3. REQUIREMENTS FOR STRUCTURES OF SHIPS OF SPECIAL DESIGN

3.1 SHIPS WITH LARGE DECK OPENINGS

3.1.1 General and symbols.

3.1.1.1 The requirements of this Chapter are additional to those of Sections 1 and 2.

3.1.1.2 The requirements for deck structure, exclusive of those for cantilever beams, apply to ships with single, twin and triple cargo hatchways which are considered to form a large deck opening meeting the following conditions:

$$b/B \geq 0{,}7; \quad l/l_m \geq 0{,}7.$$

The requirements of this Chapter shall be applicable throughout the entire cargo hatch region, including the engine room, provided it is located between the cargo holds.

3.1.1.3 The requirements for container securing arrangements and hull structures, which take up forces exerted by the said arrangements, apply to container ships.

3.1.1.4 The cantilever beam is a short deep half beam for which the supporting effect of the side hatch coaming is disregarded in the strength and buckling strength calculation to be made for deck grillage in accordance with 2.6.4.7 and 2.6.4.6.5 respectively.

3.1.1.5 Symbols:

b – breadth of deck opening determined as the distance between the outer longitudinal edges of hatchway openings at ship's sides, in m;

l – length of hatchway opening, in m;

l_m – distance between centres of transverse deck strips at each end of opening, in m.

c – distance between trasverse edges of adjoining openings, in m;

W and W_d^{Φ} – which is required by the Rules for $\eta = 1$, and actual deck section modulus according to 1.4.5 and 1.4.7;

n – total number of 20-foot containers carried by the ship.

3.1.2 Construction.

3.1.2.1 For ships with a length L≥80 m longitudinal framing system is provided for the deck and bottom.

3.1.2.2 Upper deck and side longitudinals shall be continuous within the region stated in3.1.1.2.

3.1.2.3 Ends of cargo hatch continuous side coamings shall be attached as required by 1.7 and 2.6.2. It is not recommended that continuous side coamings be attached to the front bulkhead of the aft superstructure and the aft bulkhead of the forecastle.

3.1.2.4 Abrupt changes of cross section and shape of members referred to in 3.1.2.2 over the length of the ship is generally not permitted. Where such changes are necessary, arrangements shall be such as to minimize the creation of stress concentration and attention shall be paid to provision of buckling strength.

3.1.2.5 The attachment of the forward end of the longitudinal strip to the deck where there is a cargo hatch single opening forward of the attachment shall be specially considered by the Register.

3.1.2.6 It is recommended that

transverse and longitudinal deck strips have a box-shaped crosssection.

3.1.2.7 Transverse deck strips shall be efficiently attached to the underdeck framing members and web frames in line with which they are fitted. Where the plating of the deck strips is arranged in line with the upper flanges of continuous hatch side coamings, the attachment of deck strips to the deck and side shell shall be specially considered by the Register.

3.1.2.8 Openings in the deck plating in immediate proximity to the attachments of transverse and longitudinal deck strips are not permitted.

3.1.2.9 Large deck openings:

.1 adjacent corners of hatch openings in the upper deck arranged in one line shall be rounded with a radius *r*, in m, (refer to Fig. 3.1.2.9.1) not less than:

$$r = kb, \qquad (3.1.2.9.1)$$

where k = 0,025 for $c/b \le 0{,}04$;

k = 0,050 for $c/b \ge 0{,}2$; the intermediate values of k shall be obtained by linear interpolation.

In way of longitudinal deck strips the value of *r* may be reduced by 40 per cent.

Given below are minimum radii of rounding of opening corners:

r_{min} = 300 mm in way of deck stringer plate;

r_{min} = 250 mm in way of longitudinal deck strips.

Thickened insert plates are required at hatch corners (refer to Fig. 3.1.2.9.1).

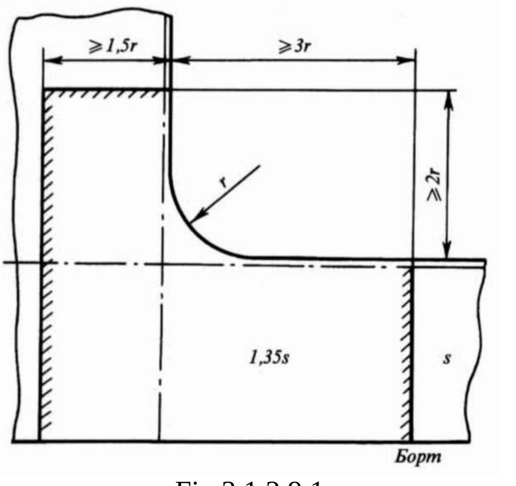


Fig.3.1.2.9.1

.2 in way of conjugations of open and enclosed parts of the hull (adjacent to the engine room, bow, etc.) the corner radius of hatch openings shall not be less than:

$$r = 0{,}07b. \qquad (3.1.2.9.2)$$

.3 hatch corners in the areas where cargo hatchways arranged abreast change in number shall be specially considered by the Register;

.4 for general requirements regarding deck openings, refer to 2.6.5.1.

3.1.2.10 The cantilever beams shall be fitted in line with web frames. Their connection shall satisfy the requirements of1.7.2.3.

The cantilever beams shall be fitted with minimum stiffeners as shown in Fig. 3.1.2.10.

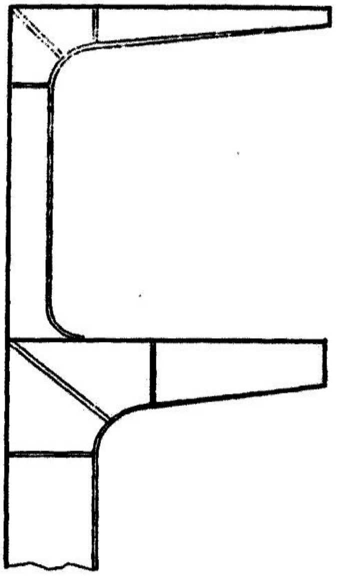


Fig.3.1.2.10. Stiffening of cantilever beams

3.1.2.11 Stiffeners, brackets or deep members shall be fitted under the vertical guides or corner fittings of containers in double bottom of container ships. The inner bottom plating in these locations shall be increased in thickness or the corner fitting sockets shall be welded therein.

The above also applies to lashing pots.

Similar increase in the plating thickness and stiffening in way of container corner fitting pockets and lashing pots shall be provided in deck structure.

3.1.3 Design load.

3.1.3.1 The design still water bending moment shall be determined in accordance with 1.4.3.

3.1.3.2 The vertical wave bending moment shall be determined in accordance with 1.4.4.

3.1.3.3 The design horizontal wave bending moment M_h, in kN/m, is determined by the formula

$M_h = 250\, k_h\, c_w\, BL^2 C_b\, \alpha_h \cdot 10^{-3}$, (3.1.3.3)

where $k_h = \alpha\, (d/b + 0{,}3)$;

$\alpha = 1 - 4d/L$;

for c_w – refer to1.3.1.4;

$\alpha_h = 0{,}5\, [1 - \cos(2\pi\, x/L)]$;

x – distance between the considered section and the after perpendicular, in m.

3.1.3.4 The design components of a wave torque, in kN/m, are determined by the formulae:

$$M_{tw_1} = 63 k_1 c_w BL^2 \alpha_{t_1} \cdot 10^{-3}; \quad (3.1.3.4\text{-}1)$$

$$M_{tw_2} = 63 k_2 c_w BL^2 C_b \alpha_{t_2} \cdot 10^{-3}; \quad (3.1.3.4\text{-}2)$$

$$M_{tw_3} = 126 k_2 c_w BL^2 C_b \alpha_{t_3} \cdot 10^{-3}. \quad (3.1.3.4\text{-}3)$$

Here: $k_1 = 2\, \alpha\, \chi_o\, [1 + 3{,}6\, (C_{WL} - 0{,}7)]\, B/L$;

$k_2 = 10\, \alpha_1\, d\, e/(LB)$;

$\alpha_1 = 1 - 8\, d/L$;

$\chi_o = 1 - 4\, C_{WL}\, B/L$;

C_{WL} – water plane area coefficient for summer load waterline;

for α – refer to 3.1.3.3;

e – vertical distance from the torque centre to a point at 0,6d above the base line; the torque centre position shall be determined in accordance with the procedure approved by the Register;

$$\alpha_{t_1} = 0{,}5\left(1 - \cos\frac{2\pi x}{L}\right);$$

$$\alpha_{t_2} = \sin\frac{3\pi x}{L};$$

$$\alpha_{t_3} = \sin\frac{2\pi x}{L};$$

for x – refer to 3.1.3.3.

3.1.3.5 For container ships, the design statical torque M_{ts}, in kN/m, is determined by the formula

$$M_{ts} = 30\sqrt{nB}, \quad (3.1.3.5)$$

where n = total number of 20-ft containers carried by ship.

3.1.3.6 For ships of restricted area of navigation, the horizontal wave bending moment (refer to 3.1.3.3) and the components of a wave torque (refer to 3.1.3.4) shall be multiplied by the reduction factor φ_r, determined in accordance with Table 1.3.1.5.

3.1.3.7 The design loads for cantilever beams are determined in accordance with 2.6.3.

3.1.3.8 The design loads on container securing arrangements are determined with due regard for the inertia forces caused by ship's accelerations at motions in accordance with 1.3.3.1. The design mass value of ISO series 1 containers is:

24,0 t for 20-ft containers,

30,5 t for 40-ft containers.

When calculating strength of container securing arrangements fitted on weather deck, account shall be taken of loads from the wind in the direction perpendicular to the centreline of the ship.

The design value of wind pressure is p = 1,0 кПа.

3.1.4 Scantlings of structural members.

3.1.4.1 The combined stresses σ_Σ, in MPa, in strength deck longitudinals, determined by Formula (3.1.4.1-1) are not to exceed 190/η.

$$\sigma_\Sigma = \sigma_{sw} + \sigma_{ts} + k_\Sigma \sigma_w, \quad (3.1.4.1\text{-}1)$$

where σ_{sw} – normal stresses, in MPa, in the section considered due to still water bending moment, determined by the formula

$$\sigma_{sw} = M_{sw} \cdot 10^3 / W_d^{\phi}; \quad (3.1.4.1\text{-}2)$$

for M_{sw} – refer to 1.4.3, кН·м;

W_d^{ϕ} – = actual hull section modulus in way of deck, as defined in 1.4.7;

σ_{ts} – normal stresses, in MPa, in the section considered due to the static torque M_{ts} (refer to 3.1.3.5), determined by the formula

$$\sigma_{ts} = B_{ts}\overline{\omega}/(I_w \cdot 10^3); \quad (3.1.4.1\text{-}3)$$

B_{ts} – biomoment in considered section along the length of open part of the ship under the effect of the static torque M_{ts}, in kN/m^2;

$\overline{\omega}$ – main sectional area at the considered section point, in m^2;

I_w – main sectional moment of inertia, in m^6;

B_{ts}, $\overline{\omega}$, I_w – are determined according to the procedure approved by the Register;

σ_w – normal stresses, in MPa, in considered section due to vertical wave bending moment, determined by the formula

$$\sigma_w = M_w \cdot 10^3 / W_d^{\phi};$$

for M_w – refer to 1.4.4;

k_Σ – factor by which vertical bend stresses are increased taking the horizontal bending and torque into account. It is determined by the formula

$$k_\Sigma = \sqrt{1 + 0{,}15(0{,}85 + L/600)^2(\overline{\sigma}_h + \overline{\sigma}_{tw})^2};$$

$$\overline{\sigma}_h = \sigma_h / \sigma_w;$$

σ_h – normal stresses, in MPa, in considered section due to design horizontal wave bending moment, determined by the formula

$$\sigma_h = M_h \cdot 10^3 / W_{dz}^{\phi}; \quad (3.1.4.1\text{-}4)$$

for M_h – refer to 3.1.3.3;

W_{dz}^{ϕ} – actual hull section modulus about the vertical axis through the centreline of the ship, in cm^3, determined by the formula

$$W_{dz}^{\phi} = I_z \cdot 10^2 / y;$$

I_z – actual inertia moment of the hull about the vertical axis, in cm^2·m^2;

y = half the ship's breadth in the considered section, in m;

$$\overline{\sigma}_{tw} = \sigma_{tw} / \sigma_w;$$

σ_{tw} – total warping stresses, in MPa, under the effects of the torques M_{tw_1}, M_{tw_2}, M_{tw_3}, determined by the formula

$$\sigma_{tw} = \sqrt{(\sigma_{tw_1} - \sigma_{tw_2})^2 + \sigma_{tw_3}^2}, \quad (3.1.4.1\text{-}5)$$

σ_{tw_i} normal warping stresses, in MPa, under the effects of the torques M_{tw_1}, M_{tw_2}, M_{tw_3} (refer to 3.1.3.4), determined by the formula

$$\sigma_{tw_i} = \frac{B_i \overline{\omega}}{I_w \cdot 10^3}; \qquad (3.1.4.1\text{-}6)$$

B_i – biomoments in considered section along the length of the open part of the ship under the effects of M_{tw_1}, M_{tw_2}, M_{tw_3} respectively, in kN/m^2. The biomoments are determined by the procedure approved by the Register.

3.1.4. Kinematic parameters of warping shall be determined.

The elongation of hatch opening diagonal under the effect of hull warping shall not exceed 35 mm. Where such elongation obtained by calculation is in excess of 35 mm, measures specially agreed with the Register shall be taken for opening edge reinforcements. The calculation shall be made in accordance with the procedure approved by the Register.

3.1.4.3 Adequate buckling strength of the longitudinal deck strip between the supports as well as that of its items as regards the compressive stresses due to longitudinal bending shall be ensured.

3.1.4.4 Where the ratio of the length of the hatch opening to the width of the deck portion from the side shell to the longitudinal edge of the nearest hatch opening exceeds 10, calculation of shape deformation of the deck portion concerned in the horizontal plane in accordance with the procedure approved by the Register and use of the results obtained in assessment of the deck stressed state, design of hatch covers and side framing may be required.

3.1.4.5 The scantlings of cantilever beams and adjoining web frames shall satisfy the following requirements:

.1 the section modulus, in cm^3, of cantilever beam at a section in way of the end of a beam knee shall not be less than:

$$W = \frac{(0,5pal + Q)\, l\, \omega_k \cdot 10^3}{k_\sigma \sigma_n}, \qquad (3.1.4.5.1)$$

where p – intensity of design loads, in kPa, on the deck plating supported by the cantilever beam, as required by 3.1.3.7;

a – distance between adjacent cantilever beams, in m;

l – span, in m, of a cantilever beam, measured from the section at the end of a beam knee to the hatch side coaming supported;

Q – design load, in kN, transmitted from hatch cover to the cantilever beam,

$$Q = 0,5\, p_1\, a\, b_1;$$

p_1 – intensity of design loads, in kPa, on the cover of hatch adjoining the cantilever beam as required by 3.1.3.7;

b_1 – width, in m, of opening for a hatch adjoining the cantilever beam;

$k_\sigma = 0,6$;

ω_k – as defined in 1.1.5.3.

The sectional area of the web of cantilever beam shall not be less than that determined according to 1.6.4.3 taking:

$k_\tau = 0,6$;

$N_{max} = pal + Q$– for the section at the end of the beam bracket;

$N_{max} = Q$ – for the section in way of the hatch side coaming adjoining the cantilever beam.

.2 the section modulus of the web frame connected to the upper deck cantilever beam at the section in way of the end of the beam bracket shall not be less than that determined by Formula (3.1.4.5.1).

The section modulus of the web frame connected to the cantilever beam of the lower deck and fitted below that deck at the section in way of the end of the beam bracket shall comply with the same requirement but may be reduced by the value of section modulus of the web frame fitted above that deck, at the section in way of the end of the bracket adjoining the deck.

3.1.4.6 The scantlings of container securing arrangements shall be determined on the basis of strength calculations using the design loads complying with the requirements of 3.1.3.8, and the resulting stresses shall not exceed the permissible ones determined using the permissible stress factors:

$$k_\sigma = k_\tau = 0,75.$$

The strength of hull structures taking up forces from the container securing arrangements shall be verified by calculation of the effects produced by these forces, and the resulting stresses shall not exceed the permissible ones specified in Section 2 for the appropriate structures.

3.2 ROLL-ON/ROLL-OFF SHIPS

3.2.1 General.

3.2.1.1 The requirements of this Chapter apply to ro-ro ships, ro-ro passenger ships and are supplementary to those of Sections 1 and 2.

These requirements also apply to decks and double bottoms of ships carrying wheeled vehicles for use in cargo handling.

3.2.1.2 Symbols:

Q_0 – static load on the axle of the wheeled vehicle, in kN;

n_0 – number of wheels on an axle;

n – number of wheels forming a design load spot (for a single wheel n = 1);

u – size of a tyre print normal to the axis of rotation, in m (Fig.3.2.1.2-1);

v_1 – size of a tyre print parallel to the axis of rotation, in m;

v – size of a tyre print parallel to the axis of rotation, in m;

for a single wheel $v = v_1$; for a group of wheels v – size of a tyre print taking into account the gaps between them (refer to Fig. 3.2.1.2-1);

e – spacing between adjacent tyre prints, in m;

l_b – design load spot dimension parallel to the larger side of the panel (directed along framing members), in m (Fig.3.2.1.2-2);

l_a – design load spot dimension parallel to the smaller side of the panel (directed across framing members), in m;

$l_{\Sigma a}$ – total extent of a tyre print along smaller side of panel along its width or across framing girder within mean spacing a_1,in m, between girders;

$l_{\Sigma b}$ – total extent of a tyre print along larger side of panel or alongwithin design member span l, in m;

a, b – smaller and larger sides of panel, respectively, in m;

a_1 – середня відстань між балкою, що розглядається, і двома сусідніми балками палубного набору, м;

l – span of the considered girder between supports, in m (refer to 1.6.3.1).

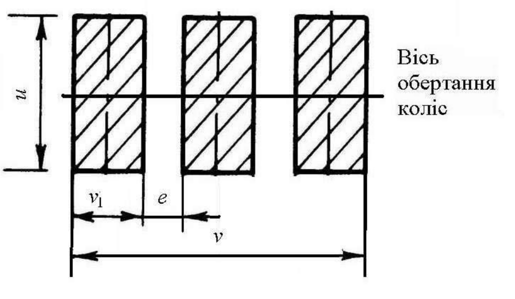
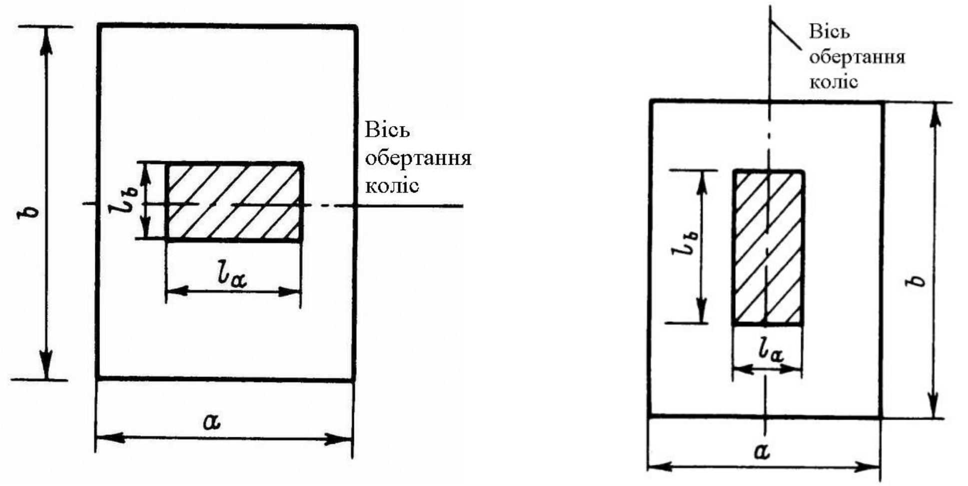


Fig. 3.2.1.2-1. Description of a tyre print



а ***б***

Fig. 3.2.1.2-2. Ratio of l_a to l_b and *u* to *v*:
а – axis of rotation is parallel to small side of plate (transversally to framing members) $l_a=v$, $l_b=u$;
б – axis of rotation is parallel to large side of plate (parallel to framing members) $l_a = u$, $l_b = v$

3.2.2 Construction.

3.2.2.1 Vehicle decks and double bottoms of ro-ro ships and car ferries shall, in general, be longitudinally framed.

If framed otherwise, the above structures are subject to special consideration by the Register.

3.2.2.2 Movable decks fitted temporarily for the carriage of vehicles shall be so fixed as to prevent these decks from taking up longitudinal forces under the hull longitudinal bending.

The Rules provide for movable deck structure consisting of a top decking with a web structure and longitudinals welded thereto. Other forms of movable deck construction shall be specially considered by the Register.

3.2.3 Loads from wheeled vehicles.

3.2.3.1 The design loads shall be based on specification details of vehicles carried on board the ship and used for cargo handling. The design documentation submitted to the Register for the consideration shall include statical load on vehicle axle, number of wheels on the axle, wheel spacing, tyre print dimensions and tyre type.

Where wheel print details are not initially available, the requirements of 3.2.3.5 shall be applied.

3.2.3.2 In general, the design loads are to determined taking into consideration specific pressure on one type print, size of prints and spacing between wheels.

However, where spacings between nearest wheels are less than one type print, the wheels may be considered as a group and spacing between wheels may be included into print area.

Design print area of wheel or group of wheels A_m, in m^2, is determined by the formula

$A_к = uv,$ (3.2.3.2)

where $v = v_1$ – for single wheel or if $e > v_1$;
$v = nv_1 + (n – 1)e$ – for group of wheel if $e \le v_1$.

3.2.3.3 To be considered are the loads resulting from the operation of vehicles during cargo handling operations and from stowage of vehicles on the deck under conditions of the ship motions.

3.2.3.4 Specific pressure *p,* in kPa, on type or group of types print is to be determined by the formula

$p = k_д p_к$, *(3.2.3.4)*

where $k_d = \alpha_1 \cdot \alpha_2$ – dynamic coefficient in the process of operation of vehicles used for cargo handling operations;

α_1 – factor equal to: 1,10 and 1,05 – for vehicles (except fork lift trucks) having an axle load less than 50 kN and 50 kN and more, respectively; 1,0 for fork lift trucks;

α_2 factor equal to: 1,03 and 1,15 for pneumatic and cast-rubber tyres, respectively; 1,25 for wheels with a steel rim;

$K_d = 1 + a_z/g$ – dynamic factor eharacterizing the ship motion;

a_z – acceleration in the ship section under consideration in accordance with 1.3.4.1;

$$p_к = \frac{n}{n_0}\frac{Q_0}{A_к};$$

p_t – static specific pressure, in kPa, on type or group of types print;

A_t – area of type or group of types print (refer to 3.2.3.2), in m^2.

Where distribution of the load between wheeled vehicle axles is not uniform, the maximum axle load is to be taken as the design load. For fork lift trucks it is assumed that the total load is applied to the forward axle.

3.2.3.5 Where specifications on tyre print dimensions are not available, static specific pressure $p_к$, in kPa, is to be taken from the Table 3.2.3.5.

Area of type or group of types print A_t, in m^2, is determined by the formula

$$A_к = \frac{n}{n_0}\frac{Q_0}{p_к}. \qquad (3.2.3.5\text{-}1)$$

The tyre print dimension normal to the wheel axle *u*, in m, is to be determined by the formulas:

for wheels with cast tyres

$$\left.\begin{aligned} &u = 0,01Q_0/n_0 \quad \text{якщо} \quad Q_0/n_0 \le 15\,\text{кН};\\ &u = 0,15 + 0,001\left(Q_0/n_0 - 15\right)\\ &\qquad\qquad \text{якщо} \quad Q_0/n_0 > 15\,\text{кН};\end{aligned}\right\} \qquad (3.2.3.5\text{-}2)$$

for wheels with pneumatic tyres

$$\left.\begin{aligned} &u = 0,15 + 0,0025Q_0/n_0\\ &\qquad\qquad \text{якщо} \quad Q_0/n_0 \le 100\,\text{кН};\\ &u = 0,175 + 0,002\left(Q_0/n_0 - 10\right)\\ &\qquad\qquad \text{якщо} \quad Q_0/n_0 > 10\,\text{кН}.\end{aligned}\right\} \qquad (3.2.3.5\text{-}3)$$

Table 3.2.3.5

Vehicle	$p_к$	
	Pneumatic tyres	Cast tyres
Cars	200	–
Lorries, motor vans	800	–
Trailers	800	1500
Fork lift trucks	800 (where n = 1)[1]	1500
	600 (where $n \ge$ 2)	1500

[1] *n* –number of tyres in agroup.

The size of a tyre print or a group of tires, parallel to axle of rotation *v*, in m, is determined by the formula

$v = A_к/u.$ (3.2.3.5-4)

3.2.3.6 For each type of load which regulated by 3.2.3.3, design loads are to be determined for two mutually perpendicular position of vehicles relatively to sides of panel or framing member: when the wheel axel is parallel to the smaller side of panel (perpendicular to the framing member) and is parallel to the larger side of panel (parallel to the framing member).

When there are not other instruction in specification the regions of tyre prints of vehicles within panel width or span length of framing member are to comply with the following requirements:

When there is odd amount of prints the centre of mean print is to be arranged in the middle of smaller side of panel or in the middle part of span of framing member (Fig.3.2.3.6,***a***);

When there is even amount of prints two cases are to be considered:

prints are to be arranged in a way when their total extension along smaller side of panel or along framing member is the longest (Fig. 3.2.3.6, b)

design amount of prints is to be reduced by 1 and the centre of mean print is arranged in the middle of smaller side of panel or in the middle part of span of framing member (Fig.3.2.3.6, c)

In all cases the prints of wheels are to be arranged in a way when their total extension along larger side of panel (for calculation of plates) or directed across framing members (for calculation of framing members) is to be the longest.

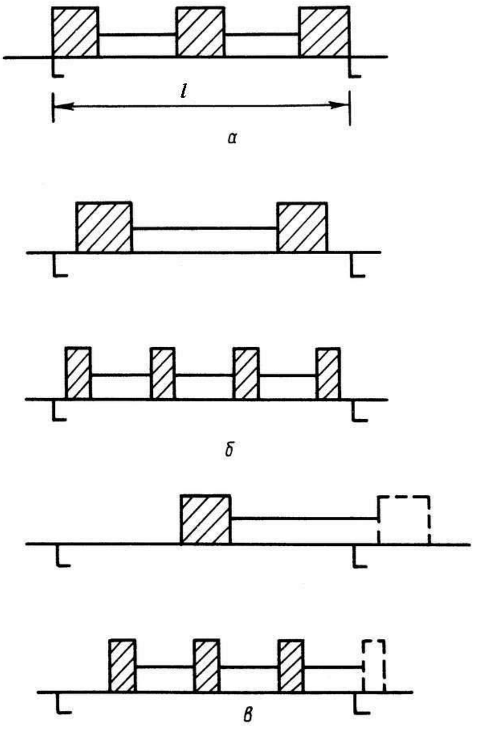


Fig.3.2.3.6. the regions of tyre prints of vehicles within panel width or span length of framing member

3.2.3.7 Design load for plating Q, in kN, is determined by the formula

$$Q = p\psi l_i, \qquad (3.2.3.7)$$

where p – in accordance with (3.2.3.4);

$\psi = 1{,}35z - 0{,}6z^2 + 0{,}09z^3$, but no greater than 1;

$z = l_b / a$ – where spacing along to larger side of the panel of one print;

$z = [n_b - (n_b - 1)\ \bar{e}\ ]\ l_b / a$ – here spacing along to larger side of the panel of several prints;

$n_b = l_{\Sigma b} / l_b;$

$$\bar{e} = \frac{e_b / l_b}{(e_b / l_b)_0} \quad \text{where } e_b / l_b < (e_b / l_b)_0;$$

$\bar{e} = 1$ where $e_b / l_b \geq (e_b / l_b)_0$;

$$\left(\frac{e_b}{l_b}\right)_0 = \frac{1-\psi}{\psi}$$

(ψ is determined for $z = l_b / a$);

e_b – gap, in m, measured along larger side of the panel between wheels or group of wheels which are located within panel length (Fig. 3.2.3.7);

$l_i = l_a$ при $l_a < a$
$l_i = a$ при $l_a \geq a$ – for single print of wheel or group of wheels in fields of plate;

$l_i = l_{\Sigma a}$ при $l_{\Sigma a} < a$
$l_i = a$ при $l_{\Sigma a} \geq a$ – for several prints of wheels in field of plate.

3.2.3.8 Design load Q, in kN, for beams and longitudinals is determined by the formula

$$Q = k_p\, p\, l_i\, e_1, \qquad (3.2.3.8)$$

where $k_p = 1$ where $l_{\Sigma a} / a_1 < 1$ i $l_{\Sigma a} / a_1 > 3$;

$$k_p = 1{,}3 - 0{,}3\left(\frac{l_{\Sigma a}}{a_1} - 2\right)^2$$ where $1 \leq l_{\Sigma a} / a_1 \leq 3$;

p – in accordance with formula (3.2.3.4);

$$\left.\begin{array}{l} l_i = l_a \text{ якщо } l_a < a_1 \\ l_i = a_1 \text{ якщо } l_a \geq a_1 \\ e_1 = l_b \text{ якщо } l_b < l \\ e_1 = l \text{ якщо } l_b \geq l \end{array}\right\} \text{для одиничного відбитка колеса (рис.3.2.3.8)}$$

$$\left.\begin{array}{l} l_i = l_{\Sigma a} \text{ якщо } l_a < a_1 \\ l_i = a_1 \text{ якщо } l_{\Sigma a} \geq a_1 \\ e_1 = l_{\Sigma b} \text{ якщо } l_b < l \\ e_1 = l \text{ якщо } l_{\Sigma b} \geq l \end{array}\right\} \text{для кількох відбитків коліс (рис.3.2.3.8)}$$

e_b – gap, in m, measured along member between the nearest wheels or group of wheels which are located within design span of member (Fig.3.2.3.8)

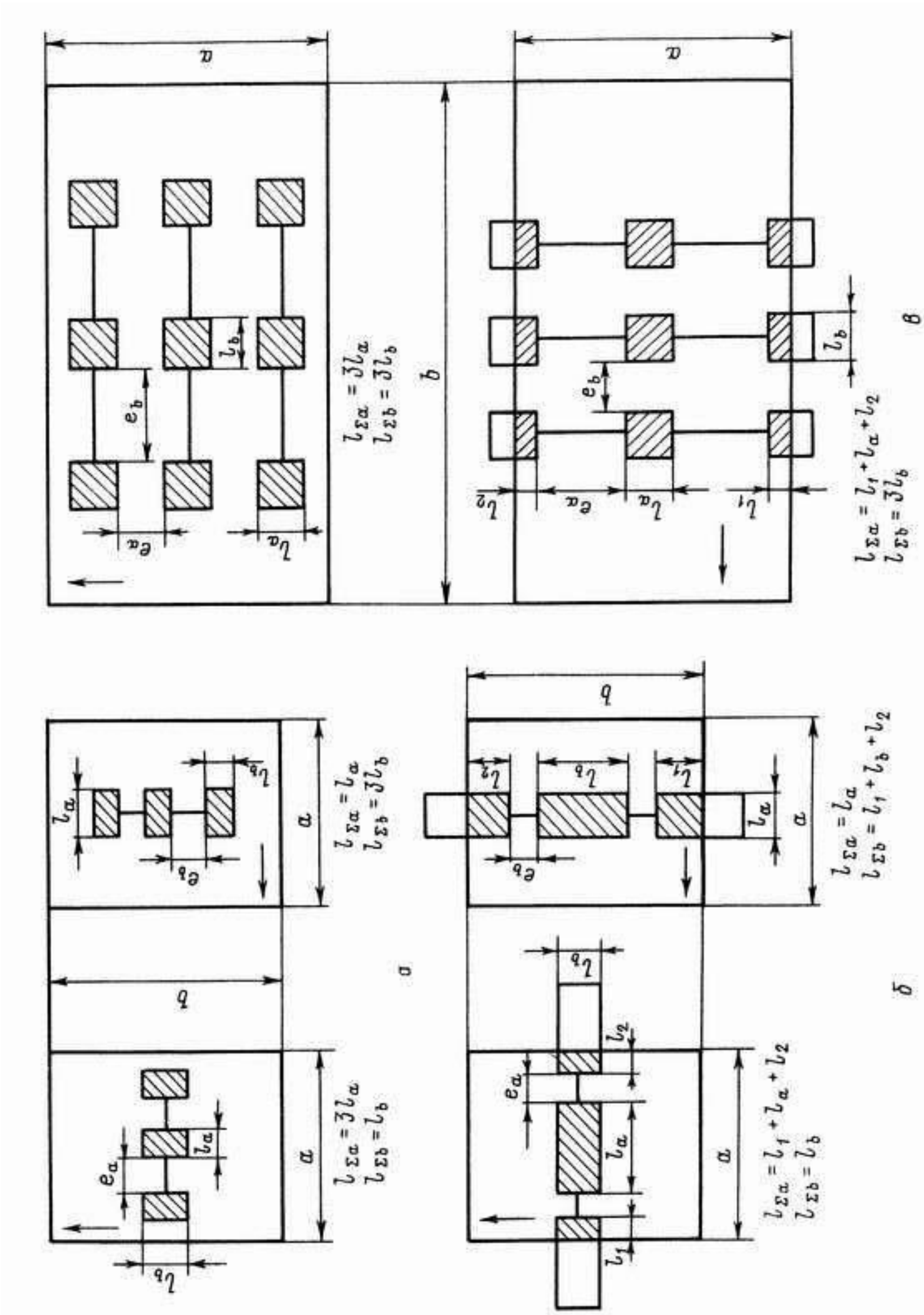


Fig.3.2.3.7. The value of parameters $l_{\Sigma a}$, $l_{\Sigma b}$, e_a, e_b for plates

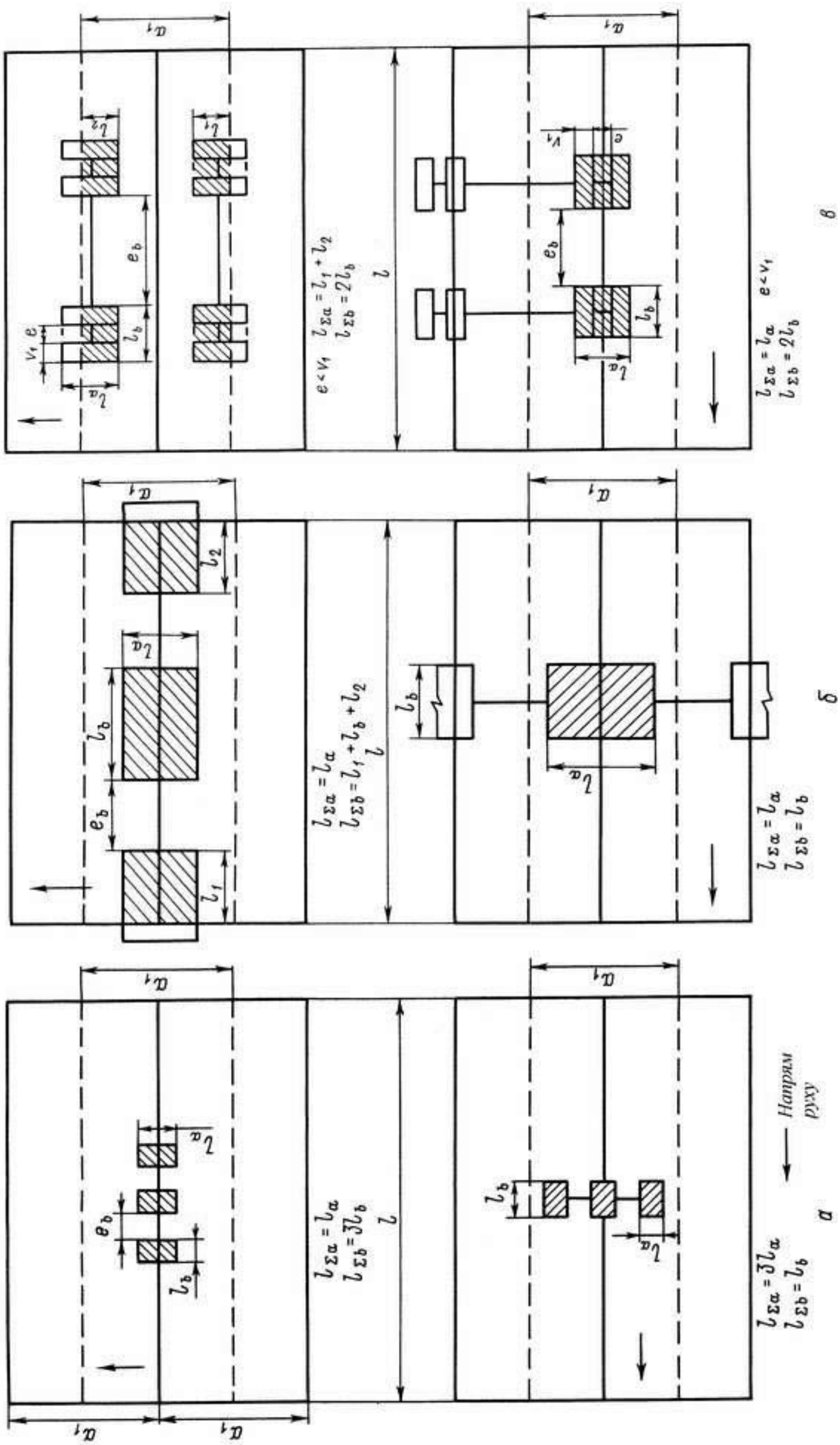


Рис. 3.2.3.8. The value of parameters $l_{\Sigma a}$, $l_{\Sigma b}$, e_a, e_b for framing member

3.2.3.9 The design load for train rails Q, in kN, is to be determined by the formula

$Q = 0,5k_д Q_0 n_1$, (3.2.3.9)

where k_d = 1,1 if the vehicle moves about during cargo-handling
operations;

$k_d = 1 + a_z / g$ – in case of the ship motions;

a_z – acceleration in considered ship section in accordance with 1.3.4.1;

n_1 – number of vehicle wheels arranged within the design span of framing member supporting railways.

3.2.3.10 The design loads for side shell and permanent deck primary members are to be those to satisfy the most severe stowage arrangement of all cargoes carried on deck (including package cargo, containers, wheeled vehicles, etc.) and to allow for statical and inertia forces resulting from the ship motions. Accelerations are to be determined in accordance with 1.3.3.1.

3.2.3.11 The design load Q, in kN, for the transverses and girders of movable decks is to be determined by the formula

$Q = k_д (p_c + p_d)a_2 l$, (3.2.3.11)

where $k_д$ – as defined in 3.2.3.4;

p_c – static deck loading from the cargo carried , in kPa;

p_d – static deck loading from deck own mass, in kPa;

a_2 – mean spacing of transverses and girders, in m.

The value of $(p_c + p_d)$ is not to be taken less than 2,5kPa.

3.2.3.12 The design pressure p_v, in kPa, for the transverce and girders of upper tweendeck of double-deck ferries without pillars is determined by the formula

$$p_в = 0{,}9 k_д q_в, \qquad (3.2.3.12)$$

where $k_д = 1 + a_z / g$ – in case of the ship motion where a_z is determined in accordance with 1.3.3.1 in the midship;

$q_в$ – allowed (specified) load on the deck from the cargo carried, in kPa.

3.2.3.13 Design force *F*, in kN, in horizontal plane for the transverce and girders of upper tweendeck of double-deck ferries without pillars is determined by the formula

$$F = 0{,}7 q_в \frac{a_y}{g} a_2 B, \qquad (3.2.3.13)$$

where a_y determined in accordance with 1.3.4.4 at the upper deck level;

a_2 – mean spacing of transverce and girders of upper tweendeck of double-deck ship without pillars;

B – ship width in the midship;

$q_в$ – in accordance with 3.2.3.12.

3.2.4 Scantlings of deck and side shell structures.

3.2.4.1 The thickness of plating *s*, in mm, is not to be less than

$$s = 58 k_1 \sqrt{\frac{k_2 Q a}{m \sigma_n}} + \Delta s, \qquad (3.2.4.1)$$

де k_1 = 1,0 – for all decks with loads during cargo handling operation in port (minimum value);

k_1 = 1,075 – for all decks with loads applied at sea (minimum value);

$k_1 = 1 / \sqrt{k_0}$ – for design deck within midship region, but not less than minimum values;

for k_0 – refer to Table3.2.4.1;

$k_2 = 1{,}25 - 0{,}5a/b$ where $a/b > 0{,}5$;

$k_2 = 1$ where $a/b \le 0{,}5$;

Q– as defined under 3.2.3.7;

m – factor equal to:

where within the panel width there is one print of wheel or group of wheels:

$$m = \frac{5{,}85}{1 - 0{,}57 l_a / a} \quad \text{при} \quad l_a / a < 1$$

$$m = 29{,}47 - \frac{l}{a}\left[23{,}65 - 8{,}75\frac{l_a}{a} + 0{,}97\left(\frac{l_a}{a}\right)^2\right]$$

при $1 \le l_a / a \le 3{,}35$;

$m = 12$ where $l_a / a > 3{,}35$;

where within the panel width there are several prints of wheel or group of

wheels $m = \dfrac{5{,}85}{1 - 0{,}57\dfrac{l_{\Sigma a}}{a} - k_3\dfrac{e_a}{a}}$;

$k_3 = l_{\Sigma a}/l_a - 1$ where $1 \le l_{\Sigma a}/l_a \le 2$;

$k_3 = 0{,}5\, l_{\Sigma a}/l_a$ where $l_{\Sigma a}/l_a > 2$;

for $l_{\Sigma a}$ – refer to Fig3.2.3.7;

e_a – gap, in m, measured along smaller side of the panel between wheels or group of wheels which are located within panel length (refer to Fig. 3.2.3.7).

Table 3.2.4.1

Frame system	k_0	
	In a port	At sea
longitudinal	$1 - 0{,}05W/W_d^{ф}$	$0{,}92 - 0{,}16W/W_d^{ф}$
transverse	$1 - 0{,}23W/W_d^{ф}$	$0{,}86 - 0{,}36W/W_d^{ф}$

for W i $W_d^{ф}$ – refer to 3.1.1.5.

3.2.4.2 The section modulus W of longitudinals and beams, in cm^3, shall not be less than obtained from 1.6.4.1 with

Q– as defined in 3.2.3.8;

m – factor equal to:

where within the design span of the members there is one print of wheel or group of wheels

$$m = \frac{5{,}85}{1 - 0{,}57\, l_b/l} \text{ with } l_b/l < 1;$$

$$m = 29{,}47 - \frac{l_b}{l}\left[23{,}65 - 8{,}75\frac{l_b}{l} + 0{,}97\left(\frac{l_b}{l}\right)^2\right]$$

with $1 \le l_b/a \le 3{,}35$;

$m = 12$ with $l_b/l > 3{,}35$;

where within the design span of the members there are several prints of wheel or group of wheels

$$m = \frac{5{,}85}{1 - 0{,}57\dfrac{l_{\Sigma b}}{l} - k_4\dfrac{e_b}{l}},$$

where $k_4 = l_{\Sigma b}/l_b - 1$ with $1 \le l_{\Sigma b}/l_b \le 2$;

$k_4 = 0{,}5\, l_{\Sigma b}/l_b$ with $l_{\Sigma b}/l_b > 2$;

for $l_{\Sigma b}$ – refer to Fig. 3.2.3.8;

e_b – gap, in m, measured along smaller side of the panel between wheels or group of wheels which are located within design span of member (refer to Fig. 3.2.3.8);

k_σ – allowed loads factor equal to:

0,8 – for all cargo decks for cargo handling operation in port;

0,7 – for all cargo decks with loads applied at sea.

For mean part of design deckk_σ is not to be greater than:

with loads during cargo handling operation in port

$$k_\sigma = 0{,}96 - 0{,}36\, W/W_d^{ф} \le 0{,}8;$$

with loads applied at sea

$$k_\sigma = 0{,}96 - 0{,}56\, W/W_d^{ф} \le 0{,}7,$$

where for W, $W_d^{ф}$ – refer to 3.1.1.5.

3.2.4.3 The plating thickness, section modulus and cross-sectional area of beams and longitudinals of movable decks shall be determined in accordance with 3.2.4.1 and 3.2.4.2. Where beams and longitudinals are freely supported by girders and transverses, the factor m shall be determined by the formula

$$m = \frac{8}{2 - l_b/l}; \qquad (3.2.4.3)$$

Otherwise, the factor m shall be determined as for beams and longitudinals of permanent cargo decks according to 3.2.4.2.

3.2.4.4 If scantlings of wheel print is in accordance with 3.2.3.5, the plating thickness is in accordance with 3.2.4.1 and the section modulus of longitudinals and beams is in accordance with 3.2.3.4 is to be increased by 15 per cent.

3.2.4.5 The section modulus of longitudinals *W*, in cm3^3, supporting fixed rails shall not be less than obtained from 1.6.4.1 with

Q– as defined in 3.2.3.9;

k_σ – factor determined by 3.2.4.2.

m – to be determined by the formula

$$m = \frac{5{,}85}{1 - k_5\, e_2/l}, \qquad (3.2.4.5)$$

where $k_5 = 0$ with $n_1 = 1$;

$k_5 = 0{,}5n_1$ with $n_1 \geq 2$;

for n_1 – refer to 3.2.3.9;

e_2 – mean spacing of centres of wheels arranged within the design member span, in m;

3.2.4.6 The scantlings of deep members of sides and permanent cargo decks, as well as of pillars shall be derived by direct calculation using the procedures approved by the Register.

3.2.4.7 The section modulus of the girders and transverses of movable decks *W*, in cm^3, shall not be less than obtained from 1.6.4.1 with

Q – as defined in 3.2.3.11;

m = 12 – for fixed members;

m = 8 – for freely supported members;

$k_\sigma = 0{,}7$.

3.2.4.8 The section modulus *W*, in cm^3, of the web frames of upper tweendeck of double-deck ferries without pillars is not to be less than determined by the formula

$$W = \frac{M_i \cdot 10^3}{k_\sigma \sigma_n} + \Delta W, \qquad (3.2.4.8)$$

where $M_i = \dfrac{p_в a_2 l_б^2}{6(2 + S/\alpha)} + \dfrac{1{,}2F\, l_{шп}}{6 + \alpha\, S_4}$, kN·m – for web frames cross-section in upper-deck area;

$$M_i = \frac{p_в a_2 l_б^2}{12(2 + S/\alpha)} + \frac{1{,}2F\, l_{шп}(1 + 0{,}33\alpha\, S_4)}{6 + \alpha\, S_4},$$

kN·m – for web frames cross-section in main deck area;

$p_в$ – in accordance with 3.2.3.12;

a_2, F – in accordance with 3.2.3.13;

$\alpha = \dfrac{l_б I_{шп}}{l_{шп} I_б}$;

$l_{шп}$ – web frame bend, in m, from main deck plating till face plate of deck transverse of upper deck;

$l_б$ – bend of deck transverse of upper deck between wall heights of web frames;

$I_{шп}$, $I_б$ – moment of inertia, in cm^4, of web frame and deck transverse of upper tweendeck respectively.

Section allowance is determined in accordance with following formulae:

$$S_1 = 1 + 7{,}8\frac{I_{шп}}{f_{шп}\, l_{шп}^2}; \quad S_3 = 1 + 31{,}2\frac{I_{шп}}{f_{шп}\, l_{шп}^2};$$

$$S_4 = 1 + 31{,}2\frac{I_б}{f_б\, l_б^2}; \quad S = \frac{S_3}{S_1};$$

$f_{шп}$, $f_б$ – the sectional area, in cm^2, of walls of web frame and deck transverse of upper tweendeck respectively;

$k_\sigma = 0{,}75$;

ΔW– corrosion and deterioration allowance, in cm^3, is determined in accordance with 1,6,4,1 for *u* = 0.03 mm per year.

Web frame modulus calculation is performed by the method of progressive approximations. It is recommended to take on:

$I_б = I_{шп}$; $S = 1{,}3$; $S_4 = 1.$ in the firs approximation

3.2.4.9 The web sectional area f_c, in cm^2, of the of deep frames wall of upper tweendeck of double-deck ferries without pillars is not to be less than determined in accordance with 1.6.4.3 with

$$N_{мах} = \frac{p_в a_2 l_б^2 (1 + 0{,}5 S_2/S_1)}{6\, l_{шп}(2 + S/\alpha)} + 0{,}4F \text{ кН},$$

where section allowance is determined in accordance with following formulae

$$S_2 = 1 - 15{,}6 \frac{I_{шп}}{f_{шп} l_{шп}^2};$$

$$k_\tau = 0{,}65.$$

Corrosion and deterioration allowance Δs, in mm, is determined in accordance with 1,1,5,1 for u ~ 0.03mm per year. Other values are in 3.2.4.8.

Calculation of web area of deep frames is to be made using method of progressive approximation. It is recommended to take on:

$I_б = I_{шп}$; $S = 1{,}3$; $S_1 = S_2 = 1.$

in the firs approximation

3.2.4.10 The section modulus W, in cm^3, of the deck transverse of upper tweendeck of double-deck ferries without pillars is not to be less than determined in accordance with 3.2.4.8 with

$$M_i = \frac{p_в a_2 l_б^2}{8}\left(1 - \frac{1{,}33}{2 + S/\alpha}\right) \text{ kN}\cdot\text{m} –$$

for deck transverse sectional in the mean part of span of the member;

$$M_i = \frac{p_в a_2 l_б^2}{6(2 + S/\alpha)} + \frac{1{,}2 F\, l_{шп}}{6 + \alpha\, S_4} \quad \text{kN}\cdot\text{m}$$

– for deck transverse sectional in a way of the side;

$k_\sigma = 0{,}75.$

Corrosion and deterioration allowance ΔW, in cm^3, is determined in accordance with 1.6.4.1 for u = 0.03mm per year. Other values are in 3.2.4.8.

Calculation of web sectional area of deck transverse is to be made using method of progressive approximation. It is recommended to take on: $I_б = I_{шп}$; $S = 1{,}3$; $S_4 = 1$.

in the firs approximation

3.2.4.11 The sectional area f_c, in cm^2, of deck transverse wall of upper tweendeck of double-deck ferries without pillars is not to be less than determined in accordance with 1.6.4.3 with

$$N_{мах} = \frac{p_в a_2 l_б}{2} + \frac{2{,}4 F\, l_{шп}}{l_б (6 + \alpha\, S_4)} \quad \text{кН};$$

$$k_\tau = 0{,}65.$$

Corrosion and deterioration allowance Δs, in mm, is determined in accordance with 1,1,5,1 for $u = 0{,}03$ 0.03mm per year. Other values are in 3.2.4.8.

Calculation of web area of deep frames is to be made using method of progressive approximation. It is recommended to take on:

$I_б = I_{шп}$; $S_4 = 1$. in the firs approximation

3.2.5 Special requirements.

3.2.5.1 A side fender protecting the ship side and stern from damage during mooring operations shall be fitted at the lower cargo deck level of Ro-Ro ships.

3.2.5.2 A longitudinal shall be fitted under each rail on the cargo decks of train ferries.

3.2.5.3 Where train decks with rails which are flush with the deck plating are provided on ships carrying railway carriages, the actual section modulus and sectional area of deck transverses shall be determined for the section located in the rail recess. Structural continuity of the effective flange of the deck transverse, where it intersects the rail, shall be ensured. In any case, the intersections of the fixed rails with deck transverses shall be specially agreed with the Register.

3.2.5.4 Where rails for the transport of railway carriages are welded to the deck plating throughout the entire length, the rail butts shall be welded with full penetration.

3.3 BULK CARRIERS AND OIL OR BULK DRY CARGO CARRIERS

3.3.1 General.

3.3.1.1 The requirements of this Chapter apply to bulk carriers and combination carriers intended for the carriage of bulk cargoes and crude oil (petroleum products) in bulk, except for ships which, according to 1.1.1.1, are not covered by the requirements of Part XVIII "Common Structural Rules for Bulk Carriers and Oil Tankers".

3.3.1.2 The scantlings of structural members bounding the cargo region shall be determined as required by Sections 1 and 2 on assumption of the carriage of bulk or liquid cargo (water ballast) in the holds primarily designed for the purpose concerned. The value to be adopted is the greater of the appropriate strength characteristics of the item.

3.3.1.3 The requirements for the structures not mentioned in this Chapter shall be as given in Sections 1 and 2.

In any case, the requirements for the hull and its structures shall not be less stringent than those stated in Sections 1 and 2.

3.3.1.4 The basic structural type of ships is considered to be a single-deck ship with machinery aft, having a flat (or nearly a flat) double bottom in the holds (permissible slope of the inner bottom from the side to the centreline is not over 3°), hopper side and topside tanks, single or double skin sides, transverse hold bulkheads of plane, corrugated or cofferdam type, which is primarily intended for balk cargoes.

3.3.1.5 In combination carrier the length of the holds shall not exceed 0,1*L*. Holds of a greater length require special consideration by the Register in each case.

It is assumed that when carrying heavy bulk cargo, certain holds remain empty, their numbers shall be indicated in line "Other characteristics" in Classification Certificate as stated in 2.3, Part I "Classification".

3.3.1.6 Descriptive notation and distinguishing mark (ESP).

3.3.1.6.1 The descriptive notation Bulk carrier and the distinguishing mark (ESP) shall be assigned to sea going self-propelled single deck ships with a double bottom, hopper side tanks and topside tanks and with single or double skin side construction intended primarily for carriage of dry cargoes in bulk. Typical midship sections are given in Fig. 3.3.1.6.1a, for the term “Bulk carrier” refer to 1.2.1 Part I “Classification”.

Bulk carrier of single skin side construction means a bulk carrier where one or more cargo holds are bound by the side shell only or by two watertight boundaries, one of which is the side shell, which are:

less than 760 mm apart in bulk carriers, the keels of which are laid or which are at a similar stage of construction before 1 January 2000;

less than 1000 mm apart in bulk carriers, the keels of which are laid or which are at a similar stage of construction on or after 1 January 2000.

3.3.1.6.2 The descriptive notation Oil/Bulk/Ore carrier and the distinguishing mark (ESP) shall be assigned to single deck ships of double skin side construction, with a double bottom, hopper side tanks and topside tanks fitted below the upper deck intended for the carriage of oil or dry cargoes, including ore, in bulk. A typical midship section is given in Fig. 3.3.1.6.1, b.

a) b)

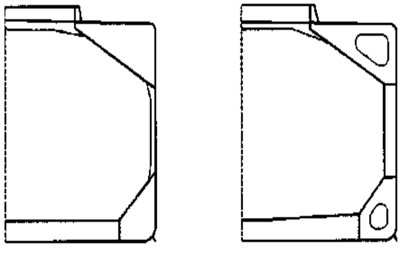


Fig. 3.3.1.6.1

3.3.2 Construction.

3.3.2.1 Longitudinal framing shall be adopted for the deck, the side shell in way of topside tanks and the sloped bulkheads of topside tanks. The deck plating between end coamings of adjacent cargo hatches shall be additionally strengthened with intercostal transverse stiffeners fitted at every frame.

The double bottom shall be longitudinally framed. The double bottom structure in which all bottom and inner bottom longitudinals are replaced by side girders may be permitted (refer to 2.4.2.4.2).

The single skin side between topside and hopper side tanks shall be transversely framed.

Longitudinal or transverse framing may be adopted for the double skin side and in the hopper side tanks.

The transverse watertight bulkheads may be plane with vertical stiffeners, corrugated with vertical corrugations or of a cofferdam type.

3.3.2.2 A hatch side coaming shall be fitted with horizontal stiffeners. A t every alternate frame the coaming shall be stiffened with vertical brackets fitted between the coaming flange and the deck.

3.3.2.3 The slope angle of topside tank walls to the horizontal axis shall not be less than 30°.

Inside topside tanks, in line with hold transverse bulkheads, diaphragms shall be fitted, the plating of which may generally have drain and access holes of minimum size. The plating of transverse bulkheads inside topside tanks shall be strengthened with stiffeners. The ends of vertical stiffeners shall be bracketed.

In topside tanks transverse beams shall be fitted in line with deck transverses.

To stiffen the plates of the tank vertical walls which are in line with the hatch side coaming, brackets shall be placed inside the tanks in line with every stay of side coaming. These brackets shall be extended to the deck and tank sloped bulkhead longitudinals nearest to the centreline.

A t every frame, in the lower corner of the tank, brackets shall be fitted in line with the brackets attaching the hold frame to the sloped bulkhead of the tank. These brackets shall be carried to the ship's side and tank sloped bulkhead longitudinals nearest to the lower corner of the tanks and welded to them so as to extend beyond the brackets of frames.

3.3.2.4 The slope angle of hopper side tank walls to the horizontal shall not be less than 45°. The extension of the tank over the ship breadth at the inner bottom level shall generally not be less than 0,125*B* on one side.

Transverse diaphragms shall be fitted in line with transverse bulkheads and every alternate plate floor. The diaphragms may have drains and access holes. The total height of openings at the section of diaphragm, in the direction along the normal to the tank plating, from a line drawn through the opening centre perpendicularly to that normal, to the plating shall not exceed 0,5 of the height of that section anywhere. The opening edges shall be reinforced with face plates or stiffeners. The diaphragm plating shall be stiffened as required by 1.7.3.2 for the floor stiffeners.

Inside longitudinally framed tank, brackets shall be fitted in line with every frame. These brackets shall be carried to the sloped bulkhead and side longitudinals and welded to them so as to extend beyond the brackets of frames.

At the outboard side girder forming transversely framed hopper side tank wall, brackets shall be fitted in line with every frame. These brackets shall be carried to the nearest bottom and inner bottom longitudinals and welded to them.

3.3.2.5 Within the cargo area, the single-side structure shall comply with the following requirements:

.1 the scantlings of side hold frames immediately adjacent to the collision bulkhead shall be increased in order to prevent excessive imposed deformation on the shell plating. As an alternative, supporting structures shall be fitted which maintain the continuity of fore peak stringers within the foremost hold.

.2 frame ends shall be attached with brackets. The vertical dimension of the lower and upper brackets, as measured at shell plating, shall not be less than 0,125 of the frame span. On the level of the frame adjoining the bilge and underdeck tank, the breadth of the lower and upper brackets shall not be less than half the web height.

.3 frames shall be fabricated symmetrical sections with integral upper and lower brackets and shall be arranged with soft toes. The end brackets adjoining the underdeck and bilge tanks shall be blunted, and the flange ends shall be sniped. The side frame flange shall be curved at the connection with the end brackets. The radius of curvature shall not be less than *r*, in mm, determined by the formula

$$r = 0{,}4b_{\text{кн}}^2 / s_{\text{кн}},$$

where b_{br} – the flange width, in mm;
s_{br} – the thickness of brackets, in mm.

.4 In ships of length less than 190 m normal steel frames may be asymmetric. The face plates or flanges of brackets shall be sniped at both ends. The brackets shall be arranged with soft toes.

.5 where, a frame being connected to an underdeck tank, the frame or its bracket overlaps with a horizontal section of an inclined wall, provision shall be made for the bracket to go over the bent section, and the angle between the plane of the face plate (bracket) and the inclined tank wall shall not be less than 30°

.6 the web depth to thickness ratio of frames shall not exceed the following values:

$60\sqrt{\eta}$ – for symmetrically flanged frames;

$50\sqrt{\eta}$ – for asymmetrically flanged frames.

.7 the outstanding flange shall not exceed $10\sqrt{\eta}$ times the flange thickness.

.8 in way of the foremost hold, side frames of asymmetrical section shall be fitted with tripping brackets which shall be welded to shell plating, webs and face plates of frames.

.9 double continuous welding shall be adopted for the connections of frames and brackets to side shell, hopper wing tank plating and web to face plates. For this purpose, the strength factor α for a weld (refer to 1.7.5.1) is adopted equal to:

0,44 where frame webs shall be welded to shell plating on lengths equal to 0,25 of the frame span as measured from the upper and lower frame end, and where bracket webs shall be welded to the plating of underdeck and bilge tanks;

0,4 where frame webs shall be welded to shell plating outside the above end sections.

Where the hull form is such as to prohibit an effective fillet weld, edge preparation of the web of frame and bracket may be required, in order to ensure the same efficiency as the weld connection stated above.

3.3.2.6 The ends of plane bulkhead stiffeners shall be bracketed to the inner bottom plating and to deck structures.

3.3.2.7 The cofferdam bulkheads shall satisfy the following requirements:

.1 the construction of cofferdam bulkheads, as stipulated under 2.7.1.2, shall consist of two tight platings, diaphragms and/or platforms. To stiffen the plating, vertical or horizontal stiffeners may be fitted.

.2 the vertical or horizontal stiffeners of both platings shall be identical, form a ring structure and pass continuous through the platforms or, accordingly, diaphragms. The vertical stiffeners of both platings shall be fitted in the same plane parallel to the centreline of the ship; the horizontal stiffeners shall be fitted in the same plane parallel to the base line of the ship.

Cross ties are permitted between the vertical or horizontal stiffeners of both platings, at the mid-span thereof.

.3 the diaphragms or platforms shall be stiffened in accordance with 1.7.3.2. The smaller side, in mm, of the panel of diaphragm or platform to be stiffened shall not exceed $100s\sqrt{\eta}$, where s – is the thickness of diaphragm or platform, in mm.

.4 for access to all parts of the cofferdam bulkhead an adequate number of openings (manholes) shall be provided in the diaphragms and platforms.

The total width of openings in one section of the diaphragm or platform shall not exceed 0,6 of the cofferdam bulkhead thickness.

Openings other than the air and drain scuppers are generally not permitted: in the platforms, at a distance not less than 1,5 times the cofferdam bulkhead thickness from the longitudinal bulkheads or side, which act as the platform supports; in the diaphragms, at the same distance from the inner bottom plating or the upper point of the bulkhead bottom trapezoidal stool, if any, and the upper deck plating or the lower point of the horizontal underdeck stiffener of rectangular or trapezoidal section, being the bulkhead top stool, if any, which act as the diaphragm supports.

Edges of the openings cut in the diaphragms and platforms located within l / 4 of the span from their supports shall be reinforced with face plates or stiffeners. The distance between the edges of adjacent openings shall be not less than the length of these openings.

3.3.2.8 Transverse bulkheads with vertical corrugations shall have plane areas at ship's sides not less than 0,08*B* in width. The upper ends of these bulkheads shall be attached to the deck by horizontal stiffeners of rectangular or trapezoidal section, complying with the requirements of 3.3.2.11, while the lower ends shall be attached directly to the inner bottom plating or to the stools of trapezoidal section fitted on the inner bottom, complying with the requirements of 3.3.2.10. The bulkheads in heavy cargo holds shall be supported by trapezoidal stools..

At lower end of corrugations there shall be fitted vertical and sloped plates so as to cover the concave portion of corrugations on each side of the corrugated bulkhead. The height of the covering plates in oil or bulk dry cargo carriers shall not be less than 0,1 of the corrugation span, and their thickness shall be not less than the lower strake thickness of the corrugation.

3.3.2.9 Where lower ends of vertical corrugations are attached directly to the inner bottom plating, floors the thickness of which shall be not less than that of the bottom strake of the corrugated bulkheads shall be aligned with transverse faces (those directed athwart the ship).

In this case, web plates (those directed along the ship) of rectangular corrugations shall be in line with inner bottom longitudinals or side girders. Side faces of trapezoidal corrugations shall be arranged so that in way of their intersection with inner bottom longitudinals hard spots are avoided.

3.3.2.10 The construction of the transverse bulkhead bottom trapezoidal stool shall comply with the following requirements:

.1 the stool is fitted on the inner bottom athwart the ship under the bulkhead. It shall consist of a top horizontal plate having a width not less than the height of the bulkhead corrugations and two sloped plates resting upon the plate floors. The height of the stool shall not exceed 0,15*D*. Stools of greater height are subject to special consideration by the Register.

.2 inner bottom longitudinals shall be cut at the floors giving support to the sloped plates of the bottom stools and to be attached to them by brackets. Brackets having a thickness not less than that of the floors, reinforced with stiffeners shall be fitted between the floors in line with the inner bottom longitudinals.

.3 diaphragms shall be fitted inside the bottom stools in line with the centre girder and side girders. Drain and access holes may be cut in the diaphragms. Size of the openings, their runforcement as well as stiffening of diaphragms shall comply with similar requirements for the diaphragms of hopper side tanks, as specified in 3.3.2.4;

.4 the horizontal and sloped plates inside the bottom stool shall be stiffened to form a ring structure, fitted in line with the inner bottom longitudinals.

3.3.2.11 The construction of the corrugated bulkhead top stool of rectangular or trapezoidal section shall comply with the following requirements:

.1 the top stool shall be fitted under the deck athwart the ship, over the bulkhead. It shall consist of a bottom horizontal plate having a width not less than the height of the bulkhead corrugations and two vertical or sloped plates. The height of the top stool shall be approximately equal to 0,1 of the distance between the topside tanks. The dimensions of the top stool shall be such as to provide access into that stool.

.2 the horizontal and vertical (sloped) plates inside the stool shall be stiffened.

The stiffeners may be fitted in line with the deck longitudinals forming ring structures with them.

Horizontal stiffeners may be fitted. In this case, webs giving intermediate support to these stiffeners as well as brackets ensuring efficient end attachment of corrugations shall be provided inside the top stool.

.3 where an angle between the sloped plate of the top stool and a vertical axis exceeds 30°, brackets ensuring efficient upper end attachment of corrugations shall be fitted inside the top stool in line with plane faces of trapezoidal corrugations.

3.3.3 Design loads.

3.3.3.1 The design loads on the inner bottom members, sides and transverse bulkheads shall be calculated as required by 2.2.3, 2.4.3, 2.5.3 and 2.7.3 respectively, taking account of the heaviest of the anticipated bulk cargoes, liquid cargo (water ballast) or empty holds, whichever is appropriate.

3.3.3.2 The design pressure on the plating and framing of the hopper side tank sloped sides and of the plates of the transverse bulkhead bottom stools shall be determined as required by 1.3.4.3 for the heaviest of the anticipated bulk cargoes and as required by 1.3.4.2 for liquid cargo, whichever is appropriate. In any case, the design pressure need not be taken less than that determined by Formula (1.3.4.2-4) and for the trapezoidal stools also in accordance with 2.7.3.1.

3.3.3.3 The design pressure on the plating and framing of the topside tank longitudinal bulkheads and of the plates of the transverse bulkhead top stools of rectangular or trapezoidal section shall be determined as required by 1.3.4.2 for the holds filled with liquid cargo (water ballast). In any case, the design pressure need not be taken less than that determined by Formula (1.3.4.2-4) and for the top stools also in accordance with 2.7.3.1.

3.3.3.4 Where the hopper side and/or topside tanks, transverse bulkhead bottom and/or top stools, space inside the cofferdam bulkheads and/or interskin space are used as tanks, the design pressure shall be determined with regard for the pressure from the inside as required by 1.3.4.2.

3.3.4 Scantlings of structural members.

3.3.4.1 The scantlings of double bottom members shall satisfy the following requirements:

.1 the scantlings of centre girder, side girders and floors shall be determined on the basis of strength calculation made for bottom grillages using design pressure stated in 3.3.3 and the following permissible stress factors:

for centre girder and side girders

$k_\sigma = 0{,}3k_B \le 0{,}6$ – in the midship region, when determining the shell plating stresses;

$k_\sigma = 0{,}35k_B \le 0{,}6$ – in the midship region, when determining the inner bottom plating stresses;

$k_\sigma = 0{,}6$ – at the ship's ends within 0.1*L*- from the fore or after perpendicular.

For regions between the midship region and the above portions of ship's ends, k_σ shall be determined by linear interpolation;

for floors

$k_\sigma = 0{,}6$;

when the strength is verified using the shear stresses,

$k_\tau = 0{,}6$.

k_B shall be determined by Formula

$$k_B = W_b^{ф} / W, \qquad (3.3.4.1.1)$$

де W – момент опору корпусу, який вимагається цими Правилами, в середній частині судна згідно 1.4.5;

$W_b^{ф}$ – actual hull modulus for the bottom in the midship region in accordance with 1.4.7.

Where combinations of empty and loaded holds are envisaged, this shall be accounted for in the strength calculation made for the bottom grillage when determining the root flexibility factor of the centre girder and side girders on the bearing contour line of the grillage. Account may be taken of the end root flexibility of floors owing to rotational stiffness of the hopper side tanks. The grillage shall be treated as a system of cross members (structural idealization using beam models).

For ships of 150 m in length and upwards, intended to carry solid bulk cargoes having a density of 1,0 t/m³ or above, the strength of double bottom structural members in the case when each cargo hold considered individually flooded shall be additionally checked according to the procedure specified in Appendix 4.

.2 the section modulus of the bottom primary members shall be determined in accordance with 2.4.4.5 taking the following permissible stress factors:

for longitudinals

$k_\sigma = 0{,}4k_B \le 0{,}65$ – in the midship region;

$k_\sigma = 0{,}65$ at the ship's ends within 0.1*L* from the fore or after perpendicular.

For regions between the midship region and the above portions of the ship's ends, k_σ shall be determined by linear interpolation;

for transverse members

$k_\sigma = 0{,}65$.

k_B shall be determined by Formula (3.3.4.1.1).

.3 the section modulus of inner bottom primary members shall be determined in accordance with 2.4.4.5 at the design pressure in accordance with 3.3.3 and the following permissible stress factors:

for longitudinals

$k_\sigma = 0{,}5k_B \le 0{,}75$ – in the midship region;

$k_\sigma = 0{,}75$ – at the ship's ends within 0.1*L* from the fore or after perpendicular.

For regions between the midship region and the above portions of the ship's ends, k_σ shall be determined by linear interpolation;

for transverse members

$k_\sigma = 0{,}75$.

k_B shall be determined by Formula (3.3.4.1.1).

3.3.4.2 the scantlings of the hopper side tank members shall comply with the following requirements:

.1 the thickness of the sloped bulkhead plating shall not be less than that determined by the Formula (1.6.4.4) taking:

m = 15,8;

p – design pressure as defined in 3.3.3;

k_σ shall be taken as for the longitudinal bulkhead plating of tankers as required by 2.7.4.1, but not more than for the inner bottom plating in accordance with 2.4.4.4.1.

The bottom strake thickness of the tank sloped bulkhead shall not be less than that of the inner bottom plate adjacent to it. The thickness of other strakes, in mm, shall not be less than

$$s_{\min} = (0{,}035L + 7)\sqrt{\eta}\,, \quad (3.3.4.2.1)$$

where η shall be obtained from Table 1.1.4.3.

but not greater than the bottom strake thickness.

Where the hold and/or tank is used for the carriage of oil, oil products or water ballast, the thickness shall not be less than required by 3.5.4.

.2 the section modulus of primary members of the sloped bulkhead shall not be less than that determined in accordance with 1.6.4.1 and 1.6.4.2 taking

p – design pressure as defined in 3.3.3;

m = 10 – for transverse stiffeners;

m = 12 – for longitudinal stiffeners;

k_σ shall be taken as for the bulkhead stiffeners of tankers as specified in 2.7.4.2, but not more than for the inner bottom primary members in accordance with 3.3.4.1.3.

The longitudinal stiffeners shall comply with buckling strength requirements, as specified in 1.6.5.

.3 the thickness of the diaphragm plating shall not be less than that of the abutting plate floors. Stiffening of the diaphragms with openings shall comply with the requirements for stiffeners of the floors, as specified in 1.7.3.2.

The thickness of plating and the scantlings of the stiffening framing members of the watertight diaphragms shall comply with the requirements for the tank bulkheads as specified in 2.7.4.1 and 2.7.4.2.

3.3.4.3 Where the frame ends are attached directly to the sloped bulkheads of tanks (without transition horizontal area), the section modulus at support section W_{sup}, in cm^3 , shall be not less than

$$W_{оп} = W_о / \cos^2\alpha\,,$$

де W_0 – section modulus at the frame support section as required by 2.5.5.1, in cm^3;

α – slope angle of the tank bulkhead to the base line, in deg.

3.3.4.4 The scantlings of the frames shall be in accordance with the requirements of 2.5.4.1 and with the following requirements.

.1 the thickness of frame webs $s_{w\min}$, in mm, shall not be less than $s_{w\min} = k(0{,}03L + 7)$,

where k = 1,15 for frame webs in way of the foremost hold;

k = 1,0 for frame webs in way of other holds.

.2 the thickness of the bracket connecting the lower end of frame to the bilge tank shall not be less than that of the frame web or $s_{w\min}$ + 2, in mm, whichever is greater. The thickness of the bracket connecting the upper end of frame to the underdeck tank shall not be less than that of the frame web.

.3 the section modulus of the frame and bracket or integral bracket, and associated shell plating, shall not be less than twice the section modulus required for the frame mid-span area.

3.3.4.5 The scantlings of the topside tank members shall comply with the following requirements:

.1 the plating thickness of the vertical and sloped bulkheads of the topside tank shall not be less than determined by Formula (1.6.4.4) taking:

m = 15,8;

p – design pressure as defined in 3.3.3;

k_σ shall be taken as for the longitudinal bulkhead plating of tankers as specified in 2.7.4.1.

The thickness, in mm, of the vertical bulkhead plating and of the adjoining sloped bulkhead plate shall not be less than

$$s_{min} = 0{,}025L+10, \qquad (3.3.4.5.1)$$

The thickness of other sloped bulkhead plates shall be not less than that determined by Formula (2.7.4.1-2). Where the hold and/or tank is used for the carriage of oil, oil products or water ballast, the thickness shall be not less than that required by 3.5.4.

.2 the section modulus of longitudinal stiffeners of the vertical and sloped bulkheads shall not be less than that determined according to 1.6.4.1 taking:

p – design pressure as defined in 3.3.3, but not less than 25 kPa;

m = 12;

k_σ shall be taken as for horizontal stiffeners of longitudinal bulkheads of tankers as specified in 2.7.4.2. The longitudinal stiffeners of the vertical and sloped bulkheads shall comply with buckling strength requirements of 1.6.5.

.3 the section modulus of the transverse web of the sloped bulkhead shall be not less than that determinated in 1.6.4.1, and the sectional area of the web plate shall not be less than that determined in accordance with 1.6.4.3 taking:

$$N_{max} = 0{,}5pal;$$

p – design pressure as defined in 3.3.3, but not less than 25 kPa;

m = 10;

$k_\sigma = k_\tau$ = 0,75.

.4 the section modulus and sectional area of the deck transverse web inside the tank shall comply with the requirements of 2.6.4.6. The section modulus and sectional area of the side transverse web inside the tank shall comply with the requirements of 2.5.4.5 at m = 10.

The section modulus and sectional area of vertical web plate of the tank vertical bulkhead shall be calculated as the mean of these values for the deck transverse and transverse web of the sloped bulkhead.

.5 the plate thickness of bulkheads inside the tanks fitted in line with the hold transverse bulkheads shall not be less than that of the latter at the same distance from the inner bottom plating. Stiffening of bulkhead plating shall comply with the requirements of 2.7.4.2 for the tank primary members.

.6 the thickness of brackets stiffening the tank vertical bulkhead and of brackets fitted at the lower corner of the tank shall not be less than 10 mm.

3.3.4.6 In any case, the hold bulkhead plating and corrugations shall have a thickness not less than 10 mm.

The height of top rectangular (trapezoidal) stool, bottom trapezoidal stool and of double bottom is not included in the span of the hold bulkhead vertical corrugations.

3.3.4.7 The scantlings of the transverse bulkhead lower trapezoidal stool members shall comply with the following requirements:

.1 the thickness of the horizontal and sloped plate shall not be less than that determined by Formula (1.6.4.4) taking:

m = 15,8;

p – design pressure as defined in 3.3.3;

$k_σ$ = 0,9.

The thickness of horizontal plate and top strake of the sloped plate shall not be less than that of the corrugation adjoining the stool. The thickness of the bottom strake of the sloped plate shall not be less than that of the inner bottom plating. The thickness of other stakes of the sloped plate shall not be less than that determined by Formula (3.3.4.2.1). Where the hold and/or stool is used for the carriage of oil, oil products or water ballast, the thickness shall be not less than that required by 3.5.4.

.2 the section modulus of the sloped plate stiffeners shall not be less than that determined in accordance with 1.6.4.1 and 1.6.4.2 taking:

p – design pressure as defined in 3.3.3;

m = 10;

$k_σ$ = 0,75.

The section modulus of the horizontal plate stiffeners shall not be less than that of the sloped plate stiffeners.

.3 the thickness of diaphragm shall not be less than that of side girders. Size of the openings cut in diaphragms and their reinforcement shall comply with the requirements for openings and reinforcement of the hopper side tank diaphragms as specified in3.3.4.2.3.

3.3.4.8 The scantlings of the transverse bulkhead top rectangular or trapezoidal stool members shall comply with the following requirements:

.1 the thickness of the horizontal and vertical (or sloped) plates shall not be less than that determined by Formula (1.6.4.4) taking:

m = 15,8;

p – design pressure as defined in 3.3.3;

$k_σ$ = 0,9.

The thickness of the horizontal plate and bottom strake of the vertical (sloped) plate shall not be less than that of the corrugation adjoining the top stool. Where the vertical plate is fitted in line with the hatch end coaming, its thickness shall not be less than that of this coaming as required by 3.3.4.11. The top strake of the sloped plate shall have the same thickness provided that its upper edge is at a distance of less than 0,4 m from the hatch end coaming. In any case, the thickness of the vertical or sloped plate shall not be less than that determined by Formula (2.7.4.1-2). Where the hold and/or interior of the top stool is used for the carriage of oil, oil products or water ballast, the thickness shall not be less than that required by 3.5.4.

.2 the section modulus of the stiffeners of vertical or sloped plate shall not be less than that determined according to 1.6.4.1 taking:

p – design pressure as defined in 3.3.3, but not less than 25 kPa;

m = 12 – for horizontal stiffeners;

m = 10 – for other stiffeners;

k_σ = 0,75.

The section modulus of the stiffeners of horizontal plate shall not be less than that of the stiffeners of vertical or sloped plate.

.3 the section modulus of the vertical or sloped plate web to be fitted where horizontal stiffeners are provided, as stated in 3.3.2.11.2, shall not be less than that determined from 1.6.4.1 and 1.6.4.2, while the sectional area of the web plate shall not be less than determined according to 1.6.4.3 taking:

$$N_{max} = 0,5pal;$$

p – design pressure as defined in 3.3.3, but not less than 25 kPa;

m = 10;

$k_\sigma = k_\tau$ = 0,75.

The section scantlings of webs fitted on the horizontal plate and under the deck shall not be less than those required for the vertical (sloped) plate web.

.4 the thickness of the brackets fitted inside the top stool to ensure efficient upper end attachment of corrugations shall not be less than that of these corrugations in the upper part of the bulkhead.

3.3.4.9 The scantlings of the cofferdam bulkhead members shall comply with the following requirements:

.1 the thickness of the cofferdam bulkhead plating shall not be less than that determined by Formula (1.6.4.4) taking:

m = 15,8;

p – design pressure as defined in 3.3.3;

k_σ = 0,9.

The plating thickness shall not be less than that determined by Formula (2.7.4.1-2) or according to 3.3.4.6, whichever is the greater. Where the hold or interior of the cofferdam bulkhead is used for the carriage of oil, oil products or water ballast, the plating thickness shall be not less than that required by 3.5.4.

.2 the section modulus of primary members stiffening the plating of cofferdam bulkheads shall not be less than that determined from 1.6.4.1 and 1.6.4.2 taking:

p – design pressure as defined in 3.3.3 but not less than 25 kPa;

m = 12;

k_σ = 0,75.

.3 where the construction of the cofferdam bulkhead incorporates only diaphragms or only platforms, their section modulus shall not be less than that determined from 1.6.4.1 and 1.6.4.2, and the sectional area is not less than that determined from 1.6.4.3 taking:

$N_{max} = 0,50pal$ – for platforms,

$N_{max} = 0,65pal$ – for diaphragm;

p – design loads as defined in 3.3.3, but not less than 25 kPa;

l – span, in m, equal to:

for diaphragms — the distance between the deck plating and inner bottom plating, at the centreline;

for platforms — the ship's breadth in way of construction bulkhead for ships having single skin side construction, the distance between the inner skins for ships having double skin side construction;

m = 10;

$k_\sigma = k_\tau$ = 0,75.

.4 where the construction of the cofferdam bulkhead consists both the diaphragms and platforms, their thickness shall be determined on the basis of the calculation of the grillage as a system using beam models, with the loads specified in 3.3.3 but not less than 25 kPa and the permissible stress factors

$k_\sigma = k_\tau = 0{,}75$.

.5 in any case, the thickness of the cofferdam bulkhead diaphragms and platforms shall not be less than that determined by Formula

$$s_{min} = 0{,}018L + 6{,}2. \quad (3.3.4.9.5)$$

be less than that determined by Formula (2.5.4.8.1). Where the interior of the cofferdam bulkhead is used as a fuel oil or ballast tank, the thickness of the diaphragms and platforms shall not be less than that required by 3.5.4.

.6 stiffening of the diaphragms and platforms shall comply with the requirements of1.7.3.2.2.

.7 the thickness of tight portions of the diaphragms and platforms and their stiffeners shall comply with the requirements of 2.7.4.1 and 2.7.4.2 for tank bulkheads.

.8 cross ties between the primary members strengthening the cofferdam bulkhead plating shall comply with the requirements for the double bottom intermediate struts, as specified in 2.4.4.7 with the design pressure determined according to 3.3.3, but not less than 25 kPa.

Where cross ties are fitted, the section modulus of the primary members, as specified in 3.3.4.9.2, may be reduced by 35 per cent.

3.3.4.10 For ships of 150 m in length and upwards, intended to carry solid bulk cargoes having a density of 1,0 t/m³ or above, the strength of vertically corrugated transverse watertight bulkheads in the case when each cargo hold considered individually flooded shall be additionally checked according to the procedure specified in Appendix 3..

3.3.4.11 The thickness of the hatch coamings shall not be less than that determined by Formula (3.3.4.4.1).

The thickness of the hatch side coamings, in mm, shall not be less than

$$s = 17a,$$

where a = vertical distance between horizontal stiffeners on coaming plate or between the lower stiffener and the deck plating, in m.

Stiffening of the coaming plates shall comply with the requirements of 1.7.3.2. The thickness of coaming plate stiffeners and brackets shall not be less than 10 mm.

The width of the coaming face plate shall comply with the requirements of 1.7.3.1.

3.3.4.12 The thickness of single-side shell plating located between hopper and upper wing tanks shall not be less than s_{min}, in mm, determined by the formula

$$s_{min} = \sqrt{L}.$$

3.3.5 Special requirements.

3.3.5.1 Provision shall be made for an efficient corrosion protection coating (epoxy coating or equivalent) for all internal surfaces of the cargo holds, excluding the flat tank top areas and the hopper tanks sloping plating, approximately 300 mm below the toe of frame brackets and for all internal and external surfaces of hatch coamings and hatch covers. In the selection of coating due consideration shall be given to intended cargo conditions expected in service.

3.3.5.2 Al l bulk carriers of 150 m in length and upwards contracted for construction on or after 1 July 2003, shall comply with the following requirements:

.1 the longitudinal strength shall be checked at departure and arrival of the ship for loading conditions specified in 1.4 and also for the following conditions:

*with **BC-A, BC-B** or **BC-C*** distinguishing marks in the class notation:

homogeneous cargo loaded condition where the cargo density corresponds to all cargo holds, including hatchways, being 100 per cent full at maximum draught with all ballast tanks empty;

*with **BC-A** or **BC-B*** distinguishing marks in the class notation:

homogeneous cargo loaded condition with cargo density 3,0 t/m^3 , and the same filling ratio (cargo mass/hold cubic capacity) in all cargo holds at maximum draught with all ballast tanks empty;

*with **BC-A*** distinguishing mark in the class notation:

at least one cargo loaded condition with specified holds empty, with cargo density 3,0 t/m^3 , and the same filling ratio (cargo mass/hold cubic capacity) in all loaded cargo holds at maximum draught with all ballast tanks empty;

normal ballast (no cargo) condition, where the ballast tanks may be full, partially full or empty, any cargo hold or holds adapted for the carriage of water ballast at sea shall be empty, the trim shall be by the stern and shall not exceed 0,015*L*, where L is the length between perpendiculars of the ship, the propeller shall be fully immersed;

normal ballast (no cargo) condition, where all ballast tanks are 100 per cent full, other conditions — refer to the previous case;

heavy ballast (no cargo) condition, where the ballast tanks may be full, partially full or empty, at least one cargo hold adapted for carriage of water ballast at sea shall be full, the trim shall be by the stern and shall not exceed 0,015L, where *L* is the length between perpendiculars of the ship, the moulded forward draught in the heavy ballast condition shall not be less than the smaller of 0,03*L* or 8 m, whichever is the less, the propeller immersion *I/D* shall be at least 60 per cent where *I* = the distance from propeller centerline to the waterline, *'D* = propeller diameter;

heavy ballast (no cargo) condition where all ballast tanks are 100 per cent full, other conditions — refer to the previous case;

At departure condition: with bunker tanks not less than 95 per cent full and other consumables 100 per cent; and at arrival condition: with 10 per cent of consumables;

.2 the structures of bottom forward shall meet the requirements of 2.8;

.3 for calculation of local strength of double bottom (vertical keel, bottom stringers and floors) the following definitions and symbols shall apply:

M_H - the actual cargo mass in a cargo hold corresponding to a homogeneously loaded condition at maximum draught ,

M_{Full} - the cargo mass in a cargo hold corresponding to cargo with virtual density (homogeneous mass/hold cubic capacity, minimum 1,0 t/m^3) filled to the top of the hatch coaming, and M_{Full} shall in no case be less than M_H ;

M_{HD} — maximum cargo mass allowed to be carried in a cargo hold with specified holds empty at maximum draught;

.4 local strength of double bottom in each cargo hold shall be checked, inter alia, for the following cases of load on the double bottom due to cargo mass in the holds, as well as mass of fuel oil and water ballast contained in double bottom tanks, as well as sea water pressure along the hold.

General conditions applicable for all ships*:*

- cargo mass M_{Full}, fuel oil tanks being 100 per cent full, ballast water tanks being empty, at maximum draught;
- cargo mass minimum 50 per cent of M_{Full}, fuel oil tanks and ballast water tanks being empty, at maximum draught;
- any cargo hold being empty, fuel oil tanks and ballast water tanks being empty, at the deepest ballast draught;

*except the ships when the entry **"no MP"*** is added to the class notation after the distinguishing marks*:*

- cargo mass M_{Full} , fuel oil tanks being 100 per cent full, ballast water tanks being empty, at 67 per cent of the maximum draught;
- any cargo hold, fuel oil tank and ballast water tank being empty, at 83 per cent of the maximum draught;
- cargo mass M_{Full} in each of two adjacent holds, fuel oil tanks being 100 per cent full, ballast water tanks being empty, at 67 per cent of the maximum draught. Applicable also in case when the adjacent hold is filled with ballast;
- two adjacent cargo holds being empty, fuel oil tanks and ballast water tanks being empty, at 75 per cent of the maximum draught;

*applicable only for ships with **BC-A*** distinguishing mark in the class notation:

- cargo holds intended to be empty at maximum draught and fuel oil tanks and ballast water tanks are being empty;
- cargo mass $M_{HD}+0,1\ M_H$ in cargo holds intended to be loaded with high density cargo, fuel oil tanks being 100 per cent full, ballast water tanks being empty, at maximum draught. In operation maximum allowable cargo mass shall be limited to M_{HD};
- cargo mass 10 per cent of M_H in each of two adjacent cargo holds which may be loaded with the next holds being empty, fuel oil tanks being 100 per cent full, ballast water tanks being empty, at maximum draught;

for ballast hold(s) only:

- cargo holds being 100 per cent full of ballast water including hatchways, fuel oil tanks and ballast tanks being 100 % full, at any heavy ballast draught;

during loading and unloading in harbour only:

maximum allowable cargo (sea-going) mass in any single cargo hold, at 67 per cent of the maximum draught;

- cargo mass M_{HD} in any two adjacent holds, fuel oil tanks being 100 per cent full, ballast water tanks being empty, at 67 per cent of the maximum draught;
- at reduced draught during loading and unloading in harbour, the maximum allowable mass in a cargo hold may be increased by 15 per cent of the maximum mass allowed at the maximum draught in sea-going condition, but shall not exceed the mass allowed at maximum draught in the sea-going condition.

3.3.5.3 Hull girder longitudinal strength for ships with of length 150 m and more, with **BC-A** or **BC-B** distinguishing marks in the class notation**,** with single hull, constructed on or after July 1 1999, and with double side plating with spacing between double side platings less than $B/5$, which were constructed on or after 1 July 2006, shall be checked for specified flooded conditions, in each of the cargo and ballast loading conditions defined in 1.4.3.1, except that harbour conditions, docking condition afloat, loading and unloading transitory conditions in port and loading conditions encountered during ballast water exchange need not be considered.

The actual hull girder bending stress σ_{fld}, in MPa, shall be determined by the formula

$$\sigma_{fld} = \frac{M_{sw}^{fld} + 0{,}8M_w}{W} \cdot 10^3, \quad (3.3.5.3\text{-}1)$$

where M_{sw}^{fld} – still water bending moment, in kN-m, in the flooded conditions for the section under consideration;

M_w – wave bending moment, in kN-m, as given in 1.4.4.1 for the section under consideration;

W – = section modulus, in cm^3, for the corresponding location in the hull girder.

The actual hull girder shear stress τ_{fld} , in MPa, shall be determined by the formula

$$\tau_{fld} = \frac{N_{sw}^{fld} + 0{,}8N_w}{2s} \frac{S}{I} \cdot 10^3, \quad (3.3.5.3\text{-}2)$$

where N_{sw}^{fld} – still water shear force, in kN, in flooded conditions for the section under consideration;

N_w – wave shear force, in kN, as given in 1.4.4.2 for the section under consideration;

I, S – as defined in 1.4.2;

s – thickness of side shell plating, in mm.

Strength calculation in flooded condition shall demonstrate that the actual hull girder bending stress shall not exceed 175/η, in MPa, and the actual shear stress shall not exceed 110/η, in MPa.

To calculate the strength in flooded condition, the following assumptions shall be made:

the damaged structure is assumed to remain fully effective in resisting the applied loading;

each cargo hold shall be considered individually flooded up to the equilibrium waterline. Position of the waterline and the volume of ingressed water are determined on the basis of damage trim and stability calculations which shall be made in accordance with a program approved by the Register;

"permeability" for solid bulk cargo means the ratio of the floodable volume between the particles, granules or any larger pieces of the cargo, to the gross volume of the bulk cargo;

the permeability of empty cargo spaces and volume left in loaded cargo spaces above any cargo shall be taken as 0,95;

appropriate permeabilities and bulk densities shall be used for any cargo carried. For iron ore, a minimum permeability of 0,3 with a corresponding bulk density of 3,0 t/m^3 shall be used. For cement, a minimum permeability of 0,3 with a corresponding bulk density of 1,3 t/m^3 shall be used;

for packed cargo conditions (such as steel mill products), the actual density of the cargo shall be used with a permeability of zero.

3.3.5.4 Al l the bulk carriers and combination carriers contracted for construction on or after 1 July 2003 shall comply with the following requirements:

.1 the ships shall have the forecastle located above the freeboard deck. In case the above requirement hinders hatch cover operation, the aft bulkhead of the forecastle may be fitted forward of the forward bulkhead of the foremost cargo hold provided the forecastle length is not less than 7 per cent of ship length abaft the forward perpendicular where the ship length — refer to 1.2.1, Part I "General" of the Load Line Rules for Sea-Going Ships.

The forecastle shall have at least a standard height according to the International Convention on Load Lines, 1966 as amended by the Protocol of 1988 or shall be by 0,5 m above the forward hatch-end coaming of the fore hold No. 1, whichever is greater. In this case, the distance between the aft edge of the forecastle deck and the forward hatch-end coaming of the fore hold No. 1 over the entire breadth of the ship's hull shall not exceed the value, in m, determined by the formula

$$l_F = \sqrt{H_F - H_C}\,, \qquad (3.3.5.4.1)$$

where H_F − forecastle height, in m;

H_C − height of the forward hatch-end coaming of the fore hold No. 1, in m.

No breakwater is allowed on the forecastle deck for protection of the forward hatch-end coaming and hatch covers of the fore hold No. 1.

However, if fitted for other purposes, the breakwater shall be placed at a distance of at least 2,75 its height along the centerline from the aft edge of the forecastle deck;

.2 a net thickness (no wear allowance) of hatch coamings shall not be less than that determined by the formula

$$s_{net} = 14,9a\sqrt{1,15p_{coam} - /0,95HR_{eH}}\,, \qquad (3.3.5.4.2)$$

where a − distance between stiffeners, in m;

p_{coam} − pressure equal to 220 kPa; if the requirements of 3.3.5.2.1 are not met, the pressure for the forward hatch-end coaming of the fore hold No. 1 shall be assumed equal to 290 kP.

The net thickness increased by 1,5 mm shall be taken as the minimum construction thickness.

In any event, the coaming thickness shall not be less than 11 mm;

.3 the section modulus of longitudinal and transverse stiffeners of hatch coamings at the net thickness of all section elements, in cm3 , shall not be less than determined by the formula

$$W_{net} = \frac{1,15al^2 p_{coam}}{0,95mc_p R_{eH}} \cdot 10^3\,, \qquad (3.3.5.4.3)$$

where for a and p_{coam} − refer to 3.3.5.2.2;

l − stiffener span, in m;

m − coefficient equal to: 16 - for snipped stiffener ends;

12 - in way of hatch corners;

c_p – plastic-to-elastic section modulus ratio for a stiffener with an effective flange $40s_{net}$, wide, where s_{net} – net thickness of a coaming.

If precise data are lacking, c_p may be assumed equal to 1,16.

The net thickness of all cross-section elements increased by 1,5 mm shall be taken as the minimum construction thickness.

.4 stays (brackets) of hatch coamings shall comply with the following requirements:

the section modulus of stays (brackets) in the plane of beams with a net thickness of all section elements shall not be less than that determined by the formula

$$W_{net} = \frac{500aH^2 p_{coam}}{0,95R_{eH}}\,, \qquad (3.3.5.4.4\text{-}1)$$

where a = distance between stays in the plane of beams, in m;

for p_{coam} – refer to 3.3.5.2.2;

H_C height of a hatch coaming, in m.

In determination of the actual section modulus, the face plate of the coaming stay may be considered only when it is welded to the deck plating with full penetration and appropriately dimensioned stiffeners, knees or brackets are fitted in its plane under the plating.

The net thickness of a web of stays in the plane of beams shall not be less than that determined by the formula

$$s_{net} = \frac{1000 a H_c p_{coam}}{0,5 h R_{eH}}, \quad (3.3.5.4.4\text{-}2)$$

where h = depth of a stay web at its attachment to deck plating, in mm;

for a and H_C – refer to Formula (3.3.5.2.4-1);

for p_{coam} – reefer to 3.3.5.2.2;

The net thickness of all cross-section elements increased by 1,5 mm shall be taken as the minimum construction thickness.

Strength calculations for stays off the plane of beams are subject to special consideration by the Register in each case.

The permissible stresses in those calculations shall be assumed equal to 0,8 and 0,46 the steel yield stress for normal and shear stresses accordingly.

The stay web shall be joined to deck plating by a double continuous weld having an effective throat thickness not less than 0,44 *s*, where *s* is the minimum construction thickness of the stay web, mm.

At least 15 per cent of the weld length therewith beginning at the "free" end of the stay shall be made with deep penetration (double-bevel preparation).

The strength of underdeck structures taking forces from coaming stays shall be checked against permissible normal and shear stresses equal to 0,95 and 0,5 the steel yield stress accordingly;

.5 longitudinal and transverse stiffeners, stays and plate elements of cargo hatch coamings shall be replaced if the actual residual thickness of the coaming element is less than t_{net} + 0,5 mm.

Where the actual residual thickness is greater than t_{net} + 0,5 mm, but less than t_{net} + 1,0 mm, a protective coating instead of replacement may be applied in accordance with the manufacturer's procedure or annual measurements of the actual residual thickness may be conducted.

3.3.6 Strength control during ship loading.

3.3.6.1 Bulk carriers, ore carriers and combination carriers of 150 m length and above shall be provided with the Loading Manual and loading instrument approved by the Register.

3.3.6.2 Loading Manual is a document approved by the Register, which describes:

a) the loading conditions on which the design of the ship has been based, including permissible limits of still water bending moments and shear forces;

b) the results of the calculations of still water bending moments, shear forces and where applicable, limitations due to torsional loads;

c) envelope results and permissible limits of still water bending moments and shear forces in the hold flooded condition according to 3.3.5.2;

d) the cargo holds or combination of cargo holds that might be empty at full draught. I f no cargo hold is allowed to be empty at full draught, this shall be clearly stated in the Loading Manual;

e) maximum allowable and minimum required mass of cargo and double bottom contents of each hold as a function of the draught at mid-hold position;

f) maximum allowable and minimum required mass of cargo and double bottom contents of any two adjacent holds as a function of the mean draught in way of these holds. This mean draught may be calculated by averaging the draught of the two mid-hold positions;

g) maximum allowable tank top loading together with specification of the nature of the cargo (density or stowage factor) for cargoes other than bulk cargoes;

h) maximum allowable load on deck and hatch covers. If the ship is not approved to carry load on deck or hatch covers, this shall be clearly stated in the Loading Manual;

i) the maximum rate of ballast change together with the advice that a load plan shall be agreed with the terminal on the basis of the achievable rates of change of ballast.

3.3.6.3 In addition to the requirements given in 1.4.3.1.1, the following conditions, subdivided into departure and arrival conditions as appropriate, shall be included in the Loading Manual:

a) alternate light and heavy cargo loading conditions at maximum draught, where applicable;

b) homogeneous light and heavy cargo loading conditions at maximum draught;

c) ballast conditions. For ships having ballast holds adjacent to double bottom tanks, it shall be strengthwise acceptable that the ballast holds are filled when double bottom tanks are empty;

d) short voyage conditions where the vessel shall be loaded to maximum draught but with limited amount of bunkers;

e) multiple port loading/unloading conditions;

f) deck cargo conditions, where applicable;

g) typical loading sequences where the vessel is loaded from commencement of cargo loading to reaching full deadweight capacity, for homogeneous conditions, relevant part load conditions and alternate conditions where applicable.

Typical unloading sequences for these conditions shall also be included.

The typical loading/unloading sequences shall also be developed to not exceed applicable strength limitations.

The typical loading sequences shall also be developed paying due attention to loading rate and the deballasting capability;

h) typical sequences for change of ballast at sea, where applicable.

3.3.6.4 A loading instrument is an approved digital system as defined in 1.4.8.4. In addition to the requirements in 1.4.8.4, it shall ascertain as applicable that:

a) the mass of cargo and double bottom contents in way of each hold as a function of the draught at mid-hold position;

b) the mass of cargo and double bottom contents of any two adjacent holds as a function of the mean draught in way of these holds;

в) the still water bending moment and shear forces in the hold flooded conditions according to 3.3.5.2; are within permissible values.

3.3.6.5 Conditions of approval of loading instruments, as stated in 1.4.8.4, shall include the following:

a) acceptance of hull girder bending moment limits for all read-out points;

b) acceptance of hull girder shear force limits for all read-out points;

c) acceptance of limits for mass of cargo and double bottom contents of each hold as a function of draught;

d) acceptance of limits for mass of cargo and double bottom contents in any two adjacent holds as a function of draught.

3.4 ORE CARRIERS AND ORE OR OIL CARRIERS

3.4.1 General.

3.4.1.1 The requirements of this Chapter apply to ships for the carriage of ore and other bulk cargoes, as well as to combination carriers for transportation of ore and oil (petroleum products).

3.4.1.2 The requirements for structures not mentioned in this Chapter shall be as stated in Sections 1 and 2, having regard to those contained in 3.3 as regards structures exposed to the loads from heavy dry bulk and liquid cargoes.

In any case, the requirements for the hull and its structures shall not be less stringent as those of Sections 1 and 2.

3.4.1.3 The basic structural type of a ship is considered to be a single deck ship, with machinery aft, having longitudinal bulkheads separating the centre ore compartment from the wing tanks and a double bottom throughout the entire breadth of the ship or the centre part between the longitudinal bulkheads.

3.4.1.4 Descriptive notation and distinguishing mark (ESP).

3.4.1.4.1 The descriptive notation **Ore carrier** and the distinguishing mark (ESP) shall be assigned to sea-going self-propelled single deck ships having two longitudinal bulkheads and a double bottom throughout the cargo region and intended for the carriage of ore cargoes in the center holds only. A typical midship section is given in Fig.3.4.1.4.1.

3.4.1.4.2 "Combination carrier" is a general term applied to ships intended for the carriage of both oil and dry cargoes in bulk; these cargoes are not carried simultaneously, with the exception of oil retained in slop tank.

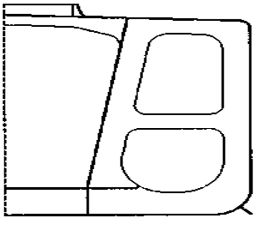


Fig. 3.4.1.4.1.

3.4.1.4.3 The descriptive notation **Ore/Oil carrier** and the distinguishing mark (ESP) shall be assigned to sea-going self-propelled single deck ships having two longitudinal bulkheads and a double bottom throughout the cargo region and intended for the carriage of ore cargoes in the centre holds or of oil cargoes in centre holds and wing tanks. Typical midship sections are given in Fig. 3.4.1.4.3.

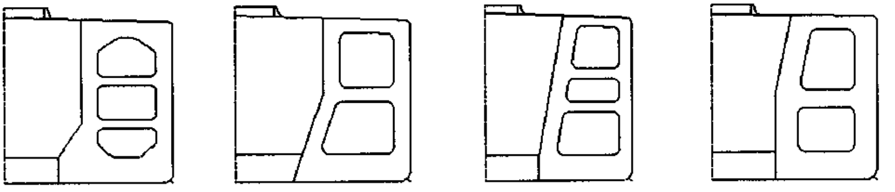


Fig. 3.4.1.4.3.

3.4.2 Construction.

3.4.2.1 The deck and bottom (double bottom) shall be longitudinally framed. The side shell and longitudinal bulkheads may, in general, be framed either longitudinally or transversely. Deck plating between end coamings of adjacent cargo hatches shall be strengthened by transverse stiffeners as required by 3.3.2.1.

Transverse bulkheads may be plane with stiffeners arranged vertically, corrugated with vertical corrugations or of a cofferdam type.

3.4.2.2 Floors in the centre hold and in the wing tanks shall be aligned and to form, in conjunction with side transverses, vertical webs of longitudinal bulkheads and deck transverses, a single transverse ring structure.

3.4.2.3 Where transverse bulkheads in the wing tanks are not aligned with centre hold bulkheads, transverse ring structures shall be fitted in line with the latter bulkheads.

In this case, provision shall be made in the wing tanks for a smooth tapering of the sloped bulkheads of trapezoidal stools fitted under centre hold bulkheads.

3.4.2.4 Longitudinal bulkheads shall, in general, be plane with horizontal or vertical stiffening. Longitudinal bulkheads may be slightly sloped or to have a knuckle.

3.4.2.5 Where a double bottom in wing tanks is omitted, floors shall be backed by substantial knees or brackets fitted in line with the inner bottom plating of the centre hold.

3.4.2.6 Diaphragms shall be fitted in line with the longitudinal bulkheads inside the bottom trapezoidal stools and top stools of rectangular or trapezoidal sections. The diaphragms of the bottom stools shall comply with the requirements of 3.3.2.10.3, the diaphragms of the top stools — with the requirements for the topside tank bulkheads as specified in 3.3.2.3.

3.4.3 Design loads.

3.4.3.1 The design pressure on the centre hold boundary structures shall be determined according to 1.3.4.3 assuming that the centre hold is loaded with ore or other heavy bulk cargo.

3.4.3.2 Structures which are likely to be subjected to one-sided pressure of a liquid cargo (ballast water) shall be examined for the design pressure of the liquid cargo as required by 1.3.4.2.

3.4.4 Scantlings of structural members.

3.4.4.1 The scantlings of structural members of the cargo spaces intended only for the carriage of bulk cargoes or bulk cargoes and oil, oil products or water ballast shall comply with the requirements of Section 2 and 3.3.4.

The scantlings of structural members of the cargo spaces intended only for the carriage of oil, oil products or water ballast shall comply with the requirements of Section 2 and 3.5.4.

3.4.4.2 The scantlings of longitudinal bulkhead members shall comply with the requirements of 2.7.4 at the design pressure defined in 3.4.3.

In any case, the thickness of longitudinal bulkhead plating shall not be less than that required by Formula (3.3.4.5.1) or, where oil, oil products or water ballast is carried in any compartment bounded by that bulkhead, it shall be not less than that required by 3.5.4, whichever is the greater.

3.4.4.3 The scantlings of structural items of diaphragms of transverse bulkhead bottom trapezoidal stool, fitted in line with the longitudinal bulkheads, shall comply with the requirements of 3.3.4.7.3.

3.4.4.4 The scantlings of structural items of diaphragms of transverse bulkhead top stool, fitted in line with longitudinal bulkheads, shall comply with the requirements of 3.3.4.5.5 for the transverse bulkheads inside the topside tanks.

3.4.5 Special requirements.

3.4.5.1 Al l ore carriers shall have the forecastle located above the freeboard deck. The forecastle arrangement and dimensions, as well as the thickness and scantlings of stiffeners and plate elements of cargo hatch coamings shall meet the requirements of 3.3.5.4.

3.5 TANKERS

3.5.1 General.

3.5.1.1 The requirements of this Chapter apply to tankers, chemical tankers, as well as to oil recovery ships and gas carriers, as applicable, with machinery aft, having a single or a double bottom arrangement and one, two or three longitudinal bulkheads. Hull structural members of tankers not covered by this Chapter shall comply with the requirements of Sections 1 and 2.

Double hull oil tankers of 150 m in length and above shall comply with the requirements of 1.1.1.1.

3.5.1.2 Descriptive notation and distinguishing mark (ESP).

3.5.1.2.1 The descriptive notation **Oil tanker** and the distinguishing mark (ESP) shall be assigned to sea-going self-propelled ships having integral tanks and intended for the carriage of oil in bulk. The above mentioned descriptive notation and distinguishing mark shall be assigned to tankers of both single and double skin side construction, as well as tankers with alternative structural arrangements, e.g. mid-deck designs.

Typical midship sections are given in Fig. 3.5.1.2.1.

3.5.1.2.2 The descriptive notation **Chemical tanker** and the distinguishing mark (ESP) shall be assigned to sea-going self-propelled ships having integral tanks intended for the carriage of chemicals in bulk. This descriptive notation shall be assigned to tankers of both single or double skin side construction, as well as tankers with alternative structural arrangements.

Typical midship sections are given in Fig. 3.5.1.2.2.

3.5.2 Construction.

3.5.2.1 The scantlings of the cofferdams shall be determined according to 2.7.5.5.

3.5.2.2 Longitudinal corrugated

bulkheads are permitted in ships under 180 m in length.

Longitudinal corrugated bulkheads shall have horizontally arranged corrugations, and their upper and lower strakes for 0,1*D* from the deck and bottom, respectively, shall be plane.

In way of connections between longitudinal and transverse bulkheads, continuity of strength shall be maintained at the top and bottom strakes of the longitudinal bulkheads.

3.5.2.3 The deck and bottom in the cargo tank region shall be framed longitudinally, for the side shell and longitudinal bulkheads, longitudinal or transverse framing may be adopted. The deck and bottom of ships under 80 m in length may be transversely framed. It is recommended that longitudinal framing be used for side shell and longitudinal bulkheads of ships over 180 m in length. Where the longitudinal framing is adopted, spacing of transverse members shall correspond to that of bottom transverses (refer to 2.3.2.4 and 2.4.2.5).

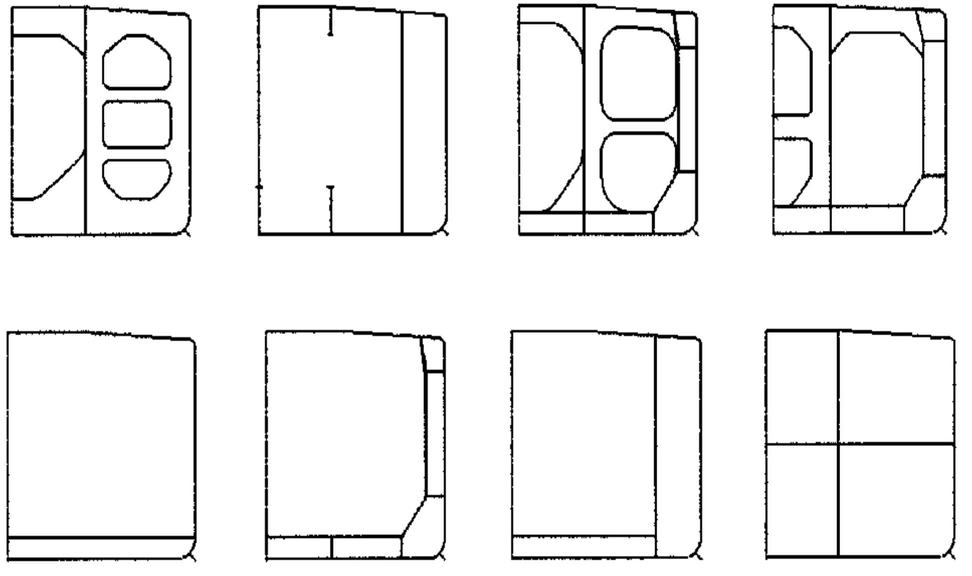


Fig. 3.5.1.2.1.

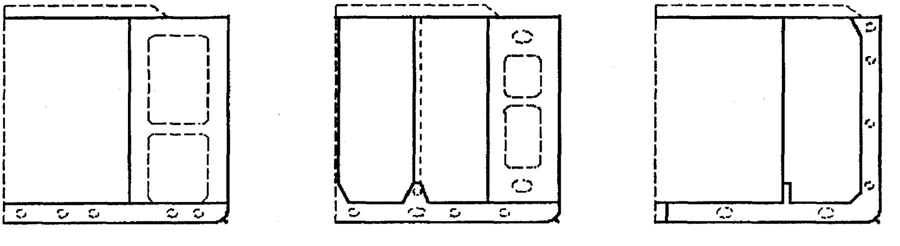


Fig. 3.5.1.2.2.

3.5.2.4 The longitudinal scantlings of deck, bottom, side shell and longitudinal bulkheads within the midship portion of the ship shall not vary. Structural continuity of the above longitudinals shall be ensured within 0,1*D* from deck and bottom.

In ships of 150 m in length and more, the above longitudinals shall pass through the transverse bulkheads without cutting.

3.5.2.5 The primary supporting members (bottom centreline girder, side girders, vertical webs on bulkheads, deck centreline girder, continuous deck girders, side and bottom transverses, side stringers and bulkhead horizontal girders) in way of cargo tanks shall form a transverse ring structure, whenever possible.

3.5.2.6 Hull structural members shall be interconnected as required by 1.7.2. The webs of primary supporting members shall be supported by horizontal or vertical stiffeners in accordance with 1.7.3.2. The inertia moment of stiffeners shall comply with 1.6.5.6.

3.5.3 Design loads.

Unless provided otherwise in this Chapter, the design loads on hull structures of tankers shall be taken according to 1.3 and relevant chapters of Section 2.

3.5.4 Scantlings of structural members.

The scantlings of structural members of tankers shall be determined in compliance with Section 2, having regard to the provisions of this Chapter.

The thickness s_{min}, in mm, of structural members, forming the boundaries of cargo and ballast tanks as well as members fitted inside these tanks shall not be less than:

$$s_{min} = 0{,}035L + 5{,}5 \quad \text{for } L < 80 \text{ m};$$

$$s_{min} = 0{,}02L + 6{,}7 \quad \text{for } L \geq 80 \text{ m}.$$

Where L >290 m L shall be taken equal to 290 m.

In this case, the minimum thickness of the primary members need not exceed 11,5 mm.

3.5.5 Special requirements.

3.5.5.1 The number of openings for access to cofferdams, pump rooms, cargo and ballast tanks shall be kept to the minimum required. They shall be as far distant as practicable from end bulkheads of superstructures. Hatches to wing tanks in line with a centre tank hatch in the athwart direction are not permitted.

Hatch openings shall be either circular or elliptical in shape, the elliptical openings having the major axis fore and aft. Structural continuity of deck girders and longitudinals shall be maintained. The thickness of cargo hatch coamings less than 750 mm high shall be 10 mm, while coamings 750 mm and more in height shall have a thickness equal to 12 mm. Coamings more than 750 mm in height, provided they are more than 1,25 m long, shall be stiffened.

3.5.5.2 Guard rails, bulwark, gangway or an equivalent arrangement shall be fitted in compliance with 8.6, Part II I "Equipment, Arrangements and Outfit". The gangway, if fitted, shall not contribute to hull longitudinal bending.

3.5.5.3 The requirements of this paragraph shall apply to tankers with length L < 80 m.

In the presence of a chest, the deck modulus according to 1.4.5 applies to the chest deck.

Closed transverse frames are to be installed in the area of cargo tanks with longitudinal framing system (with transverse system, if the distance between transverse bulkheads exceeds 10 m). The distance between the transverse frames *a*, in m, shall not be greater than determined by the formula

$$a = 0{,}0125L + 2{,}75.$$

The length *l*, in m, of any cargo tank shall not be greater than:

when two longitudinal bulkheads are installed

$$l = 0{,}1L + 7;$$

when one longitudinal bulkhead is installed within the centre line

$$l = 0{,}1L + 4.$$

With transverse framing system and depth $D > 6$ m the side stringer is to be installed approximately in the middle of its height. The primary supporting members section modulus with transverse framing is not to be less than 85 % of the required with longitudinal framing.

The scantlings of the side stringer elements are taken equal to the appropriate scantlings of a web frame. When determining the web frame and floor section modulus the design spans shall not be taken less than 2 m.

The transverse primary supporting members modulus may be reduced by 20 per cent when frame beams are installed.

Wash plate within the centre line may not be fitted. The design and scantlings of the dry cargo ships center girder shall comply with 2.3.

3.6 VESSELS OF DREDGING FLEET

3.6.1 General.

3.6.1.1 The requirements of this Chapter apply to the hulls of the vessels of dredging fleet and floating cranes. Areas where such ships operate and/or transport spoil are called work areas. The transfer of the ship from one work area to another is called a voyage.

3.6.1.2 Vessels of dredging fleet include:

d r e d g e r – are self-propelled or non-self-propelled ships designed to operate for the purpose of raising the soil (silt, sand, gravel, clay, etc.) using any dredging gear (buckets, suction pipes, grabs, etc.) and having no spaces where the soil may be stored or transported;

h o p p e r d r e d g e r s are self-propelled ships having dredging gear for raising the soil and one or two hoppers where the spoil may be stored ortransported;

h o p p e r b a r g e s are self-propelled or non-propelled ships designed only for transportation of the soil, but having no dredging gear. They can be single-hulled or double-hulled capable of opening;

f l o a t i n g c r a n e s (c r a n e s h i p s) refer for the definition to 1.1 of General Regulation for the Supervision.

3.6.1.3 ion"). 3.6.1.3 The basic structural configuration of a vessel of dredging fleet, considered in this Chapter, is a single-deck vessel with ordinary ship lines or of a pontoon shape, having a ladder well or other hull cutouts.

The pontoon hull shape may be used only in vessels of restricted service **R2**, **R2-RS**, **R2-S**, **R3-RS**, **R3-S**, **R3-IN** and **R3**.

Use of a pontoon hull in vessels of

restricted service **R1** and of unrestricted service shall be specially considered by the Register.

3.6.1.4 The requirements of this Chapter apply to dredgers, single-hulled and opening double-hulled hopper dredgers and hopper barges, floating cranes and crane ships.

3.6.1.5 In opening hopper dredgers and hopper barges, subject to the Register supervision are deck and deckhouse hinges, hydraulic presses and their hull connections as well as longitudinal and transverse structures between the hulls and deckhouses.

3.6.1.6 For the purpose of this Chapter the following symbols have been adopted:

d_1 – maximum dredging draught, in m, at which the vessel is designed to operate;

d_2 – draught during sea voyage, in m;

Δ – displacement at the draught d_1 or d_2, in t;

Δ_l – light-ship displacement without spoil mixture, in t;

l_h – full length of the hopper, in m;

$h_{l.cr.}$ – depth of a hopper lower cross-member, in m;

$l_{l.cr.}$ – hopper lower cross-member span measured at mid-depth between longitudinal bulkheads of the hopper, in m;

H_1 – distance from the mid-depth of the hopper lower cross-member to the deck at side, in m;

H_2 – distance from the base line to the upper edge of the coaming, in m;

h_c – coaming height above the deck line at side, in m;

B_2 – distance between the side shell and the longitudinal bulkhead at mid-depth of a hopper lower cross-member, in m;

B_3 – distance between the side shell and the longitudinal bulkhead at the deck level, in m;

Q_s – maximum mass of the spoil mixture in the hopper, in t;

ρ_s – density of spoil mixture, defined as a ratio of the spoil mass in the hopper at the maximum draught d_1 to the hopper volume up to the level of overflow or to the upper edge of the hopper coaming where there is no overflow, in t/m^3; it shall not be taken more than 1,8;

$A_{b.k.}$, $A_{l.cr.}$ – areas enveloped in the contour of the centre line box keel, hopper lower cross-member, respectively, in m^2; where the centre line keel and/or a hopper lower cross-member are an ordinary girder (web with a face plate), it is assumed that $A_{b.k.} = A_{l.cr} = 0$;

$b_{b.k.}$ – centre line box keel width at lower portion, in m;

b_b – bottom breadth from the side shell to the point of intersection of the hopper longitudinal bulkhead with the bottom, in m;

$b_{f.p.}$ – width of the coaming upper face plate, in m;

a – spacing of frames, hopper side stiffeners, longitudinals, in m;

b – spacing of transverse ring structures, in m;

l_1, l_2 – length of the upper and lower face plate of the hopper lower cross-member, measured from the hopper longitudinal bulkhead to the centre line box keel, in m;

$R_{up.cr.}$, $R_{l.cr.}$– axial force acting on the hopper upper and lower cross-member, respectively, in kN;

N – design axial force, in kN.

Δs - corrosion allowance, in mm, for plate thickness (refer to 1.1.5.1);

ω_K– factor taking corrosion allowance into account with regard to the section modulus of members (refer to 1.1.5.3).

Some of the symbols are shown in Fig. 3.6.1.6.

3.6.2 Construction.

3.6.2.1 Main hull structures shall comply with the requirements of Section 2, having regard to the provisions and additions given in this Chapter.

Referred to the particular structures of vessels of dredging fleet are:

hopper longitudinal and transverse bulkheads;

hopper lower and upper cross-members;

centre line box keels, hopper coamings;

diaphragms and transverse ring structures in buoyancy spaces (refer to 3.6.2.11).

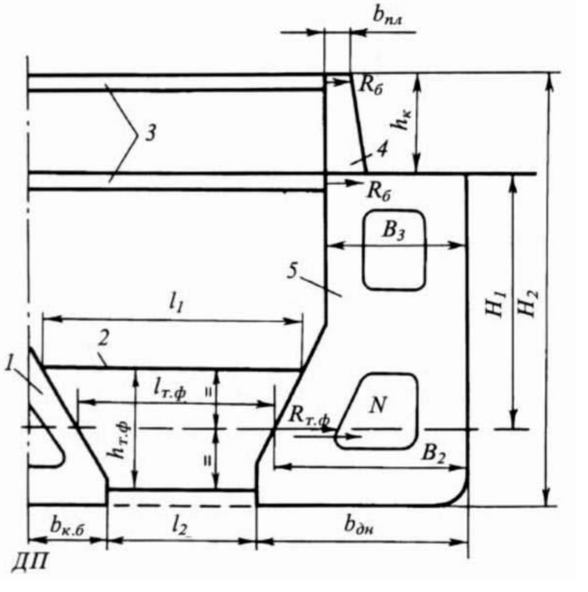


Fig. 3.6.1.6:
1 – centre line box keel, 2 – hopper lower cross member, 3 – hopper upper cross member, 4 – stay of coaming, 5 – diaphragm

For floating cranes strengthening shall be provided of the pontoon hull beneath the fixed crane tower supporting the upper crane structure, this strengthening including the crane tub, the bulkhead cross and the bearing contour (refer to Fig. 3.6.2.1).

Other construction of the pontoon strengthening in way of the tower shall be specially considered by the Register..

3.6.2.2 Shell plating:

.1 Corners of hopper and well openings in the bottom plating shall be rounded and insert plates, the dimensions of which shall be approved by the Register, shall be fitted at the corners..

.2 The cutting of overflow discharge trunk openings in the sheerstrake shall be avoided wherever practicable. Where such openings cannot be dispensed with, their upper edge shall not be within 800 mm of the deck line at side. They shall have corner radii of not less than 150 mm.

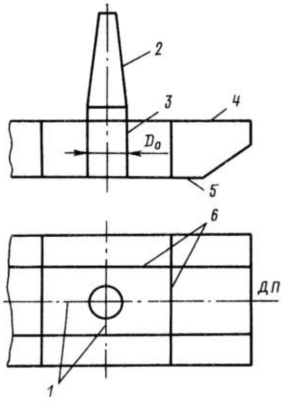


Fig.3.6.2.1:
1 – bulkhead of the cross,
2 – fixed crane tower, 3 – бараба tub,
4 – upper deck; 5 — bottom; 6 — bulkheads of the bearing contour

.3 Angular connection of the side shell plating or longitudinal bulkhead of the well with the bottom plating shall be made by means of section steel (rod, bar).

3.6.2.3 Single bottom:

.1 The bottom centre girder in way of the hopper and well of hopper dredgers shall not be fitted.

.2 The depth of floors abreast of hoppers in hopper dredgers and barges with transverse framing and abreast of dredging wells in hopper dredgers shall not be less than $1/8B_1$.

The breadth B_1 is taken:

in way of the hopper, equal to the breadth of the vessel after deducting the breadth of the hopper at bottom, but not less than $0{,}6B$;

in way of the well, equal to the breadth of the vessel after deducting the breadth of the well.

.3 Side girders shall be fitted in side buoyancy tanks of hopper dredgers and hopper barges where the tank width between the vessel's side and the longitudinal bulkhead exceeds 3,5 m in transversely framed vessels, and 4 m in longitudinally framed vessels.

Side girders in opening hopper barges may be omitted.

.4 In the pump rooms of hopper dredgers, the bottom framing shall be identical to that of the engine room.

In the area where soil pumps are located, the depth of floors and side girders may be reduced with the required section modulus and web area being maintained. Otherwise a calculation proving the strength of the bottom grillage in the region concerned shall be submitted to the Register.

.5 In floating cranes plate floors shall be fitted at every frame within $0{,}2L$ from the forward perpendicular over the entire breadth of the hull and additional bottom transverses or longitudinals spaced not more than 0,35 m apart shall be fitted.

3.6.2.4 Double bottom:

.1 In lieu of the bottom centre girder, two side girders may be fitted on each side of ship's centre line at a distance not exceeding 1 m from each other and passing into the webs of the centre line box keel or into the well sides (refer to Fig. 3.6.2.4.1).

.2 Additional side girders extending over a distance of not less than three spacings from the end of the bracket shall be fitted in the double bottom under the lower brackets of longitudinal bulkheads of the hopper space or the well and under the brackets of the centre line box keel.

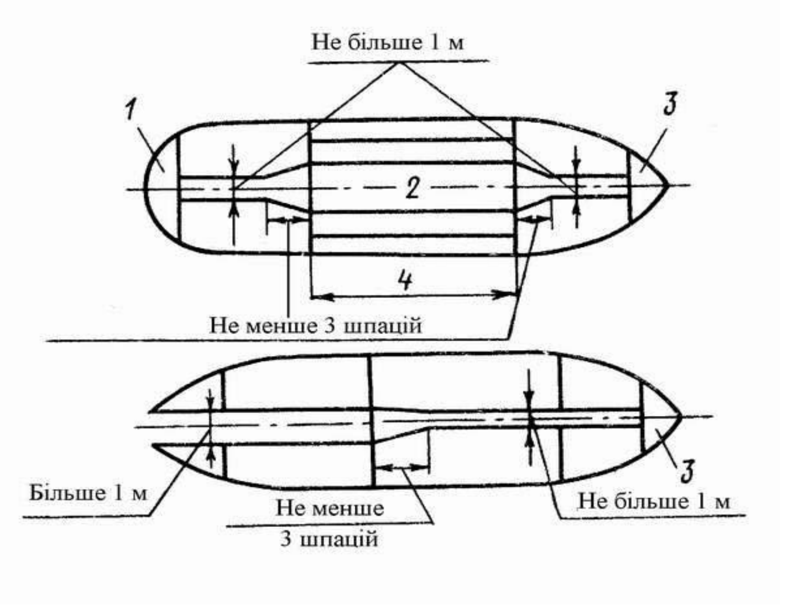


Fig. 3.6.2.4.1:

1 — after peak; 2 — centre line box keel; 3 — fore peak; 4 — hopper space

3.6.2.5 Side framing:

.1 In floating cranes, hopper dredgers designed to work in conjunction with hopper barges, and in hopper barges, the side framing shall be reinforced as follows:

two rows of efficient fenders, one fitted at the deck level or 200 mm below it, the other 200 to 300 mm above the lowest operating waterline amidships;

the upper and lower fenders in hopper dredgers shall be connected by vertical fenders fitted in line with frames;

it is recommended that a side stringer required by 2.5.4.4 which shall be taken into account in determining the scantlings of the frames or an intercostal side stringer be fitted at a level of the lower fender.

.2 In floating cranes the strengthening of the side framing within 0,2*L* from the forward perpendicular shall comply with the requirements of 3.6.2.8. Web frames shall be spaced not more than four spacings apart.

.3 In floating cranes, intermediate frames of the same scantlings as the main frames shall be fitted in the fore peak and in areas extending forward for 0,1*L* from the stern transom and inboard for 0,1*B* over the entire depth. The extension and end attachments of intermediate frames shall comply with the requirements of 3.10.

3.6.2.6 Decks and platforms:

.1 Corners of openings in the deck plating in way of the hopper and the well shall be rounded. Insert plates, the dimensions of which shall be approved by the Register, shall be fitted at the corners.

.2 In hopper side buoyancy spaces, the hopper lower cross members shall be fitted in line with the web frames unless partial bulkheads are fitted.

3.6.2.7 Watertight bulkheads:

.1 Bulkheads forming the ends of the hopper shall extend from side to side.

.2 In bucket dredgers, protective bulkheads shall be provided parallel to the well sides at a distance of not less than 600 mm from them.

The extension of protective bulkheads shall be such as to prevent the ship from flooding in case of damage to the shell plating by objects brought up in the dredge buckets.

A protective bulkhead shall be also provided at the end of the well. The scantlings of framing members and the plating thickness of the protective bulkheads shall be determined as for permanent watertight bulkheads of dry cargo ships. The framing inside the cofferdam formed by the well side and the protective bulkhead may consist of brackets with openings cut therein. Cofferdams shall have access openings for maintenance.

.3 Bulkheads forming the ladder well in hopper dredgers shall be protected against possible damage by the ladder when moved.

.4 Longitudinal bulkheads of the hopper and well sides shall terminate at deck and bottom in brackets. The length of the arms of the brackets shall not be less than 0,25*D*, and their thickness shall not be less than the plating thickness of the longitudinal bulkhead. The brackets shall be strengthened with stiffeners and to have a face plate over the free edge. The top bracket shall be extended by a deck girder, the bottom bracket by a side girder for at least three spacings beyond the bracket end.

.5 In floating cranes the bulkheads forming the cross shall be rigidly connected with the bulkheads forming the bearing contour. These bulkheads shall be carried to the nearest transverse and longitudinal bulkheads (sides, transoms).

3.6.2.8 In ships with a pontoon shape of the forward and after ends, the following structural requirements shall be fulfilled:

.1 the fore and after peak bulkheads shall be fitted at a distance of 0,1*L* from the forward and after transoms, but not less than one spacing from the line connecting the raked part and flat of the bottom.

.2 frame spacing in peaks shall be not more than 550 mm.

.3 the bottom framing within 0,15*L* from the forward and after perpendiculars shall consist of plate floors fitted at every frame, with side girder spaced not more than 1 m apart.

The scantlings of floors and side girders shall be determined as for the midship region.

.4 the side framing within 0,2*L* from the forward and after perpendiculars shall be strengthened with web frames and side stringers.

The web frames shall be fitted not more than three or four spacings.

The side stringers shall be fitted so that the distance between the side stringers measured over the vessel's side in way of the floor nearest to the fore peak bulkhead, the distance from the side stringer to the upper edge of the floor, as well as from the side stringer to the deck is not more than 2 m.

The scantlings of main frames fitted between the web frames shall comply with the requirements of 3.6.4.7 as for the midship region where side stringers are not provided.

The side stringers shall have the same scantlings as the web frames and terminate at the bulkhead or at the web frame (refer to 2.5.4.7.2).

Construction and end attachments of the web frames shall comply with the requirements of 2.5.5.

.5 the transom bulkheads shall be strengthened with vertical stiffeners spaced not more than 0,5 m apart, and with horizontal girders arranged at the side stringer level.

Vertical webs shall be fitted in line with side girders. The scantlings of the vertical webs and horizontal girders shall be the same as those of web frames and side stringers in the fore peak. The scantlings of vertical stiffeners shall be the same as those of the frames. The attachments of stiffener ends with brackets shall comply with the requirements of 2.7.2 for watertight bulkheads.

3.6.2.9 Structural requirements for hull members of opening vessels:

.1 Opening vessels consist of two separate semihulls with asymmetrical lines, connected by hinges positioned above the deck at the ends of the hopper. When discharging the spoil, the semi-hulls are opened about a common longitudinal axis on the centreline of the ship by means of hydraulic devices. The structure of each semi-hull shall comply with the requirements of Section 2 with due regard for 3.6.2; transverse or longitudinal or both framing systems may be adopted. In hopper side buoyancy tanks transverse ring structures spaced as required by 3.6.2.11.1 shall be fitted.

.2 Where hinges are installed in opening hopper dredgers and hopper barges, deck plating and framing shall be strengthened. Hinge eyes shall pierce the decks.

.3 Stops shall be fitted in the opening vessels between semi-hulls forward and aft from the hopper space. The stops shall be arranged at the levels of the bottom and the deck and shall prevent the hulls from displacement relative to one another..

.4 Scantlings of brackets connecting framing members of each semi-hull shall comply with the requirements of3.6.2.11.3.

.5 Longitudinal bulkheads and coamings of the hopper shall be extended with brackets as required by 3.6.2.7.4 and 3.6.2.11.7.

3.6.2.10 Fixing of dredging gear:

.1 Hull framing shall be strengthened in way of the main and ladder gallows.

The stanchions of the ladder gallows may terminate at the deck. In such case, pillars, vertical webs or other equivalent structures shall be provided under the stanchions or longitudinal and transverse bulkheads shall be fitted.

The stanchions of the main gallows shall extend to the bottom and be efficiently connected with longitudinal and transverse framing, otherwise transverse bulkheads shall be fitted under the stanchions.

.2 In way of grab crane, spuds and other dredging gear adequate strengthening shall be provided.

3.6.2.11 Specific structures:

.1 Whatever the hull framing of singlehull hopper dredgers and barges in way of the hopper is adopted, transverse ring structures consisting of the following items shall be fitted:

solid platforms or ring structures in the side buoyancy spaces and centre line box keel;

a lower cross member in the bottom part of the hopper, connecting the centre line box keel with longitudinal bulkheads of the hopper;

an upper cross member inside the hopper at a level of the main deck and upper edge of the coaming where its height more than 0,2 m (where the requirements of 3.6.4.11.10 are complied with, upper cross members need not be fitted);

vertical webs on the hopper coaming.

The maximum distance between transverse ring structures shall not be less than b = (0,012L + 2,9) m.

.2 The construction of diaphragms shall comply with the requirements of 2.5.2.2. Diaphragms which are more than 1 m in width shall be strengthened by vertical and horizontal stiffeners. Where longitudinal framing is adopted, horizontal stiffeners shall be fitted in line with side and bulkhead longitudinals. In lieu of the diaphragms watertight (nontight) bulkheads complying with the requirements of 2.7.2 may be used.

.3 The transverse ring structure in the side buoyancy space, fitted in lieu of the diaphragm, shall consist of side shell, bulkhead, bottom and deck transverses. The longitudinal bulkhead and side shell transverses shall be connected by means of cross ties which shall be so positioned that the distance between them, between a cross tie and a bottom or deck transverse is not more than 3 m. In lieu of the cross ties, use may be made of braces connecting a bulkhead transverse with a bilge or deck transverse bracket. Where platforms are fitted in side buoyancy spaces at the same distance as cross ties, cross ties and braces may be omitted.

The brackets connecting transverse ring structure items in the side buoyancy space shall have the length of the arms not less than one-twelfth of the greater span of the connected members. The free edge of the bracket shall have a face plate of the same width as that of the face plate of the greater member connected. The bracket thickness shall be equal to the web thickness of the greater member connected.

.4 Hopper lower cross members may consist of a web with openings and face plates provided on the upper and lower edges or may take the form of a hollow box, generally of triangular crosssection.

The web thickness of the hopper lower cross member shall be taken equal to the plating thickness of the hopper longitudinal bulkheads at the corresponding level.

A cross member web shall be strengthened with stiffeners spaced 900 mm apart.

The upper face plate of the hopper lower cross member shall be made of a tube, section, round or flat bar, the lower face plate shall be fabricated of a flat bar having a thickness not less than that of the bottom plating.

The hopper lower cross members shall be connected with the hopper longitudinal bulkhead and centre line box keel by brackets having length of the arms equal to one-tenth of the length of the cross member upper face plate. The thickness of brackets shall be taken equal to the thickness of the cross member web. Where the depth of the cross member and centre line box keel is the same, brackets on the centre keel need not be fitted. The structure of boxtype cross members is similar to that of the centre box keel. Where cross members are of a box shape, their lower and upper face plates shall be welded to the plating of the buoyancy spaces and centre line box keel.

.5 The centre line box keel fitted in the hopper is generally fabricated as a closed box structure. The plating thickness of the sides shall be equal to that of hopper longitudinal bulkheads at the corresponding level, but not less than 8 mm for vessels of 60 m in length and less than 10 mm for vessels of more than 60 m in length. The thickness of the centre line keel bottom strake shall be not less than that of the plate keel. Where the transverse framing is adopted, the stiffeners in the upper part of the centre line box keel shall be connected with brackets, the thickness of which shall be not less than that of the floor and height not less than 2,5 times the depth of the stiffener web.

Where the breadth of the centre line box keel at bottom exceeds 1 m, but not more than 2 m, a bottom longitudinal shall be fitted on centre line box keel bottom, the depth of which shall be equal to half the floor depth. Where the breadth of the centre line keel is more than 2 m, an intercostal side girder having the same scantlings as the floor shall be fitted in lieu of the above longitudinal. The scantlings of floors are assumed the same as those of floors fitted in correspondingly framed buoyancy spaces.

On the top, the centre line box keel shall terminate in a bar, or an angle, or a cover plate, the thickness of which shall be equal to that of the centre line box keel.

The centre line box keel sides shall extend beyond the hopper transverse bulkheads by brackets, the arm lengths of which shall be equal to the depth of the centre line box keel, and the thickness equal to that of the centre line box keel side.

.6 The upper cross members of the hopper space may consist of a web with openings and face plates on the upper and lower edges or be fabricated in the form of a hollow box generally of a triangular or another cross-section.

It is recommended that the upper cross members be attached to the hopper longitudinal bulkhead by brackets the arm lengths of which shall be equal to the depth of the upper cross member, and the thickness to its web thickness.

The upper cross members shall be connected to the centre line box keel by pillars, where such a keel is fitted.

.7 The hopper coaming may be transversely or longitudinally framed. The upper edge of the coaming shall be stiffened with a face plate having a width not less than one-tenth of the coaming height and a thickness not less than a coaming thickness.

In case of longitudinal framing, the coaming shall be strengthened by longitudinals spaced not more than 900 mm apart.

In case of transverse framing, vertical stiffeners shall be fitted between stays at every frame.

The hopper side coamings shall be extended beyond the hopper ends by the brackets for a distance equal to 1,5 times the coaming height. Deck girders extending not less than three frame spaces from a bracket end shall be fitted under the brackets.

.8 In floating cranes, the tub plating shall not be cut at the upper deck. No horizontal welds are permitted in the tub plating within the area extending for 0,2*h* up and down from the upper deck (where *h* – is the distance between the bottom and the upper deck in way of the tub position).

.9 Diaphragms shall be fitted inside the crane tub in line with the upper deck and platform.

.10 For outer plating of specific structures 20 mm and more in thickness in way of the hopper steel of not lower than grade *D* shall be utilized. Use of plates having a thickness 50 mm and more is subject to special consideration by the Register.

3.6.3 Design loads.

3.6.3.1 Design loads on the main hull structures shall be determined in compliance with Sections 1 and 2 at draughts d_1, d_2 and the wave coefficient c_w under dredging conditions and during voyage. For dredging conditions, the wave coefficient c_w, shall not be taken greater than

$$c_w = 2\left(D + h_к - d_1\right). \qquad (3.6.3.1)$$

3.6.3.2 The maximum value of the design load for vessel's extremities during voyages shall be obtained as required by 2.8.3 using the draught at the section 0,1*L* від носового перпендикуляра. from the forward perpendicular. For the transom bulkhead anglesα_x = 0 and β_x = 90º are assumed.

3.6.3.3 The design bending moments and shear forces in vessels of dredging fleet having*L* ≥ 60 0m shall be determined for voyage and for dredging conditions.

Д For voyage the hopper space is considered to be filled with water up to the effective waterline (or empty if such case is possible), stores and outfit are taken as 100 per cent, all gear being stowed for sea.

For the case of dredging operations, the hopper space is considered to be filled with homogeneous soil up to the upper overflow level (coaming), there are no stores on board, the draught is equal to d_1, gear being stowed for sea.

Wave bending moments and shear forces shall be determined as required by 1.4.4.

3.6.3.4 Opening vessels:

.1 In opening vessels, still water and wave bending moment is created both by vertical and horizontal forces. Bending moments are calculated first in *vGu*, coordinate system and then recalculated for the basic inertia axes *x* and and y of each semi-hull (refer to Fig. 3.6.3.4.1). A fully loaded hopper space at the maximum draught of the vessel is taken as a design case. Bending of each semi-hull hopper is considered separately. Deck hinges and hydraulic cylinders are assumed to be supports located at the hopper ends.

Besides, the following cases are considered:

sailing in the work area with soil in the hopper, dredging gear stowed for sea;

voyage with water in the hopper space or in the ballast condition (the hopper is empty, wherever practicable).

Stores and outfit are taken in full, all gear stowed for sea.

.2 The type of supporting structures and the clearance between two semi-hulls in the fore and aft ends of the hopper space determine the conditions of horizontal moments calculation.

Where supporting structures fitted at

the deck or bottom level forward or aft of the hopper space provide the absence of any clearance between the semi-hulls, and the length of the supporting structures creates adequate fixing against the horizontal forces acting athwart the hopper space, the horizontal force calculation is made assuming that a semi-hull is rigidly restrained at each hopper end.

Otherwise a semi-hull is considered to be freely supported.

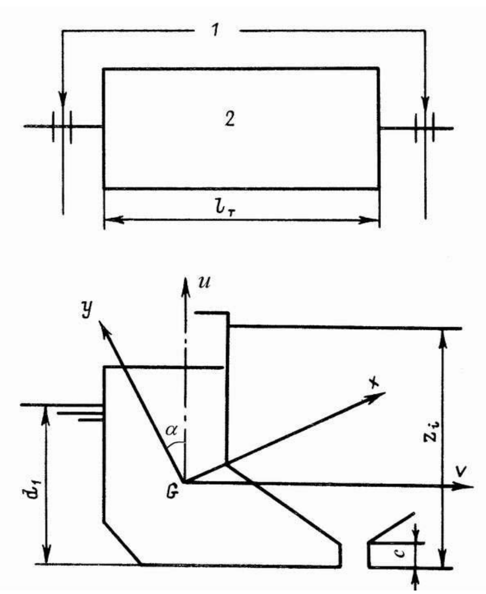


Fig. 3.6.3.4.1
1 – hinges; 2 — hopper space

.3 Vertical loads.

The vertical bending moment at any section M_v, in kN-m, acting on each semi-hull shall be determined by the formula

$$M_v = 0{,}5(M_{sw} + M_w), \qquad (3.6.3.4.3)$$

where M_{sw} – still water bending moment to be obtained by load integration of the vessel with connected hulls for loading conditions referred to in 3.6.3.4.1, in kNm;

M_w – wave bending moment for the vessel with connected hulls, to be determined as required by 1.4.4., in kN-m.

Vertical moments are considered positive in case of hogging and negative in case of sagging.

.4 Horizontal loads.

The horizontal bending moment M_{hi}, in kN·m, acting on each semi-hull at the sections taken in the middle and at ends of the hopper space shall be determined by the formula

$$M_{hi} = M_{swhi} + M_{whi}, \qquad (3.6.3.4.4\text{-}1)$$

where M_{swhi}, M_{whi} – horizontal still water and wave bending moments at the section under consideration, respectively, in kN·m.

Horizontal moments are considered positive where the outer side of one semi-hull is subjected to tensile stresses.

The horizontal moment acting on a semi-hull depends on the fixing used at the ends of the hopper space.

Where a semi-hull is considered rigidly fixed at the ends of the hopper space, the horizontal moment shall be determined using the following formulae:

in still water:

at the section taken in the middle of the hopper space $M_{swh} = 0{,}10 p l_{\text{T}}^2$;

(3.6.3.4.4-2)

at the hopper end sections

$$M'_{swh} = -0{,}10 p l_{\text{T}}^2, \qquad (3.6.3.4.4\text{-}3)$$

where $p = 0{,}5g\left(\rho_{\text{гр}} H_2^2 - \rho d_1^2\right)$ (p – in kN·m).

in waves:

at the section taken in the middle of the hopper space

$$M_{wh} = M_w \frac{d_1}{B}\left(\psi_1 + \psi_2 \frac{E}{d_1}\right);$$

(3.6.3.4.4-4)

at the hopper end sections

$$M'_{wh} = -M_w \frac{d_1}{B}\left(\psi_3 + \psi_4 \frac{E}{d_1}\right);$$

(3.6.3.4.4-5)

$\psi_1 = 0{,}61 l_T / L - 0{,}103$;
$\psi_2 = 0{,}50 l_T / L - 0{,}100$;
$\psi_3 = 0{,}85 l_T / L - 0{,}112$;
$\psi_4 = 0{,}37 l_T / L - 0{,}050$;

$$E = \chi(C_b + 0{,}7)\left[1{,}38 - 0{,}128\left(\frac{300 - L}{100}\right)^{3/2}\right];$$

$\chi = 1{,}35L / 100 - 0{,}215$.

Where the semi-hull is not fixed at the hopper ends, the horizontal moment at the section at the middle of the hopper space shall be determined by the following formulae:

in still water

$$M_{swh} = 0{,}15 p\, l_T^2; \qquad (3.6.3.4.4\text{-}6)$$

in waves

$$M_{wh} = M_w \frac{d_1}{B}\left(1 + \psi_5 \frac{E}{d_1}\right), \quad (3.6.3.4.4\text{-}7)$$

where $\psi_5 = 1{,}23(l_T / L - 0{,}5)$.

The still water and wave horizontal bending moments at the hopper end sections are equal to zero.

The sign of M_w. shall be taken into account in determination of M_{wh} i M'_{wh}.

It is assumed that M_{swh} i M'_{swh} are equal to zero during voyage whatever the fixing conditions are.

3.6.3.5 Bending moments acting on the hull of the floating crane shall be determined for operating conditions in the work area and a voyage.

For the operation in the work area the design vertical bending moment M_{op}, in kNm, shall be determined by the formula

$$M_{op} = M_{sw} + M_g + M_w, \quad (3.6.3.5)$$

where M_{sw} – still water bending moment according to 1.4.3, in kN-m;

M_g – bending moment due to the weight of the load suspended on the crane hook, in kN-m. for a voyage M_g is assumed to be equal to zero;

M_w – wave bending moment for work areas and a voyage to be determined using a procedure approved by the Register for a specified length and height of the wave.

3.6.3.6 The design pressure p_s, in kPa, on the bulkheads bounding the hopper space, on the structures of the enclosed watertight centre line box keel shall be determined by the formula

$$p_s = \rho_s g z_i, \quad (3.6.3.6)$$

where z_i – distance of the load application point from the upper weir level (upper edge of the coaming), in m.

3.6.3.7 The design load p_1, in kPa, on a partial bulkhead (diaphragm) or a transverse ring structure of the side buoyancy space at a level of the mid-height of the hopper lower cross member due to soil pressure, having regard to the outer counterpressure, shall be determined by the formula

$$p_1 = g\,(0{,}8\rho_{гр}\, H_1 - 1{,}5\rho_{гр}\, h_к - 0{,}1\rho H_1 \varepsilon), (3.6.3.7)$$

$\varepsilon = 0$ for $D \le 4$ m;
When $D > 4$ m:
$\varepsilon = 0{,}2\,D - 0{,}8$ when $d_1/D \le 0{,}75$;
$\varepsilon = 0{,}4\,D - 1{,}6$ when $d_1/D > 0{,}75$.

3.6.3.8 The vertical design load p_2, in kPa, due to soil pressure, having regard to the counterpressure of the water on the lower cross member of the hopper space shall be determined by the formula

$$p_2 = g\,[\rho_s H_2 - (\rho d_1 + 0{,}5\rho c_w) - \rho_s(l_{l.cr.} - - b_{b.k.})\, A_{l.cr.} / (b l_{l.cr}) - 1{,}5\rho_s A_{b.k.}/l_{l.cr.}]$$

(3.6.3.8)

3.6.3.9 The horizontal design load p_3, in kPa, due to the dredged spoil pressure on face plates of the hopper lower cross member shall be determined by the formulae:

для верхнього пояска $p'_3 = g\,\rho_{гр} h_{т.ф} / 6;$

для нижнього пояска $p''_3 = g\,\rho_{гр} h_{т.ф} / 3.$

(3.6.3.9)

3.6.3.10 The design load p_4, in kPa, on the framing members and on the plating of the hopper coaming shall be determined by the formula

$$p_4 = g\rho_s h_c \qquad (3.6.3.10)$$

and is taken not less than 15 kPa.

3.6.3.11 The design axial force N, in kN, acting at the mid-height level of the hopper lower cross member on a diaphragm or a transverse ring structure of the side buoyancy space shall be determined by the formula

$$N = gbH_1\,[0{,}4\rho_s H_1 + 0{,}63\rho_s h_c - 0{,}03\rho H_1 m], \qquad (3.6.3.11)$$

where $m = 0$ for $D \le 3{,}5$ m;

$m = 1$ for $D > 3{,}5$м, $d_1/D \le 0{,}75$;

$m = (9D - 31{,}5)(d_1/D - 0{,}75)$ for $D > 3{,}5$ м, $d_1/D > 0{,}75$.

3.6.3.12 The design axial force $R_{l.cr.}$, in kN , acting on the lower cross member of the hopper space shall be determined by the formula

$$R_{т.ф} = 0{,}163\,g\,\frac{b}{H_1}[\rho_{гр} H_2^2(3D - H_2) - \rho(d_1 - 0{,}5c_w)^2(3D - d_1 + 0{,}5c_w)] \qquad (3.6.3.12)$$

3.6.3.13 The design axial force $R_{up.cr.}$, in kN, acting on the upper cross members of the hopper space shall be determined by the following formulae:

.1 for the upper cross member fitted at the deck level

$$R_{up.cr.} = R_1 - R_2 - R_3 - R_4, \qquad (3.6.3.13\text{-}1)$$

where R_1 – pressure of dredged soil on the upper cross member determined as

$$R_1 = g\rho_{гр}\,\frac{0{,}082\,bH_2^2}{H_1}\left(2H_2 - 3h_{т.ф}\right);$$

R_2 – external hydrostatic pressure on the upper cross member determined as

$$R_2 = g\rho\,\frac{0{,}082b(d_1 - 0{,}5c_w)^2}{H_1}\,\text{x}$$

$$\text{x}\left(2d_1 - c_w - 3h_{т.ф}\right);$$

R_3 – reaction due to supporting bending moment at the junction of the diaphragm with the lower cross member determined as

$$R_3 = p_2\,\frac{bl_{т.ф}^2}{12H_1};$$

R_4 – force resulting from supporting reactions of the hopper lower cross member determined by the formula

$$R_4 = \frac{b\,l_{т.ф}}{4}\,\frac{b_2}{H_1}\left(p_2 + \frac{0{,}5gp_{гр}A_{к.б}}{l_{т.ф}}\right).$$

.2 for the upper cross member fitted at the upper face plate of the hopper coaming

$$R_б = g\rho_{гр} b h_к^2. \qquad (3.6.3.13.2$$

3.6.3.14 The design load on deck shall be not less than 20 kPa.

3.6.3.15 The design loads on the structures of each semi-hull of opening vessels shall be determined in compliance with 3.6.3.1 to 3.6.3.14.

3.6.3.16 In opening hopper dredgers and hopper barges, for each hydraulic press, the horizontal statical force F_H, in kN, necessary to keep the hull closed is determined by the formula (refer also to Fig. 3.6.3.16)

$$F_H = (1/n_1 a_3)[-F_h a_1 + F_d a_2 + 0{,}5(g\Delta b_1 - g\Delta_п b_2 - gQ_{гр} b_3)], \qquad (3.6.3.16\text{-}1)$$

where n_1 – number of hydraulic presses;

F_h – horizontal force of water pressure on the hull, determined by the formula

$F_h = 0{,}5\rho g l_h (d_1 - 0{,}5c)^2$;

F_d – horizontal force of dredged soil pressure on the hull, determined by the formula

$F_d = 0{,}5\rho_s g l_h (H_2 - 0{,}5c)^2$;

for c, refer to Fig. 3.6.3.4.1;

a_1, a_2, a_3, b_1, b_2, b_3 – force arms, in m (refer to Fig. 3.6.3.16).

For design force F_{des} the maximum pressure value achieved by the hydraulic press is adopted, with $F_{des} \geq F_H$.

The horizontal static force in each hinge F_{hn}, in kN, is determined by the formula

$F_{hn} = 0{,}5[F_h + n_1F_H - F_d - n_1a_3(F_{des} - F_H) / a_4]$, (3.6.3.16-2)

where a_4 – arm of the force acting upon the stop, in m.

The horizontal static force acting upon each stop is determined by the formula

$F_{st} = n_1a_3(F_{hn} - F_H) / (n_2a_4)$, (3.6.3.16-3)

where n_2 – number of stops.

The vertical components of static forces in hinges are assumed equal to zero.

3.6.3.17 The dynamic forces acting on hydraulic cylinders and deck hinges shall be determined by calculations of vessel's motions in a seaway, with various course angles, in light-ship and full-load conditions. Based on these calculations, maximum vertical and horizontal forces acting on the hydraulic presses are determined. The calculation shall be made using a procedure approved by the Register.

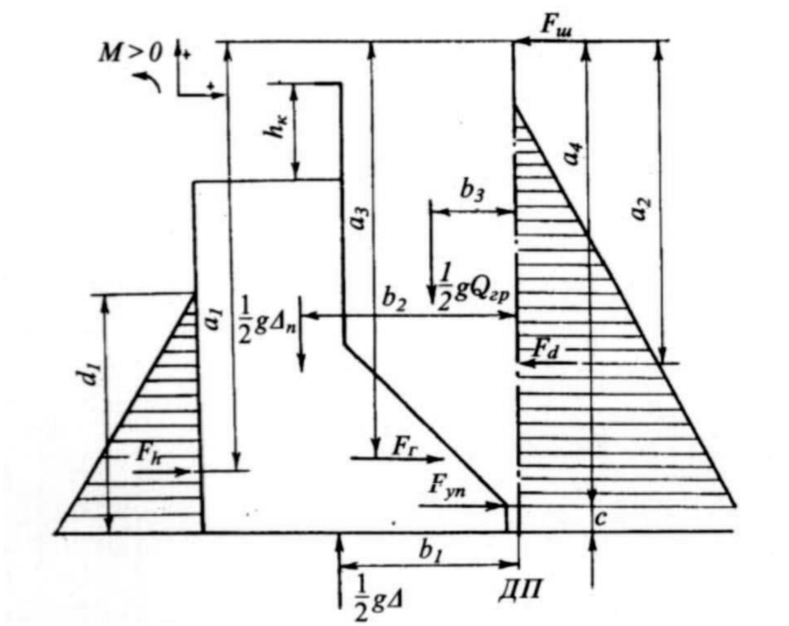


Fig. 3.6.3.16

3.6.4 Scantlings of structural members.

3.6.4.1 Scantlings of structural members shall be determined in compliance with Sections 1 and 2, having regard to the provisions of this Chapter.

3.6.4.2 The required hull section modulus of a singlehull vessel of 60 m in length and over shall be determined as required by 1.4.5 for deck, bottom, upper edge of the hopper coaming, having regard to specified work areas and voyages. The greater value obtained for the work area or voyage (refer to 3.6.3.3 and 3.6.3.4) shall be taken.

For opening hopper dredgers and hopper barges the required section modulus shall be determined for the case when both semi-hulls are connected (refer to 3.6.3.4).

3.6.4.3 When calculating the actual section modulus of the hull in way of the hopper space as required by 1.4.7, account shall be taken of all continuous longitudinals, longitudinal bulkheads and the hopper space coamings with longitudinals, 85 per cent of the total area of centre line box keel longitudinal members, provided they are properly interconnected with the longitudinal framing members beyond the hopper and fitting of transverse members regulated by the Rules, inside the hopper.

The continuous deck plating longitudinally framed above the hopper space and a wash bulkhead in the hopper may be included in the actual section modulus calculation using a procedure approved by the Register.

3.6.4.4 Longitudinal strength of each semi-hull of opening hopper dredgers and hopper barges shall be checked for vertical and longitudinal bending moments in asymmetrical bending (refer to Fig. 3.6.3.4.1).

.1 Normal stresses arising in cross-section points under conditions of asymmetrical bending shall be determined amidships and at the end bulkhead sections of the hopper space (from inside the hopper), provided the hulls at this position are rigidly restrained.

Stresses σ, in MPa, shall be determined by the formula

$$\sigma = \left(M_x \frac{y}{I_x} - M_y \frac{x}{I_y} \right) \cdot 10^{-3}, \quad (3.6.4.4.1\text{-}1)$$

where $M_x = M_v \cos\alpha - M_h \sin\alpha$;

$M_y = M_v \sin\alpha + M_h \cos\alpha$;

M_v, M_h – див.3.6.3.4.3 і 3.6.3.4.4;

α – rotation angle of main inertia axes (positive value of α – rotation *Gu* axis counterclockwise), it shall be determined by the formula

$$\mathrm{tg}\, 2\alpha = 2I_{uv}/(I_u - I_v); \quad (3.6.4.4.1\text{-}2)$$

$I_{uv} = \sum_i u_i v_i d S_i$ – centrifugal inertia moment about axes *Gu*, *Gv*, with no regard for wear allowance, in m^4;

u_i, v_i – = distance of the centre of gravity of *i*-th member area from the axes *Gu*, *Gv*, in m;

dS_i – *i*-th member area, in m^2;

I_u, I_v – inertia moments of the semi-hull cross-section about axes *Gu*, *Gv*, with no regard for wear allowance, in m^4;

x, *y* – coordinates of the section point under consideration about main axes *Gx*, *Gy* (refer to Fig. 3.6.3.4.1), in m;

I_x, I_y – inertia moments of the semi-hull cross-section about the main axes with no regard for wear allowance, in m^4.

.2 Normal stresses acting in the semi-hull cross-section (for normal strength structural steel) shall not exceed:

150 MPa for the lower edge of the deck stringer;

145 MPa for the upper edge of the

plate keel;

165 MPa in the face plate of the hopper coaming.

.3 Permissible shear stresses for members made of normal strength structural steel and participating in the longitudinal bending are assumed equal to 115 MPa. Equivalent stresses $\sigma_{eq} = \sqrt{\sigma^2 + 3\tau^2}$ at the sections where substantial normal stresses σ and shear stresses τ (at the hopper ends) act shall be not more than 170 MPa.

.4 Buckling strength of compressed members according to 1.6.5 shall be ensured.

3.6.4.5 Bottom framing:

.1 When the bottom is transversely framed, the moment of inertia and scantlings of floors in side buoyancy spaces shall be determined as required by 2.3.4.1.1; in this case, to be taken as B_1 is doubled breadth of the buoyancy space over the bottom.

.2 Where a single bottom is longitudinally framed, the section modulus of bottom longitudinals in buoyancy spaces shall be not less than that determined in compliance with 2.3.4.2.1. The floors shall be fitted in line with transverse ring structures, their section modulus and cross sectional area shall be not less than determined from 2.3.4.2.3 to 2.3.4.2.4. The section modulus and depth of a side girder shall be not less than those required for the floor. The floor web depth shall not be less than $0{,}13B_1$ (refer to 3.6.4.10.1).

.3 The scantlings of the bottom framing members in each semi-hull of opening vessels shall be determined as required by 2.3.4.2; to be taken as breadth B_1 is the breadth of one semi-hull at the section under consideration. There is no bottom centre girder in opening vessels.

.4 The scantlings of double bottom members in way of the hopper space are determined as for dry cargo ships having double skin construction according to 2.4 with regard to 3.6.2.4; beyond the hopper as for dry cargo ships with single skin construction in compliance with the requirements of the same paragraphs.

The plate floor spacing shall not exceed the maximum spacing of transverse ring structures, specified in 3.6.2.11.1..

.5 For floating cranes the section modulus of bottom transverses shall be as required by 2.3, and additional bottom longitudinals shall have the same section modulus as for main longitudinals.

.6 In calculating the section modulus and the depth of floors in accordance with 2.3, B_1 is assumed to be the floor span between the side shell and the longitudinal bulkhead or between the longitudinal bulkheads, but not less than 0,4 of the full breadth of the ship.

.7 In case of longitudinally framed bottom, the scantlings of floors and bottom longitudinals of floating cranes beyond the double bottom area shall be determined in accordance with 2.3.4.2.

3.6.4.6 Shell plating:

.1 Shell plate scantlings are determined in accordance with 2.2.4. The thickness of the bottom strakes to which hopper longitudinal bulkheads or well sides are connected shall be increased by 15 per cent as against that of the bottom plating. Where there is no centre line box keel, the thickness of the bottom strakes abutting on the hopper longitudinal bulkhead shall be increased by 50 per cent.

.2 The side shell plating thickness at the hopper ends shall not be less than required by 1.4.6.

.3 In vessels with pontoon hulls, the thickness of the bottom and side shell plating within 0,15*L*, from the forward and after perpendiculars shall not be less than the plating thickness within the midship region.

.4 The thickness of the well side plating shall be equal to the thickness of the side shell plating in area concerned, but not less than 8 mm.

.5 In opening vessels the shell plating thickness shall be determined with regard for 3.6.4.4.

The thickness of the bottom strakes at the hopper longitudinal bulkhead need not be increased.

.6 In floating cranes the thickness of the bottom plating within 0,2*L* from the forward perpendicular shall be increased over the entire breadth of the hull by 30 per cent as against the minimum thickness required by 2.2.4.8.

In the fore peak and the areas extending forward for 0,1*L* from the stern transom corners and inboard for 0,1*B* the thickness of the side shell plating shall be increased over the entire depth by 30 per cent as compared to the minimum thickness required by 2.2.4.8 (refer also to 3.6.2.5.2).

In other regions along the hull length, the minimum thickness of the shell plating shall be increased by 10 per cent as against that prescribed by 2.2.4.8.

.7 The plating thickness of the bow and stern transoms in floating cranes shall not be less than required by 3.6.4.6.3.

3.6.4.7 Side framing:

The scantlings of the side framing members shall be determined in compliance with 2.5, having regard to 3.6.2.5, 3.6.2.11 and the requirements given below.

.1 the section modulus of frames in transversely framed side buoyancy spaces shall be determined from 2.5.4.1 as for dry cargo ships.

Where a side stringer is fitted at a level of fenders, main frame span may be determined in compliance with 2.5.1.2 as for side transverses of tankers, provided the structure of the side stringer meets the requirements of 3.6.4.7.2. Where no transverse ring structures are fitted, braces may be provided in line with horizontal girders of longitudinal bulkheads.

.2 the scantlings of side stringers shall be determined as required by 2.5.4.4 as for the case of fitting web frames. The width of the side stringer shall not be less than 0,08*l* (*l* – stringer span as measured between web frames or between those and tight transverse bulkheads) or 2,5 times the frame depth, whichever is the greater. Side stringers shall be aligned with cross ties of the transverse ring structures.

.3 the section modulus of side longitudinals shall be determined as required by 2.5.4.3 with k_σ values taken as for dry cargo ships.

.4 the section modulus and cross-sectional area of web frames which are a part of a transverse ring structure shall be not less than those required in 2.5.4.5 for side transverses of tankers.

A web frame span shall be measured between the inner edges of the floor and an inner edge of the beam.

В The depth of the web frame shall not be less than 0,1*l* or 2,5 times the width of longitudinals (whichever is the greater) and may be assumed varying with reduction at the upper end and increase at the lower end by 10 per cent as against the average value.

.5 the section modulus of well longitudinal bulkhead stiffeners shall not be less than required for side frames.

.6 in floating cranes, the section modulus of main and intermediate frames in the fore peak shall be increased by 20 per cent as compared to that required by 2.8.4.2.2.

.7 the section modulus of web frames in floating cranes *W*, in cm^3, within the region specified in 3.6.2.5.3 shall not be less than

$$W = 0{,}95\left(300 + \frac{120}{\sigma_n} bp\, l^2\right)\omega_k, \qquad (3.6.4.7.7)$$

where *l* – 5(300 + ^ M> c (3.6.4.7.7) where / = web frame span measured between the deck and the upper edge of the floor, in m;

p – as defined in 3.6.3, but not less than 0,5ρ*gl*, in kPa.

.8 the scantlings of the framing members of the bow and stern transoms shall not be less than required by 3.6.4.7.2 to 3.6.4.7.4 and 3.6.4.7.6.

3.6.4.8 Decks:

.1 The plating thickness of the strength deck within the midship region shall be taken not less than the sheerstrake thickness.

The minimum thickness of the deck plating in vessels of dredging fleet shall be determined according to 2.6.4.2 as for the strength deck. For floating cranes the minimum thickness of the upper deck shall be increased by 10 per cent as against that prescribed by 2.6.4.2 as for the strength deck.

.2 Compressive stresses in deck shall be determined under the action of bending moment components according to 3.6.3. The buckling strength requirements of 1.6.5 shall be met.

.3 The depth of deck transverses in buoyancy spaces which form a part of the transverse ring structure shall be equal to two-thirds of the floor depth, while the thickness of the web plate and sizes of the face plate shall be equal to those of the vertical webs. The depth of the deck transverse shall be not less than 2,5 times the height of the deck longitudinal.

.4 For floating cranes the section modulus of deck girders shall be determined as required by 1.6.4.1 with k_σ = 0,6 and *m* = 12.

.5 The deck plating thickness under the seats of special arrangements fitted on the deck (cat cranes of suction tubes, transfer appliances, grab cranes, etc.) and where special metal structures pass through the deck (main and ladder gallows) shall be increased by 25 per cent.

3.6.4.9 The scantlings of side and deck framing members, the thicknesses of deck plating, bulkhead framing and plating, and coamings of opening vessels shall be determined with regard for 3.6.4.4.

Where vertical webs and web frames are connected by cross ties or braces, the scantlings of vertical webs, web frames and braces shall be submitted to the Register for review.

3.6.4.10 In vessels with pontoon hulls, the scantlings of side stringers at the forward end of the vessel shall be prescribed as required by 2.8.4.7, the height and thickness of vertical webs and web frames shall be the same as the width and thickness of the stringer.

3.6.4.11 Specific structures of vessels of dredging flee:

.1 The section modulus *W*, in cm [3], of the diaphragm of the buoyancy space after deduction of openings, or the total section modulus of a vertical web and a web frame of the transverse ring structure at the section of a mid-point of the hopper lower cross member depth shall not be less than

$$W = \frac{p_1 b H_1^2 \cdot 10^3}{m k_\sigma \sigma_n} \omega_k, \quad (3.6.4.11.1)$$

where for H_1 – refer to Fig.3.6.1.6;
m = 12;
k_σ = 0,6;
for p_1 – refer to3.6.3.7.

.2 The cross-sectional area *f*, in cm², of the diaphragm, or the total sectional area of a vertical web and a web frame of the transverse ring structure at a level of a mid-point of the hopper lower cross member depth shall be not less than

$$f = \frac{10N}{k_\tau \tau_n} + 0{,}1\Delta f_i, \quad (3.6.4.11.2)$$

where N – as defined in 3.6.3.11;
k_τ = 0,65;
$\Delta f_i = \Delta s b_i$;
b_i - typical member scantlings (half-breadth of deck, web height of longitudinal, etc.), in cm.

The scantlings of the transverse ring structure members (bottom transverse, vertical web, side and deck transverses) shall be not less than required by the relevant paragraphs of this Chapter for such members.

.3 The section modulus *W*, in cm³, sectional area of the hopper lower cross member web f_w, in cm², after deducting openings, sectional area of the floor with face plates f_0, in cm², shall not be less than:

$$W = \frac{p_2 b l_{т.ф}^2 \cdot 10^3}{m k_\sigma \sigma_n} \omega_k; \quad (3.6.4.11.3\text{-}1)$$

$$f = 5\frac{b l_{т.ф}^2}{k_\tau \tau_n}\left(p_2 + \frac{0{,}5\rho_{гр} g}{l_{т.ф}} A_{к.б}\right) + 0{,}1\Delta f_i; \quad (3.6.4.11.3\text{-}2)$$

$$f_0 = \frac{10 R_{т.ф}}{k_{\sigma_p} \sigma_n} + 0{,}1\Delta f_i, \quad (3.6.4.11.3\text{-}3)$$

where m = 12;
k_σ = 0,45;
k_{σ_p} = 0,2;
k_τ = 0,45;
p_2 – as defined in 3.6.3.8;
$R_{l.cr.}$ – as defined in 3.6.3.12;
For Δf_i – refer to 3.6.4.11.2.

.4 The section modulus of the face plates of the hopper lower cross members *W*, in cm³, about the horizontal axis and sectional area $f_{f.p}$, in cm², shall not be less than:

for the upper face plate

$$W = \frac{p_3' h_{т.ф} l_1^2 \cdot 10^3}{m k_\sigma \sigma_n}\left[3 - \frac{(l_1 - l_2)^2}{l_1^2}\right]\omega_k; \quad (3.6.4.11.4\text{-}1)$$

$$f_п = \frac{2{,}5 p_3' h_{т.ф}(l_1 + l_2)}{k_\tau \tau_n} + 0{,}1\Delta f_i; \quad (3.6.4.11.4\text{-}2)$$

for the lower face plate

$$W = \frac{2 p_3'' h_{т.ф} l_2^2 \cdot 10^3}{m_1 k_\sigma \sigma_n}\omega_k; \quad (3.6.4.11.4\text{-}3)$$

$$f_п = \frac{5 p_3'' h_{т.ф} l_2}{k_\tau \tau_n} + 0{,}1\Delta f_i, \quad (3.6.4.11.4\text{-}4)$$

where for l_1, l_2 – refer to3.6.1.6;
m = 24;

$m_1 = 12$;
$k_\sigma = 0{,}6$;
$k_\tau = 0{,}45$;
p'_3, p''_3 – as defined in.3.6.3.9;
for Δf_i – refer to 3.6.4.11.2.

.5 The section modulus of bulkhead vertical webs, horizontal girders, vertical stiffeners and longitudinals of the hopper longitudinal bulkheads shall be determined as for side framing according to 3.6.4.7 with substitution of p according to 2.5.3 by p_s according to 3.6.3.6.

For the longitudinal bulkhead stiffeners $m = 11$ and $k_\sigma = 0{,}75$.

The depth of the vertical web shall be not less than 0,12*l* and may be assumed varying with reduction at the upper end and increase at the lower end by 10 per cent as compared to the average value.

Two upper longitudinals shall be taken the same as the third longitudinal from the deck.

Besides, three upper and three lower longitudinals shall be checked according to 1.6.5.

The width of the horizontal girder shall be equal to that of the bulkhead vertical web.

.6 The plating thickness of the hopper longitudinal and end bulkheads shall be determined as required by

assuming $p = p_s$ (де p_s – shall be obtained from 3.6.3.6),

$k_\sigma = 0{,}7$,

$m = 15{,}8$.

The upper strake thickness of the hopper longitudinal bulkhead at 0,1*D* D below the deck shall not be less than the sheerstrake thickness. The lower strake thickness of the longitudinal bulkhead at 0,1*D* from the base line shall not be less than the bottom plating thickness.

.7 The minimum thickness of hopper bulkhead plating shall be equal to 8 mm for vessels having the length $L < 60$ m and 10 mm for vessels having the length $L \geq 80$ m. For intermediate values of *L*, the minimum thickness shall be determined by linear interpolation.

.8 The section modulus *W*, in cm^3, of vertical stiffeners and stanchions of the hopper coaming shall not be less than determined by the formula[1]

$$W = \frac{p_4 a h_к^2 \cdot 10^3}{m k_\sigma \sigma_n}\omega_k, \quad (3.6.4.11.8\text{-}1)$$

where p_4 – as defined in 3.6.3.10;

$m = 15$ for stanchions where upper cross members are fitted in line with transverse ring structures at the coaming top;

$m = 6$ for stanchions where no upper cross members are fitted at the coaming top;

$m = 15{,}6$ – 15,6 for vertical stiffeners where transverse framing is adopted;

$k_\sigma = 0{,}6$.

The section modulus *W*, in cm^3, of horizontal stiffeners and face plate of the coaming shall not be less than

$$W = \frac{p_4 a b^2 z_i \cdot 10^3}{m k_\sigma \sigma_n h_к}\omega_k, \quad (3.6.4.11.8\text{-}2)$$

where z_i – distance between the coaming top and horizontal stiffeners, but not less than half the coaming height, in m;

$m = 12$;

$k_\sigma = 0{,}2$.

The sectional area f_{st}, in cm^2, of the coaming stanchion, in cm2 , at deck shall not be less than

$$f_{ст} = \frac{4 p_4 a h_к}{k_\tau \tau_n} + 0{,}1\Delta f_i, \quad (3.6.4.11.8\text{-}3)$$

[1] For stanchions *b* is substituted for *a*.

where $k_\tau = 0,45$;

for Δf_i – refer to 3.6.4.11.2.

The plate thickness of the side (end) coaming shall be determined as for the longitudinal (end) bulkhead of the hopper p_{st} according to 3.6.3.6 as measured at the deck level, but it shall be taken not less than the upper strake thickness of the longitudinal bulkhead.

The depth of the stanchion at deck shall be not less than $0,12h_c$, and the thickness not less than the coaming thickness.

The plate thickness of the coaming and moment of inertia of the horizontal stiffeners and face plate of the coaming shall meet the buckling strength requirements according to 1.6.5.

.9 The sectional area of the upper cross members spanning hopper space at deck level and/or coaming level $f_{up.cr}$, in cm^2, shall not be less than

$$f_{up.cr} = 0,085R_{up.cr} + 0,1\Delta f_i, \quad (3.6.4.11.9\text{-}1)$$

where Δf_i – as defined in 3.6.4.11.2.

Where a load from bottom closing appliances is applied to the upper cross members, their strength shall be checked using the equivalent stress given below

$$\sigma_{eq} = \sqrt{\sigma_{max}^2 + 3\tau_{cp}^2} \le 0,75\sigma_n, \quad (3.6.4.11.9\text{-}2)$$

$$\sigma_{max} = \frac{10R_б}{f_б} + \frac{M_{зг}}{W} \cdot 10^3;$$

$$\tau_{sh} = 10N_{sh}/f_w;$$

M_b, N_{sh} – maximum bending moment, in kN.m, and shear force, in kN, due to transverse load;

W – actual section modulus of the upper cross member, in cm^3;

$f_{up.cr}$, f_w – full sectional area of the upper cross member and sectional area of the cross member web, in cm^2.

.10 Where no upper cross members are fitted at a deck level in line with transverse ring structures, a part of the coaming structure with the upper portion of the side buoyancy space located at $0,1D$ below the deck line (refer to Fig. 3.6.4.11.10) shall have a section modulus W, in cm^3, about a horizontal axis not less than

$$W = \frac{550R_б(l_т - b)^2}{b\sigma_n}\omega_k. \quad (3.6.4.11.10\text{-}1)$$

The thickness of the deck plating s, in mm, shall not be less than

$$s = \frac{1,11R_б(l_т - b)}{bB_3\tau_n} + \Delta s, \quad (3.6.4.11.10\text{-}2)$$

Where for B_3 – refer to Fig. 3.6.4.11.10.

.11 The scantlings of hull structural items in places where hinges and hydraulic presses are arranged shall be determined by direct calculation as regards the action of statical and dynamical forces in compliance with 3.6.3.16.

The calculations shall be submitted to the Register for review.

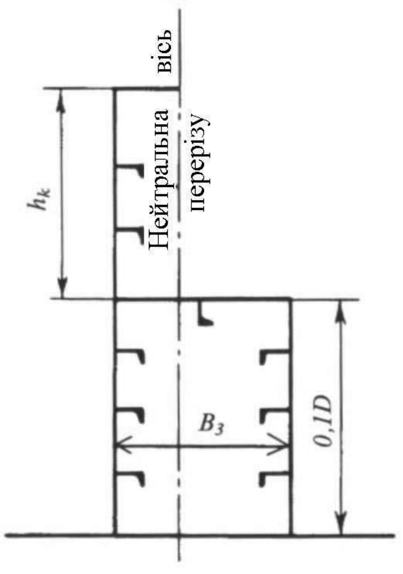


Fig. 3.6.4.11.10

.12 Hydraulic presses shall be positioned in special spaces at the hopper ends. The strength calculation of foundations and attachments of hydraulic presses shall be made as regards the action of forces determined in accordance with 3.6.4.11.11 and shall be submitted to the Register for review.

3.6.4.12 Specific structures of floating cranes:

.1 The diameter of the tub D_0, in m, at the upper deck beneath the fixed tower supporting the upper structure of the crane shall not be less than

$$D_0 = 0,37M/P, \qquad (3.6.4.12)$$

where M – total bending moment due to load and weight of the movable upper structure of the crane, applied to the supporting tower, in kN·m;

P – total vertical force due to load and weight of the movable upper structure of the crane, applied to the supporting tower, in kN.

.2 The thickness of the tub plating, in cm, at the upper deck shall be determined by calculation based on the total bending moment according to 3.6.4.12.1 and a horizontal component of the load for the case when a design safe working load of the crane with the lifting height from the water level at the maximum outreach is used.

Permissible stresses for normal strength steel shall not be more than: σ = 140 MPa and τ = 80 МПа.

The buckling strength of the tub plating over its entire height shall be ensured to the value $\sigma_{cr} = 2,5R_{eH}$. The calculations shall be submitted to the Register for review.

.3 The inertia moment I_{min}, in cm^4, of the tub(refer to 3.6.2.11.9) vertical stiffeners (if any) shall not be less than

$$I_{min} = (1,03l – 1,80y)\,s^3, \quad (3.6.4.17.3)$$

where l – stiffener span measured between the bottom and the platform or between the platform and the deck, whichever is the greater, in m. Where the platform is omitted, the distance between the bottom and the deck is measured;

y – spacing of stiffeners, measured along the chord line, in m;

s – tub plating thickness at the stiffener midspan, in mm.

.4 The plating thickness of the bulkheads forming a cross and the bearing contour shall not be less lhan determined according to 2.7.4.1, assuming

$k_\sigma = 0,70$;

$\Delta s \geq 4$ mm for bulkheads forming the cross and

$\Delta s \geq 2$ mm for those forming the bearing contour.

For cranes having a safe working load more than 100 t, the stressed condition of framing members and plating of bulkheads forming the cross under the loads transferred from the fixed supporting tower in case of using the design safe working load at the maximum outreach shall be checked according to the procedure approved by the Register.

.5 The plating thickness of the upper deck and the bottom *s'*, in mm, in way of the crane tub shall not be less than

$$s' = \alpha s, \qquad (3.6.4.12.5)$$

where s – as defined in 3.6.4.12.2;

α = 0,6 and 0,4 – for the upper deck plating and bottom plating, respectively.

The dimensions of the plates of increased thickness shall be taken in accordance with Fig. 3.6.4.12.5.

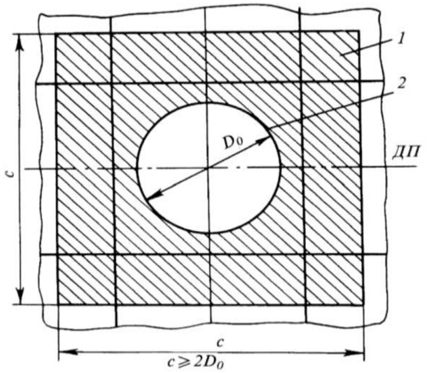


Fig. 3.6.4.12.5:
1 – thickened plate; 2 — tub

3.6.5 Special requirements..

3.6.5.1 Where vessels are intended to ground during the course of normal service, the bottom of such vessels shall be suitably strengthened, as follows.

.1 the thickness of the bottom shell plating shall be increased by 20 per cent over the minimum requirement.

.2 where the double bottom is omitted and transverse framing system is adopted, the bottom shell plating between the bottom side girders shall be strengthened by horizontal stiffeners.

In line with horizontal stiffeners vertical stiffeners shall be fitted. The horizontal stiffeners shall pass through openings in the floors and be welded to them.

.3 where double bottom is omitted and longi-tudinal framing system is adopted, the bottom shell plating shall be strengthened by additional floors, the depth of which shall be not less than 2,5 times the depth of the bottom longitudinal and a thickness equal to that of the main floors. The main floors shall be strengthened by vertical stiffeners fitted in line with bottom longitudinals. Side girders shall not be spaced more than 2,2 m apart. The scantlings of bilge longitudinals shall not be less than those required for the bottom.

.4 in transversely framed double bottom plate floors shall be fitted at every frame, side girders shall be spaced not more than 2,5 m apart, they shall be also fitted inboard or from longitudinal bulkheads at a distance not exceeding 2,5 m. The bottom shell plating shall be strengthened by horizontal stiffeners fitted between the side girders. Vertical stiffeners shall be fitted in line with horizontal stiffeners at every floor and be welded to them.

In longitudinally framed double bottom floors shall be fitted at every second frame, and side girders shall be spaced 2,5 m apart.

.5 in way of a recess for vertical girders of suction tubes, the following hull strengthening shall be provided::

side framing shall be reinforced by at least three web frames, the scantlings of which shall be the same as those required for the engine room, and by not less than three intercostal side stringers extending for three spacings from the extreme web frames which shall be fitted not less than 50 mm from the edge of the recess;

side shell plating in way of the recess shall be made of a curved welded-in plate, the vertical butt joint of this plate shall be not less than 100 mm from the edge of the recess;

the thickness of the deck stringer in way of the recess shall be increased by 60 per cent over the length equal to one spacing forward and abaft of web frames.

3.6.5.2 The requirements of 3.6.5.1 shall not apply to floating cranes for which deep sea service is specified and which are not likely to ground under any conditions of heel and trim.

3.6.5.3 The thickness of main structural items which are particularly subjected to abrasive wear due to the effect of spoil/water mixture (in particular, in case of special dredging methods used) shall be increased. These items may be made of special wearresistant materials subject to special agreement with the Register.

3.6.5.4 Dredging pumps shall be located in special spaces bounded by watertight bulkheads.

3.6.5.5 The scantlings of deck framing members on deck portions where heavy dredging (cargo handling) gear is installed, as well as where large heavy cargoes may be carried on decks of floating cranes or hopper dredgers shall be determined by calculation for the following conditions:

beams are considered to be rigidly fixed to the supporting structure;

a load (concentrated, partially distributed, etc.) shall be taken into account;

equivalent stresses for items made of normal strength steel σ_{eq}, in MPa, shall comply with the condition:

$$\sigma_{eq} = \sqrt{\sigma^2 + 3\tau^2} \le 170, \quad (3.6.5.5)$$

where σ, τ – normal and shear design stresses at the section under consideration.

The results of the calculation shall be specially considered by the Register.

3.7 FISHING VESSELS AND SPECIAL PURPOSE SHIPS USED FOR PROCESSING OF SEA LIVING RESOURCES

3.7.1 General and symbols.

3.7.1.1 The requirements of this Chapter apply to fishing vessels having a stern trawling arrangement or a side trawling arrangement and to special purpose ship intended for processing, storage and/or transportation of catch.

3.7.1.2 The requirements for hull structures not referred to in this Chapter are given in Sections 1 and 2.

In no case shall the requirements for hull structures be less stringent than those contained in Sections 1 and 2.

3.7.1.3 The requirements for ships mooring at sea provide for a damping protection of the hull for which purpose pneumatic fenders or other equivalent damping arrangements may be used.

These requirements are based on the assumption that ships would be moored at a sea state not above 6. No side or superstructure strengthening are required when ships are moored at a sea force below 4, provided the above damping protection is used.

3.7.1.4 For the purpose of this Chapter, the following symbols have been adopted:

b_{sr} – breadth of stern ramp, in m;

G_1 – greatest specified mass of catch which can be handled by a special wheeled device or another transport means, in t;

G_2 – mass of moving part of special wheeled device or another transport means, in t;

G – mass of processing equipment, in t;

S_d – factory deck area, in m ^{2},

h – spacing of boundaries of region of side strengthening from summer load line and ballast waterline;

A1–A7, E1–E6 – regions of strengthenings;

a – spacing of framing members under consideration, in m (refer to 2.1.2);

l – span of member under consideration (refer to 1.6.3.1);

Δs – corrosion and wear allowance added to plate thickness, in mm (refer to 1.1.5.1);

Ω_c – factor taking account of corrosion allowance to the section modulus of the to framing member (refer to 1.1.5.3).

3.7.1.5 The regions of side strengthening of vessels mooring at sea are to be as required by 3.7.1.5-1 (for fishing vessels) and 3.7.1.5-2 (for special purpose ships) taking account notices from Tables 3.7.1.5-1 - 3.7.1.5-2. Spacing of boundaries of region of side strengthening up from summer loadline and down from ballast waterline depending on sea state at which ship would be moored is not to be less than determined in Table3.7.1.5-3.

For special purpose ships, one or more fender areas shall be additionally established the boundaries of which are formed by sections lying within 0,05*L*, forward and aft of the forward and aft edges accordingly of a group of floating fenders providing one mooring place for all specified variants of mooring. The boundaries of fender areas shall be determined at extreme positions of fenders and for all specified variants of mooring.

3.7.1.6 Fishing vessels intended for systematic operation in ice conditions.

.1 Fishing vessels intended for systematic operation in ice conditions shall have an ice class not lower than **Ice3** in accordance with the requirements of 3.10.

.2 Fishing vessels intended for systematic operation in ice conditions, which have the ice class **Ice3**, shall comply with the requirements of 3.10, as well as with additional requirements contained in 3.7.1.6.4, 3.7.2.10, 3.7.3.4 and 3.7.4.5.

.3 No additional requirements are put forward with regard to the fishing vessels of ice class **Ice4** and above.

.4 If the loadline entrance of a fishing vessel of ice class **Ice3** exceeds 0,25*L*, an intermediate region of ice strengthening may be established the boundaries of which shall be determined as in the case of **Ice4** ice class.

3.7.2 Construction.

3.7.2.1 The after end structure of vessels having a stern ramp and/or stern trawling arrangements shall be strengthened by fitting additional longitudinal and transverse members (girders, transverses, cross ties, bulkheads and partial bulkheads)

The stern ramp shall be so constructed as to avoid flat of bottom in way of stern counter.

The connection of stern ramp sides to transom plating and of the ramp deck to bottom plating shall have a radius of rounding not less than 200 mm. This connection may be made by using a bar not less than 70 mm in diameter.

The connection of stern ramp sides to transom plating and of the ramp deck to bottom plating are to have a radius of rounding not less than 200 mm. This connection may be made by using a bar not less than 70 mm in diameter.

Where the connection of the ramp side with transom plating is rounded, the thickness of the plating strake not less than 700 mm broad, if measured from the ramp deck plating, is not to be less than 20 mm. Doubling plates are also permitted.

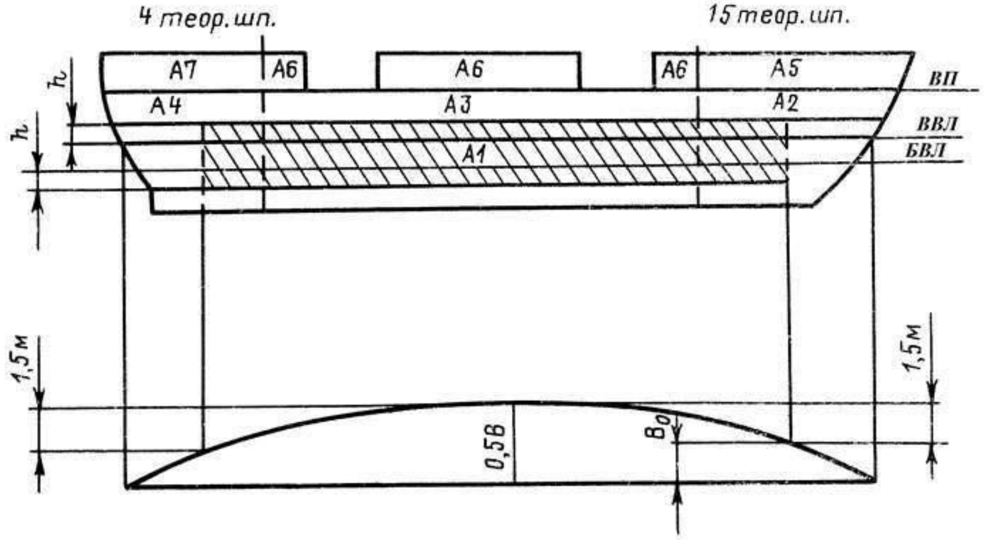


Fig. 3.7.1.5-1. Regions of strengthening of fishing vessels

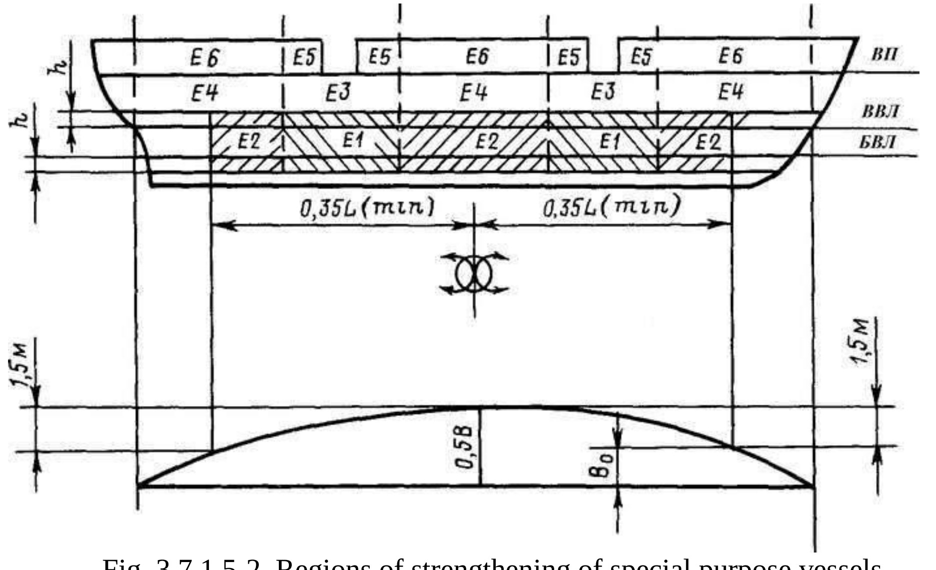


Fig. 3.7.1.5-2. Regions of strengthening of special purpose vessels

Table 3.7.1.5-1

region of strength-ening	zone of regions of strengthening	
	lengthwise	depth demention
A1	between sections in which ship half-breadth at summer loadline level B_0 = 0,5B – 1,5	Between the level higher than the summer loadline by the value of h andlevel lower than the ballast waterline by the value of h
A2	between forward part and section 0,25L from fore perpendicular	between the upper edge of A1 region and upper deck
A3	(0,25-0,80)L from fore penper-dicular	the same as for A2 region
A4	between after region and section 02L from after perpendicular	the same as for A2 region
A5	the same as for A2 region	between the upper edge of A2 region and the first tier superstructure deck
A6	the same as for A3 region	between the upper edge of A3 region and the first tier superstructure deck
A7	the,same as for A4 region	between the upper edge of A4 region and the first tier superstructure deck

Table 3.7.1.5-2

Region of strengthen-ing	Zone of regions of strengthening	
	lengthwise	depth demention
E1	From section which extended within 0.05L from forward point to forward part of the berthing region, to section which extended within 0,05L to aft point of the aft berthing region[1]	Between the level higher than the summer loadline by the value of h and level lower than the bal-last waterline by the value of h
E2	between external boundaries of El regions and sections in which ship half-breadth at summer load-line level B_0 (refer to Table 3.7.1.5 - 1), but not less than 0,35L forward and aft midship region as well as between El regions in ships with two fender are-as	The same as for El re-gion
E3	the same as for El region	between the upper edge of El region and upper deck
E4	between external edge of E3 regions and for-ward and alf region as well as between E3 regions in ships with two fender areas	The same as for A2 re-gion
E5	the same as for E3 region	between the upper edge of E3 region and the first tier superstructure deck

E6	the same as for E4 region	between the upper edge of E4 region and the first tier superstructure deck

[1] The boundaries of each berthing region are the forward edge of the bow and the aft edge of the aft floating fenders. The boundaries of the regions must be determined at the extreme positions of the fenders for any given mooring options.

Table 3.7.1.5-3

Sea force No.	*h*, m
4	0,8
5	1,2
6	2,0

3.7.2.2 Stern ramp sides shall, in general, be carried downwards to the shell plating and forward to the after peak bulkhead and shall be smoothly tapered into deck girders and transverses.

3.7.2.3 For vessels not engaged in pelagic fishing, the plating strakes of ramp sides are to be thickened, in way of connection with the transom and along the ramp deck, to a value not less than required under3.7.4.4.

he thickened side plating strakes fitted along the ramp length should have a breadth not less than 0,4 of the ramp breadth, or 1,0 m, whichever is greater. The lower edge of those strakes is to coincide with the ramp deck in vessels where the catch is dragged in and to be level

with the catch stowage surface in vessels where the catch is carried

onto the deck by a wheeled arrangement.

If measured forward of the rounding to flat-side junction line, the length of thickened section of the side plating in way of transom is not to be less than 0,5 of the ramp breadth.

3.7.2.4 In vessels engaged in pelagic fishing, ramp plating is to be strengthened with longitudinal welded segmental rod with diameter not less than 70 mm and with distance between axes not more than 200 mm. The edge of upper segmental rod is not to be on distance less than 650 mm from ramp deck.

3.7.2.5 Where the catch is dragged onto the deck, it is recommended that the stern ramp be longitudinally framed with transverses fitted at intervals not exceeding four frame spacings. The stern ramp longitudinals are to be spaced not more than 600 mm apart.

In vessels where special transport means are used to carry the catch onto the deck, the stern ramp is to be framed transversely.

The length of thickened ramp deck plating sections along the ramp length should equal:

the ramp width at least, if measured forward of the ramp edge, in way of bottom rounding;

double ramp width at least in way of top rounding.

Suitable devices are recommended to prevent excessive wear of ramp plating with wire ropes when dragging the catch. Where the rated winch pull exceeds 30 kN on each wire rope, such devices are compulsory.

Devices preventing excessive wear of plating may be substituted by doubling plates in the thickened areas of top and bottom rounding over the full breadth of the ramp, and doubling strips at least 400 mm wide may be fitted at the sides over the rest of the ramp length.

3.7.2.6 It is recommended that vessels more than 30 m in length be fitted up with a forecastle.

Within the location of each gailow, determined as the distance between sections at three spacings forward and aft of the gailow ends, the strengthening shall be as follows:

intermediate frames are to be fitted extending from the upper deck down to a level not less than 0,5 m below the ballast waterline and having a section modulus not less than 75 per cent of that required by 2.5.4.2 for the frames in the 'tweendeck space concerned;

the upper and lower ends of intermediate frames are to be secured to the decks, platforms and longitudinal intercostal members fitted between the main frames; longitudinal intercostal members are to have the same section as intermediate frames and be aligned with them;

the upper longitudinal intercostal member is to be fitted not more than 350 mm below the upper deck;

bulwark stays are to be fitted at every frame;

bulwark, sheer strake and side plating above the level of the ballast waterline shall be protected with steel rod of segment section, welded with a slop.

3.7.2.7 Structures in processing shops.

.1 Where the number of bulkheads in the processing shops located above the bulkhead deck is less than specified in 2.7.1.3 and where the distance between the bulkheads forming the boundaries of that space exceeds 30 m, partial bulkheads extending inboard for not less than 0,5 m of the 'tween deck height shall be fitted on the bulkhead deck at each side of the vessel in line with watertight bulkheads. The thickness of the partial bulkhead plating shall be not less than that of the top strake of the corresponding watertight bulkhead below the deck where the considered processing shop is located.

Partial bulkheads shall be strengthened with horizontal stiffeners in accordance with 1.7.3.2. Strengthening with vertical stiffeners is permitted with fitting the horizontal stiffeners between the side shell and the nearest vertical stiffener in compliance with 3.7.2.9.3.

Partial bulkheads shall be interconnected with deck transverses supported by pillars in a required number. Alternative structural arrangements may be used if approved by the Register as equivalent.

.2 Where multi-tier deckhouses are arranged above the processing shops, the requirements of 2.12.5.2 for rigid members (bulkheads, partial bulkheads) to be fitted in such spaces shall be complied with.

3.7.2.8 In fishing vessels, bulwark stays shall be fitted at intervals equal to not more than two frame spacings.

3.7.2.9 Structural strengthening of ships mooring at sea.

.1 In regions strengthened for mooring at sea, transverse framing shall be adopted for the vessel's sides. In single-deck ships, the deck and bottom in the above regions shall also be framed transversely. In multi-deck ships, transverse framing shall be adopted for the deck located on the fender level. Longitudinal framing of sides is permissible in the upper 'tween deck space only. In this case, the spacing of web frames shall not exceed three frame spacings or 2,4 m, whichever is less. In the regions A1 and E1 intermediate frames are recommended through the region length.

.2 In any case, it is recommended that symmetrical sections be used and the minimum possible web depth be ensured for the particular section modulus.

.3 Between the ship's side and vertical stiffener nearest to it, transverse bulkheads shall have horizontal stiffeners with a section height not less than 75 per cent of the vertical stiffener height. In ships with $L \leq 80$ m, horizontal stiffeners shall be spaced not more than 600 mm apart, and with $L \geq 150$ m, not more than 800 mm apart. For ships of intermediate lengths, linear interpolation may be used to determine this distance. The ends of horizontal stiffeners shall be welded to vertical stiffeners and sniped at the ship's sides.

.4 The bulwark shall be inclined towards the centreline of the ship at not less than one-tenth or be fitted inboard of the ship's side at not less than one-tenth of its height.

.5 Bilge keels of ships with the length $L \leq 80$ m shall be, as far as practicable, so arranged that a tangent drawn to the frame and passing through the outer free edge of the bilge keel would form an angle of not less than 15° with the vertical axis. For ships with the length $L \geq 150$ m, this angle may be zero. For ships of intermediate lengths, the above angle shall be obtained by linear interpolation.

.6 The lower end attachments of hold frames shall be as required by 2.5.5.1.

In 'tween decks, the attachments of frame lower ends shall comply with the requirements of 2.5.5.3. The frame ends shall be welded to the deck plating.

Upper ends of frames shall be carried to the deck plating and welded thereto. Beams shall be carried to the inner edges of frames with a minimal gap. Beam knees shall have a face plate or flange.

The ends of intermediate frames shall be attached to longitudinal intercostals, decks or platform.

.7 Side longitudinals shall be attached to transverse bulkheads with knees. The height and width of the knees shall comply with 1.7.2.2, taking n = 1.8.

.8 Bulwark stays welded to sheerstrake shall be so constructed as to prevent deck plating damage in case of bumping.

3.7.2.10 Besides the requirements of 3.10, the ice-strengthening structure of fishing vessels of ice class **Ice3** intended for systematic operation in ice conditions shall comply with the following requirements:

.1 for the case of transverse main framing, at least one load distributing side stringer shall be fitted in each grillage in way of region of ice strengthening AI, A_1I, BI and CI (refer to 3.11.2.1.3).

.2 bulbous forebody is not recommended.

.3 in the forepeak, the spacing of stringers and their dimensions, as well as stem dimensions, shall be in accordance with the requirements of 3.10 for fishing vessels of ice class **Ice4**.

.4 in the afterbody, provision shall be made for an appendage (ice knife) aft of the rudder to protect the latter on the sternway.

3.7.3 Design loads.

3.7.3.1 the design pressure p, in kPa, on the ramp sides and deck in vessels where the catch is dragged in shall be determined by the formula

$p = 6{,}5b$, (3.7.3.1-1)

Where the breadth of the ramp varies along its length, the minimum breadth shall be taken as the design value.

in vessels equipped with a special wheeled catch-transport arrangement, the design load, in kN, for ramp deck plating shall be determined by the formula

$p = 27(G_1 + G_2) / n_к$, (3.7.3.1-2)

where n_w – number of the wheel axes of the arrangement.

3.7.3.2 For factory decks, the design pressure p, in kPa, shall be determined by the formula

$$p = 15G / S_d. \quad (3.7.3.2)$$

3.7.3.3 The design pressure p, in kPa, on the sides and superstructure sides of ships moored at sea shall be determined by the following formulae:

$$p = \alpha_1 \alpha_2 \alpha_3 (\beta_1 + \beta_2 \sqrt{\Delta z \cdot 10^{-3} - 0{,}464}), \quad (3.7.3.3)$$

where α_1 – shall be adopted from Table 3.7.3.3-1 depending on the ship displacement and the sea conditions specified for mooring at sea;

α_2, α_3, β_1, β_2 – shall be adopted from Table 3.7.3.3-2 and 3.7.3.3-3depending on the ship purpose and the region of strengthening;

Table 3.7.3.3-1

Ship displacement, in t	Sea state No		
	4	5	6
≤ 2000	1,00	1,15	1,60
> 2000	0,82	1,00	1,16

Table 3.7.3.3-2

Factor α_2	Region of ice strengthening			
	A1 – A7	E1	E2	E3 – E6
	1,0	1,1	0,8	$1 + 0{,}05n^{1/3}$

n – number of moorings, during a voyage, alongside the ship whose displacement has been adopted as the design value in Formulae (3.7.3.3). For regions E3 – E6 α_2 is taken not less 1,1 and not greater than 1,4.

Table 3.7.3.3-3

Factors	Region of ice strengthening		
	A1, E1, E2	A2 – A4, E3, E4	A5 – A7,E5, E6
α_3	1,0	$1/(0{,}22z + 0{,}6)$	$1/(0{,}12z + 1{,}28)$
β_1	190	129	
β_2	51	59	

Δ – design ship displacement, in t. For a fishing vessel Δ displacement to the summer load waterline;

For a special purpose ship Δ shall not be taken greater than 7500 t;

z – distance in m, from the mid-span of member calculated to the summer load waterline. Where a special purpose ship has the freeboard depth $h_1 = D - d$ greater than the freeboard depth $h_2 = D - d$ of the biggest fishing vessel, the value of z shall be reduced by the difference of $h_1 - h_2$. In any case, z shall not be less than 1,0 m. in regions A1, E1, E2 $z = 1{,}0$ m.

3.7.3.4 For fishing vessels of ice class **Ice3** intended for systematic operation in ice conditions, the ice load parameters shall be determined on the basis of the following provisions:

.1 in the forward region of ice strengthening A , the load parameters shall be determined in accordance with the requirements of 3.10 for the ice class **Ice3.** In the case of a bulbous forebody, the rake angle of frame β shall be determined as stipulated in 3.10.1.4.1 for fishing vessels of ice class **Ice4.**

.2 in the midship region of ice strengthening B, the ice load intensity, in kPa, is determined by the formula

$$p_{BI} = p^{\circ}_{BI} \cdot k_B$$

where p_{BI} — ice load intensity in midship region (B), according to 3.10.3.2.3;

$k_B = 2k_1$, but not less than 1;

$$k_1 = \frac{r^2}{\sqrt{\Delta/1000}}\left(l_k / L - 0{,}18\right);$$

$$r = \frac{17{,}4P_b^{0,5}a^{0,5} - B_2}{57{,}3P_b^{0,33}};$$

Δ — displacement, in t, to summer load waterline;

p_B — shaft power, in kW, determined with due regard for power take-off in the trawling condition;

l_k — distance, in m, from forward perpendicular to a section aft where the reduction of summer load waterline breadth begins.

The height and length to which the midship region is covered by the ice load shall be determined in accordance with 3.10.3.3.3 and 3.10.3.4.3.

.3 the ice load intensity, in kPa, in the aft region of ice strengthening C is determined by the formula

$$p_{CI} = p^{\circ}_{CI} \cdot k_C$$

where p°_{CI} — ice pressure in the aft region according to 3.10.3.2.4.

k_C = 2,5 k_1, but not less than 1;

for k_1 — refer to 3.7.3.4.3.

The height and length to which the aft region is covered by the ice load shall be determined in accordance with 3.10.3.3.4 and 3.10.3.4.4.

3.7.4 Scantlings of structural members.

3.7.4.1 The section modulus of factory deck beams and longitudinals is to be determined as required by 2.6.4 with the design pressure according to 3.7.3.2 where it exceeds that required by 2.6.3.

3.7.4.2 The section modulus of longitudinals, beams and deck transverses of the stern ramp is to be determined according to 1.6.4.1, taking:

p – as obtained from (3.7.3.1-1) for vessels where the catch is dragged in or (3.7.3.1-2) – for vessels where the catch is carried onto the deck by a special wheeled arrangement;

m – згідно з табл.3.7.4.2 для суден, де передбачене підіймання улову волочінням;

$m = 9{,}3l^2\sqrt[4]{a/l}$ – for vessels where the catch is carried onto deck by a special wheeled arrangement;

k_σ = 0,6.

Table 3.7.4.2

Stern ramp framing	Fishing vessels	Special purpose ships
Deck longitudinals	11,3	7,9
Beas and deck transverses	12,6	8,8

3.7.4.3 The section modulus, in cm^3, of stern ramp side stiffeners shall not be less than determined by Formula 1.6.4.1 with the design load *p* as determined by Formula (3.7.3.1-1), k_σ = 0,9, *m* = 17,0 and 22,6 for fishing vessels and special purpose ships respectively. The stiffener span *l* shall be adopted equal to the maximum distance between the ramp deck and the nearest deck above or to the distance between two decks adjoining the ramp side, but shall not be less than 2,6 m.

In vessels engaged in pelagic fishing, the section modulus of ramp side stiffener, in cm^3, shall not be less than

$$W = 45{,}5(l - 0{,}5 / l)(820 / \sigma_n - l / a)\omega_k. \quad (3.7.4.3)$$

In no case shall the section modulus of stern ramp side stiffeners be less than required in 2.5.4.2 for the frames of upper 'tween deck and superstructure.

3.7.4.4 The length of thickened ramp deck plating sections along the ramp length shall be equal to: the ramp width at least, if measured forward of the ramp edge, in way of bottom rounding; double ramp width at least in way of top rounding

$$s = ma\sqrt{p/(k_\sigma \sigma_n)} + \Delta s, \quad (3.7.4.4)$$

where m, Δs to be adopted from Table 3.7.4.4;

p – as determined by Formula (3.7.3.1-1);

k_σ = 0,8.

Table 3.7.4.4

Ramp structure	Location along ramp length	Fishing vessels		Special purpose ships	
		m	Δs, in mm	m	Δs, in mm
Deck	Bottom rounding ans stern-counter plating	26,8	10,0	26,8	10,0
	Mid region	26,8	5,5	26,8	5,5
	Top rounding	26,8	9,5	26,8	5,5
Sides	In way of friction	25,9	5,5	21,9	5,5
	Elswhere on deck	25,9	4,5	21,9	4,5

Where doubling plates are fitted on the ramp deck in way of bottom rounding or top rounding or where devices to prevent excessive wear of stern ramp plating with wire ropes are installed, the plating thickness may be adopted as for the mid-region.

3.7.4.5 In vessels engaged in pelagic fishing, the lower strake of the side having a width from the stern ramp plating to a point at least 100 mm above the upper half-round bar shall have a thickness s, in mm, not less than

$$s = 2 \cdot 10^4 a_s / \sigma_n + 1,$$

where a_s – distance, in m, between adjacent edges of half-round bars.

3.7.4.6 Whatever the mode of carrying the catch along the stern ramp, the thickness of ramp plating in vessels of all types shall be 2 mm greater than required by 2.2.4.8 for the shell plating. This thickness shall be maintained on the length from the stern ramp end to a line at least 600 mm above the bulkhead deck within the particular section of the vessel length. Forward of this region the thickness of stern ramp plating shall be 2 mm greater than required under 2.6.4.2 for the upper deck plating at ends.

3.7.4.7 On a length at least 1,0 m forward of the stern ramp edge and at least over the whole ramp breadth, the stern-counter plating shall be 1 mm thicker than stipulated under 2.2.4.1.

3.7.4.8 In vessels over 30 m in length, the side plating and sheerstrake thickness between the gallows, determined as the distance between the section three spacings forward of the fore end of forward gallow and the section three spacings abaft the after end of after gallow, shall be 1 mm greater than stipulated under 2.2.4.1.

Within the location of each gallow, to be determined as distance between sections, located on three frame spacing to the bow and aft off the ends of the arc, provision shall be made for strengthening as follows:

sheerstrake thickness to be increased by 2 mm;

thickness of strake adjacent to sheerstrake to be increased to equal that of the sheerstrake between gallows;

deck stringer thickness to be increased by 3 mm as compared to that required by 2.6.4.1;

bulwark plate thickness to be increased by 2 mm as compared to that required by 2.14.3.1.

3.7.4.9 The side plating and sheerstrake thickness of ships below 80 m in length shall be by 1 mm greater than required under 2.2.4.8.

3.7.4.10 When determining the requirements for sternframe scantlings of ships having the length $L < 60$ m, the design length and width of a solid rectangular propeller post are to be those stipulated under 2.10.4.3, as increased by 10 per cent.

3.7.4.11 The member scantling in side and longitudinal webs of superstructure of ships mooring at sea.

.1 Main frames in A1, E1, E2 regions of strengthening where no panting frames are fitted are not to have section modulus, in cm^3, less than determined by the formula

$$W = pal^2 \cdot 10^3 \omega_k / (mk_n R_{eH}), \quad (3.7.4.11.1)$$

where $m = 6{,}8k_1k_2k_3l^2 / (l - 0{,}75)$;

k_1 – factor which adopted from Table 3.7.4.11.1 proceeding from the number of load distributing side stringers fitted in frame span and their scantlings (where intermitted stringers are fitted or where no stringers are fitted $k_1 = 1$).

k_2 – factor proceeding from the number of load distributing side stringers fitted in frame span and their continuous level:

1,0 – where intermitted stringers are fitted or where no stringers are fitted;

1,12 or 1,5 – where one or two and more continuous stingers are fitted respectively;

k_3 – factor proceeding from level of frame curvilinear, which determined by the Formulae:

where intermitted stringers are fitted or where no stringers are fitted

$$k_3 = 1{,}0 + 6{,}8\sqrt{f(f/l + 0{,}28)/l} - 12{,}5 f_1 / l;$$

where one or two and more continuous stingers are fitted

$$k_3 = 1{,}0 + 7{,}0f / l - 8{,}0f_1 / l;$$

f – distance, in m, between a section at the lower support of frame and a tangent to the frame contour in way of the section at the upper support, as measured normal to the tangent (refer to Fig. 3.7.4.11.1), in m;

f_1 – maximum deflection of frame according to Fig. 3.7.4.11.1, in m;

$k_n = 1{,}1$;

p – in accordance with 3.7.3.3;

l – frame span, in m, as measured along the chord between the upper edge of inner bottom plating or floor face plate and the lower edge of deck at side (side stringer where web frames are fitted).

Table 3.7.4.11.1

Height ratio of stringer and frame	k_1 where number of stringers is	
	1	2 and more
0,75	1,0+ +0,017l/a	1,1+ + 0,017l/a
1,00	1,0 + + 0,034l/a	1,1 + + 0,034l/a

.2 In between deck spaces and superstructures with exception of Al, El, E2 region of strengthening where no panting frames are fitted the section modulus of mane frames, in cm^3, is not to be less than determined by the formula

$$W = pal^2 \cdot 10^3 \omega_к / (mk_n R_{eH}) - \Delta W, \quad (3.7.4.11.2)$$

where $m = 1{,}63l / k_c$;

$k_c = k_5k_6 / k_2k_4$;

k_2 – factor which determined in accordance with Table 3.7.4.11.1;

k_4 – factor which determined in accordance with Table 3.7.4.11.2-1 proceeding from the number of stringers, n_c fitted in frame span and their scantlings;

k_5 – actor which determined in accordance with Table 3.7.4.11.2-2 proceeding from the region of strengthening; in all cases $k_5 \geq 1{,}0$;

k_6 – factor equal to:

1,0 – for A2-A7, E5 and E6 region of strengthening;

1,3 – for E3 i E4.

$k_n = 1{,}1$;

p – in accordance with 3.7.3.3;

l – frame span, in m, as measured along the chord between deck platings;

$$\Delta W = k_c(2{,}9 + l)s^2 R^0_{eH} / (2R_{eH});$$

s – shell plating thickness, in mm;

R^0_{eH}, R_{eH} – yield stress of material for shell plating and framing.

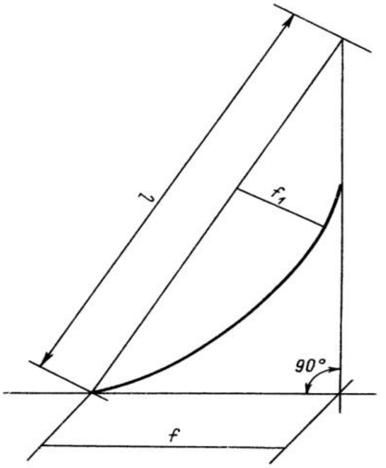


Fig. 3.7.4.11.1

Таблиця 3.7.4.11.2-1

Height ratio of stringer and frame [1]	factor k_4 [2]
0,75	$8{,}6 - l + 1{,}1n_c / a$
1,0	$8{,}6 - l + 2{,}2n_c / a$
> 1,0	$8{,}6 - l + 2{,}2W_c n_c / (aW)$

Symbols in Table 3.7.4.11.2-1:

W_c – the section of modulus of stringer, in cm^3;

n_c – number of load distributing side stringers fitted in frame span;

W – the section of modulus of main frame, in cm^3;

[1] the liner interpolation is used for intermediate values.

[2] $k_4 = 8{,}6 - l$ – where intermitted stringers are fitted or where no stringers are fitted.

Table 3.7.4.11.2-2

Region of strengthening	factor k_5
A2, A5,E3, E5	$2a$
A3, A6, E4, E6	$2a - 0{,}2$
A4, A7	$2a - 0{,}1$

.3 In changeable waterlines region where platting frames are witted and their end attachments are satisfied with 2.5.5 or 3.7.2.9.6 the section modulus of main frames sectional area is not to be less than

in zone of changeable waterlines

$$W' = W / (1 + 0{,}75k_7k_8), \quad (3.7.4.11.3.1)$$

where W – section modulus of main frame in accordance with 3.7.4.11.1 або 3.7.4.11.2;

k_7 – 1,0 i 0,69, if end attachment of platting frames are satisfied with 2.5.5 and 3.7.2.9.6 respectively;

k_8 – factor which taken from Table 3.7.4.11.3 1 proceeding from the number of stringers fitted in frame span (where intermitted stringers are fitted or where no stringers are fitted $k_8 = 1{,}0$);

a_1 – distance between main and platting frames;

in 'tween deck spaces and superstructures

$$W' = Wk'_5 / [k_5(1 + 0{,}38k_6k'_5)], \quad (3.7.4.11.3.2)$$

where k_5 i k_6 – factor in accordance with 3.7.4.11.2;

k'_5 – factor which determined in accordance with Table 3.7.4.11.2-2, for $a = a_1$.

The section modulus of platting frames sectional area is not to be less than $0,75W'$.

Table 3.7.4.11.3

Number of stringers fitted in frame span	k_8 where (l / a_1)[1], which equal to							
	5	10	15	20	25	30	35	≥ 40
1	0,77	0,71	0,80	1,0	1,0	1,0	1,0	1,0
2	0,75	0,65	0,58	0,59	0,61	0,70	0,82	1,0

[1] the linear interpolation is used for intermediate values.

.4 If longitudinal framing system is applied for 'tween deck spaces, the section modulus, in cm^3, of side longitudinals is not to be less than determined by the formula

$$W = 24pal^2\omega_k / R_{eH}, \qquad (3.7.4.11.4)$$

where p – in accordance with 3.7.3.3.

.5 In strengthened regions, the side plating and sheerstrake thickness, in mm, shall not be less than

$$s = 21{,}7\,a\sqrt{p/(k_n R_{eH}) - 0{,}242} + \Delta s, \qquad (3.7.4.11.5)$$

where a – spacing, in m, of frames; spacing of main and platting frames where platting frames are fitted;

p – in accordance with 3.7.3.3;

$k_n = 1{,}1$;

Δs = 4,0 мм – where side under consideration is used for trawling;

Δs = 1,2 mm – or A2-A7, E3-E6 regions of strengthening;

Δs = 3,0 mm – in other cases.

.6 Where superstructure sides of ships mooring at sea are inclined to the centre line at not less than 1/10 or fitted inboard at not less than 1/10 of their height, no additional strengthening as per 3.7.4.11.2, 3.7.4.11.3 and 3.7.4.11.5 is required.

Where the inclination of superstructure sides to the vessel side or the distance between those and the vessel side is less than specified above, the strengthening of their frames and shell plating shall be determined by linear interpolation proceeding from the requirements of 3.7.4.11.2, 3.7.4.11.3, 3.7.4.11.5 і 2.2.4.1, 2.5.4.2.

3.7.4.12 The vertical web plate thickness of coamings not acting as deck girders is not to be less than the deck plating thickness, or 7 mm, whichever is greater.

3.7.4.13 The member scantlings in the ice strengthened regions of fishing vessels of ice class Ice3 which are intended for systematic operation in ice conditions shall be determined in accordance with 3.10.4 where the ice load parameters are as stipulated in 3.7.3.4, bearing the following specification in mind. When determining shell plating thickness in the intermediate region of ice strengthening in accordance with 3.10.4.1, the annual average thickness reduction of shell plating as a result of corrosion wear and abrasion shall be adopted as: u = 0,25 mm/year.

3.7.5 Special requirements.

3.7.5.1 In way of heavy items of machinery and equipment installed in fish handling spaces, extra strengthening of'tween deck sides may be required by the Register where the 'tween deck height exceeds 3,5 m.

3.7.5.2 In holds and fish handling spaces in which non-packed salted catch or salt is stored or which are exposed to the detrimental effect of catch wastes and sea water, the plating thickness is to be increased by 1 mm as compared to that required by the relevant sections of the Rules. Where the structure is so influenced from both sides, relevant thickness is to be increased by 2 mm.

3.8 SUPPLY VESSELS

3.8.1 General.

3.8.1.1 The requirements of this Chapter apply to supply vessels. Structural items not covered by this Chapter shall comply with the requirements of Sections 1 and 2.

3.8.2 Construction.

3.8.2.1 onstruction. 3.8.2.1 Provision shall be made for longitudinal fenders. A t the fore end sloped fenders shall be fitted between the longitudinal fenders.

3.8.2.2 Inner bulwarks (coamings) and other similar structures protecting deck cargoes shall be properly secured to deck framing members. The scantlings of the above structures shall be agreed with the Register.

3.8.2.3 Shell in way of stern rollers and in other high load areas shall be suitably reinforced.

3.8.2.4 In deck areas where concentrated loads are applied (e.g. MOD U anchors), extra strengthening of decks shall be provided.

3.8.2.5 The sides of superstructures and the bulwark shall be inclined to the centre line of the vessel at not less than one-tenth or shall be fitted inboard from the vessel's side at not less than one-tenth of their height.

3.8.2.6 The lower ends of stiffeners of the firsttier front bulkheads shall be connected to the underdeck framing members by brackets. The lower ends of other stiffeners shall be welded to the decks. The upper ends of stiffeners shall be connected to the deck beams by means of brackets.

3.8.2.7 The stay of the bulwark welded to the sheerstrake shall be so constructed as to prevent damage of deck plating is case of bumping.

3.8.2.8 Extra strengthening of a flat portion of the bottom in way of the stern may be required to take up loads induced by slamming.

3.8.3 Design loads.

3.8.3.1 Design loads on hull structures of supply vessels shall be taken in compliance with Sections 1 and 2.

3.8.4 Scantlings of structural members.

3.8.4.1 The thickness of the side shell plating shall be 1 mm greater than required by 2.2.4. In no case the thickness of the side shell plating shall be taken less than 9,0 mm.

3.8.4.2 The thickness of open cargo deck plating shall be determined from 2.6.4, but it shall not be less than 8,0 mm.

3.8.4.3 The scantlings of open cargo deck framing members shall be obtained as required by 2.6.4 with a design load corresponding to the specified value but not less than 35 kPa.

3.8.4.4 The scantlings of girders and pillars supporting these girders shall be suitable for the weight of the deck cargo, as well as for loads induced by towing winches, supports of separate cargo platforms and other concentrated loads. Account shall be also taken of a vertical and a horizontal components of inertia forces due to the vessel's motions. As the first approximation, accelerations determined according to 1.3.3 may be used.

3.8.4.5 The section modulus of hold, ‘tween deck and forecastle frames shall not be less than determined according to (3.7.4.11-2) with p to be determined by Formula (3.7.3.3), α_1 = 1,16 і α_2 = 1,0. Facctors α_3, β_1 and β_2 are taken fron Table3.7.3.3-3 as for A1 region.

3.8.4.6 The section modulus of stiffeners of the fronts, sides and after ends of the deckhouses situated on the forecastle deck shall be not less than that required by 2.12.4.5.2.

The assumed head$p$, in kPa, shall not be taken less than given in 3.8.4.6.

Table 3.8.4.6

Deckhouse tire	p, in kPa		
	Front bulkhead	Side bulkhead	After bulkhead
First	90	60	25
Second and above	75	50	25

3.8.4.7 The plate thickness of the fronts, sides and after ends shall be taken not less than 6,5 mm for the first-tier front bulkhead and 6,0 mm for other bulkheads. These values are applicable in case of stiffener spacing 0,6 m. For stiffener spacings exceeding 0,6 m the thickness shall be increased in proportion to the increased spacings.

3.8.4.8 The plate thickness of the bulwark shall be at least 7 mm, and the width of the stiffener lower end measured along the weld shall be not less than 360 mm. The distance between stays shall not exceed two spacings or 1,3 m, whichever is the lesser.

3.8.5 Special requirements.

3.8.5.1 In vessels having a double skin construction, structures and scantlings of the inner skin framing shall comply with 2.5. Where the forces acting on the frames may be directly transmitted to the inner skin framing, the scantlings of these members shall be specially considered by the Register.

3.8.5.2 Scallops and one-sided welds shall not be used in framing-to-side-shell-plating connections.

3.9 TUGS

3.9.1 General and symbols.

3.9.1.1 The requirements of this Chapter apply to all tugs irrespective of purpose or service area.

3.9.1.2 Structural items not covered by this Chapter shall comply with the requirements of Sections 1 and 2.

3.9.1.3 Symbols:

b_s – width of stem cross section, in mm;

l_s – length of stem cross section, in mm.

3.9.2 Construction.

3.9.2.1 Plate floors shall be fitted at each frame.

Where the double bottom is omitted, the floors shall have a symmetrical face plate.

3.9.2.2 Where a main frame span exceeds 3,0 m, load distributing side stringers shall be fitted along the length of the ship except for the engine room.

3.9.2.3 In the engine roonm web frames shall be fitted between the inner bottom (floor face plates) and the upper deck at a distance not exceeding four spacings. Web frames shall be fitted at main engine ends.

3.9.2.4 A fender shall be fitted at upper deck and long forecastle deck level.

3.9.2.5 Areas to which concentrated loads are applied (e.g. due to towing winches) shall be additionally strengthened.

3.9.2.6 The stems of harbour tugs shall have rounded shape above the summer load waterline.

3.9.3 Design loads.

Design loads on hull structures of tugs shall be assumed in compliance with the requirements of Sections 1 and 2.

3.9.4 Scantlings of structural members.

3.9.4.1 The minimum plating thickness of shell and upper deck as well as of watertight bulkheads shall not be less than 5 mm.

3.9.4.2 The thickness of shell plating adjacent to the stem shall not be less than stipulated under 2.2.4.6.

The shell plating thickness in way of the engine room, when located aft, shall not be less than required for the midship region.

3.9.4.3 When determining the section modulus of the web frames in accordance with 2.5.4.7.1 the distance measured from the inner bottom plating (floor upper edge) and the upper deck at side shall be taken as the design span.

3.9.4.4 The scantlings of load distributing side stringers shall be determined in accordance with 2.8.2.7.

3.9.4.5 Within the region from the keel to the summer load waterline, the cross-section of a rectangular solid bar stem shall not be less than:

$$l_s = 1,6L + 100; \qquad (3.9.4.5\text{-}1)$$

$$b_s = 0,5L + 25. \qquad (3.9.4.5\text{-}2)$$

The scantlings and location of brackets for strengthening the stem shall be determined proceeding from 2.10.4.2.

The stem shall be extended abaft the fore peak bulkhead for not less than three spacings.

Ship-handling tugs are not permitted to have reduced cross-section and scantlings of the stem (if constructed of steel plates) above the summer load waterline.

The steel plates of the stem shall be strengthened over their length with horizontal brackets spaced not more than 0,6 m apart, the plate thickness of the stem determined in accordance with 2.10.4.2 being not reduced.

3.9.4.6 Rectangular solid propeller posts shall have scantlings from the keel to the counter not less than:

$$l_s = 1,5L + 100; \qquad (3.9.4.6\text{-}1)$$

$$b_s = 1,8L + 25. \qquad (3.9.4.6\text{-}2)$$

The sternframe shall be attached according to 2.10.2.3 to two floors, whatever the length of the tug may be.

3.9.4.7 The thickness of the bulwark plating shall be taken according to 2.14.4.1, but not less than 4 mm.

Bulwark stays shall be fitted not farther than at alternate frames. The bulwark shall be inclined to the centre line of the vessel at not less than 7°. Bulwark stays welded to the sheerstrake plate may have a flexible element in their structure.

3.9.5 Special requirements.

3.9.5.1 For unrestricted service tugs above 40 m in length, the number of watertight bulkheads shall be not less than four.

3.9.5.2 For tugs ice-strengthening refer to 3.12.

3.10 STRENGTHENING OF ICE CLASS SHIPS AND ICEBREAKERS

3.10.1 General and requirement.

3.10.1.1 Application.

.1 The requirements of this Chapter apply to self-propelled ice class ships and icebreakers, as well as to ships which may be given the same status proceeding from the conditions of their ice navigation.

.2 Self-propelled ice-strengthened ships which comply with the requirements of this Chapter are assigned an ice class mark in their class notation in accordance with 2.2.3, Part I "Classification".

.3 Requirements of this Chapter are supplementary with regard to those of other Chapters of the Rules which apply to a particular ship, and they establish the minimum strength level necessary to withstand ice loads, as well as hull structure, proceeding from the ice class mark in the class notation.

.4 The calculation procedures of this Chapter are directly applicable to those ice class ships and icebreakers only which have a standard hull form and which comply with the requirements of 3.10.1.4. The possibility of deviation from the requirements of 3.10.1.4, as well as of using bow lines (spoon-like, multi-plane) other than standard ones, is subject to special consideration by the Register.

3.10.1.2 In the Rules, an assumption is made that during service the shipowner will be guided the recommendations contained in the Ice Navigation Ship Certificate issued by the Register upon shipowner's request and specifying the conditions of ship safe operation in ice depending on the ice class mark, the ship's specific features, ice conditions and icebreaker support.

Ships intended for service in ice regions using method of pushing by icebreaker are to have higher level of strengthening. The boundaries of strengthening regions are to be taken as for icebreaker which power is equal to the sum of icebreaker power and transport ship and ice load level is subject to special consideration by the Register.

3.10.1.3 Symbols:

a – spacing of deep members measured along shell plates in accordance with 2.1.2;

l – the span of members under consideration, in accordance with 1.6.3.1;

i – actual moment of inertia of frame, in cm^4;

I – actual moment of inertia of web frame, in cm^4;

Δ – displacement, to the level of summer load waterline, in t;

ω_k – factor taking into account corrosion and deterioration allowance with regard to members section modulus, refer to 1.1.5.3;

j_k – factor taking into account corrosion and deterioration allowance with regard to moment of inertia of frame, refer to 1.1.5.3;

n – number of frames between web frames;

Δs – corrosion and deterioration allowance with regard to the plate thickness in accordance with 1.1.5.1 if there are no special notations in this Part.

3.10.1.4 The hull configuration parameters of ice class ships shall comply with the following requirements:

.1 The hull configuration parameters of ice class ships shall be within the limits stated in Table 3.10.1.4.1.

The hull configuration parameters, shall be measured in conformity with Figs. 3.10.1.4-1–3.10.1.4-4.

.2 In ships of categories **Ice6** and **Ice5** bulbous bow is not permitted. In ships of category **Ice4** this kind of bow is subject to special consideration by the Register.

.3 In the forward and intermediate region of ice strengthening of **Ice6**, **Ice5**, **Ice4** category ships and icebreakers, there are to be no areas of shell plating within which the configuration parameters β and α would simultaneously take the values β = 0 and α > 0.

.4 In the afterbody of **Ice6**, **Ice5** i **Ice4** category ships, provision should be made for an appendage (ice knife) aft of the rudder to protect the latter on the sternway. Gap between ice knife and rudder is not to be greater than 100 mm.

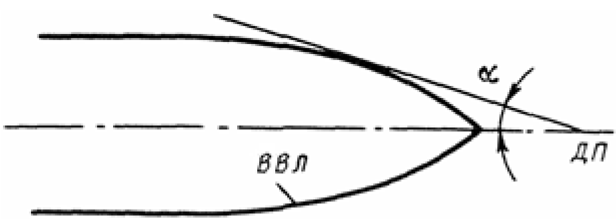


Fig.3.10.1.4-1
α – slope of summer load waterline at the section considered, in deg

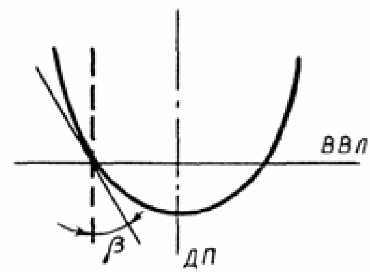


Fig.3.10.1.4-2
β – slope of frame on the level of summer load waterline at the section considered, in deg

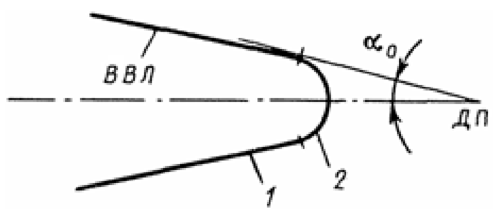


Fig.3.10.1.4-3
α_o – slope of summer load waterline at the fore perpendicular, in deg.; 1 — shell plating; 2 — stem

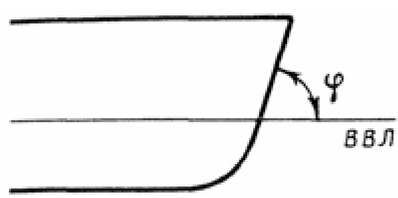


Fig.3.10.1.4-4
φ – slope of stem on the level of summer load waterline, in deg

.5 No transom stern (with the transom coming in the region of ice strengthening) is permitted for **Ice6** category ships. For **Ice5** i **Ice4** category ships having a transom stern, the value of ice loads upon the transom is subject to the special consideration of the Register.

.6 For **Ice6** category ships, provision should be made for a step in the lower part of the stem. The height of the step is to be 0,1 *d* at least. The transition from the step to the lower part of the stem should be smooth.

3.10.2 Structure.

3.10.2.1 The length and scantling of ice strake is to be determined in accordance with Fig. 3.10.2.1 and Tables 3.10.2.1-1 and 3.10.2.1-2

Ice loadline in this case is to be determined taking into account all the ship loadlines possible during ice navigation.

3.10.2.2 The length of region of strengthening is to be determined on the basis of Fig.3.10.2.1 and Table 3.10.2.1-2.

If the value of $(b + L_3) > 0,25L$, it is possible to divide A region on forward and intermediate regions of strengthening which located between sectionals $b + L_3$ and $0,25L$ from fore perpendicular.

Table 3.10.1.4.1

Parametre	Category of ice strengthening			
	Ice6	**Ice5**	**Ice4**	**Ice3**, **Ice2** і **Ice1**
φ[1], but not more than	30	45	60	–
α_o, but not more than	30	40	40	50
β_o within $0,05L$ from fore perpedicular, but not less than	40	25	20	–

[1] Якщо форштевень має значну кривизну, він може бути представлений у вигляді прямої лінії, яка з'єднує точку перетинання форштевня з верхньою межею льодового пояса і точку перетинання форштевня з лінією, яка є продовженням нижньої межі льодового пояса у середньому і кормовому районах підсилень до носа (точку, віддалену на висоту h_4 від основної площини, див. рис.3.10.2.1).

Якщо форштевень характеризується значною різницею в кутах нахилу його ділянок до горизонталі, як φ береться найбільший з цих кутів. Для суден, які мають носовий бульб, кут нахилу φ підлягає спеціальному розгляду Регістром.

3.10.2.3 Sides with transverse framing are to comply with the following requirement:

.1 The end attachments of main frames which are fitted in floors or margin bracket plate are to comply with the requirements of 2.5.5.

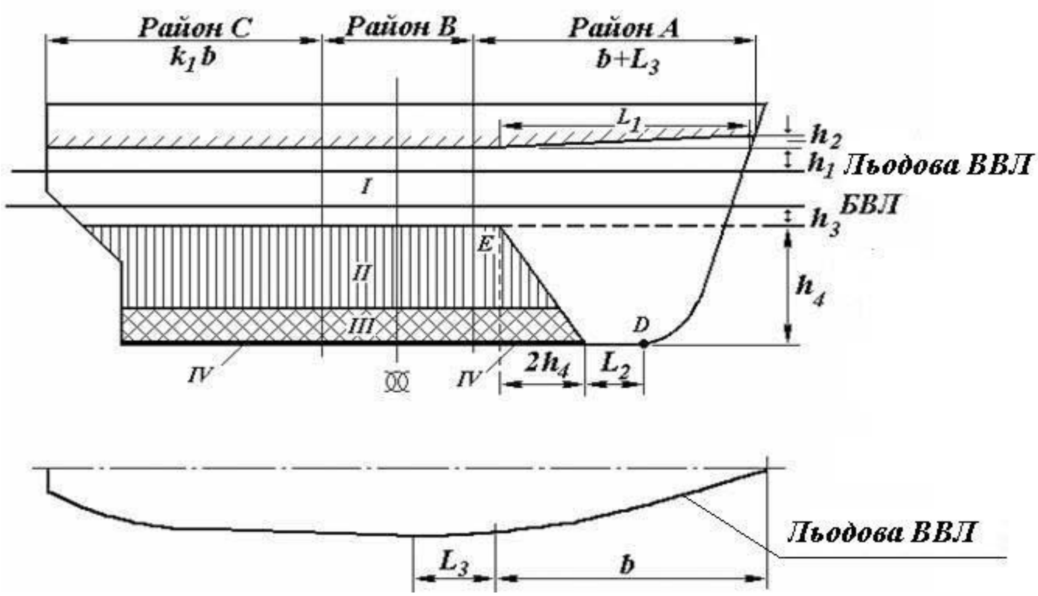
.2 In **Ice6** and **Ice5** category ships, frames are to be attached to decks and platforms with brackets; if a frame is intercostal in way of deck, platform or side stringer, brackets are to be fitted on both sides of it.

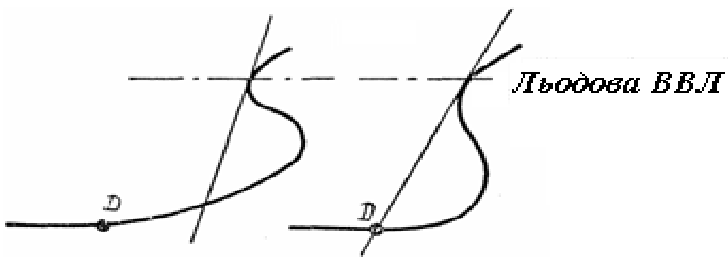
.3 In **Ice6**, **Ice5** and **Ice4** category ships, the bottom ends of intermediate frames which are not fitted in floors or margin bracket plate are to be secured at margin plate stiffened with a bracket or with (refer to Fig.1.7.1.4). Where double bottom is omitted the bottom ends of intermediate frames are to be secured with longitudinal intercostal members which are fitted not higher than the floor face-plate level.

In **Ice3** and **Ice2** category ships bottom ends of frames which are not fitted in floors or margin bracket plate can be allowed to extend as far as intercostal structure which are lilted 1000 mm beneath the lower boundary of region I. It is not allowed to snipe the ends of frames.

In **Ice6** and **Ice5** category ships, the upper ends of intermediate frames are to be secured on a deck or platform lying above the upper boundary of region I. In ships of other categories the upper ends of intermediate frames may be secured in way of an intercostal longitudinal fitted 500 mm above the upper boundary of region I.

.4 In **Ice6**, **Ice5** and **Ice4** category ships side stringers should be fitted, **the** distance between which or the stringer-to-deck or platform distance is not to exceed 2 m for ships without deep framing and 2,5 m for ships with deep framing, as measured on a chord at side. In **Ice3** and **Ice2** category ships not more than two stringers may be fitted.





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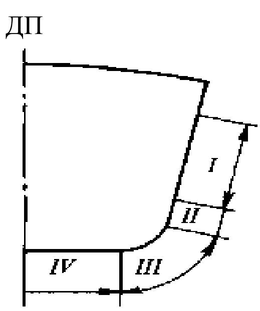


	I – Ice strake in the region of alternating drafts;
	II – from the lower boundary of region I to the upper boundary of region III;
	III – bilge strake;
	IV – from the lower boundary of bilge strake to centre plane.

Fig.3.10.2.1. Regions of ice strengthenings

N o t e s .

1. Point E is not to be further than the aft boundary of the region A.

2. *b* – distance between fore perpendicular and section where ice loadline is the widest, but not more than 0,4*L*.

3. For **Ice1** category ships, the lower boundary of the region A is by h_3 distant from the ballast waterline.

Table 3.10.2.1-1

Ice category	Vertical regioning											
	I			II			III			IV		
	Horizontal regioning											
	A	B	C	A	B	C	A	B	C	A	B	C
Ice6	+	+	+	+	+	+	+	+	+	+		+
Ice5	+	+	+	+	+	+	+	+		+		
Ice4	+	+	+	+	+		+					
Ice3	+	+	+	+								
Ice2	+	+	+									
Ice1	+											

N o t e . proceeding from the ice category, the requirements of the Chapter apply to the regions of ice strengthening marked with "+".

Table 3.10.2.1-2

Region	Extension depending on ice category					
	Ice6	**Ice5**	**Ice4**	**Ice3**	**Ice2**	**Ice1**
h_1, m ($B \le 20$ m)	0,75	0,75	0,60	0,50	0,50	0,50
h_1, m ($B > 20$ m)	$\frac{0,5B+8}{24}$	$\frac{0,5B+8}{24}$	$\frac{0,5B+8}{30}$	$\frac{0,5B+8}{36}$	$\frac{0,5B+8}{36}$	0,50
h_2, m ($L > 120$m)	$L/160$	$L/160$	$L/200$	$L/240$	$L/240$	–
L_1, m ($L > 120$m)	$0,5L – 60$	$0,5L – 60$	$0,5L – 60$	$0,5L – 60$	$0,5L – 60$	–
h_3, m	$1,6h_1$	$1,35h_1$	$1,20h_1$	$1,1h_1$	h_1	0,50
L_2, m	$0,15L$	$0,10L$	$0,05L$	$0,05L$	$0,02L$	–
L_3, m	$0,06L$	$0,05L$	$0,05L$	$0,04L$	$0,02L$	–
k_1	0,84	0,69	0,55	0,53	0,50	–

.5 Side stringers are to be fitted in the loadline and ballast water line regions. If there is a deck or platform lying on the same level, the side stringer may be omitted.

.6 Continuity of the face plates of stringers is to be secured in **Ice6**, **Ice5** and **Ice4** category ships.

.7 Side stringers are to be attached to transverse bulkhead with brackets (refer to 2.8.2.6).

3.10.2.4 Sides with longitudinal framing are to comply with the following requirement:

.1 In **Ice6**, **Ice5**, **Ice4** category ships where the spacing of frames is greater than 1,2 in, additional frames should be fitted.

Additional web frames is to be extended over boundary of region 1 not less than 1000 mm, their ends are to be secured in accordance with 3.10.2.3.3.

.2 Longitudinals which are intercostal in way of plate structures in every longitudinals plane should be fitted brackets on both sides of the plate structure, and the webs of the longitudinals should be welded to the plate structure.

3.10.2.5 Transverse bulkhead are to comply with the following requirements:

.1 Fore peak bulkheads and after peak bulkheads are to be plane. It is not permitted to use corrugated bulkheads with vertical corrugation at full length of **Ice6** category ships and in A region of **Ice5** category ships.

.2 In **Ice5** and **Ice4** category ships where corrugated bulkheads are fitted, plane spaces of bulkheads with breadth not less than 1,2 mm are to be stipulated for sides.

.3 The requirements for plate structures (refer to 3.10.2.7) apply to following regions:

fore peak and after peak bulkheads of **Ice6** and **Ice5** category ships throughout their breadth; for ships of other categories, on a breadth of 1,2 m from the shell plating;

other bulkheads of **Ice6** and **Ice5** category ships on a breadth of 1,2 m from the shell plating, of **Ice4**, **Ice3**, **Ice2** category ships on a breadth of 0,6 m from the shell plating.

3.10.2.6 Decks and platforms are to comply with the following requirements:

.1 In **Ice6**, **Ice5** and **Ice4** category ships decks and platforms within the region of 1,2 breadth from side are to be reinforce by beams which fitted at distance of not more than:

spacing of framing girders of **Ice6** category ships;

spacing of floors or margin brakes of **Ice5** and **Ice4** category ships.

Where longitudinal framing is used beam ends are to be welded to the nearest longitudinal underdeck member. Where transverse framing is used beam ends are to be ended on intercostal longitudinals.

.2 The frame on whose plane no girder is fitted in **Ice5** category ships are to be secured to the plate structure with brackets which are to terminate on the intercostal stiffener (refer to 1.7.1.4).

.3 Where longitudinal framing is used for sides, the girders should be attached with brackets reaching as far as the nearest longitudinal.

3.10.2.7 Plate structures are to comply with the following requirements:

.1 The breadth of plate structure area, which are covered by the requirements 3.10 with the exception of cases stipulated in3.10.2.5 and 3.10.2.6 is not to be taken less than 0,6 m from shell plating.

.2 It is not allowed to reinforce plate structure by stiffeners fitted in parallel to the shell platting:

in **Ice6** category ships in all regions stipulated in Table 3.10.2.1-1;

in **Ice5** category ships I, II, AIII, AIV regions;

in **Ice4** category ships in I region.

Horizontal stiffeners which reinforced plate structure of **Ice6**, **Ice5** and **Ice4**, category ships are to be welded to side and secured with brackets reached as far as the nearest frame. The thickness of brackets is not to be less than stiffener plate thickness.

.3 The distance from the edge of opening or manhole is not to be less than:

0,5 m from shell plating;

the height of girder from the edge of opening for the passage of girder.

.4 The scantling of the smaller part of plate structure panel is not to be greater than following values:

for **Ice6** category ships in all regions stipulated in Table 3.10.2.1-1 = 0,6 m,

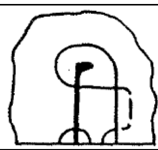
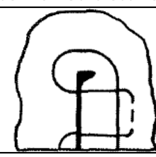
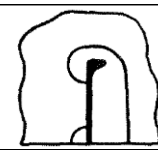
for **Ice5** category ships in A region,

for **Ice4** category ships in forepeak;

for **Ice5** category ships in other regions stipulated in Table 3.10.2.1-1 0,7 m and for **Ice4** category ships in region I**.**

.5 The requirements in accordance with 3.10.2.7.5 are put forward for the intersections (connections) of the plate structures and stiffener. Other structures, if found equivalent by the Register may be used.

Table 3.10.2.7.5

Ice category	Sketch of structure		
			
Ice6	Fore peak, region I, with longitudinal framing	Regions I (except fore peak), II, AIII, AIV, BIII	Інші райони згідно з табл.3.10.2.1-1
Ice5	Ditto	Regions I (except fore peak), II, AIII	Ditto
Ice4	–	Regions I, AII, AIII	Ditto
Ice3, **Ice2**, **Ice1**	–	–	in accordance with Table 3.10.2.1-1

.6 Strengthening of plate structure parts adjoined to shell plating are to recommend to execute in accordance with the Fig. 3.10.2.7.6.

3.10.2.8 Fore peak and after peak structure is to comply with the following requirements:

.1 category ships, platforms with lightening holes should be fitted instead of stringers and panting beams (refer to 2.8.2.3), the distance between platforms measured along a chord at side, is not to exceed 2,0 m. This structure is recommended for **Ice4** category ships as well**.**

.2 In the after peak of **Ice6** and **Ice5** category ships (see 2.8.2.10), side stringers and panting beams are to be fitted so that the distance between the stringers as measured along a chord at side, would not be greater than 2,0 m. Platforms with lightening holes are recommended instead of panting beams and stringers.

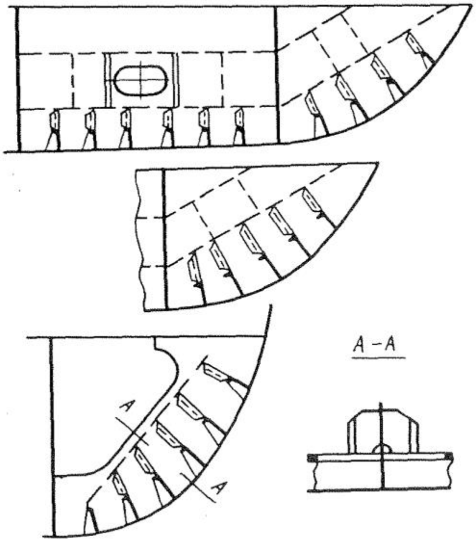


Fig.3.10.2.7.6

.3 In the fore peak and after peak, the free edges of side stringers are to be stiffened with face plates having a thickness not less than the web thickness and a width not less than ten thicknesses. The interconnections of frames with side stringers'are to be made so that the interconnections of frames with decks and platforms, and brackets should be carried to the face plates of the stringers.

3.10.2.9 Stems and sternframes are to comply with the following requirements:

.1 In **Ice6** category ships are to have a solid section stem made of steel (cast steel is recommended). In **Ice5**, **Ice4**, **Ice3**, **Ice2** and **Ice1** category ships, a stem of combined structure (a bar with thickened plates welded thereto) or plate structure may be used.

.2 In **Ice 5**, **Ice 4**, **Ice3**, **Ice 2**, **Ice 1** category ships where the ship length is under 150 m with a sharp-lined bow, the stem design shown in Fig.3.10.2.9.2may be used.

.3 In **Ice 6**, **Ice 5**, **Ice 4** category ships stem and adjacent to it structures in the region of touching with stern cut of icebreaker are to be strengthened using method approved by the Register.

.4 The stem is, where practicable, to be strengthened by a centre line web having its section depth equal to h_v at least (refer to Table 3.10.4.8.1) with a face plate along its free edge or a longitudinal bulkhead fitted on the ship centre line, on the entire stem length from the keel plate to the nearest deck or platform situated above the level referred to in 3.10.4.8.3.

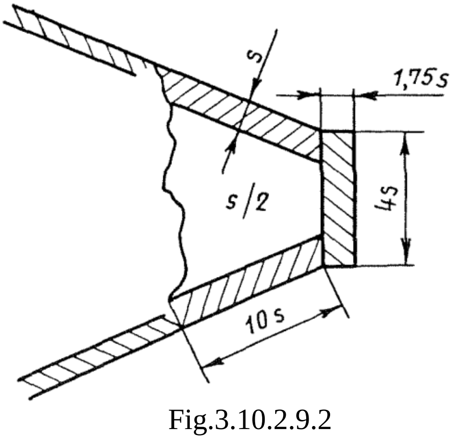


Fig.3.10.2.9.2

.5 Within the vertical extent defined in 3.10.2.9.4, the stem is to be strengthened by horizontal webs at least 0,6 m in depth and spaced not more than 0,6 m apart. The webs are to be carried to the nearest frames and connected thereto. Where in line with side stringers, the webs are to be attached to them. In stems of combined or plate type, the webs are to be extended beyond the welded butts of the stem and shell plating. Above the deck or platform located, by the value of H_1 (refer to Table 3.10.4.8.1) at least, higher than the upper boundary ice strike, the spacing of horizontal wobs may gradually increase to 1,2 m in **Ice6** category ships, and to 1,5 m in ships of other categories.

In **Ice6**, **Ice5** and **Ice4** category ships, the free edges of webs are to be strengthened with face plates welded to the frames at their ends.

In case of a full bow, vertical stiffeners may be required additionally to be fitted to the stem plates.

.6 The sternframes of **Ice6** and **Ice5** category ships, are to be made of forged or cast steel. In **Ice4**, **Ice3**, **Ice2** and **Ice1** category ships sternframes of combine structure are admissible.

3.10.3 Ice load calculation.

3.10.3.1 For ice class ships, the ice pressure *p*, in kPa, is to be determined from the formulae below.

.1 In region AI:

$$p_{AI} = 10\ a_1\ (a_2 + a_3\ \Delta/1000)\ \Delta^{1/6}\ v, \qquad (3.10.3.1.1)$$

where a_1 – factor to be adopted from Table 3.10.3.1.1-1 proceeding from the ice category;

a_2, a_3 – factor to be adopted from 'fable 3.10.3.1.1-1 proceeding from displacement Δ;

v – value of the shape factor v, which is the maximum one for the AI region, as determined at sections within 0,05*L*, 0,1*L* etc. from the forward perpendicular on ice loadline level. The value should be determined by the formulae below:

$$v = (0{,}278 + 0{,}18x/L)\sqrt[4]{\alpha^2/\beta},$$

where $x/L \le 0{,}25$;

$$v = (0{,}343 - 0{,}08x/L)\sqrt[4]{\alpha^2/\beta},$$

where $x/L > 0{,}25$,

the value v is not to be taken more than 0,72;

x/L – relative distance (from forward perpendicular) of considered section.

Table 3.10.3.1.1-1

Factor	Ice category					
	Ice6	**Ice5**	**Ice4**	**Ice3**	**Ice2**	**Ice1**
a_1	1,00	0,51	0,38	0,31	0,26	0,21

At the same time the intensity of ice load in the region AI is not to be less than given in the Table. 3.10.3.1.2-2.

Table 3.10.3.1.1-2

Factor	Displacement, in t		
	< 10000	10000 – 20000	> 20000
a_2	78	117	150
a_3	5,6	1,7	0

Ice category for isolated intermediate region is not to be less than $0{,}75p_{AI}$.

For **Ice6**, **Ice5** та **Ice4** category ships with actual power of main engines P_M more than P_{min} required by 1.4.1 of Part VII "Machinery Installation", the ice pressure is to be increased pro rata $(P_{факт} / P_{min})^{1/6}$.

.2 In region BI:

$$p_{BI} = p_{AI}\ (a_4 - a_5\ \Delta / 1000), \qquad (3.10.3.1.2)$$

where for p_{AI} – refer to 3.10.3.1.1;

for a_4, a_5 – refer to Table 3.10.3.1.2-1.

.3 In regiCI:

$$p_{CI} = a_6\ p_{BI}, \qquad (3.10.3.1.3)$$

where for p_{BI} – refer to 3.10.3.1.2.

a_6 – factor to be adopted from Table 3.10.3.1.3 proceeding from the ice category.

In all cases the ice pressure in region CI is not to be greater than $0{,}75p_{AI}$, where for p_{AI} refer to 3.10.3.1.1.

.4 In regions II, III i IV the ice pressure is determined as a part of the ice pressure in region I at the appropriate section of the ship length (refer to Table 3.10.3.1.4).

Table 3.10.3.1.2-1

Ice category	Factors	Displacement, in t	
		≤ 10000	> 10000
Ice6, **Ice5**	a_4	0,750	0,50
	a_5	0,025	0
Ice4	a_4	0,600	0,45
	a_5	0,015	0
Ice3	a_4	0,500	0,35
	a_5	0,015	0
Ice2	a_4	0,400	0,25
	a_5	0,015	0
Ice1	–	–	–

Table 3.10.3.1.2-2

Ice pressure, in kPa	Ice category					
	Ice6	**Ice5**	**Ice4**	**Ice3**	**Ice2**	**Ice1**
p_{AI}	1300	750	600	400	350	–

Table 3.10.3.1.3

Factor	Ice category					
	Ice6	**Ice5**	**Ice4**	**Ice3**	**Ice2**	**Ice1**
a_6	1,40	1,00	0,80	0,64	0,50	–

3.10.3.2 The vertical distribution of ice pressure.

Design vertical distribution of ice pressure b, in m, is not to be given less than determined by the formulae.

In region A:

$$b_A = c_1 u, \quad (3.10.3.2\text{-}1)$$

де c_1 – factor to be adopted from Table 3.10.3.2-1 proceeding from the ice category;

u – maximum value of the shape factor for the A region, to be determined in sections within 0,05L, 0,1L etc. from forward perpendicular at ice The value should be determined by the formulae:

$$u = (0{,}635 + 0{,}61x/L)\sqrt{\alpha/\beta},$$

where $x/L \le 0{,}25$;

$$u = (0{,}862 - 0{,}30x/L)\sqrt{\alpha/\beta},$$

where $x/L > 0{,}25$,

he value u is not to be taken more than 0,8;

for x/L – refer to 3.10.3.1.1.

In regions B and C:

$$b_B = b_C = c_4(c_2 + c_3\Delta/1000), \quad (3.10.3.2\text{-}2)$$

wfere for c_4 – refer to Table 3.10.3.2-2;

for c_2, c_3 – refer to Table 3.10.3.2-3.

3.10.3.3 Ice loads on edges of plate structure

In I and II regions ice loads q, in kN/m, on edges of plate structures are to determined by the formula

$$q = pb, \quad (3.10.3.3)$$

where p and b in accordance with 3.10.3.1 and 3.10.3.2

In III and IV regions ice loads q, in kN/m, on edges of plate structures are to determined as part of Ice loads on edges in I region in accordance with Table 3.10.3.1.4.

Table 3.10.3.1.4

Ice category	Ice pressure, in %											
	A region				B region				C region			
	AI	AII	AIII	AIV	BI	BII	BIII	BIV	CI	CII	CIII	CIV
Ice6	100	65	65	50	100	50	50	–	100	50	40	20
Ice5	100	65	65	45	100	50	40	–	100	50	–	–
Ice4	100	50	40	–	100	40	–	–	100	–	–	–
Ice3	100	40	–	–	100	–	–	–	100	–	–	–
Ice2	100	–	–	–	100	–	–	–	100	–	–	–
Ice1	100	–	–	–	–	–	–	–	–	–	–	–

Table 3.10.3.2-1

Factor	Ice category					
	Ice6	**Ice5**	**Ice4**	**Ice3**	**Ice2**	**Ice1**
c_1	1,10	0,80	0,75	0,70	0,70	0,70

Table 3.10.3.2-2

Factor c_4	Angle of side slope amidships, in deg									
	≤ 6	8	10	12	14	16	18	20	22	24
	1,00	0,81	0,68	0,54	0,52	0,47	0,44	0,41	0,40	0,39

Table 3.10.3.2-3

Ice category	Factor	Displacement, in t		
		<10000	10000 -20000	>20000
Ice6	c_2	0,600	0,700	1,00
	c_3	0,025	0,015	0
Ice5	c_2	0,550	0,650	0,85
	c_3	0,020	0,010	0
Ice4	c_2	0,500	0,600	0,80
	c_3	0,020	0,010	0
Ice3	c_2	0,400	0,500	0,70
	c_3	0,020	0,010	0
Ice2	c_2	0,300	0,400	0,60
	c_3	0,020	0,010	0
Ice1	–	–	–	–

3.10.4 Scantlings of ice-strengthening structures.

3.10.4.1 Shell plating is to comply with the following:

.1 In regions of ice strengthening, the shell plating thickness s, in mm, shall not be less than determined by the formula

$$s = 18{,}4a\sqrt{p/R_{eH}} + \Delta s \quad (3.10.4.1.1)$$

де p – ice pressure in the region under consideration according to 3.10.3.1, in kPa;

Δs – shell plating deterioration in the middle of service term (див.1.1.5.1).

Annual reduction of shell plating thickness is not to be less than:

for **Ice6** category ship = 0,4 mm per year;

for **Ice5** category ship = 0,3 mm per year;

for **Ice4** category ship = 0,25 mm per year.

For **Ice3**, **Ice2** та **Ice1** category ship - in accordance with 1.1.5.

.2 For **Ice4** and **Ice3** category ship the thickness of shell plating in ice strengthening region is not to be less than 10 mm.

3.10.4.2 The section modulus W_f, in cm^3, of frame is not to be less than given by the formula

$$W = 10kabl\,p\omega_k / R_{eH}, \quad (3.10.4.2\text{-}1)$$

where b – In accordance with 3.10.3.2 for considered region;

p – ice pressure for considered region in accordance with 3.10.3.1;

k – factor which determined in the following way:

for frames where there are no deep frames in framing system and more than a half of frame span is bridged by ice strengthening region

$$k = k_o\,(1 - 0{,}7b/l)\,\varphi_1, \quad (3.10.4.2\text{-}2)$$

where for k_o – refer to Table3.10.4.2-1;

φ_1 – 1,0, where every frame in lower span adjacent to considered one are continued to deck, platform or double bottom as well as for hold frame. In all other cases φ_1 is to be in accordance with 3.10.4.2-2;

for frames where there are no deep frames in framing system and less than a half of frame span is bridged by ice strengthening region

$$k = 13{,}5(1 + 0{,}9l_1/l)(1 - 0{,}7b/l\,), \qquad (3.10.4.2\text{-}3)$$

where l_1 – part of the span, in m, which bridged by ice strengthening;
for forepeak and after peak frames:

$$k = 17(1 - 0{,}6b/l\,), \qquad (3.10.4.2\text{-}4)$$

where l – the distance between platforms or stringers which strengthening by thrust member measured along a chord at side;

for frames of dry cargo ships where framing system with deep frames is fitted

$$k = 15{,}6\{c(1 - 0{,}85b/l)\varphi'_1\varphi'_2 - c_3[0{,}4 + (m - 1)/4{,}55]\varphi_1\varphi_2\}. \qquad (3.10.4.2\text{-}5)$$

where c = 1,0

where m = 1; 2 and 1,12 where m = 3 (m – number of stringers);

φ_1 and φ'_1 – factors to be adopted from Table 3.10.4.2-3 depending on l_2 / l (l_2 – lower span of frame adjacent to considered one);

φ_2 and φ'_2 – factors to be adopted from Table 3.10.4.2-4 depending on l_1 / l (l_1 – upper span of frame adjacent to considered one);

$$c_3 = (1 - i/I\,) / (1 + ni/I\,).$$

Ratio i/I is to be within $0{,}050 \le i/I \le 0{,}065$;

for frames of tankers where framing system with deep frames is fitted

$$k = 25\,[c\,(1 - 0{,}85\,b / l) - k_2], \qquad (3.10.4.2\text{-}6)$$

where c = 1,0 where m = 2; 3 (m – number of stringers);

c = 0,8 where m = 1;

k_2 = 0,3; 0,66; 0,69 where m = 1; 2; 3 respectively

Table 3.10.4.2-1

Fixation of upper end of frame	Factor k_o where l'/l, is equal to:				
	0	0,25	0,50	0,75	1,00 and more
frame without extension to upper adjacent span	15,6	17,1	18,2	19,0	19,6
frame with extension to upper adjacent span	14,3	15,3	16,1	16,6	17,0

l' – lower span of frame adjacent to considered one, in m.

Table 3.10.4.2-2

Number of stringers	φ_1	
	frame without extension to upper adjacent span	frame with extension to upper adjacent span
1	1,45	1,35
2	1,30	1,25
3 and more	1,15	1,15

The section modulus of frames which are not fitted in the plane of floors and bilge brackets is not to be greater than determined for frames which are fitted in the plane of floors and bilge brackets.

3.10.4.3 The section modulus of deep frames is to comply with the following requirements:

.1 The section modulus of deep frames W, in cm^3, is not to be less than determined by the formula

$$W = 10k_1a_1blp\omega_k / R_{eH}, \qquad (3.10.4.3.1\text{-}1)$$

where a_1 - distance, in m, between deep frames measured along side;

p, b – ice pressure and vertical distribution of ice pressure in considered region in accordance with 3.10.3.1 and 3.10.3.2;

k_1 – factor which determined in the following way:

in dry cargo ships where transverse framing is used

$$k_1 = 15{,}6\,[c_1\,(1 - 0{,}73b/l\,)\,\varphi' + c_2\,c_3\,\varphi\,]\,\psi_o, \qquad (3.10.4.3.1\text{-}2)$$

where $c_1 = 1 / (n+1)$;

$c_2 = n / (n+1)$;

$c_3 = (1 - i / I\,) / (1 + ni / I)$;

ratioя i/I is to be within $0{,}050 \le i/I \le 0{,}065$;

φ', φ – factors to be adopted from Table 3.10.4.3.1-1;

for ψ_o – refer to Table3.10.4.3.1-2;

in tankers where transverse framing is used k_1 = 13,3 [c_1 (1 – 0,73 b/l) φ' + c_2 c_3 φ] ψ_o; (3.10.4.3.1-3)

where longitudinal framing is use k_1 – in accordance with Table 3.10.4.3.1-3.

Table 3.10.4.2-3

φ'1 where l_2/l, is equal to:					m	φ1 where l_2/l, is equal to:				
0	0,25	0,50	0,75	≥1,0		0	0,25	0,50	0,75	≥1,0
1,00	1,03	1,05	1,07	1,08	1	1,00	1,09	1,16	1,22	1,25
1,00	1,10	1,17	1,22	1,22	2	1,00	1,16	1,28	1,36	1,40
1,00	1,06	1,10	1,12	1,15	3	1,00	1,07	1,12	1,16	1,20

Table 3.10.4.2-4

φ'2 where o l_1/l, is equal to:					m	φ2 where l_1/l, is equal to:				
0,25	0,5	1,0	1,5	– [1]		0,25	0,5	1,0	1,5	– [1]
0,58	0,67	0,76	0,81	1,00	1	0,19	0,34	0,51	0,63	1,00
0,84	0,88	0,91	0,93	1,00	2	0,72	0,79	0,84	0,87	1,00
0,72	0,78	0,84	0,86	1,00	3	0,64	0,71	0,79	0,82	1,00

[1] Upper span adjacent to considered one is omitted.

Table 3.10.4.3.1-1

l'/l	0	0,25	0,50	0,75	≥ 1,00
φ'	1,00	1,08	1,14	1,18	1,20
φ where m = 1; 3	1,00	1,10	1,17	1,22	1,25
φ where m = 2	0,64	0,74	0,82	0,87	0,90

N o t e . for l' – refer to Table 3.10.4.2-1.

Table я 3.10.4.3.1-2

Region along the ship length	ψ_o	
	One deck ship	Two or multideck ship
В та С	1,10	1,00
А	0,85	0,80

Table 3.10.4.3.1-3

factor k_1	The number of stringers			
	0	1	2	3
	16,2	10,4	8,0	6,7

.2 Section modulus of additional deep frames with longitudinal framing is to be at least twice as much than section modulus of side longitudinals but not more than section modulus of deep frames (refer to 3.10.2.4.1).

3.10.4.4 The section modulus of longitudinals is to comply with the following requirements:

.1 The section modulus W_c, cm^3 of cross section of side stringer where framing system with deep frames is used is not to be less than determined by the formula

$$W_c = 0{,}67 a_1 W / l, \qquad (3.10.4.4.1)$$

Where for a_1 – refer to 3.10.4.3.1;

l – deep frame span, in m;

W – section modulus of deep framing section, in cm^3 (refer to 3.10.4.3.1).

.2 The section modulus W, in cm^3 of side longitudinals is not to be less than determined by the formula

$$W = 65 p a l^2 \omega_k / R_{eH}, \qquad (3.10.4.4.2)$$

where p – ice pressure in the considered region in accordance with 3.10.3.1;
l – distance, in m, between deep frames or other plain structure.

3.10.4.5 Web cross section area of longitudinals is to comply with the following requirements:

.1 The web cross section area, S cm^2, of frames is not to be less than determined by the formula

$$S = 10k_1pba/R_{eH} + 0{,}1\Delta sh. \quad (3.10.4.5.1)$$

where k_1 – factor is to be adopted from greater one of the following values:

$k_1 = [3{,}5 - (m + 1)(1{,}75b/l + 0{,}046k)]\,k_2$;

$k_1 = 1{,}4k_2$;

wher m – number of stringers;
for k – refer to 3.10.4.2;
$k_2 = 1{,}0$ for region A;
$k_2 = 0{,}8$ for regions B and C;
for p, b – refer to 3.10.3.1, 3.10.3.2;
h – web height (net), in cm.

.2 The web cross section area, S cm^2, of side longitudinals is not to be less than determined by the formula

$$S = 10k_1paa_1/R_{eH} + 0{,}1\Delta sh, \quad (3.10.4.5.2)$$

where $k_1 = 1{,}4k_2$;
p – in accordance with 3.10.3.1;
for a_1 – refer to 3.10.4.3.1;
for k_2, h – refer to 3.10.4.5.1.

.3 The web cross section area S, in cm^2, of deep frames is not to be less than determined by the formula

$$S = 7{,}5pa_1b/R_{eH} + 0{,}1\Delta sh, \quad (3.10.4.5.3)$$

where p – in accordance with 3.10.3.1;
for a_1 – refer to 3.10.4.3.1;
b – in accordance with 3.10.3.2;
for h – refer to 3.10.4.5.1.

.4 The web cross section area, S cm^2, of side stringer in the section by deep frame is not to be less than determined by the formula

$$S = 5(1 - 0{,}5b/l)\,pa_1b/R_{eH} + 0{,}1\Delta sh, \quad (3.10.4.5.4)$$

Where for p, a_1, b, h – refer to3.10.4.5.3;
l – deep frame span, in m.

Web height within stringer span is not to be less than doubled frame height, but not greater than web height of deep frame or not less than web height of deep frame in the section by deep frame.

The face plate area, web height and web area of side stringer where framing system without deep frames is used is not to be adopted less than for frame.

3.10.4.6 Web thickness of longitudinals is to comply with the following requirements:

.1 Web thicknesses of frames and side longitudinals in ice strengthening areas s, in mm, is not to be less than determined by the formula

$$s = 0{,}0073h\sqrt{\beta_1 R_{eH}} + \Delta s, \quad (3.10.4.6.1)$$

where h – web height in longitudinal;
for β_1 – refer to Table 3.10.4.6.1.

Table 3.10.4.6.1

α_1	1,00	0,95	0,90	0,80	0,70	0,60	0,50
β_1	2,50	1,80	1,45	1,05	0,85	0,70	0,60

N o t e : For intermediate values of α_1 factor β_1 is determined by liner interpolation.

$$\alpha_1 = (S - 0{,}1\Delta sh)/(S_ф - 0{,}1\Delta sh),$$

where S – in accordance with 3.10.4.5;
$S_ф$ – adopted web area of longitudinal, in cm^2.

.2 Webs thicknesses of deep frames and side stringers s where framing system without deep frames is used is not to be less than determined by the formula

$$s = 1{,}03a\sqrt{\gamma R_{eH}} + \Delta s, \quad (3.10.4.6.2)$$

where a - less side of web panel of deep frame and side stringer, in m;

for γ – refer to Table3.10.4.6.2;

c – greater side of web panel of deep frame and side stringer, in m.

Table 3.10.4.6.2

c/a	1,0	1,2	1,4	1,6	1,8	2,0	3,0	4,0
γ	0,61	0,71	0,78	0,81	0,84	0,86	0,93	1,00

N o t e . For intermediate values of c/a factor γ is determined by liner interpolation.

Web thickness of side stringer is not to be less than web thickness of deep frames more than 1 mm for **Ice6** and **Ice5** category ships and more than 2 mm for other category ships.

3.10.4.7 Scantlings of plate structure are to comply with the following requirements:

.1 Plate thickness s_h in mm, is not to be less than the greater one of the following values

$$s_1 = \frac{3q}{R_{eH}} - 0{,}1\frac{F}{a_1} + \Delta s\,; \quad (3.10.4.7.1\text{-}1)$$

$$s_2 = 2{,}25\,\sqrt[3]{q\,a_2^2\,k_3\,k_4} + \Delta s, \quad (3.10.4.7.1\text{-}2)$$

for q – refer to 3.10.3.3;

F – cross-sectional area of stiffener, in cm^2, without effective flange where stiffeners ;irc fitted normally to shell plating. Where plate structure siiffeners are snipped near the shell plate or fitted parallel to the shell plating F = 0 in 3.10.4.7.1-1 formula;

a_1 – spacing , in m, of stiffeners fitted normal to shell plating;

a_2 – less side of plate structure;

k_3 = 1,0, where reinforced stiffeners are fitted parallel to the shell plating;

k_3 = 0,8, where reinforced stiffeners are fitted normal to the shell plating;

k_4 = 0,17, where reinforced stiffeners are fitted normal to the shell plating;

for k_4 –refer to Table3.10.4.7.1 for stiffeners which are fitted normal to the she! plating;

c – greater side of plate structure, in m.

Table 3.10.4.7.1

c/a_2	1,0	1,2	1,4	1,6	1,8	2,0	2,2	2,4
k_4	0,17	0,23	0,28	0,32	0,36	0,39	0,42	0,43

N o t e . For intermediate values of c/a_2 factor k_4 is determined by liner interpolation.

.2 Moment of inertia i, in cm^4, of plate structure stiffeners fitted normal (or approximately normal) to shell plating is not to be less than determined by the formula

$$i = 0{,}13ql^2a_1j_k\,, \quad (3.10.4.7.2)$$

where for q – refer to 3.10.3.3;

for a_1 – refer to 3.10.4.7.1.

.3 Moment of inertia I, in cm^4, of deck girders on which sides part of beams are lean in the ice strengthening region is not to be less than determined by the formula

$$I = \frac{1}{16}\,i\,\frac{c}{a}\left(\frac{c}{l}\right)^3, \quad (3.10.4.7.3)$$

where i – moment of inertia of beams, in cm^4;

c – the greater of the deck girder spans;

a – spacing of beams, in m;

l – span of beams side part, in m.

.4 Cross section area (net) S, in cm^2, in the region of openings and holes of floors, vertical and horizontal diaphragms and other plate structures is not to be less than determined by the formula

$$S = 20k_2ql/R_{eH} + 0{,}1\Delta sc, \quad (3.10.4.7.4)$$

where for k_2 – refer to 3.10.4.5.1;

for q – refer to 3.10.3.3;

l – length, in m, of opening measured along the line of joining of plate structure to shell plating;

c – distance from the edge of opening to shell plating or edge of opening for stiffeners, whichever is less.

3.10.4.8 Stems and sternframes are

to comply with the following requirements:

.1 The cross-sectional area *S*, in cm^2, of stem irrespective of design is not to be less than determined from the formula

$$s = (a + b\Delta)\sin^{2/3}\varphi , \quad (3.10.4.8.1\text{-}1)$$

where *a*, *b* – factors whose values are to be found in Table 3.10.4.8.1;

φ – slope angle, in deg., of stern to the main line at the loadline level (refer to Fig. 3.10.1.4-4).

The section modulus *W*, in cm^3, of the stem cross-sectional area with regard to an axis perpendicular to the centerline is not to be less than given by the formula

$$W = 0{,}025p^{3/2} , \quad (3.10.4.8.1\text{-}2)$$

where for *p* – refer to 3.10.3.1.1.

To be included in the design cross-sectional area of a combined or plate stem are areas of shell plates and centerline girder or of longitudinal bulkhead on the centre plane on a breadth not exceeding ten times the thickness of relevant plate.

Table 3.10.4.8.1

Parameters	Ice category					
	Ice6	**Ice5**	**Ice4**	**Ice3**	**Ice2**	**Ice1**
Section H_1, in m, from top of ice belt to upper boundary of ice strengthening of the stem	1,0	0,8	0,7	0,6	0,5	0,5
Factors of 3.10.4.8.1-l for ships with displacement not more than 2500t:						
a	180	100	75	60	50	–
b	0,140	0,037	0,020	0,014	0,012	–
the same with displacement more than 2500t:						
a	350	180	150	120	85	–
b	0,054	0,021	0,013	0,009	0,009	–
Factor k of stem plate thickening above the upper boundary of strengthening	1,0	1,1	1,1	1,15	1,20	–
Depth of centerline vertical web h_v, in m, by which the stem is strengthened	1,5	1,0	0,6	0,5	0,5	–

.2 The plate thickness *s*, in mm, of combined and plate stems, as well as of the structure shown in Fig. 3.10.2.9.2, is not to be less than determined from the formula

$$s = 22a\sqrt{p/R_{eH}} + c , \quad (3.10.4.8.2)$$

where *a* – spacing, in m, of transverse brackets;

for *p* – refer to 3.10.3.1.1;

c = 3 mm – for **Ice5**, **Ice 4** category ships;

c = 2 mm – for **Ice 3**, **Ice 2**, **Ice 1** category ships.

The thickness of vertical web (refer to 3.10.2.9.4) and cross bracket (refer to 3.10.2.9.5) is not to be adopted less than 0,5 of stem web thickness.

.3 The requirements of 3.10.4.8.1 and 3.10.4.8.2 are to be complied with on the stem section from the keel to a level extending above the upper boundary of the ice strake by a value of H_1 (refer to Table 3.10.4.8.1). Outside the borders of the area considered, the stem scantlings may gradually reduce and the cross-sectional area of the bar is not to be less than required in 2.10.4 while the plate thickness of a combined or plate stem is not to be less than *ks* (where *s* – is the shell plating thickness in way of ice strake in fore region, for *k* – refer to Table 3.10.4.8.1).

.4 Sternframes.

The sectional area *S*, in cm, of propeller post and rudder post should be as given by the formula

$$S = kS_o, \qquad (3.10.4.8.4)$$

where S_o – sectional area of propeller post or rudder post, in cm^2, as required for a ship without an ice category (refer to 2.10.4);

k – factor to be adopted from Table 3.10.4.8.4.

.5 For the sternframes of single-screw ships of categories **Ice3**, **Ice2** та **Ice1**, having no rudder post or fitted up with a rudder axle for Simplex rudders, the greatest value out of those stipulated by 2.10.4.4 (account being taken of 2.2.2.2, Part **III** "Equipment, Arrangements and Outfit") should be adopted for the scantlings of **the** sofepi'ece cross section, or they should be determined from Formufa (3.10.4.8.4), whichever is greater.

Where the sternframe has a horn for a semi-spade rudder, the scantlings of the rudder horn are to be determined according to 2.10.4.10 with due regard for the requirements of 2.2.2.2, Part III "Equipment, Arrangements and Outfit".

The sternframe sectional area of twin-screw ice ships is not to be less than the rudder post area stipulated in 3.10.4.8.4.

Table 3.10.4.8.4

Stern frame structural member	Value of factor *k* for ice category ships					
	Ice6	**Ice5**	**Ice4**	**Ice3**	**Ice2**	**Ice1**
Propeller post	1,80	1,50	1,25	1,15	1,10	1,10
Rudder post and sole-piece	2,50	2,00	1,50	1,25	1,15	1,15

3.10.4.9 Scantlings of structural members in forepeak and after-peak are to comply with the following requirements:

.1 In after-peak of **Ice6** and **Ice5** category ship the webs scantlings of stringers is not to be less than determined from the formula:

for height $c = 0{,}005L + 0{,}4$ м;

for thickness $s = 0{,}05L + 7$ мм.

.2 In **Ice4** category ship area and moment of inertia of additional beams which fitted in forepeak and after-peak is to be increased by 25 per cent in comparison with required in accordance with 2.9.4. The webs scantlings of stringers is to be determined by the formula:

for height $c = 0{,}003L + 0{,}4$ м;

for thickness $s = 0{,}04L + 6{,}5$ мм.

3.10.5 Special requirements.

3.10.5.1 For **Ice6** and **Ice5** category ship it is recommended to use transverse framing in I and II regions.

3.10.5.2 In **Ice6** category ship in the engine-room region double-side structure is to be fitted. It is recommended to fit double-side structure between webs of peaks.

3.10.5.3 In **Ice6** and **Ice5** category ship flat bars are not permitted for structure in the ice strengthening regions.

3.10.5.4 Where anti-ice appendage (ice knife) is fitted, it is to be reliably attached to the stern-post.

Attachment of the anti-ice appendage to plate structures is not allowed.

3.11 ICEBREAKERS

3.11.1 General.

3.11.1.1 Application.

The requirements' of this Chapter apply to icebreakers which have ice strengthening in accordance with requirement below and are assigned in their class notation one of the following ice category mark: **Icebreaker4**, **Icebreaker3**, **Icebreaker2** and **Icebreaker1**.

Definition of icebreaker category is given in 2.2.3, Part I "Classification".

3.11.1.2 Application of requirements:

.1 Requirements of this Chapter are supplementary with regard to those of other chapters of the Rules which apply to a particular ship, and they establish the minimum strength level necessary to withstand ice loads, as well as hull structure, proceeding from the ice mark in the class notation.

.2 Scantlings of icebreaker hull members are to fulfill requirement of Part 1 and Part 2, if special instruction are omitted in this Part.

.3 Design appearance is to fulfill requirement of 3.10 for **Ice6** category ship and Part 1 and Part 2, if special instruction are omitted in this Part.

.4 Requirements of this Chapter concerning bottom platting and scantling of bottom framing suppose normal service of icebreaker when depth under the keel is not less than ship depth. For shallow icebreaker (which intended for service in shallow water) bottom ice strengthening level will be specially considered by the Register.

3.11.1.3 Definitions are adopted in accordance with 3.10.1.3.

3.11.1.4 Hull configuration:

.1 At 0 0,25L from forward perpendicular at service draughts, straight and convex waterlines (were α_0 = 22° – 30°) are to be used.

.2 At service draughts, the angle φ must be in the range of 20°–30°. The cross section of stem should be executed in the form of a trapezoid with a bulging forward face.

.3 Slope angles of frame in sections given below must be in the range given in Table 3.11.1.4.3.

.4 Frames should have a straight-lined or moderately convex shape.

.5 The construction water line projection upon a horizontal plane should cover the blade tips of side propellers.

.6 The tip clearance δ is not to be less than stated in Table 3.11.1.4.6.

.7 Provisions should be made for a step in the lower part of the stem. The height of the step is to be 0,1 of icebreaker draught at least. The transition from the step to the lower part of the stem should be smooth.

.8 In the afterbody provision should be made for an appendage (ice knife) aft of the rudder to protect the latter on the sternway.

Table 3.11.1.4.3

Category of icebreaker	Slope angle of frames, in deg., in section along ship length from forward perpendicular			
	0,1*L*	(0,2 – 0,25)*L*	(0,4 – 0,6)*L*	(0,8 – 1,0)*L*
Icebreaker4 та **Icebreaker3**	45 – 50	25 – 30	15 – 20	Approximately coinciding with the angles β of within (0 – 0,2)*L*
Icebreaker2 та **Icebreaker1**	40 – 45			

Table 3.11.1.4.6

Category of icebreaker	**Ice-breaker 4**	**Ice-breaker 3**	**Ice-breaker 2**	**Ice-breaker 1**
Clearance δ, in mm	1500	1250	750	500

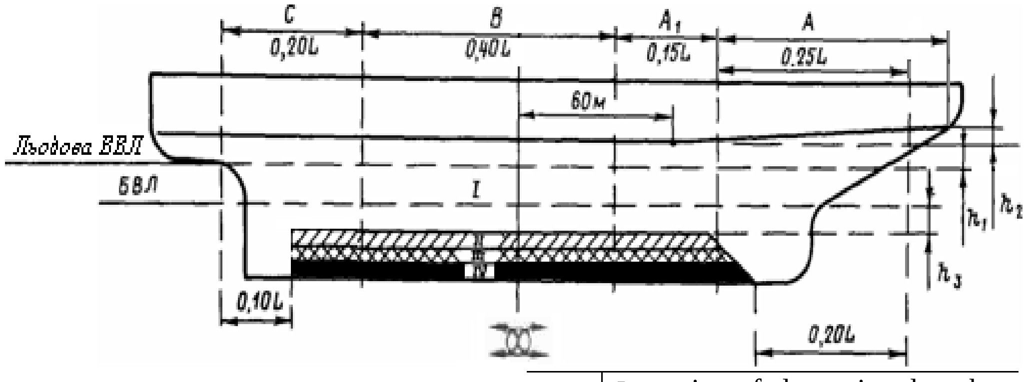
3.11.2 Structure.

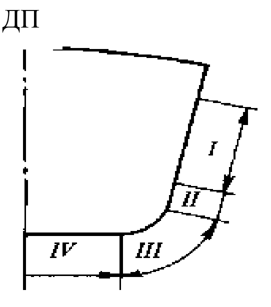
3.11.2.1 The boundaries of regions and level of requirements to hull ice strengthening.

.1 The hull length is to be subdivided into regions of ice strengthening as follows: forward region A; intermediate region A_1; midship region B; aft region C.

.2 The hull depth and bottom are subdivided into regions of ice strengthening in accordance with Fig 3.11.2.1.2 and 3.11.2.1.2.

.3 Proceeding from the ice category, the requirements of the Chapter apply to the regions of ice strengthening marked with "+" in Table 3.11.2.1.3.





I – region of alternating draughts and similar regions;

II – region from the lower edge of region 1 to the upper edge of bilge strake;

III – bilge strake;

IV – region from the lower edge of bilge strake to the centre line.

Fig. 3.11.2.1.2

Table 3.11.2.1.2

Parameter	Icebrealer category			
	Icebreaker4	**Icebreaker3**	**Icebreaker2**	**Icebreaker1**
h_1, in m ($B \le 20$ м)	1,00	0,80	0,75	0,75
h_1', in m ($B > 20$ м)	(0,5B+12)/22	(0,5B+7,6)/22	(0,5B+8)/24	(0,5B+8)/24
h_2, in m ($L > 120$ м)	L/120	L/150	L/160	L/160

h_3[1], in m	$3{,}5+1{,}6(h_1'-h_1)$	$3{,}0+1{,}6(h_1'-h_1)$	$2{,}0+1{,}6(h_1'-h_1)$	$1{,}5+1{,}6(h_1'-h_1)$

[1] For icebreakers with breadth $B \le 20$ м $h_1' - h_1 = 0$.

3.11.2.2 Transverse framing:

.1 The bottom ends of frames which are not in the floors plane are to be secure by brackets.

.2 Where deep framing is fitted it is permitted to cut conventional frames on side stringers. In this case webs of frame are to be welded to web of stringers.

Table 3.11.2.1.3

Ice category	Vertical regioning															
	I				II				III				IV			
	Horizontal regioning															
	A	A_1	B	C	A	A_1	B	C	A	A_1	B	C	A	A_1	B	C
Icebreaker4	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Icebreaker3	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Icebreaker2	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Icebreaker1	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+

3.11.2.3 Bulkheads.

Corrugated bulkheads are not permitted in the icebreakers.

3.11.2.4 Double bottom:

.1 Provisions should be made for solid floors at each frame.

.2 Scantling and thickness of main stringers is not to be less than determined in accordance with 2.4.2.4. In this case the spacing of bottom stringers is not to exceed 3,0 m.

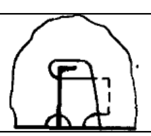
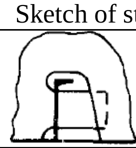
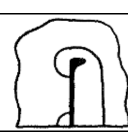
3.11.2.5 Plate structure:

.1 In the region of ice strengthening it is nit permitted to support plate structures by stiffeners fitted in parallel to the shell plating.

.2 Scantling of the less side of plane structure in the region of ice strengthening is not to exceed 0,6 m.

.3 The intersections of plate structures with main framing should be executed in accordance with Table 3.11.2.5.3. Other structures may be applied, if it recognized by the Register.

Table 3.11.2.5.3

Ice category	Sketch of structure		
			
Icebreaker4, **Icebreaker3**	Forepeak, after peak, regions 1 and II	Regions: AIII, A_1III, CIII, AIV, A_1IV	Other regions in accordance with Table 3.11.2.1.3
Icebreaker2, **Icebreaker1**	Forepeak, after peak, region I	Regions: II, AIII, A_1III, CIII	Ditto

3.11.2.6 Fore peak and after peak structure:

.1 A longitudinal bulkhead welded to the stem or sternframe is to be fitted on the centre line of the ship in the fore peak and after peak of icebreakers.

.2 In the fore peak and after peak platforms with lightening holes or deep frames should be fitted.

.3 Lower ends of all frames are to be connected to floors or brackets.

.4 The side stringers in the fore peak and after peak are generally to be a continuation of those fitted in the regions A and C.

.5 The use of a different forepeak and afterplike structure recognized by the Register as equivalent is possible.

3.11.2.7 Stem and sternframe

.1 The stems and sternfraipes of icebreakers are to be made of forged or cast steel.

Stems and sternframes welded of cast or forged parts are admissible.

.2 In icebreakers of all categories stem is to be supported by brackets which are fitted in ice strengthening region at distance not more than 0,6 m from each other.

The length and high of each brackets, measured on the centre line of the ship are not to be less than 600mm. Brackets are to be connected to the nearest frames. The side stringers are to be connected to the webs fitted in line with them.

.3 The lower edge of solepiece is to be constructed with a slope of 1:8 beginning from the propeller post.

3.11.3 Ice load.

3.11.3.1 Ice load upon the shell plating.

The ice pressure p, in kPa, is not to be adopted less than:

.1 In region AI

$$p_{A1} = 10u_1\Delta^{1/6}v; \qquad (3.11.3.1.1)$$

$$u_1 = a_1 + a_2N/1000,$$

where for a_1, a_2 – refer to Table 3.11.3.1.1;

N – propeller shaft output, in kW;

Δ – displacement, in t;

v = 0,6 – for shape recommended by the Requirements. Value of v may be specified according to the procedure approved by the Register.

.2 In region онi A_1I

$$p_{A_1I} = 0{,}85p_{AI}. \qquad (3.11.3.1.2)$$

Table 3.11.3.1.1

Factor	Ice category			
	Icebreaker 4	**Icebreaker 3**	**Icebreaker 2**	**Icebreaker 1**
a_1	380	240	160	110
a_2	0	2,5	5,0	6,4

.3 In region BI

$$p_{BI} = 0{,}6p_{AI}. \qquad (3.11.3.1.3)$$

In this case p_{BI} is not to be adopted less than 4500, 4000, 3000 and 1500 кПа kPa for icebreakers **Icebreaker4**, **Icebreaker3**, **Icebreaker2** and **Icebreaker1** respectively.

.4 In region CI

$$p_{CI} = 0{,}75p_{AI}. \qquad (3.11.3.1.4)$$

.5 Ice pressure upon the shell plating in region II, III, IV the ice pressure is determined as a part of the ice pressure in region I at the appropriate section of the ship length (refer to Table 3.11.3.1.5).

3.11.3.2 Ice load upon ice strengthening framing:

.1 Design height of distribution of ice load b, in m, upon framing is not to be adopted less than.

In regions AI – AIV i A_1I – A_1IV:

$b = u_2\Delta^{1/3}u\cdot 10^{-3}$, (3.11.3.2.1)

where $u_2 = 50 + 0{,}22N/1000$, but not more than 57;

$u = 2{,}0\,(a_4 - a_5\,x/L)/\sin 2\beta$;

factor u may be specified according to the procedure approved by the Register;

for a_4, a_5 – refer to Table 3.11.3.2.1-1;

for Δ – refer to 3.11.3.1 ;

x – distance from considered section to fore perpendicular.

Values of b is to be the upper bound within boundaries of every region along the icebreaker lengt.

Table 3.11.3.1.5

Ice category	Ice pressure, in per cent, in vertical regioning and horizontal regioning															
	A				A_1				B				C			
	AI	AII	AIII	AIV	A_1I	A_1II	A_1III	A_1IV	BI	BII	BIII	BIV	CI	CII	CIII	CIV
Icebreaker 4	100	70	60	45	100	55	55	35	100	55	45	35	100	55	40	35
Icebreaker 3	100	70	60	45	100	55	55	35	100	55	45	30	100	55	40	35
Icebreaker 2	100	70	60	50	100	60	55	40	100	55	45	25	100	55	40	30
Icebreaker 1	100	80	70	60	100	60	55	45	100	50	45	–	100	50	45	25

Table 3.11.3.2.1-1

Members	$0 < x \le 0{,}15L$		$0{,}15L < x < 0{,}30L$	
	a_4	a_5	a_4	a_5
Primary members (the section modulus) of **Icebreaker4**, **Icebreaker3** and **Icebreaker2** category icebreakers and primary and deep members of **Icebreaker1** category icebreakers	0,250	0	0,350	0,670
Webs (area) and plate structure of **Icebreaker4**, **Icebreaker3** i **Icebreaker2** category icebreakers	0,285	0	0,350	0,460

For region between stern and section which is within 0,3L from fore perpendicular b is not to be adopted less than in section $x = 0{,}3L$.

In regions BI – BIV b is to be determined by the formula

$b = c_4\,(c_2 + c_3N/1000)$,

where for c_4 – refer to Table 3.10.3.2-2;

for c_2, c_3 – refer to Table 3.11.3.2.1-2;

for N – refer to 3.11.3.1.1.

In regions CI – CIV b is to be obtained as for region AI.

Table 3.11.3.2.1-2

Factor	Ice category			
	Icebreaker4	**Icebreaker3**	**Icebreaker2**	**Icebreaker1**
c_2	1,5	2,1	1,4	1,2
c_3	0,021	0	0	0

.2 In regions AI, AII, AIII, AIV, A_1I, A_1II, A_1III, CI and CII the ice pressure upon the framing is equal to 85 per cent of ice pressure upon shell plating in regions AI, A_1I and CI respectively.

In other regions ice pressure upon framing is equal to ice pressure upon shell plating.

3.11.3.3 Ice load upon edges of plate structures:

.1 In regions I and II ice load is to be adopted in accordance with 3.10.3.3.

.2 In regions III and IV ice load edges of plate structures is determined as a part of ice load upon edges in region I in accordance with Table 3.11.3.1.5.

3.11.4 Members scantling.
Members scantling below is determined for middle of service term and is to be increase by values of Δs or ω_k in accordance with 1.1.5, if special requirements are omitted.

3.11.4.1 Shell plating thickness in ice strengthening regions is not to be less than determined by the formula (3.10.4.1.1) where p in accordance with 3.11.3.1. In this case at calculation of Δs (refer to 1.1.5.1) average annual decrease of shell plating thickness u is to be obtained in accordance with Table 3.11.4.1.

Table 3.11.4.1

Icebreaker category	*u*, in mm per year			
	A	A_1	B	C
Icebreaker4	0,70	0,70	0,40	0,60
Icebreaker3	0,70	0,60	0,40	0,60
Icebreaker2	0,50	0,50	0,30	0,40
Icebreaker1	0,25	0,25	0,25	0,25

3.11.4.2 The section modulus of frame:

.1 Section modulus of frame is not to be less than determined by the formula (3.10.4.2-1), in this case values of p, b – in accordance with 3.11.3.2, and k factor in accordance with 3.11.4.2.2–3.11.4.2.3.

.2 Where deep frames are not fitted k factor is determined by the formula

$$k = k_0\,(1 - 0{,}44b/l), \qquad (3.11.4.2.2)$$

where for k_0 – refer to 3.10.4.2.

.3 Where deep frames are fitted k factor is determined by the formula (3.10.4.2-5) for b in accordance with 3.11.3.2. Obtained factor is to be multiplied by 1,3 for **Icebreaker4** and **Icebreaker3** category icebreakers;

1,2 – for **Icebreaker2** category icebreakers and

1,0 – for **Icebreaker1** category icebreakers.

3.11.4.3 The section modulus of deep frame:

.1 Section modulus of deep frame is not to be less than determined by the formula (3.10.4.3.1-1). In this case value of p, b in accordance with 3.11.3.2 and k factor in accordance with 3.11.4.3.2.

.2 k_1 factor is determined by the formula (3.10.4.3.1-2) for ψ_0 in accordance with Table 3.11.4.3.2.

Table 3.11.4.3.2

Icebreaker category	ψ_0 for region		
	A, A_1	B	C
Icebreaker4, **Icebreaker 3**	0,6	1,0	0,8
Icebreaker 2	0,7	1,0	0,9
Icebreaker 1	0,8	1,0	1,0

3.11.4.4 Section modulus of longitudinal members is determined in accordance with 3.10.4.4 for p in accordance with 3.11.3.2.

3.11.4.5 The net section area of member webs:

.1 The net section area of frame webs is not to be less than determined by the formula (3.10.4.5.1) for value of b in accordance with 3.11.3.2, k_1 factor in accordance with 3.10.4.5.1. for **Icebreaker 1** category icebreakers;

k_1 = 1,15 for **Icebreaker 2** category icebreakers;

k_1 = 1,0 for **Icebreaker 4** and **Icebreaker 3** category icebreakers.

For **Icebreaker2**, **Icebreaker3** i **Icebreaker4** category icebreakers design value *b* in formula (3.10.4.5.1) is not t be greater than the biggest distance between brackets ends within frames span.

.2 The net section area of webs of longitudinal ribs is not to be less than determined by the formula (3.10.4.5.2) for value of *p* in accordance with 3.11.3.2 and k_1 factor in accordance with 3.11.4.5.1.

.3 The net section area of deep frames web is not to be less than determined by the formula (3.10.4.5.3) for values of *p, b* in accordance with 3.11.3.2.

.4 The net section area of side stringer web in the section at deep frame is not to be less than determined by the formula (3.10.4.5.4) for values of *p, b* in accordance with 3.11.3.2.

3.11.4.6 Member web thickness:

.1 Thickness of the frames webs and longitudinal members of framing in the ice strengthening regions is not to be less than determined by the formula (3.10.4.6.1) for *S* in accordance with 3.11.4.5.

.2 Where deep frames are fitted in framing system web thickness of deep frames and side stringers is not to be less than determined by the formula (3.10.4.6.2).

3.11.4.7 Scantling of plate structure members:

.1 The plate thickness is to be adopted not less than the greater of following values:

$$s_1 = \frac{k_2 q}{R_{eH}} - 0{,}1\frac{F}{a_1} + \Delta s; \quad (3.11.4.7.1\text{-}1)$$

$$s_1 = k_3 \sqrt[3]{\beta_1 q a_2^2 k_4} + \Delta s, \quad (3.11.4.7.1\text{-}2)$$

where for *q* – refer to 3.11.3.3;

for k_2, k_3 – refer to Table3.11.4.7.1;

for a_2, k_4, *F* – for 3.10.4.7.1;

β_1 – determined in accordance with 3.10.4.6.1 where α_1 = $(S - 0{,}1\Delta sh) / (S_\phi - 0{,}1\Delta sh)$.

Table 3.11.4.7.1

Factor	Icebreaker category			
	Icebreaker 4	**Icebreaker 3**	**Icebreaker 2**	**Icebreaker 1**
k_2	1,15	1,20	1,50	3,00
k_3	1,79	1,82	1,96	2,42

.2 Moment of inertia of plate structure stiffeners fitted normal (or approximately normal) to shell plating is not to be less than determined by the formula (3.10.4.7.2) where *q* in accordance with 3.11.3.3.

.3 Moment of inertia *i* in cm^4, of deck girders on whose sides part of beams are lean in the ice strengthening region is not to be less than determined by the formula (3.10.4.7.3).

.4 Cross section area in the region of openings and holes of floors, vertical and horizontal diaphragms and other plate structures is not to be less than determined by the formula (3.10.4.7.4) where *q* in accordance with 3.1 1.3.3, k_2 in accordance with 3.10.4.5.1.

3.11.4.8 Double bottom:

.1 The centre girder height *h*, in mm, is not to be less than determined by the formula

$$h = 9L + 800. \quad (3.11.4.8.1)$$

.2 The thicknes of floors and stingers, in mm, is not to be less than determined in Table 3.11.4.8.2.

Table 3.11.4.8.2

Region along the ship length	The thickness of floors and stringers			
	Icebreaker 4	**Icebreaker 3**	**Icebreaker 2**	**Icebreaker 1**
A	14	13	12	11
B	12	11	10	9
A_1 i C	13	12	11	10

3.11.4.9 Stem and sternframe:

.1 Stem cross-section area *S*, in cm^2, is not to be less than determined by the formula

$$S = S_0 + f\Delta/100, \qquad (3.11.4.9.1)$$

where for S_0, f – refer to Table 3.11.4.9.1;
Δ – displacement, in t.

Table 3.11.4.9.1

Icebreaker category	$\Delta \le 2500$ т		$\Delta > 2500$ т	
	S_0	f	S_0	f
Icebreaker 4	–	–	800	3,0
Icebreaker 3	–	–	700	3,0
Icebreaker 2	–	–	590	3,0
Icebreaker 1	135	9,0	250	4,0

.2 The sectional area *S*, in cm^2, of propeller post and rudder post for one-crew and three-crew icebreakers is not to be less than determined by the formula

$$S = kS_0, \qquad (3.11.4.9.2)$$

where for k – refer to Table 3.11.4.9.2;
S_0 – sectional area, cm^2, in accordance with 2.10.4.3 for single-screw ship.

Table 3.11.4.9.2

Stern frame structural members	k			
	Icebreaker 4	**Icebreaker 3**	**Icebreaker 2**	**Icebreaker 1**
Propeller post	3,0	2,5	2,0	1,75
Rudder post	4,0	3,5	2,5	2,00

.3 The sectional area of sternframe of twin-crew icebreakers is not to be less than rudder post area in accordance with 3.11.4.9.2.

3.11.5 Special requirements:

.1 It is recommended to use transverse framing in I and II regions of icebreakers.

.2 In icebreakers double-side structure is to be fitted the between sternframe bulkheads and collision bulkhead.

.3 Flat bars are not permitted in the ice strengthening regions.

.4 Where anti-ice appendage (ice knife) is fitted, it is to be reliably attached to the stern-post.

Attachment of the anti-ice appendage to plate structures is not allowed.

3.12 ICE STRENRTHENING OF TUGS

3.12.1 General.

3.12.1.1 Tugs provided with ice strengthening in compliance with the requirements stated below are provided with one of the following ice-category marks in their class notation: **Ice 5**, **Ice 4**, **Ice 3, Ice 2**.

Definition of ice-category mark is given in 2.2.3. Part I "Classification".

3.12.1.2 Requirements 3.10.1.2 are applied to tugs.

3.12.1.3 For definitions refer to 3.10.1.3.

3.12.1.4 Requirements of 3.10.1.4 are applied to **Ice 5** and **Ice 4** category tugs the same as for ships of corresponding categories.

3.12.2 Construction.

3.12.2.1 General instructions.

Requirements 3.10.2 are applied to the ice strengthening structure of corresponding categories tugs if special instructions are omitted below.

3.12.2.2 Strengthening regions.

.1 Region A extension for tugs of all categories is to be within 0,35*L* from fore perpendicular.

.2 The parameters h_1, h_3, L_2 (refer to Fig.3.10.2.1) are to be adopted from Table 3.12.2.2.2.

Table 3.12.2.2.2

Parameter, in m	Ice category	
	Ice5, **Ice4**	**Ice3, Ice2**
h_1	0,5	0,3
h_3	0,8	0,6
L_2	0,15L	0,10L

3.12.2.3 The hull attachments of ice-protection components of the screw-rudder system shall ensure their reliable connection to main and web framing and, as far as practicable, to the sternframe and to longitudinal and transverse bulkheads so as to rule out the possibility of crack formation as a result of ice impacts on the stern.

3.12.3 Ice load.

3.12.3.1 The ice pressure p, in kPa, shall be determined by the following formulae.

.1 in region AI:

$$p_{AI} = k_p\, p^c_{AI}, \quad (3.12.3.1.1)$$

where p^c_{AI} – ice pressure in region AI, as determined in accordance with 3.10.3.1.1 as in the case of a transport ship whose ice class coincides with the ice class of the tug;

k_P: – k_P = 1 whereo $N_\Sigma \leq N_0$;

– k_P = $(N_\Sigma / N_0)^{0,4}$ where $N_\Sigma > N_0$;

N_Σ – total shaft power of tug, in kW;

$N_0 = C_N \Delta^{2/3}$;

C_N – factor to be taken from Table 3.11.3.1.1

for Δ – refer to 3.10.1.3.

Table 3.12.3.1.1

Factor C_N	Ice category of tug			
	Ice5	**Ice 4**	**Ice3**	**Ice 2**
	20	18	16	14

.2 in regions BI and CI:

$$P_{kI} = a_k\, p_{AI}, \qquad (3.12.3.1.2)$$

for p_{AI} – refer to 3.12.3.1.1;

a_k – factor to be taken from Table 3.11.3.1.2 based on the region of ice strengthening and the ice class of the tug;

k = B, C.

Table 3.12.3.1.2 **Values of factor** $\boldsymbol{a_k}$

Region	Ice class of tug			
	Ice5	**Ice 4**	**Ice3**	**Ice 2**
BI	0,6	0,55	0,5	0,4
CI	0,75	0,75	0,7	0,65

.3 in regions II , II I and IV, an ice pressure shall be taken as required by 3.10.3.1.4 as in the case of transport ships of appropriate ice class.

3.12.3.2 For tugs the vertical extension of ice load shall be adopted equal in all regions and shall be determined in accordance with 3.10.3.2 as in the case of the forward region of a transport ship whose ice class coincides with that of the tug.

When determining *u* the values shall be found for those sections only which are included in the forward region of ice strengthening of the tug.

3.12.3.3 For tugs the horizontal extension of ice load shall be adopted equal in all regions and shall be determined in accordance with 3.10.3.1.1 as in the case of the forward region of a transport ship whose ice class coincides with that of the tug.

When determining β only those sections shall be considered which are included in the forward region of ice strengthening of the tug.

3.12.3.4 Ice load on plate structure edges is to be taken in accordance with 3.10.3.3 at intensity and height of load distribution according to 3.12.3.1 and 3.12.3.2.

3.12.4 Scantlings of ice-strengthening structures.

.1 The scantlings of ice-strengthening structures in tugs shall be determined in accordance with 3.10.4, unless expressly provided otherwise below.

.2 The stem and sternframe shall comply with the requirements of 3.10.4.8; sectional area *S* is not to be less than determined by the formula

$$S = kS_0, \qquad (3.12.4.2)$$

where k – factor whose values shall be found in Table 3.12.4.2;

S_0 – area of stem or sternframe of the tug without ice class to be determined in accordance with 3.9.4.5 or 3.9.4.6.

Table 3.12.4.2

Structural member	Values of factor *k*			
	Ice5	**Ice 4**	**Ice3**	**Ice 2**
Stem	1,5	1,4	1,3	1,2
Sternframe	1,3	1,3	1,2	1,1

3.13 FLOATING DOCKS

3.13.1 General.

3.13.1.1 Application.

The requirements of this Chapter apply to hull structures of wing-walled (caisson, pontoon, sectional) docks.

Caisson dock is a structure fitted with a solid pontoon and two wings continuous along the entire length and structurally inseparable (including caisson docks with end pontoons for docking a centre pontoon).

Pontoon dock is a structure fitted with two wings continuous along the entire length and several pontoons connected to the wings by bolts, rivets, welding.

Sectional dock is a structure consisting of several sections, each section being a caisson or a pontoon dock, connected by bolts, welded plates, hinges.

The requirements apply to the docks having a ratio of the length over the pontoon deck to the breadth more than 3,5.

Other structural configurations of docks and their proportions require individual consideration by the Register.

3.13.1.2 For the purpose of this Chapter, the following definitions have been adopted:

B a l l a s t   w a t e r is sea water pumped into ballast compartments in order to change dock's draught and trim.

B a l l a s t   c o m p a r t m e n t is a compartment in a pontoon or wing wall of the dock, bounded by watertight structures and intended for pumping ballast water.

D o c k   w i n g   w a l l is a part of floating dock hull structurally connected to a pontoon or pontoons and intended to provide stability when the dock is lowered and lifted;

a wing wall is divided by decks, platforms, bulkheads into spaces and compartments for arranging dock equipment and ballast.

L i f t i n g   c a p a c i t y   o f   t h e   d o c k Δ, in t is mass of the heaviest ship or ships that the dock shall lift in normal service.

D e p t h   o f   t h e   d o c k D is a vertical distance measured at the midship section from the base hne to the moulded surface of the top deck at the outer wall side.

P o n t o o n   d e p t h D_p s a distance measured at the centreline from the base hne to the moulded surface of the pontoon deck.

M a x i m u m   s u b m e r s i o n   d e p t h $d_{m.s.}$ is a vertical distance measured at the midship section from the base to the waterline to which the dock may theoretically be lowered.

L e n g t h   o f   d o c k   a t   t h e   p o n t o o n   d e c k $L_{p.d.}$ is the distance measured along the pontoon deck parallel to the base hne between moulded surfaces of the pontoon end bulkheads.

Length of keel blocks track L_k is a distance measured at the centreline parallel to the base line between outer ends of keel blocks.

Ship weight for docking Δ_s, in t is weight of the light ship to be docked with necessary stores and ballast to provide the ship's draught and trim as required for docking.

Rest water ballast is ballast water which pumps cannot discharge.

Design waterline is a waterline of a floating dock corresponding to its draught with full stores, a ship of a design weight and a required quantity of ballast.

Crinolines are cantilever structures of the dock, fitted at the end bulkheads of the dock pontoon at the pontoon deck level, aiming to increase an area available for docking operations at the ship's ends projecting beyond the pontoon deck.

Light draught d_l isa vertical distance measured at the midship section from the base line to the waterline corresponding to the dock displacement with no stores, docked ship and ballast.

Safety deck is a watertight deck in wing walls of the dock, forming a boundary of the ballast compartments from above.

Air cushion is an area of a higher air pressure between the top of compartment and a level of ballast water therein.

Pontoon is a part of the dock hull intended to maintain buoyancy of the dock which is defined by volumes of its compartments.

Compensating ballast water is ballast water pumped into ballast tanks in order to reduce transverse and/or longitudinal bending moments and deflections of pontoon and/or wing wall structures.

Design draught d is a vertical distance measured from the base line to the design waterline.

Pontoon deck is a deck on which keel blocks or bilge blocks are fitted.

Dry compartment is a compartment below the safety deck (or below the margin line where safety deck is omitted) not intended for pumping ballast water.

Top deck is a uppermost deck of dock wing walls.

Wall breadth at top deck $b_{t.d.}$ is a distance measured normal to the centreline between the moulded surfaces of the inner and outer wall sides at the level of the moulded surface of the top deck.

Wall breadth at pontoon deck $b_{p.d.}$ a distance measured normal to the centreline between the moulded surfaces of the inner and outer wall sides at the level of the moulded surface of the pontoon deck.

Breadth of the dock B is a distance measured normal to the centre line between the moulded surfaces of the outer wall sides.

Pontoon deck breadth $B_{p.d.}$ is a distance measured normal to the centre line between the lines of intersection of moulded surfaces of the inner wall sides and the pontoon deck.

3.13.1.3 Materials:

.1 When selecting steel for hull structures of floating docks, provisions of 1.2 shall be applied, having regard to subdivision of structural members into groups according to Table 3.13.1.3.1.

.2 Plate and beam items of crinolines, walkways and other secondary structures of a floating dock may be fabricated from steel having lower strength characteristics than specified in 1.2.2.1, provided their welding is guaranteed at the shipyard.

3.13.1.4 Estimation of wear. Minimum thicknesses.

.1 The effect of wear on the scantlings of structures is estimated on the basis of specification of strength to the end of the dock service life. Corrosion allowances shall permit operation of the dock during the full specified service life with average corrosion rates of structural items.

.2 Scantlings and strength characteristics of structures with due regard for wear and corrosion shall be determined in compliance with 1.1.5, with a corrosion allowance Δs, in mm, being determined by the formula

$$\Delta s = kuT, \qquad (3.13.1.4.2)$$

where k – factor taking into account zone conditions of floating dock service and equal to: 1,0 for Baltic basin; 1,1 for Northern, Black-and-Azov and Caspian-and-Volga basins; 1,2 for Pacific basin;

u – average annual reduction in thickness of structural members according to Table 3.13.1.4.2, in mm/year;

T – design service life of dock; where service life is not specified, it shall be taken as T = 50 years.

.3 Average annual thickness reduction of dock structures plates and beams, given in Table 3.13.1.4.2, shall be used when dock structures have appropriate protective paint coatings.

Specified corrosion rates may be reduced if special protective arrangements are made on agreement with the Register.

Table 3.13.1.3.1

Dock members	Group of members	
	within midship region	outside midship region (refer to 1.1.3)
Thickened top deck plates in way of openings; bottom plating of pontoon deck wing walls and plate strengthenings of pontoon structures in pontoon docks at sections between pontoons and in adjacent regions, plate members of sectional dock structures in way of dock section connections	III	II
Pontoon deck plating and bottom plating of pontoon (pontoons); transverse and longitudinal framing members of pontoon deck and bottom; plate structures of primary transverse members (non-tight and tight bulkheads) of pontoon (pontoons); bottom strakes of wing walls and adjacent strakes of shell plating, longitudinal bulkhead plating of pontoon docks	II	II
Plating strakes, framing members of top deck, safety deck, wing walls and pontoon shell plating; plates and framing members of wing wall interior structures (other than dock structural members referred to in 1 and 2)	II	I

Table 3.13.1.4.2

Nos.	Structure	u, mm/year
1	Top deck plating and wing wall plating above margin line	0,04
2	Safety deck plating	0,08[1]
3	Wing wall bottom of pontoon docks	0,08
4	Inner and outer wing wall plating from pontoon deck to the margin line	0,08[1]
5	Pontoon deck plating:	
5.1	in the middle portion	0,10
5.2	at ends over a length $0,1L_{p.d.}$	0,12
6	Side plating and outer transverse wall plating of pontoon (pontoons):	
6.1	top (≤ 1,0 m) and bottom (≤ 0,5 m) strakes	0,09[1]
6.2	other strakes	0,08[1]
7	Bottom plating of pontoon (pontoons)	0,08[1,2]
8	Interior bulkheads of ballast compartments:	
8.1	bottom strake (≤ 0,5 m)	0,09
8.2	other strakes	0,08[1]
9	Framing members, dock truss items in ballast compartments	0,10[1]
10	Plates and framing members of internal wing structures above safety deck, top deck and wing wall framing	0,04

[1] In way of compartments heated in winter by live steam, u shall be increased by 10 per cent

[2] For bottom plating in way of ballast system suctions and discharges u shall be increased by 15 per cent.

Table 3.13.1.4.4

Structure	s_{min}, in mm	Note
Plating of outer structures other than pontoon deck; structural items in ballast compartments and tanks, including framing members	7,5	a < 600 mm
	7,5 + 0,01x x(a – 600)	a ≤ 750 mm
	8,0 + 0,0065x x(a – 600)	a > 750 mm
Pontoon deck plating	9,0	a < 600 mm
	9,0 +0,013x x(a – 600)	a ≤ 750 mm
	10,0 +0,006x x(a – 600)	a > 750 mm
Top deck plating; plates and beams of structures above safety deck	6,5 + 0,008× ×(a – 600)	a ≥ 600 mm
	6,5	a < 600 mm

.4 Thickness of primary members (including corrosion allowance) shall not be less than given in Table 3.13.1.4.4, and determined depending on the assumed spacing a, in mm.

3.13.1.5 Guidelines on design of floating dock structures.

When designing floating dock structures, the following sequence is recommended:

.1 execution of structural layout of pontoon (pontoons) and wing walls (refer to 3.13.2).

2. determination of design loads resulting in local and longitudinal deflection of dock hull structures (refer to 3.13.3).

3. design of plate items and framing members of dock structures on the basis of local strength and buckling, having regard to minimum thickness restrictionsин.

4. design of structures which provide both transverse and longitudinal strength of dock pontoon. Values of structural parameters obtained in implementation of 3.13.1.5.3, are used here as initial data.

5. design of dock hull structures which provide dock longitudinal strength under design operating conditions (docking operations). Values of structural parameters obtained in implementation of 3.13.1.5.3 and 3.13.1.5.4, are used here as initial data.

6. design of structures, having regard to the requirements for strengthening (e.g. wing wall decks and sides in way of openings, engine room, etc.).

7. check calculations of both longitudinal and transverse, as well as local strength of hull structures under conditions of real ship docking.

8. check calculations of both longitudinal and transverse, as well as local strength of dock structures during passage from a place of build to a place of operation. Development of recommendations on dock structure strengthening.

3.13.2 Construction.

3.13.2.1 Framing systems of pontoon (pontoons) and wing walls.

For pontoon (pontoons) of caisson, pontoon and sectional docks transverse framing is preferable.

Wing wall sides and decks of pontoon docks with lifting capacities of 10000 t and above shall be longitudinally framed; docks having lifting capacities below 10000 t may be framed transversely.

Wing wall sides and decks of caisson docks above the safety deck shall be longitudinally framed, wing wall sides below the safety deck may be transversely framed.

For pontoon bottom plating portions of caisson docks in way of wing walls a longitudinal framing may be adopted. For transverse and longitudinal bulkheads of the pontoon and wing walls structures with horizontal and vertical stiffeners are permitted.

Truss arrangements may be used in the pontoon (pontoons) and wing walls.

3.13.2.2 Structural layout of pontoons.

Plate and beam structures of the pontoon shall maintain local strength of the appropriate pontoon strucures (pontoon deck, bottom, longitudinal and transverse bulkheads, etc.), as well as transverse strength of the pontoon.

Spacing of primary longitudinal and transverse framing members of the pontoon shall be determined according to 1.1.3 with $L = L_{p.d.}$.

Primary transverse structures of the pontoon (pontoons), i.e. non-tight bulkheads, shall be fitted in 3 to 7 spacings, but they shall not be spaced more than $(B - B_{p.d.})/6$ apart.

A centreline bulkhead shall be fitted under the keel blocks. A box structure formed by two longitudinal bulkheads arranged symmetrically on each side of the centre hne may be used in lieu of the centre hne bulkhead. Bulkheads or girders shall be aligned with inner wall sides.

Where transverse framing is adopted for a pontoon (pontoons), additional primary longitudinal supporting members may be fitted to limit a span of transverse members of the bottom and pontoon deck.

They shall be spaced not more than 3 to 5 spacings apart.

3.13.2.3 Structural layout of wing walls.

Spacing of primary longitudinal and transverse framing members of wing walls shall be determined as required by 1.1.3.

Where wall sides and decks are longitudinally framed, deck transverses and web frames shall be aligned with primary transverse structures of the pontoon (pontoons) (refer to 3.13.2.2).

Where wall sides are transversely framed, side stringers shall be fitted. Spacing of stringers and distance between stringers and deck shall, in general, not exceed 3,5 m.

Where transverse framing is adopted for wing walls below the safety deck it is advisable to provide web frames on wall sides in line with primary transverse structures of the pontoon, and deck transverses on the safety deck plating.

Primary supporting members of outer and inner wall sides below the safety deck (web frames with longitudinal framing and side stringers with transverse framing) shall be connected by cross ties which shall be fitted in line with each primary transverse of the pontoon (refer to 3.13.2.2).

3.13.2.4 Additional provisions.

Use of butt-lap connections for girders and transverses of pontoon (pontoons) and wing walls is permitted.

Where proper quaHty control of welding joints is provided, assembling joints aligned on plate structures and framing members are permitted.

Hollow square and tubular cross ties and struts shall not be used in ballast compartments and other tanks.

3.13.3 Design loads.

3.13.3.1 Loads for structure design based on local strength:

.1 Design pressure p, in kPa, for plate and beam bottom structures shall be determined by the formulae:

in way of dry compartments

$$p = 10d_{m.s.}; \qquad (3.13.3.1.1\text{-}1)$$

in way of ballast compartments not communicated with wing walls

$$p = 10(d_{m.s.} - D_p); \qquad (3.13.3.1.1\text{-}2)$$

and communicated with wing walls

$$p = 10(d_{m.s.} - z_{s.d.} + \Delta z), \qquad (3.13.3.1.1\text{-}3)$$

where $z_{s.d.}$ – distance of the safety deck from the base line, in m;

Δz – thickness of air cushion, in m.

.2 Design pressure p, in kPa, for plate and beam structures of the pontoon deck in way of dry and ballast compartments shall be determined by Formula (3.13.3.1.1-2).

.3 Design pressure p, in kPa, for plate and beam structures of pontoon sides and end bulkheads shall be determined by the following formulae:

In way of dry compartments:

$$p = 10(d_{m.s.} - z_i), \qquad (3.13.3.1.3\text{-}1)$$

where z_i – distance of the lower edge of the plate or mid-span of the framing member from the base line, in m;

in way of ballast compartments:

$$p = 10(d_0 - D_p), \qquad (3.13.3.1.3\text{-}2)$$

where d_0 – = depth of the dock corresponding to filling of a side ballast compartment up to the safety deck, in m. d_0 shall not be taken more than $d_{m.s.}$.

in the first approximation, where no special information is available, it may be assumed that

$$d_0 = D_п + G/2L_{сп}b_{сп}\rho,$$

where G – mass of dock without rest water and compensating ballast;

ρ – sea water density (refer to 1.1.3.6.4).

.4 Design pressure p, in kPa, for plate and beam structures of wall sides and end bulkheads shall be determined by the following formulae:

in way of dry compartments, using Formula (3.13.3.1.3-1);

in way of ballast compartments $p = 10(d_0 - z_i)$, (3.13.3. 4-1)

where for z_i, d_0 – refer to 3.13.3.1.3.

.5 Design pressure p, in kPa, for plate and beam structures of the safety deck in way of dry compartments shall be taken equal to 5 kPa; in way of ballast compartments p shall be determined by the formula

$$p = I0(d_{m.s} - z_{s.d} + \Delta z), \quad (3.13.3.1.5)$$

where for $z_{s.d}$, Δz – refer to3.13.3.1.1.

.6 Design pressure p, in kPa, for plate and beam structures of inner watertight bulkheads of ballast compartments shall be determined by the formula

$$p = 10(d_{m.s.} - z_t + \Delta z), \quad (3.13.3.1.6)$$

where z_t – distance of ballast compartment top from the base line, in m;

Δz – as defined in 3.13.3.1.1.

.7 Design pressure p, in kPa, for plate and beam structures of main watertight bulkheads shall be determined by Formula (3.13.3.1.3-1).

.8 Design pressure for plate and beam structures of the top deck shall be equal to 5 kPa.

.9 Design pressure p, in kPa, for plate and beam structures of fuel oil, lubricating oil, water and other tanks is determined by the following formulae: when internal pressure is calculated

$$p = 10\rho_1(z_{a.p} - z_i), \quad (3.13.3.1.9)$$

where ρ_1 – density of liquid contained in the tank, in t/m^3;

$z_{a.p}$ – distance of the upper edge of the air pipe from the base line, in m.

when external pressure is calculated, Formula (3.13.3.1.3-1) shall be used.

For plate structures arranged parallel to the base hne, z_i is a distance of the plate structure from the base line.

.10 Design pressure on crinoline structures is assumed to be equal to 5 kPa.

.11 Design pressure on walkway structures is assumed to be equal to 3,5 kPa.

.12 Design pressure on structures of safety deck, intermediate deck and platforms where equipment of the electric generating plant is arranged are assumed equal to 18 kPa; in way of accommodation and service spaces, 5 kPa.

3.13.3.2 Loads for structure design based on both transverse and longitudinal strength of pontoon (pontoons):

.1 Design loads to be used in design of pontoon structures of caisson, pontoon and sectional docks shall be calculated for the condition when the ship of length L_s and weight equal to the maximum lifting capacity of the dock is supported on the keel blocks symmetrically about the midship section of the dock. The draught of the dock shall correspond to the design one (refer to 3.13.1.2); ballast water is considered evenly distributed over the length and breadth of the dock.

.2 For pontoon and sectional docks an additional condition shall be considered for pontoons loaded by buoyancy forces the value of which corresponds to the condition specified in 3.13.3.2.1 corrected for rest-water counterpressure and gravitational forces of light-dock weight components, opposite in direction.

Where no initial data are available, buoyancy force p, in kPa, may be determined by the formula

$$p = g\Delta[BL_{p.d.} - (n - 1)Ba_0], \quad (3.13.3.2.2)$$

where n – number of pontoons of pontoon docks or sections of sectional docks;

a_0 – distance between pontoons or sections, in m.

.3 Design length of the ship L_s shall be assumed equal to the length of the shortest ship whose docking weight is equal to the maximum lifting capacity of the dock, but not more than $0{,}9L_{p.d.}$. For docks having lifting capacity more than 40 000 t, the design length of the ship L_s shall not be taken less than $0{,}9L_{p.d.}$.

.4 The weight curve of the ship shall be taken as a rectangle with a superimposed parabola of half the area of the rectangle. Linear docking load q_x, in kN/m, at the section distant at x forward and aft from the midship section shall be determined by the formula

$$q_x = \frac{g\Delta}{L_c\varphi}\left[1 - 3(1-\varphi)(2x/L_c)^2\right], \quad (3.13.3.2.4)$$

where φ – block coefficient of ship weight curve.

For docks of 40 000 t lifting capacity and less block coefficient of the ship weight curve shall be assumed depending on a design ship type according to Table.3.13.3.2.4.

For docks above 40 000 t lifting capacity φ = 0,8 shall be assumed.

Table 3.13.3.2.4

Type of ship	φ
Icebreakers	0,67
Ships with engine room amidships	0,75 – 0,8
Ships with engine room aft or semi-aft	1,0

.5 Where it is intended to lift ships simultaneously on keel and side blocks, as well as where different cases of simultaneous docking of several ships are expected, they shall be taken into account in design of structures which provide both longitudinal and transverse strength of the pontoon. Design loads shall be determined using the procedures approved by the Register.

.6 Design loads on end pontoons of pontoon and sectional docks or on the end portions of caisson docks and when ships with overhung ends are docked shall be specially considered by the Register.

3.13.3.3 Loads for design of structures based on longitudinal strength:

.1 Design loads shall be determined for the following conditions:

dock's sagging when a ship having the shortest length L_s, expected and a weight equal to the maximum lifting capacity of the dock Δ if lifted;

dock's hogging when a ship having the largest length L_s, expected and a weight equal to the maximum lifting capacity of the dock Δ is lifted, or two or more ships installed in line and having a total weight equal Δ are docked.

Ballast water is considered to be evenly distributed over the entire length of the dock.

.2 The form of ship weight curve is determined by Formula (3.13.3.2.4).

.3 The design length of the shortest ship shall be as required by 3.13.3.2.3.

The design length of the largest ship or a total length of several ships installed in Hne over the length of the dock shall not be less than $1{,}3L_{p.d.}$.

.4 The design block coefficient of the ship weight curve shall be assigned according to 3.13.3.2.4, for hogging, φ =

1,0 shall be taken, unless expressly provided otherwise.

3.13.4 Scantlings of structural members.

3.13.4.1 The thickness requirements for plate structures based on local strength.

The plating thicknesses of pontoon (pontoons), wall sides, interior and outer watertight bulkheads, decks and platforms shall be determined by Formula (1.6.4.4) with $m = 22{,}4$ and $k_\sigma = 1{,}8$. A corrosion allowance Δs shall be obtained according to the recommendations given in 3.13.1.4. The design transverse pressure p is specified in 3.13 3.1.

3.13.4.2 ScantHng requirements for framing members based on local strength.

.1 The section modulus of primary members shall be determined as required by 1.6.4.1.

.2 The net sectional area of girders and transverses, as well as sectional area of beams and longitudinals having a relationship$l/h \le 10$ (where l – design span, in m; h – web depth of a beam or longitudinal, in cm) shall be obtained from 1.6.4.3.

.3 The design pressure p shall be determined at a mid-span of framing members as required by3.13.3.1.

.4 The design span l of framing members shall be selected in accordance with1.6.3.1.

.5 Coefficients of permissible normal and shear stresses specified in 1.6.4.1 and 1.6.4.3 shall be assumed equal to $k_\sigma = 0{,}8$ and $k_\tau = 0{,}8$.

.6 The factor ω_k, which takes account of framing member wear as given in 1.1.5.3 shall be taken with Δs according to 3.13.1.4.

.7 Factors of design bending moments m and shear forces n shall be assumed as follows:

$m = 12$ and $n = 0{,}5$ – for bottom transverse and longitudinal members, beams and longitudinals of the pontoon deck; for stiffeners of watertight transverse bulkheads with longitudinally framed bottom and pontoon deck; for stiffeners of interior watertight longitudinal bulkheads with transversely framed bottom and pontoon deck; for longitudinal framing members of wall sides and decks; for safety deck beams with transversely framed wall sides below the safety deck; for girders and transverses of bottom and pontoon deck and side stringers of outer and inner wall side;

$m = 8$ and $n = 0{,}5$ – for stiffeners of watertight transverse bulkheads with transversely framed bottom and pontoon deck; for stiffeners of interior longitudinal bulkheads with longitudinally framed bottom and pontoon deck; for horizontal stiffeners of watertight transverse bulkheads of wing walls with transversely framed wall sides; for safety deck beams with longitudinally framed wall sides;

$m = 13$ and $n = 0{,}5$ – for wall deck and platform beams with transversely framed wall sides below the considered deck or platform; top deck or safety deck transverses;

$m = 11$ and $n = 0{,}6$ – for frames and web frames of the pontoon (pontoons), outer and inner wall sides.

.8 The scantlings and structures of girders and transverses of the pontoon and wing walls shall satisfy the requirements of 1.7.3.3. For girders and transverses of the wing walls above the safety deck the requirements for similar structures of dry cargo ships may be applied.

3.13.4.3 Requirements for cross ties, struts and braces:

.1 The sectional area of cross ties and struts S, in cm^2, hall not be less than determined by a successive approximation method using Formula (2.9.4.1) with a design load $P = 0{,}5\ (P_1 + P_2)$, in kN, and factor $k = 1{,}15$ (where $P_1 = p_1ac$, $P_2 = p_2ac$ – are maximum compressive forces acting at the ends of struts and cross ties; p_1, p_2 are design pressures (refer to 3.13.3.1), in kPa; a – distance between members supported by struts or cross ties, in m; c is half-sum of span lengths on each side of the strut or cross tie under consideration, in m).

As a first approximation, S may be taken as

$$S = 0{,}11P,$$

and the radius of gyration $i = \sqrt{I/S}$, in cm, may be estimated for a suitable section having this area (where I = minimum central moment of inertia, cm^4).

If the area determined by Formula (2.9.4.1) using this radius of gyration differs by more than 10 per cent from the first approximation, a second approximation calculation shall be made. The radius of gyration shall correspond to the mean area of the first and second approximation.

.2 The web plates of cross ties and struts of channel or I sections shall be so selected that the ratio of the breadth to the thickness shall not exceed $42l/i$ or 40 whichever is the greater (where l is length of a cross tie or strut, in m).

For ordinary angle or channel sections, the ratio of the breadth to the thickness of the flanges shall not exceed $14l/i$ or 13 whichever is the greater.

For cross ties of fabricated sections or I sections cross ties, the ratio of the breadth to the thickness of face plates shall not exceed$28l/i$ or 25 whichever is the greater.

The thickness of cross tie or stay items shall not be less than 7,5 mm.

.3 The scantlings of trusses shall be determined according to a procedure approved by the Register.

3.13.4.4 Additional local strength requirements for plates and beams. I f hull structures of the dock are subjected to the loads not covered by 3.13.3.1, the scantlings of plates and beams shall be determined using the procedures approved by the Register.

3.13.4.5 Scantling requirements for primary transverse and longitudinal members of pontoon (pontoons):

.1 The section modulus W, in cm^3, of the primary transverse and longitudinal members of the pontoon (pontoons) shall be determined by the formula

$$W = W' + \Delta W, \qquad (3.13.4.5.1\text{-}1)$$

where W' – required section modulus of the end of the dock service life to be determined by the formula

$$W' = M \cdot 10^3/k_\sigma\sigma_n, \qquad (3.13.4.5.1\text{-}2)$$

M – design bending moment, in kN·m (refer also to 3.13.4.5.6);

ΔW – corrosion allowance to the section modulus to be determined by the formula

$$\Delta W = 100h\left[\Delta f_{\text{п}} + \frac{\Delta f_{\text{ст}}}{6}(2-\beta)\right], \qquad (3.13.4.5.1\text{-}3)$$

where h – web depth of members of the section under consideration, in m,

Δf_d, Δf_w – additions to the upper flange and web area of members, respectively, including corrosion allowances as based on the entire service life of the dock, in cm2 , determined by the formulae

$$\Delta f_d = 10\Delta s_d b_{e.f} + \Delta f_{fr};$$
$$\Delta f_w = 10\Delta s_w h;$$

$\Delta s_{d(w)} = u_{d(w)}T$ – — reduction, in mm, of the plating thickness of the pontoon deck (member web) due to wear during service life of the dock T (years) with corrosion rate $u_{d(w)}$, , in mm/year, according to Table 3.13.1.4.2;

$b_{e.f}$ – width of the effective flange (refer to 3.13.4.5.5), in m;

Δf_{fr} – addition to the flange area of the member allowing for corrosion wear of framing members, to be taken as:

for framing members of tee sections or flat

$$\Delta f_{fr} = 0{,}1n(b_0+h_0)u_{fr}T; \quad (3.13.4.5.1\text{-}4)$$

for framing members of bulb flat

$$\Delta f_{fr} = 0{,}86nf_0u_{fr}T/s_0; \quad (3.13.4.5.1\text{-}5)$$

where when addition Δf_{fr} is determined, results obtained in design of framing members based on local strength (refer to 3.13.4.2). are used. Where the sectional area of members does not include primary members, $\Delta f_{fr} = 0$;

n – number of primary members over the breadth $b_{e.f}$;

b_0 and h_0 – face plate width and web depth of T-beam, respectively (for members of flat, $b_0 = 0$), in cm;

f_0 – area of isolated section in cm^2;

s_0 – web thickness of bulb flat;

u_{fr}, specified corrosion rate for framing members of ballast compartments (refer to Table 3.13.1.4.2), in mm/year;

β – factor dependent on web areas f'_w, of the upper f'_d and lower f'_b face plates, having regard to wear to the end of the service life, to be determined by the formula

$$\beta = \left(2 f'_{\Pi} + f'_{\text{CT}}\right)/\left(2 f'_{Д} + f'_{\text{CT}}\right); \quad (3.13.4.5.1\text{-}6)$$

as a first approximation, it may be assumed that β =1,0.

.2 The sectional area of the web f_w, in cm^2, of primary transverse members of the pontoon (pontoons) shall be determined by the formula

$$f_w = f'_{\text{CT}} + \Delta f_w, \quad (3.13.4.5.2\text{-}1)$$

where f'_w – of the web to the end of the service life of the dock, to be determined by the formula

$$f'_{\text{CT}} = 10N_x/k_\tau\tau_n; \quad (3.13.4.5.2\text{-}2)$$

N_x – designed shear force (refer to 3.13.4.5.7), in kN; for;

Δf_w – refer 3.13.4.5.1.

.3 The scantlings of the truss (struts and braces) of the pontoon (pontoons) shall be adequate to take shear forces arising in longitudinal bending of the pontoon.

.4 To be included in the design section of primary transverse members of the pontoon (pontoons) are all structural items which are continuous between the pontoon sides; design section of primary longitudinal members shall include all structural items which are continuous between the end bulkheads of the pontoon.

.5 The width of the effective flanges of the primary transverse members $b_{e.f}$, in m, of the bottom and pontoon deck plating shall be taken as:

$$b_{e.f} = \min\{(B - b_{e.f})/6;\ c\},$$

where c – average distance between the member under consideration and members on the right and on the left thereof, in m.

.6 The design bending moments M_x and M_y acting in transverse and longitudinal members at the middle of a continuous pontoon of a caisson dock (refer to Fig. 3.13.4.5.6-1) for the cases, referred to in 3.13.3.2, shall be determined by the formulae:

$$M_x = q(B - b_{p.d})\,c_x\delta_1; \quad (3.13.4.5.6\text{-}1)$$

$$M_y = q(B - b_{p.d})\,c_y\delta_2, \quad (3.13.4.5.6\text{-}2)$$

where $q = g\Delta/L_s$ – average value of the linear load of the dock, in kN/m (L_s, Δ – refer to 3.13.3.2);

B, $b_{p.d}$ – breadth of the dock and wing wall at the pontoon deck level;

c_x and c_y – distance between primary transverse and longitudinal members of the pontoon, respectively, as shown in Fig. 3.13.4.5.6-1, in m;

δ_1, δ_2 – factors to be obtained from the diagrams given in Fig. 3.13.4.5.6-2 and 3.13.4.5.6-3 as dependent on parameters $L_s / L_{p.d}$, $n = L_{p.d} / (B - b_{p.d})$ and φ.

For pontoon and sectional docks, the design bending moment in design of primary transverse members M_x, in kN-m, shall be equal to the greater of the two values:

$$M_x = 0{,}25q\frac{c_x}{\varphi}(B - b_{сп}) \text{x} \left(1 - 0{,}5\varphi\frac{L_с}{L_{сп}}\frac{B - b_{сп}}{B}\right); \quad (3.13.4.5.6\text{-}3)$$

$$M_x = 0{,}125pc_x(B - b_{сп})^2, \quad (3.13.4.5.6\text{-}4)$$

where p – as defined in 3.13.3.2.2.

.7 The design shear force N_x, in kN, taken by a transverse member of the dock (primary transverse member, or struts and braces of the pontoon truss) shall be determined by the formula

$$N_x = 0{,}75\frac{g\Delta}{L_с}\left(1 - 1{,}33\frac{L_с}{L_{сп}}\frac{y}{B}\right)c, \quad (3.13.4.5.7\text{-}1)$$

where y = distance of the section under consideration from the centreline of the dock, in m;
c = distance between the members under consideration, in m.

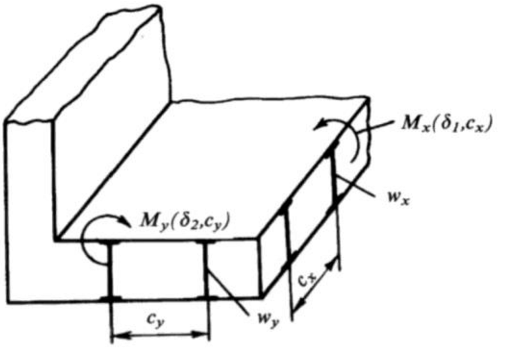


Fig.3.13.4.5.6-1

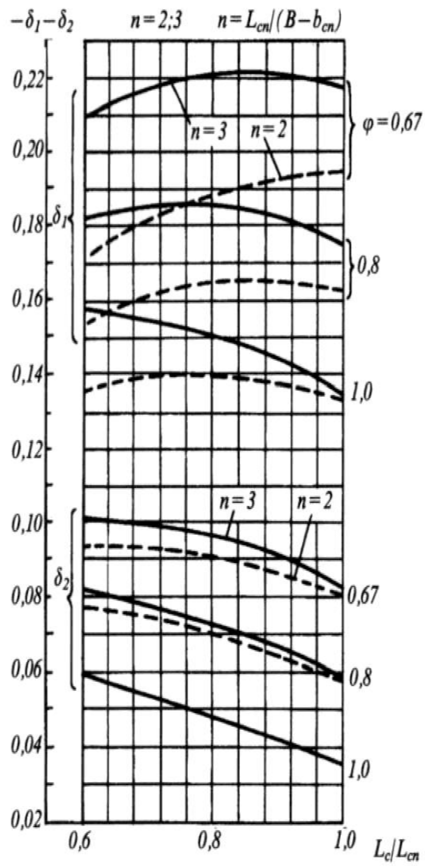


Fig.3.13.4.5.6-2

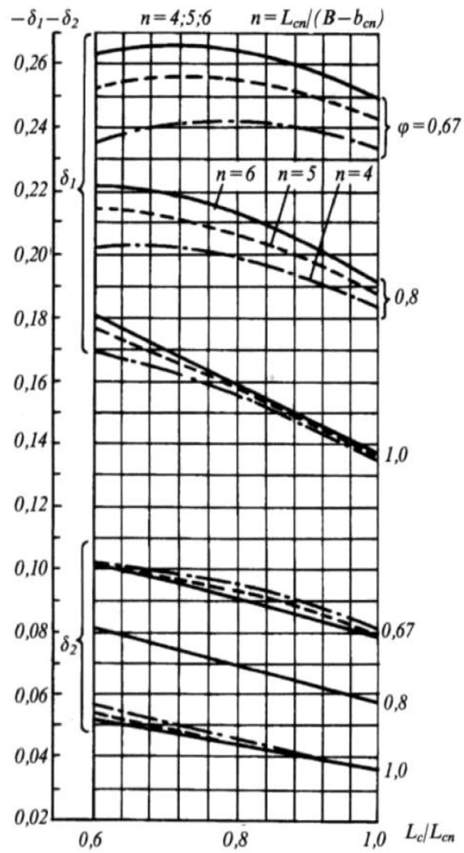


Fig.3.13.4.5.6-3

In design of the primary transverse members or struts and braces of the pontoon trusses of pontoon and sectional docks, the design shear force N_x, in kN, shall not be taken less than

$N_x = pcy$, (3.13.4.5.7-2)

where p = as defined in 3.13.3.2.2.

.8 The coefficients of permissible stresses in Formulae (3.13.4.5.1-2) and (3.13.4.5.2-2) in design of primary transverse members of the pontoon (pontoons) shall be taken as follows:

$k_\sigma = 0{,}85$; $k_\tau = 0{,}8$.

Guidelines on the selection of permissible normal stresses in primary longitudinal members of the pontoon of caisson-type docks are given in 3.13.4.6.4.

.9 The web thickness of primary transverse members shall meet the buckling strength requirements under the action of shear and normal stresses arising in transverse bending of the pontoon (pontoons). The plating thickness of the pontoon deck and bottom shall meet the requirements for buckling strength under the action of compressive stresses arising in transverse bending of the pontoon (pontoons).

.10 Buckling strength conditions shall comply with 1.6.5.2 and 1.6.5.3. Factor k in Formula (1.6.5.2) is taken equal to 0,75.

When Euler's stresses are determined according to the formulae given in 1.6.5.5 it shall be taken that $s' = s - \Delta s$, where Δs is obtained in compliance with 3.13.1.4.

3.13.4.6 The scantling requirements for structures based on strength and buckling conditions in longitudinal bending:

.1 The assumed scantlings of dock longitudinal structures (with regard to the provisions of 3.13.4.6.2) shall provide the required hull section modulus of the floating dock.

The hull section modulus W, in cm^3, of a floating dock shall not be less than

$$W = W'\,\omega_k. \qquad (3.13.4.6.1\text{-}1)$$

where W' – required section modulus to the end of the service life of the dock, in cm3 , determined by the formula

$$W' = M \cdot 10^3 / k_\sigma\,\sigma_n, \quad (3.13.4.6.1\text{-}2)$$

where M – maximum bending moment determined by Formula (3.13.4.6.3), in kN·m;

ω_k – factor which takes account of corrosion allowance to the section modulus for wear determined by the formula

$$\omega_k = \left[1 - F^{-1}\sum_i \Delta f_i \varphi_i\right]^{-1}; \quad (3.13.4.6.1\text{-}3)$$

F – sectional area of the floating dock hull, in cm^2, corresponding to the required section modulus;

Δf_i – addition to the sectional area of the i-th plate strake, which takes account of corrosion allowance to be determined by the formula

$$\Delta f_i = 10\Delta s_i\, b_i, \qquad (3.13.4.6.1\text{-}4)$$

$\Delta s_i = u_i T$ – thickness reduction of the i-th plate member due to wear during service life T (years), with a corrosion rate u_i, in mm/year, taken according to Table 3.13.1.4.2, in mm;

b_i – width of the i-th member, in m.

Additions to the sectional area of the floating dock hull which take account of corrosive wear of framing members shall be not less than those determined by the following formulae:

for framing members of tee sections or flat

$$\Delta f_i = 0{,}1 n_i (b_{0i} + h_{0i})\, u_{\text{н}i} T, \quad (3.13.4.6.1\text{-}5)$$

where n_i – number of framing members of the i-th group;

b_{0i}, h_{0i} – = face plate width and web depth of T-beam, respectively, in cm (for members of flat, $b_{0i} = 0$);

for framing members of bulb flat

$$\Delta f_i = 0{,}86 n_i\, f_{0i}\, u_{fri} T / s_{0i}, \quad (3.13.4.6.1\text{-}6)$$

where f_{0i} – sectional area of bulb flat section proper, in cm^2;

u_{fri} – corrosion rate of framing members of the i-th group, in mm/year;

s_{0i} – web thickness of bulb flat;

φ_i – multiplier taking account of the effect of changing sectional area of the i-th member on the section modulus W, to be determined by the formula

$$\varphi_i = c_i^2 (F/I) + c_i / z_0, \quad (3.13.4.6.1\text{-}7)$$

where I – hull inertia moment, in cm^2·m^2, of the dock, corresponding to the required section modulus;

z_0, c_i – distance of the point at the level of which section modulus is determined and centre of gravity of sectional area of the i-th member (i-th group of longitudinal members) from the neutral axis, the position of which corresponds to W and I; in determination of z_0 and c_i their sign shall be taken into account: positive downwards and negative upwards from the neutral axis.

.2 Wing wall and pontoon longitudinals continuous in the middle region of the dock shall be included in the design cross-section of a caisson-type floating dock.

To be included in the design section of a pontoon dock are wing wall longitudinals continuous in the middle region of the dock.

.3 The design bending moment *M*, in k N m, shall be determined for the cases referred to in3.13.4.3, by the formula

$$M = -0{,}125 q \Delta L_{сп} \left(1 - \frac{3\varphi - 1}{2\varphi} \frac{L_c}{L_{сп}} \right). \qquad (3.13.4.6.3)$$

Recommendations on the choice of design values of φ and L_s are given in 3.13.3.3.2.

.4 The coefficient of permissible stresses due to longitudinal bending referred to in Formula (3.13.4.6.1-2) shall be taken as $k_\sigma = 1{,}0$.

.5 For caisson-type docks the following condition shall be fulfilled

$$\sigma_1 + \sigma_2 \le k_\sigma \sigma_n,$$

where σ_1 – stresses in primary longitudinal members of the pontoon due to longitudinal bending of the dock;

σ_2 – stresses in primary longitudinal members of the pontoon due to longitudinal bending of the pontoon.

Stresses σ_1, in MPa, shall be determined by the formula

$$\sigma_1 = Mz \cdot 10^5 / I', \qquad (3.13.4.6.5\text{-}1)$$

where M – as defined in 3.13.4.6.3;

z – distance of the point under consideration from the neutral axis of the dock, in m;

I' – inertia moment of the dock to the end of the service life, in cm^4.

Stresses σ_2, in MPa, shall be determined by the formula

$$\sigma_2 = M_y z' \cdot 10^5 / I_y', \qquad (3.13.4.6.5\text{-}2)$$

where M_y – as defined in 3.13.4.5.6;

z' – distance of the point under consideration from the neutral axis of the section of the primary longitudinal, in m;

I_y' – inertia moment of primary longitudinal, determined with regard to the wear of the members to the end of the service life of the dock and provisions of 3.13.4.5.4, in cm^4.

.6 In design of the dock hull, the requirements for buckling strength under the action of longitudinal bending of plate structures, girders and longitudinals, such as wall sides and deck plating, shell plating, longitudinal bulkhead plating of the pontoon and pontoon deck plating of caissontype docks, bottom shell of pontoon dock wings shall be met in the middle region within $0{,}4L_{d.p}$.

The scantlings of top deck beams where transverse framing is adopted, top deck transverses in case of longitudinal framing shall be adequate to provide buckling strength of deck structure portions between deck girders, deck girders and wall sides or between wall sides where deck girders are omitted.

.7 The design compressive stresses σ_{c_i}, in MPa, obtained in estimation of the buckling strength shall be not less than

$$\sigma_{c_i} = \frac{M}{I'} z_i \cdot 10^5, \qquad (3.13.4.6.7\text{-}1)$$

where M – design bending moment causing the compression of the *i*-th member under consideration (refer to 3.13.4.6.3), in kN·m;

I' – actual central inertia moment of the hull girder with regard to wear to the end of the service life, in cm^4;

z_i – distance of the member under consideration from the neutral axis, in m (z_i is measured from the edge most distant from the neutral axis for a plate structure; from the middle of the thickness of the effective flange for a beam member of the deck and bottom; from the middle of the thickness of the beam web for a beam of the wall side, side plating and longitudinal bulkhead of the pontoon).

As a first approximation, I', value, in cm ^{4}, may be determined by the formula:

$$I' = W'_d (D_0 - e) \cdot 10^2, \quad (3.13.4.6.7\text{-}2)$$

where W'_d – required section modulus of the hull girder at a level of the lower edge of the top deck plating determined according to the requirements of (3.13.4.6.1), in cm^3;

D_0 – depth of wing walls (for pontoon docks), in m;

$D_0 = D$ – for caisson-type docks;

e – distance of the neutral axis from the base line for caissontype docks; distance of the neutral axis from the abutment line of the pontoon deck to the inner wall sides for pontoon docks, in m.

As a first approximation, it may be assumed that:

$e = 0{,}32D$ – for caisson-type docks;

$e = 0{,}5D_0$ – for pontoon docks;

.8 The buckling strength conditions shall comply with 1.6.5.2 and 1.6.5.3. Factor k in 1.6.5.2 shall be taken equal to 0,8 for the top deck plating and wall sides; for the bottom and side plating of the pontoon and pontoon deck plating of caisson-type docks, girders and longitudinals.

.9 Euler stresses for plate structures shall be determined according to 1.6.5.5, and for girders and longitudinals as required by 1.6.5.4 taking $s' = s - \Delta s$, where Δs is obtained as given in 3.13.1.4.

.10 The inertia moment of beams of the transversely framed top deck shall meet the requirements of 2.6.4.5.

The inertia moment of top deck transverses shall be as required by 2.6.4.6.5.

.11 The assumed scantlings of wing wall structures shall provide buckling strength in simple bending of the wing wall in design cases of dock sagging. The procedure of supporting buckling strength in simple bending shall be agreed with the Register.

3.13.4.7 Deflection control system.

Deflection of the dock hull shall be controlled according to the procedure approved by the Register.

In docks over 80 m in length at least two meters of different types to monitor the deflection of the dock shall be provided.

The maximum deflection stated in the Docking Manual shall be agreed with the Register. The deflections shall not exceed the values determined by the formula

$$\sigma(T) = (0{,}6 + 0{,}003T)\sigma_n,$$

where T – service life of the dock to the date of monitoring, in years;

σ_n – as defined in 1.1.4.3.

3.13.4.8 Requirements for dock towing:

.1 The minimum section modulus W_{min}, in cm^3, required to ensure the strength of the dock during towing shall be determined by the formula

$$W_{min} = \frac{M}{\sigma_{доп}} \cdot 10^3, \quad (3.13.4.8.1\text{-}1)$$

where M – design bending moment, in kN·m, determined by the formula

$$M = 5{,}03 k_w h_d B L_{сп}^2; \quad (3.13.4.8.1\text{-}2)$$

k_w – factor of wave bending moment determined by the formula

$$k_w = 7{,}93 \cdot 10^{-3} + 4{,}13 \cdot 10^{-3}(L_{p.d}/B) -$$
$$- 0{,}125(d_{tow}/L_{p.d}); \quad (3.13.4.8.1\text{-}3)$$

D_{tow} – dock draught amidships during voyage in tow, in m;

h_d – design wave height, in m, determined depending on the length of the dock:

$$h_p = 10{,}9 - \left(\frac{300 - L_{сп}}{100}\right)^2 \text{ for } L_{p.d} < 300 \text{ m};$$

(3.13.4.8.1-4)

h_d = 10,9 for $L_{p.d} \geq 300$ m;

$\sigma_{доп}$ – permissible normal stresses in longitudinal bending of the dock, in MPa, taken equal to: 150 for docks under 100 m in length; 150 + 0,75($L_{p.d}$ –100) – for docks between 100 and 200 m in length; 225 – for docks over 200 m in length.

.2 The still water bending moment *M*, in kN·m, in the midship section of the dock during the voyage in tow shall be reduced to the minimum possible level by suitable ballasting.

.3 Sea state considered permissible for voyage in tow is that corresponding to a wave height of 3 per cent probability of exceeding level $h_{3\%}$, in m, determined by the formula

$$h_{3\%} = h^0_{3\%} + m(\lambda_1^2 / \lambda_2^2 - 1), \quad (3.13.4.8.3\text{-}1)$$

where $h^0_{3\%}$ – rated wave height, in m, permissible for voyage of a floating dock, with a relationship $L_{p.d}/B = 4{,}25$, determined by the formulae:

$h^0_{3\%}$ = 0,313+ 0,0438 $L_{p.d}$

for $L_{p.d} < 130$ m;

$h^0_{3\%}$ = 3,10+ 0,0223$L_{p.d}$

for $130 \leq L_{p.d} \leq 260$ m;

$h^0_{3\%}$ = 0,422 + 0,0326$L_{p.d}$

for $L_{p.d} > 260$ m; (3.13.4.8.3-2)

m – = factor determined by the formula:

$m = 0{,}483 + 0{,}0218\, L_{p.d}$

for $L_{p.d} < 130$ m;

$m = 2{,}42 + 0{,}00685\, L_{p.d}$

foro 130 м $\leq L_{p.d} \leq 260$ m;

$m = 0{,}356 + 0{,}0148\, L_{p.d}$

for $L_{p.d} > 260$ м; (3.13.4.8.3-3)

factors λ_1 i λ_2 are determined by the formulae:

$\lambda_1 = M/M^0$;

$\lambda_2 = 1{,}276 - 0{,}065(L_{p.d}/B)$; (3.13.4.8.3-4)

M^0 – basic bending moment, in kN·m, determined by the formula

$$M^0 = 0{,}77 \cdot 10^{-2} L_{сп}^{3,65} / \eta; \quad (3.13.4.8.3\text{-}5)$$

where for η – refer to 1.1.4.3,

M – bending moment, in kN·m, corresponding to the actual section modulus of the floating dock hull, determined by the formula

$$M = k_\sigma \sigma_n W \cdot 10^{-3}; \quad (3.13.4.8.3\text{-}6)$$

W – actual minimum section modulus of the dock hull to the moment of voyage;

k_σ = 0,8 – factor of permissible normal stresse;

σ_n – as defined 1.1.4.3.

.4 Correspondence between permissible sea state during voyage and waves heights of 3 per cent probability of exceeding level shall be determined according to Table 3.13.4.8.4.

.5 A possibility of voyage of a dock in tow whose architecture and relationships of the dimensions differ from those referred to in 3.13.1.1, shall be supported using the procedure approved by the Register.

.6 Voyage of a dock in tow within the limits of one and the same sea is permitted when the environmental conditions (sea state) corresponding to the requirements of 3.13.4.8.3 – 3.13.4.8.5 are expected.

Table 3.13.4.8.4

Permissible sea state	5	6	7	8	9
$h_{3\%}$ in m	2,0 – 3,5	3,5 – 6,0	6,0 – 8,5	8,5 – 11,0	11,0

APPENDIX 1.

TESTING PROCEDURES OF WATERTIGHT COMPARTMENTS.
1. GENERAL

1.1 General requirements

1.1.1 The tests are intended to confirm the watertightness of tanks and bounding structures, correct constructive solutions and watertightness of the ship construction/equipment when at sea.
1.1.2 The tests apply to:
- new ships before their delivery;
- ships in operation, after a significant conversion or major repair of structures specified in 1.1.1.

Note:
Major repair means repairs that affect the structural integrity of the hull.
1.2 Definitions.
Leak testing is an air or other medium test carried out to demonstrate the tightness of the structure.
Hose testing is carried out to demonstrate the tightness of structural items not subjected to hydrostatic or leak testing and of other components which contribute to the watertight and weathertight integrity of the hull.
Hydropneumatic testing is a combination of hydrostatic and air testing, consisting in filling the tank with water up to its top and applying an additional air pressure. The value of the additional air pressure is at the discretion of the Register, but is to be at least as defined in 3.3.4.
Shop primer is a thin coating applied after surface preparation and prior to fabrication as a protection against corrosion during fabrication.
Protective coating is a final coating protecting the structure from corrosion.
Structural testing is a hydrostatic test carried out to demonstrate the tightness, as well as the structural adequacy of the design. Where practical limitations prevail and hydrostatic testing is not feasible (for example when it is difficult, in practice, to apply the required head at the top of the tank), hydropneumatic testing may be carried out instead. When hydropneumatic testing is performed, its conditions should simulate, as far as practicable, the actual loading of the tank.
1.3 Application.
1.3.1 All gravity tanks and other boundaries required to be watertight or weathertight shall be tested in accordance with this Appendix and proven to be tight and structurally adequate as follows:
gravity tanks for their tightness and structural adequacy;
watertight boundaries other than tank boundaries for their watertightness; and;
weathertight boundaries for their weathertightness.

Note:
Gravity tanks (tanks) means a cistern (tank), which is exposed to steam, not exceeding 70 kPa.

1.3.2 The testing of cargo containment systems of liquefied gas carriers shall be in accordance with standards deemed appropriate by the Register.

1.3.3 The testing of structures not listed in Table 4.1.1 or 4.1.2 shall be specially considered.

2. TYPES OF TESTS

2.1 General.

2.1.1 Two types of tests are considered in this section:

.1 Structural test is a test to verify the structural adequacy of tank construction. This may be a hydrostatic test or, where the situation warrants, a hydropneumatic test;

.2 Leak test is a test to verify the tightness of a boundary. Unless a specific test is indicated, this may be a hydrostatic/hydropneumatic test or an air test. A hose test may be considered an acceptable form of leak test for certain boundaries, as indicated by Footnote «3» of Table 4.1.1.

2.2 Type of test.

2.2.1 Definition of each type of test is given in Table 2.2.1

Test type	**Test method**
1	2
Hydrostatic test: (Leak and structural)	A test wherein a space is filled with a liquid to a specified head
Hydropneumatic test: (Leak and structural)	A test combining a hydrostatic test and an air test, wherein a space is partially filled with a liquid and pressurized with air
Hose test: (Leak)	A test to verify the tightness of a joint by a jet of water with the joint visible from the opposite side.
Air tests: (Leak)	A test to verify tightness by means of air pressure differential and leak indicating solution. It includes tank air test and joint air tests, such as compressed air fillet weld tests and vacuum box tests
Compressed air fillet weld test: (Leak)	An air test of fillet welded tee joints wherein leak indicating solution is applied on fillet welds.
Vacuum box test: (Leak)	A box over a joint with leak indicating solution applied on the welds. A vacuum is created inside the box to detect any leaks.
Ultrasonic test: (Leak)	A test to verify the tightness of the sealing of closing devices such as hatch covers by means of ultrasonic detection techniques
Penetration test: (Leak)	A test to verify that no visual dye penetrant indications of potential continuous leakages exist in the boundaries of a compartment by means of low surface tension liquids (i.e. dye penetrant test).

3. TEST PROCEDURES

3.1 General.

3.1.1 Tests shall be carried out in the presence of the surveyor of the Register at a stage sufficiently close to the completion of work with all hatches, doors, windows, etc., installed and all penetrations including pipe connections fitted, and before any ceiling and cement work is applied over the joints.

Specific test requirements are given in 3.3 and Table 4.1.1.

For the timing of the application of coating and the provision of safe access to joints, refer to 3.4, 3.5 and Table 4.1.3.

3.2 Structural test procedures.

3.2.1 Type and time of test.

.1 Where a structural test is specified in Table 4.1.1 or Table 4.1.2 a hydrostatic test in accordance with 3.3.1 will be acceptable.

Where practical limitations (strength of building berth, light density of liquid, etc.) prevent the performance of a hydrostatic test, a hydropneumatic test in accordance with 3.3.2 may be accepted instead.

A hydrostatic test or hydropneumatic test for the confirmation of structural adequacy may be carried out while the ship is afloat, provided the results of a leak test are confirmed to be satisfactory before the ship is afloat.

3.2.2 Обсяг конструктивних випробувань.

.1 Structural tests shall be carried out for at least one tank of a group of tanks having structural similarity (i.e. same design conditions, alike structural configurations with only minor localized differences determined to be acceptable by the attending surveyor of the Register) on each ship provided all other tanks are tested for leaks by an air test.

Where the structural adequacy of the tanks of a ship were verified by the structural testing required in Table 4.1.1, subsequent ships in the series (i.e. sister ships built from the same plans at the same shipyard) may be exempted from the structural testing of tanks, provided that watertightness of boundaries of all tanks is verified by leak tests and thorough inspections are carried out. For ships of the same type, built several years after the last vessel of the series, such exemption may be revised.

In any case, structural testing is carried out for at least one tank of each type among all tanks of each sister ship

.2 For the watertight boundaries of spaces other than tanks structural testing may be exempted, provided that the watertightness of boundaries of exempted spaces is verified by leak tests and inspections.

.3 Carrying out structural tests of the remaining tanks may be required, in the case of unsatisfactory results of testing the first tank.

.4 Tanks for structural tests shall be chosen in such a way that all typical structural elements of the hull of the ship have been tested for strength (expected stretching and compression).

3.2.3 Leak test procedures.

For the leak tests specified in Table 4.1.1, tank air tests, compressed air fillet weld tests, vacuum box tests in accordance with 3.3.3 ÷ 3.3.6 or their combination, will be acceptable.

Hydrostatic or hydropneumatic tests may also be accepted as leak tests provided that 3.4 and 3.5 are complied with.

Hose tests will also be acceptable for such locations as specified in Table 4.1.1 with footnote «3».

A ir tests of joints may be carried out in the block stage provided that all work on the block that may affect the tightness of a joint is completed before the test.

Refer also to 3.4.1 for the application of final coatings and 3.5 for the safe access to joints and the summary in Table 4.1.3.

3.3 Test features.

3.3.1 Hydrostatic test.

Unless another liquid is approved, hydrostatic tests shall consist of filling the space with fresh water or sea water, whichever is appropriate for testing, to the level specified in Table 4.1.1 or 4.1.2.

In cases where a tank for higher density cargoes shall be tested with fresh water or sea water, the testing pressure height shall be specially considered.

3.3.2 Hydropneumatic test.

Hydropneumatic tests, where approved, shall be such that the test condition, in conjunction with the approved liquid level and supplemental air pressure, will simulate the actual loading as far as practicable.

The requirements and recommendations for tank air tests in 3.3.4, will also apply to hydropneumatic tests.

3.3.3 Hose test.

Hose tests shall be carried out with the pressure in the hose nozzle maintained at least at 200 kPa during the test. The nozzle shall have a minimum inside diameter of 12 mm and be at a perpendicular distance from the joint not exceeding 1,5 m.

Where a hose test is not practical because of possible damage to machinery, electrical equipment insulation or outfitting items, it may be replaced by a careful visual examination of welded connections, supported where necessary by means such as a dye penetrant test or ultrasonic leak test or the equivalent.

3.3.4 Air test.

All boundary welds, erection joints and penetrations, including pipe connections, shall be examined in accordance with the approved procedure and under a stabilized pressure differential above atmospheric pressure not less than 15 kPa, with a leak indicating solution such as soapy water/detergent or a proprietary brand applied.

During the test the air pressure in the tank is to be raised to 20 kPa and to be maintained it at this level for about 1:00 (a minimum number of personnel is to be in the vicinity of the tank) before the pressure is to be reduced test pressure of 15 kPa.

A U-tube with a height sufficient to hold a head of water corresponding to the required test pressure shall be arranged.

Welds shall be covered with an effective leak indicating solution.

To prevent excessive pressure in the compartment being tested and to check the test pressure U-tube, which is filled with water to a level that corresponds to the pressure proving, is to installed. The cross sectional area of the U-tube shall not be less than that of the pipe supplying air to the tank. Instead of using a U-tube, two calibrated pressure gauges may be acceptable to verify required test pressure.

Air test is to be conducted prior to the application of a protective coating on all fillet welds located at the boundaries of tanks or cisterns; welds with full penetration and assembly welds, excluding welds made by automatic welding.

The Register surveyor may require that the same tests shall be carried out at selected parts of welds made by automatic welding, as well as demountable welds made by manual or automatic welding, taking into account the quality control procedures that are used at the shipyard. Other welds may be tested by air after application of the protective coating, provided that these welds are to be carefully inspected.

As agreed with the Register, other test methods may be adopted. For example, two pressure gauges and a safety valve may be installed in the compartment to be tested. Fittings for the installation of pressure gauges and safety valves are to be placed on the tanks tops, on temporary silencers or other places convenient for maintenance.

The pressure gauges shall have an accuracy class of 1.5 to 2.5 and a measurement limit of one third greater than the test pressure. The scale value of the manometer scale should not be more than 2 kPa.

3.3.5 Compressed air fillet weld test.

In this air test, compressed air is injected from one end of a fillet welded joint and the pressure verified at the other end of the joint by a pressure gauge. Pressure gauges shall be arranged so that an air pressure of at least $0{,}15\cdot10^5$ Pa, can be verified at each end of all passages within the portion being tested.

Note. Where a leak test is required for fabrication involving partial penetration welds, a compressed air test shall also be applied in the same manner as to fillet weld where the root face is large, i.e. 6 to 8 mm.

3.3.6 Vacuum box test.

A box (vacuum testing box) with air connections, gauges and an inspection window is placed over the joint with a leak indicating solution applied to the weld cap vicinity.

The air within the box is removed by an ejector to create a vacuum of $0{,}20\cdot10^5$ Pa to $0{,}26\cdot10^5$ Pa.

3.3.7 Ultrasonic test.

An ultrasonic echoes transmitter shall be arranged inside of a compartment and a receiver shall be arranged on the outside.

A location where sound is detectable by the receiver indicates a leakage in the sealing of the compartment..

3.3.8 Penetration test.

A test of butt welds or other weld joints uses the application of a low surface tension liquid at one side of a compartment boundary or structural arrangement.

If no liquid is detected on the opposite sides of the boundaries after expiration of a definite period of time, this indicates tightness of the boundaries.

3.3.9 Other tests.

Other methods of testing may be considered by Register upon submission of full particulars prior to the commencement of testing.

3.4 Application of coating.

3.4.1 Final coating.

For butt joints welded by an automatic process, the final coating may be applied any time before the completion of a leak test of spaces bounded by the joints.

For all other joints, the final coating shall be applied after the completion of the leak test of the joint. Refer also to Table4.1.3.

Register surveyor reserves the right to require a leak test prior to the application of the final coating over automatic erection butt welds.

3.4.2 Temporary coating.

Any temporary coating which may conceal defects or leaks shall be applied at the time as specified for the final coating.

This requirement does not apply to shop primer.

3.5 Safe access to joints.

For leak tests, safe access to all joints under examination shall be provided. Refer also to Table 4.1.3.

4. TEST REQUIREMENTS

4.1 General.

4.1.1 The requirements for testing of tanks and boundaries are given in Table.4.1.1.

4.1.2 Additional requirements for testing special vessels / tanks are given in Table 4.1.2.

4.1.3 Timing of the application of coating and the provision of safe access to joints are given in 4.1.3.

Table 4.1.1 **Test requirements for tanks and boundaries**

Nos.	Tank or boundary to be tested	Test type	Test head or pressure	Remarks
1	2	3	4	5
1	Double bottom tanks[4]	Leak and structural[1]	The greater of: top of the overflow; or to 2,4 m above top of tank[2], or to bulkhead deck	
2	Double bottom voids[5]	Leak	Refer to 3.3.4 ÷ 3.3.6, as applicable	
3	Double side tanks	Leak and structural[1]	The greater of: top of the overflow; or to 2,4 m above top of tank[2], or to bulkhead deck	
4	Double side voids	Leak	Refer to 3.3.4 ÷ 3.3.6, as applicable	
5	Deep tanks other than those listed elsewhere in this table	Leak and structural[1]	The greater of: top of the overflow; or to 2,4 m above top of tank[2], or to bulkhead deck	
6	Cargo oil tanks	Leak and structural[1]	The greater of: top of the overflow; or to 2,4 m above top of tank [2]; or to top of tank[2] plus setting of any pressure relief valve	
7	Ballast hold of bulk carriers	Leak and structural[1]	The greater of: top of the overflow; or top of cargo hatch coaming	
8	Peak tanks	Leak and structural[1]	The greater of: top of the overflow; or to 2,4 m above top of tank [2]	After peak to be tested after installation of stern/helmport tube
9	a) Fore peak spaces not used as tank	Leak	Refer to 3.3.4 ÷ 3.3.6, as applicable	
	б) Aft peak spaces not used as tank	Leak	Refer to 3.3.4 ÷ 3.3.6, as applicable	After peak to be tested after installation of stern/helmport tube
10	Cofferdams	Leak	Refer to 3.3.4 ÷ 3.3.6, as applicable	
11	a. Watertight bulkheads	Leak	Refer to 3.3.3 ÷ 3.3.6, as applicable	
	б. Superstructure end bulkheads	Leak	Refer to 3.3.3 ÷ 3.3.6, as applicable	

12	Watertight doors below freeboard or bulkhead deck	Leak[6, 8]	Refer to 3.3.3 ÷ 3.3.6, as applicable	
13	Double plate rudder blades spaces between inner and outer plating of fixed and steering nozzles, hollow elements of of foil structure	Leak	Refer to 3.3.4 ÷ 3.3.6, as applicable	
14	Shaft tunnels clear of deep tanks	Leak [3]	Refer to 3.3.3 ÷ 3.3.6, as applicable	
15	Shell doors	Leak [3]	Refer to 3.3.3 ÷ 3.3.6, as applicable	
16	Weathertight hatch covers and closing appliances	Leak [3, 8]	Refer to 3.3.3 ÷ 3.3.6, as applicable	Hatch covers closed by tarpaulins and battens excluded
17	Dual purpose tanks/dry cargo hatch covers	Leak [3, 8]	Refer to 3.3.3 ÷ 3.3.6, as applicable	In addition to structural test in item 6 or 7
18	Chain lockers	Leak and structural	Top of chain pipe	
19	Independent tanks	Leak and structural	The greater of: top of the overflow, but not less than 0.9 m;	
20	Ballast ducts	Leak and structural [1]	The greater of: ballast pump maximum pressure, of tank setting pressure of the safety relief valves	

[1]Structural test is to be carried out for at least one tank of the same construction (i.e., same design and same workmanship) on each vessel provided all subsequent tanks are tested for leaks by an air test. However, where structural adequacy of a tank was verified by structural testing, the subsequent vessels in the series (i.e., sister ships built in the same shipyard) may be exempted from such testing for other tanks which have the structural similarity to the tested tank, provided that the water-tightness in all boundaries of exempted tanks are verified by leak tests and thorough inspection is carried out. In any case, structural testing is to be carried out for at least one tank for each vessel in order to verify structural fabrication adequacy. (refer to 3.2.2.1).

[2] The top of a tank is the deck forming the top of the tank, excluding any hatchways.

[3] Hose Test may also be considered as a medium of the test. Refer to 2.2.1.

[4] Including tanks arranged in accordance with the provisions of SOLAS regulation II-1/9.4 as amanded.

[5] Including duct keels and dry compartments arranged in accordance with the provisions of SOLAS regulation II-1/9.4 as amanded.

[6] Where water tightness of a watertight door has not been confirmed by prototype test, testing by filling watertight spaces with water shall be carried out. Refer to SOLAS regulation II-1/16.2 and IMO circular MSC/Circ.1176.

[7] Where a hose test is not practicable, other testing methods listed in 3.3.7 to 3.3.9 may be applicable subject to adequacy of such testing methods being verified. Refer to SOLAS regulation II-l/ll.l as amanded.

[8] As an alternative to the hose testing, other testing methods listed in 3.3.7 to 3.3.9 may be applicable subject to adequacy of such testing methods being verified. Refer to SOLAS regulation II-l/ll.l as amanded.

Note.

SOLAS regulation II-1/9.4

Double bottom on passenger and cargo ships that are not tankers.

9.4. A double bottom need not be fitted in way of watertight tanks, including dry tanks, of moderate size, provided that the safety of the ship is not impaired in the event of bottom or side damage.

SOLAS regulation II-1/11.1 .

Initial testing of watertight bulkheads, etc.

1. Testing watertight spaces not intended to hold liquids and cargo holds intended to hold ballast by filling them with water is not compulsory. When testing by filling with water is not carried out, a hose test shall be carried out where practicable. This test shall be carried out in the most advanced stage of the fitting out of the ship. Where a hose test is not practicable because of possible damage to machinery, electrical equipment insulation or outfitting items, it may be replaced by a careful visual examination of welded connections, supported where deemed necessary by means such as a dye penetrant test or an ultrasonic leak test or an equivalent test. In any case a thorough inspection of the watertight bulkheads shall be carried out.

2. The forepeak, double bottoms (including duct keels) and inner skins shall be tested with water to a head corresponding to the requirements of regulation II-1/10.1.

3. Tanks which are intended to hold liquids, and which form part of the watertight subdivision of the ship, shall be tested for tightness and structural strength with water to a head corresponding to its design pressure. The water head is in no case to be less than the top of the air pipes or to a level of 2.4 m above the top of the tank, whichever is the greater.

4. The tests referred to in paragraphs 2 and 3 are for the purpose of ensuring that the subdivision structural arrangements are watertight and are not to be regarded as a test of the fitness of any compartment for the storage of oil fuel or for other special purposes for which a test of a superior character may be required depending on the height to which the liquid has access in the tank or its connections.

SOLAS regulation II-1/16.2.

Construction and initial tests of watertight doors, sidescuttles, etc.

1. In all ships:

1.1 the design, materials and construction of all watertight doors, sidescuttles, gangway and cargo ports, valves, pipes, ash-chutes and rubbish-chutes referred to in these regulations shall be to the satisfaction of the Administration;

The prototype test shall be carried out before the door is fitted. The installation method and procedure for fitting the door on board shall correspond to that of the prototype test. When fitted on board, each door shall be checked for proper seating between the bulkhead, the frame and the door.

1.2 such valves, doors and mechanisms shall be suitably marked to ensure that they may be properly used to provide maximum safety;
1.3 the frames of vertical watertight doors shall have no groove at the bottom in which dirt might lodge and prevent the door closing properly.
2. In passenger ships and cargo ships watertight doors shall be tested by water pressure to a head of water they might sustain in a final or intermediate stage of flooding. Where testing of individual doors is not carried out because of possible damage to insulation or outfitting items, testing of individual doors may be replaced by a prototype pressure test of each type and size of door with a test pressure corresponding at least to the head required for the intended location.

Table 4.1.2 **Additional test requirements for special service ships/tanks**

Nos.	Type of ship/tank	Structures to be tested	Type of test	Test head or pressure	Remarks
1	2	3	4	5	6
1	Liquefied gas carriers	Cargo systems	Refer to 3.3.1	Refer to 3.3.1	Also refer to Table 4.1.1 relative to other tanks and boundaries
2	Edible liquid tanks	Independent tanks	Leak and structural	The greater of: top of the overflow; or to 0,9 m above top of tank	
3	Chemical tankers	Integral or independent cargo tank	Leak and structural	The greater of: to 2.4 m above top of tank [1]; or to top of tank[1] plus setting of any pressure relief valve	

[1] Top of tank is deck forming the top of the tank excluding any hatchways.

Table 4.1.3 **Application of leak test, coating and provision of safe access for type of welded joints**

v		Leak test	Coating [1]		Safe acces [2]	
			Before leak test	After leak test but before structural test	Leak test	Structural test
1	2	3	4	5	6	7
Butt	Automatic	Not required	Allowed	N/A	Not required	Not required
	Manual or semiautomatic	Required	Not allowed	Allowed	Required	Not required
Fill	Boundary	Required	Not allowed	Allowed	Required	Not

et	including penetrations					required

[1] boating refers to internal (tank/hold coating), where applied, and external (shell/deck) painting. It does not refer to shop primer.
[2] Temporary means of access for verification of the leak test.

APPENDIX 2

REQUIREMENTS TO SHIP LOADING INSTRUMENTS

1. GENERA L

1.1 The present Requirements shall be applied together with those of Part I I "Hull " of these Rules and the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships when approving the loading instruments of ships whose instruments are not yet approved

1.2 The Requirements apply to loading instruments representing a computer-based system consisting of software for ship load calculation and of hardware for its realization. Requirements pertinent to the program and its functional capabilities shall be found in 3.1 and Section 4 of this Appendix respectively. Requirements pertinent to type approval for hardware shall be found in 1.8 and 3.2 of this Appendix.

1.3 A loading instrument shall not substitute for an approved Loading Manual.

1.4 The loading instrument belongs to special equipment carried onboard, and the calculation results obtained by using it apply only to the ship for which it was approved.

1.5 Ships undergoing major modifications or modernization, such as lengthening or deck removal affecting the longitudinal strength of hull, shall be considered new ships for the purpose of the Requirements.

1.6 For each ship, the loading instrument approval procedure shall include the following:

basic data verification and loading conditions approval with issuing of a Report (Form 1.9.28)[2] for subsequent testing of the program;

hardware approval with issuing of a Certificate (Form 3.2.1), where necessary;

handover tests with a subsequent issuing of a Report (Form 1.9.18).

1.7 The program for the loading instrument shall be type-approved by the Register which shall be confirmed by issuing a Type Approval Certificate for Computer Program (Form 3.4.7). In such cases, certain stages may be omitted in the basic data verification procedure for a particular ship (refer to 2.1.7).

1.8 Hardware shall be approved, i f there is a single computer for which a Type Approval Certificate (Form 3.4.1), was issued in accordance with the requirements of 3.2 of this Appendix, or there are two computers specially installed for the case one of them fails. I f

[2] The designations of the appropriate forms are in accordance with the List of Registry documents issued as a result of its supervisory activities.

there are two computers, no type approval is necessary for them but in this case, each computer shall pass handover tests. Besides, computers being a part of the shipboard net shall be approved by the Register which shall be confirmed by issuing a Certificate (Form 3.2.1) in accordance with the relevant requirements of these and the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

1.9 A Report (Form 1.9.18) shall be issued for the program on the basis of the satisfactory results of handover tests of the loading instrument carried out onboard the ship in accordance with the requirements of 2.3 of this Appendix.

2. APPROVAL PROCEDURE

2.1 Basic data verification and approval. Loading conditions approval for program testing.

2.1.1 Calculation results and the actual ship data used for the program shall be verified onboard the ship for which the program is intended.

2.1.2 On receipt of an application for data verification, the Register shall offer to the applicant four loading conditions as a minimum, borrowed from an approved Ship Loading Manual and to be used for program testing. These loading conditions shall ensure the loading of each ship compartment for one time at least. These loading conditions shall generally cover the whole range of possible ship draughts from the greatest one in the loaded condition to the smallest one in the ballasted condition.

2.1.3 Control points shall generally be positioned on transverse bulkheads or other obvious compartment boundaries. Additional control points may be necessary between the bulkheads of long holds or tanks, or between container stacks.

2.1.4 I f the torque on calm water shall be determined, the software shall demonstrate it on a single test loading condition of the ship.

2.1.5 It is important that the basic data included in the program are in agreement with those contained in the approved Loading Manual. Special attention shall be paid to the final mass value of the ship in the light condition and the position of its gravity centre adopted on the basis of inclining test or proceeding from the results of the light ship condition verification.

2.1.6 The following basic data shall be submitted to the Register by the applicant in order to verify whether they are in agreement with the ship constructed:

principal dimensions, coefficients of fineness of the lines and, where necessary, the lateral projection of the ship;

position of forward and aft perpendiculars and, where necessary, the procedure for determining the forward and stern draughts at actual draught mark locations;

light ship displacement and its distribution through the ship length;

lines drawing and/or tables of offsets, or Bonjean scales including 21st section on the length between perpendiculars;

compartments description including spacing, volume centres and volume tables (tank capacity tables/ tables showing the mass of liquid in a tank filled to different levels) where necessary;

deadweight composition for each loading condition.

Identification details of the program including the version number shall be verified also.

2.1.7 The basic data verification procedure may be considered to be completed, if:

the requirements of 3.1 of this Appendix are fulfilled in respect of the program;

the purpose of the program is clearly formulated and the calculation methods with the algorithm are in accordance with the requirements of these Rules and the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships;

the requirements of Section 4 of this Appendix are fulfilled with regard to the functional capabilities of the program;

the precision of calculations made on the basis of the program is within the tolerances stipulated by 2.5 of this Appendix;

ship particulars are in accordance with the requirements of 2.1.5 of this Appendix;

the program user's manual is clear and brief and complies with the requirements of 2.4 of this Appendix and is checked and duly noted by the Register;

data are given concerning the minimal requirements for hardware;

ship loading conditions intended for the program testing are approved which is confirmed by the Report (Form 1.9.28).

2.1.8 Type Approval Certificate for Computer Program (Form 3.4.7) shall be issued on the basis of the requirements of 2.2 of this Appendix. Where the program is type approved, the basic data verification procedure may be considered to be completed, if:

it is found that the type-approved program is applicable to the ship in question;

information contained in the valid Certificate (Form 3.4.7), is in compliance with the program being identified and its version number:

the precision of calculations made on the basis of the program is within the tolerances stipulated in 2.5 of this Appendix;

ship particulars are in accordance with the requirements of 2.1.5 of this Appendix; the program user's manual is clear and brief and complies with the requirements of 2.4 of this Appendix and is checked and duly noted by the Register;

data are given concerning the minimal requirements for hardware;

ship loading conditions intended for the program testing are approved and there is a Report (Form 1.9.28) on the program operation testing.

2.1.9 Approved loading conditions given in Ship Loading Manual and the Report (Form 1.9.28) are sent to the Branch Office by the Register Head Office noting the necessity of handover tests to be held. Where the ship is in service, the approved loading conditions and the Report (Form 1.9.28) are sent to the shipowner who shall ensure that they are delivered onboard and that handover tests are held with the surveyor of the Register participating.

2.2 Type approval.

2.2.1 A program for the loading

instrument may be type approved according to the requirements of this Chapter. If the tests are completed satisfactorily, Type Approval Certificate for Computer Program (Form 3.4.7) shall be issued for the program.

2.2.2 The Certificate (Form 3.4.7) shall be valid for an identified version of the program only.

2.2.3 After the application for the type approval of a program has been submitted, the Register will provide the applicant with data for its testing for two ship types at least. Where programs using basic data on hull shape are concerned, the program test data shall be provided for three ship types. These data shall be used by the applicant for running the program in respect of the tested ships. The results (including the data-of-the-lines-plan curve and the interpolation curve output, if applicable) obtained by using the program shall be submitted to the Register in order the precision of calculations might be assessed. The Register shall make parallel calculations using the same basic data and compare their results with those obtained by means of the program submitted.

2.2.4 The Certificate (Form 3.4.7) may be issued if:

the requirements of 3.1 of this Appendix are fulfilled in respect of the program;

the purpose of the program is clearly formulated and the calculation methods with the algorithm are in accordance with the requirements of these Rules and the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships;

the requirements of Section 4 of this Appendix are fulfilled with regard to the functional capabilities of the program;

the precision of calculations made on the basis of the program is within the tolerances stipulated in 2.5 of this Appendix;

the Program User's Manual is clear and brief, and is submitted to the Register for review;

data are given concerning the minimal requirements for hardware.

2.2.5 The Certificate (Form 3.4.7) shall include a detailed description of calculations for which the program is approved and of limitations imposed upon the program.

2.2.6 The Certificate (Form 3.4.7) shall be issued for a maximum period of 5 years. The Certificate may be extended after the developer has confirmed that the algorithm is unchanged in the program.

2.2.7 A valid Certificate (Form 3.4.7) will be invalidated, if the algorithm is changed in the program by the developer without prior agreement with the Register. In such a case, the revised program shall be considered a new one.

2.3 Handover tests.

2.3.1 Handover tests shall be held soon after the loading instrument installation aboard the ship.

2.3.2 During handover tests, the user, one of the senior officers shall use the instrument for calculating a test loading condition of the ship. The operation shall be confirmed by the Register surveyor. Data obtained by means of the instrument shall agree with those stated for the approved test loading conditions. Where the numerical output data given by the instrument do not agree with those stated in the approved test loading conditions, the Report (Form 1.9.18) shall not be issued.

2.3.3 Handover tests shall also be carried out in respect of the second computer specially installed to be used if the first one fails. Data obtained by means of the loading instrument shall agree with those stated for the approved tests loading conditions. Where the output numerical data of the loading instrument do not agree with those stipulated for the approved tests loading conditions, no Report (Form 1.9.18) shall be issued. If handover tests are effected using a computer for which the Type Approval Certificate (Form 3.4.1), was issued, the second specially installed computer need not be tested.

2.3.4 Where hardware is not approved, it shall be demonstrated that handover tests results for the program are satisfactory for both the first and the second specially installed computer, subsequent to which the Report (Form 1.9.18) on the program handover tests may be issued.

2.3.5 After satisfactory completion of handover tests, the RS surveyor shall attach the approved test loading conditions for the ship, as well as the Program Test Report (Form 1.9.28) to the Program User's Manual formerly duly noted by the Register. Then, the Report (Form 1.9.18) on handover tests of the program will be issued by the Register.

2.4 Program User's Manual.

2.4.1 The Manual shall be submitted to the Register for review. In case of satisfactory results of the consideration, the Manual shall be duly noted by the Register.

2.4.2 The Manual shall be drawn up in a brief and clear way and shall be provided preferably with drawings and block diagrams.

2.4.3 The Manual shall include the following information:

mation: general description of the program with indication of its version identification number;

a copy of Type Approval Certificate for Computer Program (Form 3.4.7);

data on minimal required hardware properties necessary for program operation;

description of error messages and warning reports that can be issued by computer and clear instructions concerning the user's subsequent steps in this case;

light ship displacement and gravity centre of the ship coordinates;

full deadweight composition for each test loading condition of the ship;

values of permissible shearing forces and bending moments in calm water given or taken into consideration by the Register;

values of permissible cargo torque, where applicable;

correction factors for shearing forces, where applicable;

local permissible limitations on the loading of particular holds and two adjacent holds proceeding from the maximum cargo mass for each hold in relation to the relevant ship draught, where applicable;

example of ship loading conditions determination with illustrations and computer data out;

example of each display screen data out with explanations.

2.5 Allowance for calculation accuracy.

The accuracy of calculations made using the program shall be within the range of acceptable allowances given in Table 2.5..

Table 2.5 **Range of allowances for calculation accuracy**

Design value	Allowance (percentage of permissible value)
Shearing force on stfll water N_{sw}	±5
Bending moment on still water M_{sw}	±5
Torque on still water M_{tsw}	±5

The accuracy of calculations can be determined by comparing, at each control point, the results of calculations made using the program to those obtained by using an independent program of the Register or an approved loading manual containing the similar basic data.

2.6 Hardware approval.

The hardware of a loading instrument shall be in accordance with the requirements of 1.8 and 3.2 of this Appendix if it is type-approved by the Register.

3. REQUIREMENTS TO THE SYSTEM

3.1 Program.

3.1.1 It is recommended that the development and release of the program be carried out in accordance with the relevant international quality standards (for instance, ISO 9000-3 or equivalent).

3.1.2 Software shall be developed so as to render it impossible for the user to modify data files of the ship containing the following information:

lightweight displacement of the ship, lightweight ship mass distribution and the relevant gravity centres;

structural restrictions imposed by the Register;

data essential for hull geometry; hydrostatic data;

description of compartments including spacing, volume centres and volume tables (tank capacity tables/tables showing the volume of liquid in a tank when filled to different levels) where necessary.

3.1.3 Any changes to software that can influence longitudinal strength shall be introduced by the developer or his appointed representative, and the Register shall be immediately notified accordingly. The absence of a notification of any changes to the program may render the Certificate (Form 3.4.7) issued by the Register invalid. When the Certificate (Form 3.4.7) is found to be invalid by the Register, the modified program will be considered anew in accordance with the requirements of this Appendix. 3.2.

3.2 Hardware of an independent computer.

3.2.1 Type Approval Certificate (Form 3.4.1), and Hardware Approval Certificate (Form 3.2.1) shall be issued by the Register on condition the hardware is in accordance with the requirements contained in 3.2.2 of this Appendix, as well as with the requirements of these Rules and the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

3.2.2 The developer shall submit the detailed information on the hardwshall be installed on board. The following information shall be submitted to the Register for review:

hardware specification;

the relevant design drawings with indicated materials, catalogues, data sheets, calculations and functional descriptions;

test program suggested for demonstration, confirming that the operational requirements of the above standards can be fulfilled;

certificates and the relevant test reports obtained for the product earlier.

3.2.3 When considering the documentation mentioned in 3.2.2, the Register may recognize the validity of certificates and reports issued by another certification body or accredited laboratory.

3.2.4 The operational and climatic tests shall be held in the presence of the Register representative under the standard test conditions so that a type approval could be issued in accordance with Part XV "Automation" of these Rules and Part IV "Technical Supervision during Manufacture of Products" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships. The following inspections and tests shall be completed satisfactorily:

external examination; functional tests;

disturbance in electric power supply;

thermal resistance testing;

moisture resistance testing;

vibration tests;

testing by oscillating and prolonged tilting motion conditions;

testing of insulation electric strength, insulation resistance measurement;

cold resistance tests;

electromagnetic compatibility tests.

3.2.5 The Register shall be notified of any modifications to hardware specification.

4. REQUIREMENTS CONCERNING FUNCTIONAL CAPABILITIES

4.1 General.

4.1.1 The computational functions inherent in the program will depend on the requirements contained in these Rules and in the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

4.1.2 The program shall be convenient for the user and be developed so as to minimize the possibility of incorrect initial data input by the user.

4.1.3 Calculations of the fore, midlength and after draughts at relevant perpendiculars shall be submitted in a form easily understandable for the user both in files and as hard copies.

4.1.4 For the case of the actual ship loadline positions of the, the fore, midlength and after draughts shall be determined and submitted in a form easily understandable for the user both in files and as hard copies. Provision shall be made for submitting the sagging/hogging data for the hull.

4.1.5 Displacement shall be determined for the particular loading condition of the ship and the corresponding value of the draught, and shall be submitted to the user both in file and as a hard copy.

4.1.6 The loading instrument shall issue printouts containing output data both in digital and graphic form. The output data in digital form shall be represented both in the absolute values and as percentage of permissible values. Printouts shall contain description of the relevant loading condition of the ship.

4.1.7 Al l the electronic and hard copy data shall be represented in a form easily understandable for the user with indication of the identification number of the program version.

4.2 Forces and moments originating in the hull.

4.2.1 The program shall ensure an analysis of the following forces and moments in the ship hull in accordance with the requirements of Part I I "Hull" :

shearing force N_{sw} in still water, with a correction where applicable;

bending moment M_{sw} in still water, with a correction where applicable;

torque M_{tsw}, in still water, where applicable.

In case of open ships, particular attention shall be paid to loads under which hull twisting occurs.

4.2.2 Data to be submitted to or duly noted by the Register are included in Table 4.2.2.

4.2.3 Forces and moments shall be determined in absolute values and as percentage of permissible values, and shall be submitted both in graphical and tabulated form. The forces and moments determined, as well as their permissible values for each of the control points indicated, shall be submitted both in files and as hard copies. Any limitations concerning hull bending in the vertical direction in still water or hull twisting, for instance, may be considered on the basis of the requirements of the Rules..

4.3 Permissible loads, loading and capacity.

4.3.1 The program user shall be timely, clearly and unambiguously informed about the following restrictions imposed by the Register, concerning:

all permissible shearing forces and bending moments in still water;

permissible torques in still water, where applicable;

all local loading restrictions pertinent to both the loading of a particular hold and of the one adjacent thereto, where applicable;

mass of cargo contained in the hold;

ballast tanks and holds capacity; restrictions on filling.

Table 4.2.2

Design value	Data to be submitted to or duly noted by the Register
Shearing force N_{sw} on still water	1. Control points (frame numbers) for N_{sw} determination. Such points shall generally be chosen on transverse bulkheads or other obvious boundaries of compartments. Additional control points may be indicated between the bulkheads of long holds or tanks, as well as between container stacks. 2. Correction factors for shearing forces and their application procedure. 3. Permissible values [N_{sw}] at sea and in port, for control points mentioned in item 1. Where necessary, an additional range of permissible values [of N_{sw}] can be specified.

Bending moment M_{sw} on still water	1. Control points (frame numbers) for M_{sw} determination. Such points shall generally be chosen on transverse bulkheads, at hold centres or other obvious boundaries of compartments. 2. Permissible values [M_{sw}] at sea and in port, for control points mentioned in item 1. Where necessary, an additional range of permissible values [M_{sw}] can be specified.
Torque M_{tsw} on still water (where applicable)	1. Control points (frame numbers) for M_{tsw} determination. 2. Permissible values [of M_{tsw}] for control points mentioned in item 1.

4.3.2 Violation of any of the restrictions imposed shall be easily detectable by the program user.

5. PERFORMANCE TEST

5.1 Загальні вимоги.

When a loading instrument shall be installed on board and Report (Form 1.9.18) or a report on its previous testing by the Register is not available, the RS surveyor shall notify the Register Head Office accordingly.

5.2 Extent of survey.

When a loading instrument is tested, the results obtained on the basis of the program shall be identical to those given in the approved test loading conditions of the ship. I f the numerical output data obtained using the loading instrument do not agree with those to be found in the approved test loading conditions, the class assignment requirements shall be applied to the ship and the owner shall be notified accordingly. The program shall be tested on all the computers intended for it (those which are type approved or specially designed for the program).

APPENDIX 3.

EVALUATION OF SCANTLINGS OF CORRUGATED TRANSVERSE WATERTIGHT BULKHEADS IN NON-CSR BULK CARRIERS CONSIDERING HOLD FLOODING

1. DEFINITIONS[3]

1.1 Definitions and explanations.

1.1.1 Definitions and explanations belonging to general terminology of the Rules are specified in 1.1.3 of this Part of the Rules.

In this Appendix, the following definitions are adopted.

Net thickness t_{net} is the thickness obtained by applying the strength criteria given in Section 4 of this Appendix.

Required thickness is obtained by adding the corrosion addition t_s given in Section 6 of this Appendix, to the net thickness t_{net}.

Homogeneous loading condition means a loading condition in which the ratio between the highest

[3] The basic constructive type for bulk carrierss is determined according to 3.3.1.4, Part II "Hull". evaluation of scantlings of corrugated transverse watertight bulkheads in bulk carriers considering hold flooding shall be determined in accordance with 3.3.4.10, Part II "Hull".

and the lowest filling ratio, evaluated for each hold, does not exceed 1,20, to be corrected for different cargo densities.

2. LOAD MODEL

2.1 General.

The loads to be considered as acting on the bulkheads are those given by the combination of the cargo loads with those induced by the flooding of one hold adjacent to the bulkhead under examination. I n any case, the pressure due to the flooding water alone shall be considered.

The most severe combinations of cargo induced loads and flooding loads are to be used for the check of the scantlings of each bulkhead, depending on the loading conditions included in the Loading Manual:

homogeneous loading conditions;

non homogeneous loading conditions;

considering the individual flooding of both loaded and empty holds.

The specified design load limits for the cargo holds are to be represented by loading conditions defined by the designer in the Loading Manual.

Non homogeneous part loading conditions associated with multiport loading and unloading operations for homogeneous loading conditions need not be considered according to these requirements.

Holds carrying packed cargoes shall be considered as empty holds for this application.

Unless the ship is intended to carry, in non homogeneous conditions, only iron ore or cargo having bulk density equal or greater than 1,78 t/m^3 , the maximum mass of cargo which may be carried in the hold shall also be considered to fill that hold up to the upper deck level at centreline.

2.2 Bulkhead corrugation flooding head.

The flooding head h_f (refer to Fig. 2.2) is the distance, in m, measured vertically, with the ship in the upright position, from the calculation point to a level located at a distance d_f, in m, from the base line equal to:

а) in general:

D for the foremost transverse corrugated bulkhead;

0,9*D* for the other bulkheads.

Where the ship shall carry cargoes having bulk density less than 1,78 t/m^3 in non homogeneous loading conditions, the following values can be assumed:

0,95*D* for the foremost transverse corrugated bulkhead;

0,85*D* for the other bulkheads;

б) for ships less than 50000 t deadweight with Type B freeboard

0,95 *D* for the foremost transverse corrugated bulkhead;

0,85 *D* for the other bulkheads.

Where the ship is to carry cargoes having bulk density less than 1,78 t/m3 in non homogeneous loading conditions, the following values can be assumed:

0,9 *D* for the foremost transverse corrugated bulkhead;

0,8 *D* for the other bulkheads.

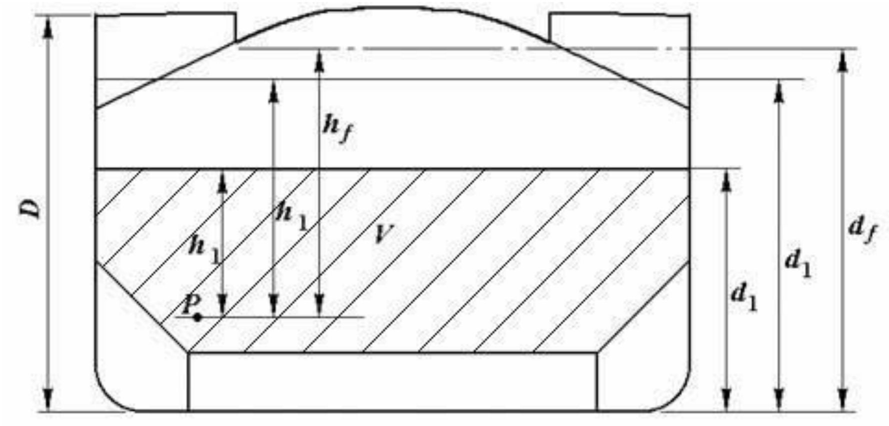


Fig.2.2:

V – volume of cargo; *P* – calculation point; *D* – distance, in m, from the base line to the freeboard deck at side amidships

2.3 Pressure in the non-flooded bulk cargo loaded holds.

A t each point of the bulkhead, the pressure p_c, in kN/m^2, shall be determined by the formula

$$p_c = \rho_c g h_1 \mathrm{tg}^2\gamma,$$

where ρ_c – bulk cargo density, in t/m3^3 ;

g – gravity acceleration equal to 9,81 m/s^2 ;

h_1 – vertical distance, in m, from the calculation point to horizontal plane corresponding to the level height of the cargo (refer to Fig. 2.2), located at a distanced ai, in m, from the base line;

$$\gamma = 45° - (\varphi / 2);$$

φ – angle of repose of the cargo, in deg., that may generally be taken as 35° for iron ore and 25° for cement.

The force F_c, in kN, acting on a corrugation shall be determined by the formula

$$F_c = \rho_c\, g\, s_1 \frac{(d_1 - h_{DB} - h_{LS})^2}{2} \mathrm{tg}^2\gamma,$$

where s_1 – spacing of corrugations, in m (refer to Fig. 2.3);

h_{LS} – mean height of the lower stool, in m, from the inner bottom;

h_{DB} – height of the double bottom, in m.

2.4 **Pressure in the flooded holds**.

2.4.1 Bulk cargo holds. Two cases shall be considered, depending on the values of d_1 and d_f.

.1 $d_1 \le d_f$.

At each point of the bulkhead located at a distance between d_1 and d_f, from the base line, the pressure $p_{c,\,f}$, in kN/m^2 , shall be determined by the formula

$$p_{c,\,f} = \rho g h_f\ ,$$

where ρ – sea water density, in t/m^3;

g – gravity acceleration (refer to 2.3);

h_f – flooding head (as defined in 2.2).

At each point of the bulkhead located at a distance lower than d_1, from the base line, the pressure $p_{c,\,f}$, in kN/m^2, shall be determined by the formula

$$p_{c,f} = \rho\, g\, h_f + [\rho_c - \rho\,(1 - \mathrm{perm})]\, g\, h_1 \mathrm{tg}^2\gamma,$$

where for ρ_c, g, h_1, γ – refer to 2.3;

perm – permeability of cargo (refer to 3.3.5.2, Part II "Hull").

The force $F_{c,f}$, in kN, acting on a corrugation shall be determined by the formula

$$F_{c,f} = s_1\left[\rho g \frac{\left(d_f - d_1\right)^2}{2} + \frac{\left[\rho g \left(d_f - d_1\right) + \left(p_{c,f}\right)_{le}\right]\left(d_1 - h_{DB} - h_{LS}\right)}{2}\right],$$

where for s_1, g, d_1, h_{DB}, h_{LS} – refer to 2.3;

d_f – as defined in 2.2;

$(p_{c,f})_{le}$ – pressure at the lower end of the corrugation, in kN/m^2.

.2 $d_1 > d_f$.

At each point of the bulkhead located at a distance between d_1 and d_f, from the base line, the pressure $p_{c,f}$, in kN/m^2, shall be determined by the formula

$$p_{c,f} = \rho_c g h_1 \mathrm{tg}^2\gamma,$$

where for ρ_c, g, h_1, γ – refer to 2.3.

A t each point of the bulkhead located at a distance lower thand_f, ^from the base line, the pressur p_c, in kN/m^2, shall be determined by the formula

$$p_{c,f} = \rho g h_f + \left[\rho_c h_1 - \rho\left(1 - \mathrm{perm}\right) h_f\right] g\, \mathrm{tg}^2\gamma$$

,

where for ρ, h_f, perm – refer to 2.4.1.1;

for ρ_c, g, h_1, γ – refer to 2.3.

The force $F_{c,f}$, in kN, acting on a corrugation shall be determined by the formula

$$F_{c,f} = s_1\left[\rho g \frac{\left(d_1 - d_f\right)^2}{2} \mathrm{tg}^2\gamma + \frac{\left[\rho_c g\left(d_1 - d_f\right)\mathrm{tg}^2\gamma + \left(p_{c,f}\right)_{le}\right]\left(d_f - h_{DB} - h_{LS}\right)}{2}\right],$$

where for s_1, ρ_c, g, d_1, γ, h_{DB}, h_{LS} – refer to 2.3;

for d_f – refer to 2.2;

$(p_{c,f})_{le}$ – pressure at the lower end of the corrugation, in kN/m^2

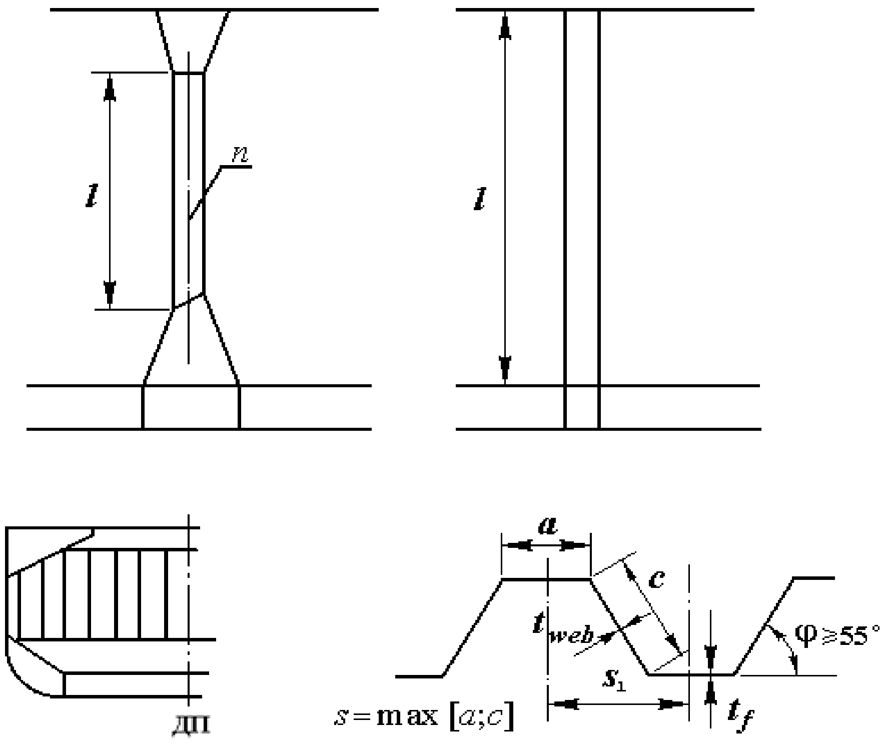


Fig. 2.3:

n – neutral axis of the corrugations;
t_f – net flange thickness, in mm;
t_{web} – corrugation web thickness.

Pressure in empty holds due to flooding water alone.

At each point of the bulkhead, the hydrostatic pressure p_f induced by the flooding head h_f, shall be considered.

The force F_f, in kN, acting on a corrugation shall be determined by the formula

$$F_f = s_1 \rho g \frac{\left(d_f - h_{DB} - h_{LS}\right)^2}{2},$$

where for s_1, g, h_{DB}, h_{LS} – refer to 2.3;
ρ – as defined in 2.4.1.1;
for d_f – refer to 2.2.

2.5 Resultant pressure and force.

2.5.1 Homogeneous loading conditions. At each point of the bulkhead structures, the resultant pressure *p*, in kN/m2 , to be considered for the scantlings of the bulkhead shall be determined by the formula

$$p = p_{c,f} - 0{,}8p_c .$$

The resultant force *F*, in kN, acting on a corrugation shall be determined by the formula

$$F = F_{c,f} - 0{,}8F_c .$$

2.5.2 Non homogeneous loading conditions.

At each point of the bulkhead structures, the resultant pressure p, in kN/m^2, to be considered for the scantlings of the bulkhead shall be determined by the formula

$$p = p_{c,f} \ .$$

The resultant force F, in kN, acting on a corrugation, shall be determined by the formula

$$F = F_{c,f} \, .$$

3. BENDING MOMENT AND SHEAR FORCE IN THE BULK-HEAD CORRUGATIONS

The bending moment M and the shear force Q in the bulkhead corrugations shall be determined by the formulae given in 3.1 and 3.2. The M and Q values shall be used for the checks in 4.5.

3.1 Bending moment.

The design bending moment M, in kN/m, for the bulkhead corrugations shall be determined by the formula

$$M = \frac{Fl}{8},$$

where F = resultant force, in kN (refer to 2.5);

l – span of corrugation, in m (refer to Figs. 2.3 and 3.1).

3.2 Shear force.

The shear force Q, in kN, at the lower end of the bulkhead corrugations shall be determined by the formula

$$Q = 0{,}8F \ ,$$

where for F, refer to 2.5.

4. STRENGTH CRITERIA

4.1 General.

4.1.1 The following criteria are applicable to transverse bulkheads with vertical corrugations (refer to Fig. 2.3).

For ships of 190 m in length and above, these bulkheads shall be fitted with a lower stool, and generally with an upper stool below deck.

For smaller ships, corrugations may extend from inner bottom to deck; if the stool is fitted, it shall comply with the requirements of this Chapter.

The corrugation angle φ, shown in Fig. 2.3 shall not be less than 55°.

Requirements for local net plate thickness are given in 4.7. In addition, the criteria as given in 4.2 and 4.5 shall be complied with.

The thickness of the lower part of corrugations determined in accordance with 4.2 and 4.3 shall be maintained for a distance from the inner bottom (if no lower stool is fitted) or the top of the lower stool not less than 0,15l.

The thickness of the middle part of corrugations determined in accordance with 4.2 and 4.4, shall be maintained to a distance from the deck (if no upper stool is fitted) or the bottom of the upper stool not greater than 0,30l.

The section modulus of the corrugation in the remaining upper part of the bulkhead shall not be less than 75 per cent of that required for the middle part, corrected for different yield stresses.

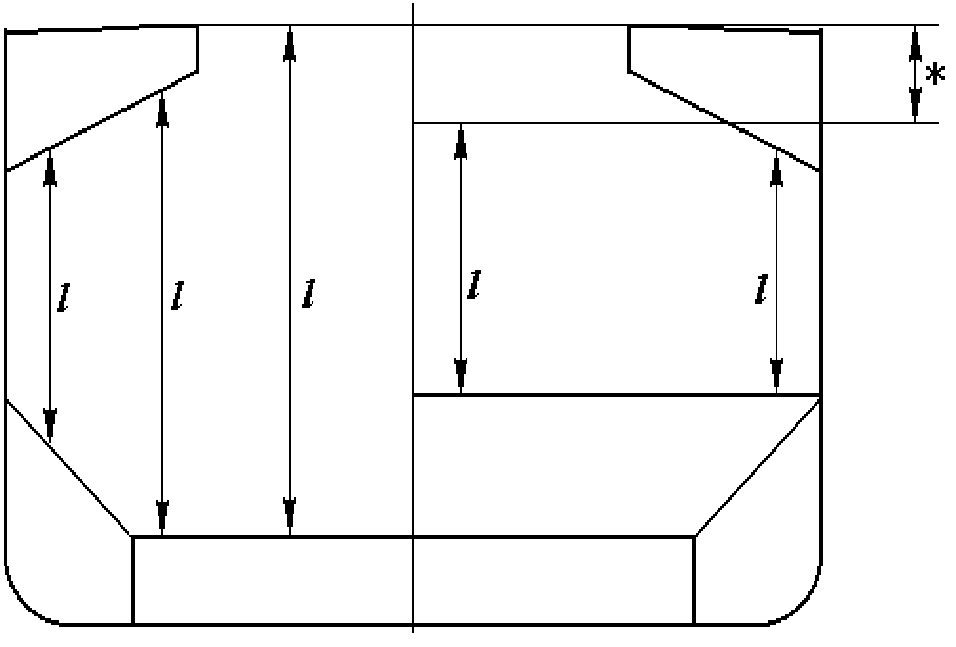


Рис.3.1:

l – span of corrugation;

∗ – for the definition of *l*, the internal end of the upper stool shall not be taken more than a distance from the deck at the centerline equal to:

3 times the depth of corrugations, in general;

2 times the depth of corrugations, rectangular stool

4.1.2 Нижня опора перегородки.

The height of the lower stool is generally shall be not less than 3 times the depth of the corrugations. The thickness and material of the stool top plate shall not be less than those required for the bulkhead plating as specified in 4.1.1. The thickness and material of the upper portion of vertical or sloping stool side plating within the depth equal to the corrugation flange width from the stool top shall not be less than the required flange plate thickness and material to meet the bulkhead stiffness requirement at lower end of corrugation. The thickness of the stool side plating and the section modulus of the stool side stiffeners shall not to be less than those required in 3.3 of this Part on the basis of the load model in Section 2 of this Appendix. The ends of stool side vertical stiffeners shall be attached to brackets at the upper and lower ends of the stool.

The distance from the edge of the stool top plate to the surface of the corrugation shall be at least 1,5 the thickness of the corrugation flange. The stool bottom shall be installed in line with double bottom floors and shall have a width not less than 2,5 times the mean depth of the corrugation. The stool shall be fitted with diaphragms in line with the longitudinal double bottom girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in corrugation flange corrugation web way of the connections to the stool top plate shall be avoided.

Where corrugations are cut at the lower stool, corrugated bulkhead plating shall be connected to the stool top plate by full penetration welds. The stool side plating shall be connected to the stool top plate and the inner bottom plating by either full penetration or deep penetration welds. The supporting floors shall be connected to the inner bottom by either full penetration or deep penetration welds.

4.1.3 Upper stool.

The upper stool, where fitted, shall have a height generally between 2 and 3 times the depth of corrugations. Rectangular stools shall have a height generally equal to 2 times the depth of corrugations, measured from the deck level and at hatch side girder. The upper stool shall be properly supported by girders or deep brackets between the adjacent hatchend beams.

The width of the stool bottom plate shall generally be the same as that of the lower stool top plate. The stool top of non rectangular stools shall have a width not less than 2 times the depth of corrugations.

The thickness and material of the stool bottom plate shall be the same as those of the bulkhead plating below.

The thickness of the lower portion of stool side plating shall not be less than 80 per cent of that required for the upper part of the bulkhead plating where the same material is used. The thickness of the stool side plating and the section modulus of the stool side stiffeners shall not be less than those required by the Register on the basis of the load model in Section 2 of this Appendix. The ends of stool side stiffeners shall be attached to brackets at upper and lower end of the stool. Diaphragms shall be fitted inside the stool in Hne with and effectively attached to longitudinal deck girders extending to the hatch end coaming girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connection to the stool bottom plate shall be avoided.

4.1.4 Alignment.

At deck, if no stool is fitted, two transverse reinforced beams shall be fitted in Hne with the corrugation flanges.

At bottom, if no stool is fitted, the corrugation flanges shall be in Hne with the supporting floors.

Corrugated bulkhead plating shall be connected to the inner bottom plating by full penetration welds. The plating of supporting floors shall be connected to the inner bottom by either full penetration or deep penetration welds.

The thickness and material properties of the supporting floors shall be at least equal to those provided for the corrugation flanges. Moreover, the cut-outs for connections of the inner bottom longitudinals to double bottom floors shall be closed by collar plates. The supporting floors shall be connected to each other by suitably designed shear plates complying with the requirements of 3.3 of this Part. Stool side plating shall aHgn with the corrugation flanges and stool side vertical stiffeners and their brackets in lower stool shall aHgn with the inner bottom longitudinals to provide appropriate load transmission between these stiffening members. Stool side plating shall not be knuckled anywhere between the inner bottom plating and the stool top.

4.2 Bending capacity and shear stress τ.

The bending capacity shall comply with the following relationship:

$$\frac{M \cdot 10^{-3}}{0{,}5 Z_{le}\ \sigma_{a,le} + Z_m\ \sigma_{a,m}} \le 0{,}95,$$

where M – bending moment, in kN·m (refer to 3.1);

Z_{le} – section modulus of one half pitch corrugation, in cm^3, at the lower end of corrugations, to be calculated according to 4.3;

Z_m – section modulus of one half pitch corrugation, in cm^3, at the mid-span of corrugations, to be calculated according to 4.4;

$\sigma_{a,le}$ – allowable stress, in N/mm^2, as given in 4.5, for the lower end of corrugations;

$\sigma_{a,m}$ – allowable stress, in N/mm^2, as given in 4.5, for the midspan of corrugations.

In no case Z_m shall be taken greater than the lesser of 1,15Z_{le} or 1,15Z'_{le} for calculation of the bending capacity, Z'_{le} being defined below.

In case shedders plates are fitted which:

are not knuckled;

are welded to the corrugations and the top of the lower stool by one side penetration welds or equivalent;

are fitted with a minimum slope of 45° and their lower edge is in Hne with the stool side plating;

have thicknesses not less than 75 per cent of that provided by the corrugation flange;

and material properties at least equal to those provided by the flanges;

or gasset plates are fitted which:

are in combination with shedder plates having thickness, material properties and welded connections in accordance with the above requirements;

have a height not less than half of the flange width;

are fitted in line with the stool side plating;

are generally welded to the top of the lower stool by full penetration welds, and to the corrugations and shedder plates by one side penetration welds or equivalent;

have thickness and material properties at least equal to those provided for the flanges, the section modulus Z_{le}, in cm^3, shall be taken not larger than the value Z'_{le}, in cm^3, to be determined by the formula

$$Z'_{le} = Z_g + [(Qh_g - 0{,}5 h_g^2 s_1 p) / \sigma_a] 10^3,$$

where Z_g – section modulus of one half pitch corrugation, in cm^3, according to 4.4, in way of the upper end of shedder or gusset plates, as applicable;

Q – shear force, in k N (refer to 3.2);

h_g – height, in m, of shedders or gasset plates (refer to Figs. 4.2-1, 4.2-2, 4.2-3 and 4.2-4);

for s_1 – refer to 2.3;

p – resultant pressure, in kN/m^2, as defined in 2.5, calculated in way of the middle of the shedders or gusset plates, as applicable;

σ_a – allowable stress, in N/mm^2, in accordance with 4..

Stresses are obtained by dividing the shear force τ by the shear area. The shear area shall be reduced in order to account for possible non-perpendicularity between the corrugation webs and flanges. In general, the reduced shear area may be obtained by multiplying the web sectional area by sin φ, φ being the angle between the web and the flange.

When calculating the section modulus and the shear area, the net plate thicknesses shall be used.

The section modulus of corrugations shall be calculated on the basis of the following requirements given in 4.3 and 4.4.

4.3 Section modulus at the lower end of corrugations.

4.3.1 The section modulus shall be calculated with the compression flange having an effective flange width b_{ef}, not larger than as given in 4.6.

If the corrugation webs are not supported by local brackets below the stool top (or below the inner bottom) in the lower part, the section modulus of the corrugations shall be calculated considering the corrugation webs 30 per cent effective.

4.3.2 Provided that effective shedder plates, as defined in 4.2, are fitted (refer to Figs. 4.2-1 and 4.2-2) when calculating the section modulus of corrugations at the lower end, the area of flange plates, in cm², may be increased by

$$\left(2{,}5a\sqrt{t_f t_{sh}}\right),$$

not to be taken greater than $2{,}5at_f$,

where a – width of the corrugation flange, in m (refer to Fig. 2.3);

t_{sh} – net shedder plate thickness, in mm;

t_f – net flange thickness, in mm.

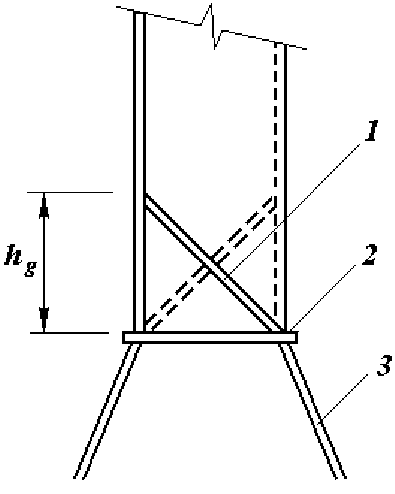


Fig.4.2-1

Symmetric shedder plates:

1 — shedder plate;

2 — top of the lower stool;

3 — vertical or sloping stool side plating

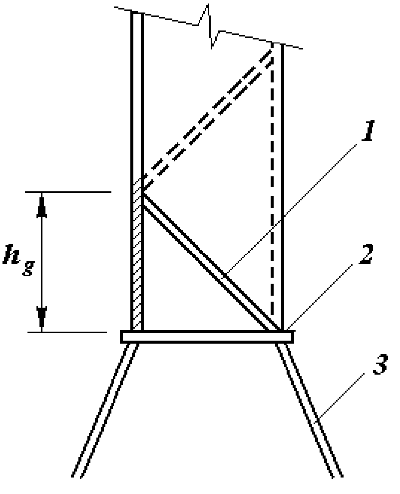


Fig.4.2-2

Asymmetric shedder plates:

1 — shedder plate;

2 — top of the lower stool;

3 — vertical or sloping stool side plating

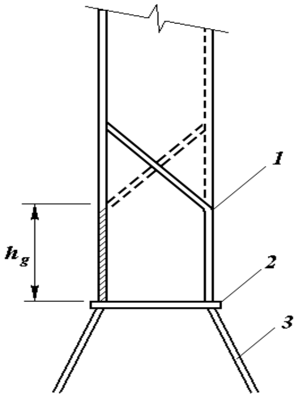


Fig. 4.2-3 Symmetric gasset/shedder plates:

1 — gasset/shedder plate;

2 — top of the lower stool;

3 — vertical or sloping stool side plating

4.3.3 Provided that effective gusset plates, as defined in 4.2, are fitted (refer to Figs. 4.2-3 and 4.2-4), when calculating the section modulus of corrugations at the lower end, the area of flange plates, in cm2 , may be increased by

$$\left(7h_g t_f\right),$$

where h_g – height of gusset plate, in m (refer to Figs 4.2-3 and 4.2-4), with $h_g \le (10/7)s_{gu}$;

s_{gu} – = width of the gusset plates, in m;

t_f – net flange thickness, in mm, based on the as built condition.

4.3.4 If the corrugation webs are welded to a sloping stool top plate which have an angle not less than 45° with the horizontal plane, the section modulus of the corrugations may be calculated considering the corrugation webs fully effective. In case effective gusset plates are fitted, when calculating the section modulus of corrugations the area of flange plates may be increased as specified in 4.3.3. No credit can be given to shedder plates only.

For angles less than 45°, the effectiveness of the web may be obtained by linear interporation between 30 per cent for 0° and 100 per cent for 45°.

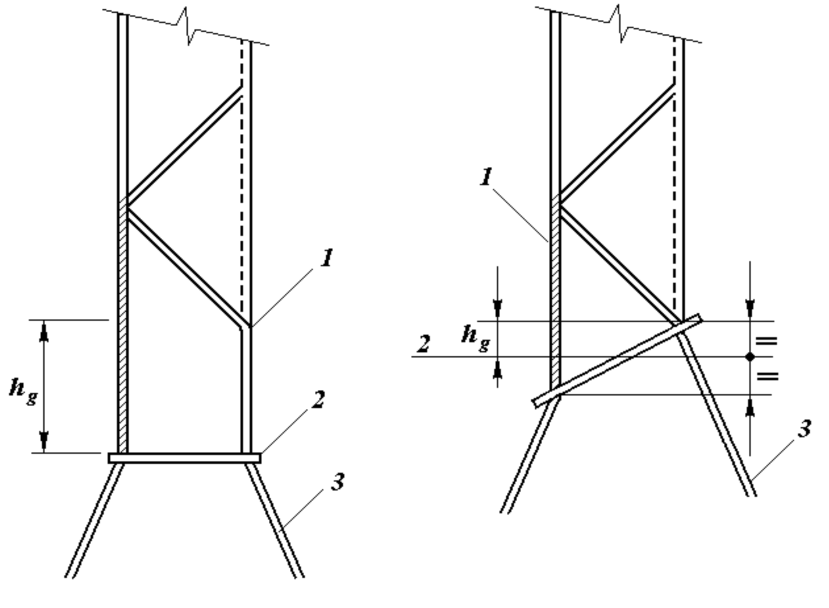


Fig. 4.2-4 Asymmetric gasset/shedder plates:
1 — gasset/shedder plate;
2 — top of the lower stool;
3 — vertical or sloping stool side plating

4.4 Modulus of corrugations at cross-sections other than the lower end.

The section modulus shall be calculated with the corrugation webs considered effective and the compression flange having an effective flange width b_{ef} not larger than as given in 4.6.1.

4.5 Allowable stress check.

The normal and shear stresses σ and τ shall not exceed the allowable values σ_a and τ_a, in N/mm^2, to be determined by the formulae:

$$\sigma_a = R_{eH};$$
$$\tau_a = 0{,}5R_{eH},$$

where R_{eH} – the minimum upper yield stress of the material, in N/mm^2.

4.6 Effective compression flange width and shear buckling check.

4.6.1 Effective width of the compression flange of corrugations.

The effective width b_{ef} in m, of the corrugation flange shall be determined by the formula

$$b_{ef} = C_e\, a,$$

where $C_e = 2{,}25 / \beta - 1{,}25 / \beta^2$ for $\beta > 1{,}25$;

$C_e = 1{,}0$ for $\beta \le 1{,}25$;

$$\beta = \frac{a}{t_f}\sqrt{R_{eH} / E}\cdot 10^3;$$

t_f – net flange thickness, in mm;

a – width of the corrugation flange, in m (refer to Fig. 2.3);

for R_{eH} – refer to 4.5;

E – modulus of elasticity of the material, in N/mm^2, to be assumed equal to $2{,}06\cdot10^5$ for steel.

4.6.2 Shear.

The buckling check shall performed for the web plates at the corrugation end.

The shear stress τ shall not exceed the critical value τ_c, in N/mm2 , to be determined by the formulae

$$\tau_c = \tau_e \quad \text{when} \quad \tau_e \le \tau_f/2;$$

$$\tau_c = \tau_f\,(1 - 0{,}25\tau_f / \tau_e) \quad \text{when} \quad \tau_e > \tau_f/2,$$

where $\tau_f = R_{eH} / \sqrt{3}$;

for R_{eH} – refer to 4.5;

$$\tau_e = 0{,}9\,k_t\,E\left(\frac{t}{1000c}\right)^2 \text{ N/mm}^2;$$

$k_t = 6{,}34$;

E – modulus of elasticity of material as given in 4.6.1;

t – net thickness of corrugation web, in mm;

c – width of corrugation web, in mm (refer to Fig. 2.3).

4.7 Local net plate thickness.

The bulkhead local net plate thickness t, in mm, shall be determined by the formula

$$t = 14{,}9\, s_w\sqrt{1{,}05\,p / R_{eH}},$$

where s_w – plate width, in m, to be taken equal to the width of the corrugation flange or web, whichever is greater (refer to Fig. 2.3).

p – resultant pressure, in kN/m^2 , as defined in 2.5, at the bottom of each strake of plating; in all cases, the net thickness of the lowest strake shall be determined using the resultant pressure at the top of the lower stool, or at the inner bottom, if no lower stool is fitted or at the top of shedders, if shedder or gusset/shedder plates are fitted;

for R_{eH} – refer to 4.5;

For built-up corrugation bulkheads, when the thicknesses of the flange and web are different, the net thickness of the narrower plating shall be not less than t_n, in mm, determined by the formula

$$t_n = 14{,}9 s_n \sqrt{1{,}05 p / R_{eH}},$$

where s_n – width of the narrower plating, in m.

The net thickness of the wider plating, in mm, shall not be taken less than the maximum of the following:

$$t_w = 14{,}9 s_w \sqrt{1{,}05 p / R_{eH}};$$

$$t_w = 20{,}98 s_w \sqrt{1{,}05 p / R_{eH} - t_{np}^2},$$

where $t_w \le$ actual net thickness of the narrower plating and shall not be greater than $14{,}9 s_w \sqrt{1{,}05 p / R_{eH}}$.

5. LOCA L DETAIL S

As applicable, the design of local details shall comply with the Register requirements for the purpose of transferring the corrugated bulkhead forces and moments to the boundary structures, in particular to the double bottom and cross-deck structures.

In particular, the thickness and stiffening of effective gusset and shedder plates, as defined in 4.3, shall comply with the requirements of the Register, on the basis of the load model in Section 2 of this Appendix. Unless otherwise stated, weld connections and materials shall be dimensioned and selected in accordance with 1.7 of this Part.

6. CORROSION ADDITION AND STEEL RENEWAL

The corrosion addition t_s shall be taken equal to 3,5 mm.

Steel renewal is required where the gauged thickness is less than t_{net} + 0,5 mm. Where the gauged thickness is within the range t_{net} + 0,5 mm to t_{net} + 1,0 mm, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal.

APPENDIX 4.

EVALUATION OF ALLOWABLE HOLD LOADING FOR NON-CSR BULK CARRIERS CONSIDERING HOLD FLOODING

1. APPLICATION AND DEFINITIONS

The loading in each hold shall not exceed the allowable hold loading in flooded condition, calculated as per Section 4 of this Appendix, using the loads given in Section 2 and the shear capacity of the double bottom given in Section 3.

In no case the allowable hold loading, considering flooding, shall be greater than the design hold loading in the intact condition.

2. LOADING MODEL

2.1 General.

The loads to be considered as acting on the double bottom are those given by the external sea pressures and the combination of the cargo loads with those induced by the flooding of the hold which the double bottom belongs to.

The most severe combinations of cargo induced loads and flooding loads shall be used, depending on the loading conditions included in the Loading Manual:

homogeneous loading conditions:

non homogeneous loading conditions;

packed cargo conditions (such as steel mill products).

For each loading condition, the maximum bulk cargo density to be carried shall be considered in calculating the allowable hold loading limit.

2.2 Inner bottom flooding head.

The flooding head h_f (refer to Fig. 2.2 of this Appendix) is the distance, in m, measured vertically with the ship in the upright position, from the inner bottom to a level located at a distance d_f, in m, from the base line equal to :

in general:

D for the foremost hold,

0,9D for the other holds;

for ships less than 50000 t deadweight with Type *B* freeboard:

0,95D for the foremost hold,

0,85D for the other holds.

3. SHEAR CAPACITY OF THE DOUBLE BOTTOM

3.1 The shear capacity.

The shear capacity C of double bottom shall be defined as the sum of the shear force at each end of:

.1 all floors adjacent to both hoppers, less one half of the shear forces of the two floors adjacent to each stool, or transverse bulkhead if no stool is fitted (refer to Fig. 3.1);

.2 all double bottom girders adjacent to both stools, or transverse bulkheads if no stool is fitted.

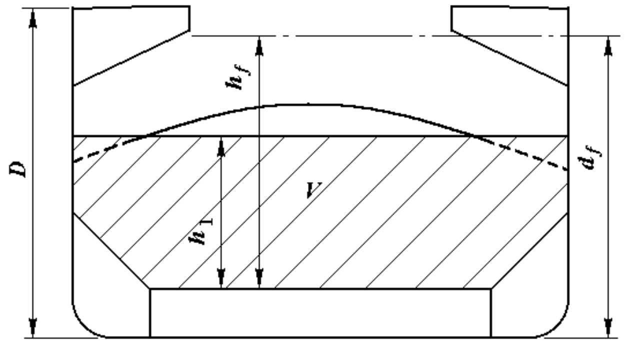


Fig. 2.2:

V – volume of cargo;

D – distance, in m, from the base line to the freeboard deck at side amidship

Where in the end holds, girders or floors run out and are not directly attached to the boundary stool or hopper girder, their shear force shall be evaluated for the one end only.

Note that the floors and girders to be considered are those inside the hold boundaries formed by the hoppers and stools (or transverse bulkheads if no stool is fitted). The hopper side girders and the floors directly below the connection of the bulkhead stools (or transverse bulkheads if no stool is fitted) to the inner bottom shall not be included.

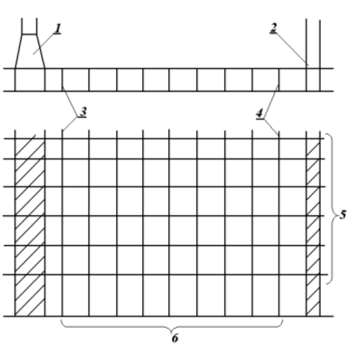


Fig.3.1:

I — lower stool; 2 — transverse bulkhead; 3 — floor adjacent to the stool; 4 — floor adjacent to transverse bulkhead; 5 — girders; 6 — floors

When the geometry and/or the structural arrangement of the double bottom are such to make the above assumptions inadequate, the shear capacity *C* of double bottom shall be calculated according to the requirements of 3.3 of this Part, or on special agreement with the Register, according to the Strength Norms for Sea-Going Ships.

In calculating the shear force, the net thickness of floors and girders is to be used. The net thickness t_{net}, in mm, shall be determined by the formula

$$t_{net} = t - 2,5 ,$$

where t – thickness of floors and girders, in mm.

3.2 Floor shear force.

The floor shear force in way of the floor panel adjacent to hoppers S_{f1}, in kN, and the floor shear force in way of the openings in the outmost bay (i.e. that bay which is closer to hopper) S_{f2}, in kN, shall be determined by the formulae:

$$S_{f1} = A_f \tau_a \cdot 10^{-3} / \eta_1;$$
$$S_{f2} = A_{f,h} \tau_a \cdot 10^{-3} / \eta_2,$$

where A_f – sectional area of the floor panel adjacent to hoppers, in mm²;

$A_{f,h}$ – net sectional area of the floor panels in way of the openings in the outmost bay (i.e. that bay which is closer to hopper), in mm²;

τ_a – allowable shear stress, in N/mm², to be taken equal to the lesser of

$$\tau_a = \frac{162 R_{eH}^{0,6}}{(s/t_{net})^{0,8}} \text{ або } R_{eH}/\sqrt{3} \text{ в}$$

For floors attached to the stools or transverse bulkheads, τ_a may be taken $R_{eH}/\sqrt{3}$,

where R_{eH} – minimum upper yield stress of the material, in N/mm²;

s – spacing of stiffening members of panel under consideration, in mm;

η_1 = 1.10;

η_2 = 1.20; whereas η_2 m a y be reduced, to the Register discretion, down to 1.10 where appropriate reinforcements are fitted.

3.3 Girder shear force.

The girder shear force in way of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted) S_{g_1}, in kN, and the girder shear force in way of the largest opening in the outmost bay (i.e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted) S_{g_2}, in kN, shall be determined by the formulae:

$$S_{g1} = A_g \tau_a \cdot 10^{-3} / \eta_1;$$
$$S_{g2} = A_{g,h} \tau_a \cdot 10^{-3} / \eta_2,$$

where A_g – minimum sectional area of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted), in mm²;

$A_{g,h}$ – net sectional area of the girder panel in way of the largest opening in the outmost bay (i.e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted), in mm²;

τ_a – allowable shear stress, in N/mm², as specified in 3.2;

η_1 = 1.10;

η_2 = 1.15; whereas η_2 may be reduced, to the Register discretion, down to 1,10 where appropriate reinforcements are fitted as specified in 3.2.

4. ALLOWABLE HOLD LOADING

The allowable hold loading W, in t, shall be determined by the formula

$$W = \rho_c V/F,$$

where F = 1.10 – in general;

F = 1.05 – for steel mill products;

ρ_c – cargo density for bulk cargoes, in t/m³ (refer to 2.1). For steel products pc shall be taken as the density of steel;

V – volume, in m³, occupied by cargo at a level h_1;

$h_1 = X / (\rho_c$ g).

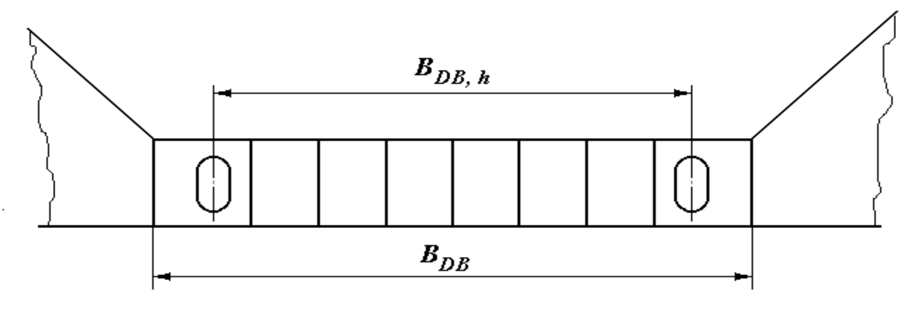


Fig. 4

For bulk cargoes, X shall be taken as the lesser of X_1 or X_2, determined by the formulae:

$$X_1 = \frac{Z + \rho g (E - h_f)}{1 + \rho / \rho_c (\text{perm} - 1)};$$

$$X_2 = Z + \rho g (E - h_f \text{perm}),$$

where $X = X_1$ – for steel products, using perm = 0;

ρ – sea water density, in t/m^3;

g – 9,81 m/s^2, gravity acceleration;

$E = d_f - 0{,}1D$ – ship immersion, in m, for flooded hold condition;

for d_f, D – refer to 2.2;

h_f – flooding head, in m (refer to 2.2);

perm – cargo permeability (i.e. the ratio between the voids within the cargo mass and the volume occupied by the cargo), it needs not be taken greater than 0,3;

Z = the lesser of Z_1 or Z_2 whereas

$$Z_1 = \frac{C_h}{A_{DB,h}};$$

$$Z_2 = \frac{C_e}{A_{DB,e}},$$

where C_h – shear capacity of the double bottom, in kN, as defined in Section 3 of this Appendix, considering, for each floor, the lesser of the shear forces S_{f1} or S_{f2} (refer to 3.2) and for each girder, the lesser of the shear forces S_{g1} or S_{g2} (refer to 3.3);

C_e – shear capacity of the double bottom, in kN, as defined in Section 3 of this Appendix, considering, for each floor, the shear force Sf (refer to 3.2), and, for each girder, the lesser of the shear forces $Sg1$ or $Sg2$ shall be determined according to 3.3;

$$A_{DB,h} = \sum_{i=1}^{i=n} S_i B_{DB,i};$$

$$A_{DB,e} = \sum_{i=1}^{i=n} S_i (B_{DB} - s_1),$$

where n – number of floors between stools (or transverse bulkheads, if no stool is fitted);

S_i – space of i-th floor, in m;

$B_{DB,i} = B_{DB} - s_1$ – for floors whose shear force is determined by S_{f1}, refer to 3.2;

$B_{DB,i} = B_{DB,h}$ – for floors whose shear force is determined by S_{f2}, (refer to 3.2);

B_{DB} – breadth of double bottom between hoppers, in m (refer to Fig. 4);

$B_{DB,h}$ – distance between the two considered openings, in m (refer to Fig. 4);

s_1 – spacing of double bottom longitudinals adjacent to hoppers, in m.