

# RULES FOR BUILDING AND CLASSING

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## STEEL VESSELS 2003

### NOTICE NO. 1 – January 2003

*Note:* This Notice is issued to reflect the Rule changes made in the *Finnish-Swedish Ice Class Rules* in October 2002. All requirements in Part 6, Chapter 1, Section 2 of the 2003 *Rules for Building and Classing Steel Vessels* are replaced with this Notice.

The requirements in this Notice will become **EFFECTIVE AS OF 1 SEPTEMBER 2003** based on the date of keel laying or similar stage of construction of the vessel.

*(Replace entire existing Section 6-1-2 with the following:)*

#### PART

# 6

#### CHAPTER      **1      Strengthening for Navigation in Ice**

#### SECTION      **2      Baltic Ice Classes**

#### **1      General**

#### **1.1      Application**

Vessels to be distinguished in the *Record* by a notation **Ice Strengthening** followed by ice class in 6-1-2/3.1 are to meet the applicable requirements in this Section.

All vessels so designated are to be self-propelled and equipped with radio telephone (VHF).

### 1.3 Northern Baltic Waters (1 September 2003)

The ice strengthening requirements in this Section are in agreement with the *Finnish-Swedish Ice Class Rules 1985*, as amended, developed for vessels trading in the Northern Baltic in winter.

## 3 Assignment of Ice Class

### 3.1 Ice Class (1 September 2003)

The requirements in this Part are intended primarily for vessels operating in the Northern Baltic in winter and are assigned to ice classes as follows:

**Ice Class I AA:** vessels whose structural strength in essential areas affecting their ability to navigate in ice essentially exceeds the requirements of ice class IA and which as regards hull form and engine output are capable of navigation under difficult ice conditions;

**Ice Class I A, I B, I C:** according to ice strengthening and engine output, vessels which meet the requirements for navigation in ice as regards structural strength and engine output and are strengthened for navigation in ice;

The administrations of Sweden and Finland (hereafter called the Administrations) provide icebreaker assistance to vessels bound for their ports in winter. Depending on the ice conditions, restrictions by the administrations may apply to the size and ice class of the vessel.

### 3.3 General Suitability for Operating in Ice

Where no specific requirements are given, vessels are assumed to be a normal seagoing cargo vessel of conventional proportions, hull form and propulsion arrangement. A vessel having very unconventional proportions, hull form or propulsion arrangement, or any other characteristics, may have a lower ice class assigned by the administrations.

### 3.5 General Suitability for Winter Conditions

These requirements are primarily for the vessel's capability to advance in ice. When designing structures, equipment and arrangements essential for the safety and operation of the vessel other problems that may be encountered are to be taken into account.

In particular, the functioning of hydraulic systems, the freezing of water piping and tanks, starting of emergency diesels, low temperature strength of materials, etc. are to be considered in conjunction with the expected air temperature which will be well below 0°C (32°F) for much of the time and may occasionally go down to about -30°C (-22°F).

## 5 Definitions

### 5.1 Ice Belt

The *Ice Belt* is the area over which the shell plating is required to be reinforced for navigation in ice, see 6-1-2/13.1 and 6-1-2/Figure 3.

### 5.3 Maximum Ice Class Draft Amidships

The *Maximum Ice Class Draft Amidships* is in general the Summer Fresh Water Load Line. Where the vessel has a Timber Load Line, the fresh water Timber Load Line in summer is to be used.

### 5.5 Load Waterline (1 September 2003)

The line defined by the maximum ice class drafts forward, amidships and aft is the *Load Waterline, LWL*. The line may be knuckled at amidships.

### 5.7 Ballast Waterline

The line defined by the minimum ballast drafts forward and aft will be referred to as the *Ballast Waterline, BWL*.

### 5.9 Main Frame

*Main Frames* are real, or in the case of longitudinal framing imaginary transverse frames, whose spacing corresponds to that of the vessel clear of the ice strengthening area, or of the vessel if it were not ice strengthened.

### 5.11 Propulsion Machinery Output

The *Propulsion Machinery Output, P*, is the maximum output in kW that the machinery can continuously deliver. If the output is restricted by technical means or by any regulations applicable to the vessel, *P* is to be taken as the restricted output.

## 7 Load and Ballast Waterlines

The load waterline, *LWL*, and the ballast waterline, *BWL*, are to be determined, clearly shown on the shell expansion plans and stated in the classification certificate.

The draft and trim limited by the *LWL* is not to be exceeded when navigating in ice. Sea water salinity along the intended route is to be considered when loading the vessel.

The vessel is always to be loaded to at least the *BWL* when navigating in ice. Any ballast tank situated above *BWL* and needed to load the vessel to this draft, is to be equipped to prevent the water from freezing in these tanks. In determining the *BWL*, consideration is to be given to the need to ensure a reasonable degree of ice-going capability in ballast. The propeller is to be fully submerged, if possible entirely below the ice.

The minimum draft forward,  $d_f$ , is to be not less than

$$d_f = (2 + 0.00025 \Delta) h_o \quad \text{m}$$

$$d_f = (2 + 0.000254 \Delta) h_o \quad \text{ft}$$

but need not exceed  $4h_o$ , where

$$\Delta = \text{displacement of the vessel, in metric tons (long tons), at the maximum ice class draft, as defined in 6-1-2/5.3}$$

$$h_o = \text{ice thickness, in m (ft), as defined in 6-1-2/11.5}$$

## 9 Power of Propulsion Machinery

### 9.1 Propulsion Machinery Output, Ice Classes I AA\*, I A\*, I B\* and I C\* (1 September 2003)

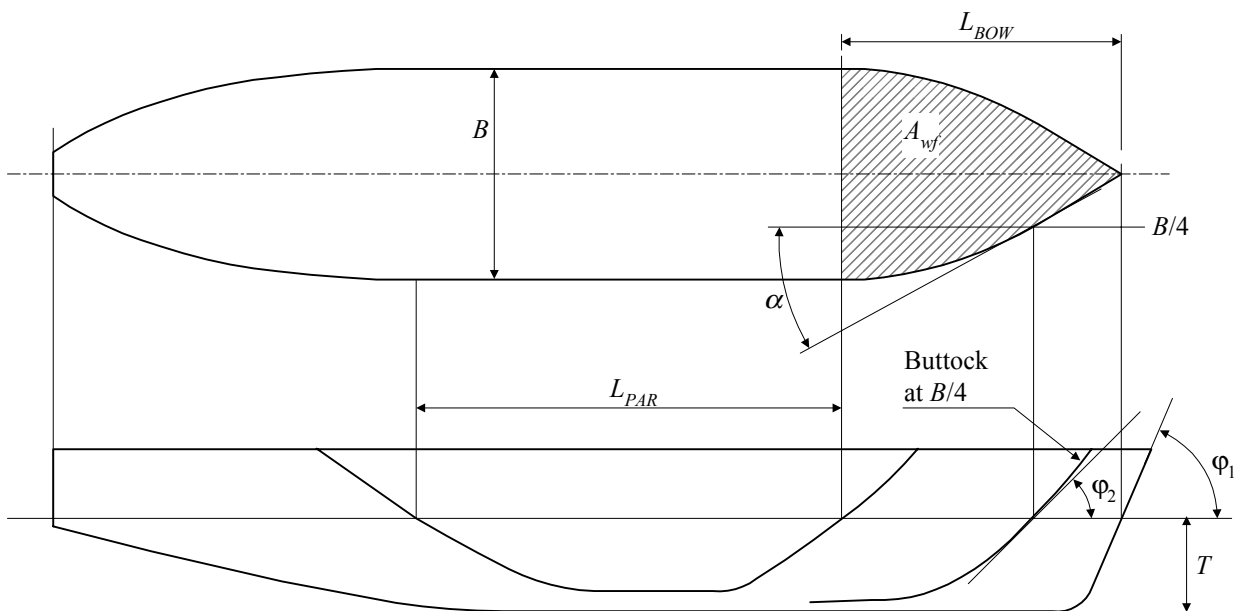
(\*NOTE: For reference purposes, the propulsion machinery output requirements for I AA, I A, I B and I C in the 1985 Finnish-Swedish Ice Class Rules were amended as follows for vessels with the keel laid or which are at a similar stage of construction on or after 1 September 2003)

9.1.1 Definitions

The dimensions of the vessel are defined below in 6-1-2/Figure 1, and are measured on the maximum ice class draft.

- $L$  = length of the vessel, m (m, ft)
- $L_{BOW}$  = length of the bow, m (m, ft)
- $L_{PAR}$  = length of the parallel mid ship body, m (m, ft)
- $B$  = maximum breadth of the vessel, m (m, ft)
- $T$  = actual ice class drafts of the vessel in accordance with 6-1-2/9.1.2, m (m, ft)
- $A_{WL}$  = area of waterline of the bow,  $m^2$  ( $m^2$ ,  $ft^2$ )
- $H_F$  = thickness of the brash ice layer displaced by the bow, m (m, ft)
- $H_M$  = thickness of the brash ice in mid channel, m (m, ft)
- $\alpha$  = the angle of the waterline at  $B/4$ , deg
- $\varphi_1$  = the rake of the stem at the centerline, deg
- $\varphi_2$  = the rake at the bow, at  $B/4$ , deg
- $D_P$  = diameter of the propeller, m (m, ft)

**FIGURE 1**  
**Vessels' Dimensions**



9.1.2 Power Calculation

To be entitled to ice class **IAA**, **IA**, **IB** or **IC**, a vessel the keel of which is laid or which is at a similar stage of construction on or after 1 September 2003 is to comply with the following requirements regarding its engine output. The engine output is to be not less than determined by the formula below and in no case less than 1000 kW (1360 mhp; 1341 hp) for Ice Class **IA**, **IB** and **IC**, and not less than 2800 kW (3807 mhp; 3754 hp) for Ice Class **IAA**.

$$P = K_C \frac{(R_{CH}/1000)^{3/2}}{D_p} \quad \text{kW (mhp, hp)}$$

where  $K_C$  is to be taken as follows:

Propeller Type or Propulsion Machinery	Controllable Pitch Propeller or Electric or Hydraulic Propulsion Machinery			Fixed Pitch Propeller		
	SI Units	MKS Units	US Units	SI Units	MKS Units	US Units
1 propeller	2.03	$26.99 \times 10^5$	$26.49 \times 10^5$	2.26	$30.06 \times 10^5$	$26.99 \times 10^5$
2 propellers	1.44	$19.15 \times 10^5$	$18.79 \times 10^5$	1.6	$21.28 \times 10^5$	$20.88 \times 10^5$
3 propellers	1.18	$15.69 \times 10^5$	$14.09 \times 10^5$	1.31	$17.42 \times 10^5$	$17.09 \times 10^5$

$R_{CH}$  is the resistance of the vessel in a channel with brash ice and a consolidated layer.

$$R_{CH} = C_1 + C_2 + C_3 - C_\mu (H_F + H_M)^2 (B + C_\emptyset H_F) + C_4 L_{PAR} H_F^2 + C_5 \left[ \frac{LT}{B^2} \right]^3 \frac{A_{WL}}{L} \quad \text{N (kgf, lbf)}$$

where

$$C_\mu = 0.15 \cos \varphi_2 + \sin \psi \sin \alpha, \quad C_\mu \text{ is to be taken equal or larger than } 0.45$$

$$C_\emptyset = 0.047\psi - 2.115, \quad \text{and } C_\emptyset = 0 \text{ if } \psi \leq 45^\circ$$

$$H_F = 0.26 + (H_M B)^{0.5} \quad \text{m}$$

$$H_F = 0.85 + (H_M B)^{0.5} \quad \text{ft}$$

$$H_M = 1.0 \text{ m (3.28 ft) for Ice Class } \mathbf{IA} \text{ and } \mathbf{IAA}$$

$$= 0.8 \text{ m (2.62 ft) for Ice Class } \mathbf{IB}$$

$$= 0.6 \text{ m (1.97 ft) for Ice Class } \mathbf{IC}$$

The coefficients  $C_1$  and  $C_2$  take into account a consolidated upper layer of the brash ice and can be taken as zero for Ice Class **IA**, **IB** and **IC**.

For Ice Class **IAA**:

$$C_1 = f_1 \frac{BL_{PAR}}{(2T/B)+1} + (1 + 0.021\varphi_1)(f_2 B + f_3 L_{BOW} + f_4 BL_{BOW}) \quad \text{N (kgf, lbf)}$$

$$C_2 = (1 + 0.063\varphi_1)(g_1 + g_2 B) + g_3(1 + 1.2T/B) \frac{B^2}{\sqrt{L}} \quad \text{N (kgf, lbf)}$$

For a vessel with a bulbous bow,  $\phi_1$  is to be taken as  $90^\circ$ .

	<i>SI units</i>	<i>MKS units</i>	<i>US units</i>
$f_1$	23 N/m <sup>2</sup>	2.35 kgf/m <sup>2</sup>	0.48 lbf/ft <sup>2</sup>
$f_2$	45.8 N/m	4.67 kgf/m	3.138 lbf/ft
$f_3$	14.7 N/m	1.50 kgf/m	1.007 lbf/ft
$f_4$	29 N/m <sup>2</sup>	2.96 kgf/m <sup>2</sup>	0.61 lbf/ft <sup>2</sup>
$g_1$	1530 N	156.02 kgf	343.96 lbf
$g_2$	170 N/m	17.34 kgf/m	11.649 lbf/ft
$g_3$	400 N/m <sup>1.5</sup>	40.79 kgf/m <sup>1.5</sup>	15.132 lbf/ft <sup>1/3</sup>
$C_3$	845 N/m <sup>3</sup>	86.2 kgf/m <sup>3</sup>	5.38 lbf/ft <sup>3</sup>
$C_4$	42 N/m <sup>3</sup>	4.28 kgf/m <sup>3</sup>	0.267 lbf/ft <sup>3</sup>
$C_5$	825 N/m	84.1 kgf/m	56.5 lbf/ft

$$\psi = \arctan[\tan \phi_2 / \sin \alpha] \text{ deg.}$$

The following is to apply:

$$20 \geq \left[ \frac{LT}{B^2} \right]^3 \geq 5$$

### 9.1.3 Other Methods of Determining $K_C$ and $R_{CH}$

The administration may for an individual vessel, in lieu of the  $K_C$  or  $R_{CH}$  values defined in 6-1-2/9.1 above, approve the use of  $K_C$  values based on more exact calculations or  $R_{CH}$  values based on model test. Such an approval will be given on the understanding that it can be revoked if experience of the vessel's performance in practice motivates this.

The design requirement for ice classes is a minimum speed of 5 knots in the following brash ice channels:

- I AA**  $H_M = 1.0$  m (3.28 ft) and a 0.1 m (0.328 ft) thick consolidated layer of ice
- I A**  $H_M = 1.0$  m (3.28 ft)
- I B**  $H_M = 0.8$  m (2.62 ft)
- I C**  $H_M = 0.6$  m (1.97 ft)

## 11 Hull Structural Design

### 11.1 Application (1 September 2003)

The requirements for the hull scantlings are based on certain assumptions concerning the nature of the ice load on the structure. These assumptions are from full scale observations made in the Northern Baltic.

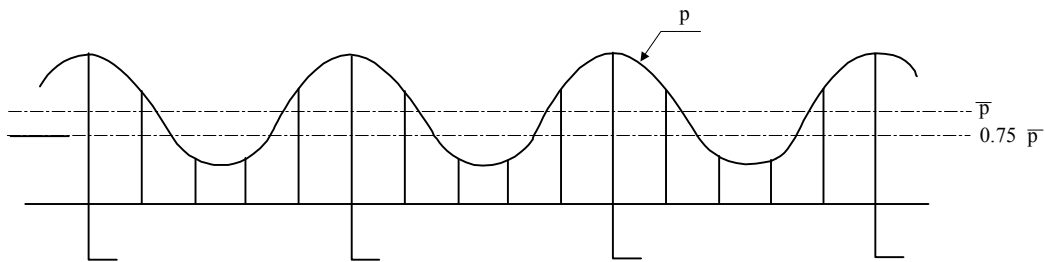
The local ice pressure on small areas can reach high values. This pressure may be well in excess of the normal uniaxial crushing strength of sea ice since the stress field is multi-axial.

It has also been observed that the ice pressure on a frame can be greater than on the shell plating at mid-spacing between frames. This is due to the different flexural stiffness of the frames and shell plating. The load distribution on the side structure is assumed to be as shown in 6-1-2/Figure 2.

As an alternative to the requirements of this Section, the hull structure may be obtained by direct engineering analysis subject to approval by the administration.

Where the scantlings given by these requirements are less than those required by the Rules for a vessel unstrengthened for navigation in ice, the greater requirements are to apply.

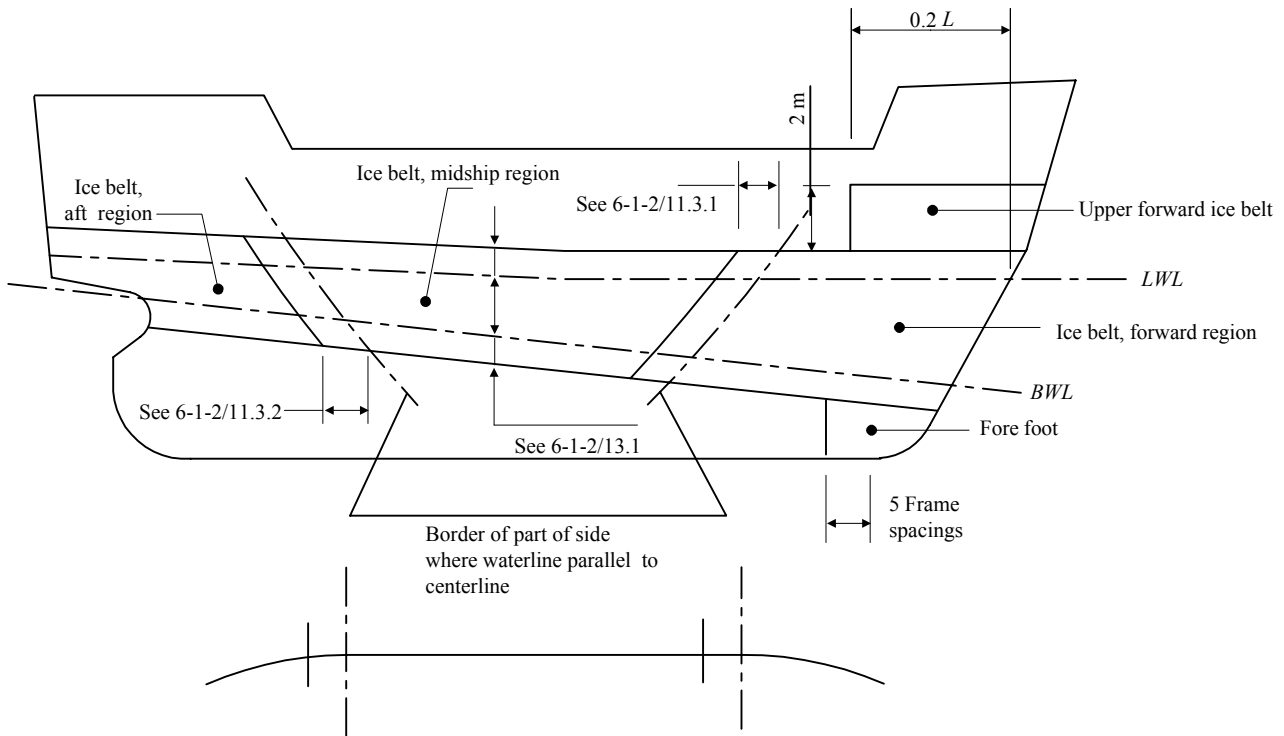
**FIGURE 2**  
**Ice Load Distribution on Vessel's Side**



**11.3 Ice Strengthening Regions**

For the application of this Section the vessel's ice belt is divided forward and aft into the following regions, see also 6-1-2/Figure 3.

**FIGURE 3**  
**Ice Strengthening Regions**



### 11.3.1 Forward

From the stem to a line through the ice belt parallel to and  $0.04L$  aft of the forward horizontal line of tangency of the parallel midbody, i.e. the forward end of the buttock line within the ice belt bounding the maximum beam. For ice classes **I AA** and **I A** the overlap over the forward line of tangency need not exceed 6 m (19.7 ft), for ice classes **I B** and **I C** this overlap need not exceed 5 m (16.4 ft).

### 11.3.2 Midship

From the aft boundary of the forward region to a line parallel to and  $0.04L$  aft of the aft horizontal line of tangency of the parallel midbody, i.e. the aft end of the buttock line within the ice belt bounding the maximum beam. For ice classes **I AA** and **I A** the overlap over the borderline need not exceed 6 m (19.7 ft), for ice classes **I B** and **I C** this overlap need not exceed 5 m (16.4 ft).

### 11.3.3 Aft

From the aft boundary of the midship region to the stern.

## 11.5 Vertical Extent of Design Ice Pressure

An ice strengthened vessel is assumed to operate in open sea conditions with level ice thickness not exceeding  $h_o$ . The design height,  $h$ , of the area actually under ice pressure at any particular time is, however, assumed to be only a fraction of the ice thickness. The values for  $h_o$  and  $h$  are given in the following table:

Ice Class	$h_o$ m (ft)	$h$ m (ft)
<b>I AA</b>	1.0 (3.28)	0.35 (1.15)
<b>I A</b>	0.8 (2.62)	0.30 (0.98)
<b>I B</b>	0.6 (1.97)	0.25 (0.82)
<b>I C</b>	0.4 (1.31)	0.22 (0.72)

## 11.7 Design Ice Pressure (1 September 2003)

The design ice pressure is to be not less than given by the following equation:

$$p = c_d c_1 c_a p_o \quad \text{N/mm}^2 \text{ (kgf/mm}^2 \text{, psi)}$$

where

$c_d$  = a factor for the influence of the size and propulsion machinery output of the vessel

$$= (ak + b)/1000$$

$$k = \sqrt{n\Delta P} / 1000$$

$a$  and  $b$  are given in the following table:

	Region			
	Forward		Midship & Aft	
	$k \leq 12$	$k > 12$	$k \leq 12$	$k > 12$
$a$	30	6	8	2
$b$	230	518	214	286

- $n$  = 1.0 (1.0, 1.016)
- $\Delta$  = displacement of the vessel, in metric tons (long tons), at maximum ice class draft as defined in 6-1-2/5.3
- $P$  = the actual continuous propulsion machinery output, in kW, as defined in 6-1-2/5.11
- $c_1$  = factor for the probability that the design ice pressure occurs in a certain region of the hull for the particular ice class

The value of  $c_1$  is given in the following table:

Ice Class	Region		
	Forward	Midship	Aft
<b>I AA</b>	1.0	1.0	0.75
<b>I A</b>	1.0	0.85	0.65
<b>I B</b>	1.0	0.70	0.45
<b>I C</b>	1.0	0.50	0.25

- $c_a$  = a factor for the probability that the full length of the area under consideration will be under pressure at the same time
- $c_a$  =  $(47 - 5\ell_a)/44$ , maximum 1.0, minimum 0.5      SI & MKS units
- $c_a$  =  $(47 - 1.52\ell_a)/44$ , maximum 1.0, minimum 0.5      US units

$\ell_a$  is as given in the following table:

Structure	Type of framing	$\ell_a$ m (ft)
Shell	Transverse	Frame spacing
	Longitudinal	2 times spacing of frame
Frames	Transverse	Frame spacing
	Longitudinal	Span of frame
Ice stringer		span of stringer
Web frame		2 times spacing of web frames

- $p_o$  = the nominal ice pressure; the value 5.6 N/mm<sup>2</sup> (0.571 kgf/mm<sup>2</sup>, 812 psi) is to be used

## 13 Shell Plating

### 13.1 Vertical Extent of Ice Strengthening

The vertical extension of the ice strengthening or the ice belt is given in the following table:

Ice class	Above LWL m (ft)	Below BWL m (ft)
<b>I AA</b>	0.6 (1.97)	0.75 (2.46)
<b>I A</b>	0.5 (1.64)	0.6 (1.97)
<b>I B</b>	0.4 (1.31)	0.5 (1.64)
<b>I C</b>	0.4 (1.31)	0.5 (1.64)

In addition, the following areas are to be strengthened:

### 13.1.1 Fore Foot

For ice class **I AA** the shell plating below the ice belt from the stem to a position five main frame spaces abaft the point where the bow profile departs from the keel line is to be at least the thickness required for the ice belt midship region.

### 13.1.2 Upper Forward Ice Belt (1 September 2003)

For ice class **I AA** and **I A** on vessels with an open water service speed equal to or exceeding 18 knots, the shell plating from the upper limit of the ice belt to 2 m (6.56 ft) above it and from the stem to a position at least 0.2L abaft the forward perpendicular, is to be at least the thickness required for the ice belt midship region.

Side lights, side scuttles etc., are not to be situated in the ice belt. If the weather deck in any part of the vessel is situated below the upper limit of the ice belt, *ie.* in way of the well of a raised quarter decker, the bulwark is to be given at least the same strength as is required for the shell in the ice belt. The strength of the construction of the freeing ports is to meet the requirements for the bulwark.

## 13.3 Ice Belt Plating Thickness

With transverse framing the thickness of the shell plating is to be not less than given by the following equation:

$$t = a s \sqrt{f_1 P_{PL} / \sigma_y} + t_c \quad \text{mm (in.)}$$

With longitudinal framing the thickness of the shell plating is to be not less than given by the following equation:

$$t = a s \sqrt{P_{PL} / f_2 \sigma_y} + t_c \quad \text{mm (in.)}$$

where

- $s$  = frame spacing, in m (ft)
- $P_{PL}$  = 0.75  $p$ , in N/mm<sup>2</sup> (kgf/mm<sup>2</sup>, psi)
- $p$  = as given in 6-1-2/11.7
- $f_1$  =  $1.3 - 4.2 / [(h/s) + 1.8]^2$ ; maximum 1.0
- $f_2$  =  $0.6 + 0.4/(h/s)$ ; when  $h/s \leq 1$
- $f_2$  =  $1.4 - 0.4 (h/s)$ ; when  $1 \leq h/s < 1.8$
- $h$  = as given in 6-1-2/11.5, in m (ft)
- $\sigma_y$  = yield strength of the material, in N/mm<sup>2</sup> (kgf/mm<sup>2</sup>, psi)
- $a$  = 667 (8)

Use of steels with yield strengths greater than 352 N/mm<sup>2</sup> (36 kgf/mm<sup>2</sup>, 51000 psi) are subject to special consideration.

- $t_c$  = increment for abrasion and corrosion, in mm (in.); normally  $t_c$  is to be 2 mm (0.08 in.); however if a special surface coating, by experience is shown capable to withstand the abrasion of ice and is applied and maintained effective, lower values may be approved.

## 15 Framing

### 15.1 General

#### 15.1.1 End Attachments

Within the ice strengthened area all frames are to be effectively attached to all supporting structure by brackets. Frames are to be connected to transverse structure on both sides of the cut-out slots, *i.e.* the free edge of a slot is to be connected to the frame by a lug.

#### 15.1.2 Frames

For Ice Class **I AA** throughout, for ice class **I A** in the forward and midship regions and for ice classes **I B** and **I C** in the forward region the following is to apply.

*15.1.2(a) Slanted frames.* Frames not at right angles to the shell are to be supported against tripping by brackets, intercostals, stringers or similar, at a distance preferably not exceeding 1300 mm (51 in.)

*15.1.2(b) Welding.* Frames are to be attached to the shell by double continuous welding. Scallops are to be avoided, except where frames cross shell plate butts.

*15.1.2(c) Web Thickness.* The web thickness of the frames is to be at least one half of the thickness of the shell plating but not less than 9 mm (0.35 in). Where a deck, tanktop or bulkhead replaces a frame this thickness is to apply, for a depth corresponding to the depth of the adjacent frame.

### 15.3 Vertical Extent of Ice Strengthening (1 September 2003)

The vertical extent of the ice strengthening of framing is to be at least as given in the following table:

<i>Ice Class</i>	<i>Region</i>	<i>Above LWL m (ft)</i>	<i>Below BWL m (ft)</i>
<b>I AA</b>	From stem to 0.3 <i>L</i> abaft stem	1.2 (3.94)	to double bottom or below top of floors
	Abaft 0.3 <i>L</i> from stem	1.2 (3.94)	1.6 (5.25)
	Midship	1.2 (3.94)	1.6 (5.25)
	Aft	1.2 (3.94)	1.2 (3.94)
<b>I A, I B, I C</b>	From stem to 0.3 <i>L</i> abaft stem	1.0 (3.28)	1.6 (5.25)
	Abaft 0.3 <i>L</i> from stem	1.0 (3.28)	1.3 (4.27)
	Midship	1.0 (3.28)	1.3 (4.27)
	Aft	1.0 (3.28)	1.0 (3.28)

Where an upper forward ice belt is required, see 6-1-2/13.1, the ice strengthening of the framing is to be extended at least to top of the ice belt.

Where the ice strengthening would go beyond a deck or a tanktop by not more than 250 mm (9.8 in), it may be terminated at that deck or tanktop.

### 15.5 Transverse Framing (1 September 2003)

#### 15.5.1 Section Modulus

The section modulus, *SM*, of a main or intermediate frame is to be not less than obtained from the equation:

$$SM = n[(psh\ell)/m_t\sigma_y] \quad \text{cm}^3 \text{ (in}^3\text{)}$$

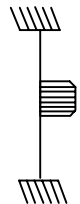
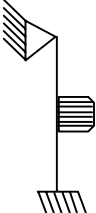
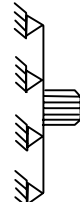
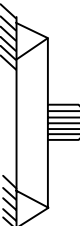
where

- $n = 10^6$  (1728)
- $\sigma_y =$  yield strength, as defined in 6-1-2/13.3, in N/mm<sup>2</sup> (kgf/mm<sup>2</sup>, psi)
- $p =$  ice pressure, as given in 6-1-2/11.7, in N/mm<sup>2</sup> (kgf/mm<sup>2</sup>, psi)
- $s =$  frame spacing, in m (ft)
- $h =$  height of load area, as given in 6-1-2/11.5, in m (ft)
- $\ell =$  span of the frame, in m (ft)
- $m_t = 7m_o/[7 - 5 (h/\ell)]$

$m_o$  values are given in 6-1-2/Figure 4a.

The boundary conditions shown are for the main and intermediate frames. Possible different conditions for the main frames are assumed to have been taken care of by interaction between the frames and are reflected in the  $m_o$  values. The load is considered applied at mid span. Where less than 15 % of the span,  $\ell$ , of the frame is situated within the ice-strengthening zone for frames as defined in 4.4.1, ordinary frame scantlings may be used.

**FIGURE 4a**  
**Web Frame Model**

<i>Boundary Condition</i>	$m_o$	<i>Example</i>
	7	Frames in a bulk carrier with top wing tanks
	6	Frames extending from the tank top to a single deck
	5.7	Continuous frames between several decks of stringers
	5	Frames extending between two decks only

### 15.5.2 Upper End of Transverse Frames

The upper end of an ice strengthened part of a main frame and intermediate ice frame is to be attached to a deck or ice stringer, see 6-1-2/17.

Where an intermediate ice frame terminates above a deck or ice stringer that is situated at or above the upper limit of the ice belt, see 6-1-2/13.1, the part above the deck or stringer may have scantlings as required for an unstrengthened vessel and the upper end of the frame may be connected to the adjacent main frames by a header of the same scantlings as the main frame. Such an intermediate frame can also be extended to the deck above and if this is situated more than 1.8 m (5.9 ft) above the ice belt the intermediate frame need not be attached to that deck, except in the Forward Region.

### 15.5.3 Lower End of Transverse Framing

The lower end of an ice strengthened part of a main frame and intermediate ice frame is to be attached to a deck, tanktop or ice stringer, see 6-1-2/17.

Where an intermediate ice frame terminates below a deck, tanktop or ice stringer which is situated at or below the lower limit of the ice belt, see 6-1-2/13.1, the lower end of the frame may be connected to the adjacent main frames by a header of the same scantlings as the main frame.

## 15.7 Longitudinal Framing

The section modulus,  $SM$ , is to be not less than obtained from the equation:

$$SM = n(f_3 f_4 p s \ell^2 / m_1 \sigma_y) \quad \text{cm}^3 \text{ (in}^3\text{)}$$

The shear area,  $A$ , is to be not less than obtained from the equation:

$$A = k (\sqrt{3} f_3 p s \ell / \sigma_y) \quad \text{cm}^2 \text{ (in}^2\text{)}$$

This is applicable only if the longitudinal frames are attached to the supporting structure by brackets as required in 6-1-2/15.1.

$f_3$  = factor for the load distribution to adjacent frames

$$f_3 = (1 - 0.2h/s) (h/s)$$

$f_4$  = factor for the concentration of load to point of support;

$$f_4 = 0.6$$

$p$  = ice pressure, as given in 6-1-2/11.7, in  $\text{N/mm}^2$  ( $\text{kgf/mm}^2$ , psi)

$h$  = height of load area, as given in 6-1-2/11.5, in m (ft)

$s$  = frame spacing, in m (ft); the frame spacing is not to exceed 0.35 m (1.15 ft) for ice class **IAA** or **IA** and is in no case to exceed 0.45 m (1.48 ft)

$n$  =  $10^6$  (1728)

$k$  =  $5 \times 10^3$  (72)

$\ell$  = span of frame, in m (ft)

$m_1$  = boundary condition factor;  $m_1 = 13.3$  for a continuous beam.

$\sigma_y$  = yield strength, as defined in 6-1-2/13.3, in  $\text{N/mm}^2$  ( $\text{kgf/mm}^2$ , psi)

## 17 Ice Stringers

### 17.1 Stringers within the Ice Belt (1 September 2003)

The section modulus,  $SM$ , within the ice belt, (see 6-1-2/13.1) is to be not less than obtained from the equation:

$$SM = n(f_5 p h \ell^2 / m_s \sigma_y) \quad \text{cm}^3 \text{ (in}^3\text{)}$$

The shear area,  $A$ , is to be not less than obtained from the equation:

$$A = k (\sqrt{3} f_6 p h \ell / \sigma_y) \quad \text{cm}^2 \text{ (in}^2\text{)}$$

where

$p$  = ice pressure, as given in 6-1-2/11.7, in N/mm<sup>2</sup> (kgf/mm<sup>2</sup>, psi)

$h$  = height of load area, as given in 6-1-2/11.5, in m (ft)

$n$  = 10<sup>6</sup> (1728)

The product ( $p \times h$ ) is not to be taken as less than 0.3 SI units (0.0306 MKS units, 142.8 US units)

$k$  = 5 × 10<sup>3</sup> (72)

$\ell$  = span of stringer, in m (ft)

$m_s$  = boundary condition factor;  $m_s = 13.3$  for a continuous beam

$f_5$  = factor for distribution of the load on the transverse frames;

= 0.9 may be used for normal construction, but  $f_5$  may also be obtained from the following equation:

$$f_5 = [1 - (d/118)] / [1 + (d/13)]$$

$d$  =  $(\ell \ell_f)^3 (\ell / s_f) (I_f / I)$

$\ell_f$  = span of transverse frames, in m (ft)

$s_f$  = frame spacing, in m (ft)

$I$  = moment of inertia of stringer, in cm<sup>4</sup> (in<sup>4</sup>)

$I_f$  = moment of inertia of transverse frames, in cm<sup>4</sup> (in<sup>4</sup>)

$f_6$  = factor for distribution of the load on the transverse frames;  $f_6 = 0.9$  may be used for normal construction but  $f_6$  may also be obtained from the following equation:

$$f_6 = \frac{1 + \frac{d}{16}n}{1 + \frac{d}{13}}$$

$n$  = number of transverse frames supported by the stringer

$\sigma_y$  = yield strength, as defined in 6-1-2/13.3, in N/mm<sup>2</sup> (kgf/mm<sup>2</sup>, psi)

### 17.3 Stringers Outside the Ice Belt

The section modulus,  $SM$ , of a stringer outside the ice belt that supports ice strengthened frames is to be not less than obtained from the equation:

$$SM = \frac{f_7 \cdot p \cdot h \cdot \ell^2}{m_s \cdot \sigma_y} \left(1 - \frac{h_s}{\ell_s}\right) n \quad \text{cm}^3 \text{ (in}^3\text{)}$$

The shear area,  $A$ , is to be not less than obtained from the equation:

$$A = \frac{\sqrt{3} f_8 \cdot p \cdot h \cdot \ell}{\sigma_y} \left(1 - \frac{h_s}{\ell_s}\right) k \quad \text{cm}^2 \text{ (in}^2\text{)}$$

where

- $p$  = ice pressure, as given in 6-1-2/11.7, in N/mm<sup>2</sup> (kgf/mm<sup>2</sup>, psi)
- $h$  = height of load area, as given in 6-1-2/11.5, in m (ft)
- $n$  = 10<sup>6</sup> (1728)

The product ( $p \times h$ ) is to be not taken as less than 0.3 SI units (0.0306 MKS units, 142.8 US units).

- $k$  = 5 × 10<sup>3</sup> (72)
- $\ell$  = span of stringer, in m (ft)
- $m_s$  = boundary condition factor;  $m_s = 13.3$  for a continuous beam
- $\ell_s$  = the distance to the adjacent ice stringer, in m (ft)
- $h_s$  = the distance to the ice belt, in m (ft)
- $f_7$  = factor for the load distribution on transverse frames.  
 $f_7 = (f_5 + 1)/2$
- $f_5$  = as given in 6-1-2/17.1
- $f_8$  = factor for the load distribution on transverse frames  
 $f_8 = (f_6 + 1)/2$
- $f_6$  = as given in 6-1-2/17.1
- $\sigma_y$  = yield strength, as defined in 6-1-2/13.3, in N/mm<sup>2</sup> (kgf/mm<sup>2</sup>, psi)

### 17.5 Deck Strips (1 September 2003)

The deck strips abreast hatches serving as ice stringers are to comply with the section modulus and shear area requirements in 6-1-2/17.1 and 6-1-2/17.3 respectively. In the case of very long hatches the product ( $p \times h$ ) may be taken as less than 0.3 SI units (0.0306 MKS units, 142.8 US units) but in no case less than 0.2 SI units (0.0204 MKS units, 95.2 US units).

In design of weather deck hatch covers and their fitting, special attention is to be paid to the deflection of the vessel's sides due to ice pressure in way of very long hatch openings.

## 19 Web Frames

### 19.1 Design Ice Load

The design load,  $F$ , on a web frame from an ice stringer or from longitudinal framing may be obtained from the following equation:

$$F = n f_6 p h S \quad \text{kN (tf, Ltf)}$$

where

- $n$  =  $10^3$  (0.0643)
- $f_6$  = as given in 6-1-2/17.1 for loads from ice stringers and, for longitudinals,  $f_6 = 1.0$
- $p$  = ice pressure, as given in 6-1-2/11.7, in  $\text{N/mm}^2$  ( $\text{kgf/mm}^2$ , psi); in calculating  $c_a$  however,  $\ell_a$  is to be taken as  $2S$
- $h$  = height of ice load area, as given in 6-1-2/11.5, in m (ft)

The product ( $p \times h$ ) is not to be taken as less than 0.3 SI units (0.0306 MKS units, 142.8 US units).

- $S$  = distance between web frames, in m (ft)

### 19.3 Section Modulus and Shear Area (1 September 2003)

When a web frame can be represented by the structural model shown in 6-1-2/Figure 4b, the section modulus and shear area may be obtained from the following equations:

*Shear area*

$$A = (\sqrt{3}) n (k_1)(F)(\alpha)/\sigma_y \quad \text{cm}^2 \text{ (in}^2\text{)}$$

where

- $k_1$  =  $1 + (1/2)(\ell_f/\ell)^3 - (3/2)(\ell_f/\ell)^2$  or
- $k_1$  =  $(3/2)(\ell_f/\ell)^2 - (1/2)(\ell_f/\ell)^3$  whichever is greater

For the lower part of the web frame the smallest value of  $\ell_f$  within the ice belt is to be used. For the upper part the greatest value of  $\ell_f$  within the ice belt is to be used.

- $n$  = 10 (2240)
- $\alpha$  = as given in the Table below
- $\sigma_y$  = yield strength, as defined in 6-1-2/13.3, in  $\text{N/mm}^2$  ( $\text{kgf/mm}^2$ , psi)
- $F$  = as in 6-1-2/19.1

*Section modulus*

$$SM = nk_2 F \ell / \sigma_y \sqrt{1 - (\gamma A / A_a)^2} \quad \text{cm}^3 \text{ (in}^3\text{)}$$

where

- $k_2$  =  $(1/2)(\ell_f/\ell)^3 - (3/2)(\ell_f/\ell)^2 + (\ell_f/\ell)$
- $\gamma$  = as given in the Table below
- $A$  = required shear area obtained using  
 $k_1 = 1 + (1/2)(\ell_f/\ell)^3 - (3/2)(\ell_f/\ell)^2$

- $A_a$  = actual cross sectional area of the web frame, in  $\text{cm}^2$  ( $\text{in}^2$ )
- $n$  = 1000 (26880)

Factors  $\alpha$  and  $\gamma$

- $A_f$  = cross section area of free flange, in  $\text{cm}^2$  ( $\text{in}^2$ )
- $A_w$  = cross section area of web plate, in  $\text{cm}^2$  ( $\text{in}^2$ )

$A_f/A_w$	0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
$\alpha$	1.5	1.23	1.16	1.11	1.09	1.07	1.06	1.05	1.05	1.04	1.04
$\gamma$	0	0.44	0.62	0.71	0.76	0.80	0.83	0.85	0.87	0.88	0.89

For web frame configurations and boundary conditions other than given above, a direct stress calculation is to be carried out.

The concentrated load on the web frame is to be as given in 6-1-2/19.1. The point of application is in each case to be chosen in relation to the arrangement of stringers and longitudinal frames to obtain the maximum shear forces and bending moments.

The allowable stresses are as follows

Shear Stress

$$\tau \leq \sigma_y / \sqrt{3}$$

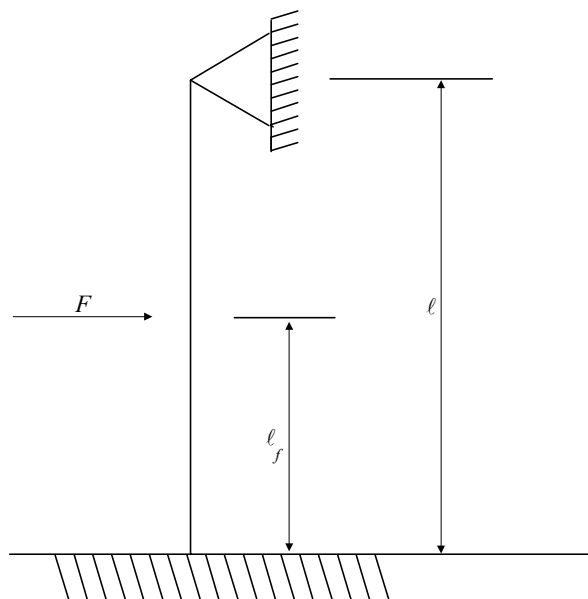
Bending Stress

$$\sigma_b \leq \sigma_y$$

Equivalent Stress

$$\sigma_c = \sqrt{\sigma_b^2 + 3\tau^2} \leq \sigma_y$$

**FIGURE 4b**  
**Web Frame Model**



## 21 Bow

### 21.1 Stem

The stem may be made of rolled, cast or forged steel or of shaped steel plates. A sharp edged stem, see 6-1-2/Figure 5, improves the maneuverability of the vessel in ice and is recommended particularly for smaller vessels with a length of less than 150 m (492.1 ft).

The thickness of a shaped plate stem and in the case of a blunt bow, any part of the shell that forms an angle of 30 degrees or more with the center line in the horizontal plane, is to be obtained from the equation in 6-1-2/13.3 where

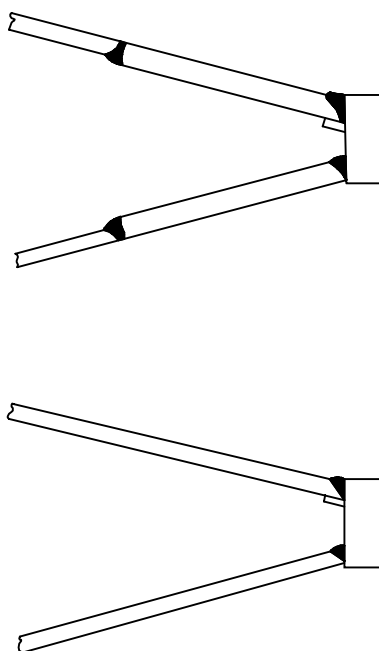
$s$  = spacing of elements supporting the plate, in m (ft)

$P_{PL}$  =  $p$ , in  $N/mm^2$  ( $kgf/mm^2$ ,  $psi$ ), see 6-1-2/11.7

$\ell_a$  = spacing of vertical supporting elements, in m (ft)

The stem and that part of a blunt bow defined above is to be supported by floors, breasthooks, or brackets spaced not more than 0.6 m (1.97 ft) apart and of a thickness at least half the shell plate thickness. This reinforcement of the stem is to extend from the keel to a point 0.75 m (2.46 ft) above *LWL* or, where an upper forward ice belt is required, see 6-1-2/13.1, to the upper limit of upper forward ice belt.

**FIGURE 5  
Ice Stems**



### 21.3 Arrangements for Towing

A mooring pipe with an opening not less than 250 mm (10 in.) by 300 mm (12 in.), a length of at least 150 mm (6 in.) and an inner surface radius of at least 100 mm (4 in.) is to be fitted in the bow bulwark at the center line.

A bitt or other means for securing a towline, dimensioned to stand the breaking force of the towline of the vessel is also to be fitted. The deck in way of the bitt is to be suitably reinforced.

On vessels with a displacement not exceeding 30,000 metric tons (29,527 long tons) that part of the bow that extends to a height of at least 5 m (16.4 ft) above the *LWL* and at least 3 m (9.84 ft) aft of the stem, is to be strengthened to take the stresses caused by fork towing. For this purpose intermediate frames are to be fitted and the framing is to be supported by stringers or decks.

It is to be noted that for vessels with a displacement not exceeding 30,000 metric tons (29,527 long tons) fork towing in many situations is the most efficient way of assisting in ice. Vessels with a bulb protruding more than 2.5 m (8.2 ft) forward of the forward perpendicular are often difficult to tow in this way. The administrations reserve the right to deny assistance to such vessels if the situation so warrants.

## 23 Stern

An extremely narrow clearance between the propeller blade tip and the stern frame is to be avoided as this causes very high loads on the blade tips.

On twin and triple screw vessels the ice strengthening of the shell and framing is to extend to the double bottom for 1.5 meters (4.92 ft) forward and aft of the side propellers.

Shafting and stern tubes of side propellers are to be normally enclosed within plated bossing. If detached struts are used, their design, strength and attachment to the hull is to be duly considered for ice loading.

A wide transom stern extending below the *LWL* will seriously impede the essential capability of the vessel to back in ice. Therefore a transom stern is not to be extended below the *LWL*, if this can be avoided. If unavoidable, the part of the transom stern situated within the ice belt is to be strengthened as for the midship region.

## 25 Bilge Keels

Bilge keels are prone to ice damage. The connection of bilge keels to the hull is to be so designed to minimize the risk of damage to the hull in the case of a bilge keel being ripped off.

To limit damage when a bilge keel may be partly ripped off, it is recommended that bilge keels be fitted in several shorter independent lengths. The bilge keels are to comply with 3-2-2/13 except the doubler may be either discontinuous with the bilge keel or continuous.

Special attention is to be given to details at the ends of the bilge keels. In general the bilge keels are to terminate on an internal structural member, in gradual *S* tapers and the shell doubler is to terminate in a reduced width taper with the end radiused.

## 27 Rudder and Steering Arrangements

### 27.1 Minimum Design Speed (1993)

The scantlings of rudder post, rudder stock, pintles, steering gear etc., as well as the capacity of the steering gear are to comply with Section 3-2-14 of the Rules. Where the design ahead speed of the vessel as defined in 3-2-14/3.1 is less than the minimum speed indicated in the table below, the latter speed is to be used in lieu of *V* in Section 3-2-14.

<i>Class</i>	<i>Minimum speed</i>
<b>I AA</b>	20 knots
<b>I A</b>	18 knots
<b>I B</b>	16 knots
<b>I C</b>	14 knots

For use with the minimum ahead speeds in the above table,  $k_c$  may be taken as 80% of that specified in Section 3-2-14. Also,  $k_1$  for rudders situated behind nozzles need not be taken as greater than 1.0.

### 27.3 Double Plated Rudders

For double plated rudders the minimum thickness of plates and horizontal and vertical webs in the ice-belt region is to be determined as for shell plating in the aft region in accordance with 6-1-2/13.

### 27.5 Rudder and Rudder Stock Protection

For the ice classes **IAA** and **IA** the rudder stock and the upper edge of the rudder are to be protected against ice pressure by an ice knife or equivalent means.

### 27.7 Overload Design

For ice classes **IAA** and **IA** due regard is to be given to the excessive loads caused by the rudder being forced out of the midship position when backing into an ice ridge. Also, relief valves for hydraulic pressure are to be effective. The components of the steering gear are to be dimensioned to withstand the yield torque of the rudder stock. Where possible rudder stoppers working on the blade or rudder stock are to be fitted.

## 29 Determination of Ice Torque for Propulsion Systems

*(1 September 2003)*

The dimensions of gears, shafting and propellers as determined from the following subsections take into account the impact that occurs when a propeller blade hits ice. The increased loading that results is designated the ice torque  $M$ , and is obtained from the following equation:

$$M = mD^2 \text{ kN-m (tf-m, Ltf-ft)}$$

$$D = \text{propeller diameter, m (ft)}$$

$$m = \text{value from the following table}$$

Class	SI Units	MKS Units	US Units
<b>IAA</b>	21.09	2.15	0.645
<b>IA</b>	15.69	1.60	0.480
<b>IB</b>	13.04	1.33	0.399
<b>IC</b>	11.96	1.22	0.366

If the propeller is not fully submerged when the vessel is in ballast condition, the ice torque for ice class **IA** is to be used for ice classes **IB** and **IC**.

## 31 Propellers

### 31.1 General *(1 September 2003)*

The elongation of the material used is not to be less than 19%, preferably less than 22% for a test piece length =  $5d$  and the value for the Charpy V-notch test is not to be less than 21 J (2.1 kgf-m, 14.7 lbf-ft) at  $-10^\circ\text{C}$  ( $14^\circ\text{F}$ ).

Where the vessel is fitted with a nozzle around the propeller, the propeller will be considered in accordance with the requirements for the ice class next lower than that requested for the vessel.

### 31.3 Propeller Section

#### 31.3.1 Width and Thickness

The thickness  $T$  and width  $W$  of propeller blade sections are to be obtained from the following equations:

*At the 0.25 radius for solid propellers*

$$WT^2 = [a_1/U(0.65 + 0.7P_{0.25})] [(a_2H/NR) + a_3M] \quad \text{cm}^3 \text{ (in}^3\text{)}$$

*At the 0.35 radius for controllable-pitch propellers*

$$WT^2 = [a_4/U(0.65 + 0.49P_{nominal})] [(a_2H/NR) + a_5M] \quad \text{cm}^3 \text{ (in}^3\text{)}$$

*At the 0.6 radius for solid propellers*

$$WT^2 = [a_6/U(0.65 + 0.7P_{0.6})] [(a_2H/NR) + a_7M] \quad \text{cm}^3 \text{ (in}^3\text{)}$$

*At the 0.6 radius for controllable-pitch propellers*

$$WT^2 = [a_6/U(0.65 + 0.49P_{nominal})] [(a_2H/NR) + a_7M] \quad \text{cm}^3 \text{ (in}^3\text{)}$$

where

$a_1$	=	2650 (270, 27,000)
$a_2$	=	272 (200, 176)
$a_3$	=	22.4 (220, 59.13)
$a_4$	=	2108 (215, 21,500)
$a_5$	=	23.5 (230, 61.822)
$a_6$	=	932 (95, 9500)
$a_7$	=	28.6 (280, 75.26)
$W$	=	expanded width of a cylindrical section at the appropriate radius, cm (in.)
$T$	=	maximum thickness at the appropriate radius from propeller drawing, cm (in.)
$U$	=	tensile strength of propeller material, N/mm <sup>2</sup> (kgf/mm <sup>2</sup> , psi)
$P$	=	pitch at the appropriate radius divided by the propeller diameter (For controllable-pitch propellers, the nominal value of pitch is to be used)
$H$	=	maximum continuous power, kW (mhp, hp)
$N$	=	number of blades
$R$	=	rpm at the maximum continuous rating
$M$	=	ice torque, as defined in 6-1-2/29

#### 31.3.2 Blade Tip Thickness

The minimum blade thickness  $t_a$ , in mm (in.), at the tip of the blade ( $D/2$ ) is to be determined from the following equations:

*For Class IAA*

$$t_a = (a_1 + a_2D) \sqrt{a_3/U} \quad \text{mm (in.)}$$

For Classes **I A**, **I B**, and **I C**

$$t_a = (a_4 + a_2 D) \sqrt{a_3 / U} \text{ mm (in.)}$$

where

$$a_1 = 20 \text{ (20, 0.787)}$$

$$a_2 = 2 \text{ (2, 0.024)}$$

$$a_3 = 490 \text{ (50, 71,000)}$$

$$a_4 = 15 \text{ (15, 0.591)}$$

$$D = \text{propeller diameter, m (ft)}$$

$$U = \text{tensile strength of the propeller material, N/mm}^2 \text{ (kgf/mm}^2, \text{ psi)}$$

### 31.5 Additional Requirements

#### 31.5.1 Rule Required Thickness

Where the blade thickness derived from the equations in 6-1-2/31.3 is less than the required thickness detailed in 4-3-3/5.1 through 4-3-3/5.7, the latter is to be used.

#### 31.5.2 Other Sections

The thicknesses of propeller sections at radii intermediate to those required by 6-1-2/31.3 are to be determined from fair curves connecting the required section thicknesses.

#### 31.5.3 Blade Edges

The thickness of blade edges is not to be less than 50% of the required tip thickness  $t_a$  measured at a point  $1.25t_a$  from the leading edge for controllable-pitch propellers, and from each edge for solid propellers.

#### 31.5.4 Controllable-pitch Propeller Bosses (*1 September 2003*)

The strength of the internal mechanisms of controllable-pitch propellers is to be at least 1.5 times that of the blade when a load is applied at the radius  $0.9D/2$  in the weakest direction of the blade. Propellers subject to repeated impact loads will be specially considered.

#### 31.5.5 Materials

Propeller materials are to be in accordance with 4-3-3/3 and 2-3-13/5.

## 33 Shafting and Reduction Gears

### 33.1 Lineshafts and Thrust Shafts

The diameter of lineshafts and thrust shafts in external bearings as determined by the appropriate equation in 4-3-3/5.1 through 4-3-3/5.5 is to be increased by at least 10% for Class **I AA**. No strengthening is required for Classes **I A**, **I B** and **I C**.

### 33.3 Tail Shaft

The diameter  $T_s$  of the tail shaft at the aft bearing is not to be less than obtained from the following equation:

$$T_s = 1.08 \sqrt[3]{UWT^2 / Y}$$

where

- $T_s$  = required tail-shaft diameter, cm (in.)
- $U$  = tensile strength of the propeller material, N/mm<sup>2</sup> (kgf/mm<sup>2</sup>, psi)
- $WT^2$  = value derived for the propeller blade section at the 0.25 radius, see 6-1-2/31.3.1
- $Y$  = yield strength of the shaft material, N/mm<sup>2</sup> (kgf/mm<sup>2</sup>, psi)

If the diameter of the propeller boss is greater than 0.25D, the tailshaft diameter  $T_s$  is to be determined from the following equation:

$$T_s = 1.15 \sqrt[3]{UWT^2 / Y}$$

where

- $WT^2$  = propeller section value derived from 6-1-2/31.3.1

$T_s$ ,  $U$ ,  $Y$  are as defined above.

### 33.5 Intermediate shafts (1 September 2003)

The diameter of intermediate shafts and thrust shafts in external bearings are not to be less than:

$$d_i = 1.1 \cdot d_{Section\ 4-3-2} \quad \text{for ice class I AA.}$$

No strengthening is required for ice classes I A, I B and I C, i.e. Section 4-3-2 requirements for shaft diameters are to be used.

### 33.7 Reduction Gears

Pinions, gears, and gear shafts are to be designed to withstand an increase in torque over that normally required for ice-free service. The following ice corrected ( $T_i$ ) torque is to be utilized in Section 4-3-1 of the Rules.

$$T_i = T + C [M I_H R^2 / (I_L + I_H R^2)]$$

where

- $T_i$  = ice corrected torque, N-m (kgf-cm, lbf-in.) see *Note*
- $T$  = torque corresponding to maximum continuous power, N-m (kgf-cm, lbf-in.)
- $M$  = ice torque, as per 6-1-2/29, kN-m (tf-m, Ltf-ft.)
- $R$  = gear ratio (pinion rpm/gear wheel rpm)
- $I_H$  = sum of mass moment of inertia of machinery components rotating at higher rpm (drive side)
- $I_L$  = sum of mass moment of inertia of machinery components rotating at lower rpm (driven side) including propeller with an addition of 30% for water.
- $C$  = 1,000 (100,000, 26,880)

( $I_H$  and  $I_L$  are to be expressed in the same units)

*Note:* For Appendix 4-3-1A1, the horsepower transmitted should be increased to correspond to the ice corrected torque.

## **35 Additional Ice Strengthening Requirements**

### **35.1 Starting Arrangements**

The capacity of the air receivers required for reversible propulsion engines is to be sufficient for at least twelve consecutive starts and that for non-reversible propulsion engines is to be sufficient for six consecutive starts of each engine.

If the air receivers supply systems other than starting the propulsion engines, the additional capacity of the receivers is to be sufficient for continued operations of these systems after the capacity for the required number of consecutive engine starts has been used.

The capacity of the air compressors is to be sufficient for charging the air receivers from atmospheric to full pressure in one hour. For a vessel with ice class **IAA** that requires its propulsion engines to be reversed for astern operations, the compressors are to be able to charge the air receivers in half an hour.

### **35.3 Sea Inlet Chests for Cooling Water Systems and Fire Main (1995)**

The sea water system is to be designed to ensure a supply of water for the cooling water system and for at least one of the fire pumps when navigating in ice. For this purpose at least one sea water inlet chest is to be arranged as follows.

#### **35.3.1**

The sea inlet is to be situated near the centerline of the vessel and well aft if possible.

#### **35.3.2**

The sea chest volume is to be on the order of 1 cubic meter (35.3 cubic foot) for every 750 kW (1033 mhp; 1019 hp) propulsion engine output including the ship's service auxiliary engine output.

#### **35.3.3**

The sea chest is to be sufficiently high to allow ice to accumulate above the inlet pipe.

#### **35.3.4**

A cooling water discharge pipe line having full capacity discharge is to be connected to the sea chest.

#### **35.3.5**

The open area of the strainer plates is to be not less than four times the inlet pipe sectional area.

Where it is impractical to meet the requirements of 6-1-2/35.3.2 and 6-1-2/35.3.3 above, two smaller sea chests may be arranged for alternating the intake and discharge of the cooling water provided 6-1-2/35.3.1, 6-1-2/35.3.4 and 6-1-2/35.3.5 above are complied with.

Heating coils, if necessary, may be installed in the upper part of the chest or chests.

The use of ballast water for cooling purposes while in the ballast condition may be acceptable as an additional means but is not to be considered a permanent substitute for the above required sea inlet chest or chests.