RUSSIAN MARITIME REGISTER OF SHIPPING

RULES
FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS

VOLUME

5

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Rules for the Classification and Construction of Sea-Going Ships of Russian Maritime Register of Shipping have been approved in accordance with the established approval procedure. The date of coming into force of the present Rules is 1 October 2008.

The Rules are based on the eleventh edition (2007) taking into account amendments developed immediately before publication.

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

The Rules are published in five volumes.

General Regulations for the Classification and Other Activity, Part I "Classification", Part II "Hull", Part III "Equipment, Arrangements and Outfit", Part IV "Stability", Part V "Subdivision", Part VI "Fire Protection" are included in Volume 1.

Part VII "Machinery Installations", Part VIII "Systems and Piping", Part IX "Machinery", Part X "Boilers, Heat Exchangers and Pressure Vessels", Part XI "Electrical Equipment", Part XII "Refrigerating Plants", Part XIII "Materials", Part XIV "Welding", Part XV "Automation", Part XVI "Hull Structure and Strength of Glass-Reinforced Plastic Ships and Boats" are included in Volume 2.

The text of the Rules in the Russian language published in 2008 shall be considered as the original.

Part XVII "Common Structural Rules for Double Hull Oil Tankers" is included in Volume 3.

In case of contradictions in the texts the English text shall be considered as the original.

Part XVIII "Common Structural Rules for Bulk Carriers" is included in Volume 4.

In case of contradictions in the texts the English text shall be considered as the original.

Part XIX "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships" is included in Volume 5.

The text of the Rules in the Russian language published in 2008 shall be considered as the original.

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As compared to the previous edition (2007), the twelfth edition contains the following amendments.

RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS

A new Part XIX "Distinguishing Marks and Descriptive Notations in the Class Notation Specifying Structural and Operational Particulars of Ships" has been introduced.

The new Part contains four Sections:

Section 1 "Requirements for Polar Class Ships";

Section 2 "Technical Requirements for Escort Tugs";

Section 3 "Requirements for the Equipment of Ships in Compliance with the Distinguishing Marks **ECO** and **ECO-S** in the Class Notation";

Section 4 "Requirements for the Equipment of Ships in Compliance with the Distinguishing Mark **ANTI-ICE** in the Class Notation".

Section 1 "Requirements for Polar Class Ships" contains requirements applied to ships constructed of steel (except icebreakers) intended for navigation in ice-infested polar waters. Such ships may be assigned the polar class (**PC**) from **PC1** to **PC7** to match the requirements for the ship with the intended voyage or service. Abbreviation "PC" means "Polar Class".

The Requirements for Polar Class Ships have been approved in accordance with the established approval procedure. The date of coming into force is 1 March 2008.

The Requirements for Polar Class Ships correspond to the IACS Unified Requirements:

I1 (Rev.1, Jan.2007) "Polar Class Descriptions and Application";

I2 (Rev.1, Jan.2007) "Structural Requirements for Polar Class Ships";

I3 (Rev.1, Jan.2007) "Machinery Requirements for Polar Class Ships".

The Requirements for Polar Class Ships do not contain the requirements for icebreakers. Such ships may have additional requirements and shall receive special consideration.

The Requirements for Polar Class Ships apply to ships contracted for construction on or after 1 March 2008.

According to the Requirements for Polar Class Ships, polar class notations will be assigned at the shipowners' discretion. At the same time, for the Register-classed ships intended for operation in Russian arctic seas as well as for icebreakers, ice category marks (**Arc4** to **Arc9** and **Icebreaker6** to **Icebreaker9**, accordingly) and the requirements for ships with such marks in the class notation according to the Register rules in force remain valid.

At the shipowners' discretion polar class notations according to the Requirements for Polar Class Ships and ice category marks according to the Register rules in force may be applied simultaneously (double ice class), providing such ships comply with the Requirements for Polar Class Ships and the relevant requirements of the Register rules in force.

Section 2 "Technical Requirements for Escort Tugs" contains additional requirements for tugs intended for escort service, which may be assigned the descriptive notation **Escort tug** in the class notation. Additional requirements cover arrangement, design and stability of tugs, as well as procedure and scope of full scale trials.

Section 3 "Requirements for the Equipment of Ships in Compliance with the Distinguishing Marks **ECO** and **ECO-S** in the Class Notation" contains requirements for 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 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 environmental pollution in case of emergency;

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 for the Equipment of Ships in Compliance with the Distinguishing Marks **ECO** and **ECO-S** in the Class Notation are based on international instruments related to marine environment protection. At the same time, some provisions of the Requirements for the Equipment of Ships in Compliance with the Distinguishing Marks **ECO** and **ECO-S** in the Class Notation are more stringent than the requirements of the relevant international instruments.

Section 4 "Requirements for the Equipment of Ships in Compliance with the Distinguishing Mark **ANTI-ICE** in the Class Notation" contains requirements for ships the design and equipment of which provide effective icing protection.

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

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 navigation in ice-infested polar waters, except icebreakers (refer to 1.1.3).

The requirements apply to ships contracted for construction on or after 1 March 2008.

Note: The date of "contract for construction" 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 "contract for construction" refer to 1.1.2, Part I "Classification".

1.1.1.2 Ships that comply with requirements of 1.2 and 1.3 can be considered for a polar class notation as listed in Table 1.1.1.2. The requirements of 1.2 and 1.3 are in addition to the Register requirements for ships without ice strengthening. 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 Classification Certificate. Compliance of the hull or machinery with the requirements of a higher polar class shall also be indicated in column "Other characteristics" of the Classification Certificate.

1.1.1.3 Ships that shall receive an "**Icebreaker**" notation may have additional requirements and shall receive special consideration. "**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, and having a Classification Certificate endorsed with this notation.

1.1.2 Polar classes.

1.1.2.1 The polar class (**PC**) notations and descriptions are given 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 owners, designers and administrations in selecting an appropriate polar class to match the requirements for the ship with its intended voyage or service.

1.1.2.2 The polar class notation is used throughout the present 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 Classification Certificate. 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 (e.g. propeller submergence).

1.2 STRUCTURAL REQUIREMENTS FOR POLAR CLASS SHIPS

1.2.1 Application.

1.2.1.1 These requirements shall be applied to polar class ships indicated in 1.1.

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, bow intermediate, midbody and stern. The bow intermediate, midbody and stern regions are further divided in the vertical direction into the bottom, lower and ice belt regions. The extent of each hull area is illustrated in Fig. 1.2.2.1.

1.2.2.2 The upper ice waterline (UIWL) and lower ice waterline (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 0,45*L* aft of the forward perpendicular (FP).

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.

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

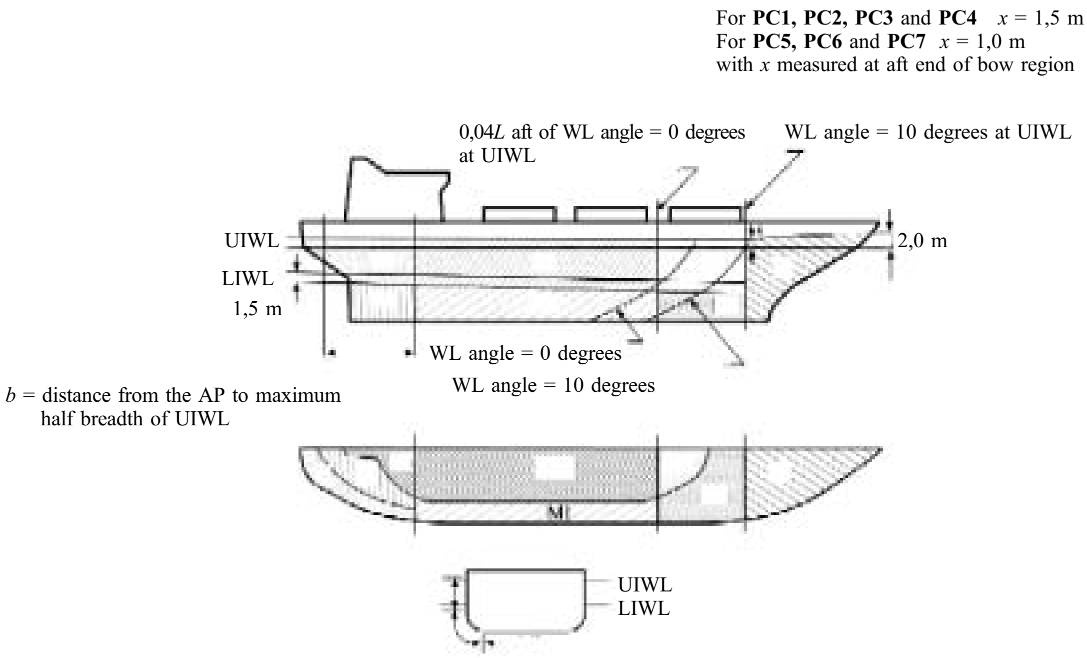


Fig. 1.2.2.1
Hull area extents

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 area requirements.

1.2.3 Design ice loads.

1.2.3.1 General.

1.2.3.1.1 For ships of all polar classes, 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 sub-regions 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 are only valid for ships with icebreaking forms. Design ice forces for any other bow forms shall be specially considered by the Register.

1.2.3.1.6 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.

1.2.3.2.1 The parameters defining the glancing impact load characteristics are reflected in the class factors listed in Table 1.2.3.2.1.

Table 1.2.3.2.1

Class factors

Polar class	Crushing failure class factor (CFC)	Flexural failure class factor (CFF)	Load patch dimensions class factor (CFD)	Displacement class factor (CFDIS)	Longitudinal strength class factor (CFL)
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

1.2.3.2.1.1 Bow area.

1.2.3.2.1.1.1 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 upper ice waterline. The influence of the hull angles is captured through calculation of a bow shape coefficient fa. The hull angles are defined in Fig. 1.2.3.2.1.1.1.

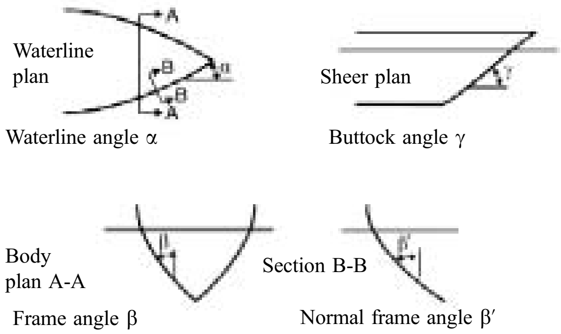


Fig. 1.2.3.2.1.1.1

Definition of hull angles

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

1.2.3.2.1.1.2 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).

1.2.3.2.1.1.3 The bow area load characteristics are determined as follows:

.1 shape coefficient fa_i shall be taken as:

$$fa_i = \min(fa_{i,1};\ fa_{i,2};\ fa_{i,3}) \qquad (1.2.3.2.1.1.3.1\text{-}1)$$

where

$$fa_{i,1} = (0{,}097 - 0{,}68(x/L - 0{,}15)^2)\cdot \alpha_i/(\beta_i')^{0,5}; \qquad (1.2.3.2.1.1.3.1\text{-}2)$$

$$fa_{i,2} = 1{,}2CF_F/(\sin(\beta_i')\cdot CF_C\cdot D^{0,64}); \qquad (1.2.3.2.1.1.3.1\text{-}3)$$

$$fa_{i,3} = 0{,}60; \qquad (1.2.3.2.1.1.3.1\text{-}4)$$

i = sub-region considered;
L = ship length measured at the upper ice waterline, m;
x = distance from the forward perpendicular to station under consideration, m;
α = waterline angle, deg (refer to Fig. 1.2.3.2.1.1.1);
β' = normal frame angle, deg (refer to Fig. 1.2.3.2.1.1.1);
D = ship displacement, kt, not to be taken less than 5 kt;
CF_C = refer to Table 1.2.3.2.1;
CF_F = refer to Table 1.2.3.2.1;

.2 force F, MN:

$$F_i = fa_i\cdot CF_C\cdot D^{0,64} \qquad (1.2.3.2.1.1.3.2)$$

where i = sub-region considered;
fa_i = shape coefficient of sub-region i;
CF_C = refer to Table 1.2.3.2.1;
D = ship displacement, kt, not to be taken less than 5 kt;

.3 load patch aspect ratio AR:

$$AR_i = 7{,}46\cdot\sin(\beta'_i) \geqslant 1{,}3 \qquad (1.2.3.2.1.1.3.3)$$

where i = sub-region considered;
β'_i = normal frame angle of sub-region i, deg;

.4 line load Q, MN/m:

$$Q_i = F_i^{0,61} CF_D/AR_i^{0,35} \qquad (1.2.3.2.1.1.3.4)$$

where i = sub-region considered;
F_i = force of sub-region i, MN;
CF_D = refer to Table 1.2.3.2.1;
AR_i = load patch aspect ratio of sub-region i;

.5 pressure P, MPa:

$$P_i = F_i^{0,22} CF_D^{\,2} AR_i^{0,3} \qquad (1.2.3.2.1.1.3.5)$$

where i = sub-region considered;
F_i = force of sub-region i, MN;
CF_D = reefer to Table 1.2.3.2.1;
AR_i = load patch aspect ratio of sub-region i.

1.2.3.2.2 Hull areas other than the bow.

1.2.3.2.2.1 In the hull areas other than the bow, the force F_{NonBow} and line load Q_{NonBow} used in the determination of the load patch dimensions b_{NonBow}, w_{NonBow} and design pressure P_{avg} are determined as follows:

.1 force F_{NonBow}, MN:

$$F_{NonBow} = 0{,}36 CF_C DF \qquad (1.2.3.2.2.1.1)$$

where CF_C = refer to Table 1.2.3.2.1;
DF = ship displacement factor:
$DF = D^{0,64}$ при $D \le CF_{DIS}$;
$DF = CF_{DIS}^{0,64} + 0{,}10(D - CF_{DIS})$ при $D > CF_{DIS}$;
D = ship displacement, kt, not to be taken less than 10 kt;
CF_{DIS} = refer to Table 1.2.3.2.1;

.2 line load Q_{NonBow}, MN/m:

$$Q_{NonBow} = 0{,}639 F_{NonBow}^{0,61} CF_D \qquad (1.2.3.2.2.1.2)$$

where F_{NonBow} force from (1.2.3.2.2.1.1), MN;
CF_D = refer to Table 1.2.3.2.1.

1.2.3.3 Design load patch.

1.2.3.3.1 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} and height b_{Bow}, m, defined as follows:

$$w_{Bow} = F_{Bow}/Q_{Bow}; \qquad (1.2.3.3.1\text{-}1)$$

$$b_{Bow} = Q_{Bow}/P_{Bow} \qquad (1.2.3.3.1\text{-}2)$$

where F_{Bow} = maximum F_i in the bow area, MN;
Q_{Bow} = maximum Q_i in the bow area, MN/m;
P_{Bow} = maximum P_i in the bow area, MPa.

1.2.3.3.2 In hull areas other than those covered by 1.2.3.3.1, the design load patch has dimensions of width w_{NonBow} and height b_{NonBow}, m, defined as follows:

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

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

where F_{NonBow} = force determined using (1.2.3.2.2.1.1), MN;
Q_{NonBow} = line load determined using (1.2.3.2.2.1.2) MN/m.

1.2.3.4 Pressure within the design load patch.

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

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

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

1.2.3.5 Hull area factors.

1.2.3.5.1 Associated with each hull area is an area factor that reflects the relative magnitude of the load expected in that area. The area factor for each hull area is listed in Table 1.2.3.5.1.

1.2.3.5.2 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.

1.2.3.5.3 Due to their increased manoeuvrability, ships having propulsion arrangements with azimuthing thruster(s) or "podded" propellers shall have specially considered by the Register stern ice belt S_i and stern lower S_l hull area factors.

Table 1.2.3.4.2

Peak pressure factors

Structural member		Peak pressure factor (PPF_i)
Plating	Transversely-framed	$PPF_p = (1{,}8 - s) \geqslant 1{,}2$
	Longitudinally-framed	$PPF_p = (2{,}2 - 1{,}2\,s) \geqslant 1{,}5$
Frames in transverse	With load distributing stringers	$PPF_t = (1{,}6 - s) \geqslant 1{,}0$
	Framing systems with no load distributing stringers	$PPF_t = (1{,}8 - s) \geqslant 1{,}2$
Load carrying stringers Side and bottom longitudinals Web frames		$PPF_s = 1$, if $S_w \geqslant 0{,}5w$ $PPF_s = 2{,}0 - 2{,}0 \cdot S_w/w$, if $S_w < 0{,}5w$
where s = frame or longitudinal spacing, m; S_w = web frame spacing, m; w = ice load patch width, m.		

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*	1,00*
	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	**	**	**	**
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	**	**
* Refer to 1.2.3.1.3. ** Indicates that strengthening for ice loads is not necessary.									

1.2.4 Shell plate requirements.

1.2.4.1 The required minimum shell plate thickness t, mm, is given by:

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

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

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

In the case of transversely-framed plating ($\Omega \geqslant 70$ deg), including all bottom plating, i.e. plating in hull areas BI_b, M_b and S_b, the net thickness is given by:

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

where Ω = smallest angle between the chord of the waterline and the line of the first level framing as illustrated in Fig. 1.2.4.2, deg;
s = transverse frame spacing in transversely-framed ships or longitudinal frame spacing in longitudinally-framed ships, m;
AF = hull area factor from Table 1.2.3.5.1;
PPF_p = peak pressure factor from Table 1.2.3.4.2;
P_{avg} = average patch pressure according to (1.2.3.4.1), MPa;
σ_y = minimum upper yield stress of the material, N/mm^2;
b = height of design load patch, m, where $b \geqslant (l - s/4)$ in the case of (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, 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.

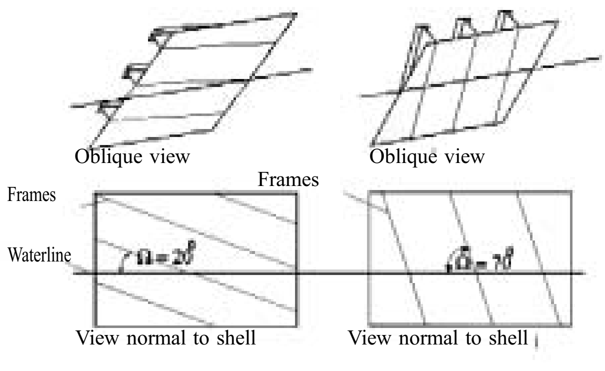


Fig. 1.2.4.2
Shell framing angle Ω

In the case of longitudinally-framed plating ($\Omega \leqslant 20$ deg), when $b \geqslant s$, the net thickness is given by:

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

In the case of longitudinally-framed plating ($\Omega \leqslant 20$ deg), when $b < s$, the net thickness is given by:

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

In the case of obliquely-framed plating (70 deg > Ω > 20 deg), linear interpolation shall be used.

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 areas of the hull exposed to ice pressure (refer to Fig. 1.2.2.1). Where load-distributing stringers have been fitted, the arrangement and scantlings of these shall be in accordance with the Register requirements.

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 details of framing member intersection with other framing members, including plated structures, as well as the details for securing the ends of framing members at supporting sections, shall be in accordance with the requirements of the Register.

1.2.5.5 The design span of a framing member shall be determined on the basis of its moulded length. If brackets are fitted, the design span may be reduced in accordance with the Register requirements. 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 (if fitted) 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, cm^2, of a framing member is given by:

$$A_w = ht_{wn}\sin\phi_w/100 \quad (1.2.5.7)$$

where h = height of stiffener, mm, refer to Fig. 1.2.5.7;
t_{wn} = net web thickness, mm;
$t_{wn} = t_w - t_c$;
t_w = as built web thickness, mm, refer to Fig. 1.2.5.7;
t_c = corrosion deduction, mm, to be subtracted from the web and flange thickness (according to 3.10.4.1, Part II "Hull", but not less than ts as required by 1. 2.11.3).
ϕ_w = smallest angle between shell plate and stiffener web, measured at the midspan of the stiffener, refer to Fig. 1.2.5.7. The angle ϕ_w may be taken as 90 deg provided the smallest angle is not less than 75 deg.

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, cm^3, is given by:

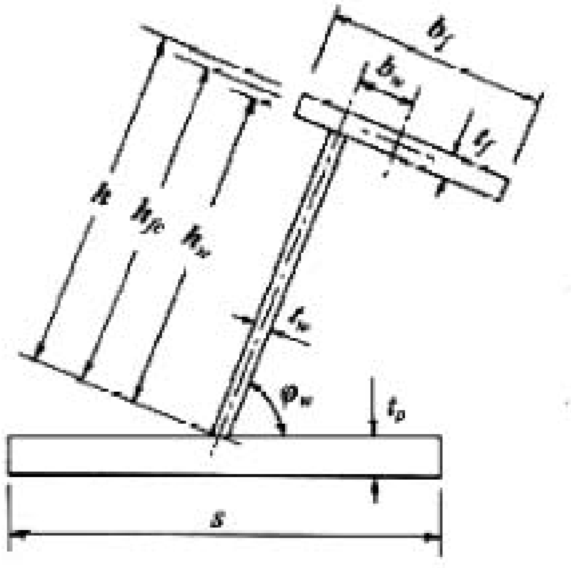


Fig. 1.2.5.7
Stiffener geometry

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

where h, t_{wn}, t_c, and ϕ_w are as given in 1.2.5.7 and s as given in 1.2.4.2;

A_{pn} = net cross-sectional area of attached plate, cm^2 (equal to $10t_{pn}s$, but not to be taken greater than the net cross-sectional area of the local frame);

t_{pn} = fitted net shell plate thickness, mm (shall comply with t_{net} as required by 1.2.4.2);

h_w = height of local frame web, mm, refer to Fig. 1.2.5.7;

A_{fn} = net cross-sectional area of local frame flange, cm^2;

h_{fc} = height of local frame measured to centre of the flange area, 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, 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 at a distance z_{na}, mm, above the attached shell plate, given by:

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

and the net effective plastic section modulus Z_p, cm^3, is given by:

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

1.2.5.9 In the case of oblique framing arrangement (70 deg > Ω > 20 deg, where Ω is defined as given in 1.2.4.2), linear interpolation shall be used.

1.2.6 Framing. Transversely-framed side structures and bottom structures.

1.2.6.1 The local frames in transversely-framed side structures and in bottom structures (i.e. hull areas BI_b, M_b and S_b) 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.

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

$$A_t = 100^2 \cdot 0{,}5LL \cdot s(AF \cdot PPF_t \cdot P_{avg})/(0{,}577\sigma y) \quad (1.2.6.2)$$

where LL = length of loaded portion of span = lesser of a and b, m;

a = frame span as defined in 1.2.5.5, m;

b = height of design ice load patch according to (1.2.3.3.1-2) or (1.2.3.3.2-2), m;

s = transverse frame spacing, m;

AF = refer to Table 1.2.3.5.1;

PPF_t = refer to Table 1.2.3.4.2;

P_{avg} = average pressure within load patch according to (1.2.3.4.1), MPa;

σ_y = minimum upper yield stress of the material, N/mm^2.

1.2.6.3 The actual net effective plastic section modulus of the plate/stiffener combination Z_p as defined in 1.2.5.8, shall comply with the following condition: $Z_p \geqslant Z_{pt}$, where Z_{pt}, cm^3, shall be the greater calculated on the basis of two load conditions:

.1 ice load acting at the midspan of the transverse frame; and

.2 the ice load acting near a support.

$$Z_{pt} = 100^3\, LL \cdot Y \cdot s(AF \cdot PPF_t \cdot P_{avg})a \cdot A_1/(4\sigma y) \quad (1.2.6.3.2)$$

where AF, PPF_t, P_{avg}, LL, b, s, a and σy are as given in 1.2.6.2;

$Y = 1 - 0{,}5(LL/a)$;

A_1 = maximum of:

$A_{1A} = 1/(1 + j/2 + k_w j/2[(1 - a_1^2)^{0,5} - 1])$;

$A_{1B} = (1 - 1/(2a_1 \cdot Y))/(0{,}275 + 1{,}44k_z^{0,7})$;

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, cm^2;

A_w = effective net shear area of transverse frame (calculated according to 1.2.5.7), cm^2;

$k_w = 1/(1+2A_{fn}/A_w)$, 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, cm^3;

$z_p = (b_f \cdot t_{fn}^2/4 + b_{eff} \cdot t_{pn}^2/4)/1000$;

b_f = flange breadth, mm, refer to Fig. 1.2.5.7;

t_{fn} = net flange thickness, mm;

$t_{fn} = t_f - t_c$ (t_c as given in 1.2.5.7);

t_f = as-built flange thickness, mm, refer to Fig. 1.2.5.7;

t_{pn} = the fitted net shell plate thickness, mm (not to be less than t_{net} as given in 1.2.4);

b_{eff} = effective width of shell plate flange, mm;

b_{eff} = 500s;

Z_p = net effective plastic section modulus of transverse frame (calculated according to 1.2.5.8), cm^3.

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

1.2.7 Framing. Side longitudinals (longitudinally-framed ships).

1.2.7.1 Side longitudinals 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 frame A_w as defined in 1.2.5.7, shall comply with the following condition: $A_w \geqslant A_L$, where:

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

where AF = refer to Table 1.2.3.5.1;
PPF_s = refer to Table 1.2.3.4.2;
P_{avg} = average pressure within load patch according to (1.2.3.4.1), MPa;
$b_1 = k_o b_2$, m;
$k_o = 1 - 0{,}3/b'$;
$b' = b/s$;
b = height of design ice load patch from (1.2.3.3.1-2) or (1.2.3.3.2-2), m;
s = spacing of longitudinal frames, m;
$b_2 = b(1-0{,}25b')$, m, if $b' < 2$;
$b_2 = s$, m, if $b' \geqslant 2$;
a = longitudinal design span as given in 1.2.5.5, m;
σ_y = minimum upper yield stress of the material, N/mm^2.

1.2.7.3 The actual net effective plastic section modulus of the plate/stiffener combination Z_p as defined in 1.2.5.8, shall comply with the following condition: $Z_p \geqslant Z_{pL}$, where:

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

where AF, PPF_s, P_{avg}, b_1, a and σ_y are as given in 1.2.7.2;
$A4 = 1/(2 + k_{wl}[(1-a_4^2)^{0,5} - 1])$;
$a_4 = A_L/A_w$;
A_L = minimum shear area for longitudinal as given in 1.2.7.2, cm^2;
A_w = net effective shear area of longitudinal (calculated according to 1.2.5.7), cm^2;
$k_{wl} = 1/(1+2A_{fn}/A_w)$, 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 limit state(s) defined by the Register. Where these members form part of a structural grillage system, appropriate methods of analysis shall be used. 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. Special attention shall be paid to the shear capacity in way of lightening holes and cutouts in way of intersecting members.

1.2.8.3 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 t_{wn} of any framing member shall not exceed:

for flat bar sections:

$$h_w / t_{wn} \leqslant 282/\sigma_y^{0,5}; \quad (1.2.9.1\text{-}1)$$

for bulb, tee and angle sections:

$$h_w / t_{wn} \leqslant 805/\sigma_y^{0,5} \quad (1.2.9.1\text{-}2)$$

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

1.2.9.2 Framing members for which it is not practicable to meet the requirements of 12.9.1 (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 t_{wn}, mm, is given by:

$$t_{wn} = 2{,}63 \cdot 10^{-3}(c_1\sigma_y/(5{,}34 + 4(c_1/c_2)^2))\hat{}(0{,}5) \quad (1.2.9.2)$$

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

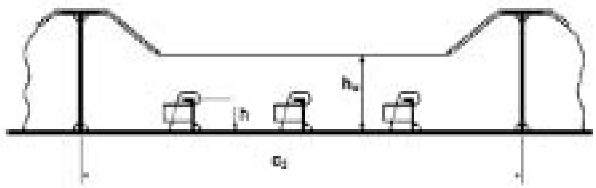


Fig. 1.2.9.2
Parameter definition for web stiffening

1.2.9.3 In addition, the following shall be satisfied:

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

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

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

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

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

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

where t_{fn} = net thickness of flange, mm;
σ_y = minimum upper yield stress of the material, 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 all polar ships.

1.2.11.2 The values of corrosion/abrasion additions t_s to be used in determining the shell plate thickness for each polar class are listed in Table 1.2.11.2.

Table 1.2.11.2

Corrosion/abrasion additions for shell plating

Hull area	t_s, 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**
Bow; bow intermediate ice belt	3,5	2,5	2,0	7,0	5,0	4,0
Bow intermediate lower; midbody and stern ice belt	2,5	2,0	2,0	5,0	4,0	3,0
Midbody and stern lower; bottom	2,0	2,0	2,0	4,0	3,0	2,5
Other areas	2,0	2,0	2,0	3,5	2,5	2,0

1.2.11.3 Polar 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 Plating materials for hull structures shall be not less than those given in Tables 1.2.12.4 and 1.2.12.5 based on the as-built thickness of the material, the polar ice class notation assigned to the ship and the material class of structural members given in Table 1.2.12.1.

1.2.12.2 Material classes specified in Table 1.2.3.7-1, Part II "Hull" are applicable to polar 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 shell plating of polar ships are given in Table 1.2.12.1. Where the material classes in Table 1.2.12.1 and those in Table 1.2.3.7-1, Part II "Hull" differ, the higher material class shall be applied.

1.2.12.3 Steel grades for all plating and attached framing of hull structures and appendages situated below the level of 0,3 m below the lower waterline, as shown in Figure 1.2.12.3, shall be obtained from Table 1.2.3.7-2, Part II "Hull" based on the material class for structural members in Table 1.2.12.1 above, regardless of polar class.

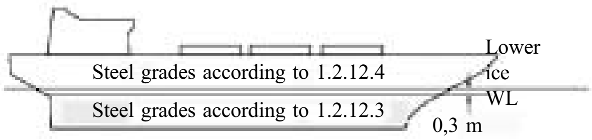


Fig. 1.2.12.3
Steel grade requirements for submerged and weather exposed shell plating

1.2.12.4 Steel grades for all weather exposed plating of hull structures and appendages situated above the level of 0,3 m below the lower ice waterline, as shown in Figure 1.2.12.3, shall be not less than given in Table 1.2.12.4.

1.2.12.5 Steel grades for all inboard framing members attached to weather exposed plating shall be not less than given in Table 1.2.12.5. This applies to all

Table 1.2.12.1

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, BIi)	II
All weather and sea exposed secondary and primary (as defined in Table 1.2.3.7-1, Part II "Hull") structural members outside 0,4*L* 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 0,2*L* from FP	II

Table 1.2.12.4

Steel grades for weather exposed plating

Thickness t, 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
$t \leqslant 10$	B	AH	B	AH	B	AH	B	AH	E	EH	E	EH	B	AH
$10 < t \leqslant 15$	B	AH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
$15 < t \leqslant 20$	D	DH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
$20 < t \leqslant 25$	D	DH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
$25 < t \leqslant 30$	D	DH	B	AH	E	EH2	D	DH	E	EH	E	EH	E	EH
$30 < t \leqslant 35$	D	DH	B	AH	E	EH	D	DH	E	EH	E	EH	E	EH
$35 < t \leqslant 40$	D	DH	D	DH	E	EH	D	DH	F	FH	E	EH	E	EH
$40 < t \leqslant 45$	E	EH	D	DH	E	EH	D	DH	F	FH	E	EH	E	EH
$45 < t \leqslant 50$	E	EH	D	DH	E	EH	D	DH	F	FH	F	FH	E	EH

Notes:

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.

Table 1.2.12.5

Steel grades for inboard framing members attached to weather exposed plating

Thickness t, mm	**PC1** to **PC5**		**PC6** and **PC7**	
	MS	HT	MS	HT
$t \leqslant 20$	B	AH	B	AH
$20 < t \leqslant 35$	D	DH	D	AH
$35 < t \leqslant 45$	D	DH	D	DH
$45 < t \leqslant 50$	E	EH	E	DH

inboard framing members as well as to other contiguous inboard members (e.g. bulkheads, decks) within 600 mm of the exposed plating.

1.2.12.6 Castings shall have specified properties consistent with the expected service temperature for the cast component.

1.2.13 Longitudinal strength.

1.2.13.1 Application.

1.2.13.1.1 Ice loads need only be combined with still water loads. The combined stresses shall be compared against permissible bending and shear stresses at different locations along the ship's length. In addition, sufficient local 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 $F_{IB,1} = 0{,}534 K_I^{0,15} \sin^{0,2}(\gamma_{stem})\,(DK_h)^{0,5} CF_L$; (1.2.13.2.1-2)

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

K_I = indentation parameter = K_f / K_h

.1 for the case of a blunt bow form:

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

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

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

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

CF_L = longitudinal strength class factor from Table 1.2.3.2.1;

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

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

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

e_b = 0 for a landing craft bow form;

an approximate e_b determined by a simple fit is acceptable;

γ_{stem} = stem angle to be measured between the horizontal axis and the stem tangent at the upper ice waterline, deg (buttock angle as per Fig. 1.2.3.2.1.1.1 measured on the centreline);

C = $1/(2(L_B/B)^{e_b})$;

B = ship moulded breadth, m;

L_B = bow length used in the equation $y = B/2(x/L_B)^{eb}$, m (refer to Figs 1.2.13.2.1-1 and 1.2.13.2.1-2);

D = ship displacement, kt, not to be taken less than 10 kt;

A_{wp} = ship waterplane area, m^2;

CF_F = flexural failure class factor from Table 1.2.3.2.1.

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

1.2.13.3 Design vertical shear force.

1.2.13.3.1 The design vertical ice shear force F_I, MN, along the hull girder shall be taken as:

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

where C_f = longitudinal distribution factor to be taken as follows:

.1 positive shear force:

C_f = 0,0 between the aft end of L and 0,6L from aft;

C_f = 1,0 between 0,9L from aft and the forward end of L;

.2 negative shear force:

C_f = 0,0 at the aft end of L;

C_f = −0,5 between 0,2L and 0,6L from aft;

C_f = 0,0 between 0,8L from aft and the forward end of L.

Intermediate values shall be determined by linear interpolation.

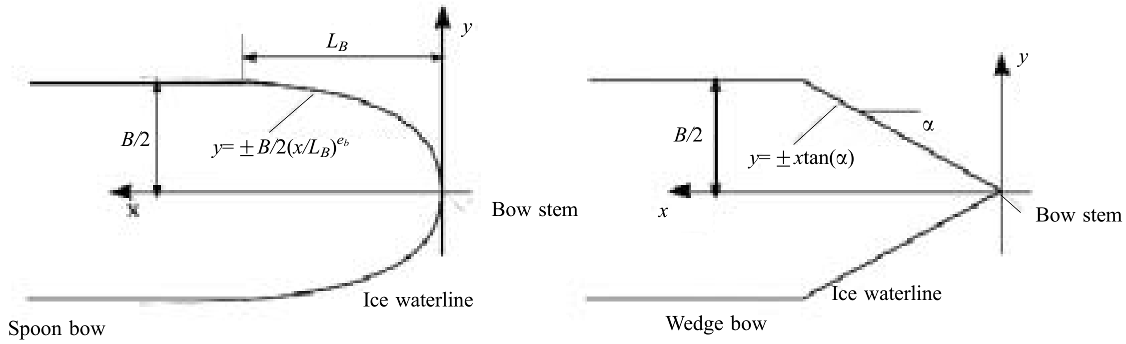


Fig. 1.2.13.2.1-1
Bow shape definition

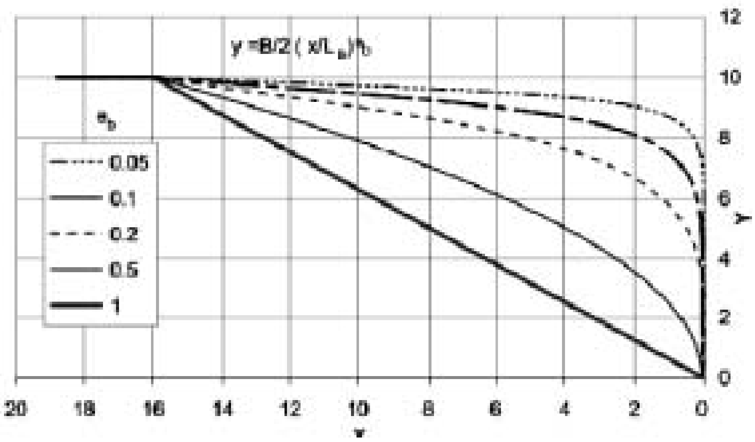


Fig. 1.2.13.2.1-2
Illustration of e_b effect on the bow shape for B = 20 and L_B = 16

1.2.13.3.2 The applied vertical shear stress τ_a shall be determined along the hull girder in a similar manner as in 1.6.5.1, Part II "Hull" by substituting the design vertical ice shear force for the design vertical wave shear force.

1.2.13.4 Design vertical ice bending moment.

1.2.13.4.1 The design vertical ice bending moment M_I, MNm, along the hull girder shall be taken as:

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

where L = ship length (length as defined in 1.1.3, Part II "Hull"), m;
γ_{stem} as given in 1.2.13.2.1;
F_{IB} = design vertical ice force at the bow, MN;
C_m = longitudinal distribution factor for design vertical ice bending moment to be taken as follows:
C_m = 0,0 at the aft end of L;
C_m = 1,0 between 0,5L and 0,7L from aft;
C_m = 0,3 at 0,95L from aft;
C_m = 0,0 at the forward end of L.

Intermediate values shall be determined by linear interpolation. Where applicable, draught dependent quantities shall be determined at the waterline corresponding to the loading condition under consideration.

1.2.13.4.2 The applied vertical bending stress σ_a shall be determined along the hull girder in a similar manner as in 1.6.5.1, Part II "Hull" by substituting the design vertical ice bending moment 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.

1.2.14 Stem and stern frames.

1.2.14.1 The stem and stern frame shall be designed according to the Register requirements. For **PC6** and **PC7** ships requiring **1AS** and **1A** equivalency, the stem and stern requirements of the Finnish-Swedish Ice Class Rules may need to be additionally considered.

1.2.15 Appendages.

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

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

1.2.16 Local details.

1.2.16.1 For the purpose of transferring ice-induced loads to supporting structure (bending moments and

Table 1.2.13.5.1

Longitudinal strength criteria

Failure mode	Applied stress	Permissible stress when $\sigma_y/\sigma_u \leqslant 0,7$	Permissible stress when $\sigma_y/\sigma_u > 0,7$
Tension	σ_a	$\eta\sigma_y$	$\eta 0,41(\sigma_u + \sigma_y)$
Shear	τ_a	$\eta\sigma_y/3^{0,5}$	$\eta 0,41(\sigma_u + \sigma_y)/3^{0,5}$
Buckling	σ_a	σ_c for plating and for web plating of stiffeners $\sigma_c/1,1$ for stiffeners	
	τ_a	τ_c	
where σ_a = applied vertical bending stress, N/mm^2; τ_a = applied vertical shear stress, N/mm^2; σ_y = minimum upper yield stress of the material, N/mm^2; σ_u = ultimate tensile strength of material, N/mm^2; σ_c = critical buckling stress in compression, according to 1.6.5.3, Part II "Hull", N/mm^2; τ_c = critical buckling stress in shear, according to 1.6.5.3, Part II "Hull", N/mm^2; η = 0,8.			

shear forces), local design details shall comply with the Register requirements.

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

1.2.17 Direct calculations.

1.2.17.1 Direct calculations shall not be utilised as an alternative to the analytical procedures prescribed in the present Chapter.

1.2.17.2 Where direct calculation is used to check the strength of structural systems, the load patch specified in 1.2.3 shall be applied.

1.2.18 Welding.

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

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

1.3 MACHINERY REQUIREMENTS FOR POLAR CLASS SHIPS

1.3.1 Application.

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

1.3.2 General.

1.3.2.1 Drawings and particulars to be submitted:

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

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

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

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

1.3.2.2 System design.

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

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

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

1.3.3 Materials.

1.3.3.1 Materials exposed to sea water.

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

Charpy V impact test shall be carried out for other than bronze and austenitic steel materials. Test pieces taken from the propeller castings shall be representative of the thickest section of the blade. An average impact energy value of 20 J taken from three Charpy V tests shall be obtained at minus 10 ºC.

1.3.3.2 Materials exposed to sea water temperature.

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

1.3.3.3 Material exposed to low air temperature.

Materials of essential components exposed to low air temperature shall be of steel or other approved ductile material. An average impact energy value of 20 J taken from three Charpy V tests shall be obtained at 10 ºC below the lowest design temperature.

1.3.4 Ice interaction load.

1.3.4.1 Propeller ice interaction.

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

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

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

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

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

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

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

1.3.4.2 Ice class factors.

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

Table 1.3.4.2

Ice class	H_{ice}, m	S_{ice}	S_{qice}
PC1	4,0	1,2	1,15
PC2	3,5	1,1	1,15
PC3	3,0	1,1	1,15
PC4	2,5	1,1	1,15
PC5	2,0	1,1	1,15
PC6	1,75	1	1
PC7	1,5	1	1

where H_{ice} = ice thickness for machinery strength design;
S_{ice} = ice strength index for blade ice force;
S_{qice} = ice strength index for blade ice torque.

1.3.4.3 Design ice loads for open propeller.

1.3.4.3.1 Maximum backward blade force F_b, kN:

when $D < D_{limit}$ —

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

when $D \geqslant D_{limit}$ —

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

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

n is the nominal rotational speed (at MCR free running condition) for CP-propeller and 85 per cent of the nominal rotational speed (at MCR free running condition) for a FP-propeller (regardless driving engine type).

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

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

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

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

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

1.3.4.3.2 Maximum forward blade force F_f, kN:

when $D < D_{limit}$ —

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

when $D \geqslant D_{limit}$ —

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

where

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

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

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

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

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

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

Refer to load cases 3, 4 and 5 in Table 1 of the Appendix.

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

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

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

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

1.3.4.3.4 Maximum propeller ice torque applied to the propeller $Q_{\max}$, kNm:

when $D < D_{limit}$ —

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

when $D \geqslant D_{limit}$ —

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

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

S_{qice} = ice strength index for blade ice torque;

$P_{0,7}$ = propeller pitch at 0,7R, m;

$t_{0,7}$ = max thickness at 0,7R, m;

n is the rotational propeller speed, rps, at bollard condition. If not known, n shall be taken according to Table 1.3.4.3.4:

Table 1.3.4.3.4

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

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

1.3.4.3.5 Maximum propeller ice thrust applied to the shaft:

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

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

1.3.4.4 Design ice loads for ducted propeller.

1.3.4.4.1 Maximum backward blade force F_b:

where $D < D_{limit}$ —

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

where $D \geqslant D_{limit}$ —

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

where D_{limit}=4H_{ice};

n shall be taken as in 1.3.4.3.1.

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

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

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

1.3.4.4.2 Maximum forward blade force F_f, kN:

when $D < D_{limit}$ —

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

when $D \geqslant D_{limit}$ —

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

where

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

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

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

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

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

when $D \leqslant D_{limit}$ —

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

when $D \geqslant D_{limit}$ —

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

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

n is the rotational propeller speed, rps, at bollard condition.

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

Таблица 1.3.4.4.3

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

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

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

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

Default value:

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

where $c_{0,7}$ the length of the blade section at 0,7R radius and F is either F_b or F_f which ever has the greater absolute value.

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

$$T_f = 1{,}1F_f; \qquad (1.3.4.4.5\text{-}1)$$

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

1.3.4.5 Reserved.

1.3.4.6 Design loads on propulsion line.

1.3.4.6.1 Torque.

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

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

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

C_q and α_i parameters are given in Table 1.3.4.6.1.

Table 1.3.4.6.1

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

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

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

The number of impacts is ZN_Q. Refer to Fig. 1 in the Appendix.

Milling torque sequence duration is not valid for pulling bow propellers, which are subject to special consideration by the Register.

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

Q_e = actual maximum engine torque at considered speed.

Design torque along propeller shaft line.

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

1.3.4.6.2 Maximum response thrust.

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

Maximum shaft thrust forwards, kN:

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

Maximum shaft thrust backwards, kN:

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

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

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

Table 1.3.4.6.2

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

1.3.4.6.3 Blade failure load for both open and nozzle propeller.

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

The blade failure load F_{ex}, kN, is:

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

where $\sigma_{ref} = 0{,}6\sigma_{0,2} + 0{,}4\sigma_u$;
σ_u and $\sigma_{0,2}$ are representative values for the blade material;
c, t and r are respectively the actual chord length, thickness and radius of the cylindrical root section of the blade at the weakest section outside root fillet, and typically will be at the termination of the fillet into the blade profile.

1.3.5 Design.

1.3.5.1 Design principle.

The strength of the propulsion line shall be designed:

for maximum loads in 1.3.4;

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

with sufficient fatigue strength.

1.3.5.2 Azimuthing main propulsors.

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

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

1.3.5.3 Blade design.

1.3.5.3.1 Maximum blade stresses.

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

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

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

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

where S = 1,5;
σ_{ref} = reference stress, defined as:
σ_{ref} = $0{,}7\sigma_u$ or (1.3.5.3.1-2)
σ_{ref} = $0{,}6\sigma_{0,2} + 0{,}4\sigma_u$, whichever is less, (1.3.5.3.1-3)
where σ_u and $\sigma_{0,2}$ = are representative values for the blade material.

1.3.5.3.2 Blade edge thickness.

The blade edge thicknesses t_{edge} and t_{ip} thickness ttip shall be greater than t_{edge} given by the following formula:

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

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

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

1.3.5.3.3 to **1.3.5.4.2** Reserved.

1.3.5.5 Reserved.

1.3.5.6 Prime movers.

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

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

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

1.3.6 Machinery fastening loading accelerations.

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

1.3.6.2 Longitudinal impact accelerations a_l.

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

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

1.3.6.3 Vertical acceleration a_v.

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

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

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

Intermediate values to be interpolated linearly.

1.3.6.4 Transverse impact acceleration a_t.

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

$$a_t = 3F_i\,F_x/\Delta \qquad (1.3.6.4)$$

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

Intermediate values to be interpolated linearly.
where ϕ = maximum friction angle between steel and ice, normally taken as 10 deg.;
γ = bow stem angle at waterline, deg.;
Δ = displacement;

L = length between perpendiculars, m;
H = distance from the waterline to the point being considered, m;
F_{IB} = vertical impact force, defined in 1.2.13.2.1;
F_i = total force normal to shell plating in the bow area due to oblique ice impact, defined in 1.2.3.2.1.

1.3.7 Auxiliary systems.

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

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

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

1.3.8 Sea inlets and cooling water systems.

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

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

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

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

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

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

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

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

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

1.3.9 Ballast tanks.

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

1.3.10 Ventilation system.

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

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

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

1.3.11 Reserved.

1.3.12 Alternative design.

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

APPENDIX

Table 1

Load cases for open propeller

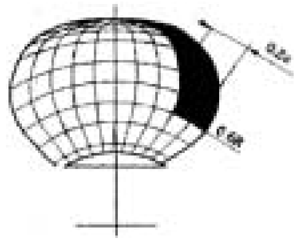
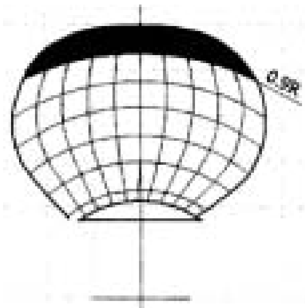
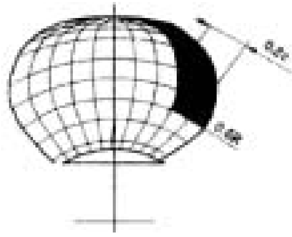
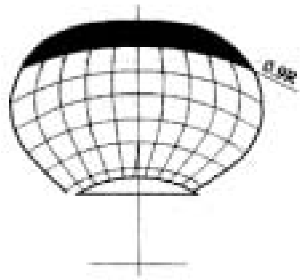
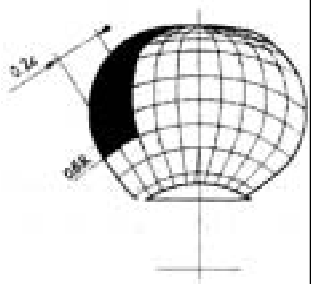
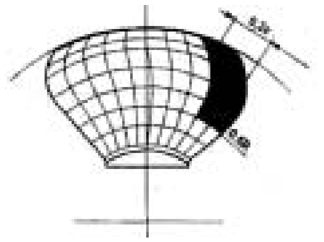
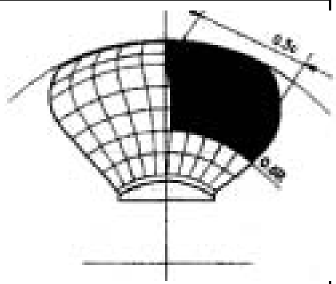
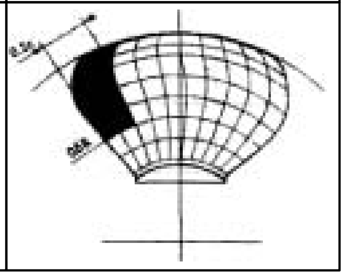
	Force	Loaded area	Right handed propeller blade seen from back
Load case 1	F_b	Uniform pressure applied on the back of the blade (suction side) to an area from 0,6R to the tip and from the leading edge to 0,2 times the chord length	
Load case 2	50 per cent of F_b	Uniform pressure applied on the back of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

Table 2

Load cases for ducted propeller

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

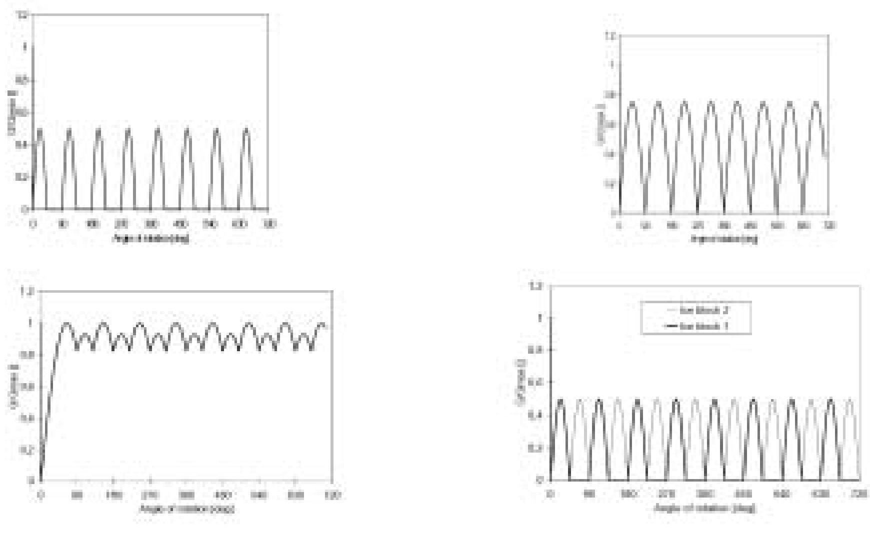


Fig. 1
The shape of the propeller ice torque excitation for 45, 90, 135 degrees single blade impact sequences and 45 degrees double blade impact sequence (two ice pieces) on a four bladed propeller

2 TECHNICAL REQUIREMENTS FOR ESCORT TUGS

2.1 GENERAL

2.1.1 Scope of application.

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

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

2.1.2 Definitions and explanations.

2.1.2.1 In the present Section the following definitions and explanations have been adopted.

Escort tug means the tug intended for escort service.

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

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

Escort characteristics:

maximum steering pull of the tug F_s, in t, at the escort test speed V, in knots, (refer to Fig. 2.1.2.1);

manoeuvring time t, in s.

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

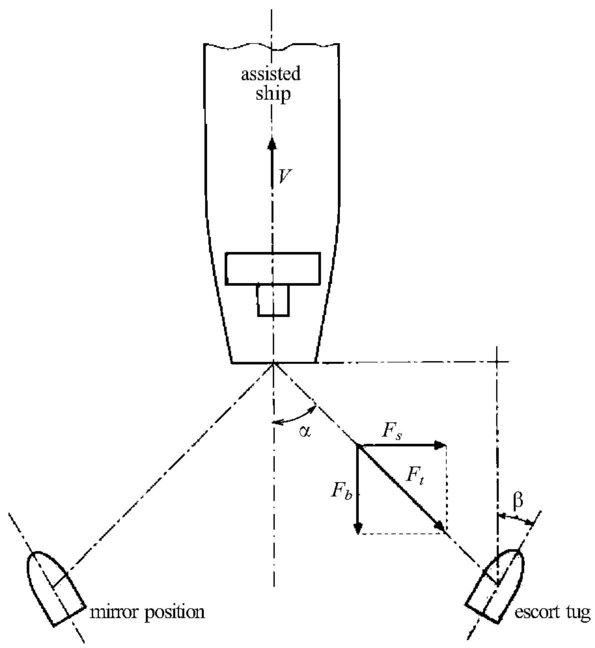


Fig. 2.1.2.1 Typical working mode of the escort tug
F_s = steering pull; F_b = braking force; F_t = towing line tension;
α = towing line angle; β = oblique angle;
V = speed of the assisted ship

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

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

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

2.1.3 Technical documentation.

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

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

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

.3 preliminary tug stability calculations for escorting service;

.4 plan of full scale trials.

2.2 TECHNICAL REQUIREMENTS

2.2.1 Arrangement and design.

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

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

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

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

2.2.2 Stability.

2.2.2.1 In addition to the requirements for tugs set forth in 3.7, Part IV "Stability", stability of the escort tug shall comply with the following criteria.

2.2.2.1.1 The ratio between the righting and heeling areas between equilibrium and 20° angle of heel obtained when the maximum steering pull F_s is applied from the tug (refer to Fig. 2.1.2.1) shall be not less than 1,25.

2.2.2.1.2 The ratio between the righting area and the heeling area due to the maximum steering pull between 0° heel and the angle of flooding or 40° angle of heel, whichever is less, shall be not less than 1,4.

2.2.2.1.3 The angle of heel of the escort tug under the effect of maximum working heeling moment, due to the towing line jerk under rolling shall not exceed the angle corresponding to the maximum of the righting lever curve θ_{max} or the angle of flooding θ_f, whichever is less.

The following requirement shall be complied with (refer to Fig. 2.2.2.1.3):

$$K_3 = \sqrt{\frac{b+c}{a+c}} \geqslant 1,0 \qquad (2.2.2.1.3\text{-}1)$$

where a = the area formed by the righting lever curve, the straight line corresponding to the lever $l + l_h$, and the angle of heel $\theta_1 - \theta_{2r}$;
b = the area formed from above by the righting lever curve, from below — by the straight line corresponding to the lever $l + l_h$, and from the right — by the angle corresponding to the maximum of the righting lever curve θ_{max} or the angle of flooding θ_f, whichever is less;
c = the area formed from the left by the righting lever curve, from above — by the straight line corresponding to the lever $l + l_h$, from the right — by the angle corresponding to the maximum of the righting lever curve θ_{max} or the angle of flooding θ_f whichever is less.

When determining the angle of flooding θ_f, the definition of the angle of flooding given in 1.2, Part IV "Stability" shall be considered.

The heeling lever l_h characterizing the effect of towing line jerk, in m, is determined by the formula

$$l_h = 0,2\left(1+2\frac{d}{B}\right)\frac{b^2}{(1+c^2)(1+c^2+b^2)}\frac{57,3}{(\theta_{2r} - \theta_1 + \theta_{lim})} \qquad (2.2.2.1.3\text{-}2)$$

where d, B = the draft and breadth of the tug respectively;
c, b are calculated in accordance with 3.7.2.2, Part IV "Stability";
θ_{lim} = θ_{max} or θ_f, whichever is less.

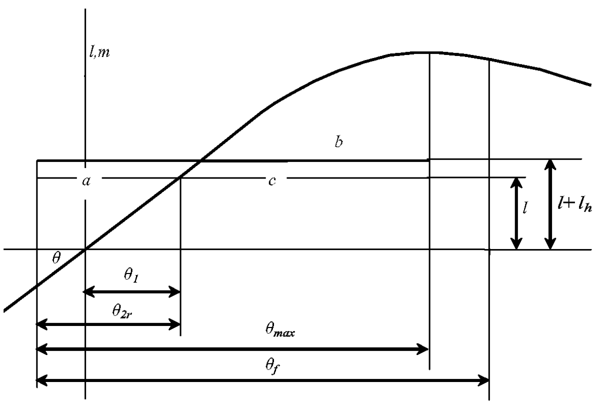


Fig. 2.2.2.1.3

2.2.2.1.4 The angle of dynamic heel of the tug which may occur during escort service in case of sudden failure of the main propulsion plant shall not exceed the angle corresponding to the maximum of the righting lever curve θ_{max} or the angle of flooding θ_f, whichever is less.

2.2.2.1.5 At the design stage, the value of the maximum steering pull and the angle of heel under its effect may be determined based on the model tests results or by means of calculations. On completion of the ship's construction, the values of the maximum steering pull and the maximum possible angle of heel of the tug shall be ascertained based on the results of full scale trials.

2.3 FULL SCALE TRIALS

2.3.1 Plan of full scale trials.

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

2.3.1.2 The plan of full scale trials shall stipulate determination of the tug's maximum transverse steering force at the speed of the assisted ship of 8 and/or 10 knots, the maximum angle of static heel at the specified modes, as well as the tug's manoeuvring time (refer to Fig. 2.1.2.1).

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

2.3.2 Procedure of trials.

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

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

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

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

.2 towing line tension;

.3 escort test speed;

.4 angle of the tug heel during escort service;

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

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

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

2.4 REPORTING

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

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

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

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

3.1 GENERAL

3.1.1 Scope of application.

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

.1 revised Annex I and Annex II of MARPOL 73/78 (IMO Resolutions MEPC.117(52) and MEPC.118(52)), Annexes IV, V, VI of MARPOL 73/78;

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

.3 provisions of the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004;

.4 Guidelines for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens (IMO Resolution A.868(20));

.5 Guidelines for On-Board Exhaust GAS-SO_x cleaning system (IMO Resolution MEPC.170(57));

.6 Code on Intact Stability for All Types of Ships Covered by IMO Instruments (IMO Resolution A.749(18));

.7 provisions of IACS Unified Requirement L5 "Onboard computers for stability calculations" (Rev. 1, Feb. 2005);

.8 IMO Guidelines on Ship Recycling, 2004 (IMO Resolution A.962(23));

.9 IMO Standards for Vapour Emission Control Systems (MSC/Circ.585);

.10 provisions of EU Directive 99/32/EC;

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

.12 Standard Specification for Shipboard Incinerators (IMO Resolution MEPC.76(40));

.13 revised Guidelines and Specifications for Pollution Prevention Equipment for Machinery Space Bilges of Ships (IMO Resolution MEPC.107(49));

.14 revised Guidelines and Specifications for Oil Discharge Monitoring and Control Systems for Oil Tankers (IMO Resolution MEPC.108(49)).

The requirements of the present 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.

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).

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

Bilge water means water accumulated in and subsequently removed from the ship's machinery spaces.

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

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 of MARPOL 73/78 when certified to carry a cargo or part cargo of noxious liquid substances.

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 water system filtering equipment.

Oily mixture means a mixture with any oil content.

Cargo residues mean any noxious liquid substance or oily mixture that remain for subsequent disposal.

Passenger ship means a ship that carries more than 12 passengers. A passenger is every person other than the master and the members of the crew or other persons employed or engaged in any capacity on board a ship on the business of that ship, and a child under one year of age.

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

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.

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

Regular service means a series of passenger ships voyages between the same two or more ports.

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.

Ballast water system means a system comprising tanks for ballast water and associated piping and pumping systems (combined cargo/ballast tanks are not considered in the present Section).

Sewage system means a system comprising the following equipment:

sewage holding tank; or

sewage holding tank and comminuter; or

sewage treatment plant;

discharge pipeline with pumps and standard discharge connections.

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

Ship at berth means a ship moored or anchored in port while loading, unloading or hosteling, including the time spent when not engaged in cargo operations.

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

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.

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.

3.2 CLASSIFICATION

3.2.1 Application.

The requirements of the present 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 the present 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 environmental pollution in case of emergency (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.

Requirements	Distinguishing marks in the class notation	
	ECO	ECO-S
Oil tankers of 600 t deadweight and over and other ships having an aggregate fuel oil tanks capacity of 600 m^3 and over, shall have prompt access to shore-based damage stability and residual structural strength computer calculation programs	×	×
Any ship shall have machinery installation automation class **AUT1** or **AUT2**	×	×
Any ship shall have onboard software to calculate intact trim, stability and strength and to calculate damage trim and stability, and special software for planning ballast water exchange at sea	×	×
Ships, having an aggregate fuel oil tanks capacity over than 600 m^3, shall have double hull and double bottom to protect fuel oil tanks in accordance with regulation 12A of Annex I of MARPOL 73/78.	×	×
Ships, having an individual fuel oil tank or oil residues tank capacity exceeding 30 m^3, shall have double bottom to protect such tanks with their arrangement in accordance with regulation 12A.6 of Annex I of MARPOL 73/78 even if an aggregate fuel oil tanks capacity is less than 600 m^3.	—	×
Any ship shall comply with the basic (main applicable) requirements of Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships regarding navigational equipment and systems, their arrangement on the navigating bridge and, in addition, shall be fitted with an automatic grounding avoidance system, and the information on the ship's manoeuvring characteristics shall be available on the navigating bridge.	—	×

3.2.3 Compliance with the requirements of the present Section shall be confirmed by surveys of ships, testing (checking) of software operation, relevant measurements and sampling, and compliance with the international instruments' requirements.

3.2.4 Assignment of the distinguishing marks in the class notation to oil tankers of less than 150 gross tonnage, to other ships of less than 400 gross tonnage and to floating facilities for oil storage and production is subject to special consideration by the Register in each particular case.

3.3 APPLICATION OF INTERNATIONAL INSTRUMENTS' REQUIREMENTS

3.3.1 The requirements of the present 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 the present 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.

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)
Oil/water interface detectors	IMO Resolution MEPC.5(XIII)
Shipboard incinerators	Regulation 16 of Annex VI of MARPOL 73/78, IMO Resolution MEPC.76(40)
Sewage treatment plants	IMO Resolution MEPC.2(VI), MEPC159(55)
Cargo vapour collection systems of oil tankers	Regulation 15 of Annex VI of MARPOL 73/78, MSC/CIRC.585
Marine diesel engines	Regulation 13 of Annex VI of MARPOL 73/78, NO_x Technical Code.
Exhaust gas cleaning systems to reduce the emission of sulphur oxides (SO_x)	Regulation 14 of Annex VI of MARPOL 73/78, IMO Resolution MEPC.170(57)

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

Required processes, specifications	International instrument
Sampling of fuel oil	IMO Resolution MEPC.96 (47), GOST 2517-85
Standard marine fuel oil	ISO 8217
Bunkering of ships	Regulation 18 of Annex VI of MARPOL 73/78, INTERTANKO Guide to Bunkering of Ships
Fuel oil sulphur content test	ISO 8754

3.4 REQUIRED DOCUMENTATION

3.4.1 Technical documentation and certificates required for assigning the distinguishing marks ECO and ECO-S in the class notation:

.1 International Air Pollution Prevention (IAPP) Certificate;

.2 Engine International Air Pollution Prevention (EIAPP) Certificate;

.3 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;

.4 SO_x Emission Control Area Compliance Certificate (SCC);

.5 Exhaust Gas Cleaning System — SO_x Technical Manual (ETM);

.6 International Sewage Pollution Prevention Certificate;

.7 Certificate of Compliance of Equipment and Arrangements of the Ship with the Requirements of Annex V of MARPOL 73/78;

.8 Certificate of Compliance with the International Convention on the Control of Harmful Anti-fouling Systems on Ships, 2001;

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

.10 approved documentation confirming compliance of the ship with the requirements for protective location of fuel oil tanks as defined in the regulation 12A of Annex I of MARPOL 73/78 (refer to 3.5.3.10.4 to 3.5.3.10.6 and 3.6.3.10.2);

.11 approved documentation on the ship's fuel oil system confirming possibility of ready change over to fuel oil with a sulphur content of less than 1,5 per cent or 0,1 per cent when approaching SO_x emission control areas established under Annex VI of MARPOL 73/78 or EU Directive 99/32/EC accordingly;

.12 Statement of Compliance to IMO Resolution on Ship Recycling "Green Passport".

3.4.2 Approved operating procedures for assigning the distinguishing marks ECO and ECO-S in the class notation:

.1 approved On-Board Monitoring Manual (OMM);

.2 approved SECA Compliance Plan (SCP);

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

.4 approved Fuel Oil Management Plan, Fuel Oil Record Book;

.5 approved ship's Ballast Water Management Plan, Ballast Water Handling Log, approved special software for ballast exchange at sea;

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

.7 approved Shipboard Oil Pollution Emergency Plan or Shipboard Marine Pollution Emergency Plan (for Oil and Noxious Liquid Substances) keeping due note of regulation 37.4, Annex I of 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 of MARPOL 73/78);

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

.9 refrigerating operations management procedure;

.10 approved Sewage Management Plan; Sewage Record Book;

.11 Record Book of Detection of Lubricating Oil and Hydraulic Oil Operating Leakages onto Seawater Surface.

3.4.3 Ship's technical documentation for assigning the distinguishing marks ECO and ECO-S in the class notation:

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

.2 fuel oil system diagram including drawings of SO_x emission control arrangements and systems, if applicable;

.3 drawings of any exhaust gas cleaning systems, which shall be approved in accordance with the IMO Guidelines;

.4 refrigerating systems diagrams, list of refrigerants used;

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

.6 incinerator systems diagrams;

.7 diagrams of manifolds in cargo and non-cargo areas including trays and appliances for prevention of oil spill;

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

.9 diagrams and drawings of the equipment for the prevention of pollution by garbage;

.10 sewage system diagram.

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

3.5.1 Introduction.

3.5.1.1 The provisions of the present 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 and ballast 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 of MARPOL 73/78, as well as EU Directive 99/32/EC 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 Plan of Compliance with the SO_x Emission Control Area (SCP) shall be readily available in all ships using exhaust gas cleaning systems to reduce SO_x emission to confirm compliance with the requirements of regulation 14(4)(b) of Annex VI of MARPOL 73/78.

This Plan shall list all ship's plants for burning fuel oil, which comply with the operating requirements in SO_x emission control areas 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 administration 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 of MARPOL 73/78, i.e. sulphur content in the supplied fuel oil complies with the applicable requirements and there are no inorganic acids and chemical wastes in this fuel oil.

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

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

In order to fulfill the requirements of IMO Resolution MEPC.96(47) 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).

3.5.2.1.6 The ship shall have a valid International Air Pollution Prevention (IAPP) Certificate in accordance with Annex VI of MARPOL 73/78.

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 more than 130 kW except engines that are part of any equipment used in emergency solely and engines on lifeboats.

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

3.5.2.2.3 If NO_x emission is monitored on ships by means of devices fitted in fuel oil or exhaust gas systems or in addition to them, then such systems shall be operated and controlled in accordance with procedures including manufacturers' manuals and shall be approved by the Register or other classification society.

3.5.2.2.4 Appropriate international 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 Annex VI of MARPOL 73/78.

3.5.2.2.5 If the exhaust gas cleaning system is used to reduce NO_x emission, the engine and the above system for which it is installed are treated as a single whole. The exhaust gas cleaning system to reduce NO_x emission shall be of approved design.

3.5.2.2.6 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 performed to assign class notation shall be documented in accordance with the requirements of the Register or other classification society.

3.5.2.2.7 Compliance with SO_x emission restrictions is mainly achieved by use of low-sulphur content fuel oil. Alternatively, an exhaust gas cleaning system may be used to reduce SO_x emission to attain the required level of SO_x emission. The maximum sulphur content in fuel oil supplied to the ship is 3,5 per cent. In case of alternative use of exhaust gas cleaning system the total quantity of SO_x emission shall not exceed 14 g SO_x/kW h.

3.5.2.2.8 If a ship operates in SO_x emission control area (including ports) the sulphur content in fuel oil shall not exceed 1,5 per cent. Transition from one type of fuel oil to another while coming in and out of the port or while coming in and out of the SO_x emission control area specified in Annex VI of MARPOL 73/78 shall be registered in the ship's log. In case of alternative use of exhaust gas cleaning system the total quantity of SO_x emission shall not exceed 6 g SO_x/KW h.

3.5.2.2.9 If a ship stays in EU ports the allowed maximum of sulphur content in fuel oil is 0,1 per cent. Transition from one type of fuel oil to another while mooring or anchoring in the EU ports shall be registered in the ship's log. In case of alternative use of exhaust gas cleaning system the total quantity of SO_x emission shall not exceed 0,4 g SO_x/KW h.

3.5.2.2.10 If a passenger ship is engaged in regular voyages to or from EU/EEC ports the maximum sulphur content in fuel oil shall not exceed 1,5 per cent. Transition from one type of fuel oil to another while coming in and out of EU territorial waters shall be registered in the ship's log. In case of alternative use of exhaust gas cleaning system the total quantity of SO_x emission shall not exceed 6 g SO_x/KW h.

3.5.2.2.11 For engines fitted with the exhaust gas cleaning systems to reduce SO_x emission, the compliance with SOx emission norms specified in the Guidelines for On-Board Exhaust GAS-SO_x Cleaning System (IMO Resolution MEPC.170(57)) shall be confirmed during survey by the Register or other classification society.

3.5.2.3 Prevention of pollution by emission from oil-fired boilers and inert gas generators.

3.5.2.3.1 Compliance with restrictions of SO_x emission from oil-fired boilers and inert gas generators is mainly achieved by use of low-sulphur content fuel oil with sulphur content complying with 3.5.2.2.7 to 3.5.2.2.10.

3.5.2.3.2 Alternatively, an exhaust gas cleaning system may be used to reduce SO_x emission to reach the required level of SO_x emission. The use of such system is subject to special consideration by the Register in each particular case.

3.5.2.4 Prevention of pollution by refrigerant emission.

3.5.2.4.1 Provisions of the present Requirements on refrigerant emission are applied to cargo refrigerating plants, air conditioning plants and refrigerating systems of all ships.

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

3.5.2.4.2 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).

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

The following substances may be used as refrigerants onboard:

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

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

3.5.2.4.4 Annual leaks of refrigerant shall be as small as possible; meanwhile, their quantity shall be not more than 10 per cent of the total quantity of a refrigerant in each system. The fact of leaks and quantity shall be documented. Meanwhile, conditions of the system recovery after leaks as well renewal of refrigerant during repair or overhauls as well as during the process of refrigerant regeneration shall be specified.

If leaks occur it is necessary to perform the corrective actions in accordance with the Refrigerant Management Procedure set forth in 3.5.2.4.8. Corrective actions shall be performed before the quantity of a leak reaches 10 per cent of the total quantity of refrigerant in each system.

3.5.2.4.5 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.

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

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

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

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

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

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

3.5.2.4.8 Refrigerant Management Procedure shall be used to control presence of leaks which shall describe as a minimum the following issues:

operating refrigerating plants to prevent/minimize possible leaks;

periodicity of inspection of refrigerating plants aimed at finding leaks;

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

3.5.2.5 Prevention of pollution by fire extinguishing media emission.

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

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

3.5.2.6 Prevention of pollution by volatile organic compounds emission.

3.5.2.6.1 In order to prevent emission of volatile organic compounds (VOC) from oil tankers carrying crude oil, petroleum products or chemical cargoes with flashpoint < 60 °C, standards for cargo vapour discharge systems shall be applied according to MSC/Circ.585.

3.5.2.6.2 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-sped or vacuum valve etc.

3.5.2.6.3 In addition 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 MSC/Circ.585.

3.5.2.7 Prevention of air pollution by emission from shipboard incinerators.

3.5.2.7.1 Shipboard incinerators shall be type-approved in accordance with IMO Resolution MEPC.76(40).

3.5.2.7.2 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.

3.5.2.7.3 The Certificate of Compliance of Equipment and Arrangements of the Ship with the Requirements of Annex V of MARPOL 73/78, as well as the Appendix to the International Air Pollution Prevention (IAPP) Certificate shall contain notes on shipboard incinerator corresponding to IMO Resolution MEPC.76(40).

3.5.2.7.4 Operation of incinerators shall be in accordance with regulation 16 of Annex VI of MARPOL 73/78 and the approved Garbage Management Plan, and be recorded in the Garbage Record Book specified in regulations 9(2) and 9(3) of Annex V of MARPOL 73/78, respectively.

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 to 3.4.

3.5.3.2 Discharge of cargo residues.

3.5.3.2.1 Discharge criteria for cargo residues 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, as well as discharge of bilge water from machinery spaces of any ship shall be carried out by the system of automatic measuring, record and control of discharge of ballast and washing water, as well as filtering equipment for discharge of bilge water, respectively. Discharge criteria shall be in compliance with Annex I of 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 of MARPOL 73/78. Discharge of contaminated water to sea shall be carried out by means specified in Annex II of 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 Means and arrangements for prevention of oil spills during cargo operations and oil bunkering.

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

3.5.3.3.2 Gutter plates on both sides of the cargo deck shall be increased in height from a point 0,2*L* forward of amidships to a termination at the aft end of the cargo deck with the minimum heights given in the following table:

Cargo deck gutter plates, minimum heights		
Ships of 100000 t deadweight and over	0,2*L* forward of amidships	0,25 m
	Aft end of cargo deck	0,40 m
Ships of less than 100000 t deadweight	0,2*L* forward of amidships	0,10 m
	Aft end of cargo deck	0,25 m

To avoid cargo flowing around the accommodation/ poop deck, transverse gutter plates shall be fitted at the aft end of the cargo area. These plates shall have the same height as the aft longitudinal gutter plates.

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 deck scupper system for collection of the spilled cargo with its accumulation in the holding tank or a slop tank. The deck scupper system may be arranged either with a manually operated valve or with automatic scuppers.

The drainage shall be used during cargo operations where cargo spills may occur, and shall not be used under normal conditions when at sea. When at sea, deck scupper system shall preclude free surface effect with negative impact on the ship's stability.

3.5.3.3.4 On oil tankers, chemical tankers and NLS tankers all cargo manifolds shall be fitted with spill trays with arrangements for spills collection to the tank.

The trays shall have the following minimum dimensions:

length — beyond forward and aft ends of the manifold;

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

minimum depth — 0,3 m.

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

3.5.3.3.6 Oil tankers, chemical tankers and NLS tankers shall be fitted with a closed sounding system with high and maximum level alarms. 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 Bunkering stations, vent and overflow pipes and other areas where petroleum products spills may occur shall be fitted with spill trays to prevent their escape to sea. Capacity: 80 l for ships of 300 to 1600 gross tonnage; 160 l for ships of 1600 gross tonnage and above.

3.5.3.4 Ballast water management.

3.5.3.4.1 Ballast water management is aimed at minimizing or prevention of transport of harmful aquatic organisms and pathogens from one geographical area to another. For this purpose the special means of ballast water handling or in-time exchange at sea specified in the IMO Resolution A.868(20) or in the International Convention for the Control and Management of Ship's Ballast Water and Sediments, 2004, shall be provided onboard.

3.5.3.4.2 All ships where the method of ballast water exchange at sea is used for ballast water management, shall be provided with the Ballast Water Management Plan according to requirements of 1.4.11.5, Part IV "Stability" and the Instruction for the Development of Ballast Water Management Plans developed for each ship and approved by the Register.

If the planning of ballast water exchange by the crew is provided for, the ship shall be additionally provided with special software programs for ballast water exchange planning.

3.5.3.4.3 Ballast system used during ballast water exchange at sea shall comply with requirements of 8.7, Part VIII "Systems and Piping".

3.5.3.5 Prevention of pollution by bilge water discharge.

3.5.3.5.1 Bilge water discharge requirements apply to all ships according to regulations 4, 14, 15 and 34 of Annex I of MARPOL 73/78.

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

3.5.3.6 Prevention of pollution by garbage.

3.5.3.6.1 Garbage disposal requirements apply to all ships according to regulations 3 to 6 and 9 of Annex V of MARPOL 73/78.

3.5.3.6.2 A procedure for garbage sorting and volume reducing shall be available onboard in addition to Garbage Management Plan required by regulation 9 of Annex V of MARPOL 73/78.

3.5.3.7 Prevention of pollution by sewage.

3.5.3.7.1 All ships shall have a valid International Sewage Pollution Prevention Certificate.

3.5.3.7.2 All ships shall as a minimum be fitted with a sewage comminution and disinfection system approved by the Administration, and a sewage holding tank of sufficient capacity with visual and audible alarm operating in case of 80 per cent filling of the tank.

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

3.5.3.7.4 All ships shall be provided with calculations of the rate of discharge of untreated sewage approved by the Register. These calculations shall be drawn up according to Recommendation on Standards for the Rate of Discharge of Untreated Sewage from Ships (refer to IMO Resolution MEPC.157(55)).

Where a ship shall discharge sewage from a holding tank using a pump with a fixed delivery, the pump can either be calibrated at the rate permitted at 4 knots, or calibrated for a specific minimum ship's speed in excess of 4 knots.

In case of pump with a variable delivery the rate of discharge may be increased up to maximum permissible discharge rate which corresponds to the ship's maximum summer draught and maximum service speed by increasing of pump delivery provided the ship's speed corresponds to the maximum rate of discharge.

3.5.3.7.5 All sewage discharges, whether to sea or to shore-based reception facilities shall be recorded in the appropriate record book 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 miles) at the moment of discharge.

3.5.3.8 Monitoring of harmful antifouling systems.

3.5.3.8.1 Harmful antifouling systems shall be monitored in all ships.

3.5.3.8.2 The ship shall have the Statement of Compliance with International Convention on the Control of Harmful Antifouling Systems, 2001.

3.5.3.8.3 Antifouling coatings containing TBT (Tributyltin) as the active ingredient are not permitted.

3.5.3.9 Prevention of lubricating oil and hydraulic oil operating leakages into seawater.

3.5.3.9.1 Lubricating oil and hydraulic oil operating leakages into seawater are possible if the following equipment is provided:

oil-lubricated stern tube bearings and sealing arrangements;

rudder bearings;

sea water cooled engines;

hydraulic systems.

3.5.3.9.2 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.

3.5.3.9.3 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").

3.5.3.10 Prevention of pollution in case of the hull damage.

3.5.3.10.1 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 of MARPOL 73/78.

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

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

3.5.3.10.4 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 of MARPOL 73/78.

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

3.5.3.10.6 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. 3.5.3.10.6).

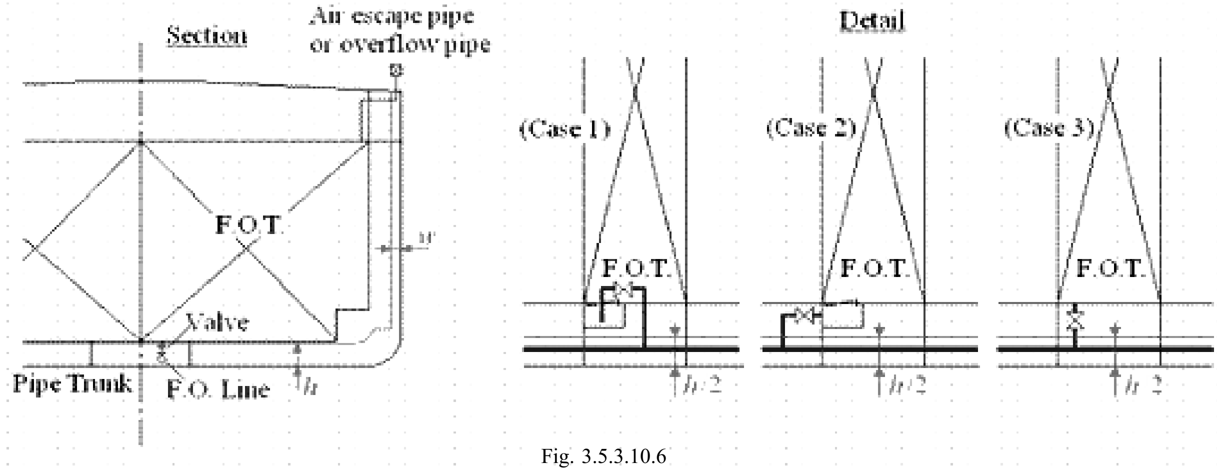


Fig. 3.5.3.10.6

3.5.4 Prevention of pollution from ship recycling.

3.5.4.1 All ships shall have a Statement of Compliance to IMO Resolution on Ship Recycling "Green Passport" (Form 2.4.8) with Supplement (Form 2.4.8-1) according to the Guidelines on Ship Recycling (refer to IMO Resolution A.962(23)), with additions or amendments thereto currently adopted.

3.5.4.2 The above Statement with Supplement shall be permanently available on board throughout the ship's operating life. The shipowner shall continuously update the Supplement and include thereto all major ship's structure and equipment changes to maintain the information of the Supplement (Form 2.4.8-1) actual.

3.5.5 Environmental responsibilities.

All ships shall have a responsible environmental officer onboard.

This officer shall be responsible for the following:

checking the compliance with the environment pollution prevention requirements;

monitoring the implementation of the relevant procedures;

maintaining the relevant ships' logs;

education and training of personnel in the relevant environmental practices.

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

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

3.6.1 Introduction.

3.6.1.1 The provisions of the present 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, antifouling systems and ballast 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.

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 to 3.4.

3.6.2.1.2 Fuel oil to be used onboard shall comply with the requirements of 3.5.2.2.7 to 3.5.2.2.10 and 3.6.2.2.4.

3.6.2.2 Prevention of pollution by emission from marine diesel engines.

3.6.2.2.1 NO_x emission restrictions are applied to engines permanently fitted onboard of power more than 130 kW except engines that are part of any equipment used in emergency solely and engines on lifeboats.

3.6.2.2.2 Level of emission from engines on all ships shall not exceed the following maximum values proceeding from nominal r.p.m. of engines:

13,3 g/Kw h when $n < 130$ r.p.m.;

$(31{,}5\ n^{(-0{,}2)} + 1{,}4)$g/Kw h when $n \geqslant 130$ r.p.m.

3.6.2.2.3 The exhaust gas cleaning system to reduce NO_x emission (if fitted) shall comply with the requirements of 3.5.2.2.

3.6.2.2.4 If a ship operates in SO_x emission control area (including ports) the sulphur content in fuel oil shall not exceed 0,5 per cent. Transition from one type of fuel oil to another while coming in and out of the port or while coming in and out of the SO_x emission control area specified in Annex VI of MARPOL 73/78 shall be registered in the ship's log. In case of alternative use of exhaust gas cleaning system the total quantity of SO_x emission shall not exceed 2,0 g SO_x/KW h.

3.6.2.2.5 For 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.170(57)) shall be confirmed during survey by the Register or other classification society.

3.6.2.3 Prevention of pollution by emission from oil-fired boilers and inert gas generators.

3.6.2.3.1 Compliance with restrictions of SO_x emission from oil-fired boilers and inert gas generators is mainly achieved by use of low-sulphur content fuel oil with sulphur content complying with 3.6.2.2.4 to 3.6.2.2.5.

3.6.2.3.2 Alternatively, an exhaust gas cleaning system may be used to reduce SO_x emission to reach the required level of SO_x emission. The use of such system is subject to special consideration by the Register in each particular case.

3.6.2.4 Prevention of pollution by refrigerant emission.

3.6.2.4.1 The requirements for refrigerant emission shall comply with the requirements of 3.5.2.4.

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

3.6.2.4.2 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.

3.6.2.4.3 Structural and operational requirements shall comply with 3.5.2.4.4 to 3.5.2.4.8.

3.6.2.5 Prevention of pollution by fire extinguishing media emission.

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

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

3.6.2.6 Prevention of pollution by volatile organic compounds emission.

In order to prevent emission of volatile organic compounds (VOC) from oil tankers carrying crude oil, petroleum products or chemical cargoes with flashpoint < 60 °C, the requirements of 3.5.2.6 shall be applied.

3.6.2.7 Prevention of air pollution by emission from shipboard incinerators.

Shipboard incinerator shall comply with the requirements of 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 to 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 of MARPOL 73/78. Discharge of contaminated water to sea shall be carried out by means specified in Annex II of MARPOL 73/78.

3.6.3.2.3 Segregated ballast tanks arranged and designed in compliance with 3.5.3.1 are mandatory for oil tankers and chemical tankers. 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.

3.6.3.3 Means and arrangements for prevention of oil spills during cargo operations and oil bunkering.

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

3.6.3.3.2 To collect possible oil spills during cargo operations the main deck in the cargo area shall be fitted with a deck scupper system for collection of the spilled cargo according to 3.5.3.3.4.

3.6.3.3.3 On oil tankers, chemical tankers and NLS tankers all cargo manifolds shall be fitted with spill trays with arrangements for spills collection to the tank 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 Spill trays to collect petroleum products in case of overflow and spillage during bunkering shall be fitted with the closed system for collecting petroleum products to the holding tank or slop tank.

3.6.3.4 Ballast water management.

The requirements of 3.5.3.4 are applicable.

3.6.3.5 Prevention of pollution by bilge water discharge.

3.6.3.5.1 Bilge water discharge requirements apply to all ships according to regulations 4, 14, 15 and 34 of Annex I of MARPOL 73/78.

3.6.3.5.2 The maximum oil content at the outlet of bilge separators fitted onboard shall be 5 ppm.

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

3.6.3.5.4 Each ship shall be fitted with the bilge water holding tank of sufficient capacity agreed with the Register for bilge water disposal to reception facilities. Bilge water shall be collected to the above holding tank from all bilge wells of machinery spaces.

3.6.3.6 Prevention of pollution by garbage.

3.6.3.6.1 Prevention of pollution by garbage shall comply with the requirements of 3.5.3.6.

3.6.3.6.2 The ship shall be equipped with arrangements for garbage sorting, collection and storage prior to incineration or disposal to shore reception facilities.

3.6.3.6.3 Ships having the descriptive notation "**Passenger ship**" in the class notation shall not discharge any waste to sea except for food waste having passed through a comminuter where permitted by international and local legislation. The ship shall have sufficient capacity for garbage collection and storage to allow 100 per cent garbage disposal to shore reception facilities, or be capable to incinerate the accumulated garbage where permitted.

3.6.3.7 Prevention of pollution by sewage.

3.6.3.7.1 Prevention of pollution by sewage shall be in accordance with 3.5.3.7 and 3.6.3.7.2 to 3.6.3.7.3.

3.6.3.7.2 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 with visual and audible alarm operating in case of 80 per cent filling of the tank.

3.6.3.7.3 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").

3.6.3.8 Monitoring of harmful antifouling systems.

The requirements of 3.5.3.8 are applicable.

3.6.3.9 Prevention of lubricating oil and hydraulics oil operating leakages into seawater.

The requirements of 3.5.3.9 are applicable.

3.6.3.10 Prevention of pollution in case of the hull damage.

3.6.3.10.1 The requirements of 3.5.3.10 are applicable considering the requirements of 3.6.3.10.2.

3.6.3.10.2 Ships having individual fuel oil tank or oil residues tank capacity exceeding 30 m^3 shall have double bottom to protect fuel oil tanks and oil residues tanks located in accordance with regulation 12A.6 of Annex I of MARPOL 73/78, even if the aggregate capacity of fuel oil tanks is less than 600 m^3.

3.6.4 Ship operation requirements.

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

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

two- and multi-shaft propulsion plants;

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

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

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

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

thrusters in case of main steering gear damage.

The alternative means to preserve the ship manoeuvrability is subject to special consideration by the Register in each particular case.

3.6.5 Prevention of pollution from ship recycling.

The requirements of 3.5.4 are applicable.

3.6.6 Environmental responsibilities.

The requirements of 3.5.5 are applicable.

3.7 RECORDS

3.7.1 As a result of applying the requirements of the present Section, the following records will 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 in compliance with the distinguishing mark **ANTI-ICE** in the class notation apply to ships the design and equipment of which provide effective icing protection. These requirements are additional to the requirements of Part I "Classification", Part III "Equipment, Arrangements and Outfit", Part VIII "Systems and Piping" and Part XI "Electrical Equipment" of the Rules for the Classification and Construction of Sea-Going Ships, as well as Part II "Life-Saving Appliances", Part III "Signal Means", Part IV "Radio Equipment" and Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships.

4.1.1.2 Ships complying with the requirements of the present Section may be assigned the distinguishing mark **ANTI-ICE** in the class notation.

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.

4.1.2.1 The following definitions and explanations have been adopted in the present Section.

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

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

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

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 arrangement plan of anti-icing means with indication of their heating capacity;

.2 calculation of heating capacity of anti-icing systems equipment;

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

.4 circuit diagram of steam and/or thermal liquids anti-icing systems (if any);

.5 arrangement diagram of de-icing means;

.6 test program for anti-icing systems.

4.1.3.2 The following documents approved by the Register shall be kept onboard:

.1 Icing Protection Manual;

.2 Information on Stability including loading cases 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 sufficient sheer to provide effective water flow under all operating loading cases.

Assignment of the distinguishing mark **ANTI-ICE** in the class notation to flush deck ships is subject to special consideration by the Register.

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.

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 (AIL);

.3 manual mechanical means including pneumatic instrument.

4.2.1.4 The use of alternative de-icing means (inflatable elastic tanks, ultrasonic and impulse means, de-icing coatings etc.) is subject to special consideration by the Register.

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

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

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

4.2.2 Stability and subdivision.

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

4.2.3 Equipment, arrangements and outfit.

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

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

4.2.3.3 Coamings of outer doors leading to the accomodation superstructure spaces and to spaces providing the ship's operation in accordance with its main purpose 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 accomodation 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 Application of anti-icing means to the perched fore structures (masts, foundations of cargo-handling gear, etc.) is subject to special consideration by the Register.

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

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

4.2.3.7 Shell doors, cargo doors and other closing appliances in the fore part of the ship providing the ship's operation in accordance with its main purpose 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).

4.2.3.8 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.

4.2.3.9 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.

4.2.3.10 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.

4.2.3.11 Proper locations shall be provided on board for at-sea storage of removable covers used to prevent icing of equipment and fittings.

4.2.3.12 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 Ventilation 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 to 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 (ESDS) 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 devices.

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.

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 Prior to tests the following shall be submitted to the Register surveyor:

.1 test program approved by the Register;

.2 Icing Protection Manual approved by the Register.

4.3.2 Anti-icing systems shall be tested in the scope of the approved program 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 for the Equipment of Ships in Compliance with the Distinguishing Mark **ANTI-ICE** in the Class Notation the following records will 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).

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