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RULES

PUBLICATION NO. 100/P

HULL CONSTRUCTION RULES FOR HIGH SPEED CRAFT

2013

Publications P (Additional Rule Requirements) issued by Polski Rejestr Statków complete or extend the Rules and are mandatory where applicable.



GDAŃSK

Publication No. 100/P – Hull Construction Rules for High Speed Craft – 2013 is an extension of the requirements contained in *Part II – Hull – 2011* of the *Rules for the Classification and Construction of Sea-Going Ships* and *Part II – Hull – 2011* of the *Rules for the Classification and Construction of Small Sea-Going Ships*.

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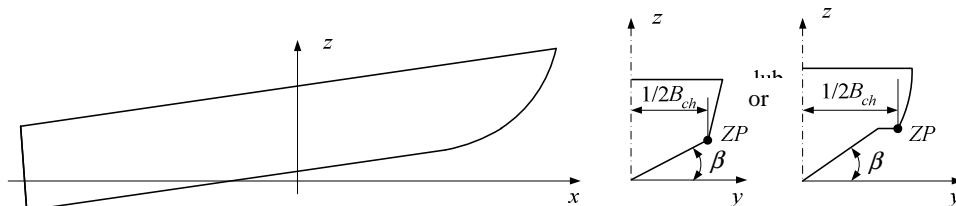
1 GENERAL

1.1 Application

1.1.1 These *Hull Construction Rules for High Speed Craft* (hereinafter referred to as the *Rules*) apply to monohull high speed craft, i.e. craft capable of a maximum speed [m/s] equal to or exceeding $V_0 = 3.7 V^{0.1667}$, where V represents displacement corresponding to the design waterline, in [m³].

Typical hull shapes for such craft are shown in Fig. 1.1.1.

a) Planning craft



b) Intermediate craft to displacement craft and planning craft

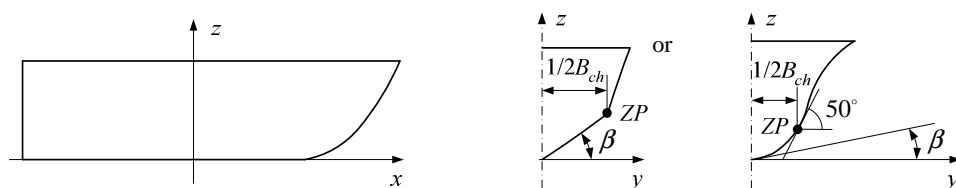


Fig. 1.1.1 Typical hull shapes of high speed craft

1.1.2 The requirements specified in these *Rules* apply to craft with steel or aluminium-alloy hulls of typical shapes and dimensional proportions.

Craft having atypical shapes or dimensional proportions are subject to PRS consideration in each particular case.

1.1.3 In addition to the requirements specified in these *Rules*, any high speed craft hull shall fulfil the strength criteria specified in *Part II – Hull* of the *Rules for the Classification and Construction of Sea-going Ships* (or the *Rules for the Classification and Construction of Small Sea-going Ships*) for loads determined for a speed $v = 0.5v_0$; for v_0 , see paragraph 1.1.1.

1.1.4 Craft service with the speed exceeding or equal to v_0 in ice conditions is not permitted (for v_0 see paragraph 1.1.1).

Where the craft is intended for service in the ice conditions with a speed less than v_0 , ice strengthening is required to be applied in accordance with Chapter 26 of *Part II – Hull* of the *Rules for the Classification and Construction of Sea-going Ships* or Chapter 21 of *Part II – Hull* of the *Rules for the Classification and Construction of Small Sea-going Ships* (see Chapter 8 hereto). Ice strengthening shall be designed having regard, to the applicable extent, to the requirements of Chapter 7 so that safe craft service be ensured at a speed not less than v_0 in no ice conditions.

1.2 Symbols and Definitions

1.2.1 General

In sub-chapters from 1.2.2 to 1.2.4, symbols and definitions are given associated with the craft hull applied in these *Rules*.

1.2.2 General Symbols

D – displacement of craft, [t] – mass of water, in tonnes, of the volume equal to the volume of the submerged part of hull. Unless specified otherwise, the sea water mass density shall be taken as 1.025 t/m^3 .

g – standard gravitational acceleration, [m/s^2] – may be taken as 9.81 m/s^2 .

H – moulded depth, [m] – vertical distance measured at the side amidships from the base plane to the upper edge of the uppermost continuous deck beam. In craft having a rounded gunwale, the moulded depth shall be measured to the point of intersection of the moulded lines of the deck and side.

If the uppermost continuous deck is stepped and the raised part of the deck extends over the point at which the moulded depth shall be determined, the moulded depth shall be measured to a line of reference extending from the lower part of the deck along a line parallel with the raised part.

k – material factor – factor dependent on the material yield point – see Chapter 2 in *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships*.

L – length of craft – means 96% of the overall length of hull measured on the waterline at 85% of the least moulded depth measured from the top of the keel, or the length from the fore side of the stem to the axis of the rudder stock on that waterline, whichever is greater.

In ships designed with a rake of keel, the waterline on which this length is measured shall be parallel to the design waterline.

L_{PP} – length between perpendiculars, [m] – distance measured between the forward perpendicular and after perpendicular

L_W – length of ship measured on waterline corresponding to draught T , [m]

L_0 – design length of craft, [m] – distance measured on summer load waterline from the fore side of the stem to the rudder stock axis. The adopted value of L_0 , shall not be taken less than 96% of the overall length of hull measured on the summer load waterline, however need not exceed 97% of that length.

$F.P.$ – forward perpendicular – the perpendicular at the intersection of the summer load waterline with the fore side of the stem.

B.P. – base plane – horizontal plane which crosses amidships the top of a flat keel or the intersection of the inner surface of the plating with the bar keel.

A.P. – after perpendicular – the perpendicular at the centre plane, at distance L_0 from *FP* aftwards.

C.P. – centre plane of craft

T – draught, [m] – vertical distance measured amidships from the base plane to the summer load waterline.

V – volume of moulded displacement, [m³] – volume of craft body defined by the outer edges of frames at draught *T*.

x, y, z – co-ordinates of a point in the craft [m] – see Fig. 1.2.3.1.

v_0 – threshold speed value above which the craft is considered as a high speed craft (see paragraph 1.1.1), [m/s].

1.2.3 Co-ordinate System

1.2.3.1 In these *Rules*, the co-ordinate system shown in Fig. 1.2.3.1 has been assumed for craft; the following reference planes have been assumed for the system: base plane, centre plane and midship section.

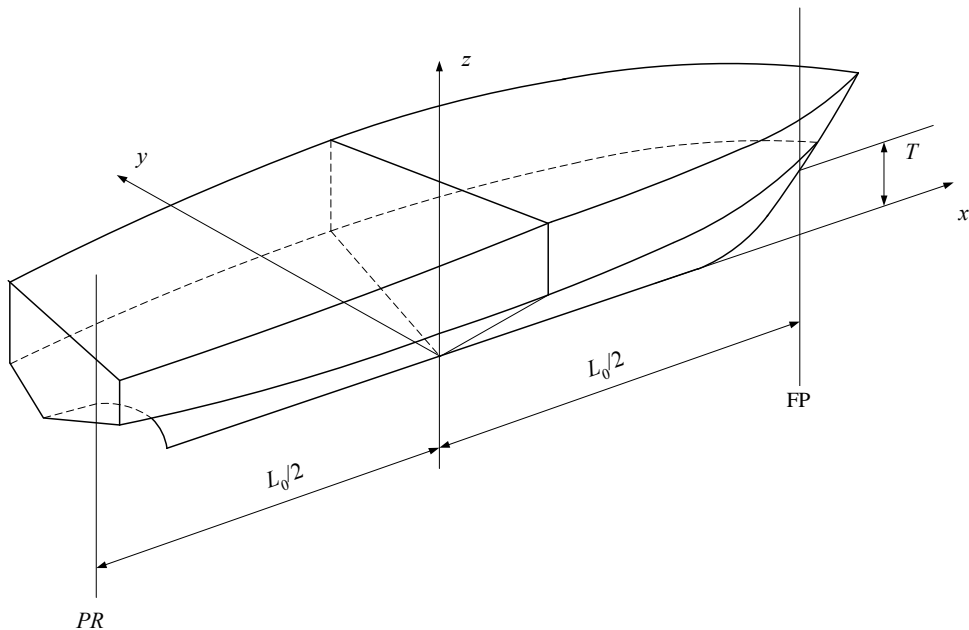


Fig. 1.2.3.1 Co-ordinate system

The intersection of the centre plane and the base plane forms x axis of the positive sense forward.

The intersection of the base plane and midship section forms y axis of the positive sense towards port side.

The intersection of the centre plane and midship section forms z axis of the positive sense upwards.

1.2.4 General Definitions and Definitions of Structural Elements

Provisions of sub-chapters 1.2.4 and 1.2.5 of *Part II – Hull* of the *Rules for the Classification and Construction of Sea-going Ships* apply within the scope applicable to high speed craft.

The following supplementary definitions have been introduced:

Craft planing – craft motion with a speed sufficient to make the craft weight fully equilibrated by the dynamic pressure on the craft bottom.

Intermediate state between planing and displacement cruising – craft motion with a speed lesser than in planing state; the craft weight partially equilibrated by the dynamic pressure on the craft bottom.

1.3 Survey and Classification

1.3.2 Survey and classification are performed in accordance with the regulations specified in *Part II – Hull* of the *Rules for the Classification and Construction of Sea-going Ships* within the scope applicable to high speed craft.

1.3.3 The Owner of craft under design shall determine the design allowable value of vertical acceleration in its centre of gravity not less than the value specified in paragraph 5.2.1.1.

The above mentioned value of acceleration is the base for determining the relation between the allowable speed of high speed craft in the planing state or in the intermediate state between planing and displacement cruising and the significant wave height value.

This relation forms an *Annex* to the *Certificate of Class* and is also entered in the *Loading Manual*.

1.3.4 More stringent limitations than those applicable to operating areas I, II or III are subject to PRS consideration in each particular case and are entered in the *Annex* to the *Certificate of Class*.

1.4 Technical Documentation

1.4.1 The requirements for technical documentation specified in *Part II – Hull* of the *Rules for the Classification and Construction of Sea-going Ships* apply within the scope applicable to high speed craft.

2 METALLIC MATERIALS AND CORROSION PROTECTION

2.1 General

Materials intended for structures covered by the requirements of these *Rules* shall fulfil the requirements specified in *Part IX – Materials and Welding*, of the *Rules for the Classification and Construction of Sea-going Ships*.

2.2 Hull Structural Steel

Material factor, k , values and steel grades for specific hull structural elements shall be selected in accordance with the requirements specified in Chapter 2 of *Part II – Hull* of the *Rules for the Classification and Construction of Sea-going Ships* – within the scope applicable to high speed craft.

Table 2.2.1.3-1 of the above mentioned *Part II* shall be modified and interpreted as follows:

- side shell plating belongs to PRIMARY structural elements;
- stiffeners and primary members of side shell and bottom and the associated brackets, web stiffeners, etc., belong to PRIMARY structural elements.

2.3 Aluminium Alloys

As regards aluminium alloys used for the craft hull, its superstructure or deckhouses, bulwarks, masts, etc., the requirements specified in sub-chapter 2.3 of *Part II – Hull* of the *Rules for the Classification and Construction of Small Sea-going Ships* apply.

2.4 Corrosion Additions

Corrosion additions for hull structural elements shall be determined in accordance with the requirements specified in sub-chapters 2.5 and 2.6 of *Part II – Hull* of the *Rules for the Classification and Construction of Small Sea-going Ships*.

3 STRUCTURE PARTICULARS

3.1 General

As regards such issues as:

- rounding of member scantlings,
- span of primary supporting members and stiffeners,
- effective flange of stiffeners or girders,
- effective cross-sectional area of stiffener web or of girder web,
- calculation of section modulus of stiffener or girder,
- details of welded structures,
- ensuring structure continuity,
- openings in structural members,
- construction of T-section primary supporting members,

the requirements of Chapter 3 of *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships* apply.

The requirements specified in Chapter 7 shall also be fulfilled.

4 JOINTS OF STRUCTURAL ELEMENTS

4.1 General

4.1.1 Requirements concerning the types and sizes of welds, welded joints of some structural elements, riveted joints as well as steel/aluminium alloy joints are specified in this Chapter.

4.1.2 The requirements of Chapter 4 in *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships* within the scope applicable to high speed craft, supplemented by the requirements specified in the following sub-chapters from 4.2 to 4.6 as well as Chapter 7, shall apply.

4.2 Butt Joints

4.2.1 All butt joints shall be made with full penetration.

Other requirements are identical with those specified in sub-chapter 4.2.1 of *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships*.

4.3 Fillet Welds

4.3.1 Fillet Weld Thickness

4.3.1.1 Fillet weld thickness shall be determined in accordance with the requirements specified in 4.2.3.1 of *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships* within the scope applicable to high speed craft.

4.3.2 Application of Double Continuous Welds

4.3.2.1 It is recommended that in any joints of structural elements where fillet welds are permitted double continuous welds be applied.

4.3.2.2 Double continuous welds are required for welding the system of stiffeners and girders to the bottom and sides in those areas where impact pressure defined in sub-chapters 5.3.2 and 5.3.3 occur.

Other cases where double continuous welds are required are specified in sub-chapter 4.2.3 of *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships*.

4.3.3 Other Welds than Double Continuous

4.3.3.1 Other welds than double continuous, e.g. double staggered welds, chain welds, scallop welds, single continuous welds or single intermittent welds are permitted in other cases than those specified in paragraph 4.3.2.2.

4.4 End Connections of Structural Members

4.4.1 General

4.4.1.1 The requirements specified in sub-chapter 4.3 of *Part II – Hull* of the *Rules for the Classification and Construction of Sea-going Ships* and paragraph 7.2.3 of this Publication shall be fulfilled.

Lap welds shall, however, be avoided. The possibility for application of such joints is subject to PRS consideration in each particular case.

4.4.2 End Connections of Primary Members

4.4.2.1 Primary member ends shall be so connected to their supporting structures that the cross-section area of the welds be not less than the cross-section area of such a member (irrespective of brackets).

The cross-section area of fillet welds shall be calculated as the product of the weld length and its thickness.

4.4.3 Connections of Plating Stiffeners to Primary Members

4.4.3.1 Cross-section areas of welds (see paragraph 4.4.2.1) connecting plating stiffeners to girders shall not be less than the value determined in accordance with formula 6.3.1.1-2.

To fulfil this condition, it may be reasonable to reinforce the connections by means of connection lugs (see paragraph 4.3.7 in *Part II – Hull* of the *Rules for the Classification and Construction of Sea-going Ships*).

4.5 Riveted or Screw Joints

4.5.1 Particulars concerning riveted joints shall be included in the technical documentation submitted to PRS for approval.

4.5.2 PRS may require that the strength of proposed riveted joints be verified by laboratory tests whose scope is subject to PRS agreement in each particular case.

4.5.3 Riveted or screw joints of structural elements made of different materials shall be so effected that the possibility for galvanic corrosion occurrence be precluded.

Riveted or screw joints are subject to PRS consideration in each particular case.

4.6 Bonded Joints Steel/Aluminium Alloy

4.6.1 Joints made by means of special fasteners (made using e.g. explosion method) shall fulfil the requirements specified in paragraph 4.4.1 of *Part II – Hull* of the *Rules for the Classification and Construction of Small Sea-going Ships*.

5 DESIGN LOADS

5.1 General

5.1.1 Design loads defined in this Chapter apply to a craft in planing state or in intermediate state between planing and displacement cruising.

The loads are used to determine the necessary scantlings of hull structural elements in accordance with the requirements specified in Chapter 6.

5.1.2 The hull shall also meet the strength criteria while cruising in displacement mode.

For that purpose the requirements specified in *Part II – Hull* of the *Rules for the Classification and Construction of Sea-going Ships* (or *Part II – Hull* of the *Rules for the Classification and Construction of Small Sea-going Ships*) shall be fulfilled in the scope agreed with PRS taking account of the specific parameters of craft under design.

The design loads shall be determined for a speed $v = 0.5v_0$; for v_0 see para. 1.1.1.

5.2 Vertical Accelerations and Sea Waving Conditions

5.2.1 Design Value of Vertical Acceleration

5.2.1.1 Design value of vertical acceleration, a_{cv} , of the craft centre of gravity which shall be exceeded neither in planing state nor in the intermediate state between planing and displacement cruising is to be determined by the Owner.

The above mentioned value shall not be less than $0.5g$ for craft engaged on voyages in operating area III and not less than g – for craft engaged on voyages in operating areas II, I and for craft with no restrictions.

5.2.1.2 The relation between the design value of vertical acceleration, a_{cv} , of the craft centre of gravity specified in paragraph 5.2.1.3 and the significant value of wave height, $H_{1/3}$, as well as the allowable speed of craft v is the base for determining restrictions on the craft motion in the planing state or in the intermediate state between planing and displacement cruising in sea waving conditions.

These restrictions are entered in the Annex to *Certificate of Class* and also in the *Loading Manual*.

It is recommended that the above mentioned restrictions be determined based on the accepted by PRS direct measurements taken on board the craft (before it has been put into service), model tank tests or direct numerical calculations of craft motion in sea waving conditions.

5.2.1.3 The values of significant wave height and allowable speed of craft in sea waving conditions depend on the allowable vertical acceleration of the craft centre of gravity in accordance with the following equation:

$$a_{cv} = 0.0015g \left(\frac{H_{1/3}}{B_w} + 0.084 \right) \tau (5 - 0.1\beta) \left(\frac{v}{\sqrt{L_w}} \right)^2 \frac{L_w}{B_w C_\Delta}, \left[\frac{m}{s^2} \right] \quad (5.2.1.3)$$

where:

- g – acceleration of gravity (9.81 m/s²);
- B_w – breadth of craft on waterline (in displacement state) in the vertical plane containing the craft centre of gravity, [m];
- $H_{1/3}$ – significant wave height, [m];
- τ – craft trim angle in the planing state or in the intermediate state between planing and displacement cruising, [deg]; the value taken for calculations shall not be less than 4°; the expected value of τ shall be documented by the Owner with the results of advanced numerical calculations, model tank tests or information based on the experience of the service of several similar craft;
- β – bottom rake angle (see Fig. 1.1.1) in the vertical plane containing the craft centre of gravity, [deg];
- v – allowable craft speed in sea waving conditions of significant wave height $H_{1/3}$, [knots];
- L_w – length of waterline at draught T , [m];
- $C_\Delta = \frac{D}{\rho B_{ch}^3}$, [-];
- D – displacement of craft, [t];
- $\rho = 1.025 \text{ t/m}^3$ – water mass density;
- B_{ch} – maximum breadth of craft measured between the plating edges (see Fig. 1.1.1), [m]; for craft with curved plating B_{ch} represents the maximum breadth between the points where the tangent of the curve forms the angle of 50° with the base plane (see Fig. 1.1.1-b).

5.2.1.4 Design value a_v of vertical acceleration in any location along the craft shall be determined in accordance with the following formula:

$$a_v = c_v \cdot a_{cv}, \text{ [m/s}^2\text{]} \quad (5.2.1.4)$$

where:

- a_{cv} – design value of vertical acceleration of the craft centre of gravity (see paragraph 5.2.1.1), [m/s²];
- c_v – coefficient taking its values depending on co-ordinate x to be determined as shown in the diagram in Fig. 5.2.1.4.

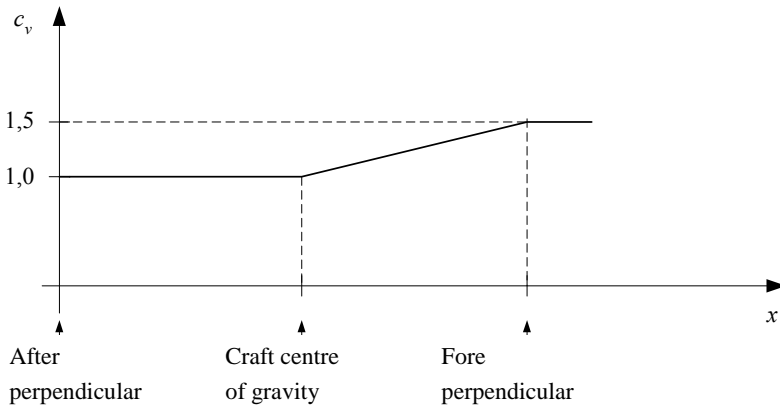


Fig. 5.2.1.4 The values of c_v

5.3 External Pressure Acting on Hull and Superstructures

5.3.1 General

In sub-chapter 5.3 are provided formulae for determining design pressures acting on the craft hull and superstructures for craft in planing state or in intermediate state between planing and displacement cruising.

5.3.2 Pressure Acting on Craft Bottom

5.3.2.1 In this sub-chapter, the term *craft bottom* means the hull region between the plating edges or between the points where the tangent of the curve forms the angle of 50° with the base plane (see point *ZP* in Fig. 1.1.1).

5.3.2.2 Pressure $p = p_d$ acting on the bottom, applied in sub-chapters 6.2 and 6.3 to determine the required plating thickness and the cross-sectional-area of plating stiffeners, shall be determined in accordance with the following formula:

$$p = p_d = K_L K_D \frac{D a_{cv}}{0.14 A_R}, [\text{kPa}] \quad (5.3.2.2)$$

where:

K_L – coefficient taking its values depending on co-ordinate x to be determined as shown in the diagram in Fig. 5.3.2.2;

$K_D = 0.7$;

D – displacement of craft, [t];

a_{cv} – design value of vertical acceleration of the craft centre of gravity (see paragraph 5.2.1.1), [m/s^2];

$A_R = 0.3 L_w B_w$, [m^2];

L_w, B_w – see paragraph 5.2.1.3.

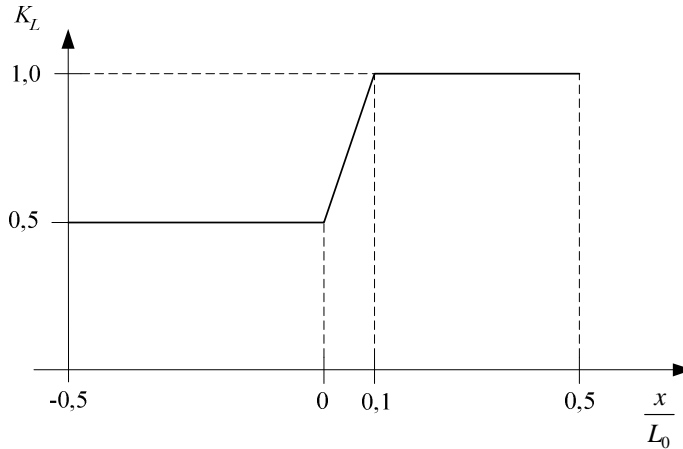


Fig. 5.3.2.2 The values of K_L

5.3.2.3 Pressure value used for the strength assessment of bottom girders in accordance with the requirements specified in sub-chapter 6.4 shall be calculated in accordance with formula 5.3.2.2, taking the value of K_D determined in accordance with the following formula:

$$K_D = 0.14 \left(\frac{A_D}{A_R} \right)^{-0.285} \quad (5.3.2.3)$$

where:

A_R – as defined in paragraph 5.3.2.2;

$A_D = lb$, [m²];

b – width of plating strake supported by girder, [m];

l – girder span (distance between adjacent members perpendicular to girder under consideration, distance between member perpendicular to girder under consideration and side or longitudinal bulkhead, etc.).

5.3.3 Pressure Acting on Craft Sides

5.3.3.1 In this sub-chapter, the term *craft side* means the hull region between the craft bottom as defined in paragraph 5.3.2.1, and upper deck.

5.3.3.2 Pressure $p = p_b$ acting on the craft sides shall be determined in accordance with the following formula:

$$p = p_b = p_d \frac{\operatorname{tg}(40^\circ - \beta_d)}{\operatorname{tg}(\beta_b - 40^\circ)}, \text{ [kPa]} \quad (5.3.3.2)$$

where:

p_d – pressure acting on the bottom, as defined in paragraph 5.3.2.2, [kPa];

β_d – average value of bottom rake angle within the region from centre plane to point *ZP* (see Fig. 1.1.1)

β_b – average value of side rake angle within the region between point *ZP* and upper deck (see Fig. 1.1.1).

The value of angle β_d taken for calculations shall not exceed 30 degrees and the value of β_b shall not be less than 50°.

Pressure p_b acts on the side in region from point *ZP* (see Fig. 1.1.1) to level at the vertical distance from *ZP* equal to half the distance from *ZP* to the centre plane, however, not higher than to the upper deck level.

5.3.4 Design Load Acting on Exposed Decks, Superstructure Walls and Deckhouse Walls

5.3.4.1 Design values of external load pressures acting on exposed decks and exposed superstructure walls and deckhouse walls shall be determined in accordance with *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships* or *Part II – Hull of the Rules for the Classification and Construction of Small Sea-going Ships*.

5.3.5 Pressure on Exposed Deck

5.3.5.1 For craft of 24 m in length and above, the pressure acting on the open deck shall be determined in accordance with paragraph 16.2.2.4 of *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships*, taking a_v determined in accordance with the requirements specified in sub-chapter 5.2 hereto.

5.3.5.2 For craft less than 24 m in length, pressure p_0 acting on the open deck shall be determined in accordance with the following formula:

$$p_0 = C_0 p, \text{ [kPa]} \quad (5.3.5.2)$$

where:

p – pressure determined in accordance with paragraph 14.2.2.3 in *Part II – Hull of the Rules for the Classification and Construction of Small Sea-going Ships*;

$$C_0 = 1 + \frac{0.5a_v}{g};$$

a_v – vertical acceleration determined in accordance with the requirements specified in sub-chapter 5.2.

5.3.6 External Pressure on Superstructures

5.3.6.1 Pressure p_0 acting on external walls of superstructures shall be determined in accordance with the following formula:

$$p_0 = C_0 p, \text{ [kPa]} \quad (5.3.6.1)$$

where:

- p – pressure determined in accordance with sub-chapter 10.4 in *Part II – Hull*, of the *Rules for the Classification and Construction of Sea-going Ships* or sub-chapter 14.2.4 in *Part II – Hull*, of the *Rules for the Classification and Construction of Small Sea-going Ships* – depending on the craft length;
- C_0 – coefficient defined in paragraph 5.3.5.2, used for external walls of the first tier;
- $C_0 = 1.0$ – for other wall regions.

5.4 Design Pressure Due to Loads, Stores and Craft Equipment

5.4.1 Pressure of Liquid in Tanks

5.4.1.1 Pressure of liquid in tanks shall be determined in accordance with the requirements of sub-chapter 16.3 in *Part II – Hull*, of the *Rules for the Classification and Construction of Small Sea-going Ships*, taking the value of a_v determined in accordance with paragraph 5.2.1.4.

5.4.2 Load on Decks

5.4.2.1 Deck load due to cargo shall be determined in accordance with the requirements specified in sub-chapter 16.4 of *Part II – Hull*, of the *Rules for the Classification and Construction of Sea-going Ships* or sub-chapters 14.2.3 and 14.4 of *Part II – Hull*, of the *Rules for the Classification and Construction of Small Sea-going Ships*, taking the value of a_v determined in accordance with paragraph 5.2.1.4.

5.4.2.2 For sheltered decks not subjected to loads due to cargo on small craft, the design pressure is the value determined in accordance with sub-chapter 14.2.3 of *Part II – Hull*, of the *Rules for the Classification and Construction of Small Sea-going Ships*, multiplied by factor equal to $1 + \frac{0.5a_v}{g}$. The value of a_v shall be determined in accordance with paragraph 5.2.1.4.

5.4.2.3 Design loads from vehicle wheels shall be determined in accordance with the requirements specified in sub-chapter 19.6 of the *Rules for the Classification and Construction of Sea-going Ships*, taking the value of a_v determined in accordance with paragraph 5.2.1.4.

6 HULL STRUCTURE STRENGTH AND BUCKLING CONTROL

6.1 Minimum Thickness of Structural Elements

6.1.2 The requirements specified in sub-chapter 13.2 of *Part II – Hull* of the *Rules for the Classification and Construction of Sea-going Ships* or sub-chapter 12.3 in *Part II – Hull*, of the *Rules for the Classification and Construction of Small Sea-going Ships* apply within the scope applicable to high speed craft hulls.

6.2 Plating Strength

6.2.1 Required Plating Thickness

6.2.1.1 Plating thickness of the bottom, sides, open deck, first tier of superstructure-deckhouse front wall and tank walls shall not be lesser than the value obtained in accordance with the following formula:

$$t = 1.6k_r s \sqrt{\frac{p}{k}} + t_k, [\text{mm}] \quad (6.2.1.1)$$

where:

s – spacing of stiffeners measured along the plating, [m];

$$k_r = 1 - 0.5 \frac{s}{r}$$

r – plating panel curvature radius, [m];

p – design pressure, [kPa], to be determined in accordance with sub-chapter 5.3 or 5.4;

t_k – corrosion addition (see sub-chapter 2.4).

6.2.1.2 Plating thickness of deck subjected to loads from vehicle wheels shall be determined in accordance with the requirements specified in Chapter 19 of *Part II – Hull* of the *Rules for the Classification and Construction of Sea-going Ships*, taking the design load value in accordance with the requirements specified in paragraph 5.4.2.3.

6.3 Strength of Plating Stiffeners

6.3.1 Required Sectional Modulus and Effective Cross-section Area

6.3.1.1 Required net sectional modulus, W , and effective net cross-section area, A_s , of stiffeners of the plating of bottom, sides, open deck, first tier of superstructure-deckhouse front wall and tank walls shall be determined in accordance with the following formulae:

$$W = \frac{1000 p s l^2}{m \sigma}, [\text{cm}^2] \quad (6.3.1.1-1)$$

$$A_s = \frac{5(l-s)sp}{\tau}, [\text{cm}^2] \quad (6.3.1.1-2)$$

where:

s – spacing of stiffeners, [m];

l – span of stiffener, [m];

p – design pressure, [kPa], to be determined in accordance with sub-chapter 5.3 or 5.4;

$m = 12$ – for longitudinal stiffeners;

$m = 10$ – for transverse stiffeners;
 $\sigma = 180 \cdot k$, [MPa];
 $\tau = 70 \cdot k$, [MPa];
 k – material factor (see Chapter 2).

6.3.1.2 The required value of net sectional modulus of longitudinals and beams of deck subjected to loads from vehicle wheels shall be determined in accordance with the requirements of Chapter 19 of *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships*, taking the design load value in accordance with the requirements specified in paragraph 5.4.2.3.

6.3.1.3 The required dimensions of brackets at the stiffener span ends shall be determined in accordance with the requirements specified in sub-chapter 13.8 of *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships*.

6.4 Strength of Primary Supporting Members

6.4.1 Scope and Method of Calculations

6.4.1.1 Strength of the hull primary supporting members system of bottom and sides shall be checked using FEM calculations.

It is recommended that the FEM model cover the entire bottom and sides as well as associated transverse and longitudinal bulkheads/divisions.

Application of FEM models covering smaller portions of hull stiffeners is subject to PRS consideration in each particular case.

6.4.1.2 The FEM model shall fulfil general requirements specified in Chapter 14 of the *Rules for the Classification and Construction of Sea-going Ships*.

It is recommended that the model where the plating and webs of primary supporting members be divided into shell finite elements, is applied.

Application of a three-dimensional frame model is subject to PRS consideration in each particular case.

6.4.2 Calculation Variants and Design Pressures

6.4.2.1 In the calculations, two variants of loads defined in paragraphs 6.4.2.2 and 6.4.2.3 shall be applied.

6.4.2.2 In the first variant, the pressure of the following value:

$$p_R = \frac{D a_{cv}}{A_R}, \text{ [kPa]} \quad (6.4.2.2)$$

where:

D , a_{cv} , A_R – as defined in paragraph 5.3.2.2, shall be applied to the bottom fragment of $0.3 L_w$ in length (see paragraph 5.3.2.1).

The region of sides in way of the above mentioned fragment shall be loaded by pressure p_0 defined by formula 5.3.3.2, where p_R shall be substituted for p_d .

Distribution of pressure p_b along the frames is as defined in paragraph 5.3.3.2.

Other parts of the structure of bottom and sides are subjected to no load.

Hull fragments in several positions along the craft hull shall be considered, so that the FEM analysis takes account of the loads on all the bottom primary members.

6.4.2.3 In the second variant, the strength of representative individual spans of bottom and side primary supporting members shall be checked by means of FEM model defined in sub-chapter 6.4.1.

Bottom plating or side shell plating in the region of dimensions $l \times b$ (see paragraph 5.3.2.3) is subjected to the load due to pressure p_d (in the case of bottom) determined in accordance with formula 5.3.2.2, where K_D shall be determined in accordance with formula 5.3.2.3 or due to pressure p_b (in the case of side) determined in accordance with formula 5.3.3.2.

Other parts of the plating are subjected to no load.

6.4.2.4 If in the calculations in accordance with the requirements specified in paragraph 6.4.2.1 any fragment of hull segment subjected to any load is located within the region of co-ordinates $-0.15 L_0 \leq x \leq 0.15 L_0$, then the normal stresses in longitudinal primary members (calculated by means of FEM) shall be combined with the stresses due to general bending determined in accordance with the requirements specified in paragraph 6.5.4.1 for bending moment defined in paragraph 6.5.2.2.

These requirements do not apply to the craft mentioned in paragraph 6.5.1.1.

6.4.3 Boundary Conditions

6.4.3.1 Clamping of FEM model nodes situated at the upper deck level is permitted.

6.4.4 Allowable Stress

6.4.4.1 Allowable stress values specified in paragraph 14.5.3 of *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships* apply to the variants of calculations defined in paragraphs 6.4.2.2 and 6.4.2.3.

6.4.4.2 Allowable normal stress values in longitudinal primary members determined in accordance with the requirements specified in paragraph 6.4.2.4 is 190k, [MPa].

6.5 Longitudinal Strength

6.5.1 General

6.5.1.1 PRS may require hull longitudinal strength analysis for craft whose:

- .1 length of craft L is less than 50 m;
- .2 $L/H < 12$.

6.5.1.2 Craft not fulfilling the conditions specified in 6.5.1.1 shall fulfil the requirements of Chapter 15 in *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships* or Chapter 13 of *Part II – Hull of the Rules for the Classification and Construction of Small Sea-going Ships*, for craft speed of $\frac{1}{2}v_0$ (for v_0 see paragraph 1.1.1) and the requirements specified in sub-chapters 6.5.2, 6.5.3 and 6.5.4.

6.5.2 Bending Moments Due to Impact Loads

6.5.2.1 Consideration shall be given to the hull bending moment due to the hull middle portion impact against water surface which causes hull hogging (in accordance with paragraph 6.5.2.2) and also due to simultaneous impact of the craft forebody and afterbody of the bottom which causes hull sagging (in accordance with paragraph 6.5.2.3).

6.5.2.2 The value $M = M_{ww}$ of the bending moment due to the hull middle portion impact against water surface (see Fig. 6.5.2.2) shall be determined in accordance with the following formula:

$$M_{ww} = 0.5D(g + a_{cv})(0.5e - 0.25l_R), \text{ [kNm]} \quad (6.5.2.2)$$

where:

D, g – as defined in sub-chapter 1.2;

a_{cv} – as defined in paragraph 5.2.1.1;

e – distance between the forebody centre of gravity of mass equal to $\frac{1}{2}D$ and

afterbody centre of gravity of mass equal to $\frac{1}{2}D$, [m]; where no accurate

data are available, $e = 0.5L_w$ shall be assumed;

l_R – length of the bottom fragment loaded by impact pressure to be taken as $l_R = 0.3L_w$.

The dependence of M_{ww} on co-ordinate x is shown in Fig. 6.5.2.2.

6.5.2.3 The value $M = M_{wu}$ of the bending moment due to simultaneous impact of the forebody and afterbody against water surface (see Fig. 6.5.2.3) shall be determined in accordance with the following formula:

$$M_{wu} = 0.5D(g + a_{cv})(0.425L_w - 0.5e), \text{ [kNm]} \quad (6.5.2.3)$$

where:

D, g, a_{cv}, L_w, e – see paragraph 6.5.2.2.

The dependence of M_{wu} on co-ordinate x is shown in Fig. 6.5.2.3; for l_R see paragraph 6.5.2.2.

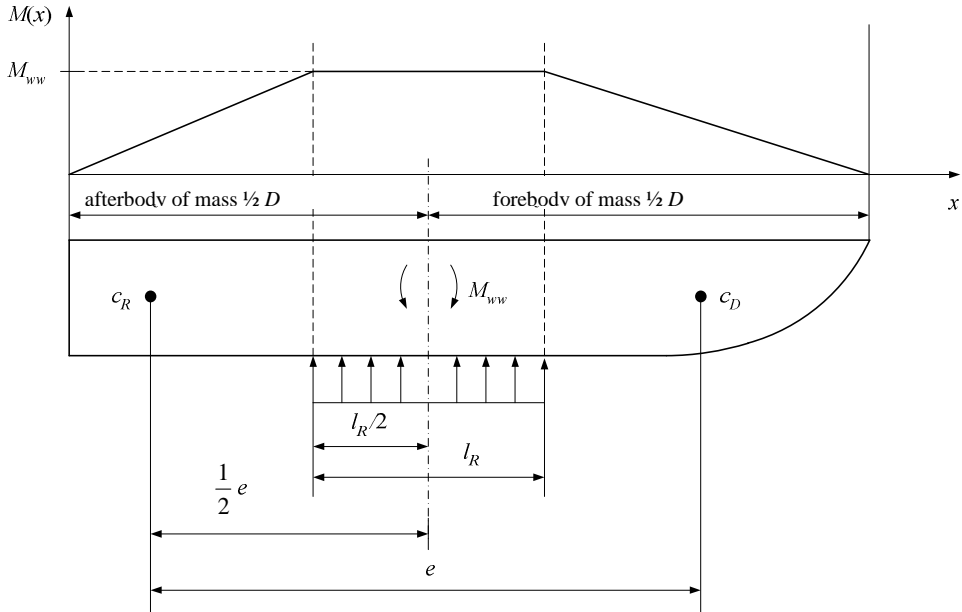


Fig. 6.5.2.2 General bending which causes hogging

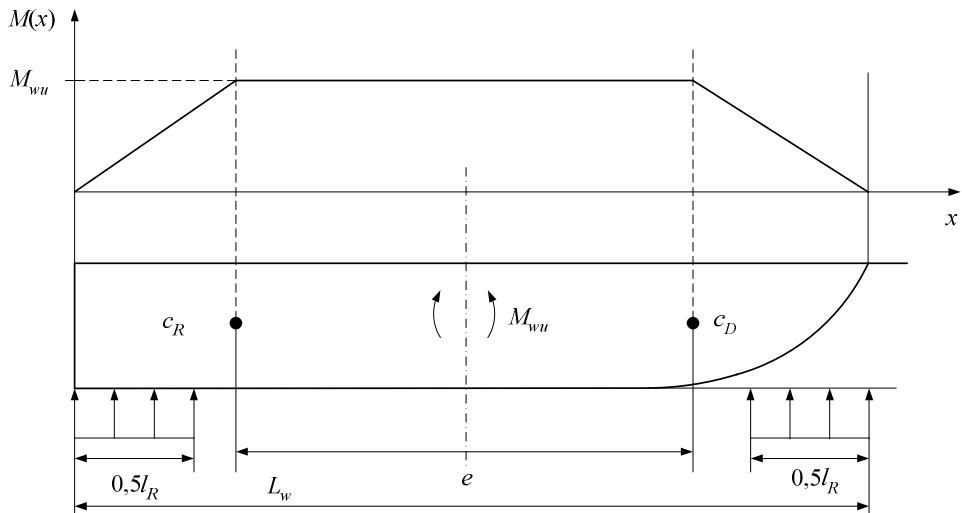


Fig. 6.5.2.3 General bending which causes sagging

6.5.3 Shear Forces Due to Impact Loads

6.5.3.1 The value of shear force Q due to impact against the water surface shall be determined in accordance with the following formula:

$$Q = 4 \frac{M}{L_w}, \text{ [kN]} \quad (6.5.3.1)$$

where:

M – design value of bending moment M_{ww} lub M_{wu} determined in accordance with paragraph 6.5.2.2 or 6.5.2.3.

Relation $Q(x)$ is shown in Fig. 6.5.3.1; for l_R see paragraph 6.5.2.2.

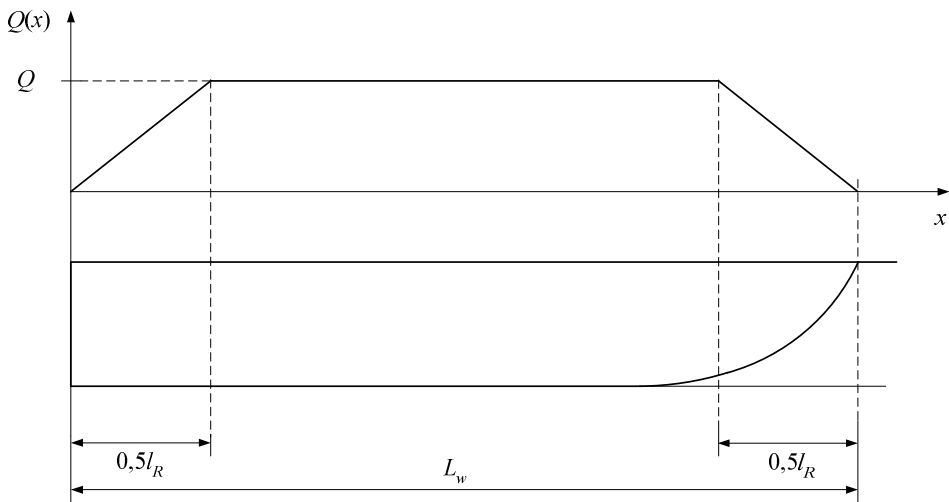


Fig. 6.5.3.1

6.5.4 Allowable Stress

6.5.4.1 Normal and shear stress in hull due to impact loads shall be determined as required in Chapter 15 of *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships*, taking the values of bending moment and shear force defined in sub-chapters 6.5.2 and 6.5.3.

Allowable values of those stresses are as in Chapter 15 of *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships*.

6.6 Buckling Control of Structure

6.6.1 Buckling strength of the hull structural elements shall be checked using the methods and criteria specified in Chapter 13 of *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships*.

7 HULL STRUCTURE

7.1 General

7.1.1 Application

7.1.1.1 General requirements regarding the construction of hull, superstructures or deckhouses, bulwark, etc., are specified in this Chapter.

The required scantlings of structural elements (plating thickness, sectional modulus of plating stiffeners, bracket scantlings) shall be determined in accordance with the requirements of Chapter 6.

7.2 Continuity of Structural Members

7.2.1 Primary Supporting Members and their Endings

7.2.1.1 Primary supporting members shall be so arranged and designed as to avoid abrupt changes of their height or cross-sectional area.

Where primary member segments are connected to both sides of the bulkhead or other hull structure element, they shall be aligned.

It is recommended that primary members in tanks form frame systems in transverse planes (i.e. frame planes) or longitudinal planes.

7.2.1.2 Buckling strength of primary members shall be ensured by effective stiffening of their webs and application of tripping brackets. Detailed requirements in respect of the above mentioned issues are specified in sub-chapter 3.6 of *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships*.

Openings in primary member webs shall have respectively rounded corners and shall not be arranged in the regions where extreme stress is expected and their presence may not significantly reduce the buckling strength of such a member.

7.2.1.3 Primary member terminating on a structural element (e.g. bulkhead) which does not form a significant constraint on rotation shall be extended beyond such a structural element for at least two frame spacings – e.g. in the form of bracket with gradually reduced height.

7.2.1.4 Segments of primary members forming planar frames shall be so connected as to avoid excess stress concentration.

It is recommended that integral brackets or smooth-ended brackets be applied.

The bracket arm lengths shall not be less than the lesser height of the connected segments of primary members.

7.2.2 General Requirements for Continuity of Structural Members

7.2.2.1 Abrupt changes of cross section shapes and size of structural members, sharp endings and other types of stress raisers shall be avoided.

7.2.2.2 Deck pillars shall, generally, be situated coaxially and supporting bulkheads – in the same vertical planes.

Unless meeting these conditions is possible, adequate design solutions shall be applied to ensure safe transmission of vertical loads on the structural elements of lower tiers.

Structural elements adjacent to pillars or primary supporting members shall provide for suitable load distribution in the form of axial forces in pillars.

7.2.2.3 In places of intersection of primary member webs of the same height, diamond plates or brackets shall be applied (Fig. 7.2.2.3).

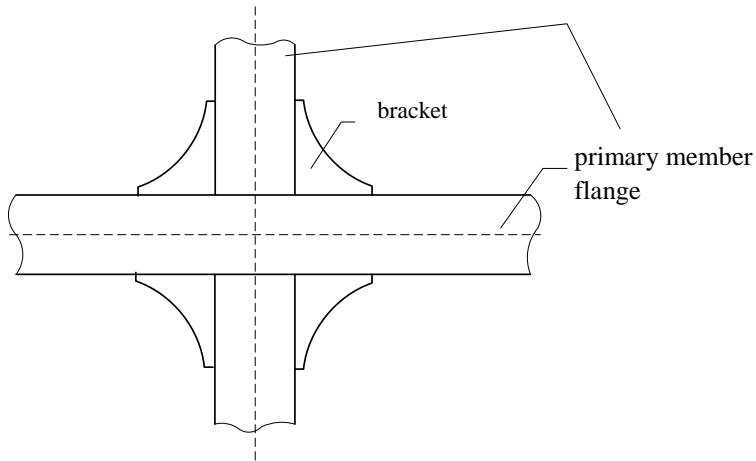


Fig. 7.2.2.3 Brackets at primary member flanges

7.2.2.4 At primary member ends, smooth-ended brackets shall be applied.

Bracket ends shall be effectively supported, i.e. they shall not be connected to unstiffened plating panels.

Bracket flange ends shall be snipped.

Where bracket flange is welded to its side surface, the bracket end shall be so shaped that the following condition is fulfilled (see Fig. 7.2.2.4):

$$h_w t_w \geq 0.6 h_m t_m \quad (7.2.2.4)$$

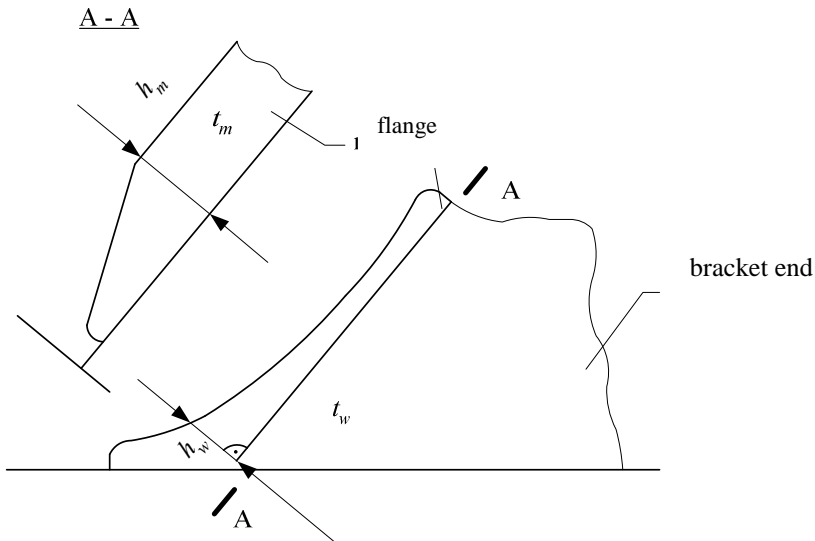


Fig. 7.2.2.4 Bracket end

7.2.3 Connection of Plating Stiffeners to Primary Members

7.2.3.1 The requirements specified in paragraph 4.3.7 of *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships* apply.

The requirements specified below apply to heavily loaded connections of the bottom and side stiffeners to primary members, subjected to impact pressures defined in sub-chapters 5.3.2 and 5.3.3.

7.2.3.2 Plating stiffeners of the bottom, sides, decks and bulkheads shall, generally, pass continuously through their primary supporting members, bulkheads or other divisions.

Cut-outs in primary member webs (or in the plating of bulkheads or other divisions) shall be so shaped that the stress concentration on their whole perimeter and in the hull shell plating in their immediate vicinity be as low as possible.

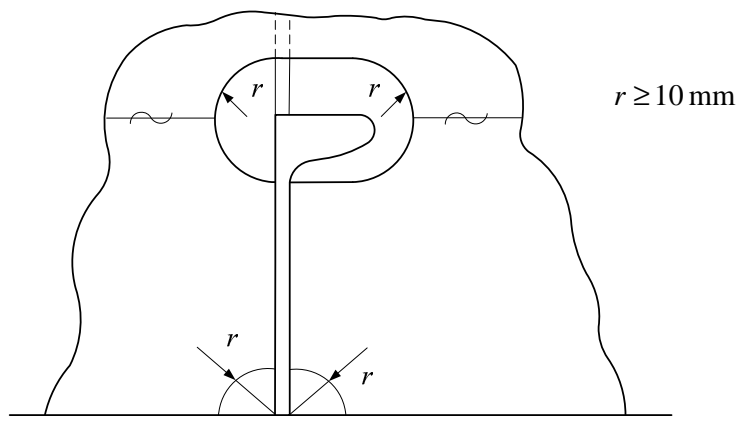
If a plating stiffener web is not directly connected to the primary member web, doubling plates shall be applied on both sides of such a stiffener.

7.2.3.3 Cut-outs for stiffeners shall be as narrow as practicable and their corners shall be rounded to a radius as large as practicable.

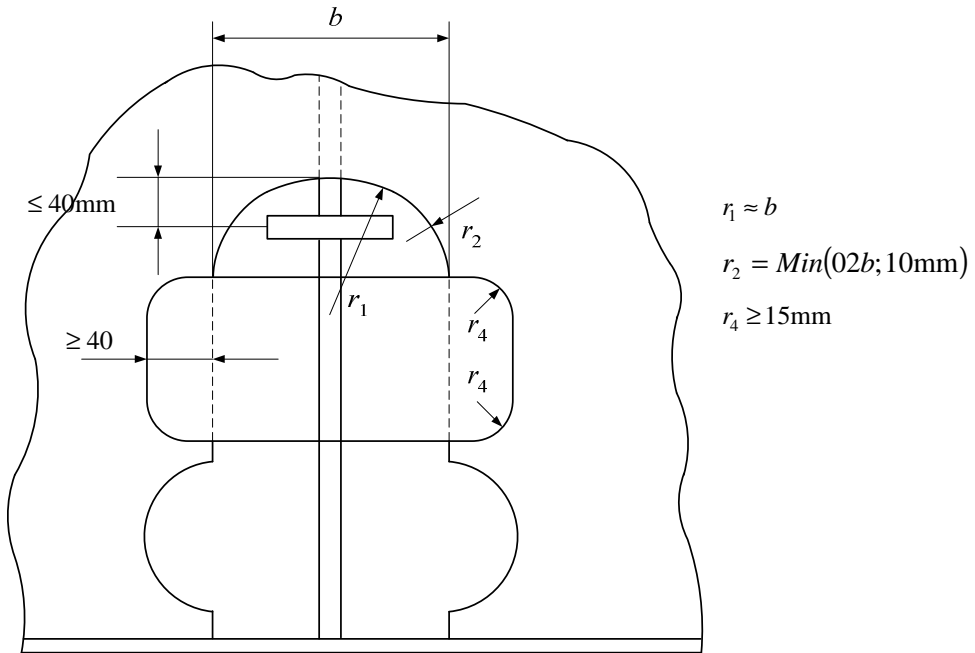
Recommended patterns of connection of plating stiffeners to primary members are shown in Fig. 7.2.3.3.

Rounding radius r_2 at the cut-out upper edge shall not be less than 20% of the cut-out width and not be less than 10 mm – for craft of a length not exceeding 24 m and 20 mm – for craft more than 24 m in length.

a)



b)



c)

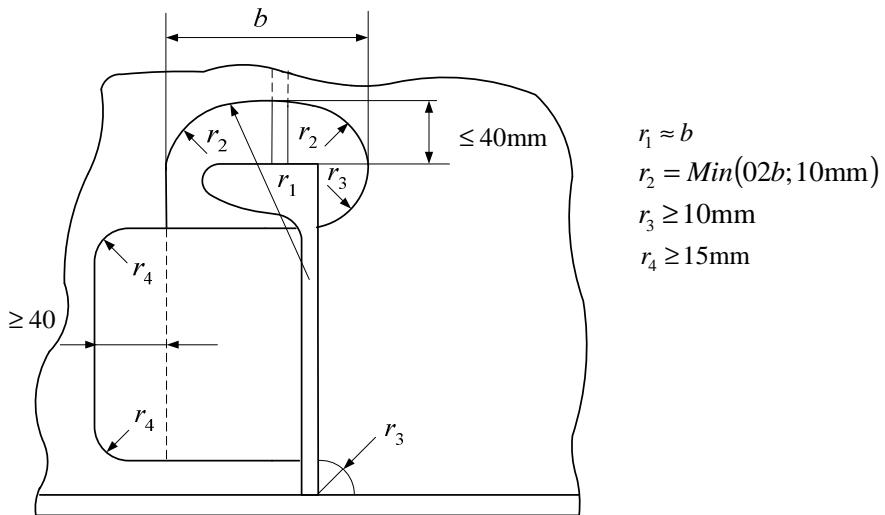


Fig. 7.2.3.3 Recommended patterns of connection of plating stiffeners to primary members

7.2.3.4 Application of primary member web stiffeners which are staggered in relation to the plating stiffener is permitted. An example of such solution is shown in Fig. 7.2.3.4.

An opening for plating stiffener and doubling plate shall fulfil the requirements specified in paragraph 7.2.3.3.

Doubling plate shall be connected by means of fillet welds of thickness determined in accordance with paragraph 4.3.1.1 using $\alpha = 0.45$.

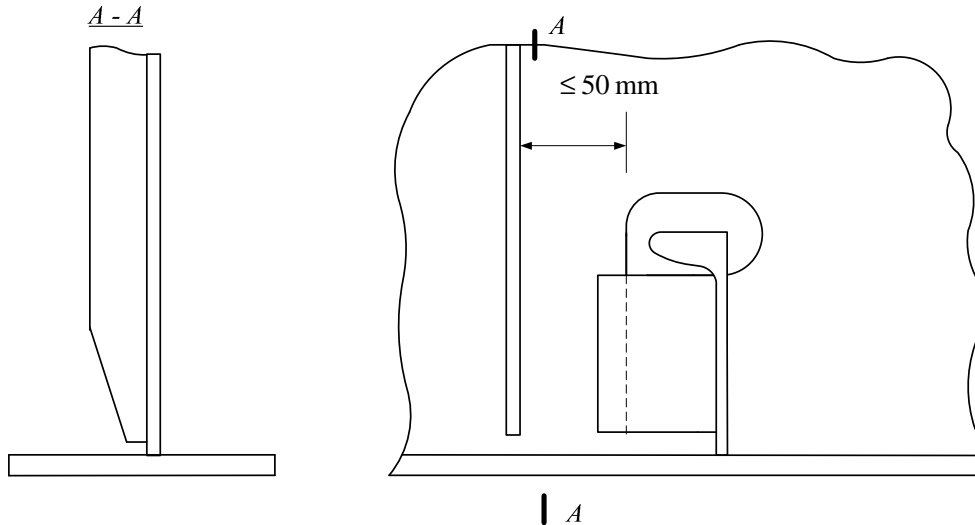


Fig. 7.2.3.4

7.2.3.5 Primary member web stiffeners may be situated perpendicularly to the planes of plating stiffener webs in order to eliminate stress concentration (occurring in the cases shown in Fig. 7.2.3.3) in places where such structural elements are connected.

The primary member web stiffener which is the closest to a plating stiffener shall not be situated farther than 150 mm from the upper edge of cut-out for the plating stiffener.

7.3 Bilge Keels and other Craft Equipment Elements Welded to Hull Structure

7.3.1 Bilge Keels

7.3.1.1 Bilge keels shall not be installed within $0.3L$ aft of the fore perpendicular in craft intended for service in ice conditions (see Chapter 8).

7.3.1.2 Recommended design of bilge keel is shown in Fig. 7.3.1.2. Bilge keel in the form of flat bar or bulb bar shall be connected to the plating by means of continuous intermediate flat bar.

Intermediate flat bar thickness shall not be lesser than plating thickness in way of the bilge keel, however, not less than 6 mm.

Intermediate flat bar and bilge keel bar shall be made of a material of the same strength and grade as the plating thickness in way of the bilge keel.

$$R_1 \geq 4h_s$$

$$R_2 \geq 2h_s$$

$$b_1 \geq 20 \text{ mm}$$

$$50 \text{ mm} \leq l_1 \leq 100 \text{ mm}$$

$$h_1 \leq 15 \text{ mm}$$

$$l_2 \geq 3h_s$$

$$l_3 \geq 100 \text{ mm}$$

intermediate
flat bar

bilge keel bar

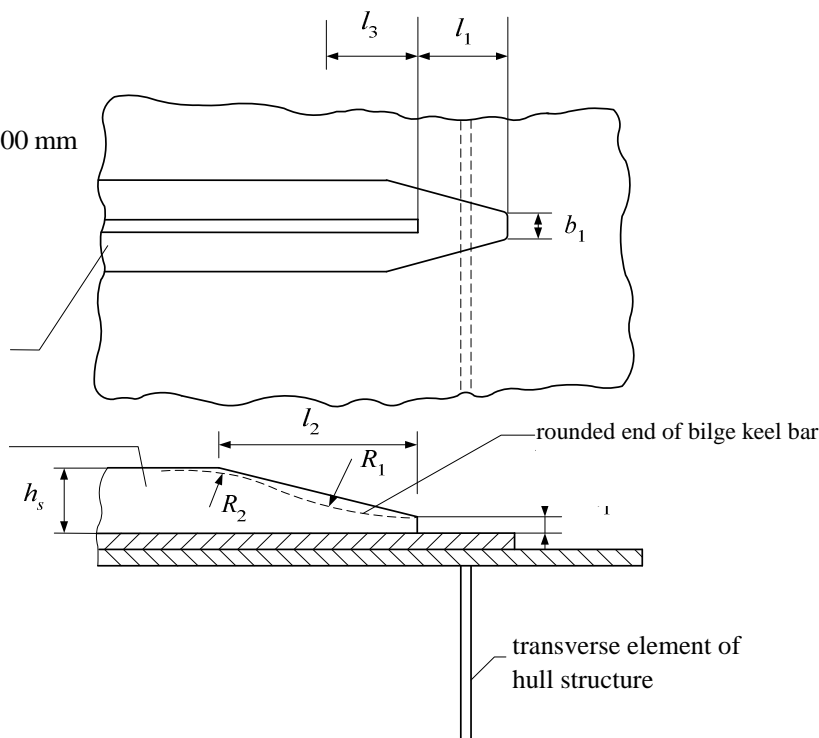


Fig. 7.3.1.2 Recommended design of bilge keel

7.3.1.3 Intermediate flat bar shall be connected to the plating by means of continuous fillet weld.

In outer segments of length $l_1 + l_3$ (see Fig. 7.3.1.2) reinforced weld of thickness determined in accordance with paragraph 4.3.1.1 and using $\alpha = 0.45$ shall be applied. In other than outer segments $\alpha = 0.25$ shall be used to determine the weld thickness.

Bilge keel bar shall be connected to the intermediate flat bar by means of surface weld where $\alpha = 0.15$ is used, except for the outer segments of length l_3 (see Fig. 7.3.1.2) where $\alpha = 0.35$ shall be used.

In the above mentioned outer segments, welds shall be ground to ensure smooth transition of their surface into the plating or intermediate flat bar.

7.3.1.4 Bilge keel bar ends shall be snipped or rounded (see Fig. 7.3.1.2).

7.3.1.5 Bilge keel bar shall be coplanar with the longitudinal stiffener of platings, and the bilge keel ends shall be situated in way of the transverse stiffener of plating, transverse primary member, division, etc.

Such a transversal hull structural element shall be situated as close as possible to the centre of the intermediate flat bar outer segment of length l_1 (see Fig. 7.3.1.2).

7.3.2 Craft Equipment Elements Welded to Hull Structure

7.3.2.1 Profiles welded to the strength deck in order to form a scupper system shall be so shaped as to minimise stress concentration in the deck plating due to general bending of hull.

7.3.2.2 Supports or hangers for pipes, wires and other craft equipment elements shall not be welded to the hull structure in the immediate vicinity of ends of brackets of plating stiffeners and primary members, as well as corners of openings in the hull structural elements or other regions where stress concentration is expected.

7.4 Single Bottom

7.4.1 General

7.4.1.1 The requirements specified in sub-chapter 7.4 apply to the single bottom structure of transverse or longitudinal framing system.

7.4.1.2 Structural continuity shall be ensured along the hull. Bottom longitudinals shall extend as close to the bow and stern as practicable. If bottom longitudinals terminate at bulkheads or other transverse divisions, then smooth-shaped brackets shall be applied at their ends.

7.4.1.3 The connections of bottom longitudinals and floors shall fulfil the requirements specified in paragraph 7.2.2.3.

7.4.2 Plating

7.4.2.1 Plating thickness shall fulfil the requirements specified in sub-chapters 6.1 and 6.2.

7.4.2.2 In way of plating edges on the bilge (point *ZP* in Fig. 1.1.1-a) plating thickness shall be increased by at least 20% compared to that required in paragraph 6.2.1.1. The applied plating thickness value shall not, however, be less than 6.0 mm.

Bottom and side shell plating panels in way of the plating edges shall be welded with full penetration.

7.4.2.3 If the bottom plating in way of plating edges is connected to the side shell plating by means of tube, then the tube wall thickness shall be greater by at least 20% than the bottom plating thickness required in that region.

Bottom and side shell plating panels shall be welded to the tube walls with full penetration.

7.4.3 Bar Keel

7.4.3.1 Bar keel scantlings shall fulfil the requirements specified in paragraph 10.6.1 of *Part II – Hull*, of the *Rules for the Classification and Construction of Small Sea-going Ships*.

7.4.4 Bottom Centre Girder

7.4.4.1 Bottom centre girder shall, in general, extend throughout the hull length.

Bottom centre girder may be waived only in the forebody and afterbody where the floor breadth measured at their upper edge level is less than 1.5 m.

7.4.4.2 Bottom centre girder face plate shall be continuous. Bottom centre girder web may be intercostal between floors.

Bottom centre girder height shall, in general, be equal to the height of floors in the centre plane.

Web thickness shall not be lesser than that specified in sub-chapter 6.1.

Web and face plate scantlings shall be so selected as to fulfil the requirements for primary members specified in sub-chapter 6.4.

Face plate thickness shall not be lesser than that of web.

7.4.5 Bottom Side Girders

7.4.5.1 Bottom side girders shall be applied where the breadth of craft at the level of floor face plates exceeds 6.0 m.

The distance between the bottom side girder and craft side or bottom centre girder and the distance between individual bottom side girders shall not exceed 3.0 m.

7.4.5.2 Bottom side girders shall be applied throughout the longest possible stretch of bottom. They shall be terminated at transverse bulkheads or floors. At bottom side girder termination smooth-ended brackets shall be applied.

7.4.5.3 Bottom side girder webs shall be intercostal between floors.

7.4.5.4 Web thickness shall not be lesser than the value specified in sub-chapter 6.1.

Face plate thickness shall not be lesser than that of webs.

Bottom side girder scantlings shall be so selected as to fulfil the strength requirements for primary members as determined in sub-chapter 6.4.

7.4.5.5 In machinery spaces additional longitudinals may be necessary to provide for engine foundations. Such longitudinals shall fulfil the requirements specified in Chapter 12 of *Part II – Hull*, of the *Rules for the Classification and Construction of Small Sea-going Ships*.

7.4.6 Floors

7.4.6.1 In the case of hull with transverse framing system, T-section floors shall be applied in all the frame planes.

7.4.6.2 In the case of hull with longitudinal plating stiffeners in the bottom, floors shall be applied in web frame planes and their spacing shall not exceed 2.0 m.

7.4.6.3 It is recommended that floor webs be continuous throughout the breadth of bottom, however they are permitted to be intercostal at the bottom centre girder.

7.4.6.4 Floor face plates need not be parallel with the base plane.

7.4.6.5 Floor web thickness shall not be lesser than the value specified in sub-chapter 6.1. Face plate thickness shall not be lesser than that of webs.

Floor scantlings shall be so selected as to fulfil the strength requirements for primary members as determined in sub-chapter 6.4.

7.4.6.6 Brackets connecting floors to frames or to stiffeners/primary members of longitudinal bulkheads shall be smooth-ended.

7.4.7 Longitudinal Bottom Stiffeners

7.4.7.1 Longitudinal bottom stiffeners shall fulfil the requirements analogous to those for double bottom stiffeners as specified in sub-chapter 7.5.8.

7.5 Double Bottom

7.5.1 General

7.5.1.1 It is recommended that double bottom be applied in the region between the after peak bulkhead and collision bulkhead.

Inner bottom shall be situated above the bottom plating edge (point *ZP* in Fig. 1.1.1).

7.5.2 Bar Keel

7.5.2.1 Bar keel scantlings shall fulfil the requirements specified in paragraph 7.4.3.1.

7.5.3 Bottom Centre Girder

7.5.3.1 Bottom centre girder height shall not be less than 650 mm.

The girder plates shall fulfil the requirements analogous to those specified in sub-chapter 7.4.4 for bottom centre girder web in craft with single bottom.

7.5.4 Duct Keel

7.5.4.1 Duct keel width shall not be less than 650 mm.

Duct keel shall also fulfil the requirements specified in sub-chapter 6.2.4 of *Part II – Hull, of the Rules for the Classification and Construction of Sea-going Ships*.

7.5.5 Bottom Side Girders

7.5.5.1 Bottom side girders shall fulfil the requirements analogous to those specified in sub-chapter 7.4.5 for girder webs in craft with single bottom.

7.5.6 Floors

7.5.6.1 Plate floors shall be continuous in the region from the side to bottom centre girder or duct keel.

7.5.6.2 In the case of craft with longitudinal framing system, the spacing of plate floors shall not exceed 2.0 m.

In machinery spaces plate floors shall, however, be applied in all the frame planes (with the spacing not exceeding 0.7 m).

In the forebody (forward of amidships), the plate floor spacing shall not exceed 1.0 m.

Plate floors shall also be applied under transverse bulkheads and at those frame planes where pillars are supported by the bottom.

7.5.6.3 Plate floor panels shall be stiffened vertically, coplanarly with the longitudinal bottom stiffeners or in their immediate vicinity (see paragraph 7.2.3.4). The height of such stiffeners shall not be less than 10 times the minimum floor thickness required in sub-chapter 6.1, and their thickness shall not be less than the required minimum floor thickness.

7.5.6.4 In the case of craft with transverse framing system in the bottom, the arrangement of plate floors shall fulfil the requirements for the bottom with longitudinal framing system (see paragraph 7.5.6.2).

Between plate floors, open floors shall be applied in all the frame planes (with the spacing not exceeding 0.7 m).

Open floors may be made of plates with holes or of sections.

7.5.6.5 Plate floors and open floors shall fulfil the strength criteria specified in Chapter 6.

7.5.6.6 Watertight floors shall fulfil the strength criteria for watertight bulkheads or tank bulkheads specified in Chapter 13 of *Part II – Hull*, of the *Rules for the Classification and Construction of Sea-going Ships*.

7.5.7 Supporting Plates

7.5.7.1 Supporting plates in the double bottom shall fulfil the requirements specified in Chapter 6 of *Part II – Hull*, of the *Rules for the Classification and Construction of Sea-going Ships*.

7.5.8 Stiffeners of Bottom Plating and Inner Bottom Plating

7.5.8.1 In the double bottom with longitudinal framing system, the stiffeners of bottom plating and inner bottom plating shall continuously run through floors or bulkheads (see paragraphs 7.2.3.2 and 7.2.3.3).

If a stiffener needs to be terminated at a floor or bulkhead, it shall be smoothly ended with an appropriate bracket.

7.5.8.2 Transverse stiffeners of the bottom and inner bottom shall continuously run through the side girders or longitudinal bulkheads (see paragraphs 7.2.3.2 and 7.2.3.3).

7.5.9 Bottom Plating and Inner Bottom Plating

7.5.9.1 Bottom plating shall fulfil requirements analogous to those for single bottom plating (see sub-chapter 7.4.2).

7.5.9.2 Inner bottom plating thickness shall fulfil the requirements specified in sub-chapters 6.1 and 6.2.

7.6 Side Shell

7.6.1 Side Shell Plating

7.6.1.1 Side shell plating thickness shall fulfil the requirements specified in sub-chapters 6.1 and 6.2.

7.6.1.2 Sheer strake thickness shall not be less than that required in paragraph 7.6.1.1. Local strengthenings (stiffeners) of sheer strake shall be provided in places where fenders are supported by the sides.

7.6.1.3 In way of superstructure outer bulkheads, sheer strake plating thickness shall be increased as required in sub-chapter 7.3.2 of *Part II – Hull*, of the *Rules for the Classification and Construction of Sea-going Ships*.

7.6.2 Longitudinal Stiffeners of Side Shell Plating

7.6.2.1 Longitudinal stiffeners of side shell plating shall be supported by web frames, transverse bulkheads, divisions, etc., spaced not more than 2.0 m apart.

They shall continuously run through the structural elements supporting them (see also sub-chapter 7.2).

If a longitudinal stiffener needs to be terminated at a web frame, bulkhead, etc., it shall be extended beyond its support by means of an appropriate bracket.

7.6.3 Transverse Stiffeners of Plating (ordinary frames)

7.6.3.1 Ordinary frames need not continuously run through lower decks.

Frame segments shall be fixed to the bottom and decks by means of brackets ensuring their maximum constraint on rotation.

7.6.3.2 Where side stringers are applied in the hull structure, frames shall run through them continuously (see also paragraphs 7.2.2 and 7.2.3).

7.6.4 Side Primary Members

7.6.4.1 Web frames shall, in general, be situated at the same frame planes where floors and transverse deck girders are applied, and shall be integrally (i.e. without added brackets) fixed to those primary members of the bottom and decks.

Application of brackets added to the primary member webs and positioning of web frames not coplanar with floors or web frames is subject PRS consideration in each particular case.

7.6.4.2 Side stringers shall run through bulkheads and transverse divisions continuously.

7.6.4.3 Intersections of side stringers and web frames shall fulfil the requirements specified in paragraph 7.2.2.3 (in the case of their equal heights).

In the case of intersection of the side primary members having different heights, the lower member shall, in general, continuously run through the higher member web.

7.7 Bulkheads

7.7.1 General

7.7.1.1 Bulkheads shall fulfil the requirements specified in Chapter 9 of *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships* or Chapter 8 of *Part II – Hull of the Rules for the Classification and Construction of Small Sea-going Ships* (where $L < 24$ m).

Additionally, the requirements specified in sub-chapter 7.7.2 shall be fulfilled.

While determining the necessary scantlings of tank bulkhead structure, the design pressure determined in accordance with paragraph 5.4.1.1 shall be taken into account.

7.7.2 Connections of Bulkhead Stiffeners and Primary Supporting Members to Bottom and Sides

7.7.2.1 Vertical stiffener ends of bulkheads shall be welded to the bottom longitudinal stiffeners or plating (where the bottom is stiffened transversely). Brackets applied at such stiffener ends shall be smooth-ended.

7.7.2.2 Where a bulkhead is stiffened by means of horizontal stiffeners, their ends shall be welded to the horizontal side stiffeners or to the side plating (where the sides are stiffened transversely). Brackets applied at such stiffener ends shall be smooth-ended.

7.7.2.3 At the ends of vertical or horizontal primary members of bulkheads smooth-ended brackets shall be applied.

7.8 Decks

7.8.1 General

7.8.1.1 It is recommended that longitudinal system of strength deck stiffeners be applied between the sides and hatch opening edges.

7.8.1.2 Deck transverses shall be situated at the same frame planes where web frames are applied.

7.8.1.3 Longitudinal stiffeners of the strength deck plating shall, in the middle portion of hull, continuously run through deck transverses and bulkheads.

7.8.1.4 Deck structure members shall fulfil the strength requirements specified in Chapter 6.

7.8.2 Deck Openings

7.8.2.1 Deck openings shall be reinforced by respectively sturdy primary members welded on the whole perimeter.

It may be reasonable to support such primary members by means of deck pillars.

The ends of stiffeners or primary members of the deck shall be welded to the coaming of such an opening.

7.8.2.2 Deck opening corners shall fulfil the requirements specified in sub-chapter 8.5 of *Part II – Hull* of the *Rules for the Classification and Construction of Sea-going Ships*.

7.9 Superstructures and Deckhouses

7.9.1 General

7.9.1.1 Superstructure and deckhouse structures shall fulfil the general requirements specified in sub-chapter 10.2 of *Part II – Hull* of the *Rules for the Classification and Construction of Sea-going Ships* in addition to those specified in this sub-chapter.

7.9.1.2 It is recommended that superstructures and deckhouses have rounded edges of side, front and aft walls.

7.9.1.3 Primary members of superstructure/deckhouse walls and decks shall form frames connected to the primary supporting members of hull.

Pillars supporting superstructure decks shall be supported by primary supporting members or pillars in the hull.

7.9.1.4 It is recommended that the stiffeners of deck and wall plating continuously run through the primary members supporting them.

7.9.1.5 Strengthening measures shall be provided for plating, stiffeners and primary members in places where stress concentration is expected (e.g. in way of deck opening corners or wall opening corners) or in places subjected to increased loads induced by masts, machinery and equipment, etc.

7.9.1.6 Adequate stiffness of superstructures/deckhouses shall be provided in the direction transverse to the centre plane by means of transverse divisions supported below the upper deck on bulkheads or divisions or robust frames.

7.9.2 Forecastle

7.9.2.1 Side shell plating thickness within the forecastle shall not be lesser than that required at the upper deck level.

7.9.2.2 Forecastle sides shall be stiffened by means of frames terminated with brackets at the upper deck. Web frames shall be applied in the side web frame planes below the upper deck.

7.9.2.3 Where the after bulkhead of forecastle is situated at a distance from the fore perpendicular $l_d > 0.2L_0$, the upper deck plating thickness shall be increased at sides.

The region of increased deck plating thickness shall include the deck portion on both sides of the forecastle after bulkhead (i.e. fore and aft) and shall extend in both directions for a distance not lesser than half the forecastle height.

The plating thickness shall be increased by 20% – where $l_d \geq 0.25L_0$, and 0% – where $l_d = 0.2L_0$.

For intermediate values of l_d , linear interpolation shall be applied.

7.9.2.4 Scantlings of the stiffeners and primary members of forecastle sides shall be determined like those of the side shell using the design pressure determined for the side shell at the upper deck level.

7.9.3 Superstructures Participating in General Bending of Hull

7.9.3.1 In the case of superstructures situated in the midship portion of craft hulls more than 40 in length or in the case of considerable openings made in superstructure side walls or considerable number of small openings (e.g. windows), direct FEM calculations are required to determine the stresses in hull and superstructure in the conditions of general bending. For this purpose, the bending moments and shear forces determined in sub-chapter 6.5 shall be used.

The FEM model shall fulfil the general requirements specified in sub-chapter 14.6 of *Part II – Hull of the Rules for the Classification and Construction of Sea-going Ships*.

7.9.4 Connection of Superstructures and Deckhouses of Aluminium Alloy to Steel Hull

7.9.4.1 General requirements specified in sub-chapter 4.4 of *Part II – Hull* of the *Rules for the Classification and Construction of Small Sea-going Ships* shall be fulfilled.

7.9.4.2 PRS may require to make direct calculations of stresses in the connection of superstructure/deckhouse to the hull using FEM in accordance with the requirements specified in paragraph 7.9.3.1.

8 STRENGTHENING REQUIREMENTS FOR NAVIGATION IN ICE CONDITIONS

8.1 General

8.1.1 High speed craft operation in ice conditions is permitted only in the displacement cruising state on condition that the hull fulfils the requirements specified in Chapter 26 of *Part II – Hull* of the *Rules for the Classification and Construction of Sea-going Ships* or Chapter 21 of *Part II – Hull* of the *Rules for the Classification and Construction of Small Sea-going Ships*.

8.1.2 Craft hull with sides stiffened transversely intended for service in ice conditions shall fulfil the requirements for basic ice strengthening (L4) specified in Chapter 26 of *Part II – Hull* of the *Rules for the Classification and Construction of Sea-going Ships* or the requirements for ice strengthening **Lm1** or **Lm2** specified in Chapter 21 of *Part II – Hull* of the *Rules for the Classification and Construction of Small Sea-going Ships*.

8.1.3 Craft hull with sides stiffened longitudinally intended for service in ice conditions shall have strength, when subjected to the load due to ice conditions, equivalent to that of hull with sides stiffened transversely resulting from the requirements specified in sub-chapter 8.1.2.

Ice strengthening construction is subject to PRS consideration in each particular case then.

8.1.4 The problem of ice strengthening of high speed craft intended for service in worse ice conditions that those specified in paragraph 8.1.2 is subject to PRS consideration in each particular case.
