2.8.1. Two pcs. for ships designed to carry containers on or above the weather deck.
[2] Refer to 29.2.8.2.
[3] Refer to 29.2.8.3.
[4] Refer to 29.2.3.
[5] Refer to 29.2.8.4.

**29.2.2 Water fire main system.**

**29.2.2.1** Water fire main system shall meet the requirements in 3.2 of Part VI "Fire Protection" relating to cargo ships, subject to the requirements below.

**29.2.2.2** The water supply to the fire main serving the cargo holds and container stowage decks shall be a ring main supplied by the main fire pumps laid to the port and starboard side with isolation valves installed at intervals not more than 40 m.

**29.2.2.3** Fixed fire pumps shall ensure simultaneous delivery of at least four water jets required in 3.2.6.2 of Part VI "Fire Protection". The number and location of fire hydrants shall ensure the delivery of at least two water jets from different hydrants, one of which shall be delivered through a hose of standard length as stipulated under 5.1.4.1 of Part VI "Fire Protection", to any part of cargo holds or container stowage deck areas. Distances shall be determined without taking containers into account.

The capacity of the fire pumps shall be sufficient for simultaneous operation of water fire main system and operation of systems and equipment specified in Tables 29.2.1.1-1 and 29.2.1.1-2 in the following combinations, whichever is larger:

**.1** operation of one fixed water monitor in accordance with 29.2.3 and operation of water-spraying system intended for protection of external surfaces of superstructures and deckhouses with capacity specified in 29.2.5.2; or

**.2** operation of mobile water monitors in accordance with 6.7.3 of Part VI "Fire Protection" and operation of the water mist lance required by Table 5.1.2 of Part VI "Fire Protection".

**29.2.3 Fixed water monitors.**

**29.2.3.1** Fixed water monitors shall be installed for protection of the weather deck areas where containers are located.

**29.2.3.2** The number and location of fixed monitors on board shall comply with the following requirements:

**.1** the number and location of monitors shall be such that any point of the top tier of containers can be reached by the water jet from at least two monitors, taking into account the maximum height of the container tier;

**.2** the monitors shall be located in such a way that the water jet is not obstructed by any ship's structures;

**.3** if the monitor is cut-off in the event of fire, the remote control shall be provided in addition to the manual control of the monitor.

**29.2.3.3** If the monitors are fed with water by pumps other than the main fire pumps, their capacity shall be sufficient for operation of one monitor at maximum supply. A connection shall be provided between the pipeline supplying monitors and the water fire main and a non-return shut-off valve shall be fitted in this connection.

If fixed monitors are fed with water by the main fire pumps, the total pump supply and pipeline diameter shall be sufficient to provide the simultaneous operation of the required number of fire hoses and fixed monitors in accordance with 29.2.2.3.

**29.2.3.4** Remote controls for monitors and controls for remote start of pumps shall be available at the control station/fire control station.

**29.2.3.5** Water monitors shall be of a type approved by the Register.

**29.2.4 Flooding system for cargo holds.**

**29.2.4.1** Flooding system for cargo holds is intended for flooding of one of the cargo holds in emergency cases. Simultaneous flooding of several cargo holds is not considered.

**29.2.4.2** If the flooding is provided by pumps other than main fire pumps, a connection shall be provided between the flooding system piping and water fire main, and a non-return shut-off valve shall be fitted in this connection.

The water fire main system, ballast system or a piping system through which water will flow to the hold by gravity or using an alternative method may be used to flood the hold.

Where the water fire main system is used, the system pumps shall be designed for delivery of at least two water jets required in 3.2.6.2 of Part VI "Fire Protection" and parallel water supply for hold flooding according to 29.2.4.3.

**29.2.4.3** In any case, the filling time of one hold shall not exceed 24 hours. In the case of carriage of containers with dangerous goods of Class 1, the time for full or partial hold flooding (for example, at the lowest tier of containers installed in the hold) shall be agreed with the Register.

**29.2.4.4** Valves and pumps controls and monitoring means shall be located at the control station/fire control station. Shut-off isolation valves shall be provided that ensure operation of the system in case of damage of water main at any point and on each pipeline leading directly to the hold. The valves shall be remotely controlled from the control station/fire control station, installed in a safe location outside of the cargo hold and, in addition, indication showing their position (open/closed) shall be provided.

The shut-off valves shall be designed to close when the actuator fails (power loss).

Valves or other means shall be provided in the flooding system to stop the flow of water to any other cargo holds in the event of damage of a common filling pipe for these holds.

Arrangements shall be provided to prevent water ingress from a flooded hold to any other space on the ship.

**29.2.4.5** Cargo holds shall be equipped with an alarm and monitoring system complying with the requirements in 7.10 of Part XI "Electrical Equipment" and in 2.4 of Part XV "Automation" and available at the control station/fire control station in order to prevent inadvertent hold flooding. The system shall provide visual and distinct audible alarm signal when water is detected in the hold and upon reaching the design water level at flooding.

**29.2.4.6** In case dangerous goods (of Class 4.3) are intended to be carried in containers, an instruction plate shall be provided close to the controls of the system, informing that these cargoes may react with water.

Enclosed and open cargo holds intended for the carriage of containers with flammable liquids having a flash point below 23 °C or toxic liquids of subclass 6.1 or 8 specified in 7.2.4 and Table 7.2.4-3 of Part VI "Fire Protection" shall be equipped with the fixed drainage system complying with the requirements in 7.14.1 of Part VIII "Systems and Piping".

**29.2.4.7** Arrangements shall be made to allow drainage of the flooding water from the cargo hold to a suitable holding tank.

Ballast tanks may be used for this purpose, provided the water from these tanks is pumped to another ship or to land-based reception facilities in order to prevent pollution.

An easily removable grating or screen shall be installed over each drain opening of the drainage system in cargo holds to prevent blocking of the drain openings according to 7.6.10 of Part VIII "Systems and Piping".

**29.2.4.8** Cargo hold flooding control booklet.

A cargo hold flooding control booklet shall be developed and be available on board the ship. This booklet shall include:

**.1** description and drawings of cargo hold flooding and drainage means;

**.2** detailed instructions covering the operations to flood and empty the cargo holds;

**.3** calculations of stability at flooding of each hold to the level of cargo height showing that the ship complies with the requirements of Sections 2 and 3 of Part V "Subdivision".

**29.2.5 Water-spraying system.**

**29.2.5.1** A water-spraying system shall be installed on board for protection of:

**.1** exposed boundaries of superstructures and deckhouses, enclosing accommodation spaces and facing container stowage deck or facing cargo holds without hatch covers designed for carriage of containers. External boundaries of unmanned forecastle spaces not containing high fire-risk materials, outfit or equipment, for example, paint store, do not require water-spray protection;

**.2** foundations of the manually-controlled monitors required under 29.2.3;

**.3** exposed lifeboats, liferafts and muster stations facing container stowage areas or facing cargo holds without hatch covers intended for carriage of containers regardless of distance to them, except for the exposed muster stations and exposed launching routes from the life rafts storage location to the ship side where rafts are located and ready for launching at both sides.

**29.2.5.2** The system shall be capable of covering all areas mentioned in 29.2.5.1.1 — 29.2.5.1.3 with a uniformly distributed water application rate of at least 10 l/m$^2$/min for the horizontal surfaces and 5 l/m$^2$/min for vertical surfaces.

The number and location of nozzles shall be such as to ensure an effective distribution of water with the specified intensity of supply. On vertical surfaces, spacing of nozzles protecting lower areas may take account of anticipated rundown from higher areas.

For structures having no clearly defined horizontal or vertical surfaces, the capacity of the water-spraying system shall not be less than the projected horizontal surface multiplied by 10 l/m$^2$/min.

**29.2.5.3** Stop valves shall be fitted in the main supply line(s) in the water-spraying system, 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 in accordance with 29.2.5.5.

**29.2.5.4** Where the water-spraying system is fed with water by dedicated pumps and piping system, the pumps shall be capable of supplying water at the required pressure simultaneously to all sections of the system to protect the exposed surfaces of superstructures, deckhouses facing the container stowage deck or facing holds without hatch covers intended for carriage of containers both in fore and aft parts of the ship. A connecting pipeline to the water fire main shall be provided and a non-return shut-off valve shall be installed on the connection.

Where the water-spraying system is fed by water from the main fire pumps, the total delivery of pumps and pipe diameter shall be sufficient to provide the simultaneous operation of the required number of fire hoses and the water-spraying system in accordance with 29.2.2.3.

**29.2.5.5** The valve controls and pump controls shall be available at the control station/fire control station.

**29.2.6 Ventilation system for cargo holds.**

**29.2.6.1** The ventilation system shall be controlled from the central control station. Ventilation of cargo holds for carriage of containers shall be fitted with controls so grouped that all fans serving the cargo hold may be stopped at once.

**29.2.6.2** Remote closing of all ventilation openings except for those located in the hatch covers shall be possible.

**29.2.6.3** The ventilation openings located in the hatch covers shall be fitted with quick-closing devices (for example, hinged cover with ear-nuts). Containers located on the hatch covers of cargo holds shall not impede closure of ventilation openings.

**29.2.7 Fire detection and alarm system.**

**29.2.7.1** Cargo spaces for carriage of containers shall be protected by the fixed fire detection and fire alarm system complying with the requirements in 4.2.1 of Part VI "Fire Protection", or the sample extraction smoke detection system complying with the requirements in 4.2.1.6 of Part VI "Fire Protection", or the multi-criteria fire detection and fire alarm system complying with the requirements in 4.2.4 of Part VI "Fire Protection".

**29.2.8 Fire-fighting equipment and outfit.**

**29.2.8.1** The water mist lance shall comply with the requirements set out in 5.1.24 of Part VI "Fire Protection".

If one water mist lance required under item 19 of Table 5.1.2 in Part VI "Fire Protection" is available on board the ship, only one lance is required additionally.

**29.2.8.2** At least 6 fireman's outfits shall be provided onboard, including as required under item 10 of Table 5.1.2 in Part VI "Fire Protection".

Fireman's outfits shall meet the requirements in 5.1.15 of Part VI "Fire Protection".

**29.2.8.3** Additionally, at least two portable thermal imaging cameras for fire patrols shall be provided. In the case of carriage of dangerous goods, the cameras shall be explosion-proof with explosion group 1Exd or 1Exp. The explosion group and temperature class shall be consistent with the category of the cargo carried. The cameras shall be kept in easily accessible place on the navigation bridge.

**29.2.8.4** The ship shall be fitted with suitably located means for full recharging of breathing air cylinders with clean air, complying with the requirements in 5.1.15.2 of Part VI "Fire Protection".

# 30 REQUIREMENTS FOR CONTAINER SHIPS AND OTHER SHIPS OF 500 GROSS TONNAGE AND OVER INTENDED FOR CARRIAGE OF REFRIGERATED CONTAINERS

## 30.1 GENERAL

**30.1.1 Application.**

**30.1.1.1** The requirements of this Section apply to ships the special equipment of which ensures refrigeration of carried containers and supplement the requirements stipulated in Part VIII "Systems and Piping", Part XI "Electrical Equipment" and Part XII "Refrigerating Plants".

**30.1.1.2** For ships with descriptive notation **Container ship** or distinguishing mark **CONT (deck)**, or **CONT (cargo hold(s) No.)**, or **CONT (deck) (cargo hold(s) No.)** in the class notation, one of the following distinguishing marks may be added to the character of classification:

**RC-C** (Refrigerated Container, Coolant) — containers are refrigerated using the secondary refrigerant cooled by a shipboard refrigerating plant. It shall be added after the distinguishing mark **REF** or **(REF)**;

**RC-A** (Refrigerated Container, Air) — containers are refrigerated with air used as the secondary refrigerant cooled by a shipboard refrigerating plant, by adjusting atmosphere parameters (temperature and humidity) inside containers. It shall be added after the distinguishing mark **REF** or **(REF)**;

**RC-IA** (Refrigerated Container, Inerted Air) — containers are refrigerated with air used as the secondary refrigerant cooled by a shipboard refrigerating plant, by adjusting, in addition to atmosphere parameters (temperature and humidity), also atmosphere composition inside containers by means of inerting. It shall be added after the distinguishing mark **REF** or **(REF)**;

**RC-E** (Refrigerated Container, Energy) — containers are fitted with their own refrigerating plant fed from the shipboard electrical power plant.

**30.1.1.3** Distinguishing marks **RC-C**, **RC-A**, **RC-IA** or **RC-E** may be assigned to ships under construction and ships in service.

**30.1.2 Technical documentation.**

**30.1.2.1** In order to assign distinguishing marks **RC-C**, **RC-A, RC-IA** or **RC-E**, the following technical documentation shall be submitted to the Register for review (A — stamped as "Approved"):

| No. | Description of documentation | Stamp | TD | DD | PAD | Remarks |
|---|---|---|---|---|---|---|
| **.1** | Circuit diagrams of refrigerant systems | A | ● | ● | ● | |
| **.2** | Diagrams of ventilation systems and system for supply of cooled air to the containers with indication of arrangement of fire dampers, closures of ventilation ducts and openings in cargo holds | A | ● | ● | ● | |

Letter abbreviations:
TD — Technical design;
PAD — Plan approval documentation;
DD — Detailed (design) documentation

## 30.2 TECHNICAL REQUIREMENTS FOR ASSIGNMENT OF DISTINGUISHING MARK RC-C, RC-A, RC-IA OR RC-E

**30.2.1 General technical requirements.**

**30.2.1.1** Under seagoing conditions, the rating of the shipboard electrical power plant shall be sufficient to supply the cargo refrigeration equipment, when one of auxiliary generating sets is out of action.

**30.2.2 Technical requirements for assigning distinguishing mark RC-C.**

**30.2.2.1** A non-flammable and non-toxic liquid shall be used as a secondary refrigerant.

**30.2.2.2** For each container at least one temperature sensor installed at the secondary refrigerant outlet shall be provided. One temperature sensor shall be located at the common secondary refrigerant supply pipeline.

**30.2.2.3** Flexible connections shall be used for connecting container cooling systems with the ship secondary refrigerant system.

**30.2.2.4** A secondary refrigerant leak detector (level sensor) shall be provided in each cargo hold. A level sensor shall be installed in the expansion tank of the secondary refrigerant system.

**30.2.3 Technical requirements for assigning distinguishing mark RC-A.**

**30.2.3.1** Ducts for discharge and suction of refrigerated air shall be suitably insulated; they shall be air-tight in order to avoid an increase in the cold demand and a decrease in the temperature of air in the holds. The insulating materials and linings used for the ducts shall comply with the requirements in 1.4.5 of Part VIII "Systems and Piping".

**30.2.3.2** Ducts for entry of fresh air and exhaust of stale air which serve a group of containers shall be arranged so that they can be segregated from the ducts serving other groups in order to avoid contamination by odour of the remains of the cargo in case of damage of cargo in one of the containers.

Ducts for exhaust of stale air may be led to the weather deck or may form a closed circulation circuit.

**30.2.3.3** At least two temperature sensors shall be provided for each container. One shall be arranged at the air supply, the other at the air outlet. The latter may, however, be common to several containers if the arrangements are such that the same air temperature is ensured at all the air supply outlets. In this case, the sensor shall be located at the air cooler exhaust in the air stream common to all these outlets.

**30.2.3.4** In case when a refrigerant plant is used for air cooling, it shall comply with the requirements of Part XII "Refrigerating Plants" in the scope required for classed plants.

**30.2.4 Technical requirements for assigning distinguishing mark RC-IA.**

**30.2.4.1** Where the atmosphere composition control in containers is provided (by means of inerting), the system shall meet all the requirements of 30.2.3 and shall be mandatorily of closed loop type. The cargo hold shall be equipped with oxygen content monitoring sensors to detect leaks. In this case, independent mechanical ventilation of cargo holds shall be provided in addition to air supply to the containers.

**30.2.5 Technical requirements for assigning distinguishing mark RC-E.**

**30.2.5.1** The electrical power for the refrigerating plants in containers carried shall be provided from a separate feeder circuit from the main switchboard.

## 31 REQUIREMENTS FOR OFFSHORE SUPPLY VESSELS INTENDED TO CARRY LIMITED AMOUNT OF HAZARDOUS AND NOXIOUS LIQUID SUBSTANCES IN BULK

**(based on IMO resolution A.1122(30) of 06.12.2017, chapter II-2 of SOLAS-74, IBC Code, IGC Code, MARPOL 73/78)**

### 31.1 GENERAL

**31.1.1 Application.**

**31.1.1.1** The requirements of this Section apply to the design, construction and operation of offshore supply vessels carrying limited amount of hazardous and noxious liquid substances in bulk[1] for the servicing and resupplying of offshore platforms, mobile offshore drilling units and other offshore installations, including those employed in the search for and recovery of hydrocarbons from the seabed.

**31.1.1.2** The Section may apply also to offshore service vessels, other than offshore supply vessels when, due to their operation, they are designed and constructed to carry limited amount of hazardous and noxious liquid substances in bulk.

**31.1.1.3** Products which may be carried subject to this Section are:

**.1** products which are listed in chapters 17 or 18 of the IBC Code[2] and the latest edition of the MEPC.2/Circular (Provisional categorization of liquid substances in accordance with MARPOL Annex II and the IBC Code) and their related references to chapters 15 and 19; or

**.2** oil-based/water-based mud containing mixtures of products listed in chapters 17 and 18 of the IBC Code and the MEPC.2/Circular; or

**.3** liquid carbon dioxide (high purity and reclaimed quality) and liquid nitrogen; or

**.4** contaminated backloads.

**31.1.1.4** If ships comply with the requirements of this Section, the distinguishing mark **HNLS** (Hazardous and Noxious Liquid Substances) may be added to the character of classification.

**31.1.2 Definitions.**

For the purpose of this Section the following definitions have been adopted:

**31.1.2.1** Safety hazard substance means a substance having an entry of "S" or "S/P" in column "d" in chapter 17 of the IBC Code.

**31.1.2.2** Pollution hazard only substance means a substance, which is specified as "P" only in column "d", chapter 17 of the IBC Code.

**31.1.2.3** Independent tank means a cargo-containment envelope, which is not contiguous with, or part of, the hull structure. An independent tank is built and installed so as to eliminate whenever possible (or in any event to minimize) its stressing as a result of stressing or motion of the adjacent hull structure.

**31.1.2.4** Lightweight means the displacement of an offshore supply vessel in metric tons without cargo, fuel, lubricating oil, ballast water, fresh water and feed water in tanks, consumable stores, and crew and their effects.

**31.1.2.5** Noxious liquid substance means any substance indicated in the Pollution Category column of chapter 17 or 18 of the IBC Code, or the current MEPC.2/Circular or provisionally assessed under the requirements of regulation 6.3 of MARPOL Annex II as falling into categories X, Y or Z.

**31.1.2.6** Integral tank means a cargo-containment envelope which forms part of the ship's hull and which may be stressed in the same manner and by the same loads which stress the contiguous hull structure and which is normally essential to the structural completeness of the ship's hull.

---

[1] For requirements regulating the transport of dangerous goods and marine pollutants in packaged form, including transport of dangerous goods in portable tanks, refer to the International Maritime Dangerous Goods Code (IMDG Code).

[2] International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk adopted by the IMO resolution MEPC.119(52).

**31.1.2.7** Cargo area is that part of the offshore supply vessel where:

**.1** a pollution hazard only substance having a flashpoint exceeding 60 °C and not defined as toxic is likely to be present and includes cargo tanks, portable tanks used as deck cargo tanks, slop tanks, cargo pump-rooms, pump-rooms adjacent to cargo tanks and enclosed spaces in which pipes containing cargoes are located. Areas on open deck are not considered part of the cargo area;

**.2** a safety hazard substance having a flashpoint exceeding 60 °C and not defined as a toxic is likely to be present and includes cargo tanks, portable tanks used as deck cargo tanks, slop tanks, cargo pump-rooms, pump-rooms adjacent to cargo tanks, hold spaces in which independent tanks are located, cofferdams surrounding integral tanks, enclosed spaces in which pipes containing cargoes are located and the following deck areas:

**.2.1** within 3 m of cargo tank installed on deck or portable tanks used as deck cargo tanks;

**.2.2** areas on open deck, or semi-enclosed spaces on deck, within 3 m of any cargo tank access outlet;

**.2.3** areas on open deck over an integral tank without an overlaying cofferdam plus the open deck area extending transversely and longitudinally for a distance of 3 m beyond each side of the tank;

**.2.4** areas on open deck, or semi-enclosed spaces on deck, within 3 m of cargo manifold valve, cargo valve, cargo pipe flange, except spaces within the 3 m zone that are separated by an enclosed bulkhead to the minimum height as given in 31.1.2.7.2.6 below;

**.2.5** areas on open deck, or semi-enclosed spaces on deck above and in the vicinity of any cargo tank vent outlet intended for the passage of large volumes of vapour mixture during cargo loading, within a vertical cylinder of unlimited height and 3 m radius centred upon the centre of the outlet, and within a hemisphere of 3 m radius below the outlet;

**.2.6** areas on the open deck within spillage coamings surrounding cargo manifold valves and 3 m beyond these, up to a height of 2,4 m above the deck;

**.2.7** compartments for cargo hoses;

**.3** a substance having a flashpoint not exceeding 60 °C, or defined as toxic (or emitting vapors of such cargo); is likely to be present and includes cargo tanks, portable tanks used as deck cargo tanks, slop tanks, cargo pump-rooms, pump-rooms adjacent to cargo tanks, hold spaces in which independent tanks are located, cofferdams surrounding integral tanks, enclosed spaces in which pipes containing cargoes are located and the following deck areas:

**.3.1** within 3 m of cargo tank installed on deck or portable tanks used as deck cargo tanks;

**.3.2** areas on open deck, or semi-enclosed spaces on deck, within 4,5 m of gas or vapor outlet, cargo manifold valve, cargo valve, cargo pipe flange, cargo pump-room ventilation outlets and cargo tank openings for pressure release provided to permit the flow of small volumes of gas or vapor mixtures caused by thermal variation;

**.3.3** areas on open deck, or semi-enclosed spaces on deck above and in the vicinity of any cargo gas outlet intended for the passage of large volumes of gas or vapour mixture during cargo loading, within a vertical cylinder of unlimited height and 10 m radius centred upon the centre of the outlet, and within a hemisphere of 10 m radius below the outlet;

**.3.4** areas on open deck, or semi-enclosed spaces on deck, within 3 m of cargo pump-room entrances, cargo pump-room ventilation inlet, openings into cofferdams;

**.3.5** areas on the open deck within spillage coamings surrounding cargo manifold valves and 3 m beyond these, up to a height of 2,4 m above the deck;

**.3.6** compartments for cargo hoses;

**.3.7** within the hose landing area.

**31.1.2.8** Cargo pump-room is a space containing pumps and their accessories for the handling of the products.

**31.1.2.9** Backload means contaminated bulk liquids, taken on board a ship offshore, for transport either back to shore or to an alternate offshore site.

**31.1.2.10** Vapor pressure is the equilibrium pressure of the saturated vapour above a liquid expressed in pascals (Pa) at a specified temperature.

**31.1.2.11** Deadweight means the difference in metric tons between the displacement of an offshore supply vessel in water of a density of 1,025 at the load waterline corresponding to the assigned summer freeboard and the lightweight of the vessel.

**31.1.2.12** Length ($L$) means 96 % of the total length on a waterline at 85 % of the least moulded depth measured from the top of the keel, or the length from the foreside of the stem to the axis of the rudder stock on that waterline, if that is greater. In ships designed with a rake of keel, the waterline on which this length is measured shall be parallel to the designed waterline.

**31.1.2.13** Blending additives mean small amounts of liquid substances used during blending of products or production processes of cargoes for use in the search for and exploitation of seabed mineral resources used to facilitate such operations.

**31.1.2.14** Accommodation spaces are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, barber shops, pantries containing no cooking appliances and similar spaces.

**31.1.2.15** Cofferdam means the isolating space between two adjacent steel bulkheads or decks. This space may be a void space or a ballast space.

**31.1.2.16** MARPOL 73/78 means the International Convention for the Prevention ofPollution from Ships, 1973 as modified by the Protocol 1978 thereto, as amended.

**31.1.2.17** Machinery spaces mean all machinery spaces of category A and all other spaces containing main machinery, boilers, fuel oil units, steam and internal combustion engines, generators and other major electrical machinery, fuel oil filling stations, machinery of refrigerating plants, stabilizing equipment, ventilation and air-conditioning installations, and similar spaces, and trunks to such spaces.

**31.1.2.18** Machinery spaces of category A mean those spaces and trunks to such spaces which either contain:

**.1** internal combustion machinery used for main propulsion;

**.2** internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW; or

**.3** any oil-fired boiler or oil fuel unit or any oil-fired equipment other than boilers, such as inert gas generators, incinerators, etc.

**31.1.2.19** International Gas Carrier Code (IGC Code) means the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IMO resolution MSC.5(48), as amended).

**31.1.2.20** IMDG Code means the International Maritime Dangerous Goods Code (IMO resolution MSC.122(75), as amended).

**31.1.2.21** Offshore supply vessels (OSV) are:

**.1** multi-mission vessels which are primarily engaged in the transport of stores, materials and equipment to and from mobile offshore drilling units, fixed and floating platforms and other similar offshore installations; or

**.2** multi-mission vessels, including well stimulation vessels, but excluding mobile offshore drilling units, derrick barges, pipe-laying barges and floating accommodation units, which are otherwise primarily engaged in supporting the work of offshore installations.

**31.1.2.22** Hazardous substance is any substance either listed in chapter 17 of the IBC Code or having a hazard more severe than one of the minimum hazard criteria given in criteria for hazard evaluation of bulk chemicals.

**31.1.2.23** Dangerous goods mean the substances, materials and articles covered by the IMDG Code.

**31.1.2.24** Dangerous chemicals mean any liquid chemicals designated as presenting a safety hazard, based on the safety criteria for assigning products to chapter 17 of the IBC Code.

**31.1.2.25** Offshore portable tank means a portable tank specially designed for repeated use for transport of dangerous goods to, from and between offshore facilities. An offshore portable tank is designed and constructed in accordance with the Guidelines for the approval of offshore containers handled in open seas (MSC/Circ.860).

**31.1.2.26** Hose landing area means an area on the main deck, except those in compartments for cargo hoses, where cargo hoses of substances having a flashpoint not exceeding 60 °C and/or defined as toxic are located during cargo transfer.

**31.1.2.27** Cargo control station means a location that is manned during cargo transfer operations for the purpose of directing or controlling the loading or unloading of cargo.

**31.1.2.28** Control stations are those spaces in which ship's radio or main navigating equipment or the emergency source of power is located or where the fire-recording or fire-control equipment is centralized.

**31.1.2.29** Well stimulation vessel means an offshore supply vessel with specialized equipment and industrial personnel that delivers products and services directly into a well-head.

**31.1.2.30** A type 1 ship is a chemical tanker intended to transport products specified in chapter 17 of the IBC Code with very severe environmental and safety hazards which require maximum preventive measures to preclude an escape of such cargo.

**31.1.2.31** A type 2 ship is a chemical tanker intended to transport products specified in chapter 17 of the IBC Code with appreciably severe environmental and safety hazards which require significant preventive measures to preclude an escape of such cargo.

**31.1.2.32** A type 3 ship is a chemical tanker intended to transport products specified in chapter 17 of the IBC Code with sufficiently severe environmental and safety hazards which require a moderate degree of containment to increase survival capability in a damaged condition.

**31.1.2.33** Gravity tank (drained by gravity) means a tank having a design pressure not greater than 0,07 MPa (gauge pressure) at the top of the tank.

A gravity tank may be independent or integral. A gravity tank shall be constructed and tested according to recognized standards, taking account of the temperature of carriage and relative density of the cargo.

**31.1.2.34** Pressure tank means a tank having a design pressure greater than 0,07 MPa (gauge pressure). A pressure tank shall be an independent tank and shall be of a configuration permitting the application of pressure-vessel design criteria according to recognized standards.

**31.1.2.35** Triple point in a single-component system is the point of convergence of the two-phase equilibrium curves in the two-dimensional P (pressure) — T (temperature) phase diagram, corresponding to the stable equilibrium of three phases.

**31.1.2.36** Oil fuel unit is the equipment used for the preparation of oil fuel for delivery to an oil-fired boiler, or equipment used for the preparation for delivery of heated oil to an internal combustion engine, and includes any oil pressure pumps, filters and heaters dealing with oil at a gauge pressure of more than 0,18 MPa.

**31.1.2.37** Breadth ($B$) means the maximum breadth of the ship, measured amidships to the moulded line of the frame in a ship with a metal shell and to the outer surface of the hull in a ship with a shell of any other material.

## 31.2 TECHNICAL DOCUMENTATION

For the project of an offshore supply vessel having the distinguishing mark **HNLS** in the class notation, in addition to those specified in Section 3 of Part I "Classification", the following documentation shall be submitted.

The letter identification (A — approved, AG — agreed, FI — for information) denotes the results of documentation review documented by stamping in accordance with 8.2 of Part II "Technical Documentation" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

| No. | Documentation description | Stamp | TD[1] | DD[2] | PAD[3] | Remarks |
|---|---|---|---|---|---|---|
| **1.** | Information regarding loading arrangement of deck cargoes, weights and their centers of gravity | AG | ● | ● | ● | |
| **2.** | Lashing arrangement of deck cargoes | A | ● | ● | ● | |
| **3.** | Details of integral liquid cargo tanks including vents and/or overflows height and location | A | ● | ● | ● | |
| **4.** | Details of independent liquid and/or dry cargo tanks | A | ● | ● | ● | |
| **5.** | Details of independent tank supports and fastening arrangements | A | | ● | ● | |
| **6.** | Piping diagrams of liquid cargo transfer systems | A | ● | ● | ● | |
| **7.** | Piping diagrams of dry bulk cargo transfer systems | A | ● | ● | ● | |
| **8.** | Ventilation diagrams of liquid cargoes | A | ● | ● | ● | |
| **9.** | Stability calculation | AG | ● | | ● | |
| **10.** | Calculation of damage trim and stability | AG | ● | | ● | |
| **11.** | Stability Booklet | AG | | ● | ● | |
| **12.** | Damage Trim and Stability Booklet | AG | | ● | ● | |
| **13.** | General arrangements of cargo areas (refer to 31.1.2.7) | A | ● | ● | ● | |

| No. | Documentation description | Stamp | TD[1] | DD[2] | PAD[3] | Remarks |
|---|---|---|---|---|---|---|
| **14.** | General arrangements of hazardous areas | A | ● | ● | ● | |
| **15.** | General arrangements of cargo tanks with adjacent cofferdams | A | ● | ● | ● | |
| **16.** | Full particulars of the intended cargo or cargoes and its properties | FI | ● | ● | ● | |
| **17.** | Cargo hatches and other openings to cargo tanks | A | ● | ● | ● | |
| **18.** | Doors, hatches and other openings to pump-rooms and other hazardous spaces | A | ● | ● | ● | |
| **19.** | Ventilation ducts and openings to pump-rooms and other hazardous spaces | A | ● | ● | ● | |
| **20.** | Doors, air locks, hatches and other openings to non-hazardous spaces adjacent to cargo area | A | ● | ● | ● | |
| **21.** | Cargo pipes with loading and discharging connections for dry bulk cargoes | A | ● | ● | ● | |
| **22.** | Vent pipes for cargo tanks | A | ● | ● | ● | |
| **23.** | Cargo piping system including drawings showing details such as expansion elements and flange connections | A | ● | ● | ● | |
| **24.** | Bilge piping systems in pump-room, cofferdams, and pipe tunnels within the cargo area | A | ● | ● | ● | |
| **25.** | Cargo heating systems | A | ● | ● | ● | |
| **26.** | Procedures and calculations of cooling down, loading and unloading operations | FI | ● | ● | ● | |
| **27.** | Drawings of pressure vacuum valves or high velocity vent valves, their details and installation, relevant calculations of their relieving capacity | A | ● | ● | ● | |
| **28.** | Arrangement and capacity of ventilation system in the cargo area | A | ● | ● | ● | |
| **29.** | Drawings of fan rotating parts and casings | A | ● | ● | ● | |
| **30.** | Portable ventilators | FI | ● | ● | ● | |

| No. | Documentation description | Stamp | TD[1] | DD[2] | PAD[3] | Remarks |
|---|---|---|---|---|---|---|
| **31.** | Arrangement of inert gas supply if applicable | A | ● | ● | ● | |
| **32.** | Drawings showing location of all electrical equipment in hazardous areas | A | ● | ● | ● | |
| **33.** | List of certified safe equipment | FI | ● | ● | ● | |
| **34.** | One-line diagram for intrinsically safe circuits and data | A | ● | ● | ● | |
| **35.** | Maintenance manual for electrical installations in hazardous areas | AG | ● | ● | ● | |
| **36.** | Arrangement and specifications of fixed fire extinguishing systems | A | ● | | ● | |
| **37.** | Diagrams of fire and gas detection and alarm systems | A | ● | ● | ● | |
| **38.** | Cargo tank level measurement system | A | ● | ● | ● | |
| **39.** | Cargo tank overflow protection system | A | ● | ● | ● | |
| **40.** | Cargo valves and pump control and monitoring system | A | ● | ● | ● | |
| **41.** | Inert gas control and monitoring system if applicable | A | ● | ● | ● | |

[1] TD — Technical design.
[2] DD — Detailed (design) documentation.
[3] PAD — Plan approval documentation.

## 31.3 TECHNICAL REQUIREMENTS

**31.3.1 Cargo tanks arrangement.**

**31.3.1.1** Cargo tanks containing products subject to the provisions of this Section shall be spaced from the outer shell plating as stated below:

**.1** cargo tanks for ship type 1 products (refer to 31.1.2) shall be located at a distance from the side shell plating, not less than the transverse extent of damage as specified in 31.3.3.7.1.1.1, and from the moulded line of the bottom shell plating at centreline, not less than the vertical extent of damage as specified in 31.3.3.7.1.2.1, and in no case nowhere less than 760 mm from the shell plating. This provision does not apply to tanks intended for collection of slops arising from tank washing;

**.2** cargo tanks for ship type 2 products (refer to 31.1.2) shall be located at a distance from the moulded line of the bottom shell plating at centreline, not less than the vertical extent of damage specified in 31.3.3.7.1.2, and in no case nowhere less than 760 mm from the shell plating. This provision does not apply to tanks intended for collection of slops arising from tank washing;

**.3** cargo tanks for ship type 3 products (refer to 31.1.2) shall be located nowhere less than 760 mm from the shell plating. This provision does not apply to tanks intended for collection of slops arising from tank washing.

**31.3.1.2** Tanks containing cargoes, residues of cargoes or mixtures containing cargoes subject to the present chapter shall be segregated from machinery spaces as defined in 31.1.2, accommodation and service spaces and from drinking water and stores for human consumption by means of a cofferdam, void space, cargo pump-room, pump-room, empty tank, oil fuel tank, or other similar space. On-deck stowage of permanently attached deck tanks or installation of independent tanks in otherwise empty hold spaces shall be considered as satisfying this provision.

**31.3.1.3** Cargo spaces containing cargoes which react in a hazardous manner with other cargoes or oil fuels shall:

**.1** be segregated from such other cargoes or oil fuels by means of a cofferdam, void space, pump-room, empty tank, or tank containing a mutually compatible cargo;

**.2** have separate pumping and piping systems which shall not pass through other cargo tanks containing such cargoes, unless encased in a tunnel; and

**.3** have separate tank venting systems.

**31.3.1.4** Cargo tanks other than those intended to carry substances with flashpoint not exceeding 60 °C, toxic products and acids may extend to the deck plating. Where cargo is handled on the deck area above a cargo tank, the cargo tank may not extend to the deck plating unless a continuous permanent deck sheathing of minimum 50 mm of wood or other suitable material of equivalent thickness and construction is fitted.

**31.3.1.5** Cargoes subject to this Section shall not be carried in either the fore or aft peak tanks.

**31.3.1.6** Tank type requirements for individual products.

**31.3.1.6.1** Requirements for both installation and design of tank types for individual products are shown in column "f" in the table in chapter 17 of the IBC Code.

**31.3.1.6.2** Instead of the use of permanently attached cargo deck tanks complying with the requirements of the IBC Code, portable tanks meeting the construction requirements of the IMDG Code or other portable tanks specifically approved by the Register may be used for cargoes indicated in 31.1.1.3, provided that the provisions of 31.3.19 are complied with. The applicable tank instruction for the products listed as dangerous goods in the IMDG Code shall apply. Products with pollution hazard only and a flashpoint above 60 °C falling within the scope of this Section, but for which the IMDG Code is not applicable, when carried in packaged form, shall be shipped under the tank instruction and special tank requirements as included in the IMDG Code for goods with UN number 3082.

**31.3.1.7** Arrangement of suction wells.

Suction wells installed in cargo tanks for ship types 2 and 3 products (refer to 31.1.2) may protrude below the inner bottom plating provided that such wells are as small as practicable and the protrusion below the inner bottom plating does not exceed 25% of the depth of the double bottom or 350 mm, whichever is less. Where there is no double bottom, the protrusion of the suction well of independent tanks below the upper limit of bottom damage shall not exceed 350 mm. Suction wells installed in accordance with this paragraph may be ignored in determining the compartments affected by damage.

**31.3.1.8** Access to spaces in the cargo area:

**.1** for pollution hazard only substances, at least one access to cargo tanks shall be direct from the open deck and designed such as to ensure complete inspection of those substances;

**.2** for safety hazard substances, at least one access to each cargo tank, cofferdams and other spaces in the cargo area shall be direct from the open deck and designed such as to ensure complete inspection of those substances;

**.3** access to double bottom spaces within the cargo area may be through a cargo pump-room, pump-room, deep cofferdam, pipe tunnel or similar dry compartments with their own direct access from open deck, subject to consideration of ventilation aspects. Where cofferdams are provided over integral tanks, small trunks may be used to penetrate the cofferdam.

**31.3.1.9** For accesses defined in 31.3.1.8 and 31.3.12.1.7 through horizontal openings, hatches or manholes, the dimensions shall be sufficient to allow a person with a self-contained air-breathing apparatus and protective equipment to ascend or descend any stairway without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the space. The minimum clear opening shall be not less than 600 × 600 mm.

**31.3.1.10** For accesses defined in 31.3.1.8 and 31.3.12.1.7 through vertical openings, or manholes providing passage through the length and breadth of space, the minimum clear opening shall be not less than 600 × 800 mm at a height of not more than 600 mm from the bottom shell or deck plating, unless gratings or other footholds are provided.

**31.3.1.11** Smaller dimensions may be approved, if at least one access defined in 31.3.1.8 and 31.3.12.1.7 has dimensions not less than those required in 31.3.1.9 and 31.3.1.10, respectively. The main access shall be identified clearly in an access plan.

**31.3.1.12** Cargo pump-rooms shall be so arranged as to ensure unrestricted access to all valves necessary for cargo handling for a person wearing the required personal protective equipment.

**31.3.1.13** For access to all spaces, the minimum spacing between cargo tank boundaries and adjacent ship structure shall be 600 mm.

**31.3.2 Accommodation, service spaces and control stations.**

**31.3.2.1** Accommodation, service spaces and control stations shall not be located within the cargo area.

**31.3.2.2** For a ship certified to carry safety hazard substances, entrances, air inlets and openings to accommodation, service and machinery spaces and control stations may be accepted in bulkheads facing the cargo deck area if they are located outside the deck areas defined in 31.1.2.2.

**31.3.2.3** Unless they are spaced at least 7 m away from the cargo area containing flammable products, entrances, air inlets and openings to accommodation, service and machinery spaces and control stations shall not face the cargo area. Doors to spaces not having access to accommodation, service and machinery spaces and control stations, such as cargo control stations and store-rooms, may be permitted within the 7 m zone specified above, provided the boundaries of the spaces are insulated to A-60 standard.

When arranged within the 7 m zone specified above, windows and side scuttles facing the cargo area shall be of a fixed type.

Such side scuttles in the first tier on the main deck shall be fitted with inside covers of steel or equivalent material.

**31.3.2.4** In order to guard against the danger of hazardous vapors, due consideration shall be given to the location of air intakes and openings into accommodation, service and machinery spaces and control stations in relation to cargo piping and cargo vent systems.

**31.3.3 Stability, unsinkability and subdivision.**

**31.3.3.1** For all types of service intact stability of the ship shall comply with the requirements of Part IV "Stability".

**31.3.3.2** Solid ballast shall not normally be used in double bottom spaces in the cargo area. Where, however, because of stability considerations, the fitting of solid ballast in such spaces becomes unavoidable, then its disposition shall be governed by the need to ensure that the impact loads resulting from bottom damage are not directly transmitted to the cargo tank structure.

**31.3.3.3** All OSVs shall be provided with the Stability Booklet complying with the requirements under 1.4.1 of Part IV "Stability", and Damage Trim and Stability Booklet in compliance with 1.4.6 of Part V "Subdivision".

**31.3.3.4** OSVs carrying over 1200 m$^3$ of ship type 2 or 3 products or over 150 m$^3$ of ship type 1 products, as well as ships of 80 m in length and above carrying not more than 1200 m$^3$ of ship types 2 or type 3 products, and not more than 150 m$^3$ of ship type 1 products, shall be fitted with a stability instrument[1], capable of verifying compliance with intact and damage stability provisions.

**31.3.3.5** Pipelines not intended for cargo discharge and having open ends below the bulkhead deck shall comply with the requirements in 4.3 of Part VIII "Systems and Piping".

**31.3.3.6** Permeability of compartments.

Permeability of compartments shall be assumed in compliance with 2.6 of Part V "Subdivision".

**31.3.3.7** Damage extent.

**.1** For ships carrying more than 1200 m$^3$ of products which are permitted for transporting on type 2 ship or type 3 ship, or more than 150 m$^3$ of products which are permitted for transporting on type 1 ship, the assumed maximum extent of damage shall be as given below:

**.1.1** Side damage

| Type | Longitudinal extent | Transverse extent | Vertical extent |
|---|---|---|---|
| 1 | $1/3L^{2/3}$ | $B/5$ (measured inboard from the ship's side at right angles to the centreline at the level of the summer load line) | Upwards without limit measured from the moulded line of the bottom shell plating at centreline |

**.1.2** Bottom damage

| Type | Location of damage | Longitudinal extent | Transverse extent | Vertical extent |
|---|---|---|---|---|
| 1 | Within 0,3 $L$, measured from the forward perpendicular | $1/3L^{2/3}$ | $B/6$ | $B/15$ or 6 m, whichever is less, measured from the moulded line of the bottom shell plating at centreline (refer to 31.3.1.7) |

[1] Refer to paras 2.2.6 and 2.2.7 of the IBC Code, IMO resolution MEPC.250(66).

| Type | Location of damage | Longitudinal extent | Transverse extent | Vertical extent |
|---|---|---|---|---|
| 2 | Any other part of the ship | $1/3L^{2/3}$ or 5 m, whichever is less | $B/6$ or 5 m, whichever is less | $B/15$ or 6 m, whichever is less, measured from the moulded line of the bottom shell plating at centreline (refer to 31.3.1.7) |

**.2** For ships carrying not more than 1200 m$^3$ of products which are permitted for transporting on type 2 or type 3 ships, and not more than 150 m$^3$ of products permitted for transporting on type 1 ship, the assumed maximum extent of damage shall be as given below:

Side damage:

| Type | Length of a ship | Longitudinal extent | Transverse extent | Vertical extent |
|---|---|---|---|---|
| 1 | $24 \le L \le 43$ m | $0,1L$ | 760 mm (measured inboard from the ship's side at right angles to the centreline at the level of the summer load line[1]) | From the underside of the cargo deck, or continuation thereof, downward for the full depth of the ship |
| 2 | $43 < L < 80$ m | 3 m + $0,03\,L$ | 760 mm (measured inboard from the ship's side at right angles to the centreline at the level of the summer load line) | From the underside of the cargo deck, or continuation thereof, downward for the full depth of the ship |
| 3 | $80 \le L \le 100$ m | $1/3L^{2/3}$ | $B/20$, but not less than 760 mm (measured inboard from the ship's side at right angles to the centreline at the level of the summer load line) | From the underside of the cargo deck, or continuation thereof, downward for the full depth of the ship |
| 4 | $L > 100$ m | $1/3L^{2/3}$ | $B/15$, but not less than 760 mm (measured inboard from the ship's side at right angles to the centreline at the level of the summer load line) | From the underside of the cargo deck, or continuation thereof, downward for the full depth of the ship |

[1] As specified in LL66.

**31.3.3.8** Standard of damage.

Ships shall be capable of surviving damage with the assumptions in 31.3.3.7 determined by the following standards:

**.1** a ship that carries more than 150 m$^3$ of ship type 1 products shall be assumed to sustain damage described in 31.3.3.7.1 anywhere along the length;

**.2** a ship with a length ($L$) greater than 150 m that carries more than 1200 m$^3$ of ship types 2 and 3 products shall be assumed to sustain damage described in 31.3.3.7.1 anywhere along the length;

**.3** a ship with a length ($L$) of 150 m or less that carries more than 1200 m$^3$ of ship types 2 or 3 products as well as a ship that carries not more than 150 m$^3$ of ship type 1 products shall be assumed to sustain damage described in 31.3.3.7.1 anywhere along the length except involving bulkheads bounding a machinery space of category A;

**.4** a ship with a length ($L$) greater than 100 m that carries 800 m$^3$ or more but not more than 1200 m$^3$ of ship types 2 and 3 products as well as a ship that carries not more than 150 m$^3$ of ship type 1 products shall be assumed to sustain damage described in 31.3.3.7.2 anywhere along the length;

**.5** a ship with a length ($L$) of 100 m or less that carries 800 m$^3$ or more but not more than 1200 m$^3$ of ship types 2 and 3 products and carries not more than 150 m$^3$ of ship type 1 products shall be assumed to sustain damage described in 31.3.3.7.2 anywhere along the length;

**.6** a ship with a length ($L$) greater than 100 m that carries less than 800 m$^3$ of ship type 2 or 3 products as well as a ship that carries not more than 150 m$^3$ of ship type 1 products shall be assumed to sustain damage described in 31.3.3.7.2 anywhere along the length between transverse watertight bulkheads;

**.7** a ship with a length ($L$) of 100 m or less that carries not more than 800 m$^3$ of ship types 2 or 3 products as well as a ship that carries not more than 150 m$^3$ of ship type 1 products shall be assumed to sustain damage described in 31.3.3.7.2 anywhere along the length between transverse watertight bulkheads.

**31.3.3.9** Survival requirements.

**31.3.3.9.1** Ships subject to this Section shall be capable of surviving the assumed damage specified in 31.3.3.7 to the standard provided in 31.3.3.8 in a condition of stable equilibrium and shall satisfy the following criteria.

**31.3.3.9.2** For ships subject to 31.3.3.7.1:

**.1** in any stage of flooding:

**.1.1** the waterline, taking into account sinkage, heel and trim, shall be below the lower edge of any opening through which progressive flooding or downflooding may take place. Such openings shall include air pipes and openings which are closed by means of weathertight doors or hatch covers and may exclude those openings closed by means of watertight manhole covers and watertight flush scuttles, small watertight cargo tank hatch covers which maintain the high integrity of the deck, remotely operated watertight sliding doors, and side scuttles of the non-opening type;

**.1.2** the maximum angle of heel due to unsymmetrical flooding shall not exceed 25°, except that this angle may be increased to 30° if no deck immersion occurs; and

**.1.3** the residual stability during intermediate stages of flooding shall never be significantly less than that required by 31.3.3.9.2.1.2;

**.2** at final equilibrium after flooding:

**.2.1** the righting-lever curve shall have a minimum range of 20° beyond the position of equilibrium in association with a maximum residual righting lever of at least 0,1 m within the 20° range; the area under the curve within this range shall not be less than 0,0175 m·radians. Unprotected openings shall not be immersed within this range unless the space concerned is assumed to be flooded. Within this range, the immersion of any of the openings listed in 31.3.3.9.2 and other openings capable of being closed weathertight may be permitted; and

**.2.2** the emergency source of power shall be capable of operating.

**31.3.3.9.3** For ships subject to 31.3.3.7.2:

**.1** the final waterline, taking into account sinkage, heel and trim, shall be below the lower edge of any opening through which progressive flooding may take place. Such openings shall include air pipes and openings which are closed by means of weathertight doors or hatch covers and may exclude those openings closed by means of watertight manhole covers and watertight flush scuttles, small watertight cargo tank hatch covers which maintain the high integrity of the deck, remotely operated watertight sliding doors, and side scuttles of the non-opening type;

**.2** in the final stage of flooding, the angle of heel due to unsymmetrical flooding shall not exceed 15°. This angle may be increased up to 17° if no deck immersion occurs; and

**.3** the stability in the final stage of flooding shall be investigated and may be regarded as sufficient if the righting-lever curve has, at least, a range of 20° beyond the position of equilibrium in association with a maximum residual righting lever of at least 100 mm within this range. Unprotected openings shall not become immersed at an angle of heel within the prescribed minimum range of residual stability unless the space in question has been included as a floodable space in calculations for damage stability. Within this range, immersion of any openings referred to in 31.3.3.9.3.1 and any other openings capable of being closed weather tight may be authorized.

**31.3.4 Piping.**

**31.3.4.1** Cargo piping shall not pass through any accommodation, service spaces or machinery spaces of category A.

**31.3.4.2** If cargo piping systems or cargo venting systems are required to be separated, this separation may be achieved by the use of design or operational methods. Operational methods shall not be used within a cargo tank or a cofferdam surrounding the cargo tanks, if entry into the cofferdam is required, and shall consist of one of the following types:

**.1** removing spool pieces, valves or other piping components and blanking the pipe ends;

**.2** arrangements of two spectacle flanges in series, with provisions for detecting leakage into the pipe between the two spectacle flanges; and

**.3** blind flange valve with double shut-off and with provisions for detecting leakage in valve body.

**31.3.4.3** Pumps, ballast lines, vent lines and other similar equipment serving ballast tanks shall be separated from similar equipment serving cargo tanks and of cargo tanks themselves.

**31.3.4.4** Piping scantlings.

**31.3.4.4.1** The walls thickness of pipes in the cargo piping system shall be in accordance with the requirements of 2.3 in Part VIII "Systems and Piping".

**31.3.4.4.2** Pumps, fittings and piping of the cargo piping system shall be designed to withstand the maximum pressure that is likely to be created in service, taking into account the highest set of pressure on any relief valve on the system.

Piping and piping system components which are not protected against excess pressure by a relief valve, or which may be isolated from their relief valve shall be designed to withstand a pressure which is maximum possible in service, with due regard for:

**.1** pressure in cargo tank;

**.2** the maximum delivery pressure of the associated pump and pressure setting of the associated relief valve;

**.3** the maximum possible total pressure head output at the outlet of the associated pumps connected with pipeline when pump discharge relief valves are not installed;

**.4** the saturated vapor pressure of the products being carried corresponding to maximum expected temperature of carriage, but not less than 45 °C;

**.5** the maximum hydrostatic head which may take place during normal cargo handling operations.

**31.3.4.4.3** The design pressure shall not be less than 1 MPa except for open-ended lines, where it shall be not less than 0,5 MPa.

**31.3.4.4.4** For pipes, the allowable stress to be considered in the strength calculations is the lowest of the following values:

$R_m/A$ or $R_e/B$,

where $R_m$ = specified minimum tensile strength at ambient temperature (N/mm$^2$);
$R_e$ = specified minimum yield strength at ambient temperature (N/mm$^2$). If the stress/strain curve does not show a defined yield stress, the 0,2 % proof stress applies.

$A$ and $B$ shall have values of at least $A$ = 2,7 and $B$ = 1,8.

**31.3.4.4.4.1** The minimum pipe wall thickness values shall comply with recognized standards.

**31.3.4.4.4.2** Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipes due to weight of pipes and content and to superimposed loads from supports, ship deflection or other causes, the wall thickness shall be increased. If this is impracticable or would cause excessive local stress, these loads shall be reduced, protected against or eliminated by other design methods.

**31.3.4.4.4.3** For flanges, valves and other fittings, compliance with recognized standards shall be ensured, considering the design pressure, as specified in 31.3.4.4.2.

**31.3.4.4.4.4** For flanges not complying with the standards, their dimensions and fixing shall be agreed with the Register.

**31.3.4.4.5** After assembly, each cargo piping system shall be subject to a hydrostatic test to at least 1,5 times the design pressure. When piping systems or parts of systems are completely manufactured and equipped with all fittings, the hydrostatic test may be conducted prior to installation aboard the ship. Joints welded on board shall be hydrostatically tested to at least 1,5 times the design pressure.

**31.3.5 Cargo piping arrangement.**

**31.3.5.1** Cargo piping shall not be installed under deck between the outboard side of the cargo-containment spaces and the skin of the ship unless clearances required for damage protection are maintained in accordance with 31.3.1.

Such distances may be reduced where damage to the pipe would not cause release of cargo provided that the clearance required for inspection purposes is maintained.

**31.3.5.2** Cargo piping located below the main deck may run from the tank it serves and penetrate tank bulkheads or boundaries common to longitudinally or transversally adjacent cargo tanks, ballast tanks, empty tanks, pump-rooms or cargo pump-rooms provided that inside the tank it serves it is fitted with a stop valve operable from the weather deck and provided cargo compatibility in adjacent tanks is assured.

Where a cargo tank is adjacent to cargo pump-room (CPR), the stop valve operable from the weather deck may be situated on the tank bulkhead on the CPR side, provided an additional valve is fitted between the bulkhead valve and the cargo pump.

A totally enclosed hydraulically operated valve located outside the cargo tank may be accepted, provided that the valve is:

**.1** designed to preclude the risk of cargo leakage;
**.2** fitted on the bulkhead of the cargo tank which it serves;
**.3** suitably protected against mechanical damage;
**.4** fitted at a distance from the shell as required for damage protection; and
**.5** operable from the weather deck.

**31.3.5.3** In cargo pump-room where a cargo pump serves more than one cargo tank, a stop valve shall be fitted in the spool pieces to each tank.

**31.3.5.4** Cargo piping shall not pass through a tank with incompatible cargo. In this case, piping shall be installed in pipe tunnel.

**31.3.5.5** Cargo pipeline installed in pipe tunnels shall comply with the requirements of 31.3.5.1 and 31.3.5.2. Pipe tunnels shall satisfy all tank requirements for construction, location, ventilation and safety of electrical equipment.

Cargo piping intended for incompatible cargoes shall not be installed in a common pipe tunnel.

The pipe tunnel shall not have any other openings except to the weather deck and CPR.

**31.3.5.6** Cargo piping passing through bulkheads shall be so arranged as to preclude excessive stresses at the bulkhead. Cargo piping passing through bulkheads shall not utilize flanges bolted through the bulkhead.

**31.3.5.7** Filling and discharge sections of the cargo piping shall reach the bottom of cargo tanks with a minimum possible clearance dictated by the service conditions of cargo piping system and special requirements for cargo.

**31.3.5.8** Cargo piping serving tanks in which incompatible cargoes are carried shall be disconnected from such tanks by means of removable spool pieces and blank flanges.

No removable spool pieces shall be replaced by stop valves (single or double) and by spectacle flanges.

**31.3.5.9** An arrangement shall be provided or cargo piping shall be installed with a permanent slope to ensure draining of the cargo contained in pumps and cargo piping into the cargo tank or another special tank.

**31.3.6 Cargo transfer control systems**.

**31.3.6.1** For the purpose of controlling cargo handling operations, piping shall be provided with:

**.1** one stop valve capable of being manually operated regardless of remote control available on each filling and discharge line, located near the tank penetration;

**.2** one stop valve at each cargo hose connection;

If deep well pumps are used to discharge the contents of cargo tanks, stop valves are not required on the discharge lines.

**.3** remote shutdown devices for all cargo pumps and similar equipment which shall be capable of being activated from a dedicated cargo control location and which is manned at the time of cargo transfer and from at least one other location outside the cargo area and at a safe distance from it. Cargo controls located in the ship wheelhouse are acceptable as one of the cargo control locations.

**31.3.6.2** For certain products, additional cargo-transfer control requirements are shown in column "o" in the table of chapter 17 of the IBC Code.

**31.3.6.3** Pump discharge pressure gauges or readouts shall be provided outside the cargo pump-room.

**31.3.7 Ship's cargo hoses.**

Ship's cargo hoses shall comply with the requirements in 1.8 of Part VI "Systems and Piping" of the Rules for the Classification and Construction of Chemical Tankers[1].

[1] Hereinafter, the Chem Rules.

**31.3.8 Cargo tank venting.**

OSV venting system shall comply with the requirements in Section 4 of Part VI "Systems and Piping" of the Chem Rules.

**31.3.9 Cargo tank gas freeing.**

**31.3.9.1** The arrangements for gas freeing cargo tanks used for cargoes other than those for which open venting is permitted shall be such as to minimize the hazards due to the dispersal of flammable or toxic vapors in the atmosphere and to flammable or toxic vapour mixtures in a cargo tank. Accordingly, gas freeing operations shall be carried out such that vapour is initially discharged:

**.1** through the venting outlets directing the vapour discharge upwards in the form of unimpeded jets and positioned at a height of not less than 6 m above the weather deck. The outlet height referred above may be reduced to 3 m above the weather deck provided that high-velocity venting valves of an approved type with an exit velocity of at least 30 m/s are fitted; or

**.2** through outlets located at least 2 m above the cargo tank deck, with a vertical discharge velocity of at least 30 m/s, maintained throughout the venting operation; or

**.3** through outlets located at least 2 m above the cargo tank deck, with a vertical discharge velocity of at least 20 m/s, protected by suitable devices to prevent flame propagation.

When the flammable vapor concentration at the outlets reaches 30 % of the lower flammable limit or, in the case of toxic products, the vapor concentration reaches a value which does not present a significant health risk, venting may be continued at cargo tank deck level.

**31.3.9.2** Outlets specified in 31.3.9.1.2 and 31.3.9.1.3 may be either fixed or removable pipes.

**31.3.9.3** Fans used for the gas freeing systems shall meet the requirements of 8.8 in Part VI "Systems and Piping" of the Chem Rules.

**31.3.10 Electrical equipment.**

**31.3.10.1** The electrical equipment shall comply with the requirements of Part VII "Electrical Equipment" of the Chem Rules.

**31.3.11 Fire-fighting requirements.**

**31.3.11.1** Requirements in this Chapter shall apply to OSVs carrying liquid cargo having a flashpoint not exceeding 60 °C.

**31.3.11.2** A liquid cargo with a flashpoint of less than 60 °C for which a regular foam fire-fighting system is not effective, is considered to be a cargo introducing additional fire hazards in this Chapter. The following additional measures are required:

**.1** the foam shall be of alcohol-resistant type;

**.2** the type of foam concentrates for use in OSVs shall be to the satisfaction of requirements set out in 3.7.1.2 of Part VI "Fire Protection"; and

**.3** the rate of supply of foam solution shall be not less than the greatest of the following:

**.3.1** 2 l/min per square metre of the cargo tanks deck area, where cargo tanks deck area means the maximum breadth of the ship times the total longitudinal extent of the cargo tank spaces;

**.3.2** 20 l/min per square metre of the horizontal sectional area of the single tank having the largest such area;

**.3.3** 10 l/min per square metre of the area protected by the largest monitor of the highest capacity and being entirely forward of the monitor. The capacity thereof shall be at least 1250 l/min.

**31.3.11.3** Applicators shall be provided for flexibility of action during fire-fighting operations and to cover areas screened from the monitors. The capacity of any applicator shall be not less than 400 l/min and the applicator throw in still air conditions shall be not less than 15 m. The number of foam applicators provided shall be not less than four. The number and disposition of foam main outlets shall be such that foam from at least two applicators can be directed to any part of the cargo tanks deck area.

**31.3.11.4** For OSVs fitted with inert gas systems, a quantity of foam concentrate sufficient for 20 min of foam generation may be accepted.

**31.3.11.5** A liquid cargo with a vapor pressure above 0,1 MPa at a temperature of 37,8 °C is considered as a cargo posing an additional fire hazard. Ships transporting such cargo shall meet the following requirements:

**.1** for a cargo referenced in column "o" in the table of chapter 17 of the IBC Code to section 15.14 of the IBC Code, a mechanical refrigeration system shall be provided unless the cargo system is designed to withstand the vapour pressure of the cargo at 45 °C. Where the cargo system is designed to withstand the vapour pressure of the cargo at 45 °C, and no refrigeration system is provided, a notation shall be made in the conditions of carriage on the International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk to indicate the required relief-valve setting for the tanks;

**.2** the mechanical refrigeration plant shall maintain the temperature of the liquid cargo below its boiling point at the design pressure in the cargo tank;

**.3** connections shall be provided for the recirculation of gases evaporated during loading to the shore system.

**.4** each tank shall be equipped with a pressure gauge showing the pressure in the vapor space above the cargo;

**.5** when cargo needs to be cooled, thermometers shall be provided at the top and bottom of each tank.

**31.3.11.6** When the hydrocarbon gas concentration reaches a pre-set level which shall not be higher than 10 % of the lower flammable limit, a continuous audible and visual alarm signal shall be automatically effected in the pump-room and cargo control room to alert personnel to the potential hazard. However, existing monitoring systems already fitted having a pre-set level not greater than 30 % of the lower flammable limit may be accepted.

**31.3.11.7** Where the fitting of a navigation position above the cargo area is shown to be necessary, it shall be for navigation purposes only and it shall be separated from the cargo tank deck by means of an open space with a height of at least 2 m. The fire protection requirements for such a navigation position shall be those required for control stations, as specified in regulation 9.2.4.2 of part C of chapter II-2 of SOLAS-74 and other provisions for tankers, as applicable.

**31.3.11.8** Means shall be provided to keep deck spills away from the accommodation and service areas. This may be accomplished by provision of a permanent continuous coaming of a height of at least 300 mm, extending from side to side. Special consideration shall be given to the arrangements associated with stern loading.

**31.3.11.9** Where there is permanent access from the pipeline tunnel to the main pump-room, a sliding door, remotely closed from the bridge, shall be installed. Indicators showing whether the door is open or closed and an audible alarm indicating that the door is closed shall be provided at the control station. The power source, controls and indicators shall be operable in the event of failure of the main power source. The door shall be fitted with an individual manual actuator to ensure the possibility of opening and closing the door manually from both sides.

**31.3.11.10** Inerting, purging and gas freeing.

**31.3.11.10.1** Arrangements for purging and/or gas freeing shall be such as to minimize the hazards due to dispersal of flammable vapors in the atmosphere and to flammable mixtures in a cargo tank.

**31.3.11.10.2** The arrangements for inerting, purging or gas freeing of empty tanks shall be to the satisfaction of the Register and shall be such that the accumulation of hydrocarbon vapors in pockets formed by the internal structural members in a tank is minimized and that:

**.1** on individual cargo tanks, the gas outlet pipe, if fitted, shall be positioned as far as practicable from the inert gas/air inlet. The inlet of such outlet pipes may be located either at deck level or at not more than 1 m above the bottom of the tank;

**.2** the cross-sectional area of such gas outlet pipe referred above shall be such that an exit velocity of at least 20 m/s can be maintained when any three tanks are being simultaneously supplied with inert gas. Their outlets shall extend not less than 2 m above deck level; and

**.3** each gas outlet referred to in 31.3.11.10.2.2 shall be fitted with suitable blanking arrangements.

**31.3.11.11** Cargo area protection.

Drip pans for collecting cargo residues in cargo lines and hoses shall be provided in the area of pipe and hose connections under the manifold area. Cargo hoses and tank washing hoses shall have electrical continuity over their entire lengths, including couplings and flanges (except shore connections), and shall be earthed for removal of electrostatic charges.

**31.3.11.12** Protection of cargo pump-rooms.

**.1** cargo pumps, ballast pumps and stripping pumps, installed in cargo pump-rooms and driven by shafts passing through pump-room bulkheads shall be fitted with temperature sensing devices for bulkhead shaft glands, bearings and pump casings. A continuous audible and visual alarm signal shall be automatically effected in the cargo control room or the pump control station;

**.2** lighting in cargo pump-rooms, except emergency lighting, shall be interlocked with ventilation such that the ventilation shall be in operation when switching on the lighting. Failure of the ventilation system shall not cause the lighting to go out;

**.3** a system for continuous monitoring of the concentration of hydrocarbon gases shall be fitted. Sampling points or detector heads shall be located in suitable positions in order that potentially dangerous leakages are readily detected. When the flammable vapour concentration reaches a pre-set level, which shall not be higher than 10 % of the lower flammable limit, a continuous audible and visual alarm signal shall be automatically effected in the pump-room, engine control room, cargo control room and navigation bridge to alert personnel to the potential hazard; and

**.4** all pump-rooms shall be provided with bilge level monitoring devices together with appropriately located alarms.

**31.3.11.13** Closing appliances and stopping devices of ventilation.

**31.3.11.13.1** The main inlets and outlets of all ventilation systems shall be capable of being closed from outside the spaces being ventilated. The means of closing shall be easily accessible as well as prominently and permanently marked and shall indicate whether the shut-off is open or closed.

**31.3.11.13.2** Power ventilation of accommodation spaces, service spaces, cargo spaces, control stations and machinery spaces shall be capable of being stopped from an easily accessible position outside the space being served. This position shall not be readily cut off in the event of a fire in the spaces served.

**31.3.11.14** Means of control in machinery spaces.

**31.3.11.14.1** Means of control shall be provided for opening and closing the skylights, closing the openings in funnels which normally allow exhaust ventilation, and for closing the ventilator dampers.

**31.3.11.14.2** Means of control shall be provided for stopping the fans. The controls for power ventilation serving the machinery spaces shall be grouped in such a way that the controls can be operated from two positions, one of which shall be outside such spaces. Means for stopping the power ventilation of the machinery spaces shall be entirely separate from the means provided for stopping ventilation of other spaces.

**31.3.11.14.3** Means of control shall be provided for stopping forced and induced draft fans, oil fuel transfer pumps, oil fuel unit pumps, lubricating oil service pumps, thermal oil circulating pumps and oil separators (purifiers).

**31.3.11.14.4** The controls required in 31.3.11.14.1 — 31.3.11.14.3 shall be located outside the space they serve so they will not be cut off in the event of fire in that space.

**31.3.11.15** Materials.

**31.3.11.15.1** Insulating materials.

With the exception of cargo areas, post offices, baggage compartments and refrigerated store-rooms of service spaces, insulating materials shall be non-combustible. Vapor insulating coatings and adhesives used in conjunction with the insulation of cooling water pipes of air conditioning and cooling systems designed to prevent condensation, and the insulation of fittings, shaped elements and connections of these pipelines may be flammable, but their quantity shall be kept to a reasonable minimum and their exposed surfaces shall have slow flame spread characteristics.

**31.3.11.15.2** Ceilings and linings.

On OSVs, all linings, ceilings, draught stops and their associated grounds shall be made of non-combustible materials in the following spaces:

**.1** in accommodation and service spaces and control stations, in the case of ships for which IC method is specified; and

**.2** in corridors and stairway enclosures which serve accommodation, service and control spaces, in the case of ships for which IIC and IIIC methods are specified.

**31.3.11.15.3** On OSVs, non-combustible bulkheads, ceilings and linings fitted in accommodation and service spaces may be faced with combustible materials, facings, mouldings, decorations and veneers provided such spaces are bounded by non-combustible bulkheads, ceilings and linings.

**31.3.11.15.4** The properties of combustible materials and their extent in the ship's spaces shall be in accordance with 2.1 of Part VI "Fire Protection".

**31.3.11.16** Detection and alarm.

**31.3.11.16.1** Protection of machinery spaces.

**31.3.11.16.1.1** Installation.

A fixed fire detection and fire alarm system shall be installed in:

**.1** periodically unattended machinery spaces;

**.2** machinery spaces where:

**.2.1** the installation of automatic and remote control systems and equipment has been approved in lieu of continuous manning of the space; and

.**2.2** the main propulsion and associated machinery, including the main sources of electrical power, are provided with various degrees of automatic or remote control and are under continuous manned supervision from a control room; and

**.3** enclosed spaces containing incinerators.

The requirements for components of the fixed fire detection and fire alarm system are stated in 4.2.1.4 of Part VI "Fire Protection".

**31.3.11.17** Protection of accommodation and service spaces and control stations.

**31.3.11.17.1** Smoke detectors in accommodation spaces.

Smoke detectors shall be installed in all stairways, corridors and escape routes within accommodation spaces. Consideration shall be given to the installation of special purpose smoke detectors within ventilation ducting.

**31.3.11.17.2** The accommodation and service spaces and control stations of OSVs shall be protected by a fixed fire detection and fire alarm system and/or an automatic sprinkler system and fire detection and fire alarm system, depending on the method of protection:

**.1** when method IC is used: a fixed fire detection and fire alarm system shall be so installed and arranged as to provide smoke detection in all corridors, stairways and escape routes within accommodation spaces;

**.2** when method IIC is used: a fixed fire detection and fire alarm system shall be so installed and arranged as to provide smoke detection in all corridors, stairways and escape routes within accommodation spaces. In addition, an automatic sprinkler system shall be so installed and arranged as to protect accommodation spaces, galleys and other service spaces except spaces posing no substantial fire risk such as void spaces, sanitary spaces, etc.;

**.3** when method IIIC is used: a fixed fire detection and fire alarm system shall be so installed and arranged as to detect the presence of fire in all accommodation and service spaces, providing smoke detection in corridors, stairways and escape routes within accommodation spaces, except spaces posing no substantial fire risk such as void spaces, sanitary spaces, etc. In addition, a fixed fire detection and fire alarm system shall be so installed and arranged as to provide smoke detection in all corridors, stairways and escape routes within accommodation spaces. However, there is no need to provide fixed fire detection and fire alarm system in service spaces built away from the accommodation block.

**31.3.11.18** Manually operated call points shall comply with 4.2.2 of Part VI "Fire Protection".

**31.3.11.19** Measures for preventing flame and smoke spread shall meet the requirements in 2.1.4 of Part VI "Fire Protection".

**31.3.11.20** Structural fire protection.

**31.3.11.20.1** Protection methods within accommodation spaces.

In way of accommodation and service spaces and control stations one of the following methods of protection shall be adopted:

**.1** method IC: construction of internal subdivision bulkheads of non-combustible "B" or "C" class divisions, generally without installation in the accommodation and service spaces of the automatic sprinkler fire extinguishing system and fire detection and fire alarm system;

**.2** method IIC: the fitting of an automatic sprinkler system and fire detection and fire alarm system in all spaces in which fire might be expected to originate, generally with no restriction on the type of internal bulkheads;

**.3** method IIIC: the fitting of a fixed fire detection and fire alarm system of approved type complying with requirements of 4.1 and 4.2 of Part VI "Fire Protection" in spaces where fire might develop, generally with no restriction on the class of internal subdivision bulkheads, except that in no case shall the area of any accommodation space bounded by "A" or "B" class division exceeds 50 $m^2$. The Register may consider increasing this area for public spaces.

**31.3.11.20.2** The bulkheads within the area of accommodation spaces shall comply with 2.3.5 of Part VI "Fire Protection".

**31.3.11.20.3** Fire integrity of bulkheads and decks shall meet the requirements in 2.3.3 of Part VI "Fire Protection".

**31.3.11.20.4** Continuous "B" class ceilings or linings, in association with the relevant decks or bulkheads, may be accepted as contributing, wholly or in part, to the required insulation and integrity of a division.

**31.3.11.20.5** External boundaries which are required in regulation 11.2 to be of steel or other equivalent material may be pierced for the fitting of windows and side scuttles provided that there is no requirement for such boundaries of OSVs to have "A" class integrity. Similarly, in such boundaries which are not required to have "A" class integrity.

**31.3.11.20.6** Saunas shall comply with the requirements in 31.3.11.20.5.

**31.3.11.20.7** Protection of stairways and lift trunks in accommodation and service spaces as well as in control stations shall meet the requirements in 2.1.4.3 of Part VI "Fire Protection".

**31.3.11.20.8** Penetrations in fire-resisting divisions shall meet the requirements in 2.1.3.3 — 2.1.3.5 of Part VI "Fire Protection".

**31.3.11.20.9** Doors in fire-resisting divisions of OSVs shall meet the requirements in 2.1.3.1, 2.3.7, 2.3.8 of Part VI "Fire Protection".

**31.3.11.20.10** Watertight doors need not be insulated.

**31.3.11.20.11** Protection of openings in boundary structures of machinery spaces shall meet the requirements in 2.1.4.2 of Part VI "Fire Protection".

**31.3.11.20.12** Ventilation systems.

Design and arrangement of ventilation ducts shall meet the requirements in 12.1.11 — 12.1.19 of Part VIII "Systems and Piping".

**31.3.11.20.13** Exhaust ducts from galley ranges shall meet the requirements in 12.3.6 of Part VIII "Systems and Piping".

**31.3.11.21** Water fire main system.

**31.3.11.21.1** OSVs water fire main system shall comply with 3.2 of Part VI "Fire Protection".

**31.3.11.21.2** During cargo transfer, water pressure shall be maintained in the fire main system.

**31.3.11.21.3** Materials readily rendered ineffective by heat shall not be used for fire mains and hydrants unless adequately protected. The pipes and hydrants shall be so placed that the fire hoses may be easily coupled to them. The arrangement of pipes and hydrants shall be such as to avoid the possibility of freezing. Suitable drainage provisions shall be provided for fire main piping. Isolation valves shall be installed for all open deck fire main branches used for purposes other than firefighting. In ships where deck cargo may be carried, the positions of the hydrants shall be such that they are always readily accessible and the pipes shall be arranged as far as practicable to avoid risk of damage by such cargo.

**31.3.11.21.3** Ventilation of emergency fire pump-room.

Ventilation arrangements to the space containing the independent source of power for the emergency fire pump shall be such as to preclude, as far as practicable, the possibility of smoke from a machinery space fire entering or being drawn into that space.

**31.3.11.21.4** Additional fire pumps for OSVs.

In addition, in OSVs where other pumps, such as general service, bilge and ballast, etc., are fitted in a machinery space, arrangements shall be made to ensure that at least one of these pumps, having the capacity and pressure required by 3.2.1.1 and 3.2.1.10 of Part VI "Fire Protection" is capable of providing water to the fire main.

**31.3.11.22** Fire hoses and monitors shall meet the requirements in 5.1 of Part VI "Fire Protection".

**31.3.11.23** The arrangement and number of portable fire extinguishers and their spare charges shall meet the requirements in 5.1.9 — 5.1.11 of Part VI "Fire Protection".

**31.3.11.24** Fixed fire extinguishing systems.

**31.3.11.24.1** Depending on purpose, in addition to water fire main system OSV spaces shall be protected by one of the following fixed fire extinguishing systems:

**.1** a fixed gas fire extinguishing system complying with the provisions of the Fire Safety Systems Code;

**.2** a fixed high-expansion foam fire extinguishing system complying with the provisions of the Fire Safety Systems Code; and

**.3** a fixed pressure water-spraying fire extinguishing system complying with the provisions of the Fire Safety Systems Code.

**31.3.11.24.2** The Register may consider the use of other equivalent systems that provide equal protection.

**31.3.11.24.3** Fire extinguishing systems using Halon 1211, Halon 1301 and Halon 2402 and perfluorocarbons shall be prohibited.

**31.3.11.24.4** Where a fixed gas fire extinguishing system is used, openings which may admit air to, or allow gas to escape from, a protected space shall be capable of being closed from outside the protected space.

**31.3.11.24.5** Pumps, other than those serving the fire main, required for the provision of water for fixed fire extinguishing systems, their sources of power and their controls shall be installed outside the spaces protected.

**31.3.11.25** Fire extinguishing means in machinery spaces.

**31.3.11.25.1** Machinery spaces of category A shall be provided with one of the fixed fire extinguishing systems specified in 31.3.11.24.1.

**31.3.11.25.2** Additional fire extinguishing arrangements.

**31.3.11.25.2.1** There shall be at least one portable foam applicator unit complying with the provisions of the Fire Safety Systems Code.

**31.3.11.25.2.2** There shall be in each such space approved foam-type fire extinguishers, each of at least 45 l capacity or equivalent, sufficient in number to enable foam or its equivalent to be directed onto any part of the fuel and lubricating oil pressure systems, gearing and other fire hazards. In addition, there shall be provided a sufficient number of portable foam extinguishers or equivalent which shall be so located that no point in the space is more than 10 m walking distance from an extinguisher and that there are at least two such extinguishers in each such space.

**31.3.11.25.3** Fixed local application fire extinguishing systems.

Fixed local application fire extinguishing systems shall comply with the requirements in 3.12 of Part VI "Fire Protection".

**31.3.11.26** Fixed gas fire extinguishing systems for dangerous goods.

A ship engaged in the carriage of dangerous goods in any cargo space shall be provided with a fixed gas fire extinguishing system complying with the provisions of the Fire Safety Systems Code or with a fire extinguishing system which, in the opinion of the Register, gives equivalent protection for the cargoes carried.

**31.3.11.27** Fire protection of cargo pump-rooms.

**31.3.11.27.1** Cargo pump-rooms of an OSV carrying both products with a flashpoint exceeding 60 °C and products with a flashpoint not exceeding 60 °C shall be provided with a fixed carbon dioxide fire extinguishing system. A notice shall be exhibited at the controls stating that the system is only to be used for fire extinguishing and not for inerting purposes, due to the electrostatic ignition hazard. The alarms shall be safe for use in a flammable cargo vapour/air mixture. For the purpose of this requirement, an extinguishing system shall be provided which would be suitable for machinery spaces. However, the amount of gas carried shall be sufficient to provide a quantity of free gas equal to 45 % of the gross volume of the cargo pump-room in all cases.

**31.3.11.27.2** Cargo pump-rooms of ships which are dedicated to the carriage of a limited amount of cargoes shall be protected by an appropriate fire extinguishing system approved by the Register.

**31.3.11.27.3** If the fire of cargoes to be carried cannot be extinguished by carbon dioxide or equivalent gas fire extinguishing system, the cargo pump-room shall be protected by a fire extinguishing system consisting of either a fixed pressure water-spraying system or high expansion foam system.

**31.3.11.28** Fire protection of cargo area.

**31.3.11.28.1** The system shall be located and sized to supply simultaneously foam to the deck area as defined in 31.1.2.7.3.3 — 31.1.2.7.3.5 and 31.1.2.7.3.7.

**31.3.11.28.2** All parts of the areas shall be protected by either fixed foam monitors or fixed nozzles or a combination of both.

**31.3.11.28.3** In case of foam monitors, one monitor may be sufficient and the distance from the monitor to the farthest extremity of the protected area shall not be more than 75 % of the monitor throw in still air conditions. The monitor(s) shall be in a location that is not above the cargo tanks and is readily accessible and operable in the event of fire in the areas protected.

**31.3.11.28.4** The deck foam system shall be capable of simple and rapid operation. The main control station for the system shall be suitably located outside of the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fires in the areas protected.

**31.3.11.28.5** Application rate shall be 10 l/min/$m^2$ with sufficient supply for at least 30 min for tanks without an overlying cofferdam and 20 min for tanks with an overlying cofferdam. Water supply to the fixed foam fire extinguishing system shall be in addition to the water supply required for the ship's fire main.

**31.3.11.28.6** The foam concentrates shall be compatible with the cargo carried.

**31.3.11.28.7** The ship shall carry in a readily available position, at cargo deck level, two portable foam applicator units with at least four portable 20 l containers with foam concentrate, for use with water supplied by the ship's fire main.

**31.3.11.29** Mechanical ventilation in the cargo area.

Ventilation system of spaces in the cargo area shall meet the requirements set out in Section 8 of Part VI "Systems and Piping" of the Chem Rules.

**31.3.11.30** Fireman's outfit.

The number of fireman's outfit sets, their extent and storage places shall comply with Table 5.1.2, 5.1.15 and Table 5.2.1 of Part VI "Fire Protection".

**31.3.11.30** Structural fire integrity.

Material of hull, superstructures, structural bulkheads, decks and deckhouses, machinery spaces shafts, deck plates shall meet the requirements in 2.1.1 of Part VI "Fire Protection".

**31.3.11.31** Notification and evacuation from control stations, accommodation and service spaces

**31.3.11.31.1** A general emergency alarm system shall be used for notifying crew and passengers of a fire.

**31.3.11.31.2** At least two widely separated means of escape shall be provided from all levels of accommodation spaces.

**31.3.11.31.3** Below the lowest open deck the main means of escape shall be a stairway and the second escape may be a trunk or a stairway.

**31.3.11.31.4** Above the lowest open deck the means of escape shall be stairways or doors to an open deck or a combination thereof.

**31.3.11.31.5** No dead-end corridors having a length of more than 7 m shall be accepted.

**31.3.11.31.6** The width, number and continuity of escape routes shall be in accordance with the requirements in the Fire Safety Systems Code.

**31.3.11.31.7** Dispensation from two means of escape.

Exceptionally, the Register may dispense with one of the means of escape, for crew spaces that are entered only occasionally, if the required escape route is independent of watertight doors.

**31.3.11.31.8** In all ships at least two emergency escape breathing device (EEBD) shall be carried within accommodation spaces.

**31.3.11.32** Means of escape from machinery spaces.

**31.3.11.32.1** Two escape routes from each category A machinery space in compliance with 4.5.10 — 4.5.12 of Part VII "Machinery Installations" shall be provided.

**31.3.11.32.2** Machinery spaces of all ships shall be provided with ready-to-use EEBDs for emergency evacuation, placed in clearly visible locations that are easily accessible at all times in the event of fire. The number and location of EEBDs shall be indicated in the fire protection diagram.

**31.3.12 Special requirements for products with a flashpoint not exceeding 60 °C, toxic products and acids.**

**31.3.12.1** General.

**31.3.12.1.1** Cargo tanks certified for products or residues of products subject to the provisions of this Chapter shall be segregated from machinery spaces, propulsion shaft tunnels, solid bulk cargo and underdeck access way if fitted, by means of a cofferdam, void space, cargo pump-room, empty tank or other similar space.

**31.3.12.1.2** Cargo tanks certified for products subject to the provisions of this Chapter shall be separated from the deck plating by cofferdams.

**31.3.12.1.3** Cargo piping shall not pass through any underdeck access way or machinery spaces.

**31.3.12.1.4** Discharge arrangements for ballast or fresh water sited immediately adjacent to cargo tanks certified for products or residues of products subject to the provisions of this Chapter shall be outside machinery spaces and accommodation spaces. Filling arrangements may be in the machinery spaces provided that such arrangements ensure filling from the main deck level and non-return valves are fitted.

**31.3.12.1.5** Bilge pumping systems serving spaces where cargoes or residues of cargoes may occur shall be independent from systems serving spaces outside such areas and shall be entirely situated within the area related to cargos subject to this Chapter. The bilge system serving these spaces shall be operable from outside the cargo area.

**31.3.12.1.6** In order to guard against the danger of hazardous vapors, due consideration shall be given to the location of air intakes and openings into accommodation, passageways, service and machinery spaces and control stations in relation to cargo piping and cargo vent systems as defined in 31.1.2.7.

**31.3.12.1.7** All access to cargo tanks, cofferdams, void spaces, cargo pump-rooms, pump-rooms, empty tanks, or other spaces adjacent to cargo tanks certified for products subject to the provisions of this Chapter, shall be direct from the open deck and such as to ensure their complete inspection. The dimensions of the accesses shall be in accordance with 31.3.1.8.

**31.3.12.2** Products with a flashpoint not exceeding 60 °C

**31.3.12.2.1** Unless they are located at least 7 m away from the deck area as defined in 31.1.2.7.3, air inlets and openings to accommodation, service and machinery spaces and control stations shall not face the cargo deck area. Doors to spaces not having access to accommodation, service and machinery spaces and control stations, such as cargo control stations and store-rooms, may be permitted within such deck area, provided the boundaries of the spaces are insulated to A-60 standard. When arranged within such deck area, windows and side scuttles facing the deck area shall be of a fixed (non-opening) type. Such side scuttles in the first tier on the main deck shall be fitted with inside covers of steel or equivalent material.

**31.3.12.3** Toxic products.

**31.3.12.3.1** Outlets of tank venting system shall be located as follows:

**.1** at a height of $B/3$ or 6 m, whichever is greater, above the weather deck or, in the case of a deck tank, the access gangway;

**.2** not less than 6 m above the fore-and-aft gangway, if fitted within 5 m of the gangway; and

**.3** 15 m from any opening or air intake to any accommodation and service spaces;

**.4** the vent height may be reduced to 3 m above the deck or fore-and-aft gangway, as applicable, provided high-velocity vent valves of a type approved by the Register, directing the vapor/air mixture upwards in an unimpeded jet with an exit velocity of at least 30 m/s, are fitted.

**31.3.12.3.2** Tank venting systems shall be provided with a connection for a vapour-return line to the shore installation.

**31.3.12.3.3** Tanks intended for transport of toxic products shall:

**.1** not be stowed adjacent to oil fuel tanks;

**.2** have separate piping systems; and

**.3** have tank vent systems separate from tanks containing non-toxic products.

**31.3.12.3.4** Cargo tank relief valve settings shall be a minimum of 0,2 bar gauge.

**31.3.12.3.5** Unless they are located at least 15 m away from the deck area as defined in 31.1.2.7.3, air inlets and openings to accommodation, service and machinery spaces and control stations shall not face the deck area. Doors to spaces not having access to accommodation, service and machinery spaces and control stations, such as cargo control stations and store-rooms, may be permitted within such deck area, provided the boundaries of the spaces have equivalent gas tightening to A-60 standard. Wheelhouse doors and wheelhouse windows may be located within the limits specified above so long as they are designed in such a way that a rapid and efficient gas- and vapour-tightening of the wheelhouse can be assured. Windows and side scuttles facing the deck area and on the sides of the superstructures and deckhouses within the limits specified above shall be of the fixed type. Such side scuttles in the first tier on the main deck shall be fitted with inside covers of steel or equivalent material.

**31.3.12.3.6** Cargo tanks certified to carry toxic products shall be fitted with fixed tank washing arrangements. Other arrangements allowing cleaning of the tank(s) without the need for personnel to enter during the cleaning process may be fitted, if proper safety equipment is used.

**31.3.12.3.7** The cargo deck area shall be such as to promote natural ventilation and to prevent toxic gas from accumulating in closed or partly closed spaces on deck. A high closed cargo rail in the stern is prohibited. However, if proper natural ventilation can be documented, a higher aft bulwark/cargo rail may be accepted.

**31.3.12.3.8** Means shall be provided to minimize the range of a possible leak in the hose landing area on the main deck. An example of such means is transverse gutter bars on both sides of the hose landing area in way of the loading stations.

**31.3.12.3.9** The set point of the pressure side of the P/V valves shall be set at a minimum 0,6 bar gauge.

**31.3.12.4** Acids.

**31.3.12.4.1** The ship's shell plating shall not form any boundaries of tanks containing mineral acids.

**31.3.12.4.2** Proposals for lining steel tanks and related steel piping systems with corrosion-resistant materials may be considered by the Register. The elasticity of the lining shall not be less than that of the supporting boundary plating.

**31.3.12.4.3** Unless constructed wholly of corrosion-resistant materials or fitted with an approved lining, the plating thickness shall take into account the corrosivity of the cargo.

**31.3.12.4.4** Flanges of the loading and discharge manifold connections shall be provided with shields, which may be portable, to guard against the danger of the cargo being sprayed; and in addition, drip trays shall also be provided to guard against leakage on to the deck.

**31.3.12.4.5** Because of the danger of evolution of hydrogen when these substances are being carried, the electrical arrangements shall comply with 20.11 of Part XI "Electrical Equipment". The certified safe type equipment shall be suitable for use in hydrogen/air mixtures. Other sources of ignition shall not be permitted in such spaces.

**31.3.12.4.6** Substances subjected to the requirements of this Section shall be segregated from oil fuel tanks.

**31.3.12.4.7** Provision shall be made for suitable apparatus to detect leakage of cargo into adjacent spaces.

**31.3.12.4.8** The cargo pump-room bilge pumping and drainage arrangements shall be of corrosion-resistant materials.

**31.3.12.4.9** Floors or decks under acid storage tanks and pumps and piping for acid shall have a lining or coating of corrosion-resistant material extending up to a minimum height of 500 mm on the bounding bulkheads or coamings. Hatches or other openings in such floors or decks shall be raised to a minimum height of 500 mm; however, where the compliance with this height requirement is not practicable, a lesser height may be accepted upon agreement with the Register.

**31.3.12.4.10** Flanges or other detachable pipe connections shall be covered by spray shields.

**31.3.12.4.11** Portable shield covers for connecting the flanges of the loading manifold shall be provided. Drip trays of corrosion-resistant material shall be provided under loading manifolds for acids.

**31.3.12.4.12** Spaces for acid storage tanks and acid pumping and piping shall be provided with drainage arrangements of corrosion-resistant materials.

**31.3.12.4.13** Deck spills shall be kept away from accommodation and service areas by means of a permanent coaming of suitable height and extension.

**31.3.13 Instrumentation and automation systems.**

**31.3.13.1** General.

**31.3.13.1.1** Each cargo tank shall be provided with a means for level indicating.

**31.3.13.1.2** If loading and unloading of the ship is performed by means of remotely controlled valves and pumps, all controls and indicators associated with a given cargo tank shall be concentrated in at least one cargo control station.

**31.3.13.1.3** Instruments shall be tested to ensure reliability under working conditions and recalibrated at regular intervals. Test procedures for instruments and the intervals between recalibration shall be in accordance with manufacturers' recommendations.

**31.3.13.2** Level indicators for cargo tanks.

**31.3.13.2.1** Each cargo tank shall be fitted with a liquid level gauging device or devices, arranged to ensure a level reading is always obtainable whenever the cargo tank is operational. The device(s) shall be designed to operate throughout the design pressure range of the cargo tank and at temperatures within the cargo operating temperature range.

**31.3.13.2.2** Where the installation of liquid level gauging devices are impractical due to the properties of the cargo, such as liquid muds, a visual means of indicating the cargo tank level shall be provided for cargo loading operations, subject to approval by the Register.

**31.3.13.2.3** Where only one liquid level gauge is fitted, it shall be arranged so that it can be maintained in an operational condition without the need to empty or gas free the tank.

**31.3.13.2.4** Cargo tank liquid level gauges may be of the following types, subject to special requirements for particular cargoes shown in column "j" in the table of chapter 17 of the IBC Code.

**.1** open device, which makes use of an opening in the tanks and may expose the gauge to the cargo or its vapor. An example of this is the ullage opening;

**.2** restricted device, which penetrates the tank and which, when in use, permits a small quantity of cargo vapour or liquid to be exposed to the atmosphere. When not in use, the device is completely closed. The design shall ensure that no dangerous escape of tank contents (liquid or spray) can take place in opening the device; and

**.3** closed device, which penetrates the tank but which is part of a closed system and keeps tank contents from being released. Examples are the float-type systems, electronic probe, magnetic probe and protected sight-glass. Alternatively, an indirect device which does not penetrate the tank shell and which is independent of the tank may be used. Examples are weighing of cargo and pipe flowmeter.

**31.3.13.3** Cargo overflow control.

**31.3.13.3.1** The provisions of this para are applicable where specific reference to chapter 15.19 of the IBC Code is made in column "o" in the table of chapter 17.

**31.3.13.3.2** In the event of a power failure on any system essential for safe loading, an alarm shall be given to the operators concerned.

**31.3.13.3.3** Loading operations shall be terminated at once in the event of any system essential for safe loading becoming inoperative.

**31.3.13.3.4** Level alarms shall be capable-of being tested prior to loading.

**31.3.13.3.5** The high-level alarm system required under 31.3.13.3.6 shall be independent of the overflow control system required by 31.3.13.3.7 and shall be independent of the cargo tank instrumentation.

**31.3.13.3.6** Cargo tanks shall be fitted with a visual and audible high-level alarm which complies with the requirements in 31.3.13.3.1 — 31.3.13.3.5 and which indicates when the liquid level in the cargo tank approaches the normal full condition.

**31.3.13.3.7** A tank overflow control system required by this Section shall:

**.1** come into operation when the normal tank loading procedures fail to stop the tank liquid level exceeding the normal full condition;

**.2** give a visual and audible tank overflow alarm to the ship's operator; and

**.3** provide an agreed signal for sequential shutdown of onshore pumps or ship's valves. The signal, as well as the pump and valve shutdown, may be dependent on operator's intervention. The use of shipboard automatic closing valves shall be permitted only when specific approval has been obtained from the Administration and the port State authority concerned.

**31.3.13.3.8** The loading rate ($LR$) of the tank shall not exceed:

$$LR = \frac{3600U}{t} \text{ m}^3\text{/h} \qquad (31.3.13.3.8)$$

where $U$ — ullage volume (m) at operating signal level;
$t$ — time (s) needed from the initiating signal to fully stopping the cargo flow into the tank, being the sum of times needed for each step in sequential operations such as operator's responses to signals, stopping pumps and closing valves;

and shall also take into account the pipeline system design pressure.

**31.3.14 Vapor detection.**

**31.3.14.1** Ships carrying toxic or flammable products or both shall be equipped with at least two instruments designed and calibrated for testing for the specific vapors in question. If such instruments are not capable of testing for both toxic concentrations and flammable concentrations, then two separate sets of instruments shall be provided.

**31.3.14.2** Vapor-detection instruments may be portable or fixed. If a fixed system is installed, at least one portable instrument shall be provided.

**31.3.14.3** Vapor-detection requirements for individual products are shown in column "k" in the table of chapter 17 of the IBC Code.

**31.3.15 Pollution prevention requirements**.

**31.3.15.1** Each ship certified to carry noxious liquid substances shall be provided with a Cargo Record Book, a Procedure and Arrangements Manual and a Shipboard Marine Pollution Emergency Plan developed for the ship in accordance with MARPOL 73/78 Annex II and approved by the Administration or an authorized entity on behalf of the Administration.

**31.3.15.2** Discharge into the sea of residues of noxious liquid substances permitted for carriage under this Section, tank washings, or other residues or mixtures containing such substances, is prohibited. Any discharges of residues and mixtures containing noxious liquid substances shall be to port reception facilities. As a consequence of this prohibition, there are no requirements for efficient stripping and underwater discharge arrangements in MARPOL 73/78 Annex II.

**31.3.16 Life-saving appliances and arrangements.**

**31.3.16.1** The scope, arrangement and design of life-saving appliances shall comply with the requirements of chapter III of SOLAS-74 for ships covered by SOLAS-74 as amended or, for ships not covered by SOLAS-74, Part II «Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships.

**31.3.16.2** In addition to para 31.3.16.1 OSVs carrying cargoes emitting toxic vapors or gases[1], shall carry, in lieu of totally enclosed lifeboats, lifeboats with a self-contained air support system.

**31.3.16.3** In addition to para 31.3.16.1, OSVs carrying cargoes having a flashpoint not exceeding 60 °C (closed-cup test) shall carry, in lieu of totally enclosed lifeboats, fire-protected lifeboats.

**31.3.17 Personnel protection.**

OSVs carrying dangerous cargoes having a reference in column "o" of the table in chapter 17 of the IBC Code to chapter 15.12 of the IBC Code shall be fitted with protection equipment complying with the requirements of Part X "Personnel Protection" of the Chem Rules.

**31.3.18 Backload of contaminated liquids in bulk.**

**31.3.18.1** Contaminated liquids in bulk shall be carried in accordance with the applicable minimum requirements for the carriage of contaminated liquids in bulk as specified in chapter 17 of the IBC Code or in the current version of MEPC.2/Circular.

**31.3.18.2** In addition to the provisions stated in 31.3.18.1, the carriage of contaminated liquids in bulk requires detection of hydrogen sulphide $H_2S$ and setting of a lower explosive limit (LEL) for gases as specified below:

**.1** by means of fixed vapour detection instruments with audible and visual alarms to indicate $H_2S$ and LEL levels exceeding 5 ppm and 10 % respectively, installed in the venting systems of the relevant tanks; and

**.2** by means of portable instruments for all personnel on the working deck.

**31.3.19 Discharging and loading of portable tanks on board.**

**31.3.19.1** General.

This Chapter shall apply when using offshore portable tanks.

Chemicals, including blending additives, transported in portable deck tanks which are considered to fall outside the scope of 31.1.1.3 may be carried in limited amounts. The aggregate amount of such chemicals which may be transported shall not exceed 10 % of the ship's maximum authorized quantity of products subject to the present Section. An individual tank shall contain not more than 10 m$^3$ of these chemicals. The discharge of these chemicals into the sea from OSVs is prohibited.

**31.3.19.2** Arrangement of deck spread.

**31.3.19.2.1** All pumping equipment, processing equipment, pipework, valves and hoses shall be compatible with the substances being transferred.

**31.3.19.2.2** Pipework connecting deck spread tanks to bulk tanks within the cargo area of the ship shall have two valve separation and shall comply with the provisions of 31.3.4.

**31.3.19.2.3** In addition to the cargo segregation required by 31.3.1 and 31.3.12, the general stowage and segregation requirements given in chapter 7 of the IMDG Code shall apply.

**31.3.19.2.4** Portable tank venting systems permitted in compliance with 31.3.1.6 shall meet the requirements of 31.3.8.

**31.3.19.2.5** Arrangements of products with a flashpoint not exceeding 60 °C, toxic products and acids shall comply with the provisions in 31.3.12, as applicable.

[1] Refer to the products for which emergency escape respiratory protection is required in chapter 17 of the IBC Code (IMO resolution MSC.4(48), as amended), and in chapter 19 of the IGC Code (IMO resolution MSC.5(48), as amended).

**31.3.19.2.6** Deck spills shall be kept away from accommodation and service areas by means of coamings of suitable height and extension.

**31.3.19.3** Shipment of cargo in portable tanks used as deck tanks.

**31.3.19.3.1** A procedure for the carriage of portable tanks shall be completed and submitted to the Administration or any organization recognized by it, for consideration and approval prior to arranging the deck spread.

**31.3.19.3.2** The portable tank shall be physically secured to the ship, in accordance with the ship's cargo securing manual to prevent loss in the event of an incident while at sea. The arrangements for securing the portable tanks to the ship shall be of such strength as to withstand the forces likely to be encountered during the voyage to and from the area of operation.

**31.3.19.3.3** The portable tank(s) and pumping system shall be monitored regularly on the sea passage to ensure the physical security of the portable tanks.

**31.3.19.3.4** The pipework and valves shall be secured to prevent movement.

**31.3.19.3.5** The loading and unloading of the portable tanks shall not be undertaken at the same time as other deck cargo is being handled.

**31.3.19.3.6** Portable tank(s) shall be filled through a manifold system.

**31.3.19.3.7** Discharge into the sea of portable tank contents, residues, tank washings, or other residues or mixtures containing such substances, is prohibited. Any discharges of residues and mixtures containing noxious liquid substances shall be to port reception facilities.

**31.3.20 Carriage of liquefied gases**.

**31.3.20.1** The provisions of this chapter shall apply when liquid carbon dioxide (high purity and reclaimed quality) and liquid nitrogen are carried.

**31.3.20.2** Liquid carbon dioxide (high purity and reclaimed quality) and liquid nitrogen shall be carried in accordance with the applicable minimum carriage requirements specified below.

**31.3.20.2.1** Nitrogen.

Materials of construction and ancillary equipment such as insulation shall be resistant to the effects of high oxygen concentrations caused by condensation and enrichment at the low temperatures attained in parts of the cargo system. Due consideration shall be given to areas where condensation may occur in order to avoid the stratification of oxygen-enriched atmosphere.

**31.3.20.2.2** Carbon dioxide: high purity.

**.1** Set pressure for the alarms and automatic actions described in this Section shall be set to at least 0,05 MPa above the triple point for the specific cargo being carried. The "triple point" for pure carbon dioxide occurs at 0,5 MPa gauge and −54,4 °C.

**.2** Means of isolating the cargo tank safety valves shall be provided. Discharge piping from safety relief valves shall be designed so they remain free from obstructions that could cause clogging. Protective screens shall not be fitted to the outlets of relief valve discharge piping.

**.3** Cargo tanks shall be continuously monitored for low pressure when a carbon dioxide cargo is carried. An audible and visual alarm shall be given at the cargo control position-and on the bridge. If the cargo tank pressure continues to fall to within 0,05 MPa of the "triple point" for the particular cargo, the monitoring system shall automatically close all cargo manifold liquid and vapour valves and stop all cargo compressors and cargo pumps.

**.4** All materials used in cargo tanks and cargo piping system shall be suitable for the lowest temperature that may occur in service.

**.5** Cargo hold spaces, cargo compressor rooms and other enclosed spaces where carbon dioxide could accumulate shall be fitted with continuous monitoring for carbon dioxide build-up.

**31.3.20.3** Accommodation, service and machinery spaces and control stations.

Unless they are located at least 7 m away from the deck area as defined in 31.1.2.7.2, entrances, air inlets and openings to accommodation, service and machinery spaces and control stations shall not face the cargo deck area. Doors to spaces not having access to accommodation, service and machinery spaces and control stations, such as cargo control stations and store-rooms, may be permitted within such deck area, provided the boundaries of the spaces have equivalent gas tightening to A-60 standard. Wheelhouse doors and wheelhouse windows may be located within the limits specified above as long as they are designed in such a way that a rapid and efficient gas and vapour tightening of the wheelhouse can be ensured. Windows and side scuttles facing the deck area and on the sides of the superstructures and deckhouses within the limits specified above shall be of the non-opening type. Such side scuttles in the first tier on the main deck shall be fitted with inside covers of steel or equivalent material.

**31.3.20.4** Design of cargo tanks.

Cargo tanks shall comply with Part IV "Cargo Containment" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk. Design and testing of tanks for liquid nitrogen shall comply with the requirements of Section 23 of Part IV "Cargo Containment" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk.

**31.3.20.5** Materials of construction.

Materials of construction shall comply with the requirements of Section 19 of Part IV "Cargo Containment" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk.

**31.3.20.6** Venting system for containment system.

Venting system for containment system shall comply with the requirements of 3.18, 5 and 12 of the Part VI of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk.

**31.3.20.7** Cargo transfer.

**.1** The cargo transfer system shall comply with the requirements of 3 of the Part VI of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk.

**.2** Drip trays resistant to cryogenic temperatures shall be provided at manifolds transferring liquefied gases or at other flanged connections in the liquefied gas system.

**31.3.20.8** Vapor detection.

Each enclosed space used for handling or storage of a liquefied gas shall be fitted with a sensor continuously monitoring the oxygen content of the space and an alarm indicating low oxygen concentration. For semi-enclosed spaces portable equipment may also be acceptable.

**31.3.20.9** Level measurement.

Level measurement arrangements shall comply with the requirements of Part VIII "Instrumentation and Automation Systems" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk.

**31.3.20.10** Emergency shutdown system.

Emergency shut-off valves shall be provided in liquid outlet lines from each liquefied gas tank. The controls for the emergency shut-off valves shall meet the provisions given in 31.3.6.1.3 for remote shutdown devices.

**31.3.20.11** In the case of transfer operations involving pressures in excess of 5 MPa, arrangements for emergency depressurizing and disconnection of the transfer hose shall be provided. The controls for activating emergency depressurization and disconnection of the transfer hose shall meet the provisions given in 31.3.6.1.3 for remote shutdown devices.

**31.3.20.12** Carriage on open deck.

Instead of the use of permanently attached deck tanks, portable tanks meeting the design requirements for type C independent tanks (refer to Section 23 of Part IV of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk) may be used provided that the provisions of 31.3.19.2 are complied with.

Carriage of liquefied gases other than those mentioned in this Section is subject to 18.12 of the Code for The Transport and Handling of Hazardous and Noxious Liquid Substances in Bulk on Offshore Support Vessels (OSV Chemical Code).

# 32 REQUIREMENTS FOR OFFSHORE SUPPLY VESSELS WITH SPECIAL EQUIPMENT FOR WELL STIMULATION IN OIL AND GAS FIELDS INSTALLED ON BOARD OR SPECIALLY PREPARED FOR INSTALLATION OF SUCH EQUIPMENT

## 32.1 GENERAL

**32.1.1 Application.**

**32.1.1.1** The requirements of this Section apply to the design, construction and operation of offshore supply vessels with permanently installed special equipment for stimulation of wells in oil and gas fields in order to improve their productivity or prepared for installation of such equipment.

**32.1.1.2** This Section is applicable to offshore supply vessels to perform well stimulation operations including transporting well stimulation substances and well fluids between onshore and offshore facilities. The requirements of this Section are not applicable to well stimulation processing equipment.

**32.1.1.3** Processing equipment (pumps, blenders, pressure vessels, hydraulic stations, coiled tubing unit, fracturing equipment, special purpose hoisting equipment, etc.) shall comply with the requirements of national supervisory bodies in the oil and gas industry and may be voluntarily taken under the technical supervision of the Register in accordance with the requirements of the Rules for the Oil-and-Gas Equipment of Floating Offshore Oil-and-Gas Product Units, Mobile Offshore Drilling Units and Fixed Offshore Platforms.

**32.1.1.4** The offshore supply vessels carry and use the following substances for well stimulation:

acids;
liquid nitrogen;
additives;
gel fluids;
proppants, etc.

**32.1.1.5** The distinguishing mark **WSV1** (well stimulation vessel type 1) may be added to the character of classification of the ships fitted with well stimulation equipment and complying with the requirements of this Section; the distinguishing mark **WSV2** (well stimulation vessel type 2) may be added to the character of classification of the ships that are prepared for installation of well stimulation equipment, but the equipment itself is not installed or dismantled.

**32.1.2 Definitions.**

Well stimulation is a type of well intervention performed on an oil or gas well to increase production by improving the flow of hydrocarbons from the drainage area into the wellbore.

Well stimulation systems are the facilities intended for operating stimulation substances, i.e. well stimulation installations, equipment and operation system. Well stimulation systems may include acidizing equipment, fracturing blenders, pumping units, hydration and chemical additive systems, supporting equipment, lifting appliances, well control equipment, pressure vessels, piping and electrical components, control systems, etc.

Well stimulation vessels are the offshore supply vessels designed for carrying and/or operating well stimulation substances. Well stimulation vessels may operate stimulation substance systems installed on board or operate stimulation substances carried by other vessels as to inject the substances into wells.

Proppants are propping agents; a proppant is a solid material, typically sand, treated sand or man-made ceramic materials, designed to keep an induced hydraulic fracture open, during or following a fracturing treatment. It is added to a fracking fluid which may vary in composition depending on the type of fracturing used.

Blending additives are small amounts of liquid substances used during blending of products or production processes of cargoes for use in the search for and exploitation of seabed mineral resources used to facilitate such operations.

Dangerous chemicals are any liquid chemicals designated as presenting a safety hazard and assigned to chapter 17 of the IBC Code[1].

Semi-enclosed spaces are those spaces that either:

are open at two ends; or

have an opening at one end and are provided with adequate natural ventilation effective over their entire length through permanent openings distributed in the side walls or from above, the openings having a total area of at least 10 % of the total area of the space sides.

[1] International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk adopted by IMO resolution MEPC.119(52).

## 32.2 TECHNICAL DOCUMENTATION

For the project of a well stimulation vessel with the distinguishing mark **WSV1** or **WSV2** in the class notation, in addition to those specified in Section 3 of Part I "Classification", the documentation below shall be submitted.

The letter identification (A — approved, AG — agreed, FI — for information) denotes the results of documentation review documented by stamping in accordance with 8.2 of Part II "Technical Documentation" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

| No. | Description of documentation | Stamp | TD[1] | DD[2] | PAD[3] | Remarks |
|---|---|---|---|---|---|---|
| **1.** | General arrangement of the vessel | FI | ● | ● | ● | |
| **2.** | General arrangement plan of well stimulation equipment including hazardous area/zone classification and chemical storage area definition, as well as decontamination and eye-washing facilities, and personnel protective equipment location | A | ● | ● | ● | |
| **3.** | Structural fire protection | A | ● | ● | ● | |
| **4.** | Tank Plan or Capacity plan, or table with centers of gravity and tank free surface corrections | AG | ● | ● | ● | |
| **5.** | Body Lines plan or Offset Table | AG | ● | ● | ● | |
| **6.** | Hydrostatic curves or table | AG | ● | ● | ● | |

| No. | Description of documentation | Stamp | TD[1] | DD[2] | PAD[3] | Remarks |
|---|---|---|---|---|---|---|
| **7.** | Cross curves of stability | AG | ● | ● | ● | |
| **8.** | Arrangement of all integral and independent tanks, including support and stays of independent tanks | A | ● | ● | ● | |
| **9.** | Structural drawings of acid tanks including vent arrangements, information on non-destructive testing of welds, strength and tightness testing, and specification of protective linings | A | ● | ● | ● | |
| **10.** | Documentation for liquid nitrogen tanks | A | ● | ● | ● | |
| **11.** | Pumping arrangement including diagrams of piping for acid, nitrogen and liquid additives, details of flange connections and pipe clamping/securing as well as specification and data on high pressure flexible hoses with end connections | A | ● | ● | ● | |
| **12.** | Arrangement of mechanical ventilation of closed and semi-closed spaces containing acid tanks, pipes, pumps, mixers and blenders | A | ● | ● | ● | |
| **13.** | Drawings showing location of all electrical equipment in areas containing installations for uninhibited acid | A | ● | ● | ● | |
| **14.** | Electrical diagrams of well stimulation systems including single line diagram for intrinsically safe circuits, control and monitoring systems for cargo tank level gauging, overflow protection and emergency shutdown, as well as indication equipment for hydrogen, hydrogen chloride and oxygen | A | ● | ● | ● | |

| No. | Description of documentation | Stamp | TD[1] | DD[2] | PAD[3] | Remarks |
|---|---|---|---|---|---|---|
| **15.** | List of explosion protected equipment together with certificates and references to specific diagrams and/or plans | AG | ● | ● | ● | |
| **16.** | Calculations demonstrating the adequacy of the vessel's stability | AG | ● | ● | ● | |
| **17.** | Calculations demonstrating adequacy of propulsion power required for the vessel to maintain station during well stimulation operations | AG | ● | ● | ● | |
| **18.** | Stress analysis of supporting structure in way of flexible hose storage reel(s) | AG | ● | ● | ● | |
| **19.** | Stress analysis of liquid nitrogen piping and heat exchangers | AG | ● | ● | ● | |
| **20.** | Personnel protective equipment scope and types | AG | ● | ● | ● | |

[1] TD — Technical design.
[2] DD — Detailed (design) documentation.
[3] PAD — Plan approval documentation.

## 32.3 TECHNICAL REQUIREMENTS

**32.3.1 Hull.**

**32.3.1.1** The structure and strength of the hull of well stimulation vessels shall comply with the requirements under 3.8 of Part II "Hull".

**32.3.2 Positioning arrangements.**

**32.3.2.1** Well stimulation vessels shall keep their position during well stimulation operations.

Position mooring or dynamic positioning systems may be a means of maintaining position.

**32.3.2.2** Position-keeping systems and components thereof shall comply with the requirements in Section 4 of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Mobile Offshore Drilling Units.

Characteristics of environmental conditions shall be assumed in compliance with the Reference Data on Wind and Wave Regime of the Barents Sea, the Sea of Okhotsk and the Caspian Sea; the Baltic, North, Black, Azov and Mediterranean Seas; the Sea of Japan and the Kara Sea; the Bering and White Seas; the Barents and Kara Sea Shelf for recurrence period of once in 10 years with averaging interval of 10 min, depending on the area of the ship's operation.

**32.3.2.3** Electric and electronic equipment of the dynamic positioning systems, automated control systems for thruster units as well as ship systems affecting dynamic positioning system operation shall comply with the requirements in Section 8 of Part XV "Automation".

**32.3.2.4** Automated control systems of power equipment of position mooring systems shall comply with the requirements in Section 9 of Part XV "Automation".

**32.3.3 Stability, unsinkability and subdivision.**

**32.3.3.1** Under all loading conditions to be encountered in service and which are in agreement with the purpose of the vessel (icing disregarded), the trim and stability of an intact well stimulation vessel shall be sufficient for satisfying damage trim and stability requirements.

**32.3.3.2** The trim and stability of an intact well stimulation vessel shall comply with the requirements in 3.11 of Part IV "Stability".

**32.3.3.3** Requirements for the ship damage trim and stability shall be considered satisfied if, in case of damage mentioned in 3.2 and 3.4.9 of Part V "Subdivision", with the permeability determined in accordance with 1.6 of Part V "Subdivision", calculations made in conformity with 3.1.3 — 3.1.7 of Part V "Subdivision", indicate that the requirements of 3.3 and 3.4 of Part V "Subdivision", are satisfied.

**32.3.4 Tanks, cargo and process piping.**

**32.3.4.1** Cargo tanks containing acids and liquefied nitrogen shall be located at least 760 mm measured inboard from the side of the vessel perpendicular to the centreline at the level of the summer load waterline, taking into account the following. Solid ballast shall not normally be used in double-bottom spaces in the cargo area. Where, however, because of stability considerations, the fitting of solid ballast in such spaces becomes unavoidable, then its disposition shall be governed by the need to ensure that the impact loads resulting from bottom damage are not directly transmitted to the cargo tank structure.

**32.3.4.2** Tanks and pumping arrangements for the well stimulation processing plants shall be segregated from machinery spaces, propeller shaft tunnels, dry cargo spaces, accommodation and service spaces, as well as from drinking water and stores for human consumption by means of cofferdam, void space, cargo pump room, empty tank, oil fuel tank or similar arrangement.

**32.3.4.3** Tanks for cargoes that react in hazardous manner with other cargoes shall be segregated from them by means of cofferdam, void space, cargo pump room, empty tank or fuel oil tank. Tanks for other purposes, except of those for fresh water and lubricating oils, may be accepted as cofferdams for these tanks. The spacing between all cargo tank boundaries and adjacent ship's structure shall be minimum 600 mm.

**32.3.4.4** Tanks and piping systems for the well stimulation processing plant shall be separated from the vessel's marine machinery and piping systems.

**32.3.4.5** Generally, piping conveying well stimulation substances shall be joined by welding except for:

**.1** approved connections to shut-off valves and expansion joints;

**.2** other exceptional cases approved by Administration.

**32.3.4.6** Tanks, pumps, valves, gaskets and piping for uninhibited acids shall be of corrosion resistant material or shall have internal lining of corrosion resistant material.

**32.3.4.7** Ship's cargo hoses for dangerous chemical cargoes shall meet the requirements in 1.8 of Part VI "Systems and Piping" of the Rules for the Classification and Construction of Chemical Tankers (the Chem Rules).

**32.3.5 Accommodation, service spaces and control stations.**

**32.3.5.1** Piping systems for the well stimulation processing plant shall not pass through any accommodation, service or machinery spaces other than pump-rooms. The area designated for well stimulation processing plants shall be arranged as far away as practical from accommodation, service spaces, machinery spaces or control stations.

**32.3.5.2** Unless accommodation, service and machinery spaces are spaced at least 7 m away from the cargo area containing flammable products, entrances, air inlets and openings to accommodation, service and machinery spaces and control stations shall not face the cargo area. Doors to spaces not having access to accommodation, service and machinery spaces and control stations, such as cargo control stations and store-rooms, may be permitted within the 7 m zone specified above, provided the boundaries of the spaces are insulated to "A-60" standard. When arranged within the 7 m zone specified above, windows and side scuttles facing the cargo area shall be of a fixed type.

Such side scuttles in the first tier on the main deck shall be fitted with inside covers of steel or equivalent material.

**32.3.5.3** For substances with pollution hazard only and having a flashpoint exceeding 60 °C, the requirements of 32.3.5.2 may be waived.

**32.3.5.4** Remote control of the well stimulation processing plant shall be arranged at a position outside the area where the well stimulation systems are located.

**32.3.6 Liquids having flashpoint < 60 °C.**

**32.3.6.1** Tanks and pumping arrangements for liquid additives having flashpoint below 60 °C shall comply with relevant requirements in Section 31.

**32.3.7 Special requirements.**

**32.3.7.1** Nitrogen.

**32.3.7.1.1** Materials of construction and ancillary components such as insulation shall be resistant to the effects of high oxygen concentrations caused by condensation and enrichment at the low temperatures attained in parts of the cargo system. Due consideration shall be given to areas where condensation might occur, to avoid the stratification of oxygen-enriched atmosphere.

**32.3.7.1.2** Tanks, pumps and piping and associated instruments shall be made of materials which are suitable to the pressure and cryogenic temperature of the liquid nitrogen system, and comply with recognized standards. In general, they shall be made of steel.

**32.3.7.1.3** Liquid nitrogen tanks shall comply with the relevant requirements for the design, installation and testing of type C independent tanks (refer to Section 23 of Part IV "Cargo Containment" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk (the LG Rules)).

**32.3.7.1.4** Materials and design of piping shall comply with the requirements in Section 2 of Part VI "Systems and Piping" of the LG Rules.

**32.3.7.1.5** Cargo hoses.

**32.3.7.1.5.1** Hoses used for cargo transfer shall be compatible with the cargo and suitable for the cargo temperature, and also comply with the requirements in Section 6 of Part VIII "Systems and Piping".

**32.3.7.1.5.2** Hoses shall be designed for a bursting pressure not less than five times the maximum pressure the hose will be subjected to during cargo transfer.

**32.3.7.1.5.3** Cargo hoses for chemical cargoes and liquefied gases transfer shall be prototype-tested at a normal temperature, with 200 pressure cycles from zero to twice the specified maximum working pressure. After this cycle pressure test has been carried out, the prototype test shall demonstrate a bursting pressure of at least 5 times its specified maximum working pressure at the upper and lower extreme service temperature. Hoses used for prototype testing shall not be used for cargo service. Thereafter, before being placed in service, each new length of cargo hose produced shall be hydrostatically tested at ambient temperature to a pressure not less than 1,5 times its specified maximum working pressure, but not more than two fifths of its bursting pressure. The hose shall be stencilled, or otherwise marked, with the date of testing, its specified maximum working pressure and, if used in services other than ambient temperature services, its maximum and minimum service temperature, as applicable. The specified maximum working pressure shall not be less than 1 MPa gauge.

**32.3.7.2** Acids.

**32.3.7.2.1** The ship's shell plating shall not form any boundaries of tanks containing mineral acids.

**32.3.7.2.2** Steel tanks and related piping systems may be lined with corrosion-resistant materials. The elasticity of the lining shall not be less than that of the supporting boundary plating.

**32.3.7.2.3** Unless constructed wholly of corrosion-resistant materials or fitted with an approved lining, the plating thickness shall take into account the corrosivity of the cargo.

**32.3.7.2.4** Flanges of the loading and discharge manifold connections shall be provided with shields, which may be portable, to guard against the danger of the cargo being sprayed; and in addition, drip trays shall also be provided to guard against leakage on to the deck.

**32.3.7.2.5** If there is the danger of evolution of hydrogen when these substances are being carried, the electrical arrangements shall comply with the requirements in Section 2 of Part VII "Electrical Equipment" of the LG Rules. The approved safe type equipment shall be suitable for use in hydrogen/air mixtures. Other sources of ignition shall not be permitted in such spaces.

**32.3.7.2.6** Substances subjected to the requirements of this Section shall be segregated from accommodation, service and machinery spaces as well as from drinking water and stores for human consumption, fuel oil tanks by means of cofferdam, void space, pump room, or similar arrangement.

**32.3.7.2.7** Provision shall be made for suitable apparatus to detect leakage of cargo into adjacent spaces.

**32.3.7.2.8** The cargo pump-room bilge pumping and drainage arrangements shall be of corrosion-resistant materials.

**32.3.7.2.9** Dimensions, manufacture, testing and location of piping shall meet the requirements in 1.2 — 1.5 of Part VI "Systems and Piping" of the Chem Rules.

**32.3.7.2.10** Cargo hoses.

Cargo hoses shall comply with the requirements in 32.3.7.1.5.

**32.3.8 Tanks venting.**

**32.3.8.1** Nitrogen tanks.

Outlets from safety valves of nitrogen tanks shall be led to open deck. Outlet pipes shall be arranged and supported such, as to allow for thermal contraction/expansion during cold gas release. Penetrations of decks or bulkheads shall be such that their structures are thermally isolated from the cold pipes.

**32.3.8.2** Acid tanks.

Vent outlets from acid tanks shall have pressure/vacuum valves fitted with flame arrestors and shall be led to open deck. The outlets shall have a minimum height of 4 m above deck and located at a minimum horizontal distance of 5 m from openings to accommodation and service spaces.

**32.3.9 Requirements for process spaces for acid, liquid nitrogen and additives storage and handling.**

**32.3.9.1** Access openings.

Enclosed spaces containing tanks, pumps, blenders and associated piping for uninhibited acid shall have entrances direct from open deck or through air lockers from other spaces. Minimum clear opening for horizontal access shall not be less than 600 mm × 600 mm and for vertical openings not less than 600 mm × 800 mm. The air lockers shall have independent mechanical ventilation.

**32.3.9.2** Ventilation of spaces for acid storage and handling.

**32.3.9.2.1** It is recommended that exhaust ventilation shall be provided. Explosion proof electrical equipment shall be used for ventilating spaces containing acetic acid.

**32.3.9.2.2** The spaces containing uninhibited acid shall have independent mechanical ventilation with a capacity of minimum 30 air changes per hour, while those containing inhibited acid a minimum of 20 air changes per hour. The intakes shall be located both, at floor and ceiling levels of the space concerned.

**32.3.9.3** Ventilation of spaces for liquid nitrogen.

Spaces containing installations for liquid nitrogen shall have independent mechanical ventilation with a capacity of minimum 20 air changes per hour.

**32.3.9.4** Ventilation of spaces for additives storage and handling.

Ventilation of spaces for storage and handling of dry and liquid additives will be case by case considered based on flammability, toxicity and reactivity criteria of the additives concerned.

**32.3.9.5** Acid spill protection.

**32.3.9.5.1** Protection of floors and decks.

**32.3.9.5.1.1** Floors or decks under acid storage tanks, pumps and piping for uninhibited acid shall have a lining or coating of acid resistant material extending up to a minimum height of 500 mm in the bounding bulkheads or coamings.

**32.3.9.5.1.2** Hatches or similar openings on those decks where acid storage tanks, pumps and piping for acid, are routed shall have watertight coamings having a minimum height of 500 mm and the coamings shall be protected by a lining or an acid resistant coating. Height requirement for coamings may be waived where this height is not practicable.

**32.3.9.5.1.3** A permanent spill coaming of 150 mm in height shall be provided on deck to keep deck spills away from accommodation and service areas.

**32.3.9.5.2** Shields and drip trays.

On acid installations spray shields shall be provided to cover flanges or other detachable pipe connections. Portable shield covers shall be provided for connecting the flanges of the loading manifold. Drip trays of acid resistant material shall be provided under loading manifolds.

**32.3.9.5.3** Drainage.

**32.3.9.5.3.1** Spaces housing tanks, pumps and piping for acids or additives shall have a separate drainage system not connected to the draining of the other areas and this system shall be made of acid resistant materials.

**32.3.9.5.3.2** Drainage arrangements for pump rooms, void spaces, any slop tank, double bottom tanks and similar spaces shall be situated entirely within the well stimulation processing area except for void spaces, double bottom tanks and ballast tanks, where such spaces are separated from tanks containing well stimulation substances or residues of such substances by a double bulkhead.

**32.3.9.6** Liquid nitrogen drip protection.

Drip trays resistant to cryogenic (ca. −200 °C) temperatures shall be provided at manifolds transferring liquefied gases and at other flanged connections in the liquid nitrogen system. When selecting materials for trays and hull structures in the area of a possible liquid nitrogen spill, the requirements in Section 2 of Part IX "Materials and Welding" of the LG Rules shall be met.

**32.3.10 Control and monitoring systems.**

**32.3.10.1** An automatic and manual control system shall be provided, with the possibility of stopping the whole process and individual work operations.

**32.3.10.2** Atmosphere monitoring.

**32.3.10.2.1** Vapour detection.

Enclosed and semi-enclosed spaces containing installations for acids shall be provided with fixed vapour detection and alarm systems capable of giving an audible and visual alarm. The vapour detection system shall be capable of detecting hydrogen and hydrogen chloride gases.

**32.3.10.2.2** Oxygen deficiency monitoring.

Enclosed spaces containing tanks and piping for liquid nitrogen shall be equipped with a sensor continuously monitoring the oxygen content of the space; an alarm shall be provided in case of low oxygen concentration. For semi-enclosed spaces portable equipment may be accepted.

**32.3.10.3** Tank level gauging systems.

**32.3.10.3.1** Nitrogen tanks.

Tanks for liquefied nitrogen are to have gauging and level detection arrangements in accordance with the requirements in Part VIII "Instrumentation an Automation Systems" of the LG Rules.

**32.3.10.3.3** Tanks for acid.

Tanks for hydrochloric acid shall have a closed gauging system. A high level alarm shall be provided to be activated by a level sensing device independent of the gauging system.

**32.3.10.4** Leakage alarm.

Spaces housing equipment and storage tanks for the well stimulation system shall be provided with detection and alarm system for liquid leakages.

**32.3.11 Emergency shutdown.**

**32.3.11.1** Pumps.

Emergency stop of all pumps in the well stimulation system shall be arranged from a dedicated cargo operations control station and at least one position located outside the area for well stimulation operations.

**32.3.11.2** Valves.

Emergency shut-off valves shall be provided in liquid nitrogen lines from each nitrogen tank. The shut-off valves shall be remotely controlled from one or more positions outside the area for well stimulation operations.

**32.3.11.3** Transfer hose.

Emergency depressurizing and disconnection of the transfer hose shall be arranged from a dedicated cargo operations control station and another location outside the cargo area and at a safe distance from it.

**32.3.12 Power supply.**

**32.3.12.1** A reliable power supply shall be provided for the operation of the emergency control and shutdown system.

**32.3.12.2** Electrical power supply shall be from a main power system and from an uninterrupted power supply (UPS) capable of continuously operating for at least 30 minutes upon loss of power from the main source. The UPS shall be powered from both the main and the emergency power systems.

**32.3.12.3** Where hydraulic or pneumatic power supply is used for actuation of emergency control and shutdown, duplication arrangements shall be made in accordance with the following requirements.

Where power supply is hydraulic, hydraulic pumps shall be fitted in duplicate. The reservoir shall be of sufficient capacity to contain all of the fluid when drained from the system, maintain the fluid level at an effective working level and allow air and foreign matter to separate out. The pump suctions shall be sized and positioned to prevent cavitation or starvation of the pump. A duplex filter, which can be cleaned without interrupting the oil supply, shall be fitted on the discharge side of pumps. The hydraulic fluid shall be suitable for its intended operation. Hydraulic supplies to safety and control systems may be derived from the same source but shall be by means of separate lines.

Where power supply is pneumatic, compressed air for control and monitoring systems shall be supplied from at least two air compressors. The starting air system, where consisting of two air compressors, may be used for this purpose. The system shall be arranged such that a single failure will not result in the loss of air supply. The required air pressure shall be automatically maintained.

Air supplies to control and monitoring systems may be derived from the same source, but shall be by separate lines incorporating shut-off valves.

Where driving power for hydraulic and/or pneumatic pumps is electric, power supply circuits shall be connected to the main and emergency power sources separately.

**32.3.13 Internal communication.**

A wired service communication shall be provided for voice communication between the control stations for well stimulation operations and the ship's control stations, meeting the requirements in 7.2 of Part XI "Electrical Equipment".

**32.3.14 Fire protection.**

**32.3.14.1** Structural fire protection.

**32.3.14.1.1** Well stimulation vessels carrying liquid cargo having a flashpoint exceeding 60 °C, other than oil and oil products, shall have structural fire protection meeting the requirements in 2.1 and 6.3 of Part VI "Fire Protection".

**32.3.14.1.2** Well stimulation vessels carrying liquid cargo having a flashpoint not exceeding 60 °C shall have structural fire protection meeting the requirements of Part V "Fire Protection" of the Chem Rules.

**32.3.14.2** Water fire main system.

The water fire main system shall comply with the requirements in 3.2 of Part VI "Fire Protection".

**32.3.14.2.1** For cargo temperatures below –110 °C, a water distribution system shall be provided for hull sections below the shore connections to create, at low pressure, a water curtain for additional protection of the steel hull material and side structures, cargo liquid and vapor discharge and loading connections, including the presentation flange and the area where their control valves are situated, which shall be at least equal to the area of the drip trays provided and shall be used during the cargo transfer operation. The water curtain system shall comply with the requirements in 3.5 of Part VI "Fire Protection".

**32.3.14.3** Foam fire extinguishing system.

The foam fire extinguishing system shall comply with the requirements in 3.7 of Part VI "Fire Protection".

**32.3.14.4** Carbon dioxide smothering system.

The carbon dioxide smothering system shall comply with the requirements in 3.8 of Part VI "Fire Protection".

**32.3.14.5** Fire-fighting outfit.

Well stimulation vessels shall have fire-fighting outfit in accordance with Section 5 of Part VI "Fire Protection".

**32.3.15 Personnel protection.**

Well stimulation vessels shall have on board protective equipment complying with the requirements in Part X "Personnel Protection" of the Chem Rules.

## 32.4 CONDITIONS FOR ASSIGNMENT OF DISTINGUISHING MARK WSV2

**32.4.1** A ship may be assigned the distinguishing mark **WSV2** if the well stimulation equipment has been removed from the ship or has not been installed on the ship after construction or repair, conversion or modernisation, but the possibility of installing such equipment, including deck tanks for the carriage of well stimulation fluids, without altering the ship design or ship systems, is retained.

In this case, the requirements of this Section shall apply selectively, taking into account the functional purpose of the ship.

## 33 REQUIREMENTS FOR MARITIME AUTONOMOUS SURFACE SHIPS AND THE TECHNICAL MEANS OF CONTROLLING THEREOF

### 33.1 GENERAL

**33.1.1 Scope of application.**

**33.1.1.1** The requirements for the maritime autonomous surface ships (MASS) are supplementary to other RS requirements applicable in accordance with the class notation and purpose of the ship.

**33.1.1.2** The requirements of this Section cover the following items, means and systems:

**.1** situational awareness system;
**.2** radiocommunication and data exchange system;
**.3** means of navigation and manoeuvring;
**.4** ship power plant;
**.5** remote control centre (fixed or mobile);
**.6** means of navigation delimiting marking (fixed or mobile).

**33.1.2 Definitions and explanations.**

**33.1.2.1** Definitions and explanations relating to general terminology of the RS rules and guidelines are given in 1.1, Part I "Classification" of the Rules for the Classification and Construction of Sea-Going Ships (hereinafter referred to as the "RS Rules/C") and in 1.1, Part I "General Regulations for Technical Supervision" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships (hereinafter referred to as the "RS Rules/TSDCS").

**33.1.2.2** For the purpose of this Section, the following terms, definitions and abbreviations shall have the meanings defined below.

Autonomous control is a mode of controlling a ship, the systems and technical means thereof without human intervention.

Autonomous ship is a self-propelled ship, which is partially or fully under control in automatic mode.

Delimitation is a method for determination of conditions for safe navigation using land-, air- (orbit-) and sea-based technical facilities applied together or separately.

Element is a constituent part of an item and/or system considered during the analysis as a whole not subject to further subdivision to constituent parts.

Fully-autonomous ship (FAS) is a ship, which is capable of navigating without the ship’s crew onboard.

Fully-autonomous ship, with an option of being controlled from RCC (FAS-RCC) is a ship, which is capable of navigating without the ship’s crew onboard, with an option of being controlled from RCC.

Life cycle is a set of interrelated processes of changing the state of an item during its design, construction, operation, repair and utilization.

MASS is a maritime autonomous or surface ship.

Navigation delimiting marking (marking) is a set of land-, sea-, air- or orbit-based technical facilities applied together or separately and ensuring safe manoeuvring during the MASS movement along the intended route, entrance to the port, departure from the port, moving in restricted waters, MASS mooring using guidance beams, virtual objects, marks.

Remote control is a control mode of a ship, its systems and technical means from a location other than aboard this ship.

Remotely controlled ship is a ship which is controlled from the remote control centre.

Semi-autonomous ship (SAS) is a manned ship, which is capable of navigating without navigational watch kept by the ship’s crew.

Semi-autonomous ship, with an option of being controlled from RCC (SAS-RCC) is a manned ship, which is capable of navigating without navigational watch kept by the ship's crew, with an option of being controlled from RCC.

Ship(s) remote control centre (RCC) is a location other than aboard the ship being controlled from which monitoring and control of the ship can be performed using methods ensuring safe navigation.

SPP is a ship power plant.

System is a combination of interacting elements organized to achieve one or more objectives.

**33.1.2.3 Risk terms and definitions.**

Event is occurrence or change of a particular set of circumstances.

Failure mode is a combination of possible or observed failures of an element and/or system clustered in a classification group based on one or several common features (causes, generation mechanism, outward appearance and other indications except for the failure effects).

Frequency is a number of events or outcomes per defined unit of time.

Harm is physical injury or damage to people health, property or to the environment.

Hazard is a source of potential harm.

Hazardous event is an event that may cause harm.

Level of risk is a magnitude of a risk expressed in terms of the combination of consequences and their likelihood.

Likelihood is a chance of something happening.

Probability is a measure of the chance of occurrence expressed as a number between 0 and 1, where 0 is impossibility and 1 is absolute certainty.

Risk is a negative effect of uncertainty on objectives assessed as a combination of the probability of hazardous event and its consequences.

Risk acceptance is an informed decision to take a particular risk.

Risk assessment is an overall process of risk identification, risk analysis and risk evaluation.

Risk aversion is attitude to turn away from risk.

Risk avoidance is an informed decision not to be involved in, or to withdraw from, an activity in order not to be exposed to a particular risk.

Risk description is a structured statement of risk usually containing four elements: sources, events, causes and consequences.

Risk evaluation is a process of comparing the results of risk analysis with risk criteria to determine whether the risk and/or its magnitude is acceptable or tolerable.

Risk identification is a process of finding, recognizing and describing of risks.

Risk source is an element which alone or in combination has the intrinsic potential to give rise to risk.

Severity category of failure effects is a classification group of failures by their effect severity characterized by certain, established prior to the analysis, combination of qualitative and/or quantitative components of the estimated (probabilistic) failure or damage caused by a failure.

Severity of failure effects is qualitative or quantitative assessment of probable (observed) damage from failure of element and/or system.

**33.1.3 MASS categories and class notation.**

Depending on the MASS category, one of the distinguishing marks given in Table 33.1.3 may be added to the character of classification for a ship, which complies with the requirements of this Section.

Table 33.1.3

| Distinguishing mark | MASS category | Crew | RCC |
|---|---|---|---|
| **SAS** | Semi-autonomous ship | + | — |
| **SAS-RCC** | Semi-autonomous ship, with an option of being controlled from RCC | + | + |
| **FAS-RCC** | Fully-autonomous ship, with an option of being controlled from RCC | — | + |
| **FAS** | Fully-autonomous ship | — | — |

## 33.2 TECHNICAL SUPERVISION DURING DESIGN

**33.2.1 Technical documentation.**

**33.2.1.1** Provisions of Section 3, Part I "Classification" of the Rules for the Classification and Construction of Sea-Going Ships, Section 2, Part I "General" of the Rules for the Equipment of Sea-Going Ships, as well as Part II "Technical Documentation" of the Rules for Technical Supervision During Construction of Ships and Manufacture of Materials and Products for Ships fully apply to technical documentation for MASS construction and manufacture of materials and products for them.

**33.2.1.2** In addition to the documentation given in 33.2.1.1, during the design of MASS and systems covered by the requirements of this Section, the following documents shall be submitted to the Register depending on the MASS category.

**33.2.1.2.1** General:

**.1** concept of MASS operation (refer to Appendix 1) including the list of systems;

**.2** MASS operational risk assessment (refer to Appendix 3);

**.3** technical requirements for newly designed MASS systems;

**.4** safety program of MASS operation.

**33.2.1.2.2** Situational awareness system:

**.1** explanations to the concept of MASS operation as regard the situational awareness, environmental perception parameters, including list of systems — sources of this information;

**.2** risk assessment of situational awareness system application;

**.3** structural and functional diagrams of situational awareness system;

**.4** arrangement plan of equipment of situational awareness system;

**.5** description of functioning of situational awareness system during the MASS operational scenarios in accordance with the concept of MASS operation;

**.6** program and procedure of both the bench tests and on-board tests of situational awareness system;

**.7** situational awareness system user manual;

**.8** guidelines on the situational awareness system maintenance.

**33.2.1.2.3** Radiocommunication and data exchange system for MASS:

**.1** diagrams of communication systems;

**.2** arrangement plans of communication equipment.

**33.2.1.2.4** Means of navigation and manoeuvring:

**.1** diagrams of the navigation control systems;

**.2** risk analysis and reliability calculation for the navigation control system;

**.3** fields of vision from the navigation bridge (where applicable);

**.4** layout and connection diagram of the navigation bridge equipment (where applicable);

**.5** program and procedure for mooring and sea trials;

**.6** technical justification for the navigation control system;

**.7** plan of mooring operations and movement in port waters;

**.8** plan of anchor operations and operations for ship's position keeping using dynamic positioning systems, where available.

**33.2.1.2.5** Ship power plant (SPP):

**.1** automatic power supply system:

description of elements of the ship's power supply system;

operating manual for power supply system of the ship containing control procedures (including control logic, functional block diagram, etc.) and description of operation of power supply system in different conditions and modes (at normal operation, failures, start, sea voyage commencement, anchorage, moving in restricted waters, entering the port, departure from the port, mooring, during cargo and ballast operations, etc.);

procedures and plans for performing by the RCC personnel: monitoring of operating parameters, condition of ship's systems, records of automatic recorders, reports;

procedures related to any failure that may occur during the operation and application of automatic power supply system;

program and procedure for verification of automatic power supply system, including inter alia checking of automatic operation of the automatic power supply system for each subsystem under different operating conditions and modes of operation; switching from autonomous to remote control, including checking of autonomy of the systems; failure test modeled in accordance with the risk assessment report;

**.2** SPP automatic control system:

arrangement of main equipment of SPP automatic control system;

algorithms of SPP automatic control system interaction with the most essential systems providing parameters for monitoring and control thereof;

control procedures (algorithms) (including control logic, functional block diagram, etc.) and description of operation of SPP automatic control system under different conditions and modes including abnormal modes;

operating and maintenance instructions for the system including procedures and plans for verification of the SPP automatic control system;

abnormal operating procedures.

**33.2.1.2.6** Remote control centre (RCC) (fixed or mobile), where available:

**33.2.1.2.6.1** Situational awareness:

**.1** design of the RCC situational awareness system equipment including system composition, technical description, structural diagram, general view, operating manual, justification for locations, operating areas, redundancy level provided for all requested areas of RCC operation;

**.2** justification of sufficiency of the received information for MASS operation under all predictable operating conditions in the permitted areas of operation, obtained using methods of mathematical modelling of integral RCC system;

**.3** justification of sufficiency of information sent to the RCC on malfunctions identified by the built-in MASS self-diagnostic means;

**.4** description of procedures and algorithms for making decisions on the possible mode of autonomy of the ship: autonomous, remote control, manual, decision support for the crew onboard the ship, depending on the information received under all predictable operating conditions in all permitted areas of operation.

**33.2.1.2.6.2** Strategic management of voyage:

**.1** description of the area of strategic management of the voyage being under the RCC control;

**.2** description of the voyage planning procedure applied in RCC;

**.3** risk analysis in case of loss of communication with MASS, error in delivery of the voyage assignment or misrepresentation thereof, inability to monitor the voyage assignment performance.

**33.2.1.2.6.3** Remote control of navigation:

**.1** functional diagram of the navigation control system operated from RCC;

**.2** description of the navigation control system operated from RCC;

**.3** risk analysis and reliability calculation for the navigation control system operated from RCC;

**.4** diagram of fields of vision around MASS from RCC;

**.5** arrangement plan of equipment of the navigation control system operated from RCC;

**.6** program and procedure of mooring and sea trials in respect of testing the interaction with RCC as regards navigation;

**.7** justification of sufficiency of the adopted engineering solutions to ensure continuous navigation control from RCC;

**.8** mooring plan under control from RCC;

**.9** weighing/anchorage plan under control from RCC.

**33.2.1.2.6.4** Anti-intrusion protection:
**.1** RCC space(s) arrangement indicating doors (passages) equipped with access system;
**.2** instructions on updating the authorized persons list;
**.3** RCC access rules for authorized persons and transfer of equipment to/from RCC.
**33.2.1.2.6.5** Electrical power supply:
**.1** RCC power supply diagram;
**.2** power supply connection diagram of RCC equipment.
**33.2.1.2.7** Means of navigation delimiting marking (fixed or mobile):
**33.2.1.2.7.1** Navigation delimiting marks:
**.1** control procedure for navigation delimiting marks;
**.2** maintenance procedure for means ensuring operability of navigation delimiting marks;
**.3** redundancy of means ensuring operability of navigation delimiting marks;
**.4** user manual for operator.
**33.2.1.2.7.2** Marking control:
**.1** risk assessment;
**.2** marking control procedure;
**.3** maintenance plan for means ensuring operation of marking;
**.4** redundancy management of marking means;
**.5** user manual for operator.
**33.2.1.2.7.3** Mooring area:
**.1** control procedure for mooring means and equipment;
**.2** arrangement plan of equipment of mooring area;
**.3** power supply connection diagrams of mooring area;
**.4** connection diagrams of mooring area indication system;
**.5** maintenance plan for means and equipment of mooring area;
**.6** description of functions of equipment and systems of mooring area.
**33.2.1.2.8** Cyber security:
**33.2.1.2.8.1** Computers and computer-based systems:
**.1** description of software architecture of control system implemented by RCC and the controlled ship:

control procedures (algorithms) (including control logic, functional block diagram, etc.) and description of the RCC systems operation under various conditions and in the various operational modes (start, sea voyage commencement, anchorage, moving in restricted waters, entering the port, departure from the port, mooring, during cargo and ballast operations, etc.);

**.2** description of data formats applied by the control system software implemented by RCC and the controlled ship;

**.3** description of operating systems and data exchange technical facilities applied by the control system software implemented by RCC and controlled ship;

**.4** procedures and plans for performing by RCC and controlled ships of self-diagnostic procedures of parameters and abnormal procedures relating to monitoring of transmitted data and in case of any failure that may occur during the operation and use of remote-control system.

**33.2.1.2.8.2** Cyber security onboard the ship:
**.1** cyber risk assessment;
**.2** cyber security management;
**.3** maintenance plan;
**.4** description of data storage redundancy management;
**.5** connection diagrams of equipment and power supply system;
**.6** procedures for cyber security risk identification and management;
**.7** justification for cyber security measures for navigation bridge systems;

**.8** justification for cyber security measures for engines, machinery and power-supply control systems;
**.9** justification for cyber security measures for ship access control systems;
**.10** justification for cyber security measures for administrative systems and networks;
**.11** justification for cyber security measures for radio and communication systems;
**.12** documents confirming implementation of measures aimed at ensuring safe software development;
**.13** list of protected information resources;
**.14** access matrix;
**.15** threat model and security model;
**.16** operating documentation on information security system.
**33.2.1.2.8.3** RCC cyber security:
**.1** cyber risk assessment;
**.2** cyber security management;
**.3** indication system of ship technical condition;
**.4** maintenance plan;
**.5** RCC functions justification;
**.6** data storage redundancy management;
**.7** power supply connection diagrams;
**.8** procedures for cyber security risk identification and management;
**.9** user manual for RCC operator;
**.10** documents confirming implementation of measures aimed at ensuring safe software development;
**.11** list of protected information resources;
**.12** access matrix;
**.13** threat model and security model;
**.14** operating documentation on information security system.
**33.2.1.2.8.4** Navigation delimiting marking:
**.1** description of software architecture of navigation delimiting marking: control procedures (algorithms) (including control logic, functional block diagram, etc.); description of navigation delimiting marking system operation in different conditions and in different operational modes (including abnormal modes);
**.2** description of data formats applied by marking system software;
**.3** description of operating systems and data exchange technical facilities applied by marking system software;
**.4** procedures and plans for self-diagnostic procedures for navigation delimiting marking parameters and abnormal procedures relating to monitoring of transmitted data and in case of any failure that may occur during the operation and use of marking system;
**.5** verification of compliance with the prescribed security requirements for information received from navigation delimiting marking and intended for MASS shall verify: availability of information security records; compliance of reported documentation with the requirements of national and international standards, as well as normative documentation of flag State Maritime Administration.

## 33.3 TECHNICAL SUPERVISION DURING MANUFACTURE OF MATERIALS AND PRODUCTS

**33.3.1** Materials and products for MASS constructed under the RS technical supervision are subject to the RS technical supervision during their manufacture with issuance of the appropriate certificates.

**33.3.2** Organization and carrying out of technical supervision shall comply with the requirements of Part I "General Regulations for Technical Supervision", Part III "Technical Supervision during Manufacture of Materials", and Part IV "Technical Supervision during Manufacture of Products" of the RS Rules/TSDCS.

**33.3.3** Technical supervision during manufacture of materials and products not included in the Nomenclature of Items of the Register Technical Supervision, but covered by the requirements of this Section shall be carried out while rendering the "Approval in Principle" (AIP) service in compliance with 3.6, Part II "Technical Documentation" of the RS Rules/TSDCS.

### 33.4 TECHNICAL SUPERVISION DURING CONSTRUCTION

**33.4.1** The requirements of Part I "General Regulations for Technical Supervision" of the RS Rules/TSDCS and the Guidelines on Technical Supervision of Ships under Construction fully apply to MASS.

**33.4.2** Preliminary list of items of technical supervision covered by the requirements of this Section is developed by the developer and subject to agreement with the RS Branch Office responsible for review of ship design documentation.

**33.4.3** List of items of technical supervision containing detailed scope and procedure of technical supervision, types of checks, tests and control is developed by the shipyard in compliance with 13.3, Part I "General Regulations for Technical Supervision" of the RS Rules/TSDCS based on the preliminary list given in 33.4.2, and reviewed and agreed by the RS Branch Office responsible for technical supervision during construction.

**33.4.4** Programs of MASS mooring and sea trials are reviewed by the Register in compliance with the provisions of Part II "Technical Documentation" of the RS Rules/TS and Section 18 of the Guidelines on Technical Supervision of Ships under Construction. The programs shall include tests of items, means and systems given in 33.1.1.2 of this Section and provided onboard the ship with account for MASS category.

**33.4.5** Systems related to systems of high and very high-risk level, as well as systems ensuring essential MASS control functions shall be preliminary verified using simulators prior to full-scale tests.

**33.4.6** After completion of mooring and sea trials, the MASS test report shall be prepared and submitted to the Register. The report shall provide evidence that all earlier planned actions for risk mitigation (safety program) have been implemented, and MASS together with the shore-based and maritime infrastructure ensures a safety level equivalent to or better than that of a conventional ship.

**33.4.7** Before the commissioning, the developer shall develop a survey plan agreed with RS, covering the total life cycle of MASS, including RCC, where available, and supporting infrastructure to determine the content and scope of each survey, as well as survey and testing procedures. The following input data shall be considered:

compliance with the applicable requirements of the RS rules;

compliance with the requirements of this Section;

compliance with the requirements of the Guidelines on Technical Supervision of Ships in Service;

maintenance and repair plan.

**33.4.8** Scope of surveys after construction shall comply with the approved survey plan to verify that MASS systems comply with the requirements of this Section.

### 33.5 SURVEY OF REMOTE CONTROL CENTRE

**33.5.1** For the initial survey, the documents listed in 33.2.1.2.6, as well as procedures and programs of RCC tests shall be submitted to the Register.

**33.5.2** The scope of survey shall include at least the following:

verification of RCC compliance with the approved design documentation;

confirmation, based on the documents issued by competent organizations that fire safety of RCC meets the requirements of national standards;

confirmation, based on the documents issued by competent organizations, that operators work stations meet the requirements and norms of national standards;

verification of personnel sufficiency and competence;

verification of documents on ensuring the safety, security and network management system and implementation efficiency;

functional tests within the scope of test program.

**33.5.3** To carry out annual survey for extension of documents confirming compliance with the requirements of this Section:

list of amendments (if any) made to the documentation for initial survey shall be submitted to the Register;

annual survey for confirmation of compliance shall be carried out 3 months before the date of expiry of the documents confirming the compliance with the requirements of this Section;

scope of survey shall comply with 33.5.2.

**33.5.4** Survey for renewal of documents upon expiry thereof:

the documentation in accordance with 33.2.1.2.6 shall be submitted to the Register;

annual survey for renewal of documents shall be carried out not less than 3 months from the date of expiry of the documents;

scope of survey shall comply with 33.5.3.

**33.5.5** The documents confirming RCC compliance with the requirements of this Section are valid 12 months from the date of the issuance of the documents.

### 33.6 DRAWING UP AND ISSUANCE OF DOCUMENTS

**33.6.1** Results of technical supervision shall be documented in the reports as per form 6.3.10.

The basic document confirming the compliance of the ship with the RS requirements for the appropriate MASS category on the date of construction or conversion completion is the Classification Certificate (form 3.1.2) with distinguishing mark **SAS**, **SAS-RCC**, **FAS,** or **FAS-RCC** in the character of classification.

**33.6.2** Upon confirmation of compliance with the requirements of this Section applicable to RCC there will be issued Statement of Compliance of MASS Remote Control Centre (form 3.1.18).

## 33.7 CONCEPT OF MASS OPERATION

**33.7.1 Tasks.**

The Concept shall specify the conditions and methods of MASS operation, as well as basic design solutions allowing compliance with the requirements of this Section.

**33.7.2 Requirements.**

**33.7.2.1** Concept of MASS operation shall include the following basic sections (refer to Appendix 1);

**.1** MASS description, name, flag, identifiers;

**.2** MASS main particulars;

**.3** MASS operational modes;

**.4** conditions and limitations of MASS operation:
ambient conditions of operation;
marine conditions of operation:
special conditions of operation;

**.5** MASS manoeuvring characteristics (for assessment of risks and manoeuvring safety) including:

general parameters of the ship movement;

controllability parameters and inertia and braking characteristics of the ship on even keel, fully loaded in deep and shallow waters (depth-to-draught ratio = 1,5);

ship behavior in full load/ballast, on even keel using ship positioning means;

**.6** control modes of MASS systems, including:

structure of control systems;

means of situational awareness, communication, navigation and manoeuvring;

ship power plant (SPP);

systems serving the hull, deck machinery, means of damage control;

means of environmental protection, means of anti-intrusion protection of the ship, means of cyber security assurance;

**.7** basics of operation (including control methods, limitations, specific operations) at anchorage and mooring; towing (other than emergency one); at launching/hoisting; during transportation; hull strength, buoyancy and stability control; engines, machinery and electrical systems of fire-fighting means and water control; control of systems of navigational equipment; systems for dangerous goods transportation; recovery of control systems after their disabling;

**.8** basics of inspection, maintenance and withdrawal.

**33.7.3 Verification methods.**

**33.7.3.1** The following documents and drawings shall be submitted to RS for the survey:

concept of MASS operation (refer to Appendix 1);

technical description of the main components of the MASS onboard equipment which ensures its unmanned operation, at least: means of operational situation assessment; means of communication; means of navigation and manoeuvring; SPP additional monitoring devices; means of additional monitoring of the hull; means of additional monitoring of movement, anchor and mooring arrangements; means of damage control (water and fire); means of environmental protection; means of anti-intrusion protection of the ship; means of cyber security assurance.

**33.7.3.2** Moreover, the compliance of the submitted concept of MASS operation (refer to Appendix 1) with the other applicable requirements of the Rules for the Classification and Construction of Sea-Going Ships shall be verified.

## 33.8 RISK-ORIENTED PROCESS OF MASS APPROVAL

**33.8.1 Purpose and application.**

This chapter contains the description and recommendations on the implementation of the process aimed at objective evidence that the operation of MASS and/or the system within MASS ensures a safety level equivalent to or better than that of a conventional ship designed and operated in accordance with the existing RS rules and regulations. This process is based on the risk assessment being a part of the risk management process, and covers all stages of the MASS life cycle involving RS and requiring RS approval or survey.

The Section contains a description of two interconnected processes:

risk assessment of MASS operation;

risk assessment of operation of systems for MASS.

**33.8.2 Normative references.**

A list of valid international and Russian standards referenced in this Section is given in 33.8.2.1 — 33.8.2.3. The list if divided into groups of standards according to their applicability to description of process of assessment and approval of MASS and systems for MASS at various stages of their life cycle. Full titles of standards are given. Hereinafter, only their alphanumeric characters are specified.

**33.8.2.1** General approach to risk management process:

ISO 31000:2009 "Risk management — Principles and guidelines";

GOST R ISO 31000-2010 "Risk management. Principles and guidelines";

ISO/IEC 27005:2018 "Information technology — Security techniques — Information security risk management";

GOST R ISO/IEC 27005-2010 "Information technology. Security techniques. Information security risk management".

Life cycle processes and stages:

ISO/IEC/IEEE 15288:2015 "Systems and software engineering — System life cycle processes";

GOST R 57193-2016 "Systems and software engineering. System life cycle processes";

ISO/IEC 12207:2008 "Systems and software engineering — Software life cycle processes";

GOST R ISO/IEC 12207-2010 "Information technology. Systems and software engineering. Software life cycle processes";

GOST 34.601-90 "Information technology. Set of standards for automated systems. Automated systems. Stages of development";

GOST R 15.301-2016 "System of product development and launching into manufacture. Products of industrial and technical designation. Procedure of product development and launching into manufacture".

**13.8.2.2** Selection of risk assessment methods:

ISO/IEC 31010:2019 "Risk management — Risk assessment techniques";

GOST R ISO/IEC 31010-2011 "Risk management. Risk assessment methods";

GOST R 51901.1-2002 "Risk management. Risk analysis of technological systems".

Description of risk assessment methods:

IEC 61882:2016 "Hazard and operability studies (HAZOP studies) — Application guide";

GOST R 51901.11-2005 (IEC 61882:2001) "Risk management. Hazard and operability studies. Application guide";

IEC 60812:2018 "Failure modes and effects analysis (FMEA and FMECA)";

GOST R 51901.12-2007 (IEC 60812:2006) "Risk management. Procedure for failure mode and effects analysis";

IEC 61025:2006 "Fault tree analysis (FTA)";

GOST R 51901.13-2005 (IEC 61025:1990) "Risk management. Event tree analysis";

IEC 62502:2010 "Analysis techniques for dependability — Event tree analysis (ETA)";

IEC TR 63039:2016 "Probabilistic risk analysis of technological systems — Estimation of final event rate at a given initial state".

**33.8.2.3** Terminology related to risk assessment and reliability:

ISO Guide 73:2009 "Risk management — Vocabulary";

GOST R 51897-2011/ISO Guidelines 73:2009 "Risk management. Terms and definitions";

GOST 27.002-2015 "Dependability in technics. Terms and definitions".

**33.8.3 Life cycle stages.**

Developers of MASS and systems for MASS may be guided by different methodologies, i.e. a complex of rules, principles, ideas, concepts, methods and techniques defining the way of development, creation and application. These methodologies also include stages/steps of the life cycle of the products being created, which are a systematic complex of steps that determine, inter alia, the processes of interested parties' interaction in the results of creation and operation of these products. Taking into account that the standards specifying different development methodologies contain various definitions of stages/steps of product life cycle, the uniform terms for these stages are adopted in this chapter.

The comparison results and the terms for the life cycle stages accepted in this chapter are given in Table 33.8.3.

Table 33.8.3

**Comparison of stages/steps of work or processes/activities**

| ISO/IEC/IEEE 15288:2015 GOST R 57193-2016 (technical processes) | ISO/IEC 12207:2008 GOST R ISO/IEC 12207-2010 (technical processes) | GOST R 34.601-90 (stages of automated systems development) | GOST R 57193-2016 (stages of life cycle of the products) | Names of the stages adopted in this chapter |
|---|---|---|---|---|
| Business or mission analysis, the interested party needs and requirements definition, system requirements definition | Defining of stakeholders' requirements, analysis of system requirements | Establishment of requirements for automated systems, development of a concept of automated systems, terms of reference | Research and design | Concept development |
| Architecture definition, design definition, system analysis | System architecture design | Conceptual design, technical design | | Design |
| Implementation, integration | Implementation, integration of system | Detailed (design) documentation | Development, manufacture (production) | Manufacture and commissioning |
| Verification, transition, validation (appraisal) | Qualification testing of the system, software installation, support of software acceptance | Commissioning | Delivery | |

| ISO/IEC/IEEE 15288:2015 GOST R 57193-2016 (technical processes) | ISO/IEC 12207:2008 GOST R ISO/IEC 12207-2010 (technical processes) | GOST R 34.601-90 (stages of automated systems development) | GOST R 57193-2016 (stages of life cycle of the products) | Names of the stages adopted in this chapter |
|---|---|---|---|---|
| Operation, maintenance | Software functioning, software maintenance | Maintenance of automated systems | Operation | Operation |
| Disposal and retirement | Software disposal | | Liquidation | Retirement |

**33.8.4 MASS operation risk assessment.**

**33.8.4.1** Development of concept of MASS operation.

At the stage of development of the concept of MASS operation, the risk assessment of its operation shall be performed by developer.

**33.8.4.1.1** The concept of MASS operation (refer to Appendix 1) shall define the factors to be considered during design. At least the following shall be referred to these factors:

MASS category (e.g. purpose, type, main particulars or gross tonnage, new or existing hull type, cargo type);

ship systems or functions (e.g. type of power plant, equipment functions);

MASS areas of navigation and maintenance (e.g. operations in the open sea, coastal area, inland waterways, service area in the port and/or during navigation);

limiting conditions of operation (e.g. seaways, wind, ice situation);

MASS external communications (e.g. with vessel traffic system, forecasting service, rescue and port services, remote control centre);

hazards with such potential sequences as injuries and/or death of passengers and mooring/service crew, environmental impact, damage of MASS or port facilities or damage to business.

**33.8.4.1.2** Based on the decisions on the degree of MASS autonomy and its purpose, the initial data for risk assessment shall be prepared by the developer. Such data include statistics of the relevant accidents and incidents, as well as the data on system and equipment reliability. These data shall be collected during the whole design period for using the experience gathered in risk assessment. As much as possible data and information shall be collected. Where the data are not sufficient, expert reviews, physical models and numerical simulation may apply. While considering a new problem for solving of which no sufficient experience and statistical data of accidents are available, the data and information of other industry branches may be reviewed and used as the reference.

**33.8.4.1.3** For obtaining the information on marine casualties and incidents, it is recommended to use well-known databases, the most overall and public database is contained in the IMO maintained Global Integrated Shipping Information System (GISIS). This data base is referred to as the "Marine Casualties and Incidents". Information resource address and access conditions to this and other database are given in Table 33.8.4.1.3.

Table 33.8.4.1.3

**Recommended database of marine casualties and incidents**

| Database | Information resource address | Access |
|---|---|---|
| Marine Casualties and Incidents | https://gisis.imo.org/Public/Default.aspx | Free |
| Marine Accident Investigation Branch (MAIB) reports | https://www.gov.uk/maib-reports | Free |
| Marine Accident Reporting Scheme (MARS) reports | https://www.nautinst.org/resource-library/mars/mars-reports.html | Free |
| Marine Accident Reports (National Transportation Safety Board (NTSB)) | https://ntsb.gov/investigations/AccidentReports/Pages/marine.aspx | Free |
| Casualty and Events (IHS Markit) | https://ihsmarkit.com/products/casualty-and-events.html | Paid |

Processed and systematical statistical data related to marine casualties for the European waters are freely available at webpage of the European Maritime Safety Agency — EMSA — http://emsa.europa.eu/implementation-tasks/accident-investigation. Statistical data for territorial waters and ships are also provided by other countries, e.g. Australia, Japan, Norway, Denmark, and Canada.

**33.8.4.1.4** Prepared initial data shall be thoroughly analyzed. The analysis is aimed at MASS operation risk ranking based on its purpose. The analysis is recommended to be performed through the following steps.

**33.8.4.1.4.1** Hazardous event identification.

Depending on the prior decision on the preparation of initial data, their scope and depth, one or more methods of identification may be chosen as specified in ISO/IEC 31010:2019 and GOST R ISO/IEC 31010-2011. Anyway, a final list of hazardous events shall be consequently defined containing a description of identification procedure, the events, causes of occurrence, sources of danger, quantitative and/or qualitative likelihood parameters. The following may refer to these events, namely:

collision — an impact or allision with another ship irrespective of the latter movement, anchorage or berthing;

grounding — ground contact, impact or touching of seabed, shore or underwater object (sunken ship, etc.);

run foul — impact with a fixed or float object not fall within the definition of collision or grounding;

fire/explosion — the events where fir/explosion are the initial causes of an incident;

flooding — solid or partial;

capsizing, high-risk list — instability;

damage to the hull due to violation of seaworthiness limitations;

damage to the equipment — a failure of machinery being an initial cause of an incident;

loss of control — inability to control seaway course and speed;

piracy — malicious actions of extraneous forces on illegal seizure, robbery or sinking of a ship;

disappearance — missing by unknown cause.

When the information on the previous marine casualties was used as the initial data, the result of hazardous event identification shall be submitted in tabular form (refer to Table 33.8.4.1.4.1):

Table 33.8.4.1.4.1

**Examples of submitting the results of hazardous event identification**

| Period from ... to ... Totally = ... years<br>Number of ships in service throughout the entire period = ... | | |
|---|---|---|
| Hazardous event | Numbers of event for the period | Frequency of event<br>(for one ship per a year) |
| | | |
| | | |

Obtained probabilities may apply as initial for the event tree analysis at the next step.

**33.8.4.1.4.2** Likelihood assessment of hazardous events.

The task of this step is identification of hazardous event scenarios and quantitative and/or qualitative assessment of likelihood thereof. Scenario means a sequence of events form the initial to the final one characterized by harm caused, taking into account different conditions of the hazardous event occurrence. It is recommended to assess the likelihood by construction of an event tree similar to event tree analysis (ETA) in accordance with IEC 62502:2010 standard. Hazardous events identified with their probability at the first step are accepted as the initial events. Further, the related events, conditions of hazard occurrence, hazardous event results shall be listed in such a way that they form event sequences — scenarios specifying each of them by the probability, likelihood value. The links of these chains may be, for example:

**.1** areas of hazardous event occurrence:
inland waters;
coastal waters;
open sea;
channels;
restricted waters;
ports;

**.2** stages of ship functioning:
berthing (loading/unloading);
entrance to the port;
departure from the port;
anchorage/moorage/weighing;
sea passage;

**.3** sources of hazards:
other ship or object;
environment;
equipment failure;
human errors.

Initial hazardous events that may result (resulted to in the past) may be accepted as the last links of the scenario chains. These terminal events shall define harm that may occur in case of implementation of each of scenarios received. Based on the IMO recommendation, three harm categories are considered with regard to assessment of safety at sea:
injury or damage to health,
harm caused by ship damage,
environmental damage.

Finally, scenarios of hazardous event occurrence shall be formed indicating quantitative and/or qualitative assessment of their likelihood. For this purpose, it is recommended to use IMO event frequency Table (refer to Table 33.8.4.1.4.2) where the correlation between the qualitative and quantitative parameters is specified and frequency indices are introduced.

Table 33.8.4.1.4.2

**Qualitative and quantitative parameters of event frequency**

| Determination of the event frequency | For one ship per a year | | Frequency index |
|---|---|---|---|
| | Qualitative parameter | Quantitative parameter | |
| Once a month on one ship | Often | 10 | 7 |
| Once a year on one ship | Sometimes | 1 | 6 |
| Once a year for the fleet of ten ships or several times throughout the life cycle of one ship | Very likely | 0,1 | 5 |
| Once a year for the fleet of 100 ships | Possibly | $10^{-2}$ | 4 |
| Once a year for the fleet of 1000 ships or throughout the life cycle of several similar ships | Probably | $10^{-3}$ | 3 |
| Once for the life cycle (20 years) of a fleet of 400 ships | Not likely | $10^{-4}$ | 2 |
| Once for the life cycle (20 years) of a fleet of 5000 ships | Most unlikely | $10^{-5}$ | 1 |

**33.8.4.1.4.3** Determination of severity effects of hazardous events.

For assessment of severity effects of each scenario in accordance with the IMO recommendation, three groups shall be considered: effects for people, ships and environment. Qualitative assessments of the effects and relevant verbal characteristics thereof, as well as values of indices for these groups are given in Tables 33.8.4.1.4.3-1 — 33.8.4.1.4.3-3.

Table 33.8.4.1.4.3-1

**Severity effects parameters for people**

| Definition of effect | Qualitative parameter | Equivalent fatalities | Severity index |
|---|---|---|---|
| Single or minor injuries | Minor | 0,01 | 1 |
| Multiple or major injuries | Serious | 0,1 | 2 |
| One fatality or multiple major injuries | Heavy | 1 | 3 |
| Multiple fatalities | Catastrophic | 10 | 4 |

Table 33.8.4.1.4.3-2

**Severity effects parameters for ship**

| Definition of effect | Qualitative parameter | Equivalent damage | Severity index |
|---|---|---|---|
| Local damage to equipment | Minor | 0,01 | 1 |
| Minor damage to the ship | Serious | 0,1 | 2 |
| Major damage to the ship | Heavy | 1 | 3 |
| Total loss | Catastrophic | 10 | 4 |

Table 33.8.4.1.4.3-3

**Severity effects parameters for environment**

| Definition of effect | Qualitative parameter | Equivalent spill of oil or chemical substances | Severity index |
|---|---|---|---|
| Local spill | Minor | < 1 ton | 1 |
| Major local spill | Serious | 1 – 100 tons | 2 |
| Serious major spill | Heavy | 100 – 10000 tons | 3 |
| Very heavy spill | Catastrophic | > 10000 tons | 4 |

Finally, each of hazardous scenarios specified in 33.8.4.1.4.2 shall be evaluated according to severity effects for people, ships and environment.

**33.8.4.1.4.4** Risk level assessment.

At this step, the quantitative and qualitative characteristic of risk level of each hazardous scenario determined by the scenario probability and its effect severity. It is recommended to assess the risk level using the risk index by addition of the frequency index and effect severity for each of three effect groups. The example is given below (refer to Table 33.8.4.1.4.4).

Table 33.8.4.1.4.4

**Risk degree parameters (examples)**

| Hazardous event | Scenario (number) | Frequency index | Severity index | | | Risk index | | |
|---|---|---|---|---|---|---|---|---|
| | | | Human | Ship | Environ ment | Human | Ship | Environ ment |
| Collision | 1 | 3 | 1 | 4 | 1 | 4 | 7 | 4 |
| | 2 | 4 | 2 | 2 | 1 | 6 | 6 | 5 |
| | | | | | | | | |
| | n | 7 | 2 | 2 | 1 | 9 | 9 | 8 |
| Fire | 1 | 4 | 1 | 4 | 2 | 5 | 8 | 6 |
| | 2 | 2 | 1 | 4 | 2 | 3 | 6 | 4 |
| | … | | | | | | | |
| | m | 1 | 2 | 3 | 3 | 3 | 4 | 4 |

**33.8.4.1.4.5** Risk evaluation.

It is recommended to perform risk evaluation of all hazardous scenarios by ranking thereof, e.g. in descending order of risk index values or other quantitative/qualitative parameters of risk level. As a result, a list shall be formed where the scenarios, having different hazardous events as the initial ones, are grouped by risk level. It is recommended to form three lists of the ranked scenarios: by severity of consequences for people, ship or environment.

The developer shall substantiate and propose the risk criteria for determination of acceptability thereof as applied to all three ranked lists of scenarios. Resulting from the risk level and risk criteria comparison, the decisions on risk acceptance or risk aversion during further MASS development shall be substantiated for each scenario. For all scenarios, where risk aversion is specified, the risk mitigation actions shall be proposed.

**33.8.4.1.5** Identification of risk mitigation actions shall finalize risk assessment at the stage of development of the concept of MASS operation. Risk mitigation actions shall be aimed at obtaining one or several of the following results:

risk probability mitigation during design, engineering implementation, operation, maintenance, training of specialists;

risk consequence prevention, for instance, by hazardous event prevention;

mitigation of risk occurrence conditions;

mitigation of severity effects of hazardous events.

The proposed risk mitigation actions may be grouped according to the achieved results or stages of MASS life cycle where they shall be implemented. Therewith, possible impact of actions on achievement of more than one outcome and their mutual impact shall be considered. The final list of risk mitigation actions shall be evidenced in the concept of MASS operation.

For this purpose, the developer shall decide on which of the functions associated with risk mitigation actions that traditionally have been performed by crew will be performed either by remote control or automatically. This solution shall also be evidenced in the concept of MASS operation. The concept shall describe all MASS functions that will be either fully or partially automated. Each function shall be additionally divided into tasks and subtasks to a level that enables a clear distinction between the tasks where a human is in charge of decision making and performing actions, and the tasks where the system is in charge of decision-making. When a human is involved in the implementation of control functions, the location of decision maker shall be clearly described: onboard, in RCC, or onboard and in RCC (in case of combined control). Risk assessment shall be finalized by the specific solutions for mitigation of risk of MASS operation and determination of degree automation thereof.

Risk analysis results including the description of all steps, methods applied, initial data, solutions adopted, and concept of MASS operation shall be submitted by the developer to the Register for review and subject to updating during the risk assessment process at the next stages of the MASS life cycle.

**33.8.4.2 Design.**

It is customary to divide a design stage into two substages: conceptual (high-level, general) and technical (detailed) design.

**33.8.4.2.1** The main objectives of conceptual design are development of variants of MASS development, their comparison and selection of the optimum variant according to specified parameters. As a result, a variant, which is optimal to the required functionality, performance characteristics, availability, safety and maintainability is selected. The major design decisions like propulsion arrangement, fire-fighting capabilities and system architecture shall typically be made at this stage. This design serves as a basis for discussion with potential system suppliers, and shall be implemented based on the information received from suppliers regarding specific system capabilities. The MASS specific systems shall be approved by RS following the verification for compliance with the requirements of 33.3 — 33.7. Potential suppliers of conventional systems shall submit the appropriate RS certificates of approval.

To confirm that operation of MASS to be designed ensures a safety level equivalent to or better than that of a conventional ship, the technical background for the conceptual design shall contain (but not limited to) the following three sections.

**33.8.4.2.1.1** Basic safety measures.

Firstly, this Section shall contain an analysis of the existing rules and requirements for operation of similar purpose ships where nonconformities and discrepancies with the intended operation of MASS to be designed will be identified. On this basis, the alternative solutions shall be outlined, and this results in requirements for systems to be supplied. In some cases, a focused risk analysis shall be provided in order to clarify that the proposed, alternative solution will result in an equivalent safety level.

Secondly, the minimum risk conditions (MRC) shall be proposed that the ship shall enter when the external conditions go outside the limits and, probably, exit of which, when the conditions allow to operate normally. These conditions shall be detailed and their position shall be determined in the hierarchy of the event tree and/or decision tree. The same MRCs may be structured in different trees for different scenarios. MRCs which serve as the last resort in the event and solution hierarchy shall be clearly indicated. These conditions shall be such that no circumstances may worsen safety level of MASS in question.

Thirdly, the formal and informal requirements regarding competency for the personnel involved with the MASS operation and maintenance shall be described. Competence criteria of the personnel involved in remote control, supervision and control of the MASS systems operation shall be specified.

**33.8.4.2.1.2** Basics of autonomous/remote control.

This Section shall contain a description of overall design solutions, requirements and limitations for systems intended for implementing autonomous/remote control functions. For these systems, such redundancy and fault tolerance shall be provided in order to ensure the capability of MASS to enter and maintain in MRC in case of any hazardous scenario.

The boundaries of each system from different suppliers shall be defined. In this regard, in order to specify the required scope of work on the RS approval of systems they shall be categorized into the following categories:

type approved systems intended used in conventional application;

type approved systems intended used in new application or serving new purpose;

conventional systems (without approval) intended used in conventional application;

conventional systems (without approval) intended used in new application or serving new purpose;

new systems having an approval for application in MASS;

newly developed systems for MASS to be designed and having no RS approval.

**33.8.4.2.1.3** Basic solutions for maintenance during operation.

This Section shall substantiate reduction in the number of required personnel in the vicinity of the systems and machinery during the introduction of autonomous and remotely controlled systems. Special attention shall be paid to maintenance of systems implementing the remote-control functions of the ship. A description containing the procedure how each system will be monitored, diagnosed, maintained and repaired shall be provided. These systems include both software and mechanical subsystems/components. Basic responsibilities of different officials both onboard the ship and onshore shall be clearly defined.

**33.8.4.2.2** The main tasks of technical design are justification and description of the previously selected MASS variant.

At this substage, the final design solutions regarding all MASS systems shall be adopted. For autonomous functions, focus of this substage is to make sure that each system selected for delivery will be able to provide desired functionalities and that interfaces between different systems are sufficiently defined. Combined, the MASS design documentation and the design documentation for ship systems shall describe the total infrastructure so to enable a decision-making on safe implementation of MASS functions. For this purpose, MASS design documentation shall in addition to the conventional content, also specify special arrangements needed to fulfil requirements for autonomous functionality and associated systems ensuring such functionality.

MASS design documentation shall define infrastructures needed off the ship in order to safely implement autonomous functions. It may be design documentation for RCC and communication systems connecting the ship and RCC. Also, the design documentation shall include other off-ship systems required for ship operation based on its operational concept. Systems of navigation delimiting marking, towing and automatic mooring system may be referred to such systems.

Design documentation shall contain a single document on detailed risk analysis of MASS operation. In total, this analysis shall be performed on basis of the concept of MASS operation, decision made during design work, information on ship systems and MASS structure. The purpose is to ensure that MASS and supporting infrastructure as a whole are able to withstand with relevant malfunctions, failures and hazardous situations at sea in safe manner. The risk analysis shall be performed using one or more standard (ISO/IEC 31010:2019, GOSTR 51901.1-2002) risk assessment methods, e.g. FTA — fault tree analysis (IEC 61025:2006, GOST R 51901.13-2005), ETA — event tree analysis (IEC 62502:2010) or FMEA (FMECA) — failure modes and effects analysis (IEC 60812:2018), GOST R 51901.12-2007).

Software products applied for quantitative risk assessment shall be agreed with RS and/or have certificates of approval issued by the appropriate regulatory bodies and governmental institutions.

All risk mitigation actions proposed at the development stage of the concept of MASS operation shall be reasonably confirmed by this analysis. Newly identified risks shall be accompanied by the justification of actions for mitigation thereof. All risks shall be documented and actions for their mitigation shall be planned, executed and monitored throughout all subsequent life cycle stages. For that, at the design stage the safety program of MASS operation shall be developed and submitted to the Register in additional to the design documentation and risk analysis.

**33.8.4.3 Manufacture and commissioning.**

At this stage a test program shall be developed containing a description of the procedure for testing MASS functional capabilities prior to its operation.

The program shall contain all required verifications and tests (provisional tests, mooring trials, sea trials, etc.) with indication of the area of their conducting. The purpose of each type of verification shall be defined and the scope and responsibilities of the involved parties shall be specified. Test medium, its capabilities and limitations shall be defined for each test. The program shall take into consideration that the systems having already obtained the RS type approval, may still require verification in real operational environment. For successful completion of test program, it is essential that the autonomous infrastructure is tested for extreme load and its actual performance is verified for compliance with the required reliability and safety parameters.

Individual programs and procedures shall be developed for particular verifications and tests. The procedures shall contain detailed information on the system intended for testing including system type, hardware identification and software versions. Any simulators used in the test setup shall also described and recorded with type and version. For redundant systems, the tests within verification of each system shall be provided. Therewith, the conclusions and recommendations made earlier at the risk assessment shall be verified, in particular, the requirements for fail safe response, the necessity of redundancy or, vice versa, absence of such necessity. The tests shall cover all specified technical system configurations. The tests for acknowledgment of redundancy necessity and tests for fault tolerance shall be performed under as realistic conditions as practicable, e.g. by use of emulators and simulators.

During the appraisals, verifications and tests, all results shall be recorded along with any discrepancies towards the expected results. Protocols and reports on appraisals, verifications and tests shall be submitted to the Register. MASS test program report shall be prepared and submitted to the Register. This report shall provide evidence that all earlier planned actions for risk mitigation (safety program) have been implemented, and MASS together with the shore-based and maritime infrastructure ensures a safety level equivalent to or better than that of a conventional ship.

**33.8.4.4 Operation.**

Data on MASS functioning shall be collected, analyzed and submitted to the Register as agreed with the shipowner and operator of the ship. The data shall include hours of operation, detected failures, entering and leaving MRCs, and other operational data used for condition monitoring of systems and ship in general. The particular data list and access procedure thereto shall be determined for each MASS in coordination with relevant interested parties. The developer's responsibility is to provide the possibility of collection, storing, processing and release of information to RS.

Any MASS in service shall be subject to survey for compliance with the applicable RS rules and regulations.

For MASS, the survey scheme shall include verification of technical means of the supporting infrastructure (remote control centre, means of navigation delimiting marking, communication means, etc.).

The developer shall develop the procedure of software maintenance and upgrade. The procedure shall contain at least the following information:

testing methodology for a new software version including simulator-based testing;

instructions for a new software version installation;

instructions for rollback to previous version.

The developer shall ensure storage of the released software versions with the possibility of rollback to previous version. Prior to making changes, RS shall be notified of the necessity of any changes to the MASS systems by sending to RS the notification of the changes to the design and program documentation, as well as description of modernization process.

**33.8.5 Risk assessment of application of systems for MASS.**

**33.8.5.1** Concept development.

Development of the concept of system for MASS is a formulation of an idea, which shall reflect the requirements of terms of reference, main and the most general proposals for their implementation, comparison of system architecture options, including the modelling results. The results of concept development shall be drawn up as technical background and submitted to RS by the developer independently or as a part of the concept of MASS operation.

For the systems to be applied for MASS, the risk assessment shall be performed by the developer at the stage of development. For complicated systems, breakdown into individual subsystems or functions is permitted. Risk assessment shall be performed for each of them. The assessment results shall be indicated in the technical background to be submitted to RS.

Risk assessment of the system application consists of the following three steps.

**33.8.5.1.1** Qualitative assessment of system failure probability.

Assessment of failure probability shall be defined based on technical complexity level of the system and the complexity level of the applicable data analysis. Qualitative descriptions of these levels are given in Tables 33.8.5.1.1-1 and 33.8.5.1.1-2, accordingly.

Table 33.8.5.1.1-1

**System complexity levels (SCL)**

| SCL | System complexity |
|---|---|
| 0 | Simple system (Isolated system) |
| 1 | Simple system (Partial integration with other systems, not every system is connected to the network) |
| 2 | Complex network (Network connection and full integration (onboard only)) |
| 3 | Multi-agent communication (Remote and shore access, onboard function is based on ground support, continuous and reliable ship-to-shore communication) |

Table 33.8.5.1.1-2

**Data analysis complexity levels (DACL)**

| DACL | Data analysis complexity |
|---|---|
| 0 | Basic (Parameter monitoring, statistics and trends) |
| 1 | Physical simulators and conventional condition monitoring methods with analytical support |
| 2 | Data models (Machine learning models and automatic control models with/or without physical model) |

As a result, the failure probability levels shall be determined by a sum of SCL + DACL. Correspondence of this sum with three failure probability levels — low, moderate and high, with system examples is given in Table 33.8.5.1.1-3.

Table 33.8.5.1.1-3

**Probability levels of failure occurrence with system examples**

| Failure probability level | SCL + DACL | System example |
|---|---|---|
| L (Low) | 0, 1 | Check of bending moment and hull slamming by means of strain-gauge transducers and accelerometers |
| M (Moderate) | 2, 3 | Check of temperature and pressure in the engine cylinder with integral temperature and pressure detectors |
| H (High) | 4, 5 | Voyage optimization (periodical use of weather forecast, performance monitoring of relevant onboard systems, data driven fuel consumption model) |

**33.8.5.1.2** Qualitative assessment of system failure effects.

Possible effects of the system failure shall be assessed based on the identified levels:

participation of the system in decision-making and implementation thereof;

integration in the onboard system;

severity categories of the system failure effects.

The appropriate levels are given in Tables 33.8.5.1.2-1 — 33.8.5.1.2-3.

Table 33.8.5.1.2-1

**Levels of participation in decision-making and implementation thereof (LDM)**

| LDM | Data processing | Decision making | Action implementation |
|---|---|---|---|
| 0 | System and human | Human | Human |
| 1 | System and human | Human with system support | Human |
| 2 | System | System under human supervision | System under human supervision |
| 3 | System | System | System |

Table 33.8.5.1.2-2

**Levels of integration in the onboard system (LIS)**

| LIS | Level of integration |
|---|---|
| 1 | Detached (separated from other systems or passively connected only for data collection in case of integration with onboard systems. No potential effect on safety and system performance of the integrated system) |

| | |
|---|---|
| 2 | Partial (one-way transmission to pull-model system. May result in performance reduction, but have no effect on the safety of the integrated system) |
| 3 | Fully integrated (two-way communications with onboard systems with the possibility of order transmission to systems for on-line adjustment or optimization. Possible effect on the safety of the integrated system application) |

Table 33.8.5.1.2-3

**Severity categories of the system failure effects (SCSF)**

| Category | Failure effect | Examples of the system functioning |
|---|---|---|
| 1 | Failure that may result in reduction of system functioning quality, but pose no hazard to the environment, ship and people's health | Monitoring function for information/administrative tasks |
| 2 | Failure that may cause delay of the task executing, reduction of readiness and efficiency of ship application, but pose no hazard to the environment, ship and people's health | Functions of alarm and monitoring Control functions required for ship maintenance in normal operating and manned conditions |
| 3 | Failure that may quickly and highly likely result in significant harm for the ship and/or environment, breaking of the performing task, but create a negligible hazard to health or life of people | Control functions for holding of speed and travel direction |
| 4 | Failure that may quickly and highly likely result in significant harm for the ship and/or environment, loss of life or heavy injuries of people, breaking of the performed task | Ship safety functions (navigational, fire explosion safety) |

Finally, possible effects of the system failure are determined by LDM + LIS + SCSF and are characterized by four levels (refer to Table 33.8.5.1.2-4).

Table 33.8.5.1.2-4

**Severity categories of the system failure effects with system examples**

| Effect severity level | LDM + LIS + SCSF | System example |
|---|---|---|
| L (Low) | 0, 1, 2 | Monitoring of ship framing condition (control panel with strain gauge transducers) |
| M (Moderate) | 3, 4, 5 | Consideration of actual weather along the route (recommendations for the route and passive data collection from the relevant systems) |
| H (High) | 6, 7, 8 | Control of power and optimization (automatic adjustment of engine performance parameters with specifying the range for better output) |
| VH (Very High) | 9, 10 | Remote control of the ship or control of fully automated ship |

**33.8.5.1.3** Assessment of risk level associated with system application.

Four risk levels of system application: L — low (green), M — moderate (yellow), H — high (orange) and VH — very high (red) shall be specified based on the qualitative levels of failure probability and effect severity of the system failure by means of risk matrix given in Table 33.8.5.1.3.

Table 33.8.5.1.3

**Risk level matrix of system application**

| Effect severity level | Failure probability level | | |
|---|---|---|---|
| | L | M | H |
| L | L | L | M |
| M | M | M | H |
| H | M | H | H |
| VH | H | VH | VH |

Risk analysis results including the description of all steps, initial data and decisions made, and application concept shall be submitted by the developer to the Register for review as a part of the concept and subject to updating during the risk assessment at the next stages of the system life cycle.

**33.8.5.2 Design.**

At the design stage, a quantitative or qualitative analysis of the system failure criticality shall be carried out depending on the risk level of the system:

VH — in-depth quantitative criticality analysis is mandatory;

H — quantitative criticality analysis is advisable;

M — only qualitative analysis may apply;

L — no analysis is required.

Criticality analysis is aimed at specifying the failure criteria of the system or its components, that severity effects within this analysis are considered as inadmissible and require special measure to be taken for reduction of the probability of such failure and/or possible damage related to its occurrence. At this stage, the developer shall substantiate and propose the risk criteria to define its acceptability. Resulting from comparison of risk level and risk criteria, the decisions on risk acceptance or risk aversion during further development shall be substantiated for each system. It is recommended to perform the criticality analysis using FMECA method — failure mode and effect critical analysis (IEC 60812:2018, GOST R 51901.12-2007).

It is recommended to perform quantitative risk analysis of the system using one or several standard methods (ISO/IEC 31010:2019, GOST R 51901.1-2002), e.g. FTA — failure tree analysis (IEC 61025:2006, GOST R 51901.13-2005), ETA — event tree analysis (IEC 62502:2010). Software products applied for risk quantitative assessment shall be agreed with RS and/or have certificates of approval issued by the appropriate regulatory bodies and governmental institutions. It is also recommended to combine risk assessment with reliability assessment of the system based on the parameters specified in the terms of reference, e.g. failure-free, repairability, and durability. In this case, a reliability program should be used if its development is provided for by the terms of reference or the methodology of development. Calculations for different options of system architecture shall clearly demonstrate the effectiveness of the proposed actions to mitigate the system's risk.

Finally, qualitative and/quantitative risk analysis of the system shall demonstrate how the designed structure of the system supports the required functionality and ensures safety of people onboard, ship and environment equivalent (as safe or safer) to the existing conventional solutions. System risk analysis as part of the design documentation shall be submitted to the Register.

**33.8.5.3 Manufacture and commissioning.**

At this stage, the programs and test procedures and all types of tests (provisional tests, acceptance tests, mooring trials, etc.) shall be developed and agreed with RS. Systems previously referred to systems of high and very high-risk level, as well as systems responsible for essential MASS functions shall be verified using simulators.

Simulator based testing shall provide objective evidence of suitable functionality (during normal, abnormal and degraded condition) of the specified target control system according to functional and safety requirements defined in this Section or originating from the previously performed risk analysis. Such testing shall be definitely performed for the functionality where it is required to verify that the function or whole system will work satisfactorily in a large range of operational scenarios including scenarios of occurrence and sequence of hazardous events. Examples of such functions are:

voyage and route planning;

continuous monitoring and situational awareness;

detection, tracking, classification of ships, navigational objects and dangers;

determine the distance to the closest point of approach and time to the closest point of approach for ships and other navigational objects;

determine the hazardous situation, e.g.: crossing of prohibited areas, dense and congested traffic, coastal navigation, weather conditions deterioration, pilot required;

avoidance of collision or grounding;

weather routing.

For redundant systems, the tests within verification of each system shall be provided. Therewith, the conclusions and recommendations made earlier at the risk assessment shall be verified, in particular, the requirements for fail safe response, necessity of redundancy, absence of such necessity. The tests shall cover all specified technical system configurations. The tests for acknowledgment of redundancy necessity and tests for fault tolerance shall be performed under as realistic conditions as practicable, e.g. by use of emulators of the interfacing systems and simulators of conditions.

Integrated systems with high level of complexity shall be subject to additional verification for the availability of new emergent properties and compliance with the requirements of the functions being the result of integration. Integration of such systems is normally done during commissioning and testing close to project completion. In some cases, this testing may be impossible due to the risk of damage to the system. Therefore, integration testing shall be carefully planned and alternatives, such as simulation, shall also be considered where appropriate. Integrated testing can be done in a simulator environment using models and emulated or hardwired control systems. Scope of testing shall also include critical failure modes (e.g. short circuit) that are challenging/impossible to perform on real equipment (hardware).

Software tests shall be performed at the earliest stage possible. The objective of the software tests is to ensure that the control system SW is ready and verified as extensively as possible before the commissioning and sea trial period starts. The developer is responsible for logging the versions of uploaded test target SW. The target SW shall not be changed during a test activity unless it is imperative to continue the test activity. The developer is responsible for documentation of changes to SW. Software versions numbers of the emulators and simulators used during testing shall also be documented.

After installation of the system onboard the ship, the system shall be subject to mandatory integration testing and network testing towards other systems and components.

During the verifications and tests, all results shall be recorded along with any discrepancies with the expected results. Protocols and reports on verifications and tests shall be submitted to the Register. A report on risk assessment based on the test results shall be prepared and submitted to the Register. This report shall also provide evidence that all earlier planned actions for risk mitigation and system reliability (reliability program) have been implemented, and the system may be applied for MASS. Therewith, a safety level equivalent to or better than that of a conventional ship will be ensured.

**33.8.5.4 Operation.**

Prior to making changes, RS shall be notified of the necessity of any changes to the MASS systems by sending to RS the notification of the changes to the design and program documentation, as well as description of modernization process. The developer shall develop the procedure of software maintenance and upgrade. The procedure shall contain at least the following information:

testing methodology of a new software version including simulator-based testing;

instructions on how to install the new software version;

instructions on how to restore the previous software version.

The developer shall ensure storage of the previous software versions with the possibility to rollback to the previous versions. Systems which include machine-learning mechanisms, automatic control can be trained with cumulative data sets obtained from operation, but shall not use the results of training prior to new version deployment. In this case, the system capabilities in operation shall be updated only at defined intervals after the successful verification of upgrade.

## 33.9 REQUIREMENTS FOR MASS AND SYSTEMS THEREOF

**33.9.1 Situational awareness system.**
**33.9.1.1** Tasks.
**33.9.1.1.1** Situational awareness system shall receive and process the information on the environmental conditions and MASS condition for making decisions on the ship and ship systems control during:
movement in the open sea;
movement in restricted waters, straits;
anchorage/weighing and at anchorage;
port entering/departing from a port;
mooring operations, movement in port waters;
during cargo operations.
**33.9.1.1.2** Situational awareness system shall consolidate all available sources of information located onboard the ship and off the ship (operator-controlled or automated) using on-line and history information.
**33.9.1.1.3** Depending on the automation level of the ship, situational awareness system is capable of addressing the task of generating command for control response. In this case, it shall be called as the system of situational awareness and decision-making related to ship control.
**33.9.1.1.4** Situational awareness system shall perform, inter alia, the following tasks:
ensure MASS operation under all operational conditions provided by the concept of operation thereof (refer to Appendix 1);
ensure timeliness and authenticity of situational information required for correct and timely decision-making related to ship control;
act in a predictable manner taking into account the safety and reliability level, specified operational requirements and safety requirements for the voyage performed.
**33.9.1.2** Requirements.
**33.9.1.2.1** Situational awareness system shall response to changing of the environmental parameters and ship conditions within the limits provided by the concept of MASS operation specified in Appendix 1 and perform automatic transition to the minimum risk condition in case of overrunning the set parameters and ensure return to normal condition when the operation conditions are re-established.
**33.9.1.2.2** Depending on the category of autonomy and the concept of use of MASS, it shall be ensured that the following information can be obtained and processed:
short-term and long-term weather forecasts along the route, including: wind speed and direction, wave height and period (including ripples), current speed and direction, ice conditions (where applicable), data of tropical cyclone or typhoon (maximum wind speed, gust speed, storm wind radius, etc.), data of extratropical cyclone (pressure in the cyclone centre, motion pattern and speed, cold/warm front, etc.), warning of high pressure in the cold front area (a great drop in temperature and storm warning);
actual meteorological information (onboard the ship) in real time, including: wind speed and direction, currents, waves (including their period), temperature, humidity, pressure, visibility;
tidal changes and ecological situation in the voyage area (based on messages);
electronic charts and their updating;
keel clearance of the ship;
heel and trim angles, bow draught, aft draught, MASS position, speed and heading;
parameters of ship systems ensuring MASS movement and manoeuvring;
hull and cargo condition;
MASS communication and alarm systems;
information on surrounding ships;

radar, video, acoustic data around the ship collected and processed in real time (including lights and shapes, sound signals according to the International Regulations for Preventing Collisions at Sea (COLREG-72);

position, size and distance to fixed unidentified marine objects *above* the *water surface*.

**33.9.1.2.3** Information acquired and processed by the situational awareness system at any operational scenario shall be transmitted to the navigation control system in real time and, if necessary, to RCC.

**33.9.1.2.4** Equipment and components of situational awareness system shall be adequately safe for minimizing the failure probability. Equipment of situational awareness system shall be completed and configurated to avoid its perceptive capability or, in case of a single failure of equipment, this capability shall be restored in the shortest time possible for the further MASS operation.

**33.9.1.2.5** Equipment of situational awareness system shall have self-diagnostic and alarm functions to ensure continuous monitoring during the normal operation of equipment. In case of equipment failure detection, the possibility of its recording and transmission of alarm message and failure message to navigation control system and RCC shall be provided.

**33.9.1.2.6** When the redundancy function is provided for the equipment of situational awareness system, its switching device shall have self-diagnostic and alarm functions.

**33.9.1.2.7** In case of failure of MASS situational awareness system leading to *inability to perceive the situation* during the navigation, the navigation control system shall perform the assessment of necessity of transition to the minimum risk condition, and the relevant alarm information shall be transmitted to RCC or other services ensuring safety of navigation.

**33.9.1.2.8** Depending on the category of autonomy and the concept of use of MASS, in order to fulfill the requirements of 33.9.1.2.4, the MASS situational awareness system can receive information from the following equipment installed onboard:

two ship radars featuring automatic radar-plotting function;

ship automatic identification system (AIS);

three different ship positioning systems (with satellite time synchronization function) equipment;

systems of server storage and processing of navigation data with redundancy functions, with the ability of connection of electronic chart display and information systems to them;

two electronic chart display and information system (ECDIS);

two gyrocompasses;

two echo sounders;

two logs (water speed, bottom speed);

inertia navigation system;

infrared (IR) camera of all-round vision system capable of operating in adverse meteorological conditions;

TV cameras for all-round vision system capable for operating in adverse meteorological conditions and different all-day lighting intensity conditions;

two electronic inclinometers;

two wind gauges indicating wind direction and speed;

two visibility detectors;

equipment for object detection at close distance to the ship side for highly precise mooring;

system for external acoustic signal receiving and recording;

systems of receiving navigational, meteorological information and information for safe navigation through the ship route based on NAVTEX, NAVDAT, VHF (including tidal changes and environmental situation in the port);

systems of short-term and long-term forecasts of weather conditions, current meteorological information in real time;

systems of ship system parameters ensuring MASS movement and controllability, conditions of hull and cargo, MASS communications and alarm systems.

**33.9.1.2.9** Conventional systems being the data resources of MASS situational awareness system shall meet the applicable RS requirements specified in the Rules for the Equipment of Sea-Going Ships.

**33.9.1.2.10** Range of measurement, accuracy and time delay of equipment for object detection at close distance shall meet the requirements for rapid decision-making during mooring operations and movement in port waters.

**33.9.1.2.11** All equipment of the situational awareness system shall collect real-time data in accordance with the requirement for timely decision making.

**33.9.1.2.12** MASS situational awareness system shall be fitted with sufficient number of sensors and systems for defining, displaying and registration of current time, position relative to the Earth, orientation and rate of changing of parameters sufficient for ensuring safety of navigation.

**33.9.1.2.13** Ship positioning systems shall ensure the absolute precision of positioning finding with 95 % accuracy:

during navigation in the open sea — 100 m;

automatic collision avoidance manoeuvre and navigation at approaching to ports and in coastal waters — 10 m;

manoeuvring in the port — 1 m;

automatic mooring — 0,1 m;

**33.9.1.2.14** Operating parameters of inertia navigation systems of MASS positioning shall be sufficient for safe navigation in ocean spaces for a time required for performance restoration of radio navigational systems or any other measures for MASS safe navigation.

**33.9.1.2.15** Inertia navigational system shall ensure continuous generating information related to MASS course, coordinates, travelling speed and angular orientation.

**33.9.1.2.16** To ensure redundancy of information on MASS position indication, radio navigation land-based systems may apply.

**33.9.1.2.17** Information on current weather conditions collected by situational awareness system shall be evaluated and compared with weather forecasts received from ashore centre and other ships. Integrated data shall form reliable information on the actual and prospective weather conditions through the ship's route. The route shall be optimized considering the weather conditions, given parameters and stability and manoeuvring conditions.

**33.9.1.2.18** Situational awareness system may include situation clarification system based on radio positioning ensuring sufficient level of spatial resolution for radio vision mode implementation.

**33.9.1.3** Verification methods.

**33.9.1.3.1** For survey, the documents according to 33.2.1.2.2 shall be submitted to the Register.

**33.9.1.3.2** Survey during the factory, mooring and sea trials shall be carried out in accordance with the approved program and procedure of testing in full extent and shall be based on the comprehensive verification of MASS situational awareness system using methods specified in Appendix 2.

**33.9.2 Means of radio communication and data exchange.**

**33.9.2.1** Tasks.

**33.9.2.1.1** Composition and functionality of means of radio communication and data exchange shall provide radio communication and data exchange with other ships, RCC, shore-based services, VTS, search and rescue centre, the shipowner and operator, both directly and via RCC throughout the voyage with the quality ensuring its safety and efficiency.

**33.9.2.1.2** In the autonomous mode, means of radio communication and data exchange shall be capable of performing the following tasks:

transmission of data (if necessary or on request) to RCC related to the environmental conditions;

transmission of data from other ships (where applicable);

mutual exchange of information flow for correcting the ship's route in general;

mutual exchange of information flow for correcting the movement parameters on certain sections of the route;

transmission of alarm messages when the control system registered that the ship safety failed to be maintained at the proper level;

receipt from RCC of instructions for ship systems operation in case of abnormal situations;

transmission of orders for activation and deactivation of autonomous control mode (transfer to remote control mode);

transmission of information for condition control of technical means, cargo and environmental situation;

receipt of charts and corrections of electronic chart display and information system;

transmission of data on parameters of movement, power plant condition, control system, communication to other ships;

transmission of data stored on the autonomous ship server to RCC.

**33.9.2.1.3** In the remote-control mode, the means of radio communication and data exchange shall perform the following tasks:

transmission of real-time information on the environmental conditions to RCC;

transmission of data to other ships;

mutual exchange of information flows for guaranteed delivery of control orders to the ship's movement and manoeuvring control systems on the basis of data on navigation situation and MASS movement based on optical, radar and satellite observations;

mutual exchange of information flows for guaranteed delivery of remote-control orders to shipboard equipment and deck machinery, main and auxiliary power plant, electrical power plant according to the data on condition monitoring of the ship technical means;

receipt and transmission of remote-control orders for changing the MASS control mode;

transmission of information on condition control of technical means, cargo and environmental situation;

receipt of charts and corrections for Electronic Chart Display and Information System;

transmission of data stored on the MASS server to RCC.

**33.9.2.1.4** For ensuring safety of navigation, MASS radio communication and data exchange systems shall be capable of recognition and establishing voice communication, respond to interrogation from other ships or ashore services, as well as carry out the reception and transmission of:

distress signals in "ship-to-shore" and "ship-to-ship" directions;

search and rescue coordination messages;

signal for position-finding;

information for the safety at sea.

**33.9.2.1.5** MASS radio communication and data exchange systems shall ensure the continuity of data exchange during the ship passage between conditional navigation areas by automatic selection of communications channel based on the conditions and type of the information transmitted. Herewith, they shall be able to provide maritime services in the context of electronic navigation (e-navigation). Examples of communication technologies, both existing (E) and prospective (P) for the selection of data transmission channels depending on the area of navigation, are given in Tables 33.9.2.1.5-1 and 33.9.2.1.5-2. Technologies preferable for application in the interests of e-navigation according to the Maritime Radio Communications Plan of the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) are highlighted in yellow in Tables 33.9.2.1.5-1 and 33.9.2.1.5-2.

Table 33.9.2.1.5-1

**Existing (E) and prospective (P) communication technologies for ship-to-shore communication**

| Areas of e-navigation | GMDSS areas | Wi-Fi | WiMax | GPRS CDMA 3G,4G LTE | AIS | VDES | Digital VHF voice data | Radar with data transmission | Geostationary satellite communication | MEO/LEO commercial satellite communication | MF/HF communication, incl. NAVTEX, DGNSS | HF-digital services | MF/HF IBM services, incl. NAVDAT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 – Port | A1 | P | P | E | E | P | P | | E | E | E | | P |
| 2 – Approaches to the port | A1 | | P | E | E | P | P | P | E | E | E | | P |
| 3A – Coastal area with mobile communications (~5 miles) | A1 | | P | E | E | P | P | P | E | E | E | E | P |
| 3B – Coastal area with VHF communications (~25 miles) | A1 | | P | | E | P | P | P | E | E | E | E | P |
| 4 – Coastal area (~100 miles) | A2 | | | | | | | | E | E | E | E | P |
| 5 – Open sea (SES) | A3 | | | | | | | | E | E | E | E | P |
| 6 – Open sea (MF/HF) | A4 | | | | | | | | | E | E | E | P |

Table 33.9.2.1.5-2

**Existing (E) and prospective (P) communication technologies for ship-to-ship communication**

| Areas of e-navigation | GMDSS areas | Wi-Fi | WiMax | GPRS CDMA 3G,4G LTE | AIS | VDES | Digital VHF voice data | Radar with data transmission | Geostationary satellite communication | MEO/LEO commercial satellite communication | MF/HF communication incl. NAVTEX, DGNSS | HF digital services | MF/HF IBM services (incl. NAVDAT) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 – Port | A1 | P | P | E | E | P | P | P | E | E | E | | P |
| 2 – Approaches to the port | A1 | | P | E | E | P | P | P | E | E | E | | P |
| 3A – Coastal area with mobile communications (~5 miles) | A1 | | | E | E | P | P | P | E | E | E | E | P |
| 3B – Coastal area with VHF communications (~25 miles) | A1 | | | | E | P | P | P | E | E | E | E | P |
| 4 – Coastal area (~100 miles) | A2 | | | | E | P | P | P | E | E | E | E | P |
| 5 – Open sea (SES) | A3 | | | | E | P | P | P | E | E | E | E | P |
| 6 – Open sea (MF/HF) | A4 | | | | E | P | P | P | | E | E | E | P |

**33.9.2.2** Requirements.

**33.9.2.2.1** Remotely controlled ships shall have at least two separate and independent radio communication means, each using different technologies.

**33.9.2.2.2** Various frequency ranges shall be used for MASS control for minimization of signal distortion due to atmospheric forcing.

**33.9.2.2.3** Radio communication equipment shall be designed for operating with different communication quality levels and shall be resistant to degradation of signal quality level.

**33.9.2.2.4** Any interference to communication channel shall not result in occurrence of unauthorized actions, in case of appeared ambiguities the possibility of repeated request or backing-up shall be provided.

**33.9.2.2.5** Radio communication means shall be resistant to malfunction and capable to automatic reconfiguration in case of emergency situations, network degradation or outage of equipment in compliance with safety requirements.

**33.9.2.2.6** At each sea route stage, voice communications and data exchange shall be performed by means of at least two devices with pass band and speed compliant with autonomous or remote control, as well as the possibility of distress signal transmission from ship to shore shall be provided.

**33.9.2.2.7** Capacity and latency of communication channel shall both be sufficient for traffic and correspond to the data size transmitted by autonomous systems.

**33.9.2.2.8** Radio communication equipment shall be designed so to allow for a separate data reception and transmission via different communication channels.

**33.9.2.2.9** In case insufficient capacity of communication channel between MASS and RCC, types of data shall be transmitted in the order ensuring safety of navigation (top priority in the first instance):

**.1** emergency control;

**.2** remote control orders including data for basic ship functions;

**.3** situational awareness data for remote control of key ship functions;

**.4** monitoring data;

**.5** service data.

**33.9.2.2.10** Communication equipment shall meet the applicable requirements for operational parameters accepted by IMO. VSAT station shall meet the requirements for navigational area conditions and comply with the recognized international or national standards. Satellite network availability shall be at least 99,9 % (equivalent to 8,8 h of total downtime per year).

**33.9.2.2.11** Direct visibility communication system shall be based on AIS, digital systems with at least two-kilometer range capacity.

**33.9.2.2.12** Wireless data transmission shall use a recognized international wireless communication system that includes the following functions:

**.1** message integrity: prevention, detection, diagnostics and rectification of errors for the received message not to be damaged or changed as compared with the transmitted one;

**.2** configuration and authentication of the device: enable connection of only those devices that included in the system draft;

**.3** message encryption: protection of confidentiality and/or criticality of data content;

**.4** safety management: protection of network assets, prevention of unauthorized access to network assets.

**33.9.2.2.13** Network appliances shall automatically start with power supply on and restart after power loss.

**33.9.2.2.14** For communication networks, in order to maintain the correct level of accessibility in the event of a failure, redundancy shall be provided for the transmission of emergency data. In case of failure, automatic transition between the main and reserve systems with automatic alarm shall be provided.

**33.9.2.2.15** Radio communication equipment shall ensure continuous twenty-four-hour functioning throughout the voyage.

**33.9.2.2.16** Information on condition of MASS radio communication equipment transmitted to RCC.

**33.9.2.2.17** Radio communication equipment shall be supplied from the main and emergency source of electrical power. Communication equipment shall be fitted with an individual backup power source enabling to supply power for 6 h.

**33.9.2.2.18** Radio communication equipment shall be arranged such that its functioning or technical condition have no adverse effect on normal operation or result in outage of radio navigational equipment or other equipment. Radio equipment shall be arranged in compliance with the requirements of its technical documentation and be available for survey, maintenance and repair.

**33.9.2.2.19** Where control station is available onboard the ship, communication equipment shall enable voice communication between RCC and control station. At the same time, it is capable for communicating between control station and adjacent shore services, VTS centre.

**33.9.2.2.20** During design and operation, interaction with other MASS and ordinary ships shall be taken into consideration. Communication channels for MASS control and monitoring shall not cause interference to other ships communication.

**33.9.2.2.21** Electromagnetic compatibility of equipment shall comply with the requirements of regulation V/17 of the international convention SOLAS-74, as amended.

**33.9.2.2.22** Communication equipment shall meet the requirements for operational parameters accepted by IMO.

**33.9.2.2.23** Communication equipment shall be subject to mandatory RS approval.

**33.9.2.3** Verification methods.

**33.9.2.3.1** For survey, the documents according to 33.2.1.2.3 shall be submitted to the Register.

**33.9.2.3.2** Survey during factory, mooring and sea trials shall be carried out in accordance with the approved test program and procedure.

**33.9.3 Means of navigation and manoeuvring.**

**33.9.3.1** Tasks.

**33.9.3.1.1** Ensure safe MASS navigation during all operational scenarios, including:

autonomous control;

remote control from RCC, where available;

control by the ship's crew using ship means for entering/departing from port, mooring, and in case of emergency at sea.

**33.9.3.1.2** Ensure safe MASS mooring, as well as conducting anchor operations and positioning (if applicable).

**33.9.3.2** Requirements.

**33.9.3.2.1** Control system of means of navigation and manoeuvring shall perform the following functions:

plotting the ship's route in accordance with the voyage assignment (with account for the ship's draught and cargo condition), capabilities of autonomous and remote control of the ship with observance of regulations concerning safety of navigation and risk assessment;

performing complex analysis and making decision on navigation and manoeuvring using the information on target situation, own ship, power plant condition, control system of movement and manoeuvring, mooring system, anchor arrangements in accordance with voyage assignment;

at en-route movement, perform manoeuvring to prevent approaching other ships in compliance with COLREG-72;

receipt of operating instructions for ship systems from RCC;

performing entering the port and departing from the port, mooring operations and ship positioning during cargo handling operations by means of ship means (where available).

**33.9.3.2.2** As a rule, navigation control system includes autonomous mode, modes of control of the ship from RCC and from navigation bridge (if any) and performs switching in accordance with the following principles:

MASS may be so designed that mooring operations and movement in port waters, as well as entrance to the port and departing from the port are performed autonomously or by remote control or using both;

MASS shall be capable of autonomous navigating at sea. Where necessary, RCC may assume control of the ship. During the remote operation, when the communication does not meet the requirements, the ship shall automatically switch to autonomous navigation;

when MASS is capable of navigation control, it may assume control subject to the approval of RCC. On completion of the approved control cycle, the control function shall return to RCC.

**33.9.3.2.3** For safe control and observation of COLREG-72 requirements, the actual situation in MASS area of navigation shall be continuously monitored.

**33.9.3.2.4** All data related to traffic shall be consolidated, analyzed and possible event scenarios shall be calculated for proper decision-making related to target divergence.

**33.9.3.2.5** Navigation control system shall include functions of route planning and optimization, control of the course and speed of the ship, prevention of navigation hazards, automatic divergence with identified hazardous floating targets, control of anchorage and mooring, position-keeping.

**33.9.3.2.6** Every MASS shall be fitted with at least two sets of navigation control system, each of them may be in a hot standby condition. Navigation control system shall be designed and constructed so that it is capable of performing autonomous navigation and switching to remote control from RCC, where available, in case of failure.

**33.9.3.2.7** Navigation control system shall be connected to situational awareness system, communication and alarm system, SPP, anchor, mooring and other arrangements by means of redundant network.

**33.9.3.2.8** Standby system and equipment responsible for navigation and manoeuvring shall be provided with independent interfaces for control implementation.

**33.9.3.2.9** In case of failure of connected executive subsystem or information source, the navigation control system shall be capable of analyzing the situation to determine the control strategy.

**33.9.3.2.10** Navigation control system shall be capable of self-diagnostics and receiving the information on failures of connected systems. MASS systems shall have built-in self-diagnostic (control) means. The system developer shall provide a justification for the sufficiency of information sent to the RCC on malfunctions identified by the built-in self-diagnostic means.

**33.9.3.2.11** Automatic collision avoidance system forming part of navigation control system shall perform the analysis and calculations for collision avoidance based on the information on particular situation.

**33.9.3.2.12** Navigation control system shall be able to receive the optimum route speed from RCC and ensure autonomous navigation. The possibility of automatic reception of weather information for autonomous plotting and route optimization onboard the MASS shall also be implemented.

**33.9.3.2.13** Navigation control system shall be able to completely monitor the propulsion, steering and auxiliary systems in all possible modes of their operation. The RCC personnel shall control the parameters and, if necessary, intervene in the MASS technological processes.

**33.9.3.2.14** Automation system shall be arranged so that the responsible personnel is duly notified or alerted of the situation before executing an order. It shall be possible to manually intervene in the control of propulsion units and thrusters from RCC.

**33.9.3.2.15** Navigation control system in the calculations and during manoeuvre performance shall:

take into account the effects of MASS own weight and size characteristics, hull thrust force, trim and heel angles, speed, under-keel clearance and stopping distances;

monitor the ship's course, rudder angle, propeller revolutions, propeller pitch (if necessary), thrust operational mode (if necessary);

monitor and consider the effects of seas, wind and current on the ship.

**33.9.3.2.16** If it is necessary to perform control from the ship's board during the pilotage, entering the port or departing from the port, as well as during mooring operations and movement in port waters, MASS shall be provided with simplified navigation system located on the navigation bridge or a manual control mode forming part of autonomous navigation system shall be implemented.

**33.9.3.2.17** Information on the MASS condition, ship machinery and movement parameters shall be displayed on the simplified navigation system, including information on the course, rudder angle, engine operation modes, navigational chart, radar data, etc.

**33.9.3.2.18** The possibility of manual control of SPP and manoeuvring system with simplified navigation system shall be provided. The possibility of such control may be provided only if confirmed by RCC or by other reliable means.

**33.9.3.2.19** Navigation bridge visibility shall comply with the requirements of regulation V/22 of SOLAS-74 or be provided with equivalent means.

**33.9.3.2.20** Navigation bridge shall be equipped with VHF apparatus for voice communications with other ships. Navigation bridge shall be provided with relevant communication terminals to ensure voice communication with RCC.

**33.9.3.2.21** Navigation bridge shall be provided with necessary personal life-saving appliances, including lifejackets, lifebuoys, etc.

**33.9.3.2.22** When the ship is equipped with simplified navigation system, the appropriate means of crew embarkation and disembarkation shall be provided which shall be capable of being remotely controlled from RCC or directly controlled by the simplified navigation system.

**33.9.3.2.23** MASS shall be fitted with backup facilities for storing the information on the ship condition and operational parameters, its equipment and systems. The capacity of each storage facility shall at least provide the possibility of keeping the data received during one voyage, but not less than 30 days. The possibility of transmitting the stored data to RCC shall be provided.

**33.9.3.2.24** Communications between the navigation control system and the RCC operator shall be continuously maintained.

**33.9.3.2.25** When the navigation control system is used as a decision support system for the RCC operator (navigator), the following shall be performed:

all actions taken by the operator in the control of propulsion and steering equipment including handling of abnormal situations shall be verified by a decision support system;

decision support system shall issue warnings in case the operator chooses actions which may lead to undesirable effects.

**33.9.3.3** Verification methods.

**33.9.3.3.1** For survey, the documents according to 33.2.1.2.4, as well as protocols and reports of all types of tests shall be submitted to the Register.

**33.9.3.3.2** Survey during shore-based tests and tests onboard the MASS shall be carried out during and in accordance with the approved program and procedure for acceptance tests in full extent and shall be based on the comprehensive verification of MASS navigation and manoeuvring systems using methods specified in Appendix 2.

**33.9.4 Ship power plant (SPP).**

**33.9.4.1** The provisions of this chapter shall apply to the SPP systems as follows:

the automatic power supply system;

the automation and control systems for the main and auxiliary machinery, and ship systems.

**33.9.4.2** Level of safety, reliability and automation degree of ship power plant shall be at least equal to the level of safety, reliability and automation degree of the ship with crew.

**33.9.4.3** Unless otherwise specified in this chapter, the requirements specified in the corresponding sections of these Rules shall be followed.

**33.9.4.4** The following possibility of SPP control shall be provided:

from local control stations, if applicable;

from ship remote control station;

by means of SPP automatic control system;

from external remote control centre, where available.

**33.9.4.5** Ship power plant shall be fitted with the necessary means enabling to:

perform autonomous operation in compliance with MASS manoeuvring needs, thereby ensuring easy control and operation, as well as tests and checks, maintenance and repair of machinery;

ensure transmission of operating parameters of essential systems and equipment to both the navigation system and RCC, where available;

specify control authority for different operational modes of essential systems and equipment.

**33.9.4.6** Automatic power supply system.

**33.9.4.6.1** Tasks.

**33.9.4.6.1.1** Ensuring continuous and safe power supply of MASS systems for safe navigation.

**33.9.4.6.1.2** Automatic power-supply control system can automatically receive information related to power sources, perform data conversion and storage, real-time monitoring and safety assessment, analyze and detect deviations/failures, generate control orders and send them to the appropriate machinery for automatic control ensuring safe power supply to MASS.

**33.9.4.6.1.3** Unless otherwise specified in this chapter, the applicable requirements of Part XI "Electrical Equipment" and Part XV "Automation" of these Rules shall be followed.

**33.9.4.6.2** Requirements.

**33.9.4.6.2.1** Automatic power supply system shall automatically provide continuous and safe power supply to the ship's equipment which is necessary for MASS operation under the operating conditions provided for in the concept of MASS operation (refer to Appendix 1).

**33.9.4.6.2.2** Automatic power supply system shall have functions of autonomous and remote control from RCC, where available, therewith:

parameters of the equipment of automatic power supply system supporting safety of navigation and the most essential MASS systems specified in Appendix 1 shall be monitored from RCC, where available. Frequency of monitoring performed by RCC shall be determined in accordance with the level of essentiality of the equipment concern;

remote control has a higher priority as compared to the priority of autonomous control.

**33.9.4.6.2.3** Automatic power supply system shall include, with necessary redundancy, the following equipment:

prime movers with starting system;

reduction gears (where required);

generators;

transformers;

frequency converters;

power distribution panel;

uninterruptable power supplies;

cables;
automatic control systems;
auxiliary systems serving the above-mentioned equipment.

**33.9.4.6.2.4** Automatic power supply system shall be fitted with:
power backup system for the case of failure resulting in MASS blackout;
automatic start system of emergency power supply facilities supplying emergency consumers ensuring safe navigation, as well as supply of equipment for resumption of normal power supply of all systems in case of failure condition of machinery installation;
system of automatic charging if backup power sources after resumption of normal power supply;
individual control system of prime movers that informs RCC and navigation system of rotation speed (including the limited rpm range) and output capacity, parameters of auxiliary (fuel, oil, cooling, air supply, compressed air) systems.

**33.9.4.6.2.5** Automatic power supply system shall have sufficient capacity to satisfy the needs of power supply under normal operating conditions and emergency conditions of partial failure of equipment.

**33.9.4.6.2.6** Automatic power supply system shall have functions of self-diagnostics and control of switching, sequence starting and standby feed of essential equipment.

**33.9.4.6.3** Verification methods.

**33.9.4.6.3.1** Prior to survey, the documents according to 33.2.1.2.5.1 shall be submitted to the Register, as well as test protocols of automatic power supply system with the analysis of effect on the redundancy of electrical power supply system and ship system in case of a single failure.

**33.9.4.6.3.2** Tests shall be carried out in accordance with the approved test program and procedure and shall be based on the comprehensive verification of automatic power supply system using methods specified in Appendix 2.

**33.9.4.7** SPP automatic control system**.**

**33.9.4.7.1** Tasks.

**33.9.4.7.1.1** MASS shall have automatic control system that monitors the condition and control of main propulsion machinery with associated systems, auxiliary machinery, power supply systems in accordance with their maintenance and inspection schedule, as well as with account for the ship's voyage assignment (route/anchorage duration).

**33.9.4.7.1.2** Safety of control by means of SPP automatic control system shall be higher than safety of ships with manned engine room.

**33.9.4.7.2** Requirements.

**33.9.4.7.2.1** To ensure SPP operation, control by means of ship's automatic control system and control from RCC, where available, shall be provided:
under normal operating conditions, the authority of RCC has the highest level, and the authority of automatic control system is under its control;
under normal operating conditions, RCC may delegate control to SPP automatic control system having therewith the means of efficient remote control of the main equipment form RCC in case of the automatic control system failure;
in case of degradation of communication, control is carried out by means of SPP automatic control system. Where robust communication is available, RCC control has primacy of control by means of SPP automatic control system.

**33.9.4.7.2.2** SPP automatic control system shall receive data from alarm system of the most essential systems and devices and, in parallel, receive information on the parameters of SPP main systems and devices and, in case of failure or outage of any part thereof, including failure of electrical power supply, shall perform the following:
sending alarm signals to RCC;
timely activation of backup devices for resumption of normal operational mode;
transition to remote control from RCC, therewith, transfer of control shall have no significant impact on SPP operating conditions.

**33.9.4.7.2.3** Own components of SPP automatic control system (including sensors, controls, cables, etc.) and power sources (including electric power, source of gas in pneumatic system, safety valves, filters and dehumidifier, hydraulic pumps of hydraulic supply system, solenoid valves, etc.) shall be designed with redundancy, and single failure shall not result in the failure of system in general.

**33.9.4.7.2.4** SPP automatic control system shall receive information on operating parameters of the following main systems of the plant and its devices: fuel system, oil system, cooling system, compressed air system, hydraulic air system, air supply system, feed water system, scavenging and condensing system, ventilation system, ballast system, fire extinguishing system, draining system, where required: cargo system, stripping system and cooling system, cargo heating, ventilation system and inert gas system, etc. (the list is specified when forming Appendix 1);

**33.9.4.7.2.5** SPP automatic control system shall be able to:

perform priority blocking of control actions in emergency situations to avoid collision;

independently or from RCC reactivate own possibilities to return the system in operable condition after activating its means of protection or blocking;

determine the self-diagnostic time of SPP automatic control system and the scope of checks of monitoring, alarm, control systems and safety system with account for the system maintenance plan;

block false signals during repeated actuation and send to RCC common alarm signal and/or indication thereof on the most important systems of the engine room;

perform correction of actuating preset parameters strictly in accordance with access authority.

**33.9.4.7.2.6** SPP automatic control system shall have a function of automatic registration of SPP actions and feedback, including registration of:

key parameters of SPP operation;

control actions and response of the main plant systems;

actuation of engine room alarm and safety measures taken;

various abnormal and emergency operations;

records of maintenance and repair.

**33.9.4.7.2.7** SPP automatic control system shall have a function of automatic recording, automatic output of different records and reports in compliance with the reporting procedures and plans of reporting to RCC, including: various reports and test results related to sea tests and checks; various instructions from navigation control system and RCC; records stipulated by the shipping company requirements, etc.

**33.9.4.7.3** Verification methods.

**33.9.4.7.3.1** For verification of SPP automatic control system, the documents according to 33.2.1.2.5.2 shall be submitted.

**33.9.4.7.3.2** The effectiveness of the algorithms of the SPP automatic control system functionality and automatic registration and reporting shall be verified as a result of bench tests prior to installation onboard the ship.

**33.9.4.7.3.3** The effectiveness of communications between the SPP automatic control system, ship's autonomous navigation control system and RCC shall be verified during MASS mooring and sea trials.

**33.9.4.7.3.4** The effectiveness of control performed by SPP automatic control system, remote control from the remote control centre, emergency control and control function by means of local control stations onboard the ship shall be verified during MASS mooring and sea trials.

**33.9.4.7.3.5** The effectiveness of condition control and performance monitoring, automatic registration and reporting of the SPP automatic control system shall be verified onboard the ship.

**33.9.4.7.3.6** The effectiveness of maintenance of the SPP automatic control system shall be evaluated based on machinery condition at the first annual survey after MASS commissioning. Upon satisfactory assessment, it is allowed to continue ship operation.

## 33.10 REMOTE CONTROL CENTRE (FIXED OR MOBILE)

**33.10.1 General.**

**33.10.1.1** Remote control centre (RCC) shall perform tasks on MASS safe operation in different operational modes in the permitted areas of navigation.

**33.10.1.2** RCC is an integrated system containing:

RCC equipment;

sea areas being under the RCC control:

area of remote and autonomous control where communications and navigating conditions allow to perform MASS remote control;

area of autonomous control where communications and navigating conditions allow to perform MASS autonomous control;

RCC personnel;

MASS controlled;

navigation delimiting marking;

additional RCC (subordinated, stand-by, mobile, etc.);

RCC safety systems protecting against natural phenomenon (electric safety, seismic hazards, flooding, etc.);

RCC fire safety systems;

RCC cyber security systems.

**33.10.2 Situational awareness.**

**33.10.2.1** Tasks.

**33.10.2.1.1** Ensure receipt of information for decision making during MASS navigation, entering ports and departing from ports, movement in port waters and during other manoeuvring by means of:

**.1** receipt of information from MASS in the extent limited by communication conditions between MASS and RCC;

**.2** receipt of information from own sources within the fields of vision of their sources;

**.3** receipt of information from other sources.

**33.10.2.1.2** RCC situational awareness system shall ensure:

**.1** sufficiency of information for MASS operation under all predictable operating conditions;

**.2** a balanced decision-making on the possible mode of autonomy of MASS: autonomous, remote control, manual, decision support for the crew onboard the ship, depending on the information received.

**33.10.2.2** Requirements.

**33.10.2.2.1** Situational awareness data content of RCC shall include:

MASS location area;

navigational and hydrometeorological conditions in the area of MASS location and adjacent areas, including navigational warnings;

navigating conditions in the area of MASS location and adjacent areas;

monitoring data of navigation delimiting marking in the area of MASS location and adjacent areas (where applicable);

data of video monitoring from the ship (where applicable), data of video monitoring from berths (where applicable);

data received from controlled MASS limited by communication conditions with the area of MASS location.

**33.10.2.2.2** The requirements for the equipment of situational awareness system (radar systems, AIS equipment, television surveillance systems, VHF radio direction-finders, meteorological and hydrological instruments) shall be established at least equal to the similar VTS equipment of high category in case it is not contravene the requirements of this Section.

**33.10.2.2.3** Location of the RCC own situational awareness means shall be established by calculations in compliance with the requirements of 33.10.8.

Location of the RCC own situational awareness means shall be confirmed by methods of mathematical modelling of operation of the RCC situational awareness means forming part of integral RCC system.

**33.10.2.2.4** Operating area of the RCC own situational awareness means is water area where the functioning of own situational awareness means is provided with intended efficiency. For each type of the RCC own situational awareness means a separate operating area is established by means of calculations in accordance with the requirements of 33.10.8.

Calculation data shall be confirmed by methods of mathematical modelling of operation of the RCC situational awareness means forming part of integral RCC system.

**33.10.2.2.5** The redundancy level of RCC situational awareness equipment shall be established in accordance of VTS of high category.

Ensuring redundancy level of the RCC situational awareness equipment shall be confirmed by methods of mathematical modelling of operation of the RCC situational awareness means forming part of integral RCC system.

**33.10.2.2.6** The RCC administration shall develop a description of procedures and algorithms for making decisions on the possible mode autonomy of MASS: autonomous, remote control, manual, decision support for the crew onboard the ship, depending on the information received under all predictable operating conditions in all permitted areas of operation.

**33.10.2.3** Verification methods.

**33.10.2.3.1** Prior to survey of RCC in respect of the requirements for the situational awareness system, the documents according to 33.2.1.2.6.1 shall be submitted.

**33.10.3. Strategic voyage management.**

**33.10.3.1** Tasks.

**33.10.3.1.1** Strategic management of MASS voyage shall be performed from RCC and shall be implemented by sending to the ship a voyage assignment for autonomous control system.

**33.10.3.1.2** Area of strategic voyage management is an area with officially announced boundaries approved during the RCC survey.

**33.10.3.2** Requirements.

**33.10.3.2.1** MASS voyage planning shall be performed from RCC ensuring safe navigation of the ship in the areas of strategic voyage management, taking into consideration possible loss of communication with the ship, weather conditions, restrictions of navigation conditions and possible abnormal situations.

**33.10.3.2.2** Strategic management of MASS voyage shall be implemented by sending to the ship a voyage assignment for autonomous control system that ensures its receipt, processing and execution within the time limit prescribed by the voyage assignment.

**33.10.3.2.3** Where no voyage assignment is available, MASS may be remotely controlled from RCC, and in case of loss of communication with RCC, the ship shall be stopped and kept by its own positioning means at the point of communication failure or automatically moved to the point of re-establishment of communication, if such task is indicated in the voyage assignment.

**33.10.3.2.4** In case the voyage assignment is loaded in the MASS control system, task 33.10.3.2.2 shall be implemented, and in case of loss of communication with RCC, MASS shall continue implementation of the voyage assignment.

**33.10.3.2.5** While implementing strategic voyage management, RCC shall provide continuous monitoring of the voyage assignment performance and, if necessary, in case of communication availability, RCC shall intervene MASS control to ensure safety of navigation, safe MASS operation and environmental pollution prevention.

**33.10.3.3** Verification methods.

**33.10.3.3.1** Prior to survey, the documents according to 33.2.1.2.6.2 shall be submitted to the Register.

**33.10.3.3.2** MASS strategic management system shall be subjected to testing and survey in accordance with the approved testing procedures to verify the functioning and efficiency of the system by performing test procedures according to the scenarios ensuring that all its capabilities are checked in compliance with the requirements specified in 33.10.3.2.

**33.10.4. Remote control of navigation.**

**33.10.4.1** Tasks.

**33.10.4.1.1** RCC shall perform tasks on safe MASS operation in the areas of voyage remote control.

Voyage remote control area of the remote control centre is an area with officially announced boundaries approved during the RCC survey, where the communication conditions between RCC and MASS, availability of navigation delimiting marking and navigation conditions allow RCC to monitor MASS operation when MASS is in the remote-control mode.

**33.10.4.2** Requirements.

RCC shall perform at least the following functions at the stage of navigation control:

**.1** development of voyage schedules and approval of scheduled routes;

**.2** continuous monitoring and displaying of MASS conditions and operations, as well as video displaying of actual situation, where required;

**.3** safety monitoring of MASS and its systems, development of maintenance recommendations based on the assessment of the ship condition aimed at preparing it for continued operation;

**.4** cancellation of autonomous mode of navigation and switching to remote control mode of MASS and its systems, if necessary;

**.5** support of voice communication with pilot, cargo terminals, auxiliary tugs, surrounding ships, shipowners and operators, vessel traffic service, etc.;

**.6** sending of additional information that shall be automatically registered by autonomous ship navigation system, including meteorological and marine situation, information on safety at sea, orders of vessel traffic service, etc.;

**.7** recording and reproduction of information on decisions, orders and MASS actions for the selected period;

**.8** monitoring of MASS loading and unloading operations.

**33.10.4.3** Verification methods.

**33.10.4.3.1** The documents according to 33.2.1.2.6.3, as well as protocols and reports for all types of tests shall be submitted to the Register.

**33.10.4.3.2** Survey of remote navigation control system performed by RCC shall be carried put in accordance with the approved test program and procedure in full and shall be based on the comprehensive verification of control system at the first stage by means of virtual platform for navigation situation modelling, and by control of existing MASS at the second stage.

**33.10.5 Anti-intrusion protection of remote control centre.**

**33.10.5.1** Tasks.

The purpose of this chapter is to define the requirements for the design, installation, maintenance and operation of intrusion prevention systems of remote control centre.

**33.10.5.2** Requirements.

**33.10.5.2.1** RCC space shall be arranged such that to prevent unauthorized access and ensure the authorized one.

**33.10.5.2.2** RCC shall be fitted with safety systems, which ensure monitoring, detection, alarm, response and storage of data on unauthorized and authorized access. Safety systems shall perform the following tasks:

storage and updating the authorized persons' data;

access of the authorized persons;

granting the possibility of equipment transfer in compliance with the RCC requirements;

access of unauthorized persons to the centre in compliance with the RCC requirements;

denial of access for unauthorized persons;

detection, alarm, response, event data storage, including but not limited to, logging of authorized access and attempts of unauthorized intrusion.

**33.10.5.2.3** RCC safety systems may be implemented on the basis of wired or wireless telecommunications isolated from systems intended for MASS control.

**33.10.5.2.4** RCC safety systems shall have communications with the RCC operator and their control shall be provided from the RCC territory.

**33.10.5.3** Verification methods.

**33.10.5.3.1** The documents according to 33.2.1.2.6.4 shall be submitted to the Register.

**33.10.5.3.2** The following verifications shall be performed upon the RS request to verify compliance with the established requirements:

verification of communication between the RCC operator and the RCC safety system;

verification of the RCC safety system by performing authorized access and unauthorized attempt of intrusion to the main of standby remote control centre.

**33.10.6 Electrical power supply of remote control centre.**

**33.10.6.1** Tasks.

**33.10.6.1.1** The purpose of this chapter is to define the requirements for the RCC power supply.

**33.10.6.2** Requirements.

**33.10.6.2.1** RCC shall have uninterruptible power supply and at least one emergency power source.

**33.10.6.2.2** To maintain continuous RCC operation, separate equipment may have own uninterruptible power supply that shall ensure continuous operation of RCC equipment during the period of changeover from one electrical power source to another or the period required for transfer of control from one RCC to another.

**33.10.6.2.3** Operating power supply of RCC from the standby power source is permitted for the duration of preventive maintenance.

**33.10.6.2.4** Climatic conditions in RCC including temperature, humidity, ventilation, etc. shall meet the requirements for office, server rooms and shall be supplied (with 25 % power reserve) by the RCC power supply systems in all operational modes and during the failures of power supply systems.

**33.10.6.2.5** RCC lighting shall be provided in all operational modes and during the failures of power supply systems. Therewith, the use of an individual uninterruptible power supply shall be permitted for illumination of main areas of operator's workplace while switching from one power source to another.

**33.10.6.2.6** RCC shall be fitted with fire alarm system with redundant power supply system.

**33.10.6.3** Verification methods.

**33.10.6.3.1** The documents according to 33.2.1.2.6.5 shall be submitted to the Register.

**33.10.6.3.2** The maintenance and verification of electrical power supply shall be performed on a regular basis. At least the following shall be verified:

continuity of operation of RCC equipment at switching of electrical power supply from one source to another;

switching time;

condition and shelf life of uninterruptible power supply batteries.

**33.10.7 Requirements for personnel.**

**33.10.7.1** Tasks.

RCC personnel shall ensure safe monitoring and control of MASS in various operational modes, as well as compliance with the requirements of RCC operating procedures, environmental protection during performance of the ship control functions, exchange of information with other services.

**33.10.7.2** Requirements.

**33.10.7.2.1** RCC shall be manned according to the manning table and the number of controlled ships. The number of personnel shall be sufficient to ensure:

safe monitoring, control and management of that number of ships which is under the RCC control;

environmental protection;

compliance with the requirements for duration of the RCC personnel working time.

**33.10.7.2.2** Continuous round-the-clock operation of RCC is ensured by means of shift-based work of the RCC personnel. The composition, organization of shift work and shift schedule shall be established by the RCC administration and shall ensure proper performance of the RCC specified functions. The work stations of the RCC commanding officers shall be simultaneously manned by at least two persons including the RCC operator (watch officer), both keeping watch round-the-clock.

RCC administration shall develop job descriptions for the personnel containing references to normative documents, guidelines, operating procedures and additional instructions, the RCC personnel shall be guided in performance of their duties.

On the basis of the Merchant Shipping Code of the Russian Federation, the RCC administration shall develop regulations on sharing responsibilities during MASS operation in various operational modes between the RCC personnel (personnel of auxiliary (mobile) RCC) and the ship's crew, if any onboard the ship, complying with the requirements of this Section.

**33.10.7.2.3** The RCC manning table shall include the following minimal complement:

MASS remote master;

MASS control operator.

**33.10.7.2.4** Competence of the MASS remote master and the MASS control operator shall be endorsed by the relevant certificates issued by Harbor Master.

**33.10.7.2.5** The complementing of the ship's crew shall be carried out by the shipowner or by an organization which is competent in autonomous navigation and possesses a relevant certificate of the Register.

**33.10.7.3** Verification methods.

**33.10.7.3.1** The following documents shall be submitted to RS for the survey:

the manning table including a shift composition, schedule and work arrangement;

a list of MASS subjected to the RCC monitoring and control;

a list of areas and possible modes of the RCC operation therein (monitoring, decision support, remote control, autonomous control);

job descriptions of the RCC personnel;

regulations on sharing responsibilities during MASS operation in various modes;

documents to endorse competence of RCC personnel, including valid pilot certificates for the areas where remote control of ships is possible and valid certificates of completed simulator-based training on remote and autonomous operation;

medical certificates of the MASS remote master and the MASS control operators to comply with the requirements for certification of masters and watch officers in accordance with the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended in 1995 (STCW Convention 78/95);

labor agreements of the RCC personnel;

operating procedures developed by the RCC administration;

an applicable certificate issued by an organization competent in autonomous navigation.

**33.10.7.3.2** The following shall be verified during the RCC survey:

complement of the duty personnel is sufficient to ensure control of all MASS at any time;

competence of the duty personnel is sufficient for operation in the specified areas of navigation under remote control;

knowledge and practical skills of the RCC personnel as regards job descriptions and operating procedures (random check);

actions of the RCC personnel during several operations of MASS control: in the modes of monitoring, support of a decision-making, remote control, and autonomous control.

**33.10.7.3.3** Based on verification results, any observations of nonconformities to the established requirements, remarks and recommendations shall be recorded in the survey report.

**33.10.8 Design principles of remote control centre.**

**33.10.8.1** Tasks.

**33.10.8.1.1** The RCC basic task is to perform safe MASS operation in the various modes of remote control and autonomous operation; ensure safety of life at sea, protection of marine environment, coastal areas, places of operation and installation of offshore installations against possible adverse effect of autonomous (remotely controlled) navigation.

**33.10.8.1.2** The task of designing RCC is to create a system to integrate RCC subjects as follows: personnel, permissible RCC areas, the equipment and ships under control, the navigation delimiting marking under control, subordinated (mobile) RCC, safety systems, fire safety systems, cyber security systems, each complying with all the requirements for autonomous (remotely controlled) navigation.

**33.10.8.1.3** RCC (including subordinated (mobile) RCC) shall have a valid statement of compliance issued by RS.

**33.10.8.2** Requirements.

**33.10.8.2.1** The procedure of designing RCC shall consist of the stages mentioned below.

**33.10.8.2.2** Development of the RCC project including justifications for:

areas of RCC operation with various operational modes (permitted areas of strategic voyage management, voyage remote control); the possibility of MASS operation in these areas while performing all permitted manoeuvres in all permitted control modes (monitoring, decision support, remote control, autonomous operation);

location and composition, characteristics of equipment of the RCC situational awareness system;

location and composition, characteristics of the RCC communication equipment;

location, composition, characteristics of the navigation delimiting marking;

location, characteristics of standby/mobile RCC, including ensuring of communication between the standby RCC and main RCC, standby RCC and MASS.

**33.10.8.2.3** Development by the RCC administration of the following procedures complying with the requirements of this Section:

operating procedures for operation in the permitted areas of the RCC operation, including the procedure of MASS control transfer between the ship′s crew (if any), RCC personnel, personnel of auxiliary (standby) RCC in all possible operating situation;

procedures for operation in emergency situations;

procedures for maintenance of equipment and systems;

procedures for cyber security risk identification and control;

procedures for RCC safety.

**33.10.8.2.3.1** Working acceptance of completed facilities.

**33.10.8.2.3.2** Acceptance-delivery tests of the RCC processing equipment.

**33.10.8.2.3.3** Initial survey of RCC as an integral system.

**33.10.8.2.3.4** Notifying the interested parties of RCC functioning, its operational modes and areas of operation thereof.

**33.10.8.2.4** Calculations on the RCC project justification shall be made using mathematical modelling of operation of integral RCC system that includes the following:

RCC controlled equipment;

permitted operating areas of different RCC modes;

area of remote control of navigation where communications and navigating conditions allow to perform MASS remote control;

area of strategic voyage management where communications, availability of navigation delimiting marking and navigating conditions allow to perform MASS operation control in the modes of monitoring, decision support, autonomous operation;

variants of standard actions of the personnel (specified in the procedures developed by the RCC administration), including the actions in emergency situations and actions for elimination of pollution from ships;

controlled MASS during manoeuvring as stipulated in the regulations developed by the RCC administration;

navigation delimiting marking;

subordinated (stand-by, mobile) RCC;

RCC safety systems;

RCC fire safety systems;

RCC cyber security systems.

**33.10.8.3** Verification methods.

**33.10.8.3.1** The following documents shall be submitted to the Register:

RCC project including documents according to 33.2.1.2.6;

procedures complying with the requirements of this Section:

operating procedures for operation in the permitted areas of the RCC functioning, including the procedure of MASS control transfer between the ship's crew (where available), RCC personnel, personnel of auxiliary (standby) RCC in all possible operating situation;

procedures for operation in emergency situations;

procedures for maintenance of equipment and systems;

procedures for cyber security risk identification and control;

procedures for RCC security;

data of latest survey of RCC and its objects.

**33.10.8.3.2** The concept of the RCC structure shall be verified during the survey.

## 33.11 MEANS OF NAVIGATION DELIMITING MARKING (FIXED OR MOBILE)

**33.11.1 Establishment of limitations and situational abilities. Navigation delimiting marks.**

**33.11.1.1** Tasks.

**33.11.1.1.1** Ensuring the detection and navigational use of means of navigational equipment at the distances far in excess of the capabilities of visual and radar equipment.

**33.11.1.1.2** Ensuring the possibility to use "virtual" and "synthetic" means of navigational equipment.

**33.11.1.1.3** Ensuring control of MASS route observance.

**33.11.1.2** Requirements.

**33.11.1.2.1** Navigation delimiting marks shall not interfere with navigation of conventional ship types and systems in operation.

**33.11.1.2.2** Virtual, synthetic and actual means of AIS navigational equipment shall be maintained.

**33.11.1.2.3** Functioning of means of navigational marking for MASS shall not affect the AIS operation when using any technology application.

**33.11.1.2.4** The possibility of developing local MASS movement marking by means of computing tools of ship navigation system shall be provided.

**33.11.1.2.5** Virtual and synthetic means of navigational equipment with the Iridium, GSM, VSAT, VDES technology may apply.

**33.11.1.2.6** Horizontal plane route trajectory with a function of MASS movement control shall be supported for waypoints passing or arrival to target point in the prescribed time.

**33.11.1.3** Verification methods.

**33.11.1.3.1** The documents according to 33.2.1.2.7.1 shall be submitted to the Register.

**33.11.2 Control of navigation delimiting marking.**

**33.11.2.1** Tasks.

**33.11.2.1.1** Ensuring autonomous, safe navigation by providing the navigation system with optimum traffic routes, with the possibility of correction with account for the received and processed situational data.

**33.11.2.1.2** Ensuring safety of MASS operation by improving accuracy of navigation.

**33.11.2.1.3** Improving efficiency and traffic capacity of water area for MASS operation both on local routes and during the voyage, mooring and unmooring by increasing the route number in the target water area.

**33.11.2.1.4** Achieving the possibility of creating the structure of dynamic and scalable routes, as well as recommended MASS movement trajectories depending on the target environmental situation. Therewith, the interests of conventional ships involved in formation of navigation situation shall be taken into account.

**33.11.2.1.5** Reducing voyage time and economic costs for MASS operation through optimization of movement trajectories.

**33.11.2.1.6** Assistance and support in decision making by visualizing the navigation situation and reducing the RCC operator's burden.

**33.11.2.2** Requirements.

**33.11.2.2.1** Formation of navigation delimiting marking (hereinafter referred to as the "marking") shall be performed with due regard of MASS operational and manoeuvring characteristics.

**33.11.2.2.2** Marking control system shall consider standard trajectories of approaching to port, departing from port.

**33.11.2.2.3** Marking control system shall consider the applicable regulations of COLREG-72.

**33.11.2.2.4** Marking control system shall consider horizontal profile of MASS movement trajectory using factual and estimated navigation data.

**33.11.2.2.5** Marking control system shall forecast at least the following parameters for each route point of the current MASS voyage plan:

estimated time of arrival to waypoint;

estimated time of voyage completion;

estimated covered distance;

required temporary waypoints of the route.

**33.11.2.2.6** All predicted and actual information of marking control system shall be displayed in the RCC.

**33.11.2.2.7** Marking control system shall ensure MASS navigation together with navigation control system for execution of voyage schedule.

**33.11.2.2.8** Formation of marking shall be performed with account for the applicable requirements of regulation V/34 of SOLAS-74 and Part 2, Section A-VIII/2 of the Seafarers' Training, Certification and Watchkeeping Code (STCW Code), as well as IMO resolution A.893(21).

**33.11.2.3** Verification methods.

**33.11.2.3.1** The documents according to 33.2.1.2.7.2 shall be submitted to the Register.

**33.11.3 Mooring area (special mooring docks).**

**33.11.3.1** Tasks.

**33.11.3.1.1** Ensuring control and safety of MASS mooring by means of preventing and avoiding of emergency situation in case of ship approaching the berth at rather high speed or at high angle.

**33.11.3.2** Requirements.

**33.11.3.2.1** Legal aspects of mandatory pilotage of ships established in some ports shall be considered.

**33.11.3.2.2** Reliable means shall be provided for ship positioning at the berth.

**33.11.3.2.3** Mooring area shall control ship movement at the berth and ensure efficiency of loading-unloading operations.

**33.11.3.2.4** In the manoeuvring, mooring and positioning modes, the place and means of mooring shall enable to control MASS in any direction, set longitudinal and transverse motions, speed of ship motion and swinging.

**33.11.3.2.5** Means and equipment of the mooring area shall perform calculations of propulsion power to be applied by each thruster replacing the conventional control methods of each thruster.

**33.11.3.2.6** In the manoeuvring, mooring and positioning modes, the directions and propulsive force using all propulsion systems and thrusters shall be specified.

**33.11.3.3** Verification methods.

**33.11.3.3.1** The documents according to 33.2.1.2.7.3 shall be submitted to the Register.

**33.11.3.3.2** Maintenance procedures shall be established for the mooring area, its systems and equipment. Maintenance and tests shall be carried out on a regular basis.

**33.11.4 Anti-intrusion protection.**

**33.11.4.1** Tasks.

**33.11.4.1.1** Safety of means of navigation delimiting marking from illegal actions shall be ensured.

**33.11.4.1.2** Timely notification of illegal actions related to means of marking shall be ensured.

**33.11.4.2** Requirements.

**33.11.4.2.1** The requirements for anti-intrusion protection of real means of marking shall be not lower than those adopted for existing means of navigation equipped with radio communication means, e.g. AIS.

**33.11.4.2.2** The requirements for protection of synthetic and virtual means of marking refer to cyber security matters of MASS and their systems.

**33.11.4.3** Verification methods.

**33.11.4.3.1** No additional documents are required to be submitted, except for the documents provided for the existing means of navigation.

## 33.12 CYBER SECURITY OF DISTRIBUTED INFORMATION NETWORK

**33.12.1 Computer and computer-based systems.**

**33.12.1.1** Tasks.

**33.12.1.1.1** Ensuring security of information to be applied for MASS operation by means of:

use of information security approaches aimed at safe SW development;

ensuring confidentiality, integrity and accessibility of information at the stage of vessel traffic system operation.

**33.12.1.1.2** Ensuring safe resumption of computer-based system operation after disabling or cyberattack.

**33.12.1.2** Requirements.

**33.12.1.2.1** SW development for MASS shall be followed by a set of actions aimed at ensuring safe development, in particular:

during SW requirements analysis;

SW architecture design;

SW development and integration;

SW testing;

SW installation and its acceptance support;

solving SW problems during the operation;

development SW documentation, as well as performance of its configuration (changing the program structure);

control of SW development environment infrastructure;

personnel management.

**33.12.1.2.2** Ensuring confidentiality, integrity and accessibility of information at the stage of MASS operation shall be provided by the following protection measures:

development of a list of protected information resources;

development of access matrix related to protected information resources;

modelling of information security threats;

development of information security measures (including, inter alia, application of technical security means ensuring identification and authentication functions, access control, event registration, integrity control, thrusted upload, antivirus protection, intrusion detection, firewalling, emergency destruction of protected information).

**33.12.1.3** Verification methods.

**33.12.1.3.1** The documents according to 33.2.1.2.8.1 shall be submitted to the Register.

**33.12.1.3.2** Verification of compliance with the specified requirements for security of information used on MASS shall be documented — the following shall be verified: availability of information security records; compliance of reported documentation with the requirements of national and international standards, as well as normative documentation of flag State Maritime Administration.

**33.12.1.3.3** The principles of operation are verified using logical analysis or hardware/software verification that simulates external cyber attacks.

**33.12.2 Onboard MASS.**

**33.12.2.1** Tasks.

**33.12.2.1.1** Performing a set of actions aimed at safe SW development for MASS control systems.

**33.12.2.1.2** Maintaining confidentiality, integrity and accessibility of information at all levels of interaction during MASS operation (from top management of the shipping company to the ship and its systems and subsystems).

**33.12.2.1.3** Ensuring reliable MASS monitoring and control.

**33.12.2.1.4** Ensuring safety of people onboard the ship, ship's equipment and the environmental protection during autonomous and remote navigation.

**33.12.2.1.5** Performing a set of actions aimed at prevention of immediate threats to security of information used for MASS operation, including:

ensuring safe and secure exchange of autonomous and remotely controlled ships with RCC and other participants of navigation;

ensuring the necessary, sufficient and excessive level of MASS cyber security;

development of plans of MASS systems and equipment resumption after cyberattacks or other critical situations affecting cybersecurity and maintenance of continuous system operation;

prevention of leakage, misrepresentation of information related to MASS operation;

prevention of unauthorized actions on destruction, misrepresentation, blocking of information and prevention of unauthorized access to MASS control systems.

**33.12.2.2** Requirements.

**33.12.2.2.1** During design of MASS information network, the following shall be taken into consideration:

the requirements of IMO resolution MSC.428(98) "Maritime Cyber Risk Management in Safety Management Systems";

provisions of the IMO Circular MSC-FAL.1/Circ.3 "Guidelines on Maritime Cyber Risk Management";

the requirements of the International Chamber of Shipping "Guidelines on Cyber Security Onboard Ships";

the requirements for components of embedded devices of cyber security management systems (CSMS) that make up industrial automation and control systems (IEC 62443 series of standards);

the requirements for cyber security for industrial automation and control systems (IEC 62443-4-1 standard);

plans and procedures of shipping company on risk management regulated by the International Safety Management Code (ISM Code — International Management Code for the Safe Operation of Ships and for Pollution Prevention) and the International Ship and Port Facility Security Code (ISPS Code);

information separation between complicated and essential systems.

**33.12.2.2.2** Measures shall be taken on multilevel security of essential systems of the information network, as well as by means of personnel both onboard the ship and in the RCC, on security of the particular procedures and technologies intended for:

enhancement of efficiency of information network cyber threats detection;

increase of means and resources required for cyber security upgrade of MASS information network systems.

**33.12.2.2.3** Ensuring cyber security onboard MASS may include:

physical security of the ship in accordance with developed security plan;

information network protection;

implementation of actions and procedures on intrusion detection to the information network and its subsystems;

periodical scanning of the information network for detection of cyber threats and vulnerabilities;

SW verification for detection of vulnerabilities and undeclared functions;

personnel training both onboard the ship and in the remote control centre.

**33.12.2.2.4** Plan of actions for prevention of cyber threats and minimization of effects of cyber security violation shall be developed, as well as the following systems and arrangements:

automatic identification system;

electronic chart and information systems;

voyage data recorder;

position, heading, speed and universal time coordinated (UTC) sources;

emergency position-indicating devices (radio beacons, etc.).

**33.12.2.2.5** Policy and procedures of cyber security assurance onboard the ship shall be considered in view of general approach to risk assessment and management specified in Appendix 3.

**33.12.2.2.6** Cyber security measures onboard the ship shall be determined upon the risk assessment results and within planning the activities on security enhancement.

**33.12.2.2.6.1** Basic cyber security measures shall comply with ISO 27032 standard, they are given in Table 33.12.2.2.6.2-1.

**33.12.2.2.6.2** Arrangements complying with the national standards are given in Table 33.12.2.2.6.2-2.

Table 33.12.2.2.6.2-1

**Main cyber security measures in accordance with ISO 27032**

| Security category | Safety measure |
|---|---|
| Security of applications and user notification on security policy | User notification on security policy |
| | Protection of Web application sessions |
| | Control of input data correctness |
| | Script security |
| | Code audit and software independent testing |
| | Provider identification for the users |
| Server security | Safe server configuration |
| | Installation of security updating system |
| | System log control |
| | Malware protection |
| | Regular scanning of systems for the malware identification |
| | Regular scanning of software vulnerabilities |
| | Tampering attempt detection |
| End user security | Use of recommended operating systems |
| | Use of recommended software versions |
| | Use of antivirus software |
| | Use of personal network firewalls and intrusion detection systems |
| | Use of automatic updates of the trusted programs |
| Cyber-attack protection by social engineering methods | Development and implementation of security policies |
| | Information categorization and classification |
| | User training and awareness-raising |
| | Personnel testing |
| | Use of technical control means |
| Enhanced readiness | Use of traps in "empty" network |
| | Malicious traffic re-direction |
| | Back-tracing |

Table 33.12.2.2.6.2-2

**National standards applicable to information security**

| GOST identification | Title |
|---|---|
| Information security management systems | |
| GOST R ISO/IEC 27000-2012 | Information technology. Security techniques. Information security management systems. Overview and vocabulary |
| GOST R ISO/IEC 27001-2006 | Information technology. Security techniques. Information security management systems. Requirements |
| GOST R ISO/IEC 27002-2012 | Information technology. Security techniques. Code of practice for information security management |
| GOST R ISO/IEC 27003-2012 | Information technology. Security techniques. Information security management systems implementation guidance |
| Risk management | |
| GOST R ISO/IEC 27005-2010 | Information technology. Security techniques. Information security risk management |
| Safety assessment | |
| GOST R ISO/IEC 15408 | Information technology. Security techniques. Evaluation criteria for IT security |
| GOST R ISO/IEC 18045-2013 | Information technology. Security techniques. Methodology for IT security evaluation |
| GOST R ISO/IEC TO 19791-2008 | Information technology. Security techniques. Security assessment of operational systems |
| Security guarantees | |
| GOST R ISO/IEC 15026 | Information technology. Systems and software engineering |
| Systems and software assurance | |
| GOST R ISO/IEC TO 27033-1-2011 | Information technology. Security techniques. Network security. Part 1. Overview and concepts |
| Systems security engineering | |
| GOST R ISO/IEC 21827-2010 | Information technology. Security techniques. Systems security engineering. Capability maturity model |
| GOST R 56939-2016 | Information protection. Secure software development. General requirements |

**33.12.2.2.7** Limitation and continuous control of networking ports, protocols and services shall be provided. Ports shall be secured against cyber attacks, and the unused ones shall be closed to prevent unauthorized access to the systems.

**33.12.2.2.8** All network appliances shall be configured by means of firewalls, gateways, routers to ensure the possibility of cyber threat prevention.

**33.12.2.2.9** Spaces containing essential elements and equipment shall be reliably closed against an unauthorized access.

**33.12.2.2.10** Restricted control of user access to systems and network shall be provided.

**33.12.2.2.11** Measures shall be taken for backing up of information snapshots and essential files.

**33.12.2.2.12** It is necessary to verify operability of SW intended for resumption of information network functioning.

**33.12.2.2.13** It is necessary to ensure continuous control of data flow of information network and subsystems for establishing threshold values and cyber threat detection.

**33.12.2.2.14** Cyber security arrangements shall comply with the applicable RS cyber security and safety assessment requirements.

**33.12.2.2.15** While establishing communications with RCC, the possibility of preventing an unauthorized connection and unauthorized access to ship systems shall be provided.

**33.12.2.2.16** For network management the following shall be provided:

limitation of number of persons authorized to perform changes in systems and new SW installation;

limitation and automatic encryption of wireless access to MASS networks;

regularly updated SW intended for detection, identification and elimination of malicious software in MASS onboard systems;

information network function redundancy for MASS control;

network protection, in particular wireless one, using secure protocols, and Internet connection shall be secured by a gateway ensuring decoupling between the Internet access and MASS internal network;

obligatory documenting of all information related to risks and MASS cyber security threats.

**33.12.2.2.17** Data servers used for data receipt and storage shall be backed up and located in different places (to be at least divided by class A-60 bulkhead) and shall be dynamically updated. Failure of one server shall have no effect on MASS operation.

**33.12.2.2.18** Precise diagram of MASS information network and communication equipment shall be developed and regularly updated. The diagram shall describe network architecture and contain a list of the identified equipment (determined by a model number) and SW (determined by a version number).

**33.12.2.2.19** User access management shall be based on the secure authentication protocol containing the best practices, such as prevention of shared or anonymous accounts, as well as regular password updating with the required high degree of complexity.

**33.12.2.2.20** In emergency, the contingency plan shall be established for operation of MASS and its system in the reduced capacity mode.

**33.12.2.2.21** SW shall be regularly updated in compliance with updating policy. This policy shall include:

list of components (machines and SW) to be updated;

duties of different participants of updating process;

means used for updating;

check of updates prior to installation;

previous configuration recovery procedure in case of system upgrade failure.

**33.12.2.2.22** SW installation and upgrade shall be performed only from the server of control system software manufacturer (supplier).

**33.12.2.2.23** Main information and SW backup means shall be available to ensure recovery.

**33.12.2.2.24** During the SW requirements analysis, the requirements for ensuring of information security considering the requirements of flag State Maritime Administration shall be specified.

**33.12.2.2.25** During SW architecture design it is necessary to:

develop a model of information security threats;

clarify the SW architecture with account for the list of actual threats;

prepare proposals on manageability of detected potential threats.

**33.12.2.2.26** During SW development and integration it is necessary to:

use identified tool for SW development;

determine and accept the formatting procedure of source code of the program;

perform statistic analysis of the source code of the program;

make an expert examination of the source code of the program.

**33.12.2.2.27** During the testing in the presence of the RS surveyor, the following shall be performed:
function testing of the program;
anti-intrusion testing.
**33.12.2.2.28** During the program installation and support of SW acceptance it is necessary to:
ensure SW protection against the threats related to violation of integrity during its delivery to the customer;
deliver operating documentation to the customer.
**33.12.2.2.29** While solving SW problems during the operation it is necessary to:
implement and use tracking and SW bugs fix, as well as program vulnerabilities;
perform systematic search of program vulnerabilities.
**33.12.2.2.30** During development of SW documentation, as well as adjustment of its configuration it is necessary to:
determine and accept the procedure of unique marking of each SW version;
determine and accept SW configuration management system.
**33.12.2.2.31** During the management of SW development framework infrastructure the following actions shall be implemented:
protection against unauthorized access to the program configuration components;
backing up of the program configuration components;
registration of events related to the facts of changing of the program configuration components.
**33.12.2.2.32** During the personnel management it is necessary to:
ensure periodical training of the personnel;
ensure periodical analysis of the personnel training program.
**33.12.2.2.33** List of protected information resources shall include:
information containing the information classified as state secret;
confidential information (including the information marked "for internal use", as well as sensitive restricted information);
information resources, whose security violation may result in performance degradation of hardware forming part of MASS and, consequently, reducing of MASS efficiency and voyage assignments failure.
**33.12.2.2.34** Access matrix of access subject related to the protected information resources shall contain an indication of location paths of the protected information resources.
**33.12.2.2.35** When modelling the security threats to information processing by MASS, the procedure for threat relevance determination shall be developed and proposals on the actual threat neutralization shall be prepared.
**33.12.2.2.36** Information security arrangements shall include conducting of organizational measures, as well as application of information security technical means ensuring the following functions performance:
identification and authentication;
access control;
event registration;
thrusted upload ensuring;
integrity control;
antivirus protection;
intrusion detection;
firewalling;
emergency destruction of sensitive information.
**33.12.2.2.37** The necessity of MASS automated systems certification in the certification system of information security system of the Maritime Administration shall be determined.

**33.12.2.3** Verification methods.

**33.12.2.3.1** The documents according to 33.2.1.2.8.2 shall be submitted to the Register.

**33.12.2.3.2** The principles of operation shall be verified using logical analysis or hardware/software verification that simulates external cyber attacks.

**33.12.3 Remote control centre.**

**33.12.3.1** Tasks.

**33.12.3.1.1** Performing a set of actions aimed at safe SW development for RCC systems.

**33.12.3.1.2** Maintenance of confidentiality, integrity and accessibility of information at all levels of interaction during RCC operation.

**33.12.3.1.3** Ensuring safe MASS monitoring and control.

**33.12.3.1.4** Ensuring safety of people onboard (operators and personnel), equipment of ships being under the RCC control, and provision of environmental protection during autonomous and remote-control navigation.

**33.12.3.1.5** Performing a set of actions aimed at prevention of immediate threats to security of information used for MASS operation, including:

ensuring safe and secure exchange of information between MASS, RCC and other participants of navigation maintained by the infrastructure of distributed information network;

ensuring the necessary, sufficient and excessive level of RCC cyber security;

generating plans of resumption of RCC systems and equipment functioning resumption after cyberattacks and other critical situations affecting cybersecurity and maintenance of continuous system operation;

prevention of leakage, misrepresentation of information related to RCC operation and MASS controlled by it;

prevention of unauthorized actions on destruction, misrepresentation, blocking of information and prevention of unauthorized access to the distributed information network infrastructure, RCC systems used for MASS control.

**33.12.3.2** Requirements.

**33.12.3.2.1** During the RCC design the following shall be taken into consideration:

the requirements for components of embedded devices of cyber security management systems (CSMS) that make up industrial automation and control systems (IEC 62443 series of standards);

the requirements for cyber security for industrial automation and control systems (IEC 62443-4-1:2018 standard);

plans and procedures of the shipping company, the ships being under the RCC control, for risk management regulated by the ISM Code and the ISPS Code;

the requirements and fundamental ergonomic principles and integrated approach to the design of work systems (ISO 6385 series of standards), basic principles and structure of ergonomic design (ISO 11064 series of standards), ergonomics of visual information perception at the operator's workplace (ISO 8995-1-2002 standard / ISO 8995-2002 standard);

the requirements and criteria for the perception of visual danger signals in the area in which people are intended to perceive and to react to such signals (ISO 11428:1996 standard);

principles of construction and safety for man-machine interface, marking and identification (IEC 60073 series of standards);

requirements for the redundancy of functions of the RCC information systems.

**33.12.3.2.2** The measures shall be taken on detection, identification and control of the possible cyber threats by means of analysis, risk assessment and control that may include:

specifying the responsibilities of operators and other key personnel;

identification of system parameters, data and technical characteristics of the RCC equipment and operational risks;

technical measures for cyber event prevention (protected networks, network access control, use of protected and detecting SW);

organizational measures for cyber even prevention (personnel training, SW update, access rights changing);

cyber event response plan (backup and network recovery after cyber event).

**33.12.3.2.3** Cyber security arrangements of RCC information systems shall include:

inhibit of external access to the RCC network structure;

lack of malicious hardware and software backdoors;

lack of hardware and software undeclared functions;

inhibit of unchecked control and technical means of RCC systems and equipment;

availability of specialists in the RCC key personnel capable of detecting, identifying and eliminating cyber threats in emergency situations;

provision of effective cyber security means (gateways, border security, unauthorized access control);

creating protected network resources;

formulation of cyber security policy;

implementation of up-to-date technical means for data security, authorization and control automation (firewalls, gateways, authorization means, antivirus systems).

**33.12.3.2.4** Control, analysis and assessment of RCC information system functioning shall be provided covering:

control equipment and systems, including cyber security control means;

valid methods of control, analysis and assessment of cyber security condition;

runtime of security level control performance;

personnel in charge of control.

**33.12.3.2.5** The following shall be developed for RCC operation:

program and procedure of information system checks indicating the intervals, methods, persons in charge considering the role of the processes to be verified and recent check results;

qualitative and quantitative criteria applicable for check performance.

**33.12.3.2.6** During the cyber security analysis and risk assessment of the RCC information systems the following shall be taken into consideration:

results of recent checks;

changes of external and internal conditions of the equipment and system operation;

information on functioning the equipment and systems ensuring cyber security;

results of assessment and fulfilment of risk management plan;

the possibility of cyber security level increase.

**33.12.3.2.7** During the detecting of nonconformities in the cyber security control parameters of the RCC information systems it is necessary to:

take measures on eliminating the nonconformities and effects;

evaluate the necessity of arrangements for eliminating the causes of cyber security violation;

perform the required corrective actions for preventing further threats;

perform analysis of the corrective actions result;

introduce changes in the RCC cyber security system.

**33.12.3.2.8** All information on cyber security risks and threats for the RCC information systems shall be documented.

**33.12.3.2.9** The procedure of cyber security risk assessment of information systems shall be specified and applied for:

specifying and ensuring the use of cyber security assessment criteria;

ensuring that the performed cyber risk assessments produce noncontradictory, reliable and comparable results;

ensuring cyber threat detection;

ensuring cyber security risk analysis;

ensuring cyber security risk assessment.

**33.12.3.2.10** During design of the RCC information systems the need in internal and external communications required for the RCC and MASS functioning shall be determined and shall include:
purpose and time of data exchange;
objects of data exchange;
technical means and procedures of data exchange.
**33.12.3.2.11** At the design stage of the RCC information systems the resources required for development, implementation and maintenance of functioning of cyber security management system shall be specified.
**33.12.3.2.12** The required competence levels of the RCC operators and other personnel shall be specified that may affect the cyber security level.
**33.12.3.2.13** RCC operator and personnel shall be familiar with:
cyber security policy;
boundaries of responsibility for cyber security ensuring;
possible effects of cyber threats in their responsibility area.
**33.12.3.2.14** Data servers used for data receipt and storage shall be backed up and located in two different places (to be at least divided by class A-60 bulkhead) and shall be dynamically updated. Failure of one server shall have no effect on RCC operation.
**33.12.3.2.15** Precise diagram of MASS information network and communication equipment shall be developed and regularly updated. The diagram shall describe network architecture and contain a list of the identified equipment (determined by a model number) and SW (determined by a version number).
**33.12.3.2.16** User access management shall be based on the secure authentication protocol containing the best practices, such as prevention of shared or anonymous accounts, as well as regular password updating with the required high degree of complexity.
**33.12.3.2.17** In emergency, the contingency plan shall be established for operation of MASS and its system in the reduced capacity mode.
**33.12.3.2.18** SW shall be regularly updated in compliance with updating policy. This policy shall include:
list of components (machines and SW) to be updated:
duties of different participants of updating process;
means used for updating;
check of updates prior to installation;
recovery procedure of the previous configuration in case of upgrade failure.
**33.12.3.2.19** SW shall be installed and upgraded only from the server of control system SW manufacturer (supplier).
**33.12.3.2.20** Basic information and SW backup means shall be available to ensure recovery.
**33.12.3.2.21** During the analysis of RCC software requirements, the requirements for ensuring of information security considering the requirements of flag State Maritime Administration shall be specified.
**33.12.3.2.22** During design of RCC software architecture it is necessary to:
develop a model of information security threats;
clarify the SW architecture with account for the list of actual threats;
prepare proposals on manageability of detected potential threats.
**33.12.3.2.23** During the development and integration of RCC software it is necessary to do the following:
use identified tool for SW development;
determine and accept the formatting procedure of source code of the program;
perform statistic analysis of the source code of the program;
make an expert examination of the source code of the program.

**33.12.3.2.24** During the testing in attendance of the RS surveyor, the following shall be performed:

function testing of the program;

anti-intrusion testing.

**33.12.3.2.25** During the program installation and support of RCC software acceptance it is necessary to:

ensure SW protection against the threats related to violation of integrity during its delivery to the customer;

deliver operating documentation to the customer.

**33.12.3.2.26** While solving the RCC software problems during its operation it is necessary to:

implement and use tracking and rectification of SW bugs, as well as program vulnerabilities;

perform systematic search of program vulnerabilities.

**33.12.3.2.27** During development of RCC software documentation, as well as adjustment of its configuration it is necessary to:

determine and accept the procedure of unique marking of each SW version;

determine and accept SW configuration management system.

**33.12.3.2.28** During the management of RCC software development framework infrastructure the following actions shall be implemented:

protection against unauthorized access to the program configuration components;

backing up of the program configuration components;

registration of events related to the facts of changing of the program configuration components;

**33.12.3.2.29** During the personnel management it is necessary to:

ensure periodical training of the personnel;

ensure periodical analysis of the personnel training program.

**33.12.3.2.30** List of protected RCC information resources shall include:

information containing the information classified as state secret;

confidential information (including the information marked "for internal use", as well as sensitive restricted information);

information resources, whose security may result in performance degradation of hardware forming part of MASS and, consequently, reducing of MASS efficiency and voyage assignment failure.

**33.12.3.2.31** Access matrix of access subject related to the RCC protected information resources shall contain an indication of location paths of the protected information resources.

**33.12.3.2.32** When modelling the security threats to information processing by RCC, the procedure for threat relevance determination shall be developed and proposals on the actual threat neutralization shall be prepared.

**33.12.3.2.33** Information security arrangements of RCC and distributed information system infrastructure shall include conducting of organizational measures, as well as application of information security technical means ensuring the following functions performance:

identification and authentication;

access control;

event registration;

thrusted upload ensuring;

integrity control;

antivirus protection;

intrusion detection;

firewalling;

emergency destruction of sensitive information.

**33.12.3.2.34** The necessity of the RCC automated systems certification and distributed information network infrastructure in the certification system of information security system of the flag State Maritime Administration shall be determined.

**33.12.3.3** Verification methods.

**33.12.3.3.1** The documents according to 33.2.1.2.8.3 shall be submitted to the Register.

**33.12.3.3.2** Systems and equipment (including software and hardware) of RCC that renders services for ships shall be subject to the RS technical supervision.

**33.12.3.3.3** Maintenance procedures shall be established for RCC. Maintenance and tests shall be carried out on a regular basis.

**33.12.3.3.4** The principles of operation shall be verified using logical analysis or hardware/software verification that simulates external cyber attacks.

**33.12.4 Navigation delimiting marking.**

**33.12.4.1** Tasks.

**33.12.4.1.1** Ensuring security of navigational information generated by the navigation delimiting marking and applied for safe MASS navigation is based on:

use of information security approaches aimed at safe SW development;

ensuring confidentiality, integrity and accessibility of information at the stage of operation of navigation delimiting marking;

use of territorial, software and hardware methods of information security.

**33.12.4.1.2** Ensuring safe resumption of operation of navigation delimiting marking after disabling, complete failure or failure of its separate elements.

**33.12.4.2** Requirements.

**33.12.4.2.1** SW development for navigation delimiting marking shall be followed by a set of actions aimed at ensuring safe development:

during SW requirements analysis;

SW architecture design;

SW development and integration;

SW testing;

SW installation and its acceptance support;

solving SW problems during its operation;

development SW documentation, as well as performance of its configuration (changing the program structure);

control of SW development environment infrastructure;

personnel management.

**33.12.4.2.2** Ensuring confidentiality, integrity and accessibility of information at the stage of operation of navigation delimiting marking shall be provided by the following main protection means:

development of a list of protected information resources;

development of access matrix related to protected information resources;

modelling of information security threats;

development of information security measures (including, inter alia, application of technical security means ensuring identification and authentication functions, access control, event registration, integrity control, thrusted upload, antivirus protection, intrusion detection, firewalling, emergency destruction of sensitive information).

**33.12.4.2.3** Ensuring territorial, software and hardware methods of the information security at the stage of operation of navigation delimiting marking shall be provided by the following main protection means:

protection of directional source used for the navigation delimiting;

location of directional sources used for the navigation delimiting in places ensuring their persistence;

prevention of distortion of the submitted information from the source use for the navigation delimiting.

**33.12.4.3** Verification methods.

**33.12.4.3.1** The documents according to 33.2.1.2.8.4 shall be submitted to the Register.

**33.12.4.3.2** The principles of operation shall be verified using logical analysis or hardware/software verification that simulates external cyber attacks.

**33.12.5 Interaction of distributed information network components.**

**33.12.5.1** Tasks.

**33.12.5.1.1** Ensuring security of information used for MASS, RCC, navigation delimiting marking, means of information delivery through hardware, software and territorial information security means.

**33.12.5.1.2** Ensuring safe resumption of operation of distributed information network after disabling, complete failure or failure of its separate elements.

**33.12.5.2** Requirements.

**33.12.5.2.1** Current list of cyber threats for the distributed information network shall be maintained. The list shall contain separate lists for the network in general and its component parts: MASS, RCC, navigation delimiting marking, standard means of information delivery, etc. (where required).

**33.12.5.2.2** Cyber threat security shall be provided by organizational and technical measures for each particular part of the distributed information network: MASS, RCC, navigation delimiting marking, standard means of information delivery (where required).

**33.12.5.2.3** Cyber threat security shall be provided by methods of SW development of the distributed information system and shall be ensured by the architectural solutions of network design at hardware-software level.

**33.12.5.2.4** Cyber threat security shall be provided by methods of operation of the distributed information system ensuring confidentiality, integrity and accessibility of information for every component thereof: MASS, RCC, navigation delimiting marking, standard means of information delivery, etc. (where required).

**33.12.5.2.5** Cyber security protection of the distributed information network shall be provided with means of self-checking and identification of abnormal scenarios of its use and shall ensure in the real time:

check of access rights for SW control, update/recovery;

detect exposure to communication channels, spoofing, etc.;

check of integrity of the transmitted data in the communication systems and navigation control systems, as well as internationally standardized and open data (AIS, ASM, AtoN, VDES, GNSS, ENC, etc.);

check of encryption of the transmitted data;

check of operability of MASS being under the RCC control with the simultaneous control of interference immunity of communications, pass band, delay in reception-transmission of data.

**33.12.5.2.6** Hardware and software means of cyber security shall be annually verified during the RCC survey based on the developed test programs and procedures.

**33.12.5.2.7** Personnel in charge of operability of the cyber security means shall undergo annual testing and training.

**33.12.5.3** Verification methods.

**33.12.5.3.1** For survey of cyber security of the distributed information, the following documents and plans/drawings shall be submitted to the Register:

documents confirming compliance with the requirements of 33.12.5.2.2 — 33.12.5.2.4;

documents according to 33.2.1.2.8 for the verification of each component of the distributed information network: MASS, RCC, navigation delimiting marking, standard means of information delivery, etc. (if required).

**33.12.5.3.2** Cyber security of the distributed information network shall be verified during the annual survey for confirmation of compliance with the established requirements.

*APPENDIX 1*

**CONCEPT OF OPERATION**
**OF MARITIME AUTONOMOUS SURFACE SHIP (MASS)**

**No._______________ date ______________**

## 1 MASS description

1.1 Name (ship's flag and name): ______________________________________

1.2 Type: ______________________________________

1.3 MASS category: ______________________________________

## 2 Variants of MASS operation

| | |
|---|---|
| 2.1 Basic variant of ship operation | (the most generic description of the basics of ship operation in compliance with the accepted design standards) |
| 2.2 Additional variant of ship operation | (the most generic description of the basics of ship operation in compliance with the accepted design standards) |

## 3 MASS main particulars

| | |
|---|---|
| Design period of use | (years) |
| Ship's control mode | Remotely controlled/Autonomous |
| Length overall (LOA) | (m) |
| Breadth overall (BOA) | (m) |
| Empty ship's weight | (t) |
| Displacement | (t) |
| Minimum draught | (m) |
| Maximum draught | (m) |
| Speed (maximum) | (knots) |
| Autonomy | (days) |
| Operational area | (restricted by distance, distance to refuge (function of time, speed and sea state), maximum operating draught) |
| Deadweight | Liquids per tanks<br>dry cargo<br>dangerous goods<br>(weight, volume and location) |

## 4 Conditions and limitations of MASS operation

| 4.1 Ambient conditions of operation | |
|---|---|
| Wind | (maximum wind force and speed for safe operation) |
| Atmospheric precipitation | (snow/rain) |
| Maximum temperature | (maximum average day air temperature to be indicated) |
| Minimum temperature | (minimum average day air temperature to be indicated) |
| Air humidity (at the temperature) | (one-hundred-percent relative humidity at all temperatures) |
| Icing | (where specially required) |
| Visibility | (with respect to night operation) |
| Atmospheric pressure | (where specially required) |
| Solar radiation | (where specially required, e.g. in the equatorial zone) |
| Electromagnetic radiation | (where specially required) |
| Air quality | (where specially required, e.g. in case of operation in coastal areas near desert) |
| Biological conditions | (where specially required, e.g. in the areas with known higher life activity) |
| 4.2 Marine conditions of operation | |
| Depth | |
| Sea state | (sea condition, operational wave height, maximum wave height) |
| Ice class | |
| Maximum sea temperature | (average day maximum to be indicated) |
| Minimum sea temperature | (average day maximum to be indicated) |
| Tidal motion | (permissible height and maximum speed (related to mooring)) |
| Ship’s deck flooding | (ship’s area subject to flooding or splashing, frequency) |
| Oceanic currents | (where specially required, e.g. for drifting objects) |
| Water quality | (where specially required, e.g. while operating in river estuaries) |

| | |
|---|---|
| Sea surface quality (flotsam, impurity, vegetation) | (where specially required, in river estuaries) |
| Acoustic fields | (where specially required) |
| Electromagnetic field | (where specially required) |
| Seabed/Ground | (where specially required) |
| Shoals, channels | (dimensions, ground condition, where specially required) |
| 4.3 Special conditions of operation | |
| Noise and vibration | |
| Mooring arrangements | (including the maximum berth-contact speed) |
| Launching/Recovery | (proposals for ship's construction) |
| Transportation/Storage | |
| Towing and salvage | |
| 4.4 Limitations of operation | |

## 5 MASS manoeuvring characteristics (for assessment of risks and manoeuvring safety)

### 5.1 General parameters of MASS movement

| Maximum from equilibrium* | | | |
|---|---|---|---|
| Parameter | | Value | Period (sec) |
| Rolling | (deg) | | |
| Pitching | (deg) | | |
| Yawing | (deg) | | |
| Heaving | (m) | | |
| Heavy seas | (m) | | |
| Swaying | (m) | | |
| Vibration | (Hz) | (caused by the action of waves) | |
| * Specify the design values of deviation from the ship's static condition | | | |

### 5.2 MASS manoeuvrability on even keel, fully loaded in deep water

| Nos. | Manoeuvre | Action/Description | Result |
|---|---|---|---|
| 1 | Turning circle | at full speed ahead, with rudder 35° to starboard | Diagram, description |
| | | at full speed ahead, with rudder 20° to starboard | Diagram, description |
| | | with speeding up 0 to 50 %, with rudder 20° to starboard | Diagram, description |
| 2 | "Zigzag" at full speed ahead | with rudder 10°/10° either side | Diagram, description |
| | | with rudder 20°/20°either side | Diagram, description |
| 3 | Assessing the ship's initial turning ability (manoeuvrability) at full speed ahead when she makes a 10° turn with her rudder 10° to starboard | | Diagram, description |
| 4 | Reaching the ship's steady angular velocity at full speed ahead with her rudder 20° to starboard/port | | Diagram, description |
| 5 | Assessing a relation between the ship's steady angular velocity, speed loss and the ship's drift when making a turn at various rudder angles to starboard/port | | Diagram, description |
| 6 | Bringing the ship to the new parallel course at full speed ahead | | Diagram, description |
| 7 | Bringing the ship to the reciprocal course at full speed ahead ("Man Overboard" manoeuvre) | | Diagram, description |

**5.3 MASS inertia-and-braking characteristics on even keel, fully loaded in deep water**

| Nos. | Manoeuvre | Action/Description | Result |
|---|---|---|---|
| 1 | Accelerating from zero initial speed up to full speed ahead upon receipt of "Full ahead!" command | | Diagram, description |
| 2 | Active slowdown from: | full speed ahead to a full stop upon receipt of "Full astern! " command | Diagram, description |
| | | slow speed ahead to a full stop upon receipt of "Slow astern! " command | Diagram, description |
| 3 | Passive slowdown from full speed ahead to 1 knot speed upon receipt of "Stop engine!" command | | Diagram, description |
| 4 | Basic parameters of the straight-line motion: | ship's speed performance (loaded/in ballast) | Diagram, description |
| | | engine telegraph parameters (position, running speed, power/rpm of main engine, pitch/propeller characteristics (for CPP)) | Diagram, description |
| 5 | Accelerating from zero initial speed up to full speed astern upon receipt of "Full astern!" command | | Diagram, description |
| 6 | Accelerating from zero initial speed up to full speed ahead using the ship's automated control system (with regard to the limitations pertinent to autopilot and the SPP remote automated control) | | Diagram, description |

**5.4 MASS inertia-and-braking characteristics on even keel, fully loaded in shallow waters (depth-to-draught ratio = 1.5)**

| Nos. | Manoeuvre | Action/Description | Result |
|---|---|---|---|
| 1 | Accelerating from zero initial speed up to full speed ahead upon receipt of "Full ahead!" command | | Diagram, description |
| 2 | Active slowdown from: | full speed ahead to a full stop upon receipt of "Full astern! " command | Diagram, description |
| | | slow speed ahead to a full stop upon receipt of "Slow astern! " command | Diagram, description |
| 3 | Passive slowdown from full speed ahead to 1 knot speed upon receipt of "Stop engine!" command | | Diagram, description |
| 4 | Accelerating from zero initial speed up to full speed astern upon receipt of "Full astern!" command | | Diagram, description |
| 5 | Accelerating from zero initial speed up to full speed ahead using the ship's automated control system (with regard to the limitations pertinent to autopilot and the SPP remote automated control) | | Diagram, description |
| 6 | Free drifting in full load, on even keel, in calm water | Decaying rolling at initial list of 10° | Diagram, description |
| | | Decaying pitching at initial trim of 2° | Diagram, description |
| 7 | Free drifting in full load, on even keel, due to windage | Ship's drift depending on wind direction | Diagram, description |
| | | Course-keeping under wind disturbance, depending on wind direction | Diagram, description |

| Nos. | Manoeuvre | Action/Description | Result |
|---|---|---|---|
| 8 | Free drifting in full load, on even keel, due to wave effect | | Diagram, description |
| 9 | Ship's drift depending on wave direction | | Diagram, description |
| 10 | Course-keeping under wind disturbance, depending on wave direction | | Diagram, description |

**5.5 MASS behavior in full load/in ballast, on even keel in the shallow waters**

| Nos. | Parameter | Result |
|---|---|---|
| 1 | Squat, depending on under-keel clearance | Diagram, description |
| 2 | Speed loss in the shallow waters | Diagram, description |
| 3 | Loss of manoeuvrability in the shallow waters | Diagram, description |

**5.6 MASS behavior in full load/ballast, on even keel, using ship's positioning means**

| Nos. | Manoeuvre | Result |
|---|---|---|
| 1 | Yawing, by means of sequentially-activated thrusters operated at full power | Diagram, description |
| 2 | Bringing ship to a full stop dropping a single anchor on a sandy bottom in shallow waters, at full length of the anchor chain | Diagram, description |

## 6 Control modes of MASS systems

| Structure | Description |
|---|---|
| Situational awareness | |
| Communications means | |
| Means of navigation and manoeuvring | |
| Ship's power plant (SPP) | |
| Hull | |
| Deck machinery | |
| Ship's damage-control means | |
| Environmental protection means | |
| Anti-intrusion protection of the ship | |
| N o t e s : 1. Add subsystems, where necessary.<br>2. It is advisable to ensure redundancy of the ship's active-control means (propulsion devices and thrusters) onboard MASS so an outage of one of those would not cause the MASS to stall and compromise safety of navigation. | |

## 7 Basics of operation

<table>
<tr><td>Control modes</td><td colspan="2">(Manual/Remote/Automatic)</td></tr>
<tr><td rowspan="5">Limitations</td><td>Cargo limitations</td><td></td></tr>
<tr><td>Loading limitations</td><td></td></tr>
<tr><td>Structural limitations</td><td></td></tr>
<tr><td>Other limitations</td><td></td></tr>
<tr><td colspan="2">(including all limitations permitted as per the variants of ship operation)</td></tr>
<tr><td>Specific operations</td><td colspan="2">(requirements related to the ship’s specifics, e.g. cargo handling operations, requirements for cargo, including stowage thereof)</td></tr>
<tr><td>Anchorage and mooring</td><td colspan="2">(frequency of using the limitation due to sea state)</td></tr>
<tr><td>Towing (not related to emergency)</td><td colspan="2">(requirements for a ship to be towed, operational scenarios, etc.)</td></tr>
<tr><td>Launching, recovery, transportation</td><td colspan="2">(the way the ship will rotate for operation, etc.)</td></tr>
<tr><td>Hull strength management</td><td colspan="2">(approaches to management of the structure states)</td></tr>
<tr><td>Buoyancy and stability</td><td colspan="2">(approaches to stability control, e.g. approval of Stability Booklet, stability instrument, Damage Stability Booklet)</td></tr>
<tr><td rowspan="12">Machines, machinery, electrical systems</td><td>Equipment</td><td>Basics of operation</td></tr>
<tr><td>Propulsion system</td><td></td></tr>
<tr><td>Manoeuvring system</td><td></td></tr>
<tr><td>Ship’s buoyancy and stability control systems</td><td></td></tr>
<tr><td>Deck machinery</td><td></td></tr>
<tr><td>Emergency power supply systems</td><td></td></tr>
<tr><td>Electrical power plant</td><td></td></tr>
<tr><td>High voltage/low voltage power supply and distribution systems</td><td></td></tr>
<tr><td>Control systems</td><td></td></tr>
<tr><td>Communication systems</td><td></td></tr>
<tr><td>Navigation systems</td><td></td></tr>
<tr><td>Auxiliary systems</td><td></td></tr>
</table>

(continued on the next page)

(Basics of operation, continued)

| | | |
|---|---|---|
| Fire safety | Fuel onboard<br>fuel in tanks<br>storage batteries/accumulators | |
| | Liquid cargo in tanks<br>cargo in tanks<br>cargo handling equipment | |
| | Anchorage, mooring, towing and other operations | |
| | Fire detection equipment | |
| | Fire extinguishing equipment | |
| | External assistance<br>shore connection<br>MASS-to-ship connection | |
| Flood control | | |
| Navigational equipment | (operational requirements for navigational equipment) | |
| Transportation of dangerous cargo | (actions during cargo transportation) | |
| Repairability | (means of ship reconditioning after failure of autonomous or remote-control system) | |

## 8 Basics of inspection, maintenance and decommissioning

| | |
|---|---|
| Basics of examination/inspection | (review of the inspection/examination basics) |
| Inspection schedule | (frequency and extent of inspection) |
| Basics of maintenance | (review of the maintenance basics) |
| Maintenance schedule | (maintenance schedule and scope of the planned maintenance) |
| Basics of decommissioning | (review of the decommissioning basics) |

*APPENDIX 2*

# METHODS OF VERIFICATION OF SYSTEMS OF MARITIME AUTONOMOUS SURFACE SHIPS (MASS)

## 1 GENERAL

Equipment of MASS control systems shall be verified under normal operating and emergency conditions of its operation by means of full-scale tests or virtual platforms for navigation situation modelling for compliance with normative documents ensuring safety of navigation for these types of ships while moving on the high seas, in restricted waters, entering the port and mooring to the equipped terminals.

## 2 VERIFICATION PROCEDURE

**2.1** The following equipment installed onboard MASS (refer to Fig. 2.1-1 — 2.1-3) is subject to verification:

**.1** that receives information on external conditions, target situation (position of target ships) in the format of data from ship devices;

**.2** that receives information on the own ship position and condition of its systems, cargo;

**.3** that transmits control commands (control actions) in the format of data from control system installed onboard the ship;

**.4** that receives own ship's response (including warning information) to control actions in the format of data from ship devices.

**2.2** The verification may be carried out onshore or onboard the ship, therewith the equipment to be verified and devices used for verification thereof shall be isolated from the ship systems.

**2.3** The verification is carried out using full-scale tests or by means of software (SW) of the virtual platform for navigation situation modelling (refer to Fig. 2.1-2), which:

**.1** simulates external conditions, target situation (target ships position) on the electronic chart basis, simulates the behavior (parameters) of the own ship movement;

**.2** transmits data from sensors (indicators), receives control commands (control actions);

**.3** monitors compliance with the requirements of COLREG-72 and SOLAS-74.

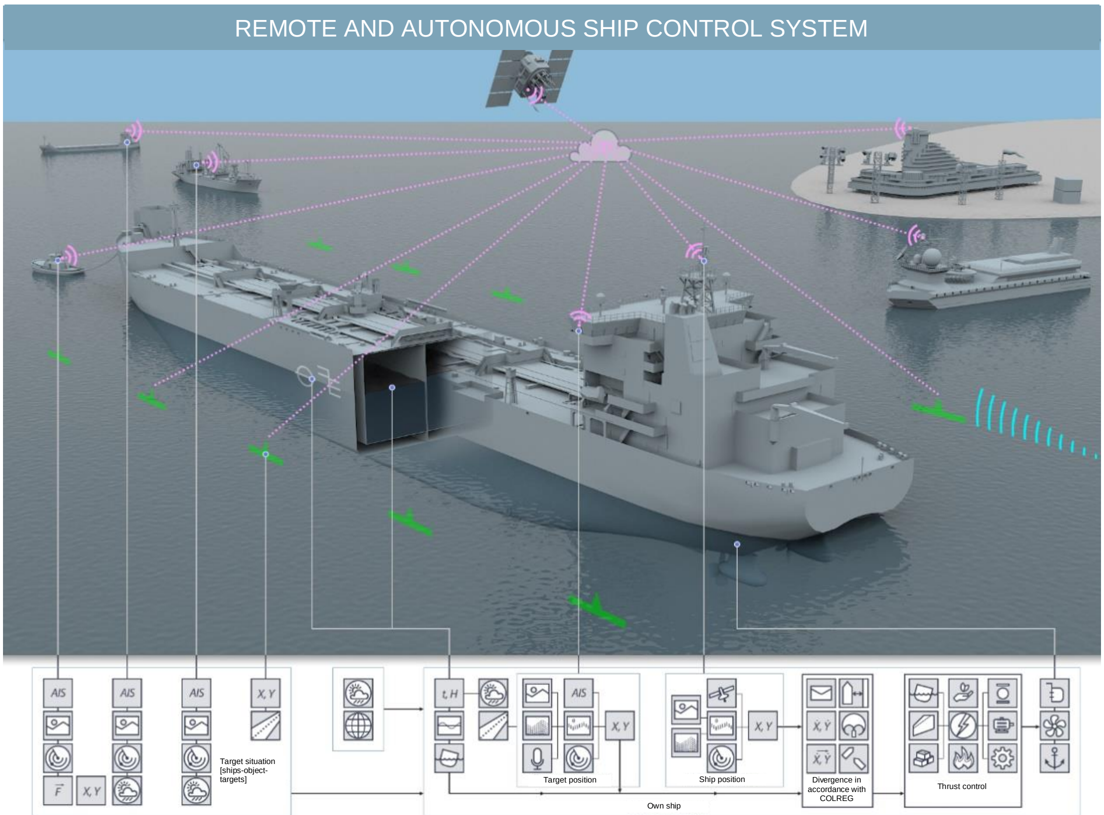



Fig. 2.1-1
Ship equipment to be verified

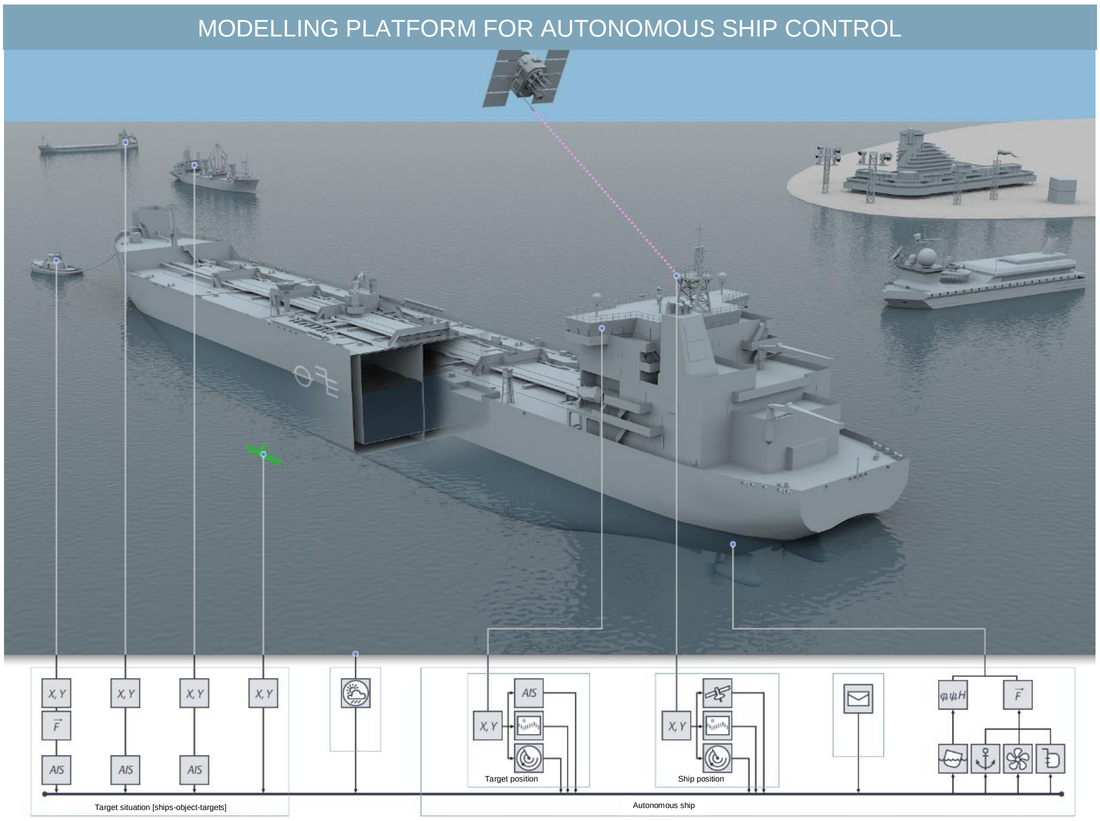



Fig. 2.1-2
Virtual platform for modelling navigation situation

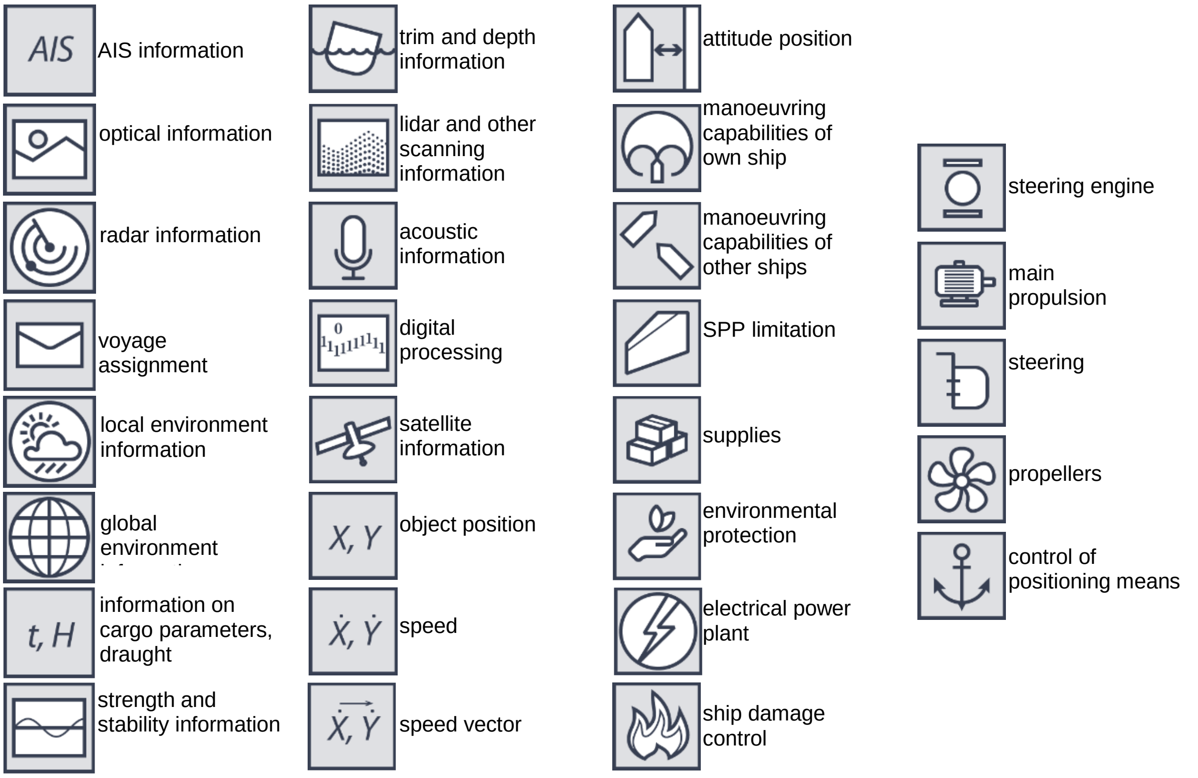



Fig. 2.1-3
Explanatory notes to pictograms given in Figs. 2.1-1 and 2.1-2

**2.4** The verification is performed in the course of full-scale tests (for example, sea trials) or using a numbered SW version of the MASS control system or a numbered SW version of virtual platform for navigation situation modelling, during the interaction of which:

**.1** all exchange data shall be documented, and in case of data loss the lost values shall be recorded with subsequent evaluation of their significance;

**.2** SW of the MASS control system and the virtual platform for navigation situation modelling shall operate synchronously in the real-time and accelerated time modes;

**.3** monitoring of exchange data between the equipment to be verified and the virtual modelling platform shall be performed;

**.4** the possibilities shall be available for inputting main failures of sensors, data delivery errors, signal noises, errors of control command.

**2.5** The verification is performed in accordance with the program and procedure of tests given for the main modules of control system, where:

**.1** the actual events specific to the type of equipment to be verified shall be reproduced in real time (and if possible, in accelerated time);

**.2** the possibilities to start and verify all functional capabilities of control system without manual (additional) adjustment of the exchange data shall be available;

**.3** the possibility shall be provided for verification of the system operational stability, verification by running the predefined tests with known result of the system operations.

**2.6** The verification is performed for separate and joint operation of three main systems used for MASS control:

**.1** target situation detection system and own ship position detection system with the possibilities of their displaying;

**.2** forecasting and safe ship passing systems in compliance with COLREG-72 regulations and good maritime practice;

**.3** movement and manoeuvring control system for thrust control based on the decisions made by the forecasting and safe ship passing systems (refer to 2.6.2).

**2.7** Generally, the verification of target situation detection system and own ships position detection system with the possibilities of their displaying is performed in compliance with the existing RS requirements for navigational equipment of ships (refer to Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships). Additionally, the following shall be verified:

**.1** correctness of the excessive positioning information processing and timing from several coordinate-time and navigation support systems;

**.2** meeting the requirements on target identification based on television information in visible and infrared bands in the conditions of increased and reduced lighting intensity;

**.3** meeting the requirements on target positioning using the redundant information of several sources operating on the basis of different physical principles (radio detection, television, AIS, lidar, etc.);

**.4** the possibility and sufficiency for ensuring safety of situation identification and positioning of the own ship with regard to its size in constraint environment conditions for manoeuvring (waterways, sea channels, port waters, in vicinity of cargo terminals, etc.);

**.5** meeting the requirements of sufficiency, operativity and fidelity of transmitting the information on target situation identification and own ship positioning to the RCC;

**.6** meeting the requirements on receipt and processing orders received from the RCC.

**2.8** The verification of forecasting system and safe ship passing systems in compliance with COLREG-72 regulations and good maritime practice is performed to verify:

**.1** receipt and processing of data on current navigation (target) situation from ship GNSS, AIS, ARPA equipment shall be verified, their synchronization and consistency check shall be made in analogy for each MASS surrounding target. Finally, the position, absolute and relative course and speed shall be established, as well as target ship identifiers (name, type, IMO number, MMSI), then the parameters for evaluation of possible manoeuvring shall be determined;

**.2** the possibility of forming an area of navigation shall be verified (with regard to limitations/recommendations) based on electronic chart information (with corrections): coastal line, isobaths, depths, recommended routes, navigation hazards, special areas of navigation;

**.3** the possibility of assessing and forecasting the development of navigation situation created by dynamics of the following shall be verified: MASS and surrounding target ships with regard to: navigation hazards, shipping route and application of regulations 13, 14, 15 and 18 of COLREG-72, as well as based on the established criteria of dangerously close approach evaluation;

**.4** the rules of decision-making on safe target ship divergence in case of dangerously close approach shall be verified that ensure divergence with all target ships at the prescribed distance from MASS by means of verifying the compliance with the regulations of COLREG-72 with respect to: draught, navigation hazards, prohibited areas of navigation, as well as using the optimality criteria, evaluation of dangerously close approach on the basis of good maritime practice;

**.5** correctness shall be verified of recommendations for choosing the safe route with safe movement parameters related to navigation hazards and target ships at a given distance;

**.6** the following shall be verified: integrity of the recorded data during the situational analysis of target ships positions; assessment and forecasting of each ship situation according to COLREG-72; hazardous target extraction for MASS control systems; and data of recommendation log of forecasting system of ship safe passing according to MASS movement parameters, target ships, applicable regulations of COLREG-72.

**2.9** The verification of movement control and manoeuvring system for thrust control is performed to verify:

**.1** ensuring movement using commands received by forecasting and safe ship passing system based on receipt of:

or route points coordinates, given speed of MASS movement on a tack (straight-line segment of the route) and turning radius of MASS transfer from one tack to another;

or given course and given speed . Or as one more variant: based on given turning radius for the given side (given turning rate) and given speed;

**.2** the possibility of speed control by means of:

by main engine rotation frequency (ME remote automated control) and, where available: by pitch of controllable pitch propeller (CPP remote automated control);

or by propeller rotation frequency and turning angle of the main azimuth thrusters (azimuth thruster remote automated control);

**.3** the possibility of course control by means of:

rudder;

or by turning angle of the main azimuth thrusters (azimuth thruster remote automated control);

**.4** the possibility of MASS positioning by means of:

thruster control system (thruster remote automated control); or

separate MASS dynamic positioning system;

**.5** operation of a separate channel for receipt of MASS position feedback based on the data from GLONASS/GPS duplicated system, log, gyrocompass, electronic or magnetic compass, two wind sensors, ME remote automated control, CPP remote automated control, remote automated control of electric propulsion motor, thruster remote automated control.

**2.10** The possibility shall be verified of transmitting the current information on MASS position, speed and course, accepted control commands and information on navigation sensor condition and movement control means to the voyage data recording system (from which the information may be transmitted to RCC).

**2.11** The comprehensive check of the simultaneous operation of three main systems (refer to 2.6) used for MASS control shall be performed for verifying the implementation possibility of the following main functions:

**.1** navigation system:

voyage planning;

passage planning;

determination of MASS position data, course and speed;

passage;

supervisory monitoring;

determination of the closest point of approach and time of the closest approach to the potential navigation hazards, objects and other ships;

monitoring of depth, sea state, tide waters, currents, weather and visibility;

monitoring of sea passage and parameters of systems involved in performance thereof;

tracking of distress signals from other seafarers and response thereon;

determination of surrounding situation (free navigation without limitations, heavy traffic, coastal navigation, moving in restricted waters, restricted visibility, bad environmental conditions, glacial weather, ice conditions, pilot assistance necessity);

berthing, mooring operations;

manoeuvring;

control of propulsion system (main engine);

course-keeping and steering;

grounding and collision avoidance;

use of weather recommendations for the passage;

communications with other ships;

ship-to-shore communication (i.e. receipt of corrections, connection with navigation control centre, weather forecast receipt, salvage operations, pilotage and other data);

indication of own and processing of navigation lights and audible signals;

overall control of all navigation bridge systems;

overall control of MASS condition and its operating capabilities;

**.2** ship power plant systems (SPP):

overall control of the systems related to engine room;

control and monitoring of main and auxiliary machinery (fuel system, cooling system, heating system, lubricating oil system, hydraulic system, high pressure air system and other systems, where necessary);

overall control of electrical power plant operation and electrical power distribution;

monitoring and control of standby and emergency power supply;

monitoring and control of ballast system (where required by quick inclining system);

control of embarkation, strength and stability systems of MASS hull, including the damaged-ship situation;

control and monitoring of draining system, bilge water and sewage system;

control and monitoring of fresh and sea water system;

control of fuel consumption and fuel consumption optimization;

monitoring and control of exhaust gas systems;

automatic planning of maintenance and repair activities with due regard to maintenance schedule for all machinery;

**.3** MASS special systems:

control and monitoring of cargo system and cargo condition;

control and monitoring of watertight closures and doors;

control and monitoring of high voltage systems;

control of anchor operations systems;

control of systems for mooring operations;

control of fire detection and fire extinguishing systems;

control of dynamic positioning systems;

control of ship's event recording systems (self-recording apparatus).

*APPENDIX 3*

# RISK ASSESSMENT PROCEDURE OF MARITIME AUTONOMOUS SURFACE SHIPS (MASS), REMOTE CONTROL CENTRE (RCC)

## 1 TASK

The procedure of MASS risk assessment in respect of the equipment onboard with regard to the equipment characteristics expressly determined by expert opinions and the probabilities of the equipment outage shall be developed within an individual project.

The procedure of RCC risk assessment in respect of the equipment onboard with regard to the equipment characteristics expressly determined by expert opinions and the probabilities of the equipment outage shall be developed in analogy and on the basis of MASS risk-assessment procedure.

This Appendix contains the fundamental requirements to be taken as a basis for the individual project.

## 2 RISK CALCULATION PROCEDURE OF MARITIME AUTONOMOUS SURFACE SHIPS (MASS)

Select experts familiar with MASS equipment and systems or those of conventional ships.

Conduct an expert assessment of the exhaustive list of risks for each individual mechanism, the MASS system. Therewith, every risk shall be presented by an event independent of other events.

Conduct an expert assessment of each simple risk proportion for each mechanism as a whole.

Conduct an expert assessment of the probability of event occurrence related to each simple risk for each mechanism installed onboard MASS (but, first of all, it shall be implemented for systems ensuring autonomous navigation and those specified in Appendix 1).

To make risk calculation per each group of simple risks.

Make a composition of complex risks according to the systems based on a composition of feature-based (simple) risks.

## 3 METHODS OF VERIFICATION OF RISK CALCULATION OF MARITIME AUTONOMOUS SURFACE SHIPS (MASS)

Based on the submitted procedure, the software (SW) shall be developed enabling to make calculations in case of changing the configuration and operability of MASS ship equipment.

Based on the submitted procedure, the software (SW) shall be developed enabling to make calculations in case of changing the configuration and operability of RCC equipment.

## 34 REQUIREMENTS FOR SHIPS CARRYING THE INDUSTRIAL PERSONNEL

### 34.1 GENERAL

**34.1.1 Application.**

**34.1.1.1** The requirements of this Section apply to cargo ships carrying the industrial personnel as determined in 1.1.1, Part I "Classification".

**34.1.1.2** Wherever the number of the industrial personnel is mentioned in this Section as a parameter, it shall be the aggregate number of the industrial personnel, special personnel and passengers carried on board. Herewith, the number of passengers shall not exceed 12 persons.

**34.1.1.3** The requirements for safe transfer of the industrial personnel on high-speed craft are given in Part XXI "Craft for Personnel Transportation" of the Rules for the Classification and Construction of High-Speed Craft.

**34.1.1.4** The cargo ship carrying in total not more than 12 persons of the industrial personnel, special personnel and passengers shall comply with the Rules for the Classification and Construction of Sea-Going Ships as well as SOLAS-74 or the Rules for the Equipment of Sea-Going Ships (whatever is applicable) for cargo ships.

**34.1.1.5** The cargo ship carrying in total more than 12 persons of the industrial personnel, special personnel and passengers shall comply at least with the Rules for the Classification and Construction of Sea-Going Ships for cargo ships considering its dimensions and type as well as additional requirements of 34.2 — 34.4 depending on the number of persons on board and gross tonnage.

**34.1.1.6** A distinguishing mark may be added to the character of classification of ships specified in 34.1.1.5:

**.1** **IPS1(N)** — for ships of 500 gross tonnage and upwards complying with the requirements of this Section except the requirements of 34.4. This mark may be assigned to special purpose ships carrying the industrial personnel and engaged on international voyages, provided that the requirements of this Section related to the personnel transfer appliances (refer to 34.3.2), life-saving appliances (refer to 34.3.12) and, if applicable, carriage of dangerous goods (refer to 34.3.13) are complied with. Besides, this mark may be assigned to special purpose ships carrying the industrial personnel and not engaged on international voyages, provided that the requirements of this Section related to life-saving appliances (refer to 34.3.12) depending on the number of persons on board and, if applicable, to carriage of dangerous goods (refer to 34.3.13) are complied with; herewith, the requirements of 34.3.2 related to the personnel transfer appliances are not mandatory to fulfill.

**.2** **IPS2(N**) — for ships of less than 500 gross tonnage complying with the requirements of 34.2 and 34.4. This mark may be assigned to special purpose ships carrying the industrial personnel, provided that the requirements of this Section related to life-saving appliances (refer to 34.4.5) depending on the number of persons on board are complied with.

**34.1.1.7** Ships specified in 34.1.1.4 are not assigned with the distinguishing marks listed in 34.1.1.6. Herewith, the Section "Other Characteristics" of the Classification Certificate may be supplemented with an entry confirming the possibility to carry up to 12 persons of the industrial personnel.

**34.1.2 Definitions.**

For the purpose of this Section the following definitions apply. For terms not defined in this Section, there shall be applied definitions given in the corresponding parts of the Rules for the Classification and Construction of Sea-Going Ships.

Length is the ship's length $L_{LL}$ as it is defined in Part II "Hull".

Carriage means transportation or accommodation or both.

Personnel transfer means the full sequence of the operation of transferring personnel and their equipment at sea to or from a ship carrying the industrial personnel or to or from another ship or an offshore facility.

IP area is any area or compartment where the industrial personnel (IP) are normally intended to stay during voyage or are allowed to access.

## 34.2 TECHNICAL DOCUMENTATION

**34.2.1** To assign distinguishing mark **IPS1(N)** or **IPS2(N)** to ships carrying the industrial personnel, the documentation listed in 3.2.1 — 3.2.10, 3.2.17.28 and 3.3, Part I "Classification" shall be submitted to the Register to confirm fulfillment of the requirements of 34.3 or 34.4 accordingly.

## 34.3 ADDITIONAL REQUIREMENTS FOR CARGO SHIPS OF 500 GROSS TONNAGE AND UPWARDS

**34.3.1 Hull.**

**34.3.1.1** A double bottom shall comply with the requirements of 1.1.6, Part II "Hull", as applicable to passenger ships.

**34.3.2 Personnel transfer appliances.**

**34.3.2.1** Ships shall be fitted with appliances to transfer personnel at sea.

**34.3.2.2** The personnel transfer appliances (PTA) shall be designed, manufactured, tested and installed in accordance with the requirements of this Section as well as 5.8 of the Rules for the Cargo-Handling Gear of Sea-Going Ships.

**34.3.2.3** The PTA design shall account for structural particulars of the ship.

**34.3.2.4** To ensure a safe transfer of personnel an analysis shall be performed in order to evaluate failures in PTA and all its associated systems which might impair serviceability of the transfer appliance(s) and/or endanger the safety of all those involved in the transfer operations. The analysis is recommended to perform using FMEA (the failure mode and effects analysis).

To perform the analysis, proceed as follows:

**.1** consider the effect of failure for all the equipment and systems in the case of a single failure, fire in any space or flooding of any watertight compartment that may affect serviceability of the transfer appliance(s);

**.2** provide solutions to ensure serviceability of PTA and safety of all those involved in case of failures specified in 34.3.2.4.1;

**.3** when a single failure results in a failure of more than one component of a system (the common-cause failure), all the resulting failures shall be considered altogether. If a failure directly causes further failures, all such failures shall be considered altogether;

**.4** means for position keeping shall be provided and arranged so to prevent accidents during the personnel transfer and be consistent with an operating mode of and interaction with other ships or offshore facilities. For doing so, the ship's maneuverability along with the expected need for the ship to keep own position over time shall be evaluated, to ensure the correct use of position-keeping equipment;

**.5** procedures shall be in place to ensure consistent monitoring of the number of persons on board during the personnel transfer operations.

**34.3.2.5** To operate PTA, there shall be provided means of communication between the responsible ship's officer overseeing the personnel transfer operations and the navigation bridge.

**34.3.2.6** All PTA shall be permanently marked so to enable identification of each appliance for the purpose of survey, inspection and record-keeping. All the records of use and maintenance of the ship's PTA shall be kept onboard.

**34.3.2.7** Passageways for the industrial personnel shall ensure safe and unobstructed movement of people between PTA and a place, where the industrial personnel are intended to be stationed or accommodated onboard a ship.

**34.3.2.8** In addition to the requirements of 6.1.1 of Part XI "Electrical Equipment", lighting with power from the emergency source of electrical power shall be provided so to illuminate PTA, the water below PTA and passageways to PTA, as specified in 34.3.2.7.

**34.3.2.9** To arrange PTA onboard the ship, there shall be designated a deck area free from any obstructions (e.g. air pipes, valves, hatches, fixed and/or detachable structures, ship's supplies or cargo, etc.).

**34.3.2.10** When carrying dangerous goods, the requirements of 34.3.13.4.3.3 and 34.3.13.4.3.4 related to PTA shall be fulfilled.

**34.3.3 Equipment, arrangements and outfit.**

**34.3.3.1** Steering system for ships having length of 120 m and more or having three (3) or more vertical zones carrying more than 240 persons shall comply with the requirements of 2.2.6.7.2 and 2.2.6.8 of Part VI "Fire Protection".

**34.3.3.2** Steering gears of ships carrying more than 240 persons shall comply with the requirements of 2.9.5 of Part III "Equipment, Arrangements and Outfit".

**34.3.3.3** Doors fitted in the subdivision bulkheads shall comply with the requirements of 7.12.5 except for 7.12.5.15, Part III "Equipment, Arrangements and Outfit".

**34.3.3.4** The power-operated doors fitted in the subdivision bulkheads for ships having length of 120 m or more or those having three (3) or more vertical zones carrying more than 240 persons shall comply with the requirements of 2.2.6.7.3 and 2.2.6.8 of Part VI "Fire Protection".

**34.3.3.5** Exits and doors shall comply with the requirements of 8.5.2.1, 8.5.2.2 of Part III "Equipment, Arrangements and Outfit".

**34.3.3.6** Corridors, passageways and means of escape for ships carrying more than 60 persons shall comply with the requirements of 8.5.3.1, 8.5.3.7, while stairways and vertical ladders for escape routes shall comply with the requirements of 8.5.4.2 of Part III "Equipment, Arrangements and Outfit".

**34.3.3.7** Low-location lighting for ships carrying more than 240 persons shall comply with the requirements of 8.5.5 of Part III "Equipment, Arrangements and Outfit".

**34.3.4 Stability.**

**34.3.4.1** A ship carrying more than 240 persons shall comply with the requirements of Part IV "Stability" for passenger ships except for 1.5.5 related to the periodical light-weight check. To apply the requirements of the said Part, the industrial personnel shall be considered as passengers.

**34.3.4.2** A ship carrying not more than 240 persons shall comply with the requirements of Part IV "Stability" for cargo ships, herewith the industrial personnel shall be considered as a crew.

**34.3.4.3** For ships of 500 gross tonnage and upwards, which are not engaged on the international voyages, as well as for ships less than 500 gross tonnage carrying not more than 240 persons, which are of a similar type to the support vessels, the requirements for the righting lever curve are allowed to be mitigated, as specified in 3.11.4 of Part IV "Stability".

**34.3.5 Subdivision.**

**34.3.5.1** Ships shall comply with the requirements of 3.4.3 of Part V "Subdivision".

**34.3.6 Fire protection.**

**34.3.6.1** Ships carrying more than 60, but not more than 240 persons shall comply with the requirements of Part VI "Fire Protection" for passenger ships carrying not more than 36 passengers, except for 2.2.6 and 2.2.7.

**34.3.6.2** Ships carrying more than 240 persons shall comply with the requirements of Part VI "Fire Protection" for passenger ships carrying more than 36 passengers.

**34.3.7 Systems and piping.**

**34.3.7.1** The piping laying through the collision bulkhead shall comply with the requirements of 5.1.2 of Part VIII "Systems and Piping".

**34.3.7.2** Bilge system shall comply with the requirements of 7.1.2 — 7.1.6 and 7.3.6, Part VIII "Systems and Piping", except for 34.3.7.3.

**34.3.7.3** Bilge system for ships having length of 120 m and more or having three or more main vertical zones carrying more than 240 persons shall comply with the requirements of 2.2.7.4, 2.2.6.7.5 and 2.2.6.8 of Part VI "Fire Protection".

**34.3.7.4** Ballast system for ships carrying more than 240 persons and having length of 120 m and more or having three or more main vertical zones shall comply with the requirements of 2.2.6.7.5 and 2.2.6.8 of Part VI "Fire Protection".

**34.3.7.5** Ventilation system for ships carrying not more than 240 persons, shall comply with the requirements of 12.2 of Part VIII "Systems and Piping" as on passenger ships carrying not more than 36 passengers.

**34.3.7.6** Ventilation system for ships carrying more than 240 persons shall comply with the requirements of 12.3 of Part VIII "Systems and Piping" as on passenger ships carrying more than 36 passengers, while for ships carrying more than 240 persons, having length of 120 m and more or having three or more main vertical zones the ventilation system shall comply with the requirements of 2.2.6.10 of Part VI "Fire Protection".

**34.3.8 Machinery installations.**

**34.3.8.1** The fuel oil tanks for ships carrying more than 60 persons shall comply with the requirements of 4.3.2 of Part VII "Machinery Installations", provided that the Register has agreed installation of free-standing tanks.

**34.3.9 Machinery.**

**34.3.9.1** It is not allowed to connect piping systems of power-operated sliding watertight doors with other hydraulic systems on board.

**34.3.9.2** Hydraulic systems of power-operated sliding watertight doors shall comply with the requirements of 7.1.5 of Part IX "Machinery".

**34.3.9.3**. Steering gears for ships carrying more than 240 persons, having length of 120 m or more or having three or more main vertical zones shall comply with the requirements of 2.2.6.7.2 and 2.2.6.8 of Part VI "Fire Protection".

**34.3.10 Electrical equipment.**

**34.3.10.1** Emergency sources of electrical power for ships having length of 50 m and more, carrying not more than 60 persons shall comply with the requirements of 20.1.2.3.1 of Part XI "Electrical Equipment".

**34.3.10.2** Emergency sources of electrical power for ships carrying more than 60 persons shall comply with the requirements of 20.1.2 of Part XI "Electrical Equipment".

**34.3.10.3** Distribution systems on ships carrying more than 60 persons shall comply with the requirements of 20.1.1.4 of Part XI "Electrical Equipment".

**34.3.11 Automation.**

**34.3.11.1** Ships shall comply with the requirements of Part XV "Automation" depending on the automation mark in the class notation in order to ensure the same safety level as in the normally attended machinery spaces.

**34.3.12 Life-saving appliances.**

**34.3.12.1** Ships carrying more than 60 persons and engaged on international voyages shall comply with the requirements of SOLAS-74 Chapter III for life-saving appliances of passenger ships engaged on international voyages which are not short international voyages.

**34.3.12.2** Ships carrying more than 60 persons and not engaged on international voyages shall comply with the requirements of Section 3, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships.

**34.3.12.3** To apply the requirements of SOLAS-74 Chapter III or the Rules for the Equipment of Sea-Going Ships as stated in 34.3.12.1, 34.3.12.2, the industrial personnel shall be considered as passengers.

**34.3.12.4** Notwithstanding the requirements of 34.3.12.3, the required number of lifejackets for infants or lifejackets for children shall be calculated solely based on the number of passengers on board.

**34.3.13 Dangerous goods.**

**34.3.13.1** The industrial personnel may only carry dangerous goods on board for their use off the ship, provided the consent of the ship's master. These dangerous goods shall be considered as cargo and be transported in accordance with 7.2 of Part VI "Fire Protection".

**34.3.13.2** Carriage of dangerous goods in a packaged form.

**34.3.13.2.1** Ships carrying more than 240 persons on board shall comply with the requirements of 7.2.10.2 of Part VI "Fire Protection" for passenger ships carrying more than 36 passengers; herewith, for complying with the International Maritime Dangerous Goods Code adopted by IMO resolution MSC.122(75), as amended, ships carrying more than 240 persons on board shall be considered as passenger ships and those carrying not more than 240 persons on board shall be considered as cargo ships.

**34.3.13.3** Carriage of dangerous goods in solid form in bulk.

**34.3.13.3.1** Ships carrying more than 240 persons on board shall comply with the requirements of 7.2.10.2 of Part VI "Fire Protection" for passenger ships carrying more than 36 passengers; herewith, for complying with the International Maritime Solid Bulk Cargoes Code adopted by IMO resolution MSC.268(85), as amended, the industrial personnel shall be considered as personnel in the context of personnel protection.

**34.3.13.4** Carriage of chemically hazardous substances, liquefied gases and oil.

**34.3.13.4.1** When simultaneously carrying the industrial personnel and chemically hazardous substances as cargo in bulk, the ship shall either comply with the Rules for the Classification and Construction of Chemical Tankers and/or the International Code for Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk adopted by IMO resolutions MSC.4(48) and MEPC.19(22), as amended, or the Code for the transport and handling of hazardous and noxious liquid substances in bulk on offshore support vessels, adopted by IMO resolution A.1122(30), whatever is applicable, and possess a relevant certificate.

**34.3.13.4.2** When simultaneously carrying the industrial personnel and liquefied gases as cargo in bulk, the ship shall either comply with the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk and/or the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk adopted by the IMO resolution MSC.5(48), as amended, if applicable, and possess a relevant certificate. When carrying liquefied gases in bulk for complying with the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk adopted by the IMO resolution MSC.5(48), as amended, the industrial personnel shall be considered as personnel in the context of personnel protection.

**34.3.13.4.3** Additionally, the following requirements shall be fulfilled:

**.1** carriage of toxic products, low-flashpoint products or acids shall not be allowed when the total number of persons on board exceeds 60;

**.2** for the purpose of carrying the industrial personnel, the areas and compartments onboard shall be clearly marked where the industrial personnel are not allowed to enter;

**.3** PTA shall be arranged beyond the limits of the cargo area;

**.4** an access to PTA shall be located outside the cargo area as far as practicable; and

**.5** embarkation or transfer of the personnel and loading or unloading of cargo shall not take place simultaneously.

**34.3.13.4.4** When simultaneously carrying the industrial personnel and oil as cargo, as defined in Annex I to MARPOL 73/78, there shall be applied the additional requirements of 34.3.13.4.3.

**34.3.13.4.5** For the purpose of 34.3.13.4, the following definitions shall apply:

**.1** "low-flashpoint products" means the following:

**.1.1** noxious liquid substances with a flashpoint not exceeding 60 °C;

**.1.2** oil with a flashpoint not exceeding 60 °C; and

**.1.3** liquefied gases which require flammable vapour detection in accordance with chapter 19 of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk adopted by the IMO resolution MSC.5(48), as amended;

**.2** "toxic products" means the following:

**.2.1** dangerous chemicals to which special requirement 15.12 of the International Code for Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk adopted by IMO resolutions MSC.4(48) and MEPC.19(22), as amended, applies (4.8 and 4.9 of Part VI "Systems and Piping" of the Rules for the Classification and Construction of Chemical Tankers);

**.2.2** liquefied gases which require toxic vapour detection in accordance with chapter 19 of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk adopted by the IMO resolution MSC.5(48), as amended (Appendices to the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk); and

**.2.3** "acids", which means dangerous chemicals to which special requirement 15.11 of the International Code for Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk adopted by IMO resolutions MSC.4(48) and MEPC.19(22), as amended, applies.

## 34.4 ADDITIONAL REQUIREMENTS FOR CARGO SHIPS OF LESS THAN 500 GROSS TONNAGE

**34.4.1 General.**

**34.4.1.1** Unless otherwise is stated in this chapter, the ships shall comply with the Rules for the Classification and Construction of Sea-Going Ships and the Rules for the Equipment of Sea-Going Ships for cargo ships of less than 500 gross tonnage as well as the requirements of 34.3.2, 34.3.3, 34.3.7 — 34.3.11 and 34.3.13 as far as reasonable and practicable, with account for the ship's structural particulars, operating conditions and voyage duration.

**34.4.2 Stability.**

**34.4.2.1** Stability shall comply with the requirements of 3.6 and 3.11.4 of Part IV "Stability".

**34.4.3 Subdivision.**

**34.4.3.1** Subdivision and damage stability of a ship shall comply with the requirements of 3.4.3 of Part V "Subdivision".

**34.4.4 Fire protection.**

**34.4.4.1** Fire protection of a ship shall comply with the requirements of Section 8, Part VI "Fire Protection".

**34.4.5 Life-saving appliances.**

**34.4.5.1** For ships carrying more than 60 persons, the requirements of Section 3, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships shall apply.

**34.4.5.2** To apply the requirements of Section 3, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships the industrial personnel shall be considered as passengers.

**34.4.5.3** Notwithstanding the provisions of 34.4.5.2 above, the required number of lifejackets for infants or lifejackets for children shall be calculated solely based on the number of passengers on board.

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**

FAI "Russian Maritime Register of Shipping"
7, Litera A, Millionnaya Ulitsa,
St. Petersburg, 191181
Russian Federation
www.rs-class.org/en/