RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part I Polar Class Ships and Ice Class Ships

RULES

2017 AMENDMENT NO.1

Rule No.29 1st June 2017

Resolved by Technical Committee on 30th January 2017

Approved by Board of Directors on 20th February 2017

An asterisk (*) after the title of a requirement indicates that there is also relevant information in the corresponding Guidance.

Rule No.29   1st June 2017
AMENDMENT TO THE RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

"Rules for the survey and construction of steel ships" has been partly amended as follows:

Title of Part I has been amended as follows.

Part I SHIPS OPERATING IN POLAR WATERS, POLAR CLASS SHIPS AND ICE CLASS SHIPS

Chapter 1 GENERAL

1.1 General

1.1.1 Application*

Sub-paragraph -4 has been amended as follows.

1 The requirements in this Part apply to ships intended for navigation in polar waters or ice-infested waters.
2 The materials, hull structures, equipment, machinery, etc. of ships operating in polar waters are to be in accordance with the requirements in **Chapter 1** to **Chapter 7** of this Part in addition to those in other Parts as well as the **Rules for Marine Pollution Prevention Systems**, **Rules for Safety Equipment** and **Rules for Radio Installations** relevant to such ships.
3 Notwithstanding the provision in **-2** above, ships corresponding to following **(1)** or **(2)** need not comply with the requirements in **Chapter 1** and **Chapter 7** of this Part.
(1) Ships not subject to the *SOLAS* convention in accordance with *SOLAS Chapter I*; and
(2) Ships owned or operated by the flag administration and used for non-commercial purposes.
4 Ships intended ~~to be registered as polar class vessels~~ for independent navigation in ice-infested polar waters (hereinafter referred to as "polar class ship" in this Part), ~~as defined in **1.2.1(20)**,~~ are to comply with **Annex 1** "**Special Requirements for the Materials, Hull Structures, Equipment and Machinery of Polar Class Ships**" in addition to requirements in other parts.
5 Where a ship is intended to be registered as an ice class vessel (hereinafter referred to as "ice class ship" in this Part) for navigation of the Northern Baltic complying with the *Finnish-Swedish Ice Class Rules 2010* or in the Canadian Arctic complying with the *Arctic Shipping Pollution Prevention Regulations*, the materials, hull structures, equipment and machinery of the ship are to be in accordance with the requirements in **Chapter 1** except for **1.3** to **1.5** and **Chapter 8** of this Part in addition to those in other Parts.

1.2 Definitions

1.2.1 Terms*

Sub-paragraph (24) has been amended as follows.

The definitions of terms which appear in this Part are to be as specified in the following **(1)** to **(27)**, unless specified elsewhere.

(24) "Lower ice waterline" (*LIWL*) is defined by the minimum draughts fore, amidships and aft when sailing in ice covered waters. The *LIWL* is determined with due regard to the vessel's ice-going capability in ballast loading conditions ~~(*e.g.* propeller submergence)~~. The propeller is to be fully submerged at the lower ice waterline.

ANNEX 1 SPECIAL REQUIREMENTS FOR THE MATERIALS, HULL STRUCTURES, EQUIPMENT AND MACHINERY OF POLAR CLASS SHIPS

Chapter 1 GENERAL

1.1 General

Paragraph 1.1.1 has been amended as follows.

1.1.1 Application

1 This Annex are to be applied to materials, constructions, equipment and machineries of polar class ships in accordance with **1.1.1-4**, **3.3**, **Part I of the Rules** and **I7.3.3**, **Part I of the Guidance**.

2 For polar class ships, the hull form and propulsion power are to be such that the ship can operate independently and at continuous speed in a representative ice condition, as defined in **Table 1.2.2-1** for the corresponding Polar Class. In cases where this Annex applies to ships and ship-shaped units which are intentionally not designed to operate independently in ice, such operational intent or limitations are to be explicitly stated in the Certificate of Classification.

3 For *PC*1 through *PC*5 polar class ships, bows with vertical sides and bulbous bows are generally to be avoided. Bow angles are to, in general, be within the range specified in **3.1.1-1**.

4 For *PC*6 and *PC*7 polar class ships designed with a bow with vertical sides or bulbous bows, operational limitations (restricted from intentional ramming, refer to **3.1.2-2**) in design conditions are to be stated in the Certificate of Classification.

1.2 Definitions

Paragraph 1.2.2 has been amended as follows.

1.2.2 Polar Classes

1 Polar Class is classified into the seven classes given in **Table 1.2.2-1**. It is the responsibility of the Owner to determine which class in **Table 1.2.2-1** is most suitable for his requirement.

2 If the hull and machinery are constructed such as to comply with the requirements of different polar classes, then both the hull and machinery are to 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 is also to be indicated in the ~~Classification Register~~ Certificate of Classification.

3 Polar class ships having powering and dimensions that allow it to undertake aggressive operations in ice-covered waters and complying with the relevant requirements of this annex are given the additional notation "*Icebreaker*" (abbreviated to *ICB*) to Polar Class notation.

Table 1.2.2-1 Polar Classes

Polar Class	Symbol	Ice description
Polar Class 1	*PC*1	Year-round operation in all Polar waters
Polar Class 2	*PC*2	Year-round operation in moderate multi-year ice condition
Polar Class 3	*PC*3	Year-round operation in second-year ice which may include multi-year ice inclusion
Polar Class 4	*PC*4	Year-round operation in thick first-year ice which may include multi-year and/or second-year ice inclusion
Polar Class 5	*PC*5	Year-round operation in medium first-year ice which may include multi-year and/or second-year ice inclusion
Polar Class 6	*PC*6	Summer/autumn operation in medium first-year ice which may include multi-year and/or second-year ice inclusions
Polar Class 7	*PC*7	Summer/autumn operation in thin first-year ice which may include multi-year and/or second-year ice inclusions

Notes:

Multi-year ice, second-year ice and first-year ice are based on WMO (World Meteorological Organization) Sea Ice Nomenclature.

Multi-year ice: old ice which has survived at least two summer's melt

Second-year ice: Sea ice which has survived only one summer's melt

First-year ice: Sea ice of not more than one winter's growth, developing from young ice

Thick first-year ice: first-year ice of about 120-250 *cm* in thickness and which has a high strength. Only when strong pressure is received, this ice forms an ice hill of about 150-250 *cm* in height.

Medium first-year ice: first-year ice of about 70-120 *cm* in thickness. In the ice water regions other than Polar Regions, this kind of one-year ice is a limit stage of growth, and it is formed in the severest winter. In this kind of ice, there might be a lot of intersecting ice hills, and the height of the ice hill reaches 170 *cm*. This kind of ice melts in summer and disappears almost completely.

Thin first-year ice: first-year ice of about 30-70 *cm* in thickness. In this kind of ice, there might be straight ice hills, and the height of the ice hill reaches 30-75 *cm* on the average. Thin first-year ice may be subdivided to the thin fires-year in the first stage (30-50 *cm* in thickness) and second stages (50-70 *cm* in thickness).

Paragraph 1.2.3 has been amended as follows.

1.2.3 Hull Areas

The hull areas are defined as areas reflecting the magnitude of the loads that are expected to act upon them, and divided into the following (see **Fig. 1.2.3-1**). ~~If a ship with special ice breaking aft construction and propulsion system is intended to operate astern in ice-infested water, the hull areas of the aft structures are to be deemed appropriate by the Society.~~ If a polar class ship that installed special icebreaking stern structure and propulsion unit intended to operate astern in ice regions, the hull area of the ship is to refer to **Fig. 1.2.3-2**.

(1) Bow area

(a) Bow area of *PC*1, *PC*2, *PC*3 and *PC*4 polar class ships

"Bow area" is defined as the hull area which is located forward of the intersection point of the *UIWL* and the line with a waterline angle (as defined in **1.2.4**) of 10 *degrees* at the *UIWL* (hereinafter referred to as "the aft boundary of the Bow area"), and below the line connecting the point 1.5 *m* above the *UIWL* at the aft boundary of the Bow area and the point 2.0 *m* above the *UIWL* at the stem.

(b) Bow area of *PC*5, *PC*6 and *PC*7 polar class ships

"Bow area" is defined as the hull area which is located forward of the intersection point of the *UIWL* and the line with a waterline angle (as defined in **1.2.4**) of 10 *degrees* at the *UIWL*, and below the line connecting the point 1.0*m* above the *UIWL* at the aft boundary of the Bow area and the point 2.0*m* above the *UIWL* at the stem.

Notwithstanding the provision in (a) and (b), the aft boundary of the Bow area is not to be forward of the intersection point of the extended line of the stem frame and the baseline of the ship. In addition, the aft boundary of the Bow area need not be more than 0.45 times L_{UIWL} (length of the ship at the *UIWL*) aft of the *F.P.*

(2) Bow Intermediate area

(a) Bow Intermediate area of *PC*1, *PC*2, *PC*3 and *PC*4 polar class ships with

"Bow Intermediate area" is defined as the hull area which is located aft of the aft boundary of the Bow area, and forward of the vertical line $0.04L_{UIWL}$ aft of the point on the *UIWL* where the waterline angle is 0 *degrees* (hereinafter referred to as "the aft boundary of the Bow Intermediate area"), and below the line 1.5 *m* above the *UIWL*.

(b) Bow Intermediate area of *PC*5, *PC*6 and *PC*7 polar class ships with

"Bow Intermediate area" is defined as the hull area which is located aft of the aft boundary of the Bow area, and forward of the vertical line $0.04L_{UIWL}$ aft of the point on the *UIWL* where the waterline angle is 0 *degrees*, and below the line 1.0 *m* above the *UIWL*.

(3) Stern area

(a) Stern area of *PC*1, *PC*2, *PC*3 and *PC*4 polar class ships with

"Stern area" is defined as the hull area aft of the *A.P.* to the vertical line located 70% of the distance from the *A.P.* forward the maximum breadth point at the *UIWL* (hereinafter referred to as "the fore boundary of the Stern area"), and below the line 1.5 *m* above the *UIWL*.

(b) Stern area of *PC*5, *PC*6 and *PC*7 polar class ships

"Stern area" is defined as the hull area aft of the *A.P.* to the vertical line located 70% of the distance from the *A.P.* forward the maximum breadth point at the *UIWL*, and below the line 1.0 *m* above the *UIWL*.

However, the distance from the *A.P.* to the fore boundary of the Stern area is not to be less than 0.15 times L_{UIWL}. If the ship is assigned the additional notation "*Icebreaker*" (abbreviated to *ICB*), the forward boundary of the stern region is to be at least $0.04L$ forward of the section where the parallel ship side at the *UIWL* ends.

(4) Midbody area

(a) Midbody area of *PC*1, *PC*2, *PC*3 and *PC*4 polar class ships with

"Midbody area" is defined as the hull area which is located aft of the aft boundary of the Bow Intermediate area, and forward of the fore boundary of the Stern area, and below the line 1.5 *m* above the *UIWL*.

(b) Midbody area of *PC*5, *PC*6 and *PC*7 polar class ships

"Midbody area" is defined as the hull area which is located aft of the aft boundary of the Bow Intermediate area, and forward of the fore boundary of the Stern area, and below the line 1.0 *m* above the *UIWL*.

(5) Bottom area

"Bottom area" is defined as the hull area which is located inside the line circumscribed by the points where the bottom shell is inclined 7 *degrees* from horizontal (hereinafter referred to as "the upper boundary of the Bottom area") in the Bow Intermediate area, the Midbody area and the Stern area.

(6) Lower area

"Lower area" is defined as the hull area which is located upside of the upper boundary of the Bottom area, and below the line 1.5*m* below the *LIWL* (hereinafter referred to as "the upper boundary of the Lower area") in the Bow Intermediate area, the Midbody area and the Stern area.

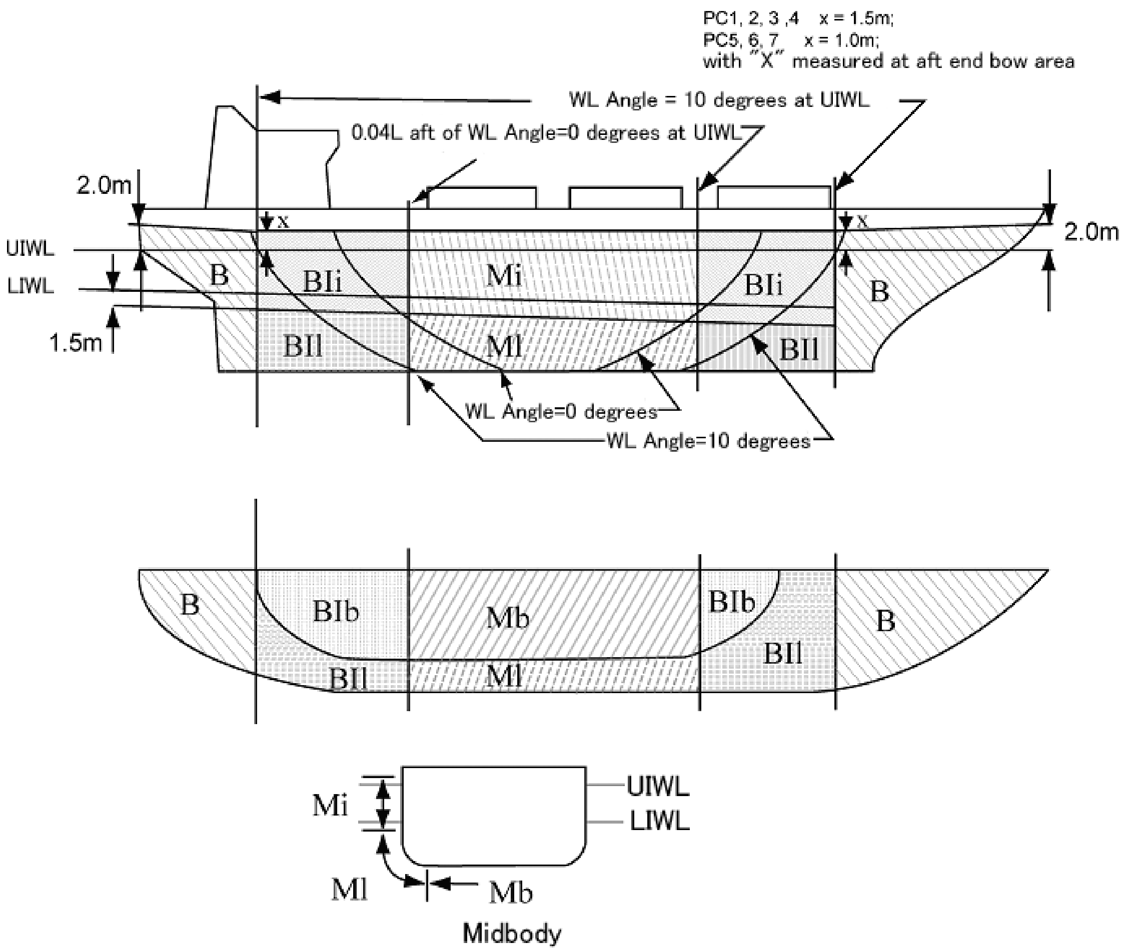
(7) Icebelt area

For *PC*1, *PC*2, *PC*3 and *PC*4 polar class ships, “Icebelt area” is defined as the hull area which is located upside of the upper boundary of the Lower area, and below the line 1.5*m* above the *LIWL* in the Bow Intermediate area, the Midbody area and the Stern area.

For *PC*5, *PC*6 and *PC*7 polar class ships, “Icebelt area” is defined as the hull area which is located upside of the upper boundary of the Lower area, and below the line 1.0*m* above the *LIWL* in the Bow Intermediate area, the Midbody area and the Stern area.

Title of Fig. 1.2.3-2 has been amended as follows.

Fig. 1.2.3-2 Hull Area <u>for polar class ship intended to operate astern in ice regions</u>



Notes:
Symbols in the figure are as follows:
B: Bow Area
BIi: Bow Intermediate Icebelt Area
BIl: Bow Intermediate Lower Area
BIb: Bow Intermediate Bottom Area
Mi: Midbody Icebelt Area
Ml: Midbody Lower Area
Mb: Midbody Bottom

Chapter 2 MATERIALS AND WELDING

2.1 Material

2.1.2 Material Classes and Grades*

1 Material classes and grades used for the hull structure are given in **Table 2.1.2-1** to **Table 2.1.2-4**.

2 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 class ships are given in **Table 2.1.2-5**.

3 For polar class ships designed base on a designated design temperature, the steels used for hull structures are to comply with the requirements in **1.1.12, Part C of the Rules**. However, regardless of the design temperature, the steel grades are not to be of lower than the steel grade provided in **Part I of the Rules**.

4 The steel grade of rolled steels with a thickness of 50 *mm* or more and/or a minimum upper yield stress of 390 N/mm^2 or more is deemed appropriate by the Society.

5 Where stainless clad steel is used for hull structure, **Table 2.1.3-1** ~~to~~ and **Table 2.1.3-~~3~~2** are to apply according to thickness of the base metal in lieu of thickness of the plates.

Table 2.1.2-1 has been amended as follows.

Table 2.1.2-1 Material Classes for Structural Members in general

Structural Member Category	Material Class/Grade
SECONDARY: A1. Longitudinal bulkhead strakes, other than that belonging to the Primary category A2. Deck plating exposed to weather, other than that belonging to the Primary or Special category A3. Side plating	-Class I within 0.4*L* amidships -Grade *A*/*AH* (~~2~~3) outside 0.4*L* amidships
PRIMARY: B1. Bottom plating, including keel plate B2. Strength deck plating, excluding that belonging to the Special category B3. Continuous longitudinal members above strength deck, excluding hatch coamings B4. Uppermost strake in longitudinal bulkhead B5. Vertical strake (hatch side girder) and uppermost sloped strake in top wing tank	-Class II within 0.4*L* amidships -Grade *A*/*AH* (~~2~~3) outside 0.4*L* amidships
SPECIAL C1. Sheer strake at strength deck (~~1~~2) C2. Stringer plate in strength deck (~~1~~2) C3. Deck strake at longitudinal bulkhead, excluding deck plating in way of inner-skin bulkhead of double-hull ships(~~1~~2)	-Class III within 0.4*L* amidships -Class II outside 0.4*L* amidships -Class I outside 0.6*L* amidships
C4. Strength deck plating at outboard corners of cargo hatch openings in container carriers and other ships with similar hatch opening configuration	-Class III within 0.4*L* amidships -Class II outside 0.4*L* amidships -Class I outside 0.6*L* amidships -Min. Class III within cargo region
C5. Strength deck plating at corners of cargo hatch openings in bulk carriers, ore carriers, combination carriers and other ships with similar hatch opening configuration	-Class III within 0.6*L* amidships -Class II within rest of cargo region
C6. Bilge strake in ships with double bottom over the full breadth and length less than 150 *m*(~~1~~2)	-Class II within 0.6*L* amidships -Class I outside 0.6*L* amidships
C7. Bilge strake in other ships (~~1~~2)	-Class III within 0.4*L* amidships -Class II outside 0.4*L* amidships -Class I outside 0.6*L* amidships
C8. Longitudinal hatch coamings of length greater than 0.15*L* C9. End brackets and deck house transition of longitudinal cargo hatch openings	-Class III within 0.4*L* amidships -Class II outside 0.4*L* amidships -Class I outside 0.6*L* amidships -Not to be less than Grade *D*/*DH* (~~3~~4)

Notes:

(1) Shell strakes in way of hull areas specified in **1.2.3** for plates are not to be less than Grade *B*/*AH*.

(~~1~~2) Single strakes required to be of class III within 0.4*L* amidships are to have breadths not less than 5*L*+800 *mm*, need not be greater than 1,800 *mm*, unless limited by the geometry of the ship's design.

(~~2~~3) *A* means *KA*, *AH* means *KA*32 ~~or~~, *KA*36 or *KA*40

(~~3~~4) *D* means *KD*, *DH* means *KD*32 ~~or~~, *KD*36 or *KD*40

Note of Table 2.1.2-2 has been amended as follows.

Table 2.1.2-2 Minimum Material Grades for ships with length exceeding 150 *m* and single strength deck

Structural Member Category	Material Grade
Longitudinal strength members of strength deck plating	Grade *B*/*AH*(1) within 0.4*L* amidships
Continuous longituginal strength members above strength deck	Grade *B*/*AH*(1) within 0.4*L* amidships
Single side strakes for ships without inner continuous longituginal bulkhead(s) between bottom and the strength deck	Grade *B*/*AH*(1) within cargo region

Note:

(1) *B* means *KB*, *AH* means *KA*32 ~~or~~, *KA*36 or *KA*40

Notes of Table 2.1.2-3 have been amended as follows.

Table 2.1.2-3 Minimum Material Grades for ships with length exceeding 250 *m*

Structural Member Category	Material Grade
Shear strake at strength deck(1)	Grade *E*/*EH*(2) within 0.4*L* amidships
Stringer plate in strength deck(1)	Grade *E*/*EH*(2) within 0.4*L* amidships
Bilge strake(1)	Grade *D*/*DH*(3) within 0.4*L* amidships

Notes:

(1) Single strakes required to be of Grade *E*/*EH* and within 0.4*L* amidships are to have breadths not less than 5*L*+800 *mm*, need not be greater than 1,800 *mm*, unless limited by the geometry of the ship's design.

(2) *E* means *KE*, *EH* means *KE*32 ~~or~~, *KE*36 or *KE*40

(3) *D* means *KD*, *DH* means *KD*32 ~~or~~, *KD*36 or *KD*40

Notes of Table 2.1.2-4 have been amended as follows.

Table 2.1.2-4 Minimum Material Grades for ships of *BC-A* and *BC-B*

Structural Member Category	Material Grade
Lower bracket of ordinary side frame(1)(2)	Grade *D*/*DH*(3)
Side shell strakes included totally or partially between the two points located to 0.125*l* above and below the intersection of side shell and bilge hopper sloping plate or inner bottom plate(2)	Grade *D*/*DH*(3)

Notes:

(1) The term "lower bracket" means webs of lower brackets and webs of the lower part of side frames up to the point of 0.125*l* above the intersection of side shell and bilge hopper sloping plate or inner bottom plate.

(2) The span of the side frame, *l*, is defined as the distance between the supporting structures.

(3) *D* means *KD*, *DH* means *KD*32 ~~or~~, *KD*36 or *KD*40

2.1.3 Steel Grade

Sub-paragraph -3 has been deleted.

1 Steel grades for all plating and attached framing of hull structures and appendages situated below the level of 0.3 *m* below the *LIWL*, are to be obtained from **Table 2.1.3-1** based on the Material Classes for Structural members in **Table 2.1.2-1** to **Table 2.1.2-5** above, regardless of polar classes.

2 Steel grades for all weather exposed plating of hull structures and appendages situated above the level of 0.3 *m* below the *LIWL* are to be not less than that given in **Table 2.1.3-2** based on the

Material Class for Structural Members in **Table 2.1.2-1** to **Table 2.1.2-5** above, regardless of polar class.

~~**3** Steel grades for all inboard framing members attached to weather exposed plating are not to be less than that given in **Table 2.1.3-3**. This applies to all inboard framing members as well as to other contiguous inboard members (*e.g.* bulkheads, decks) within 600 *mm* of the exposed plating.~~

Notes of Table 2.1.3-1 have been added as follows.

Table 2.1.3-1 Steel Grades for Plating and attached Framing below the Level of 0.3*m* below the *LIWL*

	Material Class I		Material Class II		Material Class III	
Thickness *t* (*mm*)	*MS*	*HT*	*MS*	*HT*	*MS*	*HT*
$t \le 15$	*A*	*AH*	*A*	*AH*	*A*	*AH*
$15 < t \le 20$	*A*	*AH*	*A*	*AH*	*B*	*AH*
$20 < t \le 25$	*A*	*AH*	*B*	*AH*	*D*	*DH*
$25 < t \le 30$	*A*	*AH*	*D*	*DH*	*D*	*DH*
$30 < t \le 35$	*B*	*AH*	*D*	*DH*	*E*	*EH*
$35 < t \le 40$	*B*	*AH*	*D*	*DH*	*E*	*EH*
$40 < t \le 50$	*D*	*DH*	*E*	*EH*	*E*	*EH*

Notes:

(1) Shell strakes in way of hull areas specified in **1.2.3** for plates are not to be less than Grade *B*/*AH*.

(2) *A*, *B*, *D*, *E*, *AH*, *DH* and *EH* mean following steel grades;

A: *KA*

B: *KB*

D: *KD*

E: *KE*

AH: *KA*32, *KA*36 or *KA*40

DH: *KD*32, *KD*36 or *KD*40

EH: *KE*32, *KE*36 or *KE*40

Table 2.1.3-2 has been amended as follows.

Table 2.1.3-2 Steel Grades for Weather Exposed Plating

Thickness, *t* (*mm*)	Material Class I				Material Class II				Material Class III					
	*PC*1-5		*PC*6&7		*PC*1-5		*PC*6&7		*PC*1-3		*PC*4&5		*PC*6&7	
	MS	*HT*	*MS*	*HT*	*MS*	*HT*	*MS*	*HT*	*MS*	*HT*	*MS*	*HT*	*MS*	*HT*
$t \le 10$	*B*	*AH*	*B*	*AH*	*B*	*AH*	*B*	*AH*	*E*	*EH*	*E*	*EH*	*B*	*AH*
$10 < t \le 15$	*B*	*AH*	*B*	*AH*	*D*	*DH*	*B*	*AH*	*E*	*EH*	*E*	*EH*	*D*	*DH*
$15 < t \le 20$	*D*	*DH*	*B*	*AH*	*D*	*DH*	*B*	*AH*	*E*	*EH*	*E*	*EH*	*D*	*DH*
$20 < t \le 25$	*D*	*DH*	*B*	*AH*	*D*	*DH*	*B*	*AH*	*E*	*EH*	*E*	*EH*	*D*	*DH*
$25 < t \le 30$	*D*	*DH*	*B*	*AH*	*E*	*EH*(1)	*D*	*DH*	*E*	*EH*	*E*	*EH*	*E*	*EH*
$30 < t \le 35$	*D*	*DH*	*B*	*AH*	*E*	*EH*	*D*	*DH*	*E*	*EH*	*E*	*EH*	*E*	*EH*
$35 < t \le 40$	*D*	*DH*	*D*	*DH*	*E*	*EH*	*D*	*DH*	-(2)	*FH*	*E*	*EH*	*E*	*EH*
$40 < t \le 45$	*E*	*EH*	*D*	*DH*	*E*	*EH*	*D*	*DH*	-(2)	*FH*	*E*	*EH*	*E*	*EH*
$45 < t \le 50$	*E*	*EH*	*D*	*DH*	*E*	*EH*	*D*	*DH*	-(2)	*FH*	-(2)	*FH*	*E*	*EH*

Notes:

(1) 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.

(2) *MS* is not to be used.

(3) *B*, *D*, *E*, *AH*, *DH*, *EH* and *FH* mean following steel grades;

B: *KB*
D: *KD*
E: *KE*
AH: *KA*32, *KA*36 or *KA*40
DH: *KD*32, *KD*36 or *KD*40
EH: *KE*32, *KE*36 or *KE*40
FH: *KF*32, *KF*36 or *KF*40

Table 2.1.3-3 has been deleted.

~~Table 2.1.3-3 Steel Grades for Inboard Framing Members Attached to Weather Exposed Plating~~

~~Thickness, *t* (*mm*)~~	~~*PC*1-5~~		~~*PC*6&7~~	
	~~*MS*~~	~~*HT*~~	~~*MS*~~	~~*HT*~~
~~$t \le 20$~~	~~*B*~~	~~*AH*~~	~~*B*~~	~~*AH*~~
~~$20 < t \le 35$~~	~~*D*~~	~~*DH*~~	~~*B*~~	~~*AH*~~
~~$35 < t \le 45$~~	~~*D*~~	~~*DH*~~	~~*D*~~	~~*DH*~~
~~$45 < t \le 50$~~	~~*E*~~	~~*EH*~~	~~*D*~~	~~*DH*~~

~~Note:~~

~~In **Table 2.1.3-1**, **Table 2.1.3-2** and **Table 2.1.3-3**, *MS* means mild steel, *HT* means high tensile steel, *A*, *B*, *D*, *E* and *AH*, *DH*, *EH*, *FH* mean the grades of steel as follows :~~

~~*A*: *KA*~~
~~*B*: *KB*~~
~~*D*: *KD*~~
~~*E*: *KE*~~
~~*AH*: *KA*32 and/or *KA*36~~
~~*DH*: *KD*32 and/or *KD*36~~
~~*EH*: *KE*32 and/or *KE*36~~
~~*FH*: *KF*32 and/or *KF*36~~

Chapter 3 has been amended as follows.

Chapter 3 HULL STRUCTURE

3.1 Application

3.1.1 General

~~**1** Design ice loads specified in this Chapter are applied to polar class ships with icebreaking forms.~~

~~**2** Design ice loads for any other bow forms are to be specially considered at the Society's discretion.~~

1 Design ice forces calculated according to **3.3.1-1(3)** are applicable for bow forms where the buttock angle γ at the stem is positive and less than 80 degrees, and the normal frame angle β' at the centre of the foremost sub-region, as defined in **Fig. 3.3.2-1**, is greater than 10 degrees.

2 Design ice forces calculated according to **3.3.1-1(4)** are applicable for *PC*6 or *PC*7 polar class ships having a bow form with vertical sides. This includes bows where the normal frame angles β' at the considered sub-regions, as defined in **Fig. 3.3.2-1**, are between 0 and 10 degrees.

3 For *PC*6 or *PC*7 polar class ships equipped with bulbous bows, the design ice forces on the bow are to be determined according to **3.3.1-1(4)**. In addition, the design forces are not to be taken less than those given in **3.3.1-1(3)**, assuming fa = 0.6 and AR = 1.3.

4 For ships with bow forms other than those defined in **-1** to **-3** above, design forces are to be specially considered by the Society.

3.1.2 Load Scenario

1 The design ice load provided in ~~this Chapter~~ **3.3** is based on the collision load scenario, i.e., a glancing impact on the bow and determined in consideration of the following **(1)** to **(4)**.

(1) 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.

(2) Within the Bow area of all polar classes, and within the Bow Intermediate Icebelt area of *PC*6 and *PC*7 polar class ships, 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 fa_i, total glancing impact force F_i, line load Q_i and pressure P_i.

(3) In other ice-strengthened areas (within Midbody and Stern, Bow Intermediate Lower and Bow Intermediate Bottom areas of all polar classes, and within the Bow Intermediate Icebelt area of *PC*1, *PC*2, *PC*3, *PC*4 and *PC*5 polar class ships), 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.

(4) 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 by each member society, are to be considered in the design of these structures.

2 The longitudinal strength requirements given in **3.5** are based upon a ramming scenario. Intentional ramming is not considered as a design scenario for ships which are designed with vertical or bulbous bows, see **1.1.1-4**. Hence the longitudinal strength requirements given in **3.5** are not to be applied to ships with stem angle γ stem equal to or larger than 80 degrees.

3.2 Subdivision and Stability

3.2.1 Intact Stability*

1 Intact stability of all polar class ships is to meet the requirements in **Part U of the Rules**. In addition, stability calculation is to be carried out to demonstrate the following **(1)** and **(2)**. The effect of icing on the weather exposed area is to be taken into account in the stability calculation.

(1) During a disturbance causing roll, pitch, heave or heel due to turning or any other cause, sufficient positive stability is to be maintained.

(2) When riding up on ice and remaining momentarily poised at the lowest stem extremity, sufficient positive stability is to be maintained.

Sufficient positive stability means that the ship is in a positive state of equilibrium with a positive metacentric height of at least 150*mm*, and a line 150*mm* below the edge of the freeboard deck as defined in **Part V of the Rules**, is not submerged.

2 The stability in the state of riding up onto the ice is to be calculated by the procedure deemed appropriate by the Society.

3 For polar class ships without the capability of ride up on ice which is accepted by the Society, the stability calculation specified in **-1(2)** may be dispensed with taking into account the service features and hull forms, etc.

4 When the stability calculation of the polar class ship is performed, it is necessary to consider the influence due to icing up at least given in the following **(1)** and **(2)**.

(1) The icing up condition of $30 kg/m^2$ or more is to be considered for the horizontal area on the weather exposed deck.

(2) The icing up condition of $7.5 kg/m^2$ or more is to be considered for the vertical area of weather exposed deck.

5 In case where a more severe icing up is assumed, the designer is to decide the icing up condition used for the stability calculation.

Ships are to have sufficient stability in intact conditions when subject to ice accretion. Accordingly, the following **(1)** and **(2)** are to apply:

(1) For ships operating in areas and during periods where ice accretion is likely to occur, the following icing allowance is to be made in the stability calculations:
   - (a) $30\ kg/m^2$ on exposed weather decks and gangways;
   - (b) $7.5\ kg/m^2$ for the projected lateral area of each side of the ship above the water plane; and the projected lateral area of discontinuous surfaces of rail, sundry booms, spars (except masts) and rigging of ships having no sails and the projected lateral area of other small objects is to be computed by increasing the total projected area of continuous surfaces by 5% and the static moments of this area by 10%.

(2) Ships operating in areas and during periods where ice accretion is likely to occur are to be:
   - (a) designed to minimize the accretion of ice; and
   - (b) equipped with such means for removing ice as the Society may require; for example, electrical and pneumatic devices, and/or special tools such as axes or wooden clubs for removing ice from bulwarks, rails and erections.

3.2.2 Stability in Damaged Condition

1 All polar class ships are to have sufficient stability to withstand flooding resulting from hull

penetration due to ice damage of the extent specified in the following **(1)** to **(4)**.
(1) Longitudinal extent 0.045 of the *UIWL* length, if centered forward of the point of maximum beam on the *UIWL*.
(2) Longitudinal extent 0.015 of the *UIWL* length, if centered backwards of the point of maximum beam on the *UIWL*.
(3) Vertical extent the lesser of 0.2 of deepest ice draught, or of longitudinal extent.
(4) Depth 760*mm* measured normal to the shell over the full extent of the damage.
2 The centre of the ice damage is to be assumed to be located at any point between the keel and 1.2 times the deepest ice draught.
3 For *PC*5, *PC*6 and *PC*7 polar class ships not carrying polluting or hazardous cargoes, damage may be assumed to be confined between watertight bulkheads, except where such bulkheads are spaced at less than the damage dimensions.

Ships are to be able to withstand flooding resulting from hull penetration due to ice impact, of which the damage extent is to be in accordance with the following **(1)** to **(3)**. The residual stability following ice damage is to be such that the factor s_i, as defined in **4.2.3-1**, **Part C** or **4.2.3-1**, **Part CS**, is equal to one for all loading conditions used to calculate the attained subdivision index *A* in **4.2.1-2**, **Part C** or **4.2.1-2**, **Part CS**. However, for cargo ships that comply with subdivision and damage stability regulations, the residual stability criteria of that instrument is to be met for each loading condition.
(1) the longitudinal extent is 0.045 times the upper ice waterline length if centred forward of the maximum breadth on the upper ice waterline, and 0.015 times the upper ice waterline length otherwise, and are to be assumed at any longitudinal position along the ship's length;
(2) the transverse penetration extent is 760 *mm*, measured normal to the shell over the full extent of the damage; and
(3) the vertical extent is the lesser of 0.2 times the upper ice waterline draught or the longitudinal extent, and is to be assumed at any vertical position between the keel and 1.2 times the upper ice waterline draught.

3.3 Subdivision

3.3.1 General

The subdivision of polar class ships is to be applied in **3.3**, in addition to complying with the requirements in other Parts and related Conventions.

3.3.2 Double Bottom

1 All polar class ships are to have double bottoms over the breadth and the length between forepeak and aft peak bulkheads.
2 All polar class ships with icebreaking bow forms and short forepeaks may dispense with double bottoms up to the forepeak bulkhead in the area of the inclined stem, provided that the watertight compartments between the forepeak bulkhead and the bulkhead at the junction between the stem and the keel are not used to carry pollutants.

3.3.3 Carriage of Pollutants

1 No polar class ship is to carry any pollutant directly against the outer shell.
2 Any pollutant is to be separated from the outer shell of the ship by double skin construction of at least 760*mm* in width.

3 Double bottoms in PC6 and PC7 polar class ships with may be used for the carriage of any working liquids where the tanks are aft of midship and within the flat of the bottom. However, it is not permitted when it is prohibited by the requirements in other Parts and related Conventions.

3.43 Design Ice Load

3.43.1 Glancing Impact Load Characteristics

The parameters defining the glancing impact load characteristics are reflected in the Class Factors listed in **Table 3.4.1-1**.

3.4.2 Bow Area

1 Bow area

1(1) In the Bow area for all polar class ships and the Bow Intermediate Icebelt area for *PC6* and *PC7* polar class ships, the force *F*, line load *Q*, pressure *P* and load patch aspect ratio *AR* associated with the glancing impact load scenario are functions of the hull angles measured at the *UIWL*. The influence of the hull angles is captured through calculation of a bow shape coefficient f_a. The hull angles are defined in **Fig. 3.43.2-1**.

2(2) The waterline length of the bow region is generally to be divided into 4 sub-regions of equal length. The force *F*, line load *Q*, pressure *P* and load patch aspect ratio *AR* are to be calculated with respect to the mid-length position of each sub-region (each maximum of *F*, *Q* and *P* is to be used in the calculation of the ice load parameters P_{avg}, *b* and *w*).

(3) The Bow area load characteristics for bow forms defined in **3.1.1-1** are determined as follows:

3(a) Shape coefficient fa_i is to be taken as the minimum value obtained from the following two formulas. However, when the shape coefficient fa_i is 0.6 or more, it is taken to be 0.6.

$$fa_{i,1} = \left\{0.097 - 0.68\left(\frac{x}{L'} - 0.15\right)^2\right\}\frac{\alpha_i}{\sqrt{\beta_i'}}$$

$$fa_{i,2} = \frac{1.2CF_F}{\sin(\beta_i')CF_C(\frac{\Delta_1}{1000})^{0.64}}$$

where

i :sub-region considered

L' :ship length (m) measured on the *UIWL* from the forward side of the stem to the after side of the rudder post, or the centre of the rudder stock if there is no rudder post. L' is to be not less than 96% and need not exceed 97% of the extreme length on the *UIWL*.

x :distance (m) from the forward perpendicular to station under consideration

α :waterline angle (deg), see **Fig. 3.4.2-1**

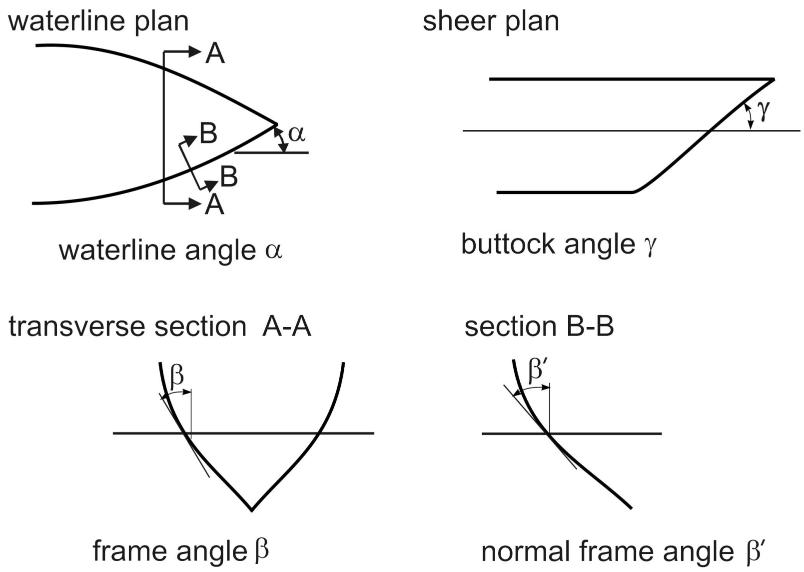
β' :normal frame angle (deg), see **Fig. 3.4.2-1**

Δ_1 :ship displacement (t) at the *UIWL*, not to be taken as less than 5,000t

CF_C :Crushing Failure Class Factor from **Table 3.4.1-1**

CF_F :Flexural Failure Class Factor from **Table 3.4.1-1**

Fig. 3.~~4~~3.2-1 Definition of Hull Angles



Notes :

β' : normal frame angle (*deg*) at the *UIWL*

α : upper ice waterline angle (*deg*)

γ : buttock angle (*deg*) at the *UIWL* (angle of buttock line measured from horizontal)

$\tan(\beta) = \tan(\alpha)/\tan(\gamma)$

$\tan(\beta') = \tan(\beta)\cos(\alpha)$

~~4~~(b) Force F is to be obtained from the following formula.

$$F_i = fa_i CF_C \left(\frac{\Delta_1}{1000}\right)^{0.64} \times 1000 \quad (kN)$$

~~where~~

~~i : sub-region considered~~

~~fa_i : shape coefficient of sub-region i, see **-3**~~

~~CF_C : Crushing Failure Class Factor from **Table 3.4.1-1**~~

~~Δ_1 : ship displacement (t), not to be taken as less than 5,000t~~

~~5~~(c) Load patch aspect ratio AR_i is to be obtained from the following formula, however, when load patch aspect ratio AR_i is less than 1.3, it is taken to be 1.3.

$$AR_i = 7.46 \sin(\beta'_i)$$

~~where~~

~~i : sub-region considered~~

~~β'_i : normal frame angle (*deg*) of sub-region i~~

~~6~~(d) Line load Q is to be obtained from the following formula.

$$Q_i = \left(\frac{F_i}{1000}\right)^{0.61} \frac{CF_D}{AR_i^{0.35}} \times 1000 \quad (kN/m)$$

~~where~~

~~i : sub-region considered~~

~~F_i and AR_i : the values specified in **-4** and **-5**, respectively~~

~~CF_D : Load Patch Dimensions Class Factor from **Table 3.4.1-1**~~

7(e) Pressure P is to be obtained from the following formula:

$$P_i = \left(\frac{F_i}{1000}\right)^{0.22} CF_D^{\ 2} AR_i^{\ 0.3} \times 1000 \quad (kN/m^2)$$

where

i : sub-region considered

CF_D : Load Patch Dimensions Class Factor from **Table 3.4.1-1**

F_i and AR_i : the values specified in -4 and -5, respectively

where

i :sub-region considered

L' :ship length (m) measured on the *UIWL* from the forward side of the stem to the after side of the rudder post, or the centre of the rudder stock if there is no rudder post. L' is to be not less than 96% and need not exceed 97% of the extreme length on the *UIWL*.

x :distance (m) from the forward perpendicular to station under consideration

α :waterline angle (deg), see **Fig. 3.3.2-1**

β' :normal frame angle (deg), see **Fig. 3.3.2-1**

Δ_1 :ship displacement (t) at the *UIWL*, not to be taken as less than 5,000 t

CF_C :Crushing failure Class Factor from **Table 3.3.1-1**

CF_F :Flexural failure Class Factor from **Table 3.3.1-1**

CF_D :Load patch dimensions Class Factor from **Table 3.3.1-1**

Table 3.43.1-1 Class Factors

Polar Class	Crushing Ffailure Class Factor (CF_C)	Flexural Ffailure Class Factor (CF_F)	Load Ppatch Ddimensions Class Factor (CF_D)	Displacement Class Factor (CF_{DIS})	Longitudinal Sstrength Class Factor (CF_L)
*PC*1	17.69	68.60	2.01	250	7.46
*PC*2	9.89	46.80	1.75	210	5.46
*PC*3	6.06	21.17	1.53	180	4.17
*PC*4	4.50	13.48	1.42	130	3.15
*PC*5	3.10	9.00	1.31	70	2.50
*PC*6	2.40	5.49	1.17	40	2.37
*PC*7	1.80	4.06	1.11	22	1.81

(4) The Bow area load characteristics for bow forms defined in **3.1.1-2** are determined as follows:

(a) Shape coefficient, fa_i, is to be taken as

$$fa_i = \frac{\alpha_i}{30}$$

(b) Force, F_i:

$$F_i = fa_i CF_{CV} \left(\frac{\Delta_1}{1000}\right)^{0.64} \times 1000 \quad (kN)$$

(c) Line load, Q_i:

$$Q_i = \left(\frac{F_i}{1000}\right)^{0.22} CF_{QV} \times 1000 \quad (kN/m)$$

(d) Pressure, P_i:

$$P_i = \left(\frac{F_i}{1000}\right)^{0.56} CF_{PV} \times 1000 \quad (kN/m^2)$$

where

i :sub-region considered

α :waterline angle (deg), see **Fig. 3.3.2-1**

Δ_1 :ship displacement (t) at the $UIWL$, not to be taken as less than 5,000 t

CF_{CV} :Crushing failure Class Factor from **Table 3.3.1-2**

CF_{QV} :Line load Class Factor from **Table 3.3.1-2**

CF_{PV} :Pressure Class Factor from **Table 3.3.1-2**

Table 3.3.1-2 Class Factors

Polar Class	Crushing failure Class Factor (CF_{CV})	Line load Class Factor (CF_{QV})	Pressure Class Factor (CF_{PV})
$PC6$	3.43	2.82	0.65
$PC7$	2.60	2.33	0.65

~~8 In the Bow area, and the Bow Intermediate Icebelt area for $PC6$ and $PC7$ polar class ships, the design load patch has dimensions of width, w_{Bow}, and height, b_{Bow}, defined as follows:~~

~~$w_{Bow} = F_{Bow} / Q_{Bow}$ (m)~~

~~$b_{Bow} = Q_{Bow} / P_{Bow}$ (m)~~

~~where~~

~~F_{Bow} : maximum force F_i (kN) in the Bow area from **-4**~~

~~Q_{Bow} : maximum line load Q_i (kN/m) in the Bow area from **-6**~~

~~P_{Bow} : maximum pressure P_i (kN/m^2) in the Bow area from **-7**~~

~~9 The average pressure, P_{avg}, within a design load patch is determined as follows:~~

~~$P_{avg} = F_{Bow} / (b_{Bow} \cdot w_{Bow})$ (kN/m^2)~~

~~**3.4.3 Hull Areas other than the Bow**~~

2 Hull Areas other than the Bow

~~1~~(1) ~~Midbody, Stern, Bow Intermediate Lower, Bow Intermediate Bottom Area and the Bow Intermediate Icebelt area for $PC1$, $PC2$, $PC3$, $PC4$ and $PC5$ polar class ships with~~ 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:

(a) Force, F_{NonBow}

$$F_{NonBow} = 0.36 CF_C DF \times 1000 \quad (kN)$$

~~where~~

~~CF_C : Crushing Failure Class Factor from **Table 3.4.1-1**~~

~~DF : ship displacement factor, obtained from the following formula.~~

~~$$DF = \left(\frac{\Delta_2}{1000}\right)^{0.64} \quad \text{if} \quad \frac{\Delta_2}{1000} \le CF_{DIS}$$~~

$$DF = CF_{DIS}^{0.64} + 0.10\left(\frac{\Delta_2}{1000} - CF_{DIS}\right) \text{ if } \frac{\Delta_2}{1000} > CF_{DIS}$$

where

Δ_2 : ship displacement (t) at the *UIWL*, not to be taken as less than 10,000t

CF_{DIS} : Displacement Class Factor from **Table 3.4.1-1**

(b) Line load Q_{NonBow}

$$Q_{NonBow} = 0.639\left(\frac{F_{NonBow}}{1000}\right)^{0.61} CF_D \times 1000 \quad (kN/m)$$

where

F_{NonBow} : the force (kN) obtained from **(a)**

CF_D : Load Patch Dimensions Class Factor from **Table 3.4.1-1**

where

CF_C : Crushing failure Class Factor from **Table 3.3.1-1**

DF : ship displacement factor, obtained from the following formula.

$$DF = \left(\frac{\Delta_2}{1000}\right)^{0.64} \text{ if } \frac{\Delta_2}{1000} \le CF_{DIS}$$

$$DF = CF_{DIS}^{0.64} + 0.10\left(\frac{\Delta_2}{1000} - CF_{DIS}\right) \text{ if } \frac{\Delta_2}{1000} > CF_{DIS}$$

where

Δ_2 : ship displacement (t) at the *UIWL*, not to be taken as less than 10,000 t

CF_{DIS} : Displacement Class Factor from **Table 3.3.1-1**

CF_D : Load patch dimensions Class Factor from **Table 3.3.1-1**

2 In the Midbody area, the Stern area, and the Bow Intermediate Lower area, and the Bow Intermediate Bottom area for all polar class ships and the Bow Intermediate Icebelt area for *PC*6 and *PC*7 polar class ships, the design load patch has dimensions of width, w_{NonBow}, and height, b_{NonBow}, defined as follows:

$w_{NonBow} = F_{NonBow} / Q_{NonBow}$ (m)

$b_{NonBow} = w_{NonBow} / 3.6$ (m)

where

F_{NonBow} : force (kN) obtained from **3.4.3-1(a)**

Q_{NonBow} : line load (kN/m) obtained from **3.4.3-1(b)**

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

$P_{avg} = F_{NonBow} / (b_{NonBow} \cdot w_{NonBow})$ (kN/m^2)

where

F_{NonBow}, b_{NonBow} and w_{NonBow} : the values specified in **-1** and **-2**, respectively.

3.3.2 Design Load Patch

1 In the Bow area, and the Bow Intermediate Icebelt area for *PC*6 and *PC*7 polar class ships, the design load patch has dimensions of width, w_{Bow}, and height, b_{Bow}, defined as follows:

$w_{Bow} = F_{Bow} / Q_{Bow}$ (m)

$b_{Bow} = Q_{Bow} / P_{Bow}$ (m)

where

F_{Bow} : maximum force F_i (kN) in the Bow area
Q_{Bow} : maximum line load Q_i (kN/m) in the Bow area
P_{Bow} : maximum pressure P_i (kN/m^2) in the Bow area

2 In hull areas other than those covered by **-1** above, the design load patch has dimensions of width, w_{NonBow}, and height, b_{NonBow}, defined as follows:

$w_{NonBow} = F_{NonBow} / Q_{NonBow}$ (m)
$b_{NonBow} = w_{NonBow} / 3.6$ (m)

where

F_{NonBow} : force (kN) as defined in **3.3.1-2(1)(a)**
Q_{NonBow} : line load (kN/m) as defined in **3.3.1-2(1)(b)**

3.3.3 Average Pressure

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

$P_{avg} = F / (b\ w)$ (kN/m^2)

where

$F = F_{Bow}$ or F_{NonBow} as appropriate for the hull area under consideration (kN)
$b = b_{Bow}$ 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)

3.~~4~~3.4 Peak Pressure

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 3.~~4~~3.4-1** are used to account for the pressure concentration on localized structural members.

Table 3.~~4~~3.4-1 Peak Pressure Factors

Structural member ~~Member~~		Peak Pressure Factor (PPF_i)
Plating	Transversely ~~Framed~~ framed	$PPF_p = (1.8 - s)$, not to be less than 1.2
	Longitudinally ~~Framed~~ framed	$PPF_p = (2.2 - 1.2s)$, not to be less than 1.5
Frames in transverse framing systems ~~Transverse Framing Systems~~	With ~~Load Distributing Stringers~~ load distributing stringers	$PPF_t = (1.6 - s)$, not to be less than 1.0
	With ~~No Load Distributing Stringers~~ no load distributing stringers	$PPF_t = (1.8 - s)$, not to be less than 1.2
Frames in bottom structures		$PPF_s = 1.0$
Load ~~Carrying Stringers~~ carrying stringers Side and Bottom ~~Longitudinals~~ longitudinals Web ~~Frames~~ frames		$PPF_s = 1.0$, if $S_w \geq 0.5w$ $PPF_s = 2.0 - 2.0S_w / w$, if $S_w < 0.5w$
where	s = frame or longitudinal (m) S_w = web frame spacing (m) w = ice load patch width (m)	

3.~~4~~3.5 Hull Area Factors

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 AF for each hull area is listed in **Table 3.~~4~~3.5-1**. However, for ships assigned the additional notation "*Icebreaker*" (abbreviated to *ICB*), the Area Factor AF for each hull area is listed in **Table 3.3.5-2** instead of **Table 3.3.5-1**.

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

3 Due to their increased manoeuvrability, ships having propulsion arrangements with azimuthing thruster(s) or "podded" propellers are to have specially considered the Stern Icebelt S_i and the Stern Lower S_l hull area factors.

Table 3.~~4~~3.5-1 Hull Area Factors *AF*

Hull Area		Area	Polar Class						
			*PC*1	*PC*2	*PC*3	*PC*4	*PC*5	*PC*6	*PC*7
Bow (B)	All	B	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Bow Intermediate (BI)	Icebelt	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)	Icebelt	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)	Icebelt	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	**	**

Notes :

* See **3.1.2-1(2)**

** Indicates that strengthening for ice loads is not necessary.

Table 3.3.5-2 Hull Area Factors *AF* for ships with additional notation "*Icebreaker*" (abbreviated to *ICB*)

Hull Area		Area	Polar Class						
			*PC*1	*PC*2	*PC*3	*PC*4	*PC*5	*PC*6	*PC*7
Bow (B)	All	B	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Bow Intermediate (BI)	Icebelt	BI_i	0.90	0.85	0.85	0.85	0.85	1.00	1.00
	Lower	BI_l	0.70	0.65	0.65	0.65	0.65	0.65	0.65
	Bottom	BI_b	0.55	0.50	0.45	0.45	0.45	0.45	0.45
Midbody (M)	Icebelt	M_i	0.70	0.65	0.55	0.55	0.55	0.55	0.55
	Lower	M_l	0.50	0.45	0.40	0.40	0.40	0.40	0.40
	Bottom	M_b	0.30	0.30	0.25	0.25	0.25	0.25	0.25
Stern (S)	Icebelt	S_i	0.95	0.90	0.80	0.80	0.80	0.80	0.80
	Lower	S_l	0.55	0.50	0.45	0.45	0.45	0.45	0.45
	Bottom	S_b	0.35	0.30	0.30	0.30	0.30	0.30	0.30

3.~~5~~4 Local Strength

3.~~5~~4.1 Shell Plate Requirements

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

$t = t_{net} + t_s$ (mm)

where

t_{net} : plate thickness (mm) required to resist ice loads according to **-2**

t_s : corrosion and abrasion allowance (mm) according to **2.3.2**

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

(1) In the case of transversely-framed plating ($\Omega \geq 70$ deg):

$$t_{net} = 500s \times \sqrt{\frac{AF \times PPF_P \left(\frac{P_{avg}}{1000} \right)}{\sigma_y}} \frac{1}{1 + \frac{s}{2b}} \quad (mm)$$

(2) In the case of longitudinally-framed plating ($\Omega \leq 20$ *deg*) :

$$t_{net} = 500s \times \sqrt{\frac{AF \times PPF_P \left(\frac{P_{avg}}{1000} \right)}{\sigma_y}} \frac{1}{1 + \frac{s}{2l}} \quad (mm), \text{ if } b \geq s$$

$$t_{net} = 500s \times \sqrt{\frac{AF \times PPF_P \left(\frac{P_{avg}}{1000} \right)}{\sigma_y}} \sqrt{\frac{2b}{s - \left(\frac{b}{s} \right)^2}} \frac{1}{1 + \frac{s}{2l}} \quad (mm), \text{ if } b < s$$

where

Ω : smallest angle (*deg*) between the chord of the waterline and the line of the first level framing as illustrated in **Fig. 3.~~5~~4.1-1**

s : transverse frame spacing (*m*) in transversely-framed ships or longitudinal frame spacing (*m*) in longitudinally-framed ships

AF : Hull Area Factor from **Table 3.~~4~~3.5-1** or **Table 3.3.5-2**

PPF_p : Peak Pressure Factor from **Table 3.~~4~~3.4-1**

P_{avg} : average patch pressure (kN/m^2) according to **~~3.4.3-3~~3.3.3**

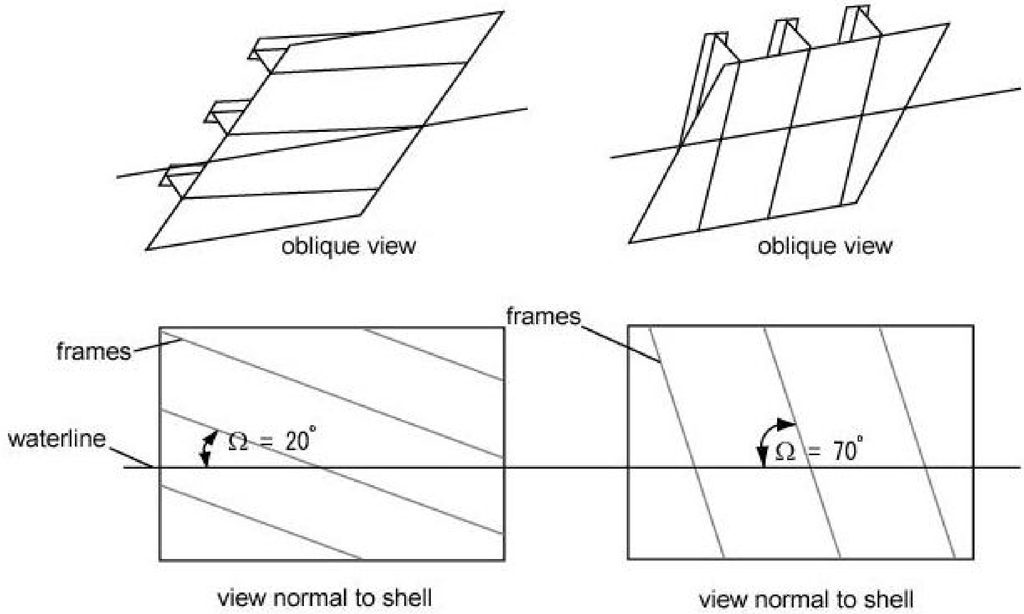
σ_y : minimum upper yield stress of the material (N/mm^2)

b : height (*m*) of design load patch, where b ≤ (l - s/4) in the case of transversely-framed plating

l : distance (*m*) between frame supports, i.e. equal to the frame span as given in **3.4.2-5**, but not reduced for any fitted end brackets. 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.

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

Fig. 3.~~5~~4.1-1 Shell Framing Angle Ω



3.~~5~~4.2 Framing - General

1 Framing members of polar class ships are to be designed to withstand the ice loads defined in **3.~~4~~3**.

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, see **Fig. 1.2.3-1** and **Fig. 1.2.3-2**. Where load-distributing stringers have been fitted, the arrangement and scantlings of these are to be as deemed appropriate by the Society.

~~2~~3 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 is to be assumed unless the connection can be demonstrated to provide significant rotational restraint. Fixity is to be ensured at the support of any framing which terminates within an ice-strengthened area.

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, are to be in accordance with the relevant requirements of other Parts.

5 The design effective span of a framing member is to be determined on the basis of its moulded length. If brackets are fitted, the design effective span may be reduced as deemed appropriate by the Society. Brackets are to be configured to ensure stability in the elastic and post-yield response regions.

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 are to 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.

~~3~~7 The actual net effective shear area, A_w, of a ~~framing member~~ transverse or longitudinal local frame is given by:

$$A_w = \frac{h t_{wn} \sin\varphi_w}{100} \quad (cm^2)$$

where

h : height of stiffener (mm), see **Fig. 3.~~5~~4.2-1**

t_{wn} : net web thickness (mm), $t_{wn} = t_w - t_c$

t_w : as built web thickness (mm), see **Fig. 3.~~5~~4.2-1**

t_c : corrosion deduction (mm) to be subtracted from the web and flange thickness (as specified by other Parts , but not less than t_s as required by **2.3.3**).

φ_w : smallest angle (deg) between shell plate and stiffener web, measured at the mid-span of the stiffener, see **Fig. 3.~~5~~4.2-1**. The angle φ_w may be taken as 90 *degrees* provided the smallest angle is not less than 75 *degrees*.

8 The actual net effective plastic section modulus of a transverse or longitudinal local frame is given by following **(1)** or **(2)**.

(1) 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, is given by:

$$Z_p = \frac{A_{pn} t_{pn}}{20} + \frac{h_w^2 t_{wn} \sin\varphi_w}{2000} + \frac{A_{fn}(h_{fc} \sin\varphi_w - b_w \cos\varphi_w)}{10} \quad (cm^3)$$

where

~~s : frame spacing (m)~~

h, t_{wn}, t_c and, φ_w : as given in **-7** above

A_{pn} : net cross-sectional area (cm^2) of the local frame

t_{pn} : fitted net shell plate thickness (mm) (is to comply with t_{net} as required by **3.~~5~~4.1-2**)

h_w : height (mm) of local frame web, see **Fig. 3.~~5~~4.2-1**

A_{fn} : net cross-sectional area (cm^2) of local frame flange

h_{fc} : height (mm) of local frame measured to centre of the flange area, see **Fig. 3.~~5~~4.2-1**

b_w : distance (mm) from mid thickness plane of local frame web to the centre of the flange area, see **Fig. 3.~~5~~4.2-1**

(2) When the cross-sectional area of the local frame exceeds the cross-sectional area of the attached plate flange, the plastic neutral axis is located a distance z_{na} above the attached shell plate, given by:

$$Z_{na} = \frac{100 A_{fn} + h_w t_{wn} - 1000 t_{pn} s}{2 t_{wn}} \quad (mm)$$

where

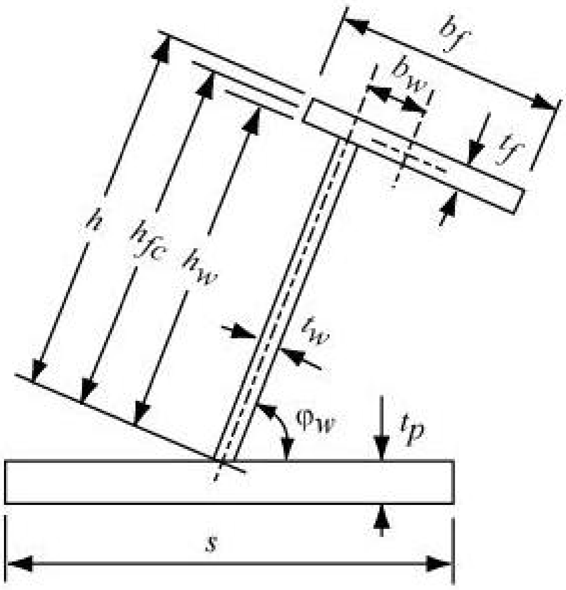
s : frame spacing (m)

The net effective plastic section modulus, Z_p, is given by:

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

9 In the case of oblique framing arrangement (70 $deg > \Omega > 20$ deg, where Ω is defined as given in **3.4.1**), linear interpolation is to be used.

Fig. 3.~~5~~4.2-1 Stiffener Geometry



3.~~5~~4.3 Framing - ~~Transversely-framed Side Structures and Bottom Structures~~ Local Frames in Bottom Structures and Transverse Local Frames in Side Structures

1 The local frames in bottom structures (i.e. hull areas BIb, Mb and Sb) and transverse local frames in ~~transversely-framed~~ side structures ~~and in bottom structures (i.e. hull areas is the Bow Intermediate Bottom area, the Midbody Bottom area and the Stern Bottom area)~~ are to 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 mid-span load that causes the development of a plastic collapse mechanism. For bottom structure the patch load shall be applied with the dimension, b, parallel with the frame direction.

2 The actual net effective shear area of the frame, A_w, as defined in ~~**3.5.2-3**~~**3.4.2-7** is to be not less than A_t determined as follows:

~~$A_t = \dfrac{100^2 \times 0.5 \times LLsAF \times PPF_t \dfrac{P_{avg}}{1000}}{0.577\sigma_y}$~~

$$A_t = \frac{100^2 \times 0.5LLsAF \times PPF \dfrac{P_{avg}}{1000}}{0.577\sigma_y} \quad (cm^2)$$

where

LL : length of loaded portion of span (m), taken equal to lesser of a and b

a : local frame span as defined in **3.4.2-5** (m)

b : height (m) of design ice load patch as defined in **3.3.2-1** or **3.3.2-2**~~according to **3.5.1-2**~~

s : ~~transverse~~ spacing of local frame ~~spacing~~ (m)

AF : Hull Area Factor from **Table 3.~~4~~3.5-1** or **Table 3.3.5-2**

PPF~~$_t$~~ : Peak Pressure Factor, PPF_t or PPF_s as appropriate from **Table 3.~~4~~3.4-1**

P_{avg} : Average pressure (kN/m^2) within load patch ~~according to 3.4.3-3~~ as defined in **3.3.3**

σ_y : Minimum upper yield stress of the material (N/mm^2)

3 The actual net effective plastic section modulus of the plate/stiffener combination Z_p as defined in ~~**3.5.2-3**~~**3.4.2-8** is to be not less than Z_{pt} determined as follows:

$$Z_{pt} = \frac{100^3 \times LL \times YsAF \times PPF_t \dfrac{P_{avg}}{1000} a A_1}{4\sigma_y} \quad (cm^3)$$

where

AF, PPF_t, P_{avg}, LL, b, s, a and σ_y are as given in **3.~~5~~4.3-2.**

$Y = 1 - 0.5\ (LL / a)$

A_1 : taken equal to the greater of following **(a)** and **(b)**

(a) When ice load acting at the mid-span of the ~~transverse~~ local frame

$$A_1 = \frac{1}{1 + \dfrac{j}{2} + \dfrac{k_w j}{2\left(\sqrt{1 - a_1^2} - 1\right)}}$$

(b) When ice load acting near a support

$$A_1 = \frac{1 - \dfrac{1}{2 a_1 Y}}{0.275 + 1.44 k_z^{0.7}}$$

j = 1 for ~~framing~~ a local frame with one simple support outside the ice-strengthened areas

j = 2 for ~~framing~~ a local frame without any simple supports

$a_1 = A_t / A_w$

A_t : Minimum shear area (cm^2) of ~~transverse~~ the local frame as given in **3.~~5~~4.3-2**

A_w : Effective net shear area (cm^2) of ~~transverse~~ the local frame (calculated according to ~~**3.5.2-3**~~**3.4.2-7**)

$k_w = 1 / (1 + 2A_{fn} / A_w)$ with A_{fn} as given in ~~**3.5.2-3(1)**~~**3.4.2-8**

k_z : Section modulus ratio

$k_z = z_p / Z_p$ in general

k_z = 0.0 when the frame is arranged with end bracket

z_p : Sum of individual plastic section modulus (cm^3) of flange and shell plate as fitted

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

b_f : Flange breadth (mm), see **Fig. 3.~~5~~4.2-1**

t_{fn} : net flange thickness (mm)

$t_{fn} = t_f - t_c$ (t_c as given in ~~**3.5.2-3**~~**3.4.2-7**)

t_f : As-built flange thickness (mm), see **Fig. 3.~~5~~4.2-1**

t_{pn} : The fitted net shell plate thickness (mm), not to be less than t_{net} as given in **3.~~5~~4.1**.

b_{eff} : Effective width (mm) of shell plate flange

$b_{eff} = 500\ s$

Z_p : Net effective plastic section modulus (cm^3) of ~~transverse~~ the local frame (calculated according to ~~**3.5.2-3(1) and (2)**~~**3.4.2-8**)

3.~~5~~4.4 Framing - ~~Side Longitudinals (longitudinally-framed ships)~~ Longitudinal Local Frames in Side Structures

1 ~~Side longitudinals~~ Longitudinal local frames in side structures are to 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 mid-span load that causes the development of a plastic collapse mechanism.

2 The actual net effective shear area of the frame, A_w, as defined in ~~**3.5.2-3**~~**3.4.2-7** is to be not less than A_L determined as follows:

$$A_L = \frac{100^2\left(AF \times PPF_s \dfrac{P_{avg}}{1000}\right) \times 0.5 b_1 a}{0.577\varphi_y} \quad (cm^2)$$

where

AF : Hull Area Factor from **Table 3.4~~4~~3.5-1** or **Table 3.3.5-2**

PPF_s : Peak Pressure Factor from **Table 3.4~~4~~3.4-1**

P_{avg} : Average pressure (kN/m^2) within load patch ~~according to **3.4.3-3**~~ as defined in **3.3.3**

$b_1 = k_o\ b_2\ (m)$

$k_o = 1 - 0.3 / b'$

$b' = b / s$

b : Height (m) of design ice load patch ~~from~~ as defined in ~~**3.4.2-8**~~**3.3.2-1** or ~~**3.4.3-2**~~ **3.3.2-2**

s : Spacing (m) of longitudinal frames

b_2 : as given by

$b_2 = b\ (1 - 0.25\ b')\ (m)$, if $b' < 2$

$b_2 = s\ (m)$, if $b' \geq 2$

a : ~~Longitudinal design~~ Effective span (m) of longitudinal local frame as given in **3.4.2-5**

σ_y : Minimum upper yield stress of the material (N/mm^2)

3 The actual net effective plastic section modulus of the plate/stiffener combination Z_p as defined in ~~**3.5.2-3(1)**~~**3.4.2-8** is to be not less than Z_{pL} determined as follows:

$$Z_{pL} = \frac{100^3\left(AF \times PPF_s \dfrac{P_{avg}}{1000}\right) b_1 a^2 A_4}{8\sigma_y} \quad (cm^3)$$

where

AF, PPF_s, P_{avg}, b_1, a and σ_y are as given in **3.~~5~~4.4-2.**

$$A_4 = \frac{1}{2 + k_{wl}\left(\sqrt{1 - a_4{}^2} - 1\right)}$$

$a_4 = A_L / A_w$

A_L : Minimum shear area (cm^2) for longitudinal as given in **3.~~5~~4.4-2**

A_w : Net effective shear area (cm^2) of longitudinal (calculated according to ~~**3.5.2-3**~~**3.4.2-7**)

$k_{wl} = 1 / (1 + 2 A_{fn} / A_w)$ with A_{fn} as given in ~~**3.5.2-3(1)**~~**3.4.2-8**

3.~~5~~4.5 Framing - Web Frame and Load~~-c~~ Carrying Stringers

1 Web frames and load-carrying stringers are to be designed to withstand the ice load patch as defined in **3.~~4~~3**. The load patch is to be applied at locations where the capacity of these members under the combined effects of bending and shear is minimised.

2 Web frames and load-carrying stringers are to be dimensioned such that the combined effects of shear and bending do not exceed the plastic strength of the structural members. ~~Where these members form part of a structural grillage system, appropriate methods of analysis are to 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 3.~~4~~3.4-1** is to be used, and the requirements specified in **3.~~5~~4.2** to **3.~~5~~4.4** are to be applied to the members.

3 Special attention is to be paid to the shear capacity in way of lightening holes and cut-outs in way of intersecting members.

4 For determination of scantlings of load carrying stringers, web frames supporting local frames, or web frames supporting load carrying stringers forming part of a structural grillage system, appropriate methods as outlined in **3.4.12** are normally to be used.

3.~~5~~4.6 Framing - Structural Stability

1 To prevent local buckling in the web, the ratio of web height h_w to net web thickness t_w of any framing member is not to exceed:

For flat bar sections: $\dfrac{h_w}{t_{wn}} \le \dfrac{282}{\sqrt{\sigma_y}}$

For bulb, tee and angle sections: $\dfrac{h_w}{t_{wn}} \le \dfrac{805}{\sqrt{\sigma_y}}$

where

h_w : web height (mm)

t_{wn} : net web thickness (mm)

σ_y : minimum upper yield stress of the material (N/mm^2)

2 Framing members for which it is not practicable to meet the requirements of **3.~~5~~4.6-1** (*e.g.* load carrying stringers or deep web frames) are required to have their webs effectively stiffened. The scantlings of the web stiffeners are to ensure the structural stability of the framing member. The minimum net web thickness for these framing members is not to be less than of the maximum value obtained from following **(a)** and **(b)**:

(a) $t_{wn} = 2.63 \times 10^{-3} \times c_1 \sqrt{\dfrac{\sigma_y}{5.34 + 4(c_1 / c_2)^2}}$ (mm)

where

$c_1 = h_w - 0.8h$ (mm)

h_w : web height (mm) of stringer / web frame, see **Fig. 3.~~5~~4.6-1**.

h : height (mm) of framing member penetrating the member under consideration, 0 if no such framing member, see **Fig. 3.~~5~~4.6-1**.

c_2 : spacing (mm) between supporting structure oriented perpendicular to the member under consideration, see **Fig. 3.~~5~~4.6-1**.

σ_y : minimum upper yield stress of the material (N/mm^2)

(b) $t_{wn} = 0.35 t_{pn} \sqrt{\frac{\sigma_y}{235}}$ (mm)

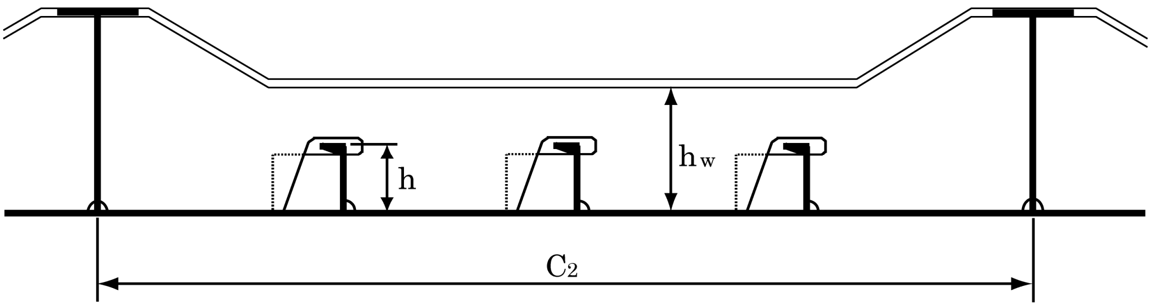
where

σ_y : minimum upper yield stress of the shell plate in way of the framing member (N/mm^2)

t_{wn} : net thickness (mm) of the web

t_{pn} : net thickness (mm) of the shell plate in way of the framing member

Fig. 3.~~5~~4.6-1 Parameter Definition for Web Stiffening



3 To prevent local flange buckling of welded profiles, the following **(1)** and **(2)** are to be satisfied:

(1) The flange width, b_f (mm) is not to be less than five times the net thickness of the web, t_{wn}.

(2) The flange outstand, b_{out} (mm) is to meet the following requirement:

$$\frac{b_{out}}{t_{fn}} \leq \frac{155}{\sqrt{\sigma_y}}$$

where

t_{fn} : net thickness (mm) of flange

σ_y : minimum upper yield stress of the material (N/mm^2)

3.~~5~~4.7 Plated Structures

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

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

3 The stability of the plated structure is to adequately withstand the ice loads defined in **3.3**.

3.~~5~~4.8 Stem and Stern Frames

The stem and stern frame are to be designed according to the requirements deemed appropriate by the Society. For $PC6$ and $PC7$ polar class ships, the stem and stern requirements of ~~**8.3.7 and 8.3.9**~~ **Chapter 8**, **Part I of the Rules** may need to be additionally considered.

3.~~5~~4.9 Bilge Keel

1 The connection of bilge keels to the hull is to be so designed, that the risk of the hull, in case a bilge keel is ripped off, is minimized.

2 It is recommended that bilge keels are cut up into several shorter independent lengths.

3.~~5~~4.10 Appendages

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

2 Load definition and response criteria are deemed appropriately by the Society.

3.~~5~~4.11 Local Details

1 Local design details are to comply with the requirements deemed appropriate by the Society.

2 The collar plate is to be fitted in way of the cut-out for longitudinal penetration in the ice reinforcement region in principle.

3 The loads carried by a member in way of cut-outs are not to cause instability. Where necessary, the structure is to be stiffened.

3.~~5~~4.12 Direct Calculations

1 Direct calculations are to not to be utilised as an alternative to the analytical procedures prescribed ~~in this unified requirement~~ for the shell plating and local frame requirements given in **3.4.1**, **3.4.3**, and **3.4.4**.

2 Direct calculations are to be used for load carrying stringers and web frames forming part of a grillage system.

~~2~~3 Where direct calculation is used to check the strength of structural systems, the load patch specified in **3.~~4~~3** is to be applied, without being combined with any other loads. The load patch is to be applied at locations where the capacity of these members under the combined effects of bending and shear is minimised. Special attention is to be paid to the shear capacity in way of lightening holes and cut-outs in way of intersecting members.

4 The strength evaluation of web frames and stringers may be performed based on linear or non-linear analysis. Recognized structural idealisation and calculation methods are to be applied, but the detailed requirements are to be as deemed appropriate by the Society. In the strength evaluation, the guidance given in **-5** and **-6** may generally be considered.

5 If the structure is evaluated based on linear calculation methods, the following are to be considered:

(1) Web plates and flange elements in compression and shear to fulfil relevant buckling criteria as deemed appropriate by the Society

(2) Nominal shear stresses in member web plates to be less than $\sigma_y / \sqrt{3}$

(3) Nominal von Mises stresses in member flanges to be less than $1.15\sigma_y$

6 If the structure is evaluated based on non-linear calculation methods, the following are to be considered:

(1) The analysis is to reliably capture buckling and plastic deformation of the structure

(2) The acceptance criteria are to ensure a suitable margin against fracture and major buckling and yielding causing significant loss of stiffness

(3) Permanent lateral and out-of plane deformation of considered member are to be minor relative to the relevant structural dimensions

(4) Detailed acceptance criteria to be as deemed appropriate by the Society

3.4.13 Rudders

The scantlings of rudders are to be determined in consideration of the loads generated by the impact of ice on the rudders.

3.~~6~~5 Longitudinal Strength

3.~~6~~5.1 General

1 Ice loads for examination of longitudinal strength in navigating ice-infested polar waters ~~need~~ are only to be combined with still water loads.

2 The combined stresses are to be compared against permissible bending and shear stresses at different locations along the ship's length.

3 In addition, sufficient local buckling strength is also to be verified.

3.~~6~~5.2 Design Vertical Ice Force at the Bow

The design vertical ice force at the bow F_{IB} is to be taken the minimum value of following $F_{IB,1}$ and $F_{IB,2}$.

$$F_{IB,1} = 1000 \times 0.534 K_I^{0.15} \sin^{0.2}(\gamma_{stem}) \sqrt{\frac{\Delta_2}{1000}\frac{K_h}{1000}} CF_L \quad (kN)$$

$$F_{IB,2} = 1000 \times 1.20 CF_F \quad (kN)$$

where

K_I : indentation parameter, $K_I = 1000\dfrac{K_f}{K_h}$

where

(a) for the case of a blunt bow form

$$K_f = \left(\frac{2CB^{1-e_b}}{1+e_b}\right)^{0.9} \tan(\gamma_{stem})^{-0.9(1+e_b)}$$

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

$$K_f = \left(\frac{\tan(\alpha_{stem})}{\tan^2(\gamma_{stem})}\right)^{0.9}$$

$$K_h = 10 A_{WP} \quad (kN/m)$$

CF_L : Longitudinal Strength Class Factor from **Table 3.4~~3~~.1-1**

e_b : bow shape exponent which best describes the waterplane, see **Fig. 3.~~6~~5.2-1** and **Fig. 3.~~6~~5.2-2**

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 (*deg*) to be measured between the horizontal axis and the stem tangent at the *UIWL* (buttock angle (*deg*) as per **Fig. 3.~~4~~3.2-1** measured on the centreline)

α_{stem} : waterline angle (*deg*) measured in way of the stem at the *UIWL*, see **Fig. 3.~~6~~5.2-1**

$$C = \frac{1}{2\left(\frac{L_B}{B}\right)^{e_b}}$$

B : ship moulded breadth (*m*)

L_B : bow length (*m*), see **Fig. 3.~~6~~5.2-1** and **Fig. 3.~~6~~5.2-2**.

Δ_2 : ship displacement (*t*), not to be taken less than 10,000*t*

A_{wp} : ship waterplane area (m^2)

CF_F : Flexural Failure Class Factor from **Table 3.~~4~~3.1-1**

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

Fig. 3.~~6~~5.2-1 Bow Shape Definition

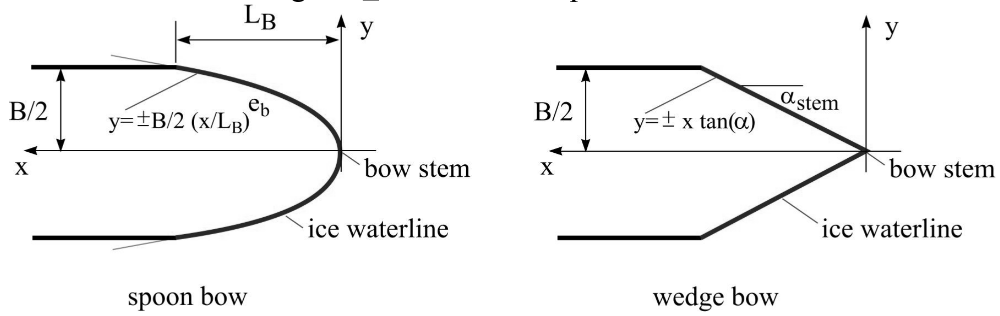
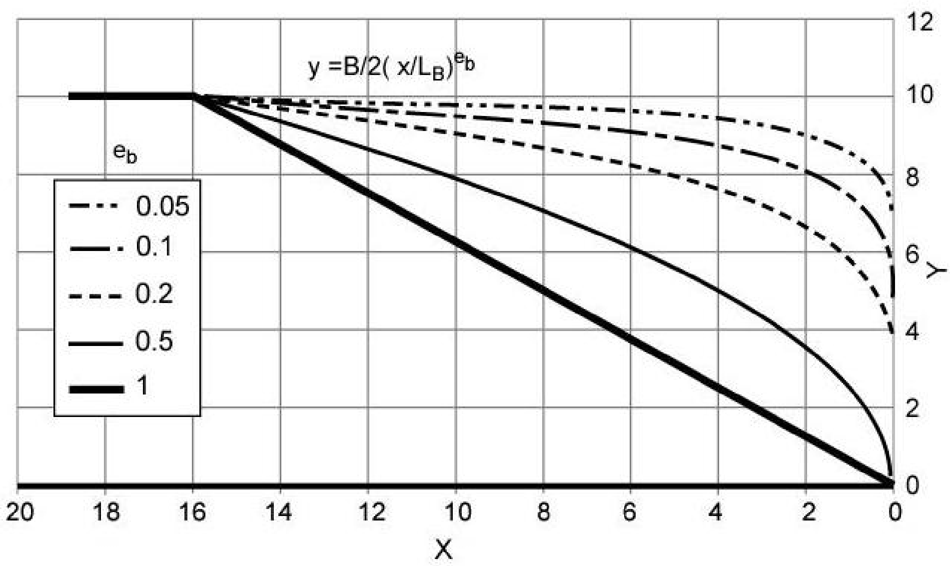


Fig. 3.~~6~~5.2-2 Illustration of e_b Effect on the Bow Shape for B=20 and L_B=16



3.~~6~~5.3 Design Vertical Shear Force

1 The design vertical ice shear force F_I along the hull girder is to be taken as:

$F_I = C_f F_{IB}$ (kN)

where

C_f= longitudinal distribution factor to be taken as follows:

(a) Positive share 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

(b) Negative share 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 are to be determined by linear interpolation

2 The applied vertical shear stress τ_a is to be determined along the hull girder in a similar manner as in **15.4.2-2, Part C of the Rules** by substituting the design vertical ice shear force for the design vertical wave shear force.

3.~~6~~5.4 Design Vertical Ice Bending Moment

1 The design vertical ice bending moment M_I along the hull girder is to be taken as:

$$M_I = 0.1 C_m L' \sin^{-0.2}(\gamma_{stem}) F_{IB} \quad (kNm)$$

where

L': ship length (m) measured on the *UIWL* from the forward side of the stem to the after side of the rudder post, or the centre of the rudder stock if there is no rudder post. L' is to be not less than 96% and need not exceed 97% of the extreme length on the *UIWL*.

γ_{stem}: as given in **3.~~6~~5.2**

F_{IB}: design vertical ice force (kN) at the bow, see **3.~~6~~5.2**

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 are to be determined by linear interpolation.

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

2 The applied vertical bending stress σ_a is to be determined along the hull girder in a similar manner as in **15.4.2-1, Part C of the Rules**, by substituting the design vertical ice bending moment for the design vertical wave bending moment.

3.~~6~~5.5 Longitudinal Strength Criteria

The strength criteria provided in **Table 3.~~6~~5.5-1** are to be satisfied. The design stress is not to exceed the permissible stress.

Table 3.~~6~~5.5-1 Longitudinal Strength Criteria

Failure Mode	Applied Stress	Permissible Stress when σ_y / $\sigma_u \le 0.7$	Permissible Stress when σ_y / $\sigma_u > 0.7$
Tension	σ_a	~~0.8~~η σ_y	~~0.8~~$\eta \times 0.41 (\sigma_u + \sigma_y)$
Shear	τ_a	~~0.8~~η $\sigma_y / \sqrt{3}$	~~0.8~~$\eta \times 0.41 (\sigma_u + \sigma_y) / \sqrt{3}$
Buckling	σ_a	σ_c for plating and for web plating of stiffeners σ_c / 1.1 for stiffeners	
	τ_a	τ_c	

~~where~~ Notes:

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 (N/mm^2) in compression, according to **15.4, Part C of the Rules**

τ_c : critical buckling stress (N/mm^2) in shear, according to **15.4, Part C of the Rules**

η = 0.8. However, for ships which are assigned the additional notation "*Icebreaker*" (abbreviated to *ICB*), η = 0.6.

Chapter 4 MACHINERY INSTALLATIONS

4.3 Design of Propulsion Shafting System

4.3.2 Azimuthing Main Propulsors

Sub-paragraph (4) has been amended as follows.

In the design of the azimuthing main propulsors, the following are to be taken into account in addition to the requirements specified in **4.3.1**.

(4) Azimuth thrusters are to be designed for estimated loads specified in **3.~~5~~4.10**.

4.5 Fastening Loading Accelerations

4.5.1 Machinery Fastening Loading Accelerations

Sub-paragraph (3) has been amended as follows.

Supports of essential equipment and main propulsion machinery are to be suitable for the accelerations given by the following formulae. Accelerations are to be considered as acting independently.

(3) Combined transverse impact acceleration at any point along hull girder:

$$a_t = 3F_i \frac{F_X}{\Delta} \quad (m/s^2)$$

Where

F_X = 1.5 (at fore perpendicular)
=0.25 (at midships)
=0.5 (at aft perpendicular)
=1.5 (at aft perpendicular for vessels conducting ice breaking astern)

Intermediate values to be interpolated linearly.

where

ϕ: Maximum friction angle (*deg*) between steel and ice, normally taken as 10 *degrees*

γ: Bow stem angle (*deg*) at the *UIWL*

Δ: Displacement at the *UIWL* (*t*)

L: Length of ship (*m*) defined in **2.1.2, Part A of the Rules**

H: Distance (*m*) from the *UIWL* to the point being considered

F_{IB}: Vertical impact force (*kN*) defined in **3.~~6~~5.2**

F_i: Force (*kN*) defined in **~~3.4.2-4~~3.3.1-1(3)(b)**

EFFECTIVE DATE AND APPLICATION

1. The effective date of the amendments is 1 July 2017.
2. Notwithstanding the amendments to the Rules, the current requirements apply to ships for which the date of contract for construction* is before the effective date.
   * "contract for construction" is defined in the latest version of IACS Procedural Requirement (PR) No.29.

IACS PR No.29 (Rev.0, July 2009)

1. The date of "contract for construction" of a vessel is the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder. This date and the construction numbers (i.e. hull numbers) of all the vessels included in the contract are to be declared to the classification society by the party applying for the assignment of class to a newbuilding.

2. The date of "contract for construction" of a series of vessels, including specified optional vessels for which the option is ultimately exercised, is the date on which the contract to build the series is signed between the prospective owner and the shipbuilder.
For the purpose of this Procedural Requirement, vessels built under a single contract for construction are considered a "series of vessels" if they are built to the same approved plans for classification purposes. However, vessels within a series may have design alterations from the original design provided:
(1) such alterations do not affect matters related to classification, or
(2) If the alterations are subject to classification requirements, these alterations are to comply with the classification requirements in effect on the date on which the alterations are contracted between the prospective owner and the shipbuilder or, in the absence of the alteration contract, comply with the classification requirements in effect on the date on which the alterations are submitted to the Society for approval.
The optional vessels will be considered part of the same series of vessels if the option is exercised not later than 1 year after the contract to build the series was signed.

3. If a contract for construction is later amended to include additional vessels or additional options, the date of "contract for construction" for such vessels is the date on which the amendment to the contract, is signed between the prospective owner and the shipbuilder. The amendment to the contract is to be considered as a "new contract" to which **1.** and **2.** above apply.

4. If a contract for construction is amended to change the ship type, the date of "contract for construction" of this modified vessel, or vessels, is the date on which revised contract or new contract is signed between the Owner, or Owners, and the shipbuilder.

Note:
This Procedural Requirement applies from 1 July 2009.

GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part I Polar Class Ships and Ice Class Ships

GUIDANCE

2017 AMENDMENT NO.1

Notice No.27 1st June 2017

Resolved by Technical Committee on 30th January 2017

Notice No.27 1st June 2017
AMENDMENT TO THE GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

"Guidance for the survey and construction of steel ships" has been partly amended as follows:

Title of Part I has been amended as follows.

Part I SHIPS OPERATING IN POLAR WATERS, POLAR CLASS SHIPS AND ICE CLASS SHIPS

I1 GENERAL APPLICATION

I1.1 General

Paragraph I1.1.1 has been deleted.

~~**I1.1.1 Application**~~

~~In addition to the requirements of **Part I of the Rules**, additional requirements deemed appropriate by the Society may be applied to any icebreaker 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.~~

Paragraph I1.1.2 has been amended as follows.

I1.1.2 Documentation

1 With respect to the provisions of **1.1.2-1 and 1.1.2-2, Part I of the Rules**, draughts at fore, midship and aft corresponding to the upper ice waterline and the lower ice waterline are to be ~~registered in the Classification Register as descriptive notes~~ indicated in the Certificate of Classification for a polar class ship.

2 With respect to the provisions of **1.1.2-1 and 1.1.2-3, Part I of the Rules**, draughts at fore, midship and aft corresponding to the upper ice waterline and the lower ice waterline are to be ~~registered in the Classification Register as descriptive notes~~ indicated in the Certificate of Classification for an ice class ship.

EFFECTIVE DATE AND APPLICATION

1. The effective date of the amendments is 1 July 2017.

2. Notwithstanding the amendments to the Guidance, the current requirements apply to ships for which the date of contract for construction* is before the effective date.

* "contract for construction" is defined in the latest version of IACS Procedural Requirement (PR) No.29.

IACS PR No.29 (Rev.0, July 2009)

1. The date of "contract for construction" of a vessel is the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder. This date and the construction numbers (i.e. hull numbers) of all the vessels included in the contract are to be declared to the classification society by the party applying for the assignment of class to a newbuilding.

2. The date of "contract for construction" of a series of vessels, including specified optional vessels for which the option is ultimately exercised, is the date on which the contract to build the series is signed between the prospective owner and the shipbuilder.

For the purpose of this Procedural Requirement, vessels built under a single contract for construction are considered a "series of vessels" if they are built to the same approved plans for classification purposes. However, vessels within a series may have design alterations from the original design provided:

(1) such alterations do not affect matters related to classification, or

(2) If the alterations are subject to classification requirements, these alterations are to comply with the classification requirements in effect on the date on which the alterations are contracted between the prospective owner and the shipbuilder or, in the absence of the alteration contract, comply with the classification requirements in effect on the date on which the alterations are submitted to the Society for approval.

The optional vessels will be considered part of the same series of vessels if the option is exercised not later than 1 year after the contract to build the series was signed.

3. If a contract for construction is later amended to include additional vessels or additional options, the date of "contract for construction" for such vessels is the date on which the amendment to the contract, is signed between the prospective owner and the shipbuilder. The amendment to the contract is to be considered as a "new contract" to which **1.** and **2.** above apply.

4. If a contract for construction is amended to change the ship type, the date of "contract for construction" of this modified vessel, or vessels, is the date on which revised contract or new contract is signed between the Owner, or Owners, and the shipbuilder.

Note:
This Procedural Requirement applies from 1 July 2009.