PART II. HULL

1. DESIGN PRINCIPLES

1.1 GENERAL

1.1.1 Application.

1.1.1.1 Unless provided otherwise, requirements of the present Part of the Rules apply to steel ships of welded construction, from 12 to 350 m in length whose proportions are taken within the limits given in Table 1.1.1.1.

Table 1.1.1.1

Proportion of ship	Navigaton Area					
	Unrestricted, A	R1, A-R1	R2, A-R2	R2-S, R2-RS, A-R2-S, A-R2-RS	R3-S, R3-RS, B-R3-S, B-R3-RS	R3-S, C-R3-RS, D-R3-S,
The length of the ship to the depth *L*/*D*	18	19	20	21	22	23
The breadth of the ship to the depth *B*/*D*	2,5	2,5[1]	3[2]	3	3	4[3]

[1] For vessels of dredging fleet, not more than 3.
[2] For vessels of industrial fleet, not more than 4.
[3] For floating cranes, not less than 4,5.

The requirements of the present Part of the Rules do not apply to oil tankers of 150 m in length and above and to bulk carriers of 150 m in length and above, of unrestricted navigation area, which design includes one deck, topside tanks and and side hopper tanks in cargo areas excluding ore carriers and combined ships:

- contracted for construction on or after 1 July 2015;
- in the absence of a contract for construction, which keels were laid or which were at a similar stage of construction on July 1, 2017 or after that date; or
- which were commissioned on July 1, 2020[1] or after that date.

The scantlings of hull members, essential to the strength of hull and the construction of the said ships are regulated by XVII “Common Structural Rules for Oil Tankers with Double Sides ” and Part XVIII “Common Structural Rules for Bulk Carriers” of the Rules. The requirements of this part may be used if it is stipulated in these parts.

1.1.1.2 The scantlings of hull members, essential to the strength of ships whose construction and main dimensions are not regulated by the present Rules are subject to special consideration by the Register.

1.1.1.3 Statement of passenger ship with sign **A**, **A-R1, A-R2**, **A-R2-RS**, **A-R2-S**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, **D-R3-S**, **D-R3-RS** in ship’s Class notation compliance with the provisions of the European Parliament and Council Directive 2009/45 / EC of 6 May 2009 in relation to regulations and safety standards for shipss which entered into force on 15 July 2009 (revised version, as amended by Directive 2010/36 / EU Commission on 01.06. 2010), followed by Directive 2009/45 / EC, shall be in accordance with the requirements of section 2.6.1 of the General regulations for the technical

[1] Refer to IMO Resolution MSC.290(87)

supervision activities with application these Rules to a ship and/or the special requirements of these Rules, depending on the sign in the ship's class notation as for new or existing (refr to 2.6.1.1.4.2 or 2.6.1.1.4.3 General regulations for the technical supervision activities, respectively) ships referred to in certain points with reference or without such a reference on the sign in the ship's class notation, namely compliance with the following requirements:

- new ships with signs **A**, **A-R1, A-R2**, **A-R2-RS**, **A-R2-S** – to all applicable requirements of this part considering indicated in the case of specific requirements to these signs at certain points, references to the sign in the ship's class notation;

- existing ships with sign **B-R3-S, B-R3-RS -** to 1.1.6.1, 2.7.1.3, 2.7.1.4, Appendix 1;

- new ships with signs **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS** i **D-R3-S, D-R3-RS** and existing ships with sign **B-R3-RS**, with length up to 24 m and over **-** to 1.1.6.4;

- new ships with sign **B-R3-S**, **B-R3-RS**, **C-R3-S, C-R3-RS** and **D-R3-S, D-R3-RS –** to 1.1.6.3, 2.7.1.3, 2.7.1.4, Appendix 1.

1.1.2 General.

1.1.2.1 All hull structures regulated by the present Part of the Rules are subject to the Register survey. For this purpose an access shall be provided for their survey.

1.1.2.2. The structures regulated by the present Part of the Rules shall comply with the requirements of Part XII I "Materials" and Part XI V "Welding" and with the approved technical documentation listed in 4.2.3, Part I "Classification Rules for classification and construction of ships [2]

1.1.2.3 Tightness test of ship's hull shall be carried out according to the provisions of Appendix 1.

1.1.3 Definitions and explanations.

1.1.3.1 The definitions and explanations relating to the general terminology of the Rules are given in Part I "Classification".

For the purpose of the present Part of the Rules the following definitions and explanations have been adopted..

1.1.3.2 Ship dimensions and draft.

.1 L e n g t h *L*, is the distance, in m, on the summer load waterline from the forward side of the stem to the after side of the rudder post or to the centre of the rudder stock if there is no rudder post, or the distance equal to 96 per cent of the length on the summer load waterline from the forward side of the stem to the after side of after end of the ship, whichever is the greater.

However, *L* need not be greater than 97 per cent of the ship's length on the summer load waterline.

Where the fore or after end is of an unusual form, length *L* is subject to special consideration by the Register..

.2 M o u l d e d b r e a d t h *B* – is the greatest moulded breadth, in m, measured amidships from outside of frame to outside of frame.

.3 M o u l d e d d e p t h *D* is the vertical distance measured amidships from the top of the plate keel or from the point where the inner surface of shell plating abuts upon the bar keel, to the top

[2] Hereinafter – Part I "Classification".

of the upper deck beam at side. In ships having a rounded gunwale, the depth is measured to the point of intersection of the moulded lines of upper deck and side, the lines extending so as if the gunwale were of angular design.

.4 Draught *d* is the vertical distance measured amidships from the top of the plate keel, or the point where the inner surface of the shell plating abuts upon the bar keel, to the summer load waterline. In ships with timber freeboard the draught shall be measured at side to the summer timber load waterline.

1.1.3.3 Decks and platforms.

.1 Upper deck is the uppermost continuous deck extending the full length of the ship.

.2 Strength deck – is the deck forming the upper flange of hull girder. The uppermost continuous deck, long bridge deck, long forecastle or long poop deck outside end regions, or quarter deck outside the transition area may be considered as the strength deck (refer to 2.12.1.2).

.3 Bulkhead deck is the deck to which the main transverse watertight bulkheads are carried.

.4 Freeboard deck is the deck from which the freeboard is calculated.

.5 Lower decks are the decks located below the upper deck.

Where the ship has several lower decks, they are called: second deck, third deck, etc., counting from the upper deck.

.6 Platform is a lower deck extending over portions of the ship's length or breadth.

.7 Superstructure deck is a deck forming the top of a tier of superstructure. Where the superstructure has several tiers, the superstructure decks are called as follows: first tier superstructure deck, second tier superstructure deck, etc., counting from the upper deck.

.8 Deckhouse top is a deck forming the top of a tier of a deckhouse.

Where the deckhouse has several tiers, the deckhouse tops are called as follows: first tier deckhouse top, second tier deckhouse top, etc., counting from the upper deck. If a deckhouse is fitted on a superstructure deck of first tier, second tier, etc., the deckhouse top is called accordingly the top of second tier deckhouse, third tier deckhouse, etc.

1.1.3.4 Structures.

.1 Superstructure is a decked structure on the upper deck extending from side to side of the ship or with the side plating not being inboard of the shell plating more than 4 per cent of the breadth of the ship.

.2 Deckhouse is a decked structure on the upper deck or superstructure deck with its side plating, on one side at least, being inboard of the shell plating by more than 4 per cent of the breadth of the ship.

1.1.3.5 Main concepts.

.1 After perpendicular (AP) is a vertical line run through the ship centreline, which limits the ship length *L* at the aft end.

Forward perpendicular (FP) is a vertical line run through the ship centreline at a point where the summer loadline and the fore side of stem intersect.

.2 Midship section is the hull section at the middle of ship's length *L*.

.3 Midship region is the part of the ship's length equal to 0,41- (0,21- forward and aft of amidships), unless expressly provided otherwise.

.4 Ship's ends are portions of

the ship's length beyond the midship region.

.5 Engine room aft corresponds to the position of the mid-length of the engine room beyond 0,3*L*- aft of amidships.

1.1.3.6 Explanation.

.1 Summer load waterline (SLW) is the waterline on the level of the centre of the load line ring for the ship's position without heel and trim.

.2 Block coefficient C_b is the block coefficient at draught *d* corresponding to summer load waterline, based on length *L* and breadth *B*, determined by the formula

$$C_b = \frac{\text{Moulded displacement (m}^3\text{)}}{LBd}.$$

.3 g = 9,81 m/s^2 – acceleration due to gravity.

.4 ρ = 1,025 t/m^3 – density of sea water.

.5 Specified speed of ship v_0 is the maximum speed of the ship, in knots, at the summer load waterline in still water at rated engine speed of propulsion plant.

.6 Tight structure is a structure impervious to water and other liquids.

.7 Main frames are vertical side framing members fitted in the plane of floors or bilge brackets within a spacing of each other.

.8 Intermediate frames are additional frames fitted between main frames.

1.1.3.7 Spacing – is the distance between primary members.

Normal spacing is the distance between primary members, determined on the basis of the value of standard spacing a0 , in m, determined by the formula

$a_0 = 0{,}002L + 0{,}48$.

Deviation from normal spacing may be permitted within the following limits:

$0{,}75a_0$ to $1{,}25a_0$ for ships of unrestricted service including with the sign A and restricted area of navigation **R1**, **A-R1**;

from $0{,}7a_0$ to $1{,}25a_0$ for ships of restricted areas of navigation **R2**, **R2-S**, **R2-RS**, **A-R2**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS, C-R3-S**, **C-R3-RS**;

from $0{,}65a_0$ to $1{,}25a_0$ for ships of restricted areas of navigation **R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS**.

In the fore and after peaks the spacing of primary members shall not exceed 0,6 m; between the fore peak bulkhead and 0,2*L*, aft of the forward perpendicular — not more than 0,7 m. Variations from these values are subject to special consideration by the Register.

In all cases the spacing of primary members shall not exceed 1 m.

1.1.4 Basic provisions for determining the scantlings of hull members.

1.1.4.1 The scantlings of hull members are regulated based on the Rule design loads, calculation methods and safety factors with due regard to corrosion allowance (refer to 1.1.5).

1.1.4.2 Derivation of the scantlings of hull members in the Rules is based on structural idealization using beam models subject to bending, shear, longitudinal loading and torsion having regard to the effect of adjacent structures.

1.1.4.3 For the purpose of the present Part of the Rules, the design characteristics of the material used for hull structures shall be as follows:

R_{eH} – upper yield stress, in MPa;

σ_n – = design specified yield stress for normal stresses, in MPa, determined by the formula

$$\sigma_n = 235/\eta, \qquad (1.1.4.3\text{-}1)$$

where η – application factor of mechanical properties of steel, determined from Table 1.1.4.3;

τ_n – design specified yield stress for shear stresses, in MPa, determined by the formula

$$\tau_n = 0{,}57\sigma_n\,. \quad (1.1.4.3\text{-}2)$$

Table 1.1.4.3

R_{eH}	235	315	355	390
η	1,0	0,78	0,72	0,68

1.1.4.4 The requirements for strength of structural members and structures as a whole aiming at determining their scantlings and strength characteristics are set forth in the Rules by assigning the specified values of permissible stresses for design normal $\sigma_д = k_\sigma\sigma_n$ and shear $\tau_д = k_\tau\tau_n$, (where k_σ and k_τ – factors of permissible normal and shear stresses respectively).

The values of k_σ and k_τ are given in the relevant Chapters of this Part.

1.1.4.5 The buckling strength requirements are imposed upon the structural members subject to considerable compressive normal and/or shear stresses (refer to 1.6.5).

1.1.4.6 The thickness of hull structural members determined according to the requirements of the present Part of the Rules shall be the minimum thickness specified for particular structures in the relevant Chapters of this Part.

Minimum thickness are given for structural elements of usual carbon steel. When using high-strength steel minimum thickness may be reduced in proportion to the value of $\sqrt{\eta}$. This decrease is not subject to the minimum thickness of the vertical keel, bottom stringers and floors of Group I ships and the minimum thickness of the structures inside the cargo and ballast tanks of Group II ships (the division of ships into groups according to the terms of corrosion wear - refer to 1.1.5.2), as well as plating and members of tanks framing.

For ships of restricted areas of navigation**R2**, **R2-S**, **R2-RS**, **A-R2**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS, C-R3-S**, **C-R3-RS, R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** a reduction in the thickness of hull members is permitted, but not in excess of the values given in Table 1.1.4.6.

Table 1.1.4.6 **Permissible reduction of minimum hull member thickness**

Hull members	Service area	
	R2, R2-S, R2-RS, A-R2, A-R2-S, A-R2-RS, B-R3-S, B-R3-RS, C-R3-S, C-R3-RS	**R3-S, R3-RS, R3, R3-IN, D-R3-S, D-R3-RS**
Primaty support members in way of ballast tanks	15%	30%
Other hull members	10%	20%

In all cases, unless expressly provided otherwise, the hull member thickness shall not be less than 4 mm.

1.1.4.7 In the present Part of the Rules, the requirements for determining the hull member scantlings are based on the assumption that during the construction and service of a ship measures are taken for the corrosion prevention of the hull in accordance with current standards and other current normative documents.

1.1.4.8 On agreement with the shipowner, a reduction in the scantlings of certain hull members may be permitted within the limits agreed with the Register..

The reduced scantlings as well as scantlings determined in accordance with the requirements of the present Rules for the 25-years service life of the ship shall be expressly indicated in the hull structural drawings submitted to the Register for review.

A special entry shall be made in the Classification Certificate of such ships (refer to 2.3.1, Part I "Classification").

1.1.5 Corrosion allowance.

1.1.5.1 Corrosion allowance Δs, in mm, is set for the structures whose planned service life exceeds 12 years and is determined by the formula

$$\Delta s = u\left(T - 12\right), \qquad (1.1.5.1)$$

where u average annual reduction in thickness of the member, in mm per annum, due to corrosion wear or tear according to 1.1.5.2;

T – planned service life of structure, in years;

if service life is not specially prescribed, T shall be taken equal to $T = 25$.

For the structures whose planned service life is less than 12 years, $\Delta s = 0$.

In the drawings of hull structures, which planned service life has been taken to be less than 25 years, scantlings determined at $T = 25$ shall be additionally indicated.

A special entry shall be made in the Classification Certificate of such ships (refer to 2.3.1, Part I "Classification").

1.1.5.2 When there are no special requirements for service conditions and means of corrosion prevention of the hull for determining the scantlings of hull members according to the Rules one shall be guided by the data on the average annual reduction in thickness u, of structural member given in Table 1.1.5.2-1 and 1.1.5.2-2, depending on the group of ships and the designation of the space.

Tables 1.1.5.2-1 and 1.1.5.2-2 provide for division of all ships into two groups depending on corrosion wear conditions:

I – dry cargo ships and similar ships as regards the service conditions;

II – tankers, bulk carriers, combination carriers and similar ships as regards the service conditions.

For the webs separating the different purpose compartments, u is determined as the average value for adjacent compartments.

In sound cases, in agreement with the shipowner thickness of some hull structural members may be reduced to values , agreed with the Register.

The average structural members thickness reduction of restricted navigation area ships operated in fresh water for 50 and more per cent of the service life is specified in the Table 1.1.5.2-2. If the ship is operated in fresh water at least 50% of operational service life, average structural hull members thickness reduction shall be determined by linear interpolation between Tables 1.1.5.2-1 and 1.1.5.2-2 depending on the percentage of ship in fresh water. For ships of restricted service, intended to operate only in fresh water basins, the value of u may be reduced 2,5 times for group I and 1,2 times for group II relative to the corresponding values specified in the Table 1.1.5.2-1.

In the drawings of hull structures, which scantlings have been adopted with regard to the reduced value of *u*, the reduced scantlings determined at *u* according to Tables 1.1.5.2-1 and 1.1.5.2-2. shall be additionally indicated.

A special entry shall be made in the Classification Certificate of such ships (refer to 2.3.1, Part I "Classification").

Table 1.1.5.2-1 **Average annual reduction in thickness of structural members**

Nos.	Structural member	*u*, in mm per annum	
		Group I	Group II
1	**2**	3	4
1	**Plating of decks and platforms**		
1.1	Upper deck	0,10	0,20[1, 2]
1.2	Lower deck	0,11	–
1.3	Deck in accommodation and working spaces	0,14	0,14
2	**Side plating**		
2.1	Side (no inner skin is provided):		
2.1.1	freeboard	0,10	0,13[2]
2.1.2	in the region of alternating waterlines	0,17	0,19[2]
2.1.3	below the region of alternating waterlines	0,14	0,16
2.2	Side (inner skin is provided) (compartments of double skin side are not designed to be filled):		
2.2.1	freeboard	0,10	0,10
2.2.2	in the region of alternating waterlines	0,17	0,17
2.2.3	below the region of alternating waterlines	0,14	0,14
2.3	Side (inner skin is provided) (compartments of double skin side are designed for the of carriage cargo, fuel oil or water ballast):		
2.3.1	freeboard:		
	.1 tanks filled with fuel oil	0,19	0,19
	.2 tank for reception of water ballast	0,21	0,21
2.3.2	in the region of alternating waterlines:		
	.1 tanks filled with fuel oil	0,18	0,18
	.2 tank for reception of water ballast	0,21	0,21
2.3.3	below the region of alternating waterlines:		
	.1 tanks filled with fuel oil	0,17	0,17
	.2 tank for reception of water ballast	0,18	0,18
3	**Bottom plating**		
3.1	Bottom (inner bottom is not provided):		
3.1.1	including bilge	0,14	–
3.1.2	in way of cargo tanks	–	0,17
3.1.3	in way of fuel oil tanks	0,17	0,17
3.1.4	in way of ballast compartments	0,20	0,20
3.1.5	flat keel	0,23	0,25
3.2	Bottom (inner bottom is provided):		

Nos.	Structural member	*u*, in mm per annum	
		Group I	Group II
3.2.1	including bilge	0,14	0,14
3.2.2	in way of cargo tanks	0,15	0,15
3.2.3	in way of ballast compartments	0,20	0,20
3.2.4	flat keel	0,20	0,20
4	**Plating of inner bottom, hopper tank and trapezoidal stools under transverse bulkheads**		
4.1	Inner bottom in the area of cargo holds (tanks):		
4.1.1	in way of fuel oil tanks	0,12	0,17
4.1.2	in way of ballast compartments	0,15	0,20
4.1.3	in way of boiler room	0,30	0,30
4.1.4	in way of engine room	0,20	0,20
4.1.5	with no wood sheathing in holds if cargo is expected to be discharged by grabs	0,30	0,30
4.2	Hopper tanks, trapezoidal stools under transverse bulkheads, margin plate:		
4.2.1	plating of hopper tanks and trapezoidal stools:		
	bottom strake	0,25	0,30
	other strakes	0,12	0,17
4.2.2	margin plate (inclined and horizontal)	0,20	0,22
4.2.3	margin plate in boiler room::		
	inclined	0,28	0,30
	horizontal	0,23	0,28
5	**Plating of longitudinal and transverse bulkheads of inner skin**		
5.1	Watertight bulkheads:		
5.1.1	top strake	0,10	–
5.1.2	middle strake	0,12	–
5.1.3	bottom strake	0,13	–
5.2	Bulkheads between holds loaded with bulk cargoes:		
5.2.1	top strake (0,1 *D* from the upper deck)	–	0,13
5.2.2	other strakes	–	0,18
5.3	Bulkheads between holds loaded with oil cargo or bulk cargo:		
5.3.1	top strake (0,1 *D* from the upper deck)	–	0,16
5.3.2	other strakes	–	0,18
5.4	Bulkheads between cargo tanks:		
5.4.1	top strake (0,1 *D* from the upper deck)	–	0,20[2]
5.4.2	middle strake	–	0,13[2]
5.4.3	bottom strake	–	0,18
5.5	Bulkheads between cargo and ballast compartments:		
5.5.1	top strake (0,1 *D* from the upper deck)	0,13	0,30
5.5.2	middle strake	0,15	0,25
5.5.3	bottom strake	0,16	0,20

Nos.	Structural member	*u*, in mm per annum	
		Group I	Group II
5.6	Topside tanks	0,12	0,20
6	**Framing of decks and platforms**		
6.1	Deck longitudinals and beams of decks and platforms forming boundaries of:		
6.1.1	holds loaded with general cargoes	0,12	–
6.1.2	holds loaded with bulk cargoes	–	0,15
6.1.3	holds loaded with crude oil and petroleum products or bulk cargoes	–	0,18
6.1.4	cargo tanks	–	0,25[2]
6.1.5	fuel oil tanks	0,15	0,17
6.1.6	ballast compartments	0,18	0,20
6.2	Deck girders, transverses of decks and platforms forming boundaries of:		
6.2.1	holds loaded with general cargoes	0,12	–
6.2.2	holds loaded with bulk cargoes	–	0,13
6.2.3	holds loaded with crude oil and petroleum products or bulk cargoes	–	0,15
6.2.4	cargo tanks	–	0,20[2]
6.2.5	fuel oil tanks	0,19	0,19
6.2.6	ballast compartments	0,21	0,21
6.3	Cargo hatch coamings	0,10	0,12
7	**Framing of sides and bulkheads**		
7.1	Longitudinals, main and web frames, cross ties, vertical stiffeners and horizontal girders of sides and bulkheads forming boundaries of:		
7.1.1	holds loaded with general cargoes	0,10	–
7.1.2	holds loaded with bulk cargoes	–	0,13
7.1.3	holds loaded with crude oil and petroleum products or bulk cargoes	–	0,15
7.1.4	cargo tanks	–	0,20[2,3]
7.1.5	fuel oil tanks	0,18[3]	0,18[3]
7.1.6	ballast compartments	0,21	0,21
8	**Framing of bottom and inner bottom**		
8.1	Bottom centre girder, side girders, floors and bottom longitudinal girders (inner bottom is omitted):		
8.1.1	in general cargo compartments	0,14	–
8.1.2	in cargo tanks	–	0,20
8.1.3	in ballast compartments	0,20	0,20
8.1.4	under the boilers	0,30	0,30
8.2	Bottom centre girder, side girders, floors, bottom and inner bottom longitudinals in double bottom compartments:		
8.2.1	not intended to be filled	0,14	0,14
8.2.2	in oil fuel tanks	0,15	0,15
8.2.3	in water ballast tanks	0,20	0,20

Nos.	Structural member	*u*, in mm per annum	
		Group I	Group II
8.2.4	under the boilers	0,25	0,25
9	**Superstructures, deckhouses and bulwarks**		
9.1	Shell plating	0,10	0,10
9.2	Framing	0,10	0,10

[1] For combination carriers and ships for the carriage of bulk cargoes, *u* = 0,15 mm per annum.

[2]With a compartment filled with inert gas, *u* is increased by 10 per cent.

[3]For horizontal stiffeners arranged in the upper portion having a width of 0,1 times the compartment height, u = 0,25 mm per annum.

Table 1.1.5.2- **Average annual reduction in thickness of structural members for ships intended for operation in fresh water for 50 and more percent of operational service life**

Nos	Structural member	*u*, in mm per annum	
		Group I	
1	**2**	**3**	**4**
1	**Plating of decks and platforms**		
1.1	Upper deck	0,08	0,13[1]
1.2	Lower deck	0,08	–
1.3	Deck in accommodation and working spaces	0,08	0,08
2	**Side plating**		
2.1	Side (no inner skin is provided):		
2.1.1	freeboard	0,08	0,08
2.1.2	in the region of alternating waterlines	0,12	0,12
2.1.3	below the region of alternating waterlines	0,12	0,12
2.2	Side (inner skin is provided) (compartments of double skin side are not designed to be filled):		
2.2.1	freeboard	0,08	0,08
2.2.2	in the region of alternating waterlines	0,12	0,12
2.2.3	below the region of alternating waterlines	0,12	0,12
2.3	Side (inner skin is provided) (compartments of double skin side are designed for the of carriage cargo, fuel oil or water ballast):		
2.3.1	freeboard:		
	.1 tanks filled with fuel oil	0,15	0,15
	.2 tank for reception of water ballast	0,15	0,15
2.3.2	in the region of alternating waterlines:		
	.1 tanks filled with fuel oil	0,15	0,15
	.2 tank for reception of water ballast	0,15	0,15
2.3.3	below the region of alternating waterlines:		
	.1 tanks filled with fuel oil	0,15	0,15
	.2 tank for reception of water ballast	0,15	0,15
3	**Bottom plating**		
3.1	Bottom (inner bottom is not provided):		
3.1.1	including bilge	0,12	–
3.1.2	in way of cargo tanks	–	0,15

Nos	Structural member	*u*, in mm per annum	
		Group I	
3.1.3	in way of fuel oil tanks	0,15	0,15
3.1.4	in way of ballast compartments	0,15	0,15
3.2	Bottom (inner bottom is provided):		
3.2.1	including bilge	0,12	0,12
3.2.2	in way of cargo tanks	0,15	0,15
3.2.3	in way of ballast compartments	0,15	0,15
4	**Plating of inner bottom, hopper tank and trapezoidal stools under transverse bulkheads**		
4.1	Inner bottom in the area of cargo holds (tanks):		
4.1.1	in way of fuel oil tanks	0,12	0,15
4.1.2	in way of ballast compartments	0,15	0,15
4.1.3	in way of boiler room	0,17	0,17
4.1.4	in way of engine room	0,10	0,17
4.1.5	with no wood sheathing in holds if cargo is expected to be discharged by grabs	0,17	0,17
4.2	Hopper tanks, trapezoidal stools under transverse bulkheads, margin plate:		
4.2.1	plating of hopper tanks and trapezoidal stools:		
	bottom strake	0,17	0,17
	other strakes	0,12	0,15
4.2.2	margin plate (inclined and horizontal)	0,17	0,17
4.2.3	margin plate in boiler room:		
	inclined	0,17	0,17
	horizontal	0,17	0,17
5	**Plating of longitudinal and transverse bulkheads of inner skin**		
5.1	Watertight bulkheads:		
5.1.1	top strake	0,10	–
5.1.2	middle strake	0,12	–
5.1.3	bottom strake	0,13	–
5.2	Bulkheads between holds loaded with bulk cargoes:		
5.2.1	top strake (0,1 *D* from the upper deck)	–	0,13
5.2.2	other strakes	–	0,15
5.3	Bulkheads between holds loaded with oil cargo or bulk cargo:		
5.3.1	top strake (0,1 *D* from the upper deck)	–	0,16
5.3.2	other strakes	–	0,18
5.4	Bulkheads between cargo tanks:		
5.4.1	top strake (0,1 *D* from the upper deck)	–	0,13[1]
5.4.2	middle strake	–	0,10[1]
5.4.3	bottom strake	–	0,13
5.5	Bulkheads between cargo and ballast compartments:		
5.5.1	top strake (0,1 *D* from the upper deck)	0,13	0,15
5.5.2	middle strake	0,15	0,15

Nos	Structural member	*u*, in mm per annum	
		Group I	
5.5.3	bottom strake	0,15	0,17
5.6	Topside tanks	0,12	0,15
6	**Framing of decks and platforms**		
6.1	Deck longitudinals and beams of decks and platforms forming boundaries of:		
6.1.1	holds loaded with general cargoes	0,12	–
6.1.2	holds loaded with bulk cargoes	–	0,15
6.1.3	holds loaded with crude oil and petroleum products or bulk cargoes	–	0,15[1]
6.1.4	cargo tanks	–	0,15
6.1.5	fuel oil tanks	0,15	0,15
6.1.6	ballast compartments	0,15	0,15
6.2	Deck girders, transverses of decks and platforms forming boundaries of:		
6.2.1	holds loaded with general cargoes	0,08	–
6.2.2	holds loaded with bulk cargoes	–	0,12
6.2.3	holds loaded with crude oil and petroleum products or bulk cargoes	–	0,15
6.2.4	cargo tanks	–	0,15[1]
6.2.5	fuel oil tanks	0,10	0,10
6.2.6	ballast compartments	0,10	0,10
6.3	Cargo hatch coamings	0,08	0,10
7	**Framing of sides and bulkheads**		
7.1	Longitudinals, main and web frames, cross ties, vertical stiffeners and horizontal girders of sides and bulkheads forming boundaries of:		
7.1.1	holds loaded with general cargoes	0,10	–
7.1.2	holds loaded with bulk cargoes	–	0,13
7.1.3	holds loaded with crude oil and petroleum products or bulk cargoes	–	0,15
7.1.4	cargo tanks	–	0,15[1]
7.1.5	fuel oil tanks	0,15	0,15
7.1.6	ballast compartments	0,15	0,15
8	**Framing of bottom and inner bottom**		
8.1	Bottom centre girder, side girders, floors and bottom longitudinal girders (inner bottom is omitted):		
8.1.1	in general cargo compartments	0,14	–
8.1.2	in cargo tanks	–	0,15
8.1.3	in ballast compartments	0,15	0,15
8.1.4	under the boilers	0,17	0,17
8.2	Bottom centre girder, side girders, floors, bottom and inner bottom longitudinals in double bottom compartments:		
8.2.1	not intended to be filled	0,12	0,12
8.2.2	in oil fuel tanks	0,15	0,15

Nos	Structural member	*u*, in mm per annum	
		Group I	
8.2.3	in water ballast tanks	0,15	0,17
8.2.4	under the boilers	0,17	0,17
9	**Superstructures, deckhouses and bulwarks**		
9.1	Shell plating	0,06	0,06
9.2	Framing	0,06	0,06

[1] – for tankers carrying crude oil, *u* is increased by 50 %.

1.1.5.3 The factors ω_k and j_k, taking into account corrosion allowance with regard to the cross-sectional area of the web and to the section modulus of members of rolled section are determined by the formulae:

.1 for rolled tee, angular and symmetrical flat bulb profile members:

$$\omega_k = \left(2{,}15/\sqrt[3]{W'}\right) + \sqrt[3]{\Delta s/2},$$

$$\omega_k = 0{,}1\Delta s + 0{,}96;$$

.2 for band and flat profile members

$$\omega_k = \left(0{,}85/\sqrt[3]{W'}\right) + \sqrt[3]{\Delta s/2},$$

but at least 1,05,

where W' – section modulus of the member under consideration in accordance with 1.6.4.2;

Δs – refer to 1.1.5.1;

$$j_k \approx \omega_k$$

1.1.6 Compliance with statutary requirements.

1.1.6.1 In passenger ships, the keels of which were laid or which were at a similar stage of construction before 1 January 2009, the peak and machinery space bulkheads, shaft tunnels, etc. shall comply with the following requirements[3].

.1 a fore peak or collision bulkhead shall be fitted which shall be watertight up to the bulkhead deck. This bulkhead shall be located at a distance from the forward perpendicular of not less than 5 per cent of the length of the ship and not more than 3 m plus 5 per cent of the Where the stem forms the external contour of the hull from the forward end with no protruding parts except the bulbous bow, the forward perpendicular shall coincide with the forward edge of the stem on the level of the deepest subdivision load line;

.2 where any part of the ship below the waterline extends forward of the forward perpendicular, e.g. a bulbous bow, the distances stipulated in 1.1.6.1.1, shall be measured from a point either at the midlength of such extension, or at a distance 1,5 per cent of the length of the ship forward of the forward perpendicular, or at a distance 3 m forward of the forward perpendicular, whichever gives the smallest measurement.

.3 where a long forward superstructure is fitted, the fore peak or collision bulkhead on all passenger ships shall be extended weathertight to the next full deck above the bulkhead deck. The

[3] For the purpose of this paragraph, "length of ship" is the length measured between perpendiculars from the extreme points of the ship on the level of the deepest subdivision load line. For the definitions of the deepest subdivision load line refer to 1.2, Part V "Subdivision".

extension shall be so arranged as to preclude the possibility of the bow door causing damage to it in the case of damage to, or detachment of, the bow door.

.4 The extension required in 1.1.6.1.3 need not be fitted directly above the bulkhead below, provided that all parts of the extension are not located forward of the forward limit specified in 1.1.6.1.1 or 1.1.6.1.2.

However, in ships constructed before 1 July 1997:

.4.1 where a sloping ramp forms part of the extension, the part of the extension which is more than 2,3 m above the bulkhead deck may extend no more than 1 m forward of the forward limits specified in 1.1.6.1.1 or 1.1.6.1.2; and

.4.2 where the existing ramp does not comply with the requirements for acceptance as an extension to the collision bulkhead and the position of the ramp prevents the siting of such extension within the limits specified in 1.1.6.1.1 or 1.1.6.1.2, the extension may be sited within a limited distance aft of the aft limit specified in 1.1.6.1.1 or 1.1.6.1.2. The limited distance aft shall be no more than is necessary to ensure noninterference with the ramp.

The extension to the collision bulkhead shall open forward. The extension shall comply with the requirements of 1.1.6.1.3 and shall be so arranged as to preclude the possibility of the ramp causing damage to it in the case of damage to, or detachment of, the ramp.

.5 ramps that do not comply with the above requirements shall be disregarded as an extension of the collision bulkhead.

.6 in ships constructed before 1 July 1997, the requirements of 1.1.6.1.3 and 1.1.6.1.4 shall apply not later than the date of the first periodical survey after 1 June 1997.

.7 an after peak bulkhead dividing the engine room from the cargo and passenger spaces forward and aft, shall also be fitted and made watertight up to the bulkhead deck.

The after peak bulkhead may, however, be stepped below the bulkhead deck, provided the degree of safety of the ship as regards subdivision is not thereby diminished.

.8 in all cases sterntubes shall be enclosed in watertight spaces of moderate volume. The stern gland shall be situated in a watertight shaft tunnel or other watertight space separate from the sterntube compartment and of such volume that, if flooded by leakage through the stern gland, the margin line will not be submerged.

1.1.6.2 In cargo ships, other than tankers, the keels of which were laid or which were at a similar stage of construction before 1 January 2009, as well as in tankers irrespective of the construction date the peak and machinery space bulkheads, stern tubes shall comply with the following requirements [4].

.1 a collision bulkhead shall be fitted which shall be watertight up to the freeboard deck. This bulkhead shall be located at a distance from the forward perpendicular of not less than 5 per cent of the length of the ship or 10 m,

[4] For the purpose of the present paragraph "freeboard deck", "length of ship" and "forward perpendicular" have the meanings as defined in 1.2 of Load Line Rules for Sea-Going Ship.

whichever is the less, in separate cases other value may be permitted, but not more than 8 per cent of the length of the ship.

.2 where any part of the ship below the waterline extends forward of the forward perpendicular, e.g. a bulbous bow, the distances stipulated in 1.1.6.2.1 shall be measured from a point either at the midlength of such extension, or at a distance 1,5 per cent of the length of the ship forward of the forward perpendicular, or at a distance 3 m forward of the forward perpendicular, whichever gives the smallest measurement.

.3 the bulkhead may have steps or recesses provided they are within the limits prescribed in 1.1.6.2.1 or 1.1.6.2.2.

.4 where a long forward superstructure is fitted, the collision bulkhead shall be extended weathertight to the deck next above the freeboard deck. The extension need not be fitted directly above the bulkhead below provided it is located within the limits prescribed in 1.1.6.2.1 or 1.1.6.2.2 with the exemption permitted by 1.1.6.2.5 and the part of the deck which forms the step is made effectively weathertight.

.5 where bow doors are fitted and a sloping loading ramp forms part of the extension of the fore peak bulkhead above the freeboard deck, the part of the ramp which is more than 2,3 m above the freeboard deck may extend forward of the limit specified in 1.1.6.2.1 or 1.1.6.2.2. The ramp shall be weathertight over its complete length.

.6 the number of openings in the extension of the fore peak bulkhead above the freeboard deck shall be restricted to the minimum compatible with the design and normal operation of the ship.

.7 bulkheads shall be fitted separating the engine room from cargo and passenger spaces forward and aft and made watertight up to the freeboard deck.

.8 sterntubes shall be enclosed in a watertight space (or spaces) of moderate volume. Other measures may be taken to minimize the danger of water penetrating into the ship in case of damage to sterntube arrangements.

1.1.6.3 In passenger ships and cargo ships, other than tankers, the keels of which were laid or which were at a similar stage of construction on 1 January 2009 or after that date, the peak and machinery space bulkheads, shaft tunnels, etc. shall comply with the following requirements.

.1 a collision bulkhead shall be fitted which shall be watertight up to the bulkhead deck. This bulkhead shall be located at a distance from the forward perpendicular of not less than 5 per cent of the length of the ship or 10 m, whichever is the less, and if other value is not permitted, not more than 8 per cent of the length of the ship or 3 m plus 5 per cent of the length of the ship, whichever is the greater.

.2 where any part of the ship below the waterline extends forward of the forward perpendicular, e.g. a bulbous bow, the distance stipulated in 1.1.6.3.1 shall be measured from a point either at the midlength of such extension, or at a distance 1,5 per cent of the length of the ship forward of the forward perpendicular, or at a distance 3 m forward of the forward perpendicular, whichever gives the smallest measurement.

.3 the bulkhead may have steps or recesses provided that they are within the limits prescribed in 1.1.6.3.1 or 1.1.6.3.2.

.4 no doors, manholes, access openings, ventilators or any other openings shall be fitted in the collision bulkhead below the bulkhead deck.

.5 except as provided in 1.1.6.3.6, the collision bulkhead may be pierced below the bulkhead deck by not more than one pipe for dealing with the forepeak tank, provided that the pipe is fitted with a screwdown valve capable of being operated from above the bulkhead deck, the valve chest being secured inside the forepeak tank to the collision bulkhead. This valve may be fitted on the after side of the collision bulkhead provided that the valve is readily accessible under all service conditions and the space in which it is located is not a cargo space. Al l valves shall be of steel, bronze or other approved ductile material. Valves of ordinary cast iron or similar material are not acceptable.

.6 if the forepeak is divided to hold two different kinds of liquids, the collision bulkhead to be pierced below the bulkhead deck by two pipes, each of which is fitted as required by 1.1.6.3.5, provided that there is no practical alternative to the fitting of such a second pipe and that, having regard to the additional subdivision provided in the forepeak, the safety of the ship is maintained.

.7 where a long forward superstructure is fitted, the collision bulkhead shall be extended weathertight to the deck next above the bulkhead deck. The extension of the collision bulkhead need not be fitted directly above the bulkhead below provided it is located within the limits prescribed in 1.1.6.3.1 or 1.1.6.3.2 with the exemption permitted by 1.1.6.3.8 and the part of the deck which forms the step is made effectively weathertight. The extension shall be so arranged as to preclude the possibility of the bow door causing damage to it in the case of damage to, or detachment of, the bow door.

.8 where bow doors are fitted and a sloping loading ramp forms part of the extension of the collision bulkhead above the bulkhead deck, the ramp shall be weathertight over its complete length. In cargo ships, the part of the ramp which is more than 2,3 m above the bulkhead deck may extend forward of the limit specified in 1.1.6.3.1 or 1.1.6.3.2. Ramps not meeting the above requirements shall be disregarded as an extension of the collision bulkhead.

.9 the number of openings in the extension of the collision bulkhead above the freeboard deck shall be restricted to the minimum compatible with the design and normal operation of the ship. Al l such openings shall be capable of being closed weathertight.

.10 bulkheads shall be fitted separating the machinery space from cargo and accomodation spaces forward and aft and made watertight up to the bulkhead deck.

In passenger ships, an afterpeak bulkhead shall also be fitted and made watertight up to the bulkhead deck. The afterpeak bulkhead may, however, be stepped below the bulkhead deck, provided the degree of safety of the ship as regards subdivision is not thereby diminished.

.11 in all cases stern tubes shall be enclosed in watertight spaces of moderate volume.

In passenger ships, the stern gland shall be situated in a watertight shaft tunnel or other watertight space separate from the stern tube compartment and of such volume that, if flooded by leakage through the stern gland, the bulkhead deck will not be immersed.

In cargo ships, other measures to minimize the danger of water penetrating into the ship in case of damage to stern tube arrangements may be taken.

1.1.6.4 In passenger ships, the keels of which were laid or which were at a similar stage of construction before 1 January 2009, the double bottom shall comply with the following requirements:

.1 a double bottom shall be fitted extending from the fore peak bulkhead to the after peak bulkhead as far as this is practicable and compatible with the design and proper working of the ship.

In ships of 50 m and upwards but less than 61m in length a double bottom shall be fitted at least from the engine room to the fore peak bulkhead, or as near thereto as practicable.

In ships of 61 m and upwards but less than 76 m in length a double bottom shall be fitted at least outside the engine room, and shall extend to the fore and after peak bulkheads, or as near thereto as practicable.

In ships of 76 m in length and upwards, a double bottom shall be fitted amidships, and shall extend to the fore and after peak bulkheads, or as near thereto as practicable.

.2 where a double bottom is required to be fitted, its depth shall be in accordance with the requirements of 2.4.4.1 and the inner bottom shall be continued out to the ship's sides in such a manner as to protect the bottom to the turn of the bilge. Such protection will be deemed satisfactory if the line of intersection of the outer edge of the margin plate with the bilge plating is not lower at any part than a horizontal plane passing through the point A at midship section, as shown in Fig. 1.1.6.4.

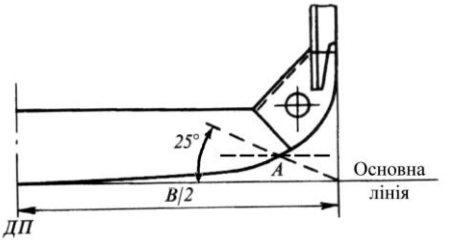


Fig.1.1.6.4

.3 small wells constructed in the double bottom in connection with drainage arrangements of holds, etc. shall not extend downwards more than necessary. The depth of the well shall in no case be more than the depth less 460 mm of the double bottom at the centreline, nor shall the well extend below the horizontal plane referred to in 1.1.6.4.2. A well extending to the outer bottom is, however, permitted at the after end of the shaft tunnel. Other wells (e.g., for lubricating oil under main engines) may be permitted if the arrangements give protection equivalent to that afforded by a double bottom complying with the requirements of present paragraph.

.4 a double bottom need not be fitted in way of watertight compartments of moderate size used exclusively for the carriage of liquids, provided the safety of the ship, in the event of bottom or side damage, is not thereby impaired.

.5 In ships of restricted navigation area **B-R3-S,B-R3-RS, C-R3-S, C-R3-**

RS та D-R3-S, D-R3-RS The Register may permit not to arrange a double bottom in any part of the ship, with subdivision index less than 0.50 if the arrangement of double bottom in this part of the ship is not compatible with her design and normal operation.

1.1.6.5 In cargo ships other than tankers, the keels of which were laid or which were at a similar stage of construction before 1 January 2009, the double bottom shall comply with the following requirements:

.1 a double bottom shall be fitted extending from the collision bulkhead to the after peak bulkhead, as far as this is practicable and compatible with the design and proper working of the ship.

.2 the double bottom depth shall be in conformity with 2.4.4.1, and the inner bottom shall be continued out to the ship's side in such a manner as to protect the bottom to the turn of the bilge.

.3 small wells constructed in the double bottom, in connection with the drainage arrangements of holds, shall not extend in depth more than necessary. A well extending to the outer bottom may, however, be permitted at the after end of the shaft tunnel of the ship. Other wells may be permitted if the arrangements give protection equivalent to that afforded by a double bottom complying with the present paragraph.

.4 a double bottom need not be fitted in way of watertight compartments used exclusively for the carriage of liquids, provided the safety of the ship in the event of bottom damage is not thereby impaired.

1.1.6.6 In passenger ships and cargo ships, other than tankers, the keels of which were laid or which were at a similar stage of construction on 1 January 2009 or after that date, the double bottom shall comply with the following requirements:

.1 a double bottom shall be fitted extending from the collision bulkhead to the after peak bulkhead, as far as this is practicable and compatible with the design and proper working of the ship.

.2 the double bottom depth shall be in accordance with the requirements of 2.4.4.1 and the inner bottom shall be continued out to the ship's sides in such a manner as to protect the bottom to the turn of the bilge.

But in any case the height of double bottom shall beat least 0.76 m, and is not required more than 2.0 m.

.3 small wells constructed in the double bottom, in connection with the drainage arrangements of holds, etc. shall not extend downward more than necessary. A well extending to the outer bottom is, however, permitted at the after end of the shaft tunnel. Other wells (e.g., for lubricating oil under main engines) may be permitted if the arrangements give protection equivalent to that afforded by a double bottom complying with the present paragraph.

In no case shall the vertical distance from the bottom of such a well to a plane coinciding with the keel line be not less than 500 mm.

.4 a double bottom need not be fitted in way of small-sized watertight compartments used exclusively for the carriage of liquids, provided the safety of the ship in the event of bottom or side damage is not thereby impaired.

.5 any part of a passenger ship or a cargo ship that is not fitted with a double bottom in accordance with 1.1.6.6.1 or

1.1.6.6.4 shall comply with the requirements of 2.9, Part V "Subdivision".

.6 in case of unusual bottom arrangement in a passenger ship or a cargo ship it shall be demonstrated that the ship is capable of withstanding bottom damages as specified in 2.9.3, Part V "Subdivision".

1.1.6.7 The freeing ports in bulwarks shall be assigned proceeding from 3.2.13 of the Load Line Rules for Sea-Going Ships.

The lower edges of freeing ports shall be arranged as near to the deck as practicable, but they shall not bear upon the sheerstrake.

In ships of 65 m in length and upwards a continuous slot shall generally be provided between the freeboard and sheerstrake edge instead of freeing ports.

1.1.6.8 In passenger ships and cargo ships, the design of watertight decks, trunks, etc. shall comply with the following requirements.

.1 watertight decks, trunks, tunnels, duct keels and ventilation ducts shall have a strength equal to that of watertight bulkheads fitted on the same level. Watertight ventilation ducts and trunks shall be carried at least to the bulkhead deck in passenger ships and at least to the freeboard deck in cargo ships.

.2 where a ventilation trunk passing through a structure penetrates the bulkhead deck, the trunk shall be capable of withstanding the water pressure that may be present within the trunk, after having taken into account the maximum heel angle allowable during intermediate stages of flooding, in accordance with 3.3.3, Part V "Subdivision".

.3 where all or part of the penetration of bulkhead deck is on the main ro-ro deck, the trunk shall be capable of withstanding impact pressure due to internal water motions of the trapped water on the vehicle deck.

.4 In ships constructed before 1 January 2002, the requirements of 1.1.6.8.2 shall apply not later than the date of the first periodical survey after 1 July 2002.

1.2 MATERIALS

1.2.1 General.

The materials used for hull structures regulated by this Part of the Rules shall comply with the requirements of Part XII I "Materials".

1.2.2 Steel grades for hull structures.

1.2.2.1 Hull members shall be fabricated of mild steel grades A, B, D and E with the upper yield stress R_{eH}= 235 MPa and of AH , DH , E H and F H high tensile steel grades A32, D32, E32 and F32 with the upper yield stress R_{eH} = 315 MPa; A3 6, D36, E36 and F36 steel grades with the upper yield stress R_{eH} = 355 MPa, and A40, D40, E40 and F40 steel grades with the upper yield stress R_{eH} = 390 MPa.

The application of high strength steel grades D, E, F with the upper yield stress of 420 MPa and above is subject to special consideration by the Register in each case.

1.2.2.2 In case of high local stresses in the thickness direction, Z-steel (refer to 3.14, Part XII I "Materials") shall be used for the fabrication of structural members having a thickness in excess of 18 mm unless no measures are taken to structurally prevent lamellar tearing.

1.2.2.3 Where clad steel is used, the mechanical properties of the base material shall not be lower than those required for the steel grade specified in 1.2.3.1.

Hull structural steel stated in 3.17, Part XII I "Materials" shall be used as the base material..

1.2.3 Selection of steel grades for hull structures.

1.2.3.1 Steel grades for hull structural members shall be selected according to 1.2.3.7, whereas steel grades for structural members designed for prolonged exposure to low service temperatures according to Figs. 1.2.3.1-1 to 1.2.3.1-3 shall be selected for various Classes of structural members proceeding from the actual thickness adopted for the member concerned and the design temperature of structures to be determined by a procedure agreed with the Register.

For hull structural members of icebreakers and ice ships of categories **Ice 4** – **Ice 6**, the design temperature for which does not exceed -30 ºC, with member thickness exceeding 25 mm, the Register may require for application of steel of improved weldability and of steel complying with specific Register requirements for viscosity and cold resistance properties (steels marked with an additional superscript "Arc").

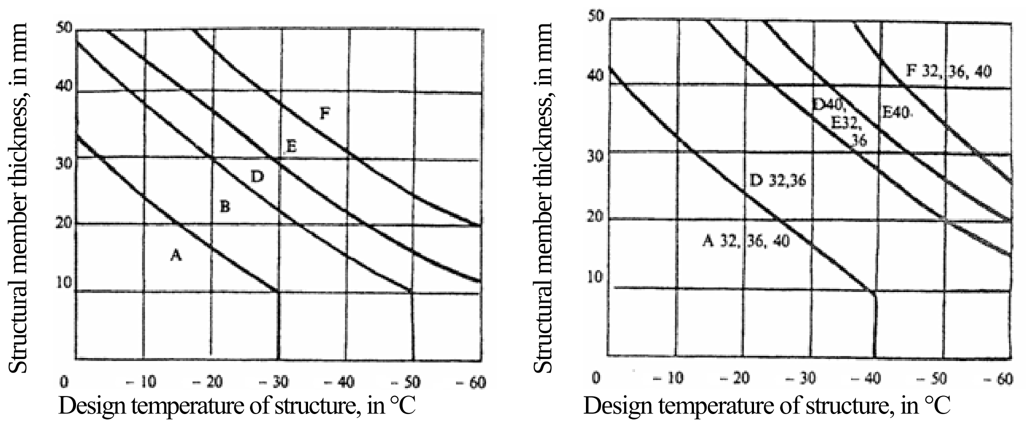
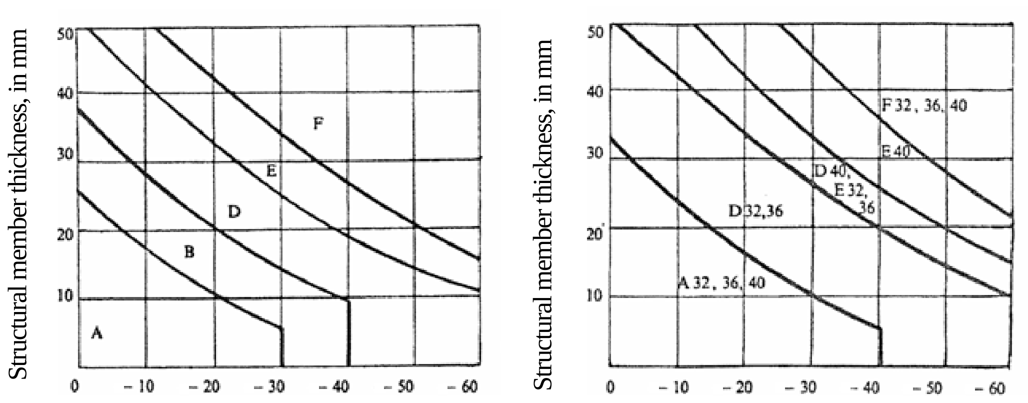
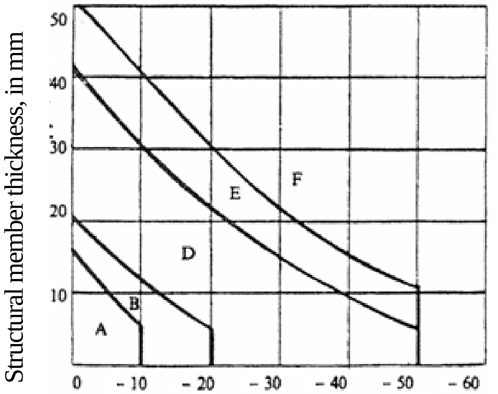


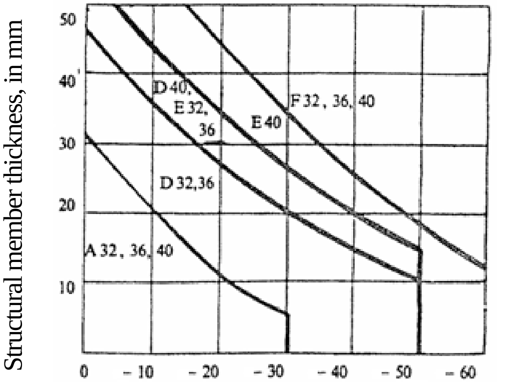
Fig. 1.2.3.1-1 Structural members of Class I



Design temperature of structure, in °C Design temperature of structure, in °C

Fig. 1.2.3.1-2 Structural members of Class II





Design temperature of structure, in °C Design temperature of structure, in °C

Fig. 1.2.3.1-3 Structural members of Class III

1.2.3.2 The design temperature of the structures which come constantly or periodically in contact with ambient air are expressed in terms of minimum design temperature of ambient air T_A.

In the absence of any other provisions, for the value of T_A the minimum average daily air temperature is adopted which can take place during a five-year period of operation on the routes passing in the most unfavourable waters as regards cooling conditions.

1.2.3.3 In all cases the value of T_A shall not excee:

– 40 °C[5] – for icebreakers of ice classes **Icebreaker2, Icebreaker3, Ice-breaker4** and ships of ice classes **Ice6, Ice5**;

– 30 °C – for icebreakers of ice class **Icebreaker1** and ships of ice class**Ice4**;

– 10 °C – for ships of ice classes **Ice3, Ice2**;

0 °C – for ships of ice class **Ice1**, and ships without ice class.

1.2.3.4 A n approximate determination of temperatures of structures is permitted based on the values ofT_A obtained by this method in accordance with the recommendations given in Table 1.2.3.4.

1.2.3.5 At the design tensile stresses in the upper deck and side longitudinals (of sheerstrake) due to the still water hogging moment (σ_{sw}), exceeding the value 65/η, the design temperature of longitudinals may be corrected by the value of

$$\Delta T_p = -10(\sigma_{sw}/65 - 1),\ ^\circ C.$$

1.2.3.6 The design temperature of hull structures located within the refrigerated cargo spaces shall be assumed equal to the temperature in the refrigerated cargo space.

The design temperature of the structures forming boundaries of the refrigerated cargo spaces shall be assumed as follows:

[5] When operating with calls at the mouth of the northern rivers the value of T_A shall not exceed –50 °C.

with no insulation fitted on the side of the refrigerated cargo space, the temperature in this space;

with insulation fitted on the side of the refrigerated cargo space and with no insulation on the other side, the temperature on the uninsulated side of the boundary in the space;

with insulation fitted on both sides, arithmetical mean of the temperatures in the adjacent spaces.

1.2.3.7 Depending on the level and type of applied stress, presence of stress concentrations, complexity of structural design of the assemblies and the workmanship, the assumed damage consequences for safety of the ship as a whole, the structural members are grouped into three Classes according to Table 1.2.3.7-1.

The steel grade of structural members shall not be below the grade specified in Tables 1.2.3.7-1–1.2.3.7-6.

Additional requirements:

for single deck ships with length exceeding 150 m, excluding those covered in Table 1.2.3.7-3, are given in Table1.2.3.7-2;

for membrane type liquefied gas carriers with length exceeding 150 m are given in Table 1.2.3.7-3;

for ships with length exceeding 250 m are given in Table 1.2.3.7-4;

for ships with ice strengthening are given in Table 1.2.3.7-5.

The steel grade depending on the structural member thickness is determined in accordance with Table 1.2.3.7-6.

Table 1.2.3.4

<table>
<tr><th rowspan="3">Hull structure</th><th colspan="2">Operation conditions</th><th colspan="3">Design temperature t_p</th></tr>
<tr><th rowspan="2">Insulation</th><th rowspan="2">Heating</th><th colspan="2">Cargo space region</th><th rowspan="2">Region of spaces other than cargo spaces</th></tr>
<tr><th>tanks</th><th>holds</th></tr>
<tr><td rowspan="3">Exposed part of strength deck, side plating portion above summer load waterline (for ice class ships — above ice belt) as well as adjacent framing and portions up to 1,0 m wide of bulkhead structures, decks, platforms, topside tanks, etc.</td><td>Fitted</td><td>Not provided</td><td colspan="3">T_A</td></tr>
<tr><td>–</td><td>Fitted</td><td colspan="3">0,50 T_A</td></tr>
<tr><td>Not provided</td><td>Not provided</td><td>0,70 T_A</td><td>T_A + 5 °C</td><td>0,60 T_A</td></tr>
<tr><td>Strength deck portion under unhealed superstructures.</td><td>–</td><td>Not provided</td><td colspan="3">–10 °C</td></tr>
<tr><td>External structures of superstructures</td><td>Fitted</td><td>Fitted</td><td colspan="3">0,50 T_A</td></tr>
</table>

and deckhouses.		Not provided	0,70 T_A
Structures cooled on both sides with ambient air	Not provided	Not provided	T_A
Side plating portion in the region of alternating waterline. Ice belt of ice class ships	Fitted	Not provided	0,55 T_A
	–	Fitted	0,35 T_A
	Not provided	Not provided	0,40 T_A

N o t e s t o T a b l e *1.2.3.4* : 1. For external structures of underwater portion of the hull t_p = 0 °C.

2. "–" means that the isolation does not affect the design temperature T_p.

Table 1.2.3.7-1

Nos	Structural member category	Material class/grade
1	2	3
1	Longitudinal bulkhead strakes, other than that given in para 7	Class I throughout the length of a ship
2	Deck plating exposed to weather, other than that given in paras 5, 12, 13, 15 and 16	
3	Side plating	
4	Bottom plating, including keel plate	Class II amidships. Class I outside of amidships.
5	Strength deck plating, excluding that given in paras 12, 13, 14, 15 and 16	
6	Continuous longitudinal plating of strength members above strength deck, excluding hatch coamings	
7	Uppermost strake in longitudinal bulkhead	
8	Vertical strake (hatch side girder) and uppermost sloped strake in top wing tank	
9	Longitudinal hatch coamings of length less than 0,15*L*	
10	External longitudinal members, plating and framing of long superstructures and plating of sides of short superstructures and deckhouses (first tier)	
11	Sheerstrake [1].	Class III amidships Class II outside of amidships Class I outside 0,6*L* amidships
12	Stringer plate in strength deck [1].	
13	Deck strake at longitudinal bulkhead, excluding deck plating in way of inner-skin bulkhead of double-hull ship [1].	

14	Lower deck strakes at cargo hatch corners in refrigerated spaces[2].	
15	Strength deck plating at outboard corners of cargo hatch openings in container carriers and other ships with similar hatch opening configurations	Class III amidships Class II outside of amidships Class I outside 0,6*L* amidships Class III within cargo region.
16	Strength deck plating at corners of cargo hatch openings in bulk carriers, ore carriers, combination carriers and other ships with similar hatch opening configurations.	Class III within 0,6*L* of the ship Class II within rest of cargo region.
17	Trunk deck and inner deck plating at corners of openings for liquid and gas domes in membrane type liquefied gas carriers	Class III within 0,6*L* of the ship Class II within rest of cargo region.
18	Bilge strake in ships with double bottom over the full breadth and length less than 150 m[1]	Class II within 0,6*L* amidships Class I outside 0,6*L* amidships.
19	Bilge strake in other ships[1]	Class III amidships Class II outside of amidships Class I outside 0,6*L* amidships.
20 21	Longitudinal hatch coamings of length greater than 0,15L, including coaming top plate and flange. End brackets and deck house transition of longitudinal cargo hatch coamings.	Class III amidships Class II outside of amidships Class I outside 0,6*L* amidships.[3]
22	Side plating at cargo port corners	Class II throughout the length of a ship
23	Plating and framing (welded members) in ice-strengthening region I (refer to Figs. 3.10.1.3.2 and 3.10.1.3.3), welded plate stems and stern frames of: **.1** ships of ice classes **Ice4**, **Ice3, Ice2, Ice1**	Class I throughout the length of a ship
	.2 ships of ice classes **Ice6**, **Ice5** and icebreakers irrespective of ice class	Class II throughout the length of a ship
24	Rolled section framing of: **.1** ships irrespective of ice class and icebreakers of ice class **Icebreaker1**	Class I throughout the length of a ship
	.2 icebreakers of ice classes **Icebreaker2, Icebreaker3, Icebreaker4**	Class II throughout the length of a ship

[1] Single strakes required to be of Class III within 0,4Z amidships shall have breadths not less than 800+ 5*L* mm, need not be greater than 1800 mm, unless limited by the geometry of the ship's design.

[2] The boundaries of areas for members related to this category correspond to Fig. 1.2.3.7.

[3] Not to be less than Grade D/D H

Table 1.2.3.7-2

Structural member category	Material grade
Longitudinal plating of strength deck where contributing to the longitudinal strength.	Grade B/AH amidships.
Continuous longitudinal plating of strength members above strength deck.	Grade B/AH amidships.
Single side strakes for ships without inner continuous longitudinal bulkhead(s) between bottom and the strength deck.	Grade B/AH within cargo region

Table1.2.3.7-3

<table>
<tr><th colspan="2">Structural member category</th><th>Material class/grade</th></tr>
<tr><td colspan="2">Longitudinal plating of strength deck where contributing to the longitudinal strength.</td><td>Grade B/AH amidships.</td></tr>
<tr><td rowspan="2">Continuous longitudinal plating of strengt h member s above the strength deck</td><td>Trunk deck plating</td><td>Class II amidships.</td></tr>
<tr><td>Inner deck plating.
Longitudinal strength member plating between the trunk deck and inner deck</td><td>Grade B/AH amidships.</td></tr>
</table>

Table is applicable to similar ship types with a "double deck" arrangement above the strength deck.

Table 1.2.3.7-4

Structural member category	Material grade
Sheerstrake at strength deck[1].	Grade E/EH amidships
Stringer plate in strength deck[1].	Grade E/EH amidships
Bilge strake1[1]	Grade D/DH amidships

[1] Single strakes required to be of Grade E/EH and have breadths not less than 800 + 5L mm, need not be greater than 1800 mm, unless limited by the geometry of the ship's design.

Table 1.2.3.7-5

Structural member category	Material grade
Shell strakes in way of ice strengthening area for plates.	Grade B/AH.

Table 1.2.3.7-6

<table>
<tr><th rowspan="3">Structural member thickness S, in mm</th><th colspan="6">Class, hull member is related to</th></tr>
<tr><th colspan="2">I</th><th colspan="2">II</th><th colspan="2">III</th></tr>
<tr><th>Mild steel</th><th>High tensile steel</th><th>Mild steel</th><th>High tensile steel</th><th>Mild steel</th><th>High tensile steel</th></tr>
<tr><td>S ≤ 15,0</td><td rowspan="4">A</td><td rowspan="6">AH</td><td rowspan="2">A</td><td rowspan="3">AH</td><td>A</td><td rowspan="2">AH</td></tr>
<tr><td>15<S<20</td><td>B</td></tr>
<tr><td>20<S<25</td><td>B</td><td rowspan="2">D</td><td rowspan="2">DH</td></tr>
<tr><td>25<S<30</td><td rowspan="3">D</td><td rowspan="3">DH</td></tr>
<tr><td>30<S<35</td><td rowspan="2">B</td><td rowspan="3">E</td><td rowspan="3">EH</td></tr>
<tr><td>35<S<40</td></tr>
<tr><td>40<S<50</td><td>D</td><td>DH</td><td>E</td><td>EH</td></tr>
</table>

1.2.3.8 Structural members not mentioned in Tables 1.2.3.7-1 to 1.2.3.7-5, whose scantlings are regulated by the present Part, shall be referred to Class I .

The steel grade shall correspond to the asbuilt plate thickness and material class.

1.2.3.9 For structures with high level of stress concentration, subject to dynamic loads (e.g. when mooring at sea) or being in combined stress state, the use of steel grade D or grade E may be required.

Steel grade A is not permitted.

1.2.3.10 Single strakes required to be of Class III or steel grade E/EH and have breadths not less than 800 + 5*L* mm, need not be greater than 1800 mm.

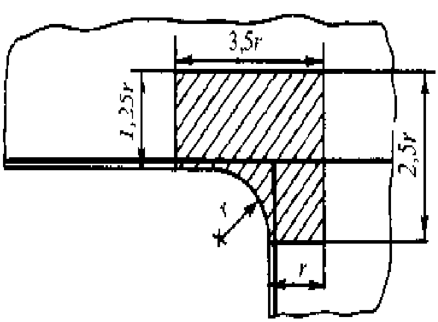


Fig.1.2.3.7. Areas of cargo hatch corners (lined) belonging to members referred to Class III.

1.2.3.11 For ships less than 40 m in length, steel specified for Classes of structural members outside amidships according to Table 1.2.3.7-1 may be used throughout the length of the ship.

1.2.3.12 Plating materials for sternframes supporting the rudder and propeller boss, rudders, rudder horns and shaft brackets shall in general not be of lower grades than corresponding to Class II.

For rudder and rudder body plates subjected to stress concentrations (e.g. in way of lower support of semispade rudders or at upper part of spade rudders), Class III shall be applied.

1.2.4 Aluminium alloys.

1.2.4.1 This Part of the Rules admits the following applications of aluminium alloys:

hull, superstructures and deckhouses, if $12 < L \le 40$ m;

superstructures and deckhouses, if $L > 40$ m.

1.2.5 Anticorrosive protection and coatings.

1.2.5.1 Effective protective coatings complying with the requirements of 6.5.1.1, Part XII I "Materials" shall be applied to the inner surfaces of ballast tanks.

It is recommended to protect the inner spaces of cofferdams, duct keels, supports of transverse bulkheads and other similar void spaces of oil tankers and bulk carriers with protective coatings in accordance with 6.5.1.2 of Part XII I "Materials".

1.2.5.2 Anti-fouling coatings of ship hulls, in case of their application, shall comply with the requirements of Part VI " Requirements to Anti-fouling Systems " Rules for the Prevention Pollution from Ships.

1.2.5.3 For cargo tanks of oil tankers of 500 t deadweight and over carrying crude oil, one of the following effective measures on corrosion protection shall be implemented:

applying protective coatings in compliance with IMO resolution MSC.288(87) amended by IMO Resolution MSC.342 (91) (refer to 6.5.1.2, Part XII I "Materials");

using alternative means of protection or corrosion resistant materials to maintain the required structural integrity for 25 years in accordance with IMO resolution MSC.289(87) (refer to 3.16.1.1, Part XIII "Materials").

1.2.5.4 All specially designed for seawater ballast tanks in all types of ships with a gross tonnage of 500 and double side areas, fitted on bulk carriers up to 150 m and more, shall be protected by applying a protective coating specifically designed for seawater in accordance with IMO Resolution MSC.215 (82) amended by IMO Resolution MSC.341 (91) (refer to 6.5.1.1, Part XII I "Materials").

1.3 DESIGN LOADS

1.3.1 General.

1.3.1.1 This Chapter contains the basic formulae for determining the design weather loads on hull, ship acceleration at motions as well as loads from dry and liquid cargoes.

1.3.1.2 Wave induced loads on the forward portion of the bottom and flare, loads from vehicles and deck heavy cargo as well as emergency loads are given in the Chapters of this Part pertaining to the appropriate structures.

1.3.1.3 Rules of determining the load value and the load point are specified in the appropriate chapters pertaining to particular structures. In the absence of such provisions the load is assumed to be on the lower edge of the plate, at the middle of design span of the member or at the centre of the area taking up distributed load.

1.3.1.4 The basic parameter of design load and accelerations on ship's hull exposed to weather is the wave factor c_w, determined by the formulae:

$$c_w = 0{,}0856\,L \quad \text{for} \quad L \le 90 \text{ m},$$
$$c_w = c_w = 10{,}75 - \{(300 - L)/100\}^{3/2} \quad \text{for} \quad 90 < L < 300 \text{ m}, \qquad (1.3.1.4)$$
$$c_w = 10{,}75 \text{ for } 300 \le L \le 350 \text{ m}.$$

1.3.1.5 For ships of restricted area of navigation the wave factor c_w, shall be multiplied by the reduction factor φ_r, obtained from Table 1.3.1.5.

1.3.2 Wave loads.

1.3.2.1 The design pressure p, in kPa, acting on the ship's hull exposed to weather is determined by the following formulae:

for the points of application of the loads below the summer load waterline,

$$p = p_{st} + p_w ; \qquad (1.3.2.1\text{-}1)$$

for the points of application of the loads above the summer load waterline,

$$p = p_w , \qquad (1.3.2.1\text{-}2)$$

where p_{st} – static pressure, in kPa, determined by the formula

$$p_{st} = 10 z_i ;$$

z_i – distance form the point of application of the load to the summer load waterline, in m;

p_w – as defined in 1.3.2.2.

Table 1.3.1.5

Area of navigation	Factor φ_r,
1	2
R1, A-R1	1
R2, A-R2	$1{,}25 – 0{,}25L \cdot 10^{-2} \leq 1$
R2-S, R2-RS**, A-R2-S, A-R2-RS**	$1{,}0 – 0{,}20L \cdot 10^{-2}$
R2-S (4,5), R2-RS (4,5)	$0{,}94 – 0{,}19L \cdot 10^{-2}$
R3-S, **R3-RS**, **B-R3-S***, **B-R3-RS***, **C-R3-S**, **C-R3-RS**	$0{,}86 – 0{,}18L \cdot 10^{-2}$
R3, **R3-IN**, **D-R3-S**, **D-R3-RS**	$0{,}75 – 0{,}18L \cdot 10^{-2}$

* For ships with a sign B-R3-S and B-R3- subject to the establishment of the area of operation with a wave height of at 3% provided between 3.5 m and 6.0 m, φ_r is determined by linear interpolation between the values for R2-S і R2-RS and R3-S and R3-RS, respectively to a specific waves height values.

** For ships with a sign **R2-S і R2-RS** subject to the establishment of the area of operation with a wave height of at 3% provided between 4,5 m and 6,0 m, φ_r is determined by linear interpolation between the values for **R2-S** і **R2-RS** та **R2-S(4,5)** and **R2-RS(4,5)**, respectively to a specific waves height values.

1.3.2.2 The design pressure p_w, kPa, due to ship's hull motion about the wave contour is determined by the following formulae:

for the points of application of the loads below the summer load waterline,

$$p_w = p_{w0} – 1{,}5\, c_w (z_i/d) \qquad (1.3.2.2\text{-}1)$$

for the points of application of the loads above the summer load waterline,

$$p_w = p_{w0} – 7{,}5\, a_x z_i \qquad (1.3.2.2\text{-}2)$$

where $p_{w0} = 5\, c_w a_v a_x$;

c_w – as defined in 1.3.1.4 і 1.3.1.5;

$$a_v = 0{,}8 v_0 \left(L/10^3 + 0{,}4\right)/\sqrt{L} + 1{,}5 ;$$

$a_x = k_x (1 – 2 x_1 / L) \geq 0{,}267$;

k_x – factor equal to 0,8 and 0,5 for hull sections forward and aft of the midship section respectively;

x_1 – distance of the considered section from the nearest fore or after perpendicular, in m.

z_i – refer to 1.3.2.1-2.

In any case, the product $a_v a_x$ shall not be taken as less than 0,6.

Distribution of load p_w over the hull section contour is shown in Fig. 1.3.2.2.

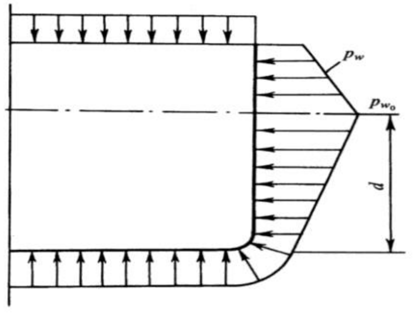


Fig.1.3.2.2

1.3.3 Acceleration at motions.

1.3.3.1 Design acceleration a, m/s^2, at motions in waves is determined by the formula

$$a=\sqrt{a_c^2+a_к^2+0{,}4a_б^2}\ , \quad (1.3.3.1\text{-}1)$$

where a_c – projection of ship's centre of gravity acceleration on the appropriate direction;

$a_к$, $a_б$ – projections of pitching and rolling acceleration on the appropriate directions at the point under consideration.

Acceleration projections for the considered member on the vertical ((index z), horizontal-transverse (index y) and horizontal-longitudinal (index x) directions are determined by the following formulae:

$$\left.\begin{aligned}
a_{cx} &= 0{,}1(100/L)^{1/3}g\varphi_r;\\
a_{cy} &= 0{,}2(100/L)^{1/3}g\varphi_r;\\
a_{cz} &= 0{,}2(100/L)^{1/3}g\varphi_r;\\
a_{кx} &= (2\pi/T_к)^2\psi z_0;\\
a_{кy} &= 0;\\
a_{кz} &= (2\pi/T_к)^2\psi x_0;\\
a_{бx} &= 0;\\
a_{бy} &= (2\pi/T_б)^2\theta z_0;\\
a_{бz} &= (2\pi/T_б)^2\theta y_0,
\end{aligned}\right\} \quad (1.3.3.1\text{-}2)$$

where φ_r – is given in Table 1.3.1.5 (φ_r =1 for ships of unrestricted service);

x_0 – distance of the considered point from the transverse plane passing through the ship's centre of gravity, in m;

y_0 , z_0 – distance of the considered point from the centreline and the horizontal plane passing through the ship's centre of gravity respectively, in m;

$T_к$ i $T_б$ – pitching and rolling periods, in s, determined by the formulae:

$$T_к=\frac{0{,}8\sqrt{L}}{1+0{,}4\dfrac{v_0}{\sqrt{L}}\left(\dfrac{L}{10^3}+0{,}4\right)}; \quad (1.3.3.1\text{-}3)$$

$$T_б=cB/\sqrt{h},$$

where c – numerical factor determined on the basis of the data for the ship of similar type. As a first approximation, c = 0,8;

h – metacentric height for the most unfavourable conditions of operation; for a ship in fully loaded condition, $h \approx 0{,}07B$ unless more detailed data are available.

For a tanker in ballast condition, T_b as a first approximation, can be determined by the formula:

$$T_б\approx 3\sqrt[3]{B};$$

ψ – design angle of trim, in rad, determined by the formula:

$$\psi=\varphi\ \frac{0{,}23}{1+L\cdot 10^{-2}} \quad (1.3.3.1\text{-}4)$$

For φ – refer to Table 1.4.4.3 (φ =1 for ships of unrestricted service);

θ – design angle of heel, in rad., determined by the formula:

$$\theta=\varphi_r\ \frac{0{,}60}{1+0{,}5L\cdot 10^{-2}}, \quad (1.3.3.1\text{-}5)$$

If $L \le 40$ м m in Formulae (1.3.3.1-4) and (1.3.3.1-5), L shall be taken equal to L = 40 m.

At all types of motions, the total acceleration in the vertical direction a_z, in m/s^2, can be determined by the formula

$$a_z=g\frac{0{,}9}{\sqrt[3]{L}}\left(1+k_a\right), \quad (1.3.3.1\text{-}6)$$

where $k_a = 1{,}6\ (1 - 2{,}5x_1 / L) \ge 0$ in the forward region;

$k_a = 0{,}5\ (1 - 3{,}33x_1 / L) \ge 0$ in the aft region;

x_1 – refer to 1.3.2.2.

If $L \leq 80$ m in Formula (1.3.3.1-6) shall be taken equal to tensile 80 m.

1.3.4 Cargo, fuel and ballast loads.

1.3.4.1 Design pressure p_c, kPa, on the grillages of cargo decks, platforms and double bottom from package cargo is determined having regard to inertia forces by the formula

$$P_c = h\rho_c g(1+a_z/g), \quad (1.3.4.1)$$

but not less than 20 kPa,

where h – design stowage height, in m;

ρ_c – density of the cargo carried, in t/m³;

$$a_z = \sqrt{a_{cz}^2 + a_{\kappa z}^2 + 0{,}4a_{бz}^2} \text{ м/с}^2,$$

where for a_{cz}, $a_{\kappa z}$, $a_{бz}$ – refer to 1.3.3.1.

Where decks and platforms are designed only to accommodate the crew and passengers, the design pressure p_{min} is taken equal to 5 kPa.

For platforms in the engine room p_{min} = 18 kPa.

1.3.4.2 boundaries of the compartments intended for the carriage of liquid cargoes and ballast in tankers, the ballast tanks in dry cargo ships as well as the tanks for ballast and fuel oil is determined depending on their dimensions, the extent of filling and the height of air pipe. By compartment is meant a tank or a part of a tank confined between the effective bulkheads. Both watertight and wash bulkheads with the total area of openings not over 10 per cent of the bulkhead area are considered as effective bulkheads.

.1 The design pressure p_c, in kPa, on the structures of fully loaded compartments is determined by the following formulae:

$$P_c = \rho_c g (1 + a_z/g) z_i, \quad (1.3.4.2.1\text{-}1)$$

$$P_c = \rho_c g (z_i + b\,\theta), \quad (1.3.4.2.1\text{-}2)$$

$$p_c = \rho_c g (z_i + l\,\psi), \quad (1.3.4.2.1\text{-}3)$$

$$p_c = 0{,}75\rho_в g (z_i + \Delta z), \quad (1.3.4.2.1\text{-}4)$$

$$p_c = \rho_c g z_i + p_\kappa, \quad (1.3.4.2.1\text{-}5)$$

where ρ_c – cargo, ballast or fuel density, in t/m³, whichever is appropriate;

a_z – design acceleration in the vertical direction according to 1.3.3.1;

z_i – distance, in m, from the member concerned to the deck level (tank top) as measured at the centreline;

θ and ψ – as determined by Formulae (1.3.3.1-4) and (1.3.3.1-5).

Δz – height, in m, of air pipe above deck (tank top), but shall not be less than: 1,5 m for the ballast tanks of dry cargo ships and for fresh water tanks, 2,5 m for the tanks of tankers and for fuel oil and lubricating oil tanks; for small expansion tanks and for lubricating oil tanks of less than 3 m³ capacity, the minimum values of Δz are not stipulated;

p_κ – pressure, in kPa, for which the safety valve is set, if fitted, but shall not be less than: 15 kPa for the ballast tanks of dry cargo ships and for fresh water tanks, 25 kPa for the tanks of tankers and for fuel oil and lubricating oil tanks; for small expansion tanks and for lubricating oil tanks of less than 3 m³ capacity, the minimum values of p_c are not stipulated;

l and b – length and breadth, in m, of a compartment as measured at mid-height; if the values of l and/or b change abruptly over the compartment height, l and/or b are measured at midheight of each compartment section where their variation is not appreciable; the Formulae (1.3.4.2.1-2) and (1.3.4.2.1-3) are used for each measured value of l and b accordingly.

whichever is the greater.

.2 Where a compartment shall be partially filled proceeding from service conditions, with the compartment length $l \leq 0{,}13L$ and compartment breadth $b \leq 0{,}6B$, the design pressure p_c, in kPa, for the structures mentioned below shall not be less than:

for the side, longitudinal bulkheads and adjoining compartment top within 0,25b of the line of compartment top and side intersection, or of the longitudinal bulkhead

$p_c = \rho_c(5 - B/100)b$; (1.3.4.2.2-1)

for transverse bulkheads and adjoining compartment top within 0,25*l* of the line of compartment top and transverse bulkhead intersection

$p_c = \rho_c(4 - L/200)l$. (1.3.4.2.2-2)

l and *b* shall be measured on the level of the free surface of liquid.

For compartments where $l > 0{,}13L$ and/or $b > 0{,}6B$, the design pressure for the case of partial flooding is determined in accordance with a special procedure approved by the Register.

1.3.4.3 The design pressure p_c, in kPa, on structures bounding the bulk cargo hold is determined by the formula

$p_c = \rho_c\, g k_c (1 + a_z/g)\, z_i$, (1.3.4.3)

but not less than 20 kPa.

where for ρ_c – refer to 1.3.4.1;

$$K_c = \sin^2(\alpha - \theta)\,\mathrm{tg}^2(45 - \varphi_{в.т}/2) + \cos^2(\alpha - \theta),$$

where α – angle of web inclination to the base line, in deg.;

where $[\alpha - 57{,}3\,\theta] < 10°$ is taken $k_c = 1$;

θ – refer to Formula (1.3.3.1-5); for transverse bulkheads $\theta = 0$;

$\varphi_{i.f}$ – internal friction angle of bulk cargo, in deg;

a_z – design acceleration in the vertical direction according to 1.3.3.1, m/s^2;

z_i – vertical distance from the load application point to the free surface level of cargo, in m.

The pressure on the inner bottom is determined by Formula (1.3.4.3) where $k_c = 1$.

1.3.4.4 The design pressure from package cargo acting upon the structures in horizontal plane is determined with regard for inertia forces. In Formula (1.3.3.1-1) the acceleration in the horizontal-transverse direction is determined by the formula:

$$a_y = \sqrt{a_{сy}^2 + \left(a_{бy} + g\sin\theta\right)^2}\ , \quad (1.3.4.4\text{-}1)$$

and in the horizontal-longitudinal direction

$$a_x = \sqrt{a_{сx}^2 + \left(a_{кx} + g\sin\psi\right)^2}\ , \quad (1.3.4.4\text{-}2)$$

where θ, ψ – are determined by Formulae (1.3.3.1-4) and (1.3.3.1-5).

1.4 LONGITUDINAL STRENGTH

1.4.1 General and definitions.

1.4.1.1 The requirements of this Chapter apply to ships of unrestricted service **A** and of restricted areas of navigation **R1, A-R1, R2** and **A-R2**, 65 m in length and upwards, as well as to ships of restricted areas of navigation **R2-S**, **R2-RS**, **A-R2**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS, R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS,** 60 m in length and upwards, whose proportions are stated in 1.1.1.1..

Ships with large deck openings and vessels of dredging fleet shall comply additionally with the requirements of 3.1 and 3.6 respectively.

1.4.1.2 Special consideration shall be given to ships having the following characteristics:

.1 proportion:

$L/B \le 5$,

$B/D \ge 2{,}5$ ((for ships of restricted areas of navigation **R2, A-R2, R2-S**, **R2-RS**, **A-R2**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **B-R3-RS, C-R3-S**, **C-R3-RS, R3-SN**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** the ratio *B/D* is obtained from Table 1.1.1.1);

.2 block coefficient $C_b < 0{,}6$;

.3 specified speed v_o, exceeding the value of v, in knots, determined by the formula $v = k\sqrt{L}$,

where k = 2,2 if $L \le 100$ m;

k = 2,2 – 0,25(L–100)/100 if $L > 100$ m.

Special consideration will also be given to ships carrying heated cargoes and ships of unusual design and/or type.

1.4.1.3 For longitudinal strength calculation, design loads shall include still water bending moments and shear forces, wave bending moments and shear forces, and for ships with large flare, bending moments due to wave impacts on the flare as well.

Design wave and impact loads may be calculated both from formulae given in the Rules and according to the approved procedure taking into consideration the rolling in waves, long-term distribution of wave conditions and area of navigation.

1.4.1.4 Downward shear forces are assumed to be taken as positive values and upward shear forces — as negative values. The hogging bending moments are assumed to be taken as positive values and sagging bending moments — as negative values.

For the calculation of still water bending moment and shear force, transverse loads shall be integrated in the forward direction from the aft end of L ; in this case, downward loads are assumed to be taken as positive values. The sign conventions of still water bending moment and shear force are as shown in Fig. 1.4.1.4.

1.4.2 Symbols.

L_1 – length of the compartment considered, in m;

B_1 – breadth of the compartment considered, in m;

A_F - difference between the area of horizontal upper deck projection (including forecastle deck) and summer load waterline on a length up to 0,2L aft from the forward perpendicular, in m^2;

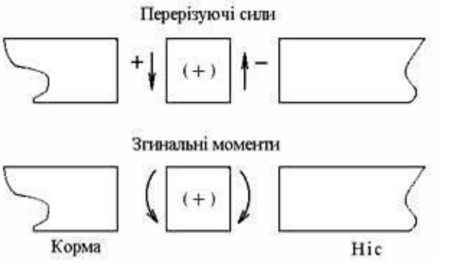


Fig.1.4.1.4

z_F – vertical distance from the summer load waterline to the upper deck (forecastle deck included), as measured on the forward perpendicular, in m;

I – actual inertia moment of the hull about the horizontal neutral axis of the hull section under consideration, in cm^4;

S – actual statical moment, about the neutral axis, of the portion of the considered hull section, located above or below the level at which the thickness of the web is determined, in cm^3;

x – distance of the considered hull section from the after perpendicular, in m.

1.4.3 Still water bending moments and shear forces.

1.4.3.1 The still water bending moments and shear forces shall be calculated for all actually possible cases of weight distribution over the length of the ship including full-load and ballast conditions for departure and arrival of the ship.

The bending moments and shear forces in the course of consuming the contents of each tank with ship's stores (fuel oil, water, lubricating oil) during voyage shall be also calculated if the above moments and forces exceed those for departure or arrival of the ship.

The same applies to ship's ballasting/deballasting at sea. In so doing, partially filled ballast tanks, including peak tanks, shall be ignored in the consideration excepting the following cases:

calculated bending moments and shear forces do not exceed the maximum design values at all levels of ballast tanks filling from an empty condition to full filling;

for bulk carriers, all intermediate conditions of ballast tanks filling from an empty condition to full filling with each cargo hold flooded are considered (refer to 3.3.5).

As a rule, when determining the scantlings of framing members, consideration shall be given to the following loading conditions:

.1 for dry cargo ships, ships with large deck opening, roll on-roll off ships, refrigerated cargo ships, bulk carriers and ore carriers:

homogeneous loading conditions at maximum draught; ballast condition;

special loading conditions, e.g. container or light load conditions at less than the maximum draught, heavy cargo, empty holds or non-homogeneous cargo conditions, deck cargo conditions, etc., where applicable;

short voyage, where applicable;

loading and unloading transitory conditions;

docking condition afloat;

all cases of loading specified in 3.3.

.2 for oil tankers: homogeneous loading conditions (excluding dry and clean ballast tanks);

partly loaded and ballast conditions for both departure and arrival;

any specified non-uniform distribution of loads;

mid-voyage conditions relating to tank cleaning or other operations where these differ significantly from the ballast conditions;

loading and unloading transitory conditions;

docking condition afloat.

.3 for combination carriers:

loading conditions as specified for dry cargo ships and oil tankers;

.4 ballast loading conditions where forepeak, afterpeak and/or other ballast tanks are partly filled at the departure, arrival or mid-voyage, shall not be considered as the design loading conditions. The exception shall be the cases where any partial filling of the tank does not exceed the permissible strength limitations. A notion "any partial filling" in the present paragraph assumes loading condition, which corresponds to an empty tank, fully loaded tank and a tank filled up to the prescribed level.

Where there are several partly loaded tanks, then all the combinations comprising empty, full and partly filled tanks shall be considered.

For ore carriers with large side ballast tanks in cargo area for the case where empty or full loading of one or maximum two pairs of these ballast tanks causes a trim exceeding at least one of the values mentioned below, then it shall be sufficient to demonstrate compliance with maximum, minimum and assigned partial filling levels of these one or maximum two pairs of side tanks, so that actual trim does not exceed any of these trim values. Fill up levels for the rest side ballast tanks shall be considered between full and empty.

The abovementioned trim values are as follows:

trim by the stern for 3 per cent of ship length;

trim by the bow for 1,5 per cent of ship length;

any trim, at which propeller depth axis constitutes 25 per cent of its diameter.

Maximum and minimum filling levels of the abovementioned one or maximum two pairs of side ballast tanks shall be included to the Loading Manual.

In cargo loading conditions, the requirements of the present paragraph apply to the peak tanks only. The requirements of the present paragraph do not apply to ballast water exchange at sea using the sequential method.

However, bending moment and shear force calculations for each ballasting or deballasting stage in the ballast water exchange sequence shall be included in the Loading Manual or the Guidelines for Safe Ballast Water Exchange at Sea of any ship that intends to employ the sequential ballast water exchange method.

1.4.3.2 The maximum absolute values of sagging and hogging bending moments M_{sw} and shear force N_{sw} shall be determined for any section along the ship's length for all the still water loading conditions, which are possible in service. The values M_{sw} and N_{sw} are regarded further as design values for the section under consideration.

1.4.3.3 For ships without effective longitudinal bulkheads, with non-uniform distribution of loads, i.e. alternation of loaded and empty holds, the still water shear force curve may be corrected by reducing its ordinates on transverse bulkheads by a value equal to the total of bottom longitudinal responses in way of those bulkheads in the event of bottom bending (refer to Fig. 1.4.3.3).

The bottom longitudinal responses in way of transverse bulkheads shall be determined on the basis of the bottom grillage calculation in accordance with 3.3.4.1. The design loads to be considered shall not include the wave loads mentioned under 1.3.2.2, the angles of heel, trim and accelerations at motions determined in accordance with 1.3.3.1.

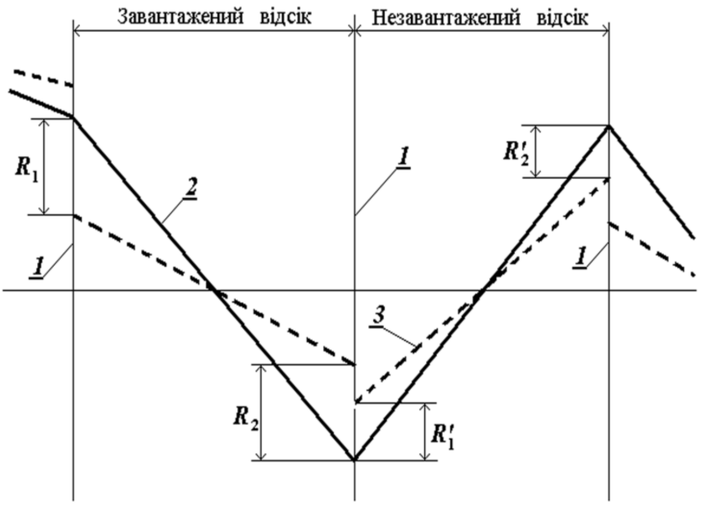


Fig.1.4.3.3. Shear force curve correction diagram

1 — transverse bulkhead; 2 — uncorrected curve; 3 — corrected curve; R_1 and R_2 – total of bottom longitudinal responses for a loaded hold in way of aft bulkhead and forward bulkhead accordingly; R'_1 and R'_2 – same for an empty hold.

1.4.3.4 Where provision is made in ship's design for loading conditions resulting in regular change of a sign of the still water bending moment (in fully loaded and ballast conditions on direct and return voyages), its components at the section with the maximum range of bending moment (refer to Fig. 1.4.3.4) shall be determined for use in the calculation under 1.4.5.3.

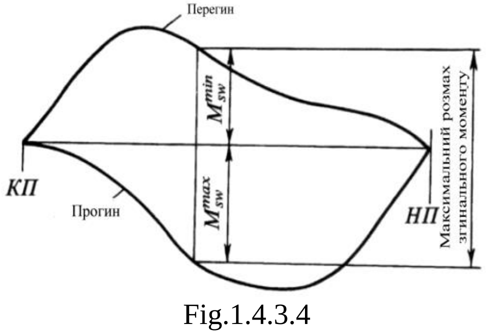


Fig.1.4.3.4

1.4.4 Wave bending moments and shear forces.

1.4.4.1 The wave bending moment M_w, in kN-m, acting in the vertical plane at the section under consideration shall be determined by the formulae:

hogging bending moment

$$M_w = 190\, c_w B L^2 C_b\, \alpha \cdot 10^{-3}\,; \quad (1.4.4.1\text{-}1)$$

sagging bending moment

$$M_w = -110\, c_w B L^2 (C_b + 0{,}7)\, \alpha \cdot 10^{-3}, \quad (1.4.4.1\text{-}2)$$

where c_w – as determined from 1.3.1.4;

α – coefficient determined from Table 1.4.4.1 or Fig.1.4.4.1;

C_b – as defined in 1.1.3, but not less than 0,6.

Table 1.4.4.1

Position of section along the ship's length	α
$x/L <$ 0,4	2,5 x/L

$0{,}4 \le x/L \le 0{,}65$	1
$x/L > 0{,}65$	$(1 - x/L)/0{,}35$

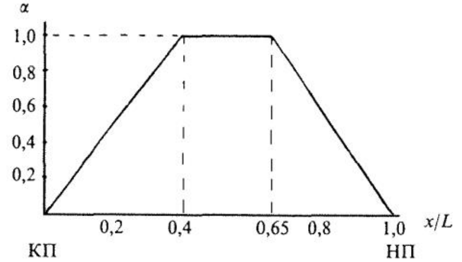


Fig.1.4.4.1

1.4.4.2 in kN, at the section concerned shall be determined by the formulae:

positive

$$N_w = 30\, c_w\, B\, L\, (C_b + 0{,}7)\, f_1 \cdot 10^{-2}, \quad (1.4.4.2\text{-}1)$$

negative

$$N_w = -30\, c_w\, B\, L\, (C_b + 0{,}7)\, f_2 \cdot 10^{-2}, \quad (1.4.4.2\text{-}2)$$

where c_w – as determined from 1.3.1.4;

C_b – as defined in 1.1.3, but not less than 0,6.

.

f_1 i f_2 – coefficients determined from Table 1.4.4.2, Figs.1.4.4.2-1 and 1.4.4.2-2.

Table 1.4.4.2

Position of section along the ship's length	f_1	f_2
1	2	3
$0 \le x/L < 0{,}2$	$7{,}945\, f_o\, x/L$	$4{,}6\, x/L$
$0{,}2 \le x/L \le 0{,}3$	$1{,}59\, f_o$	0,92
$0{,}3 < x/L < 0{,}4$	$1{,}59\, f_o - (15{,}9\, f_o - 7)\ (x/L - 0{,}3)$	$0{,}92 - 2{,}2(x/L - 0{,}3)$
$0{,}4 \le x/L \le 0{,}6$	0,7	0,7
$0{,}6 < x/L < 0{,}7$	$0{,}7 + 3(x/L - 0{,}6)$	$0{,}7+(17{,}3\, f_o - 7)\ (x/L - 0{,}6)$
$0{,}7 \le x/L \le 0{,}85$	1,0	$1{,}73\, f_o$
$0{,}85 < x/L \le 1{,}0$	$1 - 6{,}67(x/L - 0{,}85)$	$f_o\, [1{,}73 - 11{,}53(x/L - 0{,}85)]$

$f_o = C_b / (C_b + 0{,}7)$

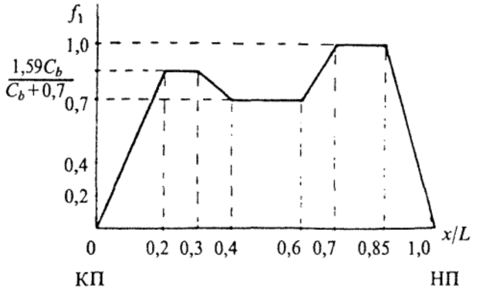


Fig.1.4.4.2-1

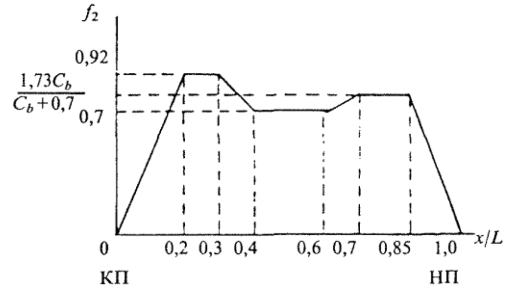


Fig.1.4.4.2-2

1.4.4.3 For ships of restricted area of navigation, the wave bending moments and shear forces determined in accordance with 1.4.4.1 and 1.4.4.2 shall be multiplied by the reduction factor φ, Table 1.4.4.3 as well as by the factors ϕ and v, determined by the following formulae:

$$\phi = (1 + \rho_n f 10^{-2}); \quad (1.4.4.3\text{-}1)$$

$$v = 1/(1+\Delta), \quad (1.4.4.3\text{-}2)$$

where $\rho_n = \alpha^2(0,5 + 2,5 \sin\beta_0) \geq \alpha$ – for conventional bow shape (no bulb);

$\rho_n = \alpha^2(1 + \alpha^2) \geq 1$ – for a bulbous bow;

α – waterplane area coefficient for summer load waterline;

β_0 – angle, in deg., between a frame tangential and a vertical at the level of summer load waterline at the section within $0,4(1 - C_b) L \leq 0,1L$ from the fore perpendicular.

$$f = \{\frac{Lv_0}{430 D_1 \eta\varphi}[\frac{2,5}{\varphi^{0,3}} + 1,5(\frac{L}{100})^{2/3}]\}^{1,5}(\frac{L}{100})^{0,75}$$

$D_1 = D + h_k$;

h_k – height of continuous hatch side coamings, in m (where these are not fitted, $h_k = 0$);

$$\Delta = 0,045(\alpha - 0,25)^2 \cdot (L/\ 20\ D_1\ \varphi\eta) \cdot (L/\ 100).$$

Table 1.4.4.3

Area of navigation	φ
R1, A-R1	$1,1 - 0,23\ L \cdot 10^{-2} \leq 1$
R2, A-R2	$1,0 - 0,25\ L \cdot 10^{-2}$
R2-S, R2-RS**, A-R2-S, A-R2-RS**	$0,94 - 0,26\ L \cdot 10^{-2}$
R2-S (4,5), R2-RS (4,5)	$0,92 - 0,29\ L \cdot 10^{-2}$
R3-S, R3-RS, B-R3-S*, B-R3-RS*, C-R3-S, C-R3-RS	$0,71 - 0,22\ L \cdot 10^{-2}$
R3, R3-IN, D-R3-S, D-R3-RS	$0,60 - 0,20\ L \cdot 10^{-2}$

* For ships with a sign **B-R3-S** and **B-R3-** subject to the establishment of the area of operation with a wave height of at 3% provided between 3.5 m and 6.0 m, φ_r is determined by linear interpolation between the values for **R2-S** i **R2-RS** and **R3-S** and **R3-RS**, respectively to a specific waves height values.

** For ships with a sign **R2-S i R2-RS** subject to the establishment of the area of operation with a wave height of at 3% provided between 4,5 m and 6,0 m, φ_r is determined by linear interpolation between the values for **R2-S** i **R2-RS** та **R2-S(4,5)** and **R2-RS(4,5)**, respectively to a specific waves height values.

The above requirements apply to ships of restricted area of navigation, from 60 to 150 m in length.

Application of the requirements to ships of a different length is subject to special consideration by the Register.

1.4.4.4 Bending moment due to wave impacts on the flare.

.1 The bending moment due to wave impacts on the flare shall be calculated only for ships of length from 100 to 200 m where the relationship $A_F / L\ z_F \geq 0,1$.

.2 The sagging bending moment due to wave impacts on the flame M_F, in kN·m, shall be calculated as follows

$$M_F = -k_F c_w BL^2(C_b + 0,7)\ \alpha_F\ 10^{-3}, \quad (1.4.4.4.2)$$

where $k_F = 7(1 + 1,25\ v_o / L)\ c_1 c_2$ but not more than 23;

$c_1 = (L - 100)/30$ for $100 \leq L < 130$ м;

$c_1 = 1$ for $130 \leq L < 170$м;

$c_1 = 1 - (L - 170)/30$ for $170 \leq L \leq 200$ м;

$c_2 = 5\ A_F / L\ z_F - 0,5$ for $0,1 \leq A_F / L z_F \leq 0,3$;

$c_2 = A_F / L\ z_F + 0,7$ for $0,3 < A_F / L\ z_F < 0,4$;

$c_2 = 1,1$ for $A_F / L\ z_F \geq 0,4$;

for c_w – refer to1.3.1.4;

for v_o – refer to 1.4.1.2.3;

α_F – is obtained from Table 1.4.4.4.2 or Fig 1.4.4.4.2.

Table 1.4.4.4.2

Position of section along the ship's length	α_F

$x/L \le 0,15$	$0,667x/L$
$0,15<x/L<0,45$	$0,1 + 3(x/L – 0,15)$
$0,45\le x/L\le 0,75$	1
$x/L>0,75$	$1 – 4(x/L – 0,75)$

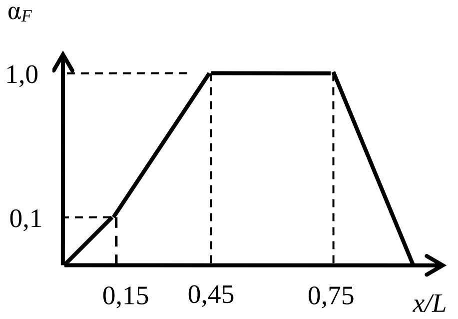


Fig.1.4.4.4.2

.3 For ships of restricted area of navigation, the bending moment due to wave impacts on the flare M_F, calculated in accordance with 1.4.4.4.2, shall be multiplied by the reduction factor φ, determined from Table 1.4.4.3.

For ships of restricted areas of navigation **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** $M_F=0$.

1.4.5 Hull section modulus and moment of inertia.

1.4.5.1 The requirements of this paragraph regulate the hull section modulus and moment of inertia about the horizontal neutral axis.

1.4.5.2 The hull section modulus (for deck and bottom) W, in cm ^{3}, at the section concerned shall not be less than

$$W = M_т \cdot 10^3 / \sigma \ , \qquad (1.4.5.2)$$

where $M_т$ = | M_{sw} + M_w | design bending moment, in kN-m, at the section concerned equal to the maximum absolute value of algebraic sum of M_{sw} and M_w components at this section;

for M_{sw} – refer to1.4.3, in kN·m;

for M_w – refer to 1.4.4;

$\sigma = 175 / \eta$ MPa.

1.4.5.3 In cases specified by 1.4.3.4, the section modulus W, determined in accordance with 1.4.5.2, shall be multiplied by the factor m, determined by the formula

$$m = 1 + \frac{M_{sw}^{\min}}{10M_{sw}^{\max}}\left(\frac{M_{sw}^{\min} + M_{sw}^{\max}}{0,076c_w BL^2\left(C_b + 0,7\right)} - 1\right), \qquad (1.4.5.3)$$

but not less than 1,

where $M_{sw}^{\min}$, $M_{sw}^{\max}$ – absolute values of hogging and sagging bending moments at the maximum range section, in kNm (refer to Fig. 1.4.3.4);

1.4.5.4 For ships for which the bending moment due to wave impacts on the flare (refer to 1.4.4.4), shall be considered the section modulus W, in cm^3, at the section concerned shall not be less than

$$W = \frac{M_T \cdot 10^{-3}}{\sigma} \ , \qquad (1.4.5.4)$$

where: M_T = | $M_{sw} + M_w + M_F$ | - design bending moment, in kNm, at the section concerned equal to the maximum absolute value of algebraic sum of M_{sw}, M_w and M_F components at this section;

M_{sw} - maximum still water sagging bending moment or minimum hogging bending moment if solely the hogging bending moments occur at this hull section, in, kN·m;

M_w - wave sagging bending moment (refer to 1.4.4);

M_F as determined from 1.4.4.5;

for σ refer to 1.4.5.2.

1.4.5.5 The hull section modulus determined from 1.4.5.2 – 1.4.5.4 for maximum value of design bending moment shall be maintained within 0,4L, amidships. However, if the maximum design bending moment occurs outside 0,4L, amidships, the steady section modulus requirement is applicable over the ship's length up to the section where maximum design bending moment acts.

The section modulus shall be gradually reduced towards the ship's ends outside the region in which it is being maintained.

1.4.5.6 For sharp-lined ships without middlebody, deviation from the requirements of 1.4.5.5 may be permitted on agreement with the Register.

1.4.5.7 In any case, the hull section modulus, in cm^3, within the midship region (for deck and bottom) shall not be less than

$$W_{min} = c_w B L^2 (C_b + 0{,}7)\eta, \quad (1.4.5.7\text{-}1)$$

where for c_w – refer to 1.3.1.4.

For ships of restricted area of navigation, the minimum hull section modulus, in cm^3, within the midship region (for deck and bottom) shall not be less than W_{min1} or W_{min2}, whichever is the greater, determined by the following formulae:

$$W_{min1} = \varphi W_{min}; \quad (1.4.5.7\text{-}2)$$

$$W_{min2} = 0{,}95 \phi v \varphi W_{min}, \quad (1.4.5.7\text{-}3)$$

where: for φ– refer to Table 1.4.4.3;
for ϕ- refer to Formula 1.4.4.3-1;
for v- refer to Formula 1.4.4.3-2.

1.4.5.8 Scantlings of all continuous longitudinal members of hull girder based on the section modulus requirement in 1.4.5.7, shall be maintained within amidships. However, in special cases, based on consideration of type of ship, hull form and loading conditions, the scantlings may be gradually reduced towards the ends of the 0,4*L*, part, bearing in mind the desire not to inhibit the ship's loading flexibility.

1.4.5.9 The moment of inertia of hull section *I*, in cm^4, within the midship region shall not be less than

$$I_{min} = 3 c_w B L^3 (C_b + 0{,}7), \quad (1.4.5.9\text{-}1)$$

where c_w as determined from 1.3.1.4.

For ships of restricted area of navigation I_{min} shall be multiplied by the reduction factor φ_0, determined by the formula

$$\varphi_0 = \varphi\,\eta\,\frac{18}{(L/D)_{max}}, \quad (1.4.5.9\text{-}2)$$

where for φ – refer to Table1.4.4.3;
for η – refer to1.1.4.3;
$(L/D)_{max}$ – maximum permissible value of *L/D*, for the area of navigation under consideration, obtained from Table 1.1.1.1.

1.4.5.10 As a minimum, hull longitudinal strength checks shall be carried out at the following locations outside amidships:

in way of the forward end of the engine room;

in way of the forward end of the foremost cargo hold;

where there are significant changes in the hull cross-section;

where there are changes in the framing system.

The following shall be made outside amidships:

buckling strength of members contributing to the longitudinal strength and subjected to compressive and shear stresses shall be checked, in particular in regions where changes in the framing system or significant changes in the hull cross-section occur in compliance with 1.5.5;

continuity of structure shall be maintained throughout the length of the ship. Where significant changes in structural arrangement occur adequate transitional structure shall be provided; for ships with large deck openings such as a containerships, sections at or near to the aft and forward quarter length positions shall be checked.

For such ships with cargo holds aft of the superstructure, deckhouse or engine room, strength checks of sections in way of the aft end of the aft-most holds, and the aft end of the deckhouse or engine room shall be performed.

1.4.6 Thickness of side shell plating and continuous longitudinal bulkhead plating.

1.4.6.1 The thickness of side shell plating *s*, in mm, at the considered section over the length and depth of the ship where longitudinal bulkheads are not fitted shall not be less than

$$s = S\,(N_{sw} + N_w) \cdot 10^2 / (2\,\tau\, I), \quad (1.4.6.1)$$

where for N_{sw} – refer to1.4.3.2, кН;
N_w – refer to 1.4.4.2 i 1.4.4.3;
$\tau = 110/\eta$ MPa.

1.4.6.2 The thickness of side shell plating s_s and thickness of longitudinal bulkhead plating s_l, in mm, at the section under consideration for ships with two plane longitudinal bulkheads shall not be less than:

$$s_s = S\,\alpha_s\,(N_{sw} + N_w) \cdot 10^2 / (\tau\, I); \quad (1.4.6.2\text{-}1)$$

$$s_l = S\,\alpha_l\,(N_{sw} + N_w) \cdot 10^2 / (\tau\, I); \quad (1.4.6.2\text{-}2)$$

Where for N_{sw}, N_w, τ – refer to1.4.6.1;
$\alpha_s = 0{,}27$;
$\alpha_l = 0{,}23$.

1.4.6.3 For ships having one or more than two continuous plane longitudinal bulkheads as well as longitudinal bulkheads with horizontal corrugations the required thickness of side plating and members in question shall be calculated according to the procedure approved by the Register.

Appropriate calculation may also be required for ships with two continuous longitudinal bulkheads if the transverse distribution of load is substantially different from uniform distribution a.

1.4.7 Calculation of actual hull section modulus.

1.4.7.1 The hull section modulus is determined: for strength deck $W_d^{ф}$ – at moulded deck line at side (lower edge of deck stringer); for bottom $W_b^{ф}$ – at moulded base line (top of plate keel).

For ships with continuous longitudinal strength members above strength deck including trunk and continuous hatch side coamings $W_d^{ф}$ is calculated by dividing the moment of inertia of hull section about the horizontal neutral axis by the value of z_T, determined by the formula

$$z_T = z(0{,}9+0{,}2\,y/B),$$

where z – distance from neutral axshall the top of continuous strength member above deck included in the calculation of $W_d^{ф}$, in m;

y – horizontal distance from the centreline of the ship to the top of continuous strength member above deck included in the calculation of $W_d^{ф}$, in m.

z and y shall be measured to the point giving the largest value of z_T.

1.4.7.2 When calculating the hull section modulus, all continuous longitudinal strength members shall be taken into account, including continuous hatch side coamings, and, where the ship's design provides for multiple hatchways — the longitudinal deck strips between them on condition the deck strips are effectively supported by longitudinal bulkheads, including the topside tank bulkheads (inner skins).

The sectional area of long bridges or deckhouses shall be included with the reduction coefficient which similarly to stresses in the ship's hull and superstructure (deckhouse) is determined according to the procedure approved by the Register.

Continuous hatch side coamings in ships with single hatches not above the mentioned structures may be included in the calculation of the hull section modulus only if the calculation has been specially approved to this effect.

The sectional area of longitudinal deck strips, each being of a uniform width throughout the length, including deck plating with longitudinal framing and hatch side coamings not supported by longitudinal bulkheads, is included with the reduction coefficient ξ determined by the formula

$$\zeta = m + \frac{0{,}65 + C_b}{3} \frac{L}{\Sigma l_н + \Delta l_1 + \Delta l_2}, \quad (1.4.7.2)$$

where $m = \begin{cases} -0{,}10 \text{ якщо } n = 1, \\ -0{,}12 \text{ якщо } n = 2; \end{cases}$

n – number of longitudinal strips over ship's breadth;

$\Sigma l_Н$ – total length of longitudinal deck strips, in m;

Δl_1, Δl_2 – length of end attachments of longitudinal deck strips aft and forward, in m.

If the end of the longitudinal deck strip is effectively attached to continuous deck and/or longitudinal bulkhead (refer to Fig.1.4.7.2)

$$\Delta l_{1,2} = 4f / B_{1,2} s_{d_{1,2}},$$

where f – sectional area of one longitudinal deck strip, in cm^2;

$B_{1,2}$ – breadth of ship in way of longitudinal deck strip termination, in m;

$s_{d_{1,2}}$ – average thickness of the portion of deck plating between the extension of longitudinal deck strip and ship's side along the effective attachment, in mm.

Where a longitudinal deck strip terminates at the transverse deck strip, provided

$$10b'' s'_d \geq nf \quad \text{i} \quad b'' > b$$

$$\Delta l_{1,2} = 1{,}3n \frac{f}{10 s'_d} \left(\frac{b'}{b''} + 1 \right),$$

where s'_d – average plate thickness of the transverse deck strip, in mm;

b' – distance between longitudinal edge of the hatch opening and symmetry plane of the longitudinal deck strip, in m;

b'' – length of transverse deck strip, in m.

1.4.7.3 Large openings, i.e. openings exceeding 2,5 m in length and/or 1,2 m in breadth, and scallops, where scallop-welding is applied, shall be deducted from the sectional areas used in the section modulus calculation.

Smaller openings (manholes, lightening holes, single scallops in way of welds, etc.) need not be deducted, if the following conditions are met:

the sum of their breadths and shadow area breadths (refer to Fig.1.4.7.3) in one transverse section of the hull does not exceed 0,06 $(B - \Sigma b)$ (where Σb – is the total breadth of openings) or does not reduce the section modulus at deck or bottom by more than 3 per cent;

the height of lightening holes, drain holes and single scallops in longitudinal members does not exceed 25 per cent of the web depth, and the height of scallops in way of welds is not over 75 mm.

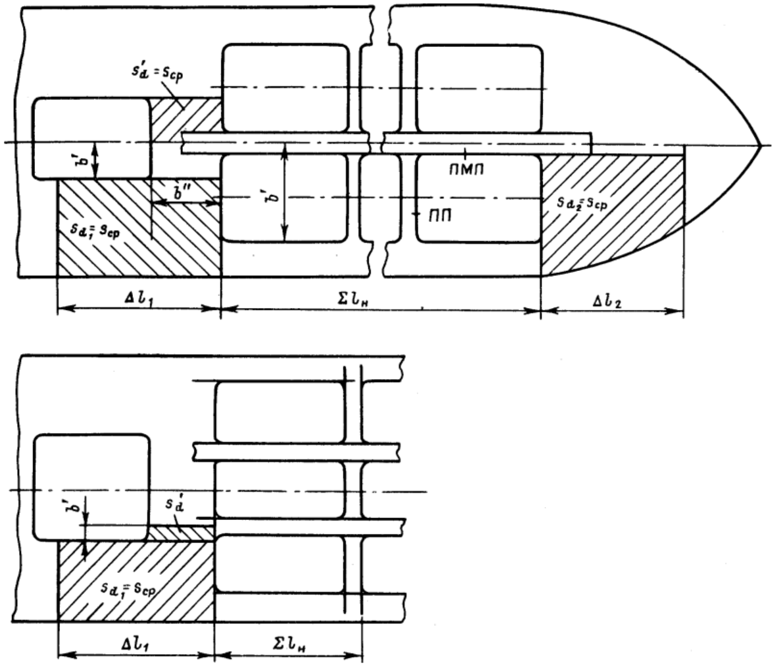


Fig. 1.4.7.2. Longitudinal deck strips to be included in the calculation of hull section modulus

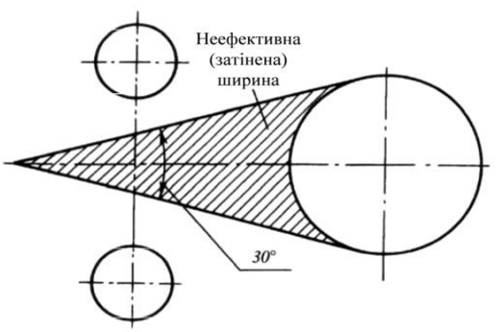


Fig.1.4.7.3. Design section

1.4.7.4 Where continuous longitudinal members are built of higher tensile steel, they shall extend so far beyond amidships towards the ends as to provide a hull section modulus in way where the yield stress changes not less than required for an identical hull of ordinary steel.

1.4.7.5 The continuous longitudinal members at a distance from horizontal neutral axis of hull section greater than

$$\frac{z}{\eta}\frac{W_{факт}}{W_{\eta=1}}, \qquad (1.4.7.5)$$

shall be made of steel with the same yield stress as the strength deck (continuous hatch coaming) or bottom.

where: z – distance of strength deck (upper face plate of continuous hatch side coaming) or bottom from neutral axis, in m;

η – factor given in Table 1.1.4.3 for the members of the remainder of hull section;

W_a , $W_{\eta=1}$ – actual section modulus and required section modulus with

$\eta = 1$ for the deck (continuous hatch coaming) or bottom respectively.

1.4.8 Loading control facilities.

1.4.8.1 By loading control facilities are meant Loading Manual and loading instrument by means of which it can be ascertained that the still water bending moments, shear forces, and the still water torsional and lateral loads, where applicable, in any load or ballast condition will not exceed the specified permissible values.

1.4.8.2 Ships to be provided with loading control facilities are categorized as follows:

Category I :

ships with large deck opening, for which combined stresses due to vertical and horizontal hull girder bending, as well as torsional and lateral loads, shall be considered;

ships for which uneven loading, i.e. uneven distribution of cargo and/or ballast, is possible;

chemical tankers and gas carriers.

Category II:

ships with arrangement giving small possibilities for variation in cargo and ballast distribution;

ships on regular and fixed trading pattern where the Loading Manual gives sufficient guidance;

ships not falling under category I including ships of less than 120 m in length, which design takes uneven distribution of cargo or ballast into account.

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

the loading conditions on which the design of the ship has been based;

permissible limits of still water bending moment and shear force and, where applicable, limitations due to torsional and lateral loads

the results of the calculations of still water bending moments, shear forces for loading conditions stated in1.4.3.1;

the allowable local loadings for the structure (hatch covers, decks, double bottom, etc.).

The Loading Manual shall be prepared in a language understood by the users and in English.

1.4.8.4 A loading instrument is an instrument approved by the Register, which is either analog or digital by means of which the still water bending moments, shear forces and torsional and lateral loads, where required, in any load or ballast condition can be easily and quickly checked at specified readout points.

The number and position of sections and permissible still water bending moments and shear forces as well as the limitations due to torsional and lateral loads shall be approved by the Register.

Single point loading instruments are not acceptable.

An approved Operational Manual shall be provided for the loading instrument.

The Operational Manual and calculation results shall be prepared in a language understood by the users and in English.

1.4.8.5 Al l ships other than category II ships of less 90 m in length, which deadweight is not greater than 30 per cent of summer load line displacement, shall be provided with the Loading Manual approved by the Register.

In addition to the Loading Manual, all ships of category I having length of 100 m and more shall carry a loading instrument approved by the Register (requirements for loading instruments are given in Appendix 2).

1.4.8.6 For ore carriers, ore-oil carriers and oilbulk carriers having a length of 150 m and more, additional requirements for strength control during loading are given in 3.3.6.

1.4.8.7 Information (booklet) on Stability and Strength during Loading, Unloading and Stowage of Bulk Cargoes Other than Grain.

To prevent excessive hull stresses, provision shall be made for Information (booklet) on Stability and strength during Loading, Unloading and Stowage of Bulk Cargoes other than Grain to be carried on board, including the following as a minimum:

.1 stability data required in 1.4.11, Part IV "Stability";

.2 data on the capacity of ballast tanks and of equipment for their filling and emptying;

.3 maximum permissible load upon a unit of double-bottom plating surface;

.4 maximum permissible cargo hold load;

.5 general instructions concerning loading and unloading and pertinent to hull strength, including any limitations due to the worst operating conditions during loading, unloading, handling of water ballast, and during the voyage;

.6 any special limitations, for instance, those due to the worst operating conditions, where applicable;

.7 where necessary — strength calculations:

maximum permissible forces and moments affecting the hull during loading, unloading and the voyage.

The Information (booklet) shall be prepared in a language understood by the ship officers, and in English.

1.5 VIBRATION OF HULL STRUCTURES. VIBRATION STANDARDS

1.5.1 General.

1.5.1.1 The present Chapter shall establish the highest permissible vibration levels (hereinafter, vibration standards) of hull structures in sea-going displacement ships.

1.5.1.2 The vibration standards are set down proceeding from the condition of ensuring the strength of hull structures and the dependability of machinery, instruments and equipment installed on board the ship.

1.5.1.3 The application of standards stipulated in this Chapter does not release one from compliance with sanitary norms and requirements of Ukraine health authorities and other requirements for permissible vibration parameters at work places in the accommodation, service and other spaces of ships.

1.5.1.4 Vibration standards for ship machinery and equipment are specified in Section 9, Part VII "Machinery Installations".

1.5.1.5 Regardless of vibrations measurements results in the first ship of a series and in single buildings vibration measurements to assess their vibration characteristics based on the standards of acceptable vibration parameters specified in 1.5.3 of this unit shall be carried out.

1.5.1.6 The procedure, scope and sequence of vibration measurement shall be approved by the Register.

1.5.1.7 On special agreement with the Register, deviation from the present standards may be permitted in well-grounded cases.

1.5.2 Technical documentation.

After mooring tests and sea trials, a report on vibration measurement shall be submitted to the Register, which shall be approved by the management of the firm having carried out the evaluation of the vibration characteristics of the ship. Where additional measures are taken to reduce vibration, the report shall contain those measures as well as the results of a second measurement of vibrations to confirm the efficiency of measures taken.

In some cases, the Register reserves the right to request a preliminary conclusion of the enterprise that carried out vibration measurements.

1.5.3 Measured vibration parameters.

1.5.3.1 For the purpose of the present Chapter, the following vibration parameters have been adopted as main ones:

root mean square value of vibration velocity measured in one-third octave bands and, where necessary, in octave bands;

root mean square value of vibration acceleration and, in well-grounded cases, the root mean square or peak value of vibratory displacement.

1.5.3.2 Vibration parameters shall be measured in absolute units or in logarithmic units (decibels) with regard to standard threshold values of vibration velocity or acceleration equal to $5 \cdot 10^{-5}$ mm/s i $3 \cdot 10^{-4}$ m/s^2 accordingly.

1.5.3.3 Measurements shall be carried out in the following directions:

in each of the inter-perpendicular directions with regard to the ship: vertical, horizontal-transverse and horizontal-longitudinal direction, when measuring the main hull vibration;

in the direction normal to the plane of ship structures (deck, side, bulkheads, etc.) or in the lowest-rigidity direction of the hull girder, when measuring local vibration.

1.5.3.4 The permissible root mean square values of vibration velocity and vibration acceleration of the hull and superstructures as well as hull structures are mentioned in Table 1.5.3.4 and in Fig. 1.5.3.4.

1.5.3.5 When measuring the parameters in octave bands, the permissible values stated in Table 1.5.3.4 for mean geometric frequencies of 2, 4, 8, 16, 31,5 and 63 Гц, may be increased 1,41($\sqrt{2}$) times or by 3 dB as compared to tabulated values.

1.5.3.4 Permissible values given in Table 1.5.3.4 and in Fig. 1.5.3.4 shall not be exceeded at specified ship speeds and at zero speed, if specified.

1.5.4 Definitions and explanations.

For the purpose of the present Chapter:

.1 main vibration – vibration of ship's hull, generated by forces on account, of operation of propeller, main engine or caused by the action of waves;

.2 vibration of superstructures and

deckhouses means vibrations superstructures and deckhouses about the hull generated by its vibrations (mainly bending and longitudinal)

.3 Local vibration means vibration of hull structures (plates, stiffeners, framing members, grillages, etc.) generated by propeller, un balanced machinery located near these structures or by the main hull » -bration of the ship under way;

.4 Exciting forces means any external forces or moments *q:* forces acting on vibrating system and causing its vibration;

.5 First-order frequency – means frequency of exciting forces variation equal to the propeller speed. Forced vibration of the system arising at this frequency is called first-order vibration;

.6 Top-order frequencies means frequencies of exciting forces variation equal to the doubled, trebled, etc. propeller speed. Forced vibration of the system arising at such frequencies multiple to propeller speed is called vibration of the second, third, etc., order, respectively. In this case frequency of exciting force variation equal to the product of propeller speed by the number of blades is called first-blade (or blade); frequencies multiple to it are called second-blade, third-blade, etc., and vibration arising at these frequencies, for example, in case of four-bladed propeller is called blade vibration of the fourth order, second-blade vibration of the eighth order, etc. respectively;

.7 Main order frequencies of exciting forces, generated by internal combustion engines means frequencies of variation of unbalanced forces and moments of inertia forces equal to the engine crankshaft speed (first order) or double speed (second order) as well as frequencies of variation of capsizing moments the order of which is equal to the cylinder number (two-stroke engines) or to half the number of cylinders (four-stroke engines).

Table 1.5.3.4 **The hull, superstructure and hull structures viration sstandards**

Mean geometric values of octave ranges, in Hz	Hull and superstructure, rigid members [1]				Hull structures							
					frames[2]				plates			
	Permissible root mean square values											
	vibration velocity		vibration acceleration		vibration velocity		vibration acceleration		vibration velocity		vibration accelera-tion	
	mm/s	dB	m/s^2	dB	mm/s	dB	m/s^2	dB	m m/s	dB	m/s^2	dB
1,6	5,6	101	0,054	45	5,6	101	0,054	45	5,6	101	0,054	45
2	5,6	101	0,067	47	5,6	101	0,067	47	5,6	101	0,067	47
2,5	5,6	101	0,084	49	5,6	101	0,084	49	5,6	101	0,084	49
3,15	5,6	101	0,106	51	7,1	103	0,135	53	7,1	103	0,135	53
4	5,6	101	0,135	53	8,9	105	0,21	57	8,9	105	0,21	57
5	5,6	101	0,17	55	11	107	0,34	61	11	107	0,34	61
6,3	5,6	101	0,21	57	11	107	0,43	63	14	109	0,54	65
8	5,6	101	0,27	59	11	107	0,54	65	16	110	0,75	68

Mean geometric values of octave ranges, in Hz	Hull and superstructure, rigid members [1]				Hull structures							
					frames[2]				plates			
	Permissible root mean square values											
	vibration velocity		vibration acceleration		vibration velocity		vibration acceleration		vibration velocity		vibration accelera-tion	
	mm/s	dB	m/s^2	dB	mm/s	dB	m/s^2	dB	mm/s	dB	m/s^2	dB
10	5,6	101	0,34	61	11	107	0,65	67	16	110	0,94	70
12,5	5,6	101	0,43	63	11	107	0,84	69	16	110	1,2	72
16	5,6	101	0,54	65	11	107	1,06	71	16	110	1,5	74
20	5,6	101	0,67	67	11	107	1,35	73	16	110	1,9	76
25	5,6	101	0,84	69	11	107	1,7	75	16	110	2,4	78
31,5	5,6	101	1,06	71	11	107	2,1	77	16	110	3,0	80
40	5,6	101	1,35	73	11	107	2,7	79	16	110	3,8	82
50	5,6	101	1,7	75	8,9	105	2,7	79	12,5	108	3,8	82
63	5,6	101	2,1	77	7,1	103	2,7	79	10	106	3,8	82
80	5,6	101	2,7	79	5,6	101	2,7	79	8	104	3,8	82

[1] Hull and superstructures, rigid members are the intersections of decks with main transverse and longitudinal bulkheads, sides, transom, superstructure walls, etc.

[2] Girders supporting the foundations of ship machinery and equipment are included.

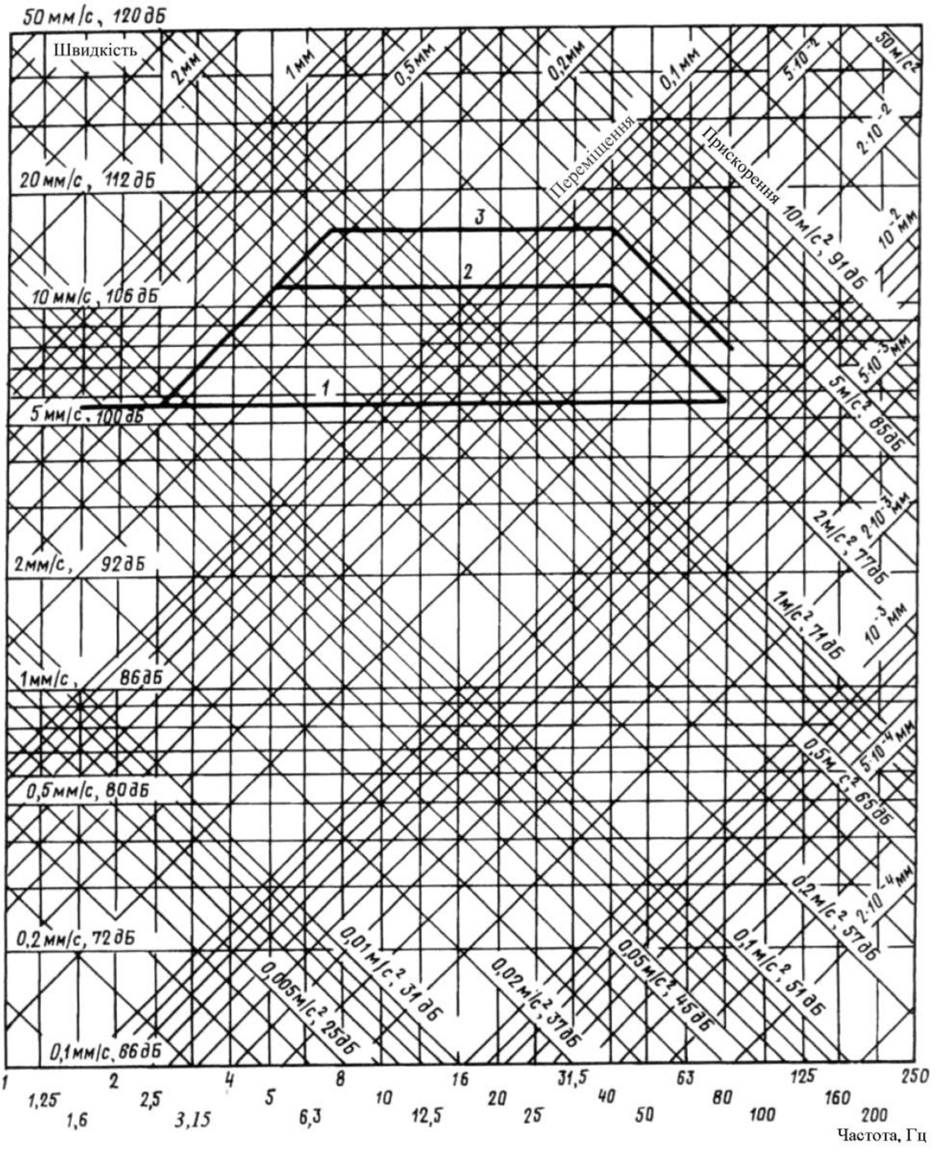


Fig.1.5.3.4. Permissible mean root values of vibration velocity and vibrational acceleration:

1 — hull, superstructures and rigid members; 2 — framing members including the girders by which the foundations of ship machinery and equipment are supported; 3 — plates.

Calculation of main hull vibration of the ship

1.5.5.1 Calculations of frequencies and basic modes of natural frequencies of hull vibration for ship being designed as well as estimation of parameters of its forced vibration under way are carried out according to the procedure approved by the Register.

1.5.5.2 Calculations of main hull vibration of the ship under way are to be carried out for the main operating loading conditions.

The calculation of natural (resonant) frequency spectra of hull vibration in vertical and horizontal-transverse directions within the range of inducing forces frequency variation to the blade frequency inclusive is to be made.

In this case for horizontal-transverse vibrations of hull of dry cargo ships, is a rule, consideration is to be given to their interdependency with torsional vibrations; deviations may be permitted on special agreement with the Register. when calculating the natural frequency of vibration, it is recommended to take into account the interaction of hull and added large masses (grillages, deckhouses, etc.). For the top mode vibrations (generally, above the third mode) ac count of such interaction is necessary.

In addition, the amplitude estimation of vibration displacement of the hull forced vibration (including resonant) is to be carried out in the aftermost section at the point where vibration is normalized. Such estimation is carried out for the main specified running conditions. The obtained values are compared with the values specified in 1.5.7.

1.5.6 Calculation of local vibration of hull structures.

1.5.6.1 The local vibration strength of the hull structures subject to vibration loads is checked by the appropriate calculations performed at the designing stage according to the procedure approved by the Register.

1.5.6.2 The basic condition of ensuring the vibration strength of hull structures in way of influence of vibration loading is to prevent the possibility of origination of their resonance oscillations for the main operating conditions of the ship.

In this case, only local vibration calculation is to be made to evaluate the lowest natural frequencies of hull structure vibration and to correlate them with the relevant frequencies of excitation forces listed in 1.5.6.7. When comparing these frequencies, one should be guided by conditions of prevention of resonant fenomena stated in 1.5.6.6.

1.5.6.3 For the hull structures in way of direct influence of pulsating pres sures from propellers (see 1.5.6.4.1) as well as for the structures in way of unbalanced machinery (see 1.5.6.4.3) in addition to the calculations specified by 1.5.6.2 it is recommended to make additional calculations of their forced vibration under the action of forces with the blade frequency (for the region stated in 1.5.6.4.1) or with the rotor speed (for rotor-type machinery), or with the first-and second-order frequencies for internal combustion engines (as applied to the region according to 1.5.6.4.3). These calculations are carried out to determine the vibration stresses arising in the plates and framing members which are to be correlated with the standards given in Table 1.5.7.2.4.

N o t e . When the propeller is located in the nozzle, the calculations of forced vibration of hull structures of the after end of the ship according to 1.5.6.4.1 need not be performed. However, in this case it is necessary to carry out the estimation of the local vibration strength of structures*of the nozzle itself according to 1.5.6.2.

1.5.6.4 Calculations specified in

1.5.6.2 are to be performed for the hull structures arranged in the following regions of the ship:

.1 in way of the direct influence of pulsating hydrodynamical pressures from propellers; this region extends from the aftermost section (transom) to the section located at a distance equal to single propeller diameter forward of the disc centre of the latter;

.2 in machinery spaces in way of unbalanced main and auxiliary machinery;

.3 in other spaces in way of unbalanced machinery.

1.5.6.5 To be calculated according to 1.5.6.4 under vibration loading are the following structures:

.1 after peak structures (refer also to 1.5.6.4.1) shell plating with associated framing, inner bottom plating, bulkhead plating and stiffeners, plating and stiffening of platforms;

.2 engine room structures similar to those listed in 1.5.6.5.1;

.3 structures of other ship spaces in way of unbalanced machinery similar to those listed in 1.5.6.5.1.

1.5.6.6 To prevent origination of the resonance vibration, natural frequencies of the first mode hull structure vibration are to exceed the relevant frequencies of the excitation forces specified in 1.5.6.7 at least 1,5 times for the plates and 1,3 times for the framing members and stiffeners.

1.5.6.7 When determining the possibility of origination of resonance vibration of hull structures, the frequencies of excitation forces are to be taken equal to:

.1 double blade frequency corresponding to the range of full speed of the ship for the structures subject to direct action of pulsating pressures from propellers (see 1.5.6.4.1). As an exception and on special agreement with the Register the blade frequency may be used as design frequency of the excitation forces for the structures stated in 1.5.6.4.1

.2 blade frequency corresponding to the range of full speed of the ship for the structures of engine room (where located aft) as well as for the hull part between the engine room and region according to 1.5.6.4.1.

Where the engine room is located amidships or displaced aft the frequencies corresponding to the first and second orders of variation of unbalanced forces of main and auxiliary machinery are taken as design frequencies;

.3 the first and second orders of frequencies of unbalanced forces of unbalanced machinery for the structures in way of this machinery.

1.5.7 Vibration standards.

1.5.7.1 Standard vibration parameters.

.1 The root-mean-square value of the vibration rate measured in 1/3-octave band is taken as the basic parameter characterizing the vibration.

Vibration measurement in the octave band is permitted together with analysis in 1/3-octave band.

.2 The measured parameters may be the root-mean-square value of vibration acceleration together with vibration rate and, in well-grounded cases, the root-mean-square or peak values of vibration displacement.

.3 The vibration parameters are measured in accordance with 1.5.3.2.

1.5.7.2 Permissible values of vibration.

.1 Main hull and superstructure vibration and local vibration of ship structures are considered permissible if the root-mean-square values of vibration rate or vibration acceleration measured in 1/3-octave band do not exceed the values (levels) stated in Table 1.5.7.2.1 (Fig. 1.5.7.2.1) for each of three inter-perpendicular directions about ship axes: vertical, horizontal-transverse and horizontal-longitudinal (main vibration) or for the direction normal to the structure plane (plate members, panels, grillages and their girders and stiffeners) or for the direction corresponding to the lowest bending rigidity for isolated girders and beam members (local vibration).

.2 When measuring the vibration in octave bands the permissible values of the measured parameter according to 1.5.3.5.

.3 Permissible values of the vibration parameters (levels) stated in 1.5.3.4 and 1.5.3.4 are not to be exceeded in specified ranges of ship speed (including the range without speed if such range is a specified one) under operating loading conditions.

.4 For the plates and framing members, exceeding of permissible values (levels) is allowed provided the vibration strength of these structural members is found to be sufficient and the vibration of the equipment contacting with the members in question is considered allowable.

The local vibration strength of plates and framing nr considered to be sufficient if the values of the vibration stressesi do not exceed the permissible values given in Table 1.5.7.2.4.

Table 1.5.7.2.4

Material	Upper yieldd stree R_{eH}, MPa	Permissible normal stresses in way of welded joints, MPa
Steel	235 – 390	40
Alluminium alloy	150 – 220	20

N o t e : 1. This Table shows permissible stresses for T-connections with double welds.

2. The maximum vibration stresses σ, in MPa, acting in the plates may be estimated by the formulae:

for steel plates

$$\sigma = 3{,}5\,\bar{f}\,s/a^2;$$

for allumimium alloy plates

$$\sigma = 1{,}25\,\bar{f}\,s/a^2,$$

where $\bar{f} = f_c - f_p$;

f_c, f_p – amplitudes of vibration in the centre of plate and its contour, in mm;

s – thikness of plate, in mm;

a – length of short side of plate, in mm.

3. The maximum vibration streese σ, MPa, acting in the framing members may be estimated by the formulae:

for steel framing members

$$\sigma = 64I\,\bar{f}/(l^2 W_{min});$$

for allumimium framing members

$$\sigma = 23I\,\bar{f}/(l^2 W_{min}),$$

where I – moment of inertia of member section, im cm^4;

$$\bar{f} = f_m - f_p;$$

f_m – vibration amplitudeof the member in mid-span normal to the grillage, in mm;

f_p – as defined in Note 2;

l – length of beam between supports, in m;

W_{min} – minimumsection modulus of the member, in cm^3.

.5 Deviations from these standards may be permitted on agreement with the Register.

1.6 REQUIREMENTS FOR SCANTLINGS OF HULL STRUCTURAL MEMBER S

1.6.1 General.

1.6.1.1 This Chapter contains general requirements for plating and framing.

1.6.1.2 Plate structure means a portion of plating bounded by stiffening members. By plate structures are meant portions of the deck, platform and inner bottom plating and portions of the bottom, side, bulkhead plating as well as webs of deep members.

1.6.1.3 In this Part the term "framing" includes primary members and deep members strengthening the plate structures. Deep members also serve as supporting structures for primary members. Primary members are deck longitudinals, side longitudinals, bulkhead longitudinals, inner bottom plating and bottom longitudinals, as well as vertical and horizontal stiffeners of bulkheads, frames, beams, reverse and bottom frames of bracket floors, etc. Deep members are deck transverses, deck girders, web frames, side stringers, floors, side girders, centre girder, vertical webs and horizontal girders of bulkheads, etc.

1.6.1.4 The scantlings of primary and deep members are based on the required section modulus, moment of inertia, web sectional area, thicknesses of web and face plate, as well as width of the face plate. Geometric properties of the member section, unless stated otherwise, are determined taking into account the effective flange.

If the member is so arranged that it is not normal to the effective flange, the section modulus shall be increased in proportion to $1/\cos\alpha$ (where α – is the angle, in deg., between the member web and the perpendicular to the effective flange at the section considered). If $\alpha \le 15^{o}$, no increase of section modulus is required.

1.6.1.5 Rounding off the required scantlings of structural members generally shall be made in the direction of increase. Plate thickness shall be rounded off to the nearest 0,5 or integer of millimetres.

The values of negative rolling tolerances for plates shall comply with the requirements of 3.2.7, Part XII I "Materials".

1.6.2 Symbols.

z_i – vertical distance from horizontal neutral axis of ship to the centre of section area of the longitudinal considered, in m;

i – actual moment of inertia of the longitudinal taking into account the effective flange, in cm^4;

I – actual moment of inertia of the hull about the horizontal neutral axis, in cm^4;

W – section modulus of the member taking into account the effective flange, cm^3;

f – actual section of the member without the effective flange, in cm^2;

f_c – section of the member rib taking into account openings, net, cm^2;

h – depth of the member web, in cm;

l – span of concerned member, determined from 1.6.3.1, in m;

a – spacing, in m, of concerned primary or deep members of longitudinal or transverse framing system; where this varies, a is a half-sum of distances of adjacent members from the member concerned;

$a_п$ – primary member effective flange width, in m;

$c_п$ – deep member effective flange breadth, in m;

p – design pressure at the point of load application, determined in the relevant Chapters of this Part, in kPa.

σ_n – = design specified yield stress for normal stresses, in MPa, determined from 1.1.4.3;

τ_n – design specified yield stress for shear stresses, in MPa, determined from 1.1.4.3;

Δs – corrosion allowance, in mm, determined from 1.1.5.1.

1.6.3 Span and effective flange of member.

1.6.3.1 The span of primary and deep member l is measured along the member face plate as the distance between its span points. Unless provided otherwise, where the end brackets are fitted, the span points shall be taken at the mid-length of the bracket. In this case, the span point position shall be such that the height of the end bracket in it does not exceed the web depth of the member considered (refer to Fig. 1.6.3.1).

For curvilinear members the span shall be taken equal to the chord connecting the span point centres.

1.6.3.2 The thickness of the effective flange is taken equal to its mean thickness in the considered section of the member.

1.6.3.3 The width of the effective flange a_f, in m, of primary members shall be determined by the formulae:

$$a_f = l / 6; \qquad (1.6.3.3\text{-}1)$$

$$a_f = 0,5(a_1 + a_2), \qquad (1.6.3.3\text{-}2)$$

where a_1, a_2 – distance of the considered member from the nearest members of the same direction located on both sides of the considered member, in m.

whichever is the smaller

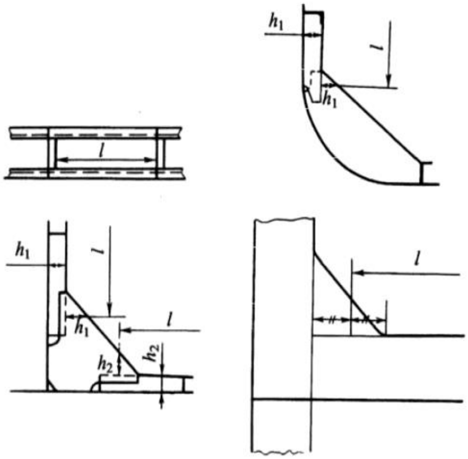


Fig. 1.6.3.1

1.6.3.4 The width of the effective flange of deep members c_f, in m, is determined by the formula:

$$c_{П} = k\,c, \qquad (1.6.3.4)$$

where $c = 0,5(c_1 + c_2)$;

c_1, c_2 – distance of the considered deep member from the nearest deep members of the same direction located on both sides of the considered member, in m;

k – factor obtained from Table 1.6.3.4 depending on c, given span l_{sp} and number n of members supported by considered deep members.

For simply supported deep members the given span $l_{sp} = l$, and for fixed deep members $l_{sp} = 0,6l$.

For intermediate values l_{sp}/c and n factor k is determined by linear interpolation.

The way in which the framing members shall be supported (simple supporting or fixing) is determined proceeding from the general engineering principles with regard for the actual structure (presence of brackets, welding of webs, face plates, etc.) and is characterized by the presence or absence of bending moment effects in the span point of the member.

1.6.3.5 The width of the hatch coaming effective flange shall be equal to one-twelfth of their span but not more than half the distance between the cargo hatch and the ship's side for the side coaming and, accordingly, half the distance between a cargo hatch and a transverse bulkhead (or the beam nearest to the cargo hatch) for the hatch end coaming.

1.6.3. The width of the effective flange of deep members located normal to the direction of corrugations shall be taken equal to 15*s* and 20*s* for trapezoidal and wave-shaped corrugations respectively (*s* = thickness of corrugated plates, in mm) or 0,1*c* (for *c*, refer to 1.6.3.4), in mm, whichever is less.

1.6.3.7 Where primary members parallel to deep members are fitted over the width of the effective flange of the latter, full cross-sectional areas of the above primary members shall be adopted for calculation when determining the inertia moment and section modulus of the deep members.

Table 1.6.3.4

Number of members n	k values at l_{sp}/c						
	1	2	3	4	5	6	7 and more
≥ 6	0,38	0,62	0,79	0,88	0,94	0,98	1
≤ 3	0,21	0,4	0,53	0,64	0,72	0,78	0,8

N o t e . For intermediate values of l_{sp}/c and n the factor k is determined by linear interpolation.

1.6.3.8 In case the area of the effective flange is less than that of the face plate, the determination of section modulus and moment of inertia of the deep members is subject to special consideration by the Register. This requirement applies to deep members of corrugated structures.

1.6.4 Scantlings of structural members.

1.6.4.1 The section modulus W, in cm^3 and moment of inertia i, in cm^4, of primary members of rolled section shall not be less than:

$$W = W'\omega_k, \qquad (1.6.4.1\text{-}1)$$

$$i = i' j_k;$$

for built-up welded members

$$W = W' + \Delta W, \qquad (1.6.4.1\text{-}2)$$

$$i = i' + \Delta i,$$

where W' – section modulus of member considered, in cm^3, in the middle of service life, determined from 1.6.4.2;

i' – moment of inertia of the member considered, in cm^4 in the middle of service life, determined in the relevant sections of these Rules;

ω_k, j_k – multipliers taking into account corrosion allowance, determined in accordance with 1.1.5.3;

ΔW, Δi – part of the section modulus and moment of inertia, which is determined by subsequent increase in thickness of profile elements by the value Δs.

1.6.4.2 The section modulus of member considered, in cm^3, in the middle of service life is determined by the formula

$$W' = Ql \cdot 10^3/(m\, k_\sigma\, \sigma_n), \qquad (1.6.4.2)$$

where $Q = pal$ – transverse load on member considered, in kN;

m, k_σ – factors of bending moment and permissible stresses to be found in the relevant Chapters of this Part.

1.6.4.3 The net sectional area (excluding openings)

f_w, cm², of primary and deep member webs shall not be less than:

.1 for members of rolled section

$$f_c = \frac{10N_{\max}}{k_\tau \tau_n}\omega_k, \qquad (1.6.4.3\text{-}1)$$

.2 for built-up welded members

$$f_c = \frac{10N_{\max}}{k_\tau \tau_n} + 0{,}1h\Delta s, \qquad (1.6.4.3\text{-}2)$$

where $N_{\max}$, k_τ – maximum shear force value and permissible shear stress factor as defined in the relevant Chapters of this Part;

h – general height of the member profile, in cm;

ω_k - refer to 1.1.5.3;

τ_n – refer to 1.1.4.3;

Δs – refer to 1.1.5.1.

1.6.4.4 The thickness s, in mm, of the plates under transverse load shall not be less than

$$s = mak\sqrt{\frac{p}{k_\sigma \sigma_n}} + \Delta s, \qquad (1.6.4.4)$$

where m, k_σ – bending moment and permissible stress factors as defined in the relevant Chapters of this Part;;

$k = 1$ at $a_1/a > 2$;

$k = 0{,}16(a_1/a + 4{,}2)$ at $1{,}5 < a_1/a \le 2{,}0$;

$k = 0{,}70(a_1/a - 0{,}2)$ at $1{,}0 \le a_1/a \le 1{,}5$;

a, a_1 – smaller and greater sizes, in m, of supporting contour sides of plate structure;

Δs – corrosion allowance, in mm, determined from 1.1.5.1.

1.6.4.5 The scantlings of the corrugated structures shall comply with the following requirements:

.1 the thickness of the trapezoidal corrugations shall be determined by Formula (1.6.4.4), taken a equal to b or c, whichever is the greater (refer to Fig. 1.6.4.5).

The following relationship shall be satisfied

$$b/s \le 0{,}95/\sqrt{R_{eH}}, \qquad (1.6.4.5.1)$$

where b – width of the panel parallel to the bulkhead plane, in m (refer to Fig. 1.6.4.5).

Angle φ (refer to Fig. 1.6.4.5*a*) shall be assumed not less than 40°.

.2 the thickness of the wave-shaped corrugations s, in mm, shall not be less than

$$s = 22\beta_0 R\sqrt{\frac{p}{k_\sigma \sigma_n}} + \Delta s, \qquad (1.6.4.5.2\text{-}1)$$

where β_0 – half-angle of spread of corrugation (refer to Fig. 1.6.4.5 ***b***), in rad;

R – radius of corrugation, in m;

k_σ – factor of permissible stresses determined in the relevant Chapters of this Part.

In this case, the following relationship shall be satisfied

$$R/s \le 17/R_{eH}. \qquad (1.6.4.5.2\text{-}2)$$

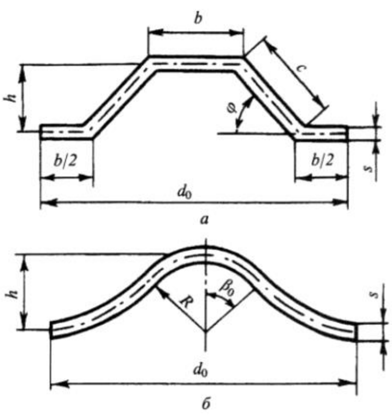


Рис.1.6.4.5. Trapezoidal (***a***) and wave-shaped (***b***) corrugations

.3 the section modulus of the corrugation is determined according to 1.6.4.1, причому

$Q = pd_0 l$,

for d_0 – refer to Fig.1.6.4.5).

The spacing and section modulus of corrugations can be determined by the formulae given in Table 1.6.4.5 (Linear dimensions are expressed in cm, φ, β_0 – in deg.).

Factor γ is determined by the formula:

$$\gamma = 2\frac{\beta_0 + 2\beta_0\cos^2\beta_0 - 1{,}5\sin 2\beta_0}{1 - \cos\beta_0}. \quad (1.6.4.5.3)$$

In calculating the factor γ, the angle β_0 shall be taken in rad.

Table 1.6.4.5

Type of corrugation	Spacing of corrugations	Section modulus
Trapezoidal	$d_0 = 2(b + c\cos\varphi)$	$W = hs(b + c/3)$
Wave-shaped	$d_0 = 4R\sin\beta_o$	$W = \gamma s R^2$

1.6.4.6 Permissible stress factors k_σ and k_τ, defined in the relevant Chapters of this Part may be increased by 5 per cent for ships of restricted areas of navigation:

R2, A-R2, R2-S, R2-RS, A-R2-S, A-R2-RS;

and by 10 per cent for **R3-S, R3-RS, B-R3-S, B-R3-RS, C-R3-S, C-R3-RS, R3, R3-IN, D-R3-S, D-R3-RS**,

unless dependent upon the factors k_B and k_D determined by Formula (2.2.4.1).

The above applies only to hull members, not participating in a longitudinal bending under 1.4.

1.6.5 Buckling strength of hull structural members.

1.6.5.1 The buckling strength of longitudinals, shell plates and hull structure plating shall be ensured in ships of unrestricted service **A** and ships of restricted areas of navigation **R1**, **A-R1** i **R2**, **A-R2** 65 m and greater in length, of restricted areas of navigation **R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, **R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** 60 m and greater in length subject to compressive stresses due to longitudinal bending of the hull girder.

Effective compressive streses σ_c, in MPa, shall be determined by the following formula

$$\sigma_c = M_T z_i \cdot 10^5 / I \geq 30/\eta, \quad (1.6.5.1\text{-}1)$$

where M_T – design bending moment, in kN-m, at the section under consideration equal to the maximum absolute value of algebraic sum of the moment components; $M_T = |M_{sw} + M_w|$ - for longitudinal members arranged below the neutral axis;

$M_T = |M_{sw} + M_w + M_F|$ - for longitudinal members arranged above the neutral axis;

M_{sw} – as defined in 1.4.3, in kN·m;

M_w – as determined from 1.4.4, in kN·m.

M_F – refer to1.4.4.4, in kN·m.

The maximum hogging bending moment shall be assumed as design value M_T for longitudinal members arranged below the neutral axis, and the maximum sagging bending moment — for longitudinal members arranged above the neutral axis.

The buckling strength of side shell and longitudinal bulkheads at the section considered shall be ensured under shear stresses τ_c, in MPa, calculated by the following formulae:

for side shell plating in ships without effective longitudinal bulkheads

$$\tau_c = \frac{N_{sw} + N_w}{2s}\frac{S}{I}\cdot 10^2, \quad (1.6.5.1\text{-}2)$$

for side shell plating in ships with

two effective longitudinal bulkheads

$$\tau_c = \frac{N_{sw} + N_w}{s_s} \frac{S}{I} \alpha_s \cdot 10^2 ,(1.6.\ 5.1\text{-}3)$$

for longitudinal bulkhead plating in ships with two effective longitudinal bulkheads

$$\tau_c = \frac{N_{sw} + N_w}{s_l} \frac{S}{I} \alpha_l \cdot 10^2 \ , (1.6.5.1\text{-}4)$$

where N_{sw} – still water shear force at the section considered, defined in 1.4.3, in kN;

N_w – wave vertical shear force determined from 1.4.4.2;

s – actual thickness of side shell plating in ships without longitudinal bulkheads, in mm;

s_s, s_l – actual thicknesses of side shell plating and longitudinal bulkhead plating at the section considered in ships with two longitudinal bulkheads, in mm;

S, I – as defined in 1.4.2;

for α_s, α_l – refer to 1.4.6.2.

Where one or more than two continuous longitudinal plane bulkheads or longitudinal bulkheads with horizontal corrugations are fitted, the shear stresses are determined by a procedure approved by the Register.

1.6.5.2 The buckling strength of longitudinal members is considered sufficient if the following conditions are met:

$$k\, \sigma_c \le \sigma_{cr}; \quad \tau_c \le \tau_{cr}, \quad (1.6.5.2\text{-}1)$$

where k = 1,0 – for plating and for web plating of stiffeners;

k = 1,1 – for stiffeners;

for σ_c i τ_c – refer to1.6.5.1;

for σ_{cr} *i* τ_{cr} – refer to1.6.5.3.

For plate panels, the factor *k* may be reduced in respect of ships of restricted navigation areas:

R1, **A-R1** – by 10 per cent;

R2, **A-R2**, **R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS** – by 15 per cent;

B-R3-S, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, **R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** – by 20 per cent

The factor k for plate panels of a hull of berth connected ships is subject to special consideration of the Register.

In this case, when determining the actual section modulus of hull in accordance with 1.4.7 the strength reduction of compressed plate shall be considered, i.e. where $\sigma_{cr} < \sigma_c$ the plates shall be included in the hull girder section, except for the areas adjoining the longitudinals and having a breadth equal to 0,25 of the shorter side of supporting contour, with the reduced factor ψ_n, to be determined by the formula

$$\psi_n = \sigma_{cr} / \sigma_c\ . \qquad (1.6.5.2\text{-}2)$$

1.6.5.3 Critical stresses σ_{cr} and τ_{cr}, in MPa, shall be determined by the formulae:

$\sigma_{cr} = \sigma_e$ when $\sigma_e \le 0,5\, R_{eH}$;

$\sigma_{cr} = R_{eH}\ (1,00 - R_{eH} / 4\sigma_e)$ when $\sigma_e > 0,5\, R_{eH}$;

$\tau_{cr} = \tau_e$ when $\tau_e \le 0,29\, R_{eH}$;

$\tau_{cr} = R_{eH}\ (0,58 - 0,08\, R_{eH} / \tau_e)$ when $\tau_e > 0,29\, R_{eH}$,

where σ_e and τ_e – = Euler normal and shear stresses to be determined in accordance with 1.6.5.4 and 1.6.5.5.

1.6.5.4 When checking the buckling strength, the Euler stresses σ_e, in MPa, for primary and deep longitudinal members shall be determined by the following formulae:

.1 for column buckling of primary longitudinal members without rotation of the cross section,

$$\sigma_e = 206\, i / f\, l^2\ , \qquad (1.6.5.4.1)$$

where i – moment of inertia, in cm^4, of longitudinal, including plate flange and calculated with thickness reduced by the value of Δs (for Δs – refer to Table 1.6.5.5-2);

f – cross-sectional area, in cm^2, of longitudinal, including plate flange and calculated with a thickness reduced by the value of Δs (for Δs refer to Table 1.6.5.5-2); a plate flange equal to the frame spacing may be included;

.2 for torsional buckling of primary longitudinal members

$$\sigma_e = (203/l^2)(i_w/i_p)(m^2+k/m^2)+79310\, i_t/i_p, \quad (1.6.5.4.2)$$

where $k = 0{,}05\, c\, l^4 / i_w$;

m – number of half waves, given by Table 1.6.5.4;

i_t – moment of inertia, in cm ^{4}, of profile under simple torsion (without plate flange), determined as follows:

$i_t = h_c\ s_c^3 / 30000$ – for flat bars;

$i_t = [h_c\, s_c^3 + b_п\, s_п^3\, (1 - 0{,}63\, s_п / b_п)] / 30000$ – for angles, bulb, symmetrical bulb and T-profiles;

i_p – polar moment of inertia, in cm^4, of profile about connection of stiffener to plate, determined as follows:

$i_p = h_c^3\, s_c / 30000 - 4$ for flat bars;

$i_p = (h_c^3\, s_c + 3\, h_c^2\, b_п\, s_п) / 30000$ – for angles, bulb, symmetrical bulb and T-profiles;

i_w – sectional moment of inertia, in cm^6, of profile about connection of stiffener to plate, determined as follows:

$i_w = h_c^3\, s_c^3 \cdot 10^{-6} / 36$ – for flat bars;

$i_w = s_п\ b_п^3\ h_c^2 \cdot 10^{-6} / 12$ – for T- and symmetrical bulb profiles;

$$i_w = \frac{b_п^3 h_c^2}{12\,(b_п + h_c)^2}\left[s_п\left(b_п^2 + 2b_п h_c + 4h_c^2\right) + 3s_c b_п h_c\right]\cdot 10^{-6}$$

– for angles and bulb profiles;

h_c – web height, in mm;

s_c – web thickness, in mm, reduced by the value of Δs (for Δs – refer to Table 1.6.5.5-2);

b_f – flange width, in mm, for angles and T-profiles or bulb width, in mm, for bulb and symmetrical bulb profiles;

$s_п$ – flange thickness or bulb thickness, in mm, reduced by the value of Δs for Δs – refer to Table 1.6.5.5-2). For bulb and symmetrical bulb profiles, s_f may be adopted equal to the mean thickness of the bulb;

c – spring stiffness exerted by supporting plate panel, determined by the formul

$$c = \frac{68{,}7\, k_p\, s^3}{\left(1 + \dfrac{1{,}33\, k_p\, h_c\, s^3}{a\, s_c^3}\cdot 10^{-3}\right) a};$$

$k_p = 1 - \sigma_c/\sigma_e \geq 0$ (to be taken not less than 0,1 for angles, bulb, symmetrical bulb and T-profiles);

σ_c – compressive stress according to 1.6.5.1;

σ_e – Euler stress of supporting plate according to 1.6.5.5;

s – supporting plate thickness, in mm, reduced by the value of Δs for Δs – refer to Table 1.6.5.5-2);

a – distance between longitudinals.

Table 1.6.5.4

k	$0 < k < 4$	$4 < k < 36$	$36 < k < 144$	$(m-1)^2 m^2 < k < m^2(m+1)^2$
m	1	2	3	m

.3 for web and flange buckling

$$\sigma_e = 7{,}83(s_c/h_c)^2 \cdot 10^5; \quad (1.6.5.4.3)$$

for flanges of deep longitudinal members buckling is taken care by the following requirement

$$b_f / s_f \geq 15,$$

where b_f – flange width, in mm, for angles, half the flange width for T-sections;

s_f – flange thickness, in mm.

1.6.5.5 Euler normal σ_e and shear τ_e stresses, in MPa, for plate structures shall be determined as for rectangular plates by the formulae:

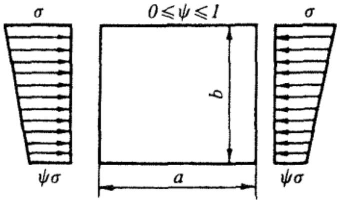
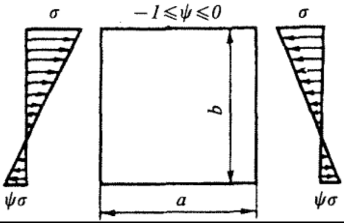
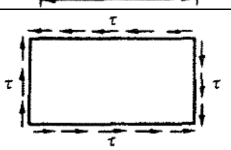
$$\sigma_e = 0{,}1854\, n\, (s' / b)^2; \quad (1.6.5.5\text{-}1)$$

$$\tau_e = 0{,}1854\, n\, (s' / b)^2, \quad (1.6.5.5\text{-}2)$$

where n factor depending on the load type of the plate and the ratio of sides (Table 1.6.5.5-1);

s' – as-built thickness of the plate reduced by the value of Δs, obtained from Table 1.6.5.5-2;

Table 1.6.5.5-1

Type of load	$\gamma = a / b$	n
	$\gamma > 1$	$\dfrac{8,4}{\psi + 1,1}$
	$\gamma \le 1$	$\varepsilon\left(\gamma + \dfrac{1}{\gamma}\right)^2 \dfrac{2,1}{\psi + 1,1}$
	$\gamma > 1$	$10\,\psi^2 - 6,4\,\psi + 7,6$
	$\gamma \le 1$	$\varepsilon\left[10\,\psi^2 - 14\psi + 1,9\,(1+\psi)\,(\gamma + 1/\gamma)^2\right]$
	$\gamma > 1$	$5,34 + 4 / \gamma^2$

N o t e s :

1. ψ – ratio between smallest and largest compressive stress when linear variation across panel;
2. ε = 1,3 – when plating is stiffened by floors or deep girders;
   1,21 – when stiffeners are angles, symmetrical bulbs or T-sections;
   1,1 – when stiffeners are bulb flats;
   1,05 – when stiffeners are flat bars.

Table 1.6.5.5-2

Structure	Δs, mm
Compartments carrying dry bulk cargoes. Vertical surfaces and surfaces sloped at an angle greater than 25° to the horizontal line. One side exposure to ballast and/or liquid cargo	0,05 s ($0,5 \le \Delta s \le 1$)
Horizontal surfaces and surfaces sloped at an angle less than 25° to the horizontal line. One side exposure to ballast and/or liquid cargo Vertical surfaces and surfaces sloped at an angle greater than 25° to the horizontal line. Two side exposure to ballast and/or liquid cargo	0,10 s ($2 \le \Delta s \le 3$)
Horizontal surfaces and surfaces sloped at an angle less than 25° to the horizontal line. Two side exposure to ballast and/or liquid cargo	0,15 s ($2 \le \Delta s \le 4$)

s – as-built thickness, in mm, of the structural member under consideration.

N o t e . Δs = 0 otherwise.

b – plate side located normal to the direction of normal compressive stresses; when the plate is exposed to shear stresses, b is the smaller side of the plate, in m.

1.6.5.6 The moment of inertia i, in cm^4, of the stiffeners on deep girder webs (refer to 1.7.3.2) shall not be less than determined by the formulae:

for the stiffeners fitted normal to the girder face plate

$$i = \gamma\, a\, s^3 \cdot 10^{-3}; \qquad (1.6.5.6\text{-}1)$$

for the stiffeners parallel to the girder face plate

$$i = 2{,}35(f + 0{,}1\, a\, s)\, l^2/\eta, \qquad (1.6.5.6\text{-}2)$$

where γ – coefficient obtained from Table 1.6.5.6 depending on the ratio of the girder web depth h to the spacing of stiffeners a;

a – spacing of stiffeners, in cm;

s – actual thickness of the web, in mm;

f – actual cross-sectional area of the stiffener, in cm^2 ;

l – span of the stiffener, in m;

η – as determined according to 1.1.4.3.

Table 1.6.5.6

h/a_1	1 and less	1,2	1,4	1,6	1,8	2,0	2,5	3,0	3,5	4,0
γ	0,3	0,6	1,3	2,0	2,9	4,1	8,0	12,4	16,8	21,2

N o t e : The intermediate values of y are determined by linear interpolation.

1.6.6 Aluminium alloy structures.

1.6.6.1 The scantlings of aluminium alloy structures shall be determined by conversion of the scantlings relating to the corresponding steel structures. The conversion shall be made using the formulae of Table 1.6.6.1 without considering the limits by minimum scantlings of steel structures.

1.6.6.2 The sectional area of sternframe, stem, bar keel and propeller shaft brackets shall be 1,3 times that required for steel application.

1.6.6.3 Where continuous welds (fillets, butt welds) are located in most stressed positions, account shall be taken of the reduction in strength at the welded joint location depending on the given aluminium alloy and the process of welding.

Таблиця 1.6.6.1

Parameter	Requirement
Thickness of plating for the shell, decks (without covering), bulkheads, enclosures and other details made of plates	$s_1 = s\sqrt{R_{eH} / R_{p_{0,2}}}$ – for superstructures; $s_1 = 0{,}9s\sqrt{R_{eH} / R_{p_{0,2}}}$ – for main hull
Section modulus of framing members	$W_1 = W \cdot R_{eH} / R_{p0,2}$
Cross-sectional area of pillars	$f_1 = f \cdot R_{eH} / R_{p0,2}$
Moment of inertia of pillars and framing members	$I_1 = 3I$

N o t e . $R_{p_{0,2}}$ – proof stress of aluminium alloy, in MPa.

The values of *s, W, f, I,* as stipulated by the Rules may be adopted without corrosion allowance.

1.6.6.4 On agreement with the Register, the bimetallic (steel — aluminium) pressed elements for connection of steel and aluminium alloy structures may be used.

1.7 WELDED STRUCTURES AND JOINTS

1.7.1 General.

1.7.1.1 Any change in the shape or section of the members of welded hull structure shall take place gradually. Al l openings shall have rounded corners and smooth edges.

1.7.1.2 The scantlings of sections and the thicknesses of plates used for longitudinal members shall change gradually throughout the ship's length.

Any change of framing system and plating thicknesses used for the strength deck, bottom, side shell and longitudinal bulkheads shall not be permitted in areas where mechanical properties of steel change.

1.7.1.3 Continuity shall be ensured for as many of main longitudinal members as possible, and a gradual change of their sections is required in way of the ends together with other arrangements, contributing to the reduction of stress concentration.

1.7.1.4 In tight structures, as well as in non-tight structures subject to intense vibration, stiffeners and similar details shall be fitted to prevent hard spots in the plating at the toes of brackets and in way of face plates of the members passing through, or terminating at the above-mentioned structures.

1.7.1.5 The length of unsupported plating between the end of a longitudinal and the nearest web normal to direction member shall be as short as possible, however, not more than 4*s* or 60 mm, whichever is less (*s* = plate thickness, in mm).

1.7.1.6 For the purpose of this Part of the Rules, the hull structures subject to intense vibration are those situated in way of machinery and equipment which constitute a source of vibration.

Considered as regions with high level of vibration in all ships are the regions situated below the lower platform continuous within the engine room and bounded:

at aft end, by a section forward of the edge of propeller boss at twice the propeller diameter, but not less than to the after peak bulkhead;

in the engine room, by the bulkheads of this space.

The bulkheads forming boundaries of engine room, the after peak bulkhead and the lower continuous platform in the above regions throughout the length of the ship are considered to be structures subject to intense vibration.

1.7.1.7 In way of the ends of bulwark, bilge keels, and other details welded to the hull, as well as generally of gutterway bars, their height shall decrease on a length of at least 1,5 times the height of these members. The ends of bulwarks shall be tapered. This is also recommended for the portions of the ends of the gutter bars.

1.7.1.8 Welded joints, welding consumables and procedures, testing and inspection methods of welded joints shall comply with requirements of Part XI V "Welding".

1.7.2 Connections of framing members.

1.7.2.1 In general, the framing members shall have butt-welded joints. Overlapping joints may be allowed on agreement with the Register, except in regions with high level of vibration, deep member connections and in way of heavy concentrated loads.

In general, brackets shall be made of steel having the same yield stress as the steel of the members connected.

1.7.2.2 Connections of primary members.

.1 Unless provided otherwise, the size of brackets *c*, in cm, measured in accordance with Fig. 1.7.2.2.1 shall be determined by the formula

- for rolled profiles members:

$$c = 5{,}5\sqrt[3]{W_0}, \quad (1.7.2.2\text{-}1)$$

- for welded profile members:

$$c = 4{,}0\sqrt[3]{W}, \quad (1.7.2.2\text{-}2)$$

where W – required section modulus of the member attached, in cm^3;

W_0 – section modulus of the fixed member, not taking into account the effective flange, in cm^3;

The thickness of bracket is taken equal to that of the member web. Where the web thickness is more than 7 mm the bracket thickness may be reduced by 1 mm; where the web thickness is more than 12 mm, the bracket thickness may be reduced by 2 mm.

Where a bracket connects two members of different profile, the characteristics of the smaller profile shall be used for determining the bracket size.

The bracket height *h* (refer to Fig. 1.7.2.2.1) shall be not less than 0,7 times the required size *c.*

The size of brackets determined as indicated above, refers to the case when the members to be interconnected are not welded to each other or the member butts are not welded to the plating. The allowable gap shall not exceed 40 mm or 25 per cent of size c, whichever is less. Otherwise, *c* may be required to be increased.

.2 If the free edge *l* in mm, of a bracket (refer to Fig. 1.7.2.2.1) is longer than 45*s* (*s* – thickness of the bracket, in mm) the bracket shall have a flange (face plate).

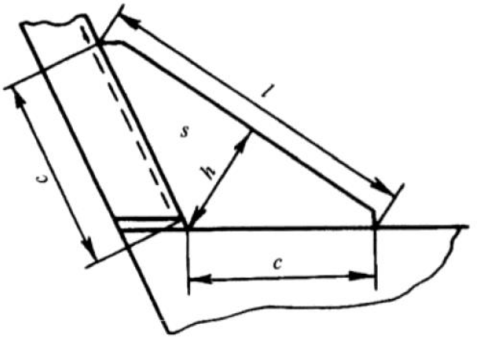


Fig.1.7.2.2.1

The width of the flange shall be not less than 50 mm, the width of the face plate, not less than 75 mm. The thickness of the face plate shall not be less than that of the bracket. The width of the flange (face plate) shall be in accordance with the requirements of 1.7.3.1.

.3 The size of brackets may be reduced:

by 10 per cent, where the framing members are welded to each other or to the plating;

by 15 per cent, where a face plate or flange is provided;

by 25 per cent, where the framing members are welded to each other and the brackets are provided with a face plate or flange.

.4 In regions with high level of vibration the butt ends of framing members shall generally be connected, with the minimum dimensions of the plating portions unsupported by the framing (refer to Fig. 1.7.2.2.4).

.5 Where there is a gap between the butt of beam and the frame in way of side strengthening of ships mooring at sea, in region I of ships of ice classes **Ice6, Ice5, Ice4,** and in region **AI** of ships of ice class **Ice3**, the beam bracket shall have a face plate or flange.

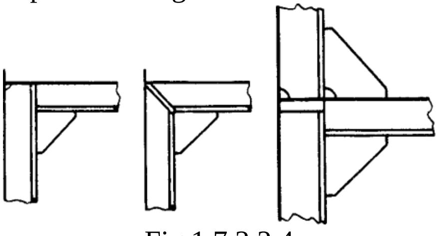


Fig.1.7.2.2.4

1.7.2.3 Deep members are recommended to be connected by rounded brackets with smooth change of web depth and face plate size.

.1 The height and width of brackets interconnecting the members, or attaching them to bulkheads are, unless provided otherwise, to be not less than the members web depth (or the lesser web depth of the members connected). The bracket thickness is assumed equal to the lesser of the member web thicknesses. In member connections no gaps are permissible.

.2 The brackets connecting the members shall have a face plate or flange along the free edge. In places of transition from the face plates of brackets to those of members, the width and thickness of the face plate along the free edge at different sizes of the member face plates shall change smoothly. The area of face plate (or flange) of tripping bracket shall be taken not less than 0,8 times the area of lesser face plate of the members connected.

If the distance, in mm, between bracket ends exceeds $l \geq 160s\sqrt{\eta}$, in mm, (*s* - thickness of bracket) a stiffener shall be fitted parallel to the line connecting bracket ends at the distance a equal to l / 4 of the bracket height or 35 times its thickness (whichever is less). The inertia moment of the stiffener shall be determined by Formula (1.6.5.6-2).

Brackets shall be additionally stiffened depending on their size and configuration (refer to 1.7.3.2.2).

.3 The radius of rounding shall not be less than the depth of the smaller members connected.

The webs and face plates shall be supported by stiffeners and tripping brackets in way of rounding (refer to Fig. 1.7.2.3).

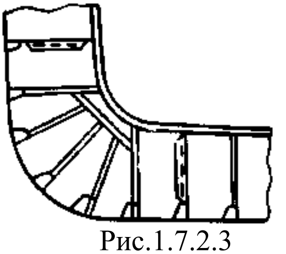


Рис.1.7.2.3

1.7.2.4 The constructions used for the attachment of primary members to supporting members shall comply with existing standards.

1.7.3 Construction of deep member.

1.7.3.1 The depth *h* and thickness s_w of member webs (as well as of built-up primary members) and their sectional area are regulated by the relevant Chapters of this Part. The width of member face plate *b*, in mm, as measured from its web, shall not be more than

$$b = 200s_{п} / \sqrt{R_{eH}}, \qquad (1.7.3.1)$$

where $s_{f.p}$ – thickness of member face plate, in mm.

The thickness of face plate shall not normally exceed a triple thickness of the web plate.

1.7.3.2 Where $h/s_c \geq 60\sqrt{\eta}$, (for h and s_w, in mm, refer to 1.7.3.1), the webs of members (except for those whose buckling strength shall be checked in accordance with 1.6.5) shall be stiffened by tripping brackets and stiffeners (refer to Fig. 1.7.3.2)..

.1 Where $h/s_c \geq 160\sqrt{\eta}$, the webs of members shall be stiffened with the stiffeners fitted parallel to the member face plate (refer to Fig. 1.7.3.2,***a***) The spacing of stiffeners (width of non-stiffened web area), in mm, shall not be greater than $a_1 = 890 s_c / \sqrt{R_{eH}}$.

Where $h/s_c < 160\sqrt{\eta}$, stiffening may be carried out as shown in Fig. 1.7.3.2 ***b*** and ***c***.

The spacing of stiffeners (width of non-stiffened web area), in mm, shall not be greater than $a_2 = 1300\, s_c / \sqrt{R_{eH}}$.

On agreement with the Register, the structure shown in Fig. 1.7.3.2 ***d*** may be permitted.

In way of portions equal to 0,2l, but not less than l,5h from supports (l and h are the span and depth of member web respectively), the spacings a_1 and a_2 shall be reduced 1,5 times.

Stiffeners fitted normal to the face plate of the member supporting primary members (e.g. longitudinals, bulkhead stiffeners, frames, etc.) shall be fitted not further than in line with every second member in question.

The smaller side b of the double bottom floor web panel shall not be greater than $b = 1600\, s_c / \sqrt{R_{eH}}$.

Variation from the above spacing of stiffeners may be allowed on the basis of the results of direct strength calculation..

.2 The thickness of stiffener shall not be less than 0,8s_w. Moment of inertia of the stiffeners is determined according to 1.6.5.6.

.3 The tripping brackets stiffening deep members shall be fitted at the toes of brackets securing the members in way of roundings and struts as well as in way of span of the member (refer to Fig. 1.7.3.2, ***a*** and ***b***).

In any case, the spacing of brackets shall not exceed 3,0 m or 15 $b_{f.p}$ ($b_{f.p}$ – full width of face plate, in mm), whichever is less.

The thickness of the tripping brackets shall be not less than required for the member web. The brackets shall be extended to the member face plate and be welded to it if the width of the face plate exceeds 150 mm, as measured from the member web to the free edge of face plate. The width of the bracket section being welded shall be at least 10 mm smaller than the face plate width. Where the width of face plates symmetric to the member web exceeds 200 mm, small brackets shall be fitted at the opposite side of the web in line with the tripping bracket.

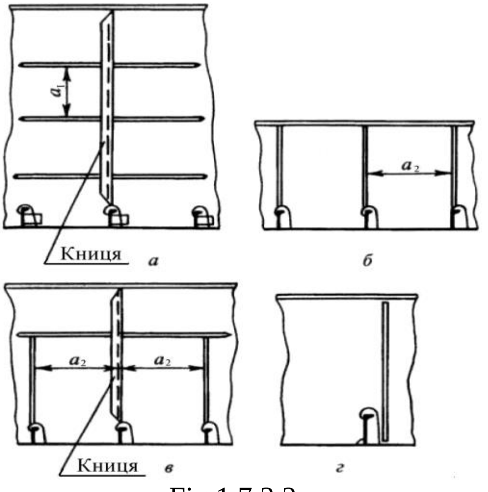


Fig.1.7.3.2

The width of the tripping brackets, measured at the base shall not be less than half their depth.

The bracket shall have a face plate or flange if the length of free edge $l > 60s$ (s – thickness of bracket, in mm). The width of the face plate or flange shall not be less than l / s. Face plates or flanges ends of the tripping brackets shall be sniped.

1.7.3.3 Lightening holes, cut-outs for the passage of framing members, etc. are permitted in the member webs.

The total depth of openings in the same section shall not exceed 0,5 of the member depth. For deck transverses, deck girders, webs and girders of watertight bulkheads in dry cargo ships, this value may be increased to 0,6 of the member depth.

The distance from the edges of all openings in deep members to the edges of cut-outs for the passage of primary members shall not be less than the depth of these members.

The openings in deep member webs, except for cut-outs for the passage of primary members, shall be located at a distance not less than half the deep member depth from the toes of brackets attaching this member.

Where it is impossible to satisfy this requirement, compensation shall be provided by local thickening of the web, fitting of collars, etc. In all cases, the sectional area of a deep member (excluding openings) shall not be less than required in the relevant Chapters of this Part.

For requirements regarding openings in floors, side girders and centre girder, refer to 2.4.2.7.

1.7.4 Details of welded structures.

1.7.4.1 The face plates and/or webs shall be sniped at the member ends depending on the construction used for attachment of members

1.7.4.2 The width of flange (face plate) of brackets shall not be less than 8 bracket thicknesses unless expressly provided otherwise in the relevant Chapters of this Part.

1.7.4.3 The edges of brackets, face plates and webs of the members shall be welded all round and shall have no craters. This requirement also applies to air and drain holes and cut-outs for the passage of framing members and welded joints.

Where these openings are carried to the deck or bottom shell plating, their length as measured at the plating, shall comply with the requirements of 1.7.5.8.

1.7.4.4 Welded joints shall be arranged in least stressed structural sections, as far as practicable from abrupt changes of sections, openings and details which were subject to cold forming.

1.7.4.5 The butt joints of face plates of the intersection girders under variable dynamic loads (e.g. in regions with high level of vibration) shall be made with smooth transition by means of diamond plates.

1.7.4.6 It is recommended that local concentration of welds, crossings of welds at an acute angle, as well as close locations of parallel butts or fillet welds and butt welds, be avoided. The distance between parallel welded joints, whatever their direction, shall not be less than:

200 mm between parallel butt welds;

75 mm between parallel fillet and butt welds;

50 mm between parallel fillet and butt welds on a length not exceeding 2 m.

On agreement with the Register, the distance between welded joints may be reduced.

The angle between two butt welds shall not be less than 60° (refer to Fig.1.7.4.6).

1.7.4.7 The butts (seams) in assembling joints of the plating shall be located at a distance not less than 200 mm from the bulkheads, decks, inner bottom plating, deep members fitted parallel to the abovementioned joints.

In assembling joints, the welded butts of built-up members shall be arranged so that the butts of a member web are not less than 150 mm clear of the butts of this member face plate. On agreement with the Register, the butts of webs and face plates may be arranged in the same plane provided that:

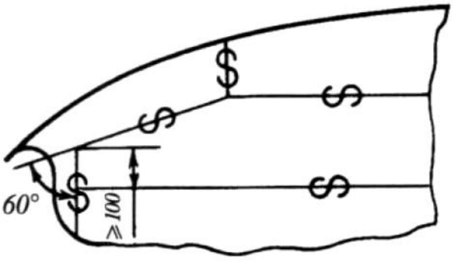


Fig.1.7.4.6

full penetration welding is ensured at the connection of the web to face plate on a length of at least 100 mm each side of the butt by non-destructive testing (NDT) of the welded butt in every third member;

overlapping of the butt by the framing elements (knees, brackets, etc., fitted in line with the web) is ensured on a length not less than the face plate width each side of the butt.

1.7.5 Types and dimensions of fillet welds.

1.7.5.1 The design throat thickness *a*, in mm, of fillet welds for tee-connections for manual and semiautomatic welding shall not be less than

$$a = \alpha\beta s, \qquad (1.7.5.1)$$

where α – weld factor given in Table 1.7.5.1-1. For structures inside cargo tanks of tankers α shall be increased by 0,05;

β – factor given in Table 1.7.5.1-2 depending on the ratio of weld pitch *t*, in mm, to weld length *l*, in mm (refer to Fig. 1.7.5.1-1);

s – thickness of the lesser of the parts joined.

The relationship between the leg length of the fillet weld and the height of the isosceles triangle inscribed into the cross section of the weld (refer to Fig. 1.7.5.1-2) shall be assumed as $k = 1,4a$ or $a = 0,7k$. When automatic welding is employed instead of the proposed manual welding, the weld throat or leg length, whichever is adopted in calculation, may be reduced in height for single-run welds by not more than 30 per cent.

For multirun welds the percentage of the above reduction is subject to special consideration by the Register.

If the thickness of the thinner of the items to be joined is less than half the thickness of the thicker item, then the leg lengths are subject to special consideration by the Register.

The throat thickness a of a fillet weld shall not be less than:

2,5 mm for $s \le 4$ mm;
3,0 mm for $4 < s \le 10$ mm;
3,5 mm for $10 < s \le 15$ mm;
0,25s mm for $s > 15$ mm.

The dimensions of fillet welds taken from calculations shall not exceed $a \le 0{,}7s$ ($k \le s$).

1.7.5.2 Overlapping connections, if allowed (refer to 1.7.2.1), shall be welded all round by continuous weld with factor 0,4. The length of overlap, in mm, shall be not less than $b = 2s + 25$, but not more than 50 mm (s – thickness of the thinner of the plates joined).

1.7.5.3 The primary members (beams, deck longitudinals, frames, bulkhead stiffeners, etc.) shall be connected to supporting members (deck girders, deck transverses, side stringers, horizontal girders, etc.) by welds with factor 0,35.

Table 1.7.5.1-1

Nos.	Connection of structural members	Weld factor α
1	**2**	3
1	**Double bottom**	
1.1	Centre girder and duct keel to plate keel	0,35
1.2	Ditto to inner bottom plating	0,25
1.3	Ditto to inner bottom plating in the engine room and in way of thrust bearings	0,35
1.4	Floors to centre girder and duct keel under engines, boilers, thrust bearings and within 0,25L from F.P.	0,35
1.5	Floors to centre girder and duct keel elsewhere	0,25
1.6	Floors to margin plate and inner bottom plating under the corrugated bulkhead plates	0,35
1.7	Watertight floors, portions of side girders or centre girder round the boundaries of tanks, plating of bilge wells to their bottom plates and to inner bottom, floors and side girders	0,35
1.8	Floors and side girders to shell plating within 0,25L from F.P.	0,25
1.9	Ditto, elsewhere	0,20
1.10	Floors and side girders to inner bottom plating under engines, boilers and thrust bearings	0,25
1.11	Ditto, elsewhere	0,15
1.12	Floors to side girders within 0,25L from F.P.	0,25
1.13	Ditto, elsewhere	0,20
1.14	Margin plate to shell plating	0,35

Nos.	Connection of structural members	Weld factor α
1.15	Inclined margin plate to inner bottom plating	0,35
1.16	Bracket floors: bottom frames and brackets to shell plating	0,15
1.17	Reverse frames and brackets to inner bottom plating	0,10
1.18	Brackets, frames (refer to 2.4.4.5) to duct keel, plate keel, shell and inner bottom plating	0,35
1.19	With longitudinal framing, bottom transverses to shell, inner bottom plating, centre girder and duct keel, margin plate where the floor spacing is less than 2,5 m outside the regions defined in 1.4 and 1.7	0,25
1.20	Ditto, with floor spacing 2,5 m and more, in all regions	0,35
1.21	Longitudinals to shell plating within 0,25L from F.P.	0,17
1.22	Ditto, with floor spacing 2,5 m and more, in all regions	0,35
1.23	Longitudinals to inner bottom plating	0,10
1.24	Brackets (refer to 2.4.2.5.2) to shell plating, margin plate, inner bottom plating and longitudinals	0,25
2	**Single bottom**	
2.1	Centre girder to plate keel	0,35
2.2	Centre girder to face plate	0,25
2.3	Floors to centre girder and longitudinal bulkheads	0,45
2.4	Floors and side girder webs to their face plates and to shell plating under engines, boilers and thrust bearings, as well as in the after peak	0,25
2.5	Floors and side girder webs to shell plating elsewhere	refer to 1.8, 1.9, 1.19 i 1.20
2.6	Floors and side girder webs to their face plates elsewhere	0,15
2.7	Side girder webs to floors	0,20
2.8	Bottom longitudinals to shell plating	refer to 1.21 i 1.22
3	**Side framing**	
3.1	Frames (including web frames) and side stringers to shell plating within 0,25L from F.P. in tanks, in the engine room, in way of ice strengthening and strengthening of sides of ships mooring at sea alongside other ships or offshore units	0,17
3.2	Ditto, elsewhere	0,13
3.3	Frames (including web frames) and side stringers to their face plates in regions defined in 3.1	0,13
3.4	Ditto, elsewhere	0,10
3.5	Frames (including web frames) and side stringers to shell plating in the after peak	0,25
3.6	Ditto to their face plates	0,17
3.7	Side stringers to web frames	0,25
3.8	Side longitudinals to shell plating	0,17
3.9	Ditto to face plates	0,13
3.10	Bilge brackets to margin plate and face plates of floors outside double bottom	0,35[1]
3.11	Ditto to shell plating	0,25
4	**Deck framing and decks**	

Nos.	Connection of structural members	Weld factor α
4.1	Deck transverses and girders to deck plating	0,17
4.2	Ditto to their face plates	0,13
4.3	Cantilever beams to deck plating and to their face plates	0,25
4.4	Webs of deck transverses to girder webs and bulkheads	0,25
4.5	Beams in way of tanks, fore and after peaks, as well as hatch end beams, to deck plating	0,15
4.6	Ditto, elsewhere	0,10
4.7	Deck longitudinals to deck plating and their face plates	0,10
4.8	Stringer plate of strength deck to shell plating	0,45[2]
4.9	Ditto for other decks and platforms	0,35[1]
4.10	Hatch coamings to deck plating at hatch corners	0,45[2]
4.11	Ditto, elsewhere	0,35[3]
4.12	Face plates of hatch coamings to vertical plates of same	0,25
4.13	Stays, horizontal and vertical stiffeners to vertical plates of hatch coamings	0,20
4.14	Side and end bulkheads of superstructures and deckhouses to deck plating	0,35
4.15	Other bulkheads of superstructures and deckhouses to deck plating	0,25
4.16	Bulwark stays to bulwark plating	0,20
4.17	Bulwark stays to deck and guard rails	0,35
4.18	Pillars to deck and inner bottom, pillar brackets to pillars, decks, inner bottom and other structures	0,35
5	**Bulkheads and partitions**	
5.1	Fore and after peak bulkheads, tank (cargo oil tank) boundaries, bulkheads (including wash bulkheads) inside after peak around the perimeter	0,35
5.2	Other watertight bulkheads (including wash bulkheads) to bottom shell or inner bottom plating, shell plating in way of the bilge	0,35
5.3	Ditto to sides and deck	0,25
5.4	Vertical box corrugations of corrugated bulkheads to inner bottom plating or upper strake of lower stool	0,35
5.5	Shaft tunnel plating all round	0,35
5.6	Vertical and horizontal stiffeners to bulkhead plates under 5.1, and to wash bulkheads	0,15
5.7	Ditto of other bulkheads	0,10
5.8	Vertical webs and horizontal girders to bulkhead plates according to 5.1, and to wash bulkheads	0,17
5.9	Ditto to their face plates	0,13
5.10	Vertical webs and horizontal girders to plating of other bulkheads	0,13
5.11	Ditto to their face plates	0,10
5.12	Transverse bulkheads to wash bulkheads	0,35[1]
6	**Brackets and stiffeners**	
6.1	Brackets for interconnection of structural members	0,35[3]
6.2	Stiffeners and tripping brackets (refer to 1.7.3.2) of deep members, floors, etc	0,10

Nos.	Connection of structural members	Weld factor α
7	**Foundations for main engines, boilers and other machinery**	
7.1	Vertical plates to shell, inner bottom and deck plating	0,35[4]
7.2	Top plates (face plates) to longitudinal girders, brackets, knees	0,45[2]
7.3	Brackets and knees of foundations to vertical plates, shell plating, inner bottom (floor face 0,353 plates) and to deck plating	0,35[4]
7.4	Brackets and knees to their face plates	0,25

[1] Double continuous weld shall be applied.

[2] Welding through the entire thickness is to be provided.

[3] Fillet welds attaching face plates to member webs shall be welded in way of brackets with weld factor 0,35. The face plates shall be welded to the brackets by the same weld as that of the face plate of the member in the span between the bracket.

[4] The structures under the girder webs, brackets and knees of foundations shall be welded to the inner bottom and decks by double continuous fillet welds with factor 0,35.

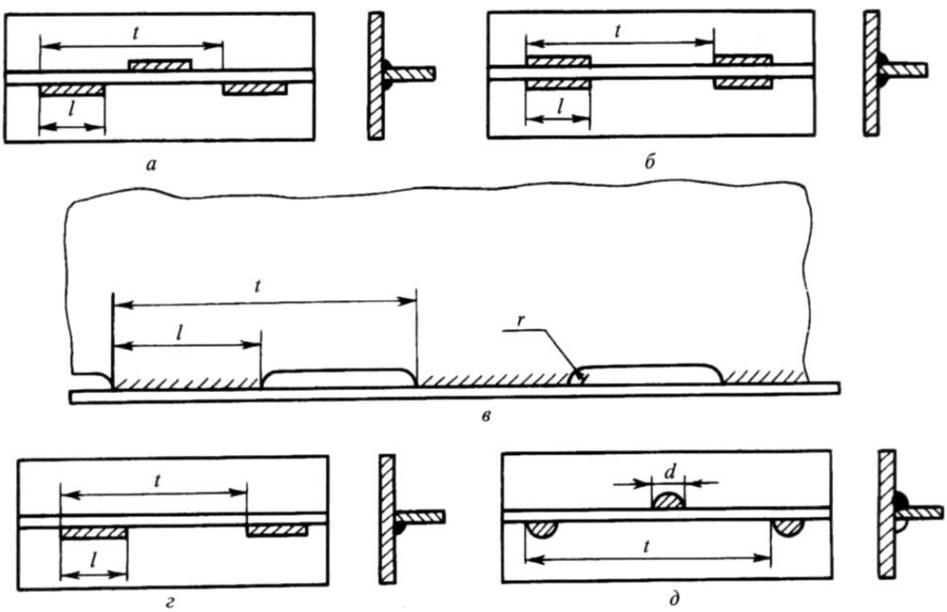


Fig.1.7.5.1-1. Weld types:

a — staggered intermittent; b — chain intermittent; c — scalloped; d — single intermittent; e — staggered spot

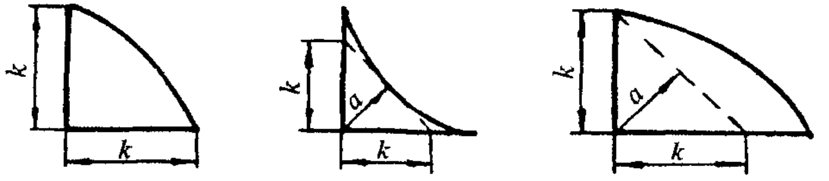


Рис.1.7.5.1-2.

Table 1.7.5.1-2

Type of fillet weld	β
Double continuous	1,0
Staggered, chain and scalloped	t / l
Single continuous	2,0
Single intermittent	$2t / l$

The sectional area f, in cm^2, of the welds connecting the primary members to supporting members shall not be less than determined by the formula

$$f = 25pal / \sigma_n, \qquad (1.7.5.3)$$

where p – pressure, in kPa, specified in appropriate Chapters of this Part;
a – spacing of members, in m;
l – span of member, in m;
for σ_n – refer to 1.1.4.3.

The weld sectional area f, in cm^2, is determined by summing up the results obtained by multiplying the throat thickness by the weld length of each portion of the connection of member web to supporting member

1.7.5.4 The framing members cut at intersection with other structures shall be in good alignment. A nonalignment shall not exceed half the thickness of the member. Where continuity is obtained by directing welding of the members to the structure involved, the throat thickness of the weld shall be determined considering the thickness of the member concerned. Otherwise, through penetration welding shall be performed. If the thickness of the thinner of the parts joined is less than 0,7 of the thickness of the other part, the throat thickness shall be calculated with regard to the particular loading conditions in way of the intersection. Where longitudinals are cut at transverse bulkheads, the construction used for their attachment shall comply with the following requirements:

.1 when the brackets are fitted in line on both sides of the bulkhead, the area f_1, in cm^2, of the weld connecting the brackets (and the longitudinal butt ends, if they are welded) to transverse bulkheads (refer to Fig. 1.7.5.4***a***) shall not be less than determined by the formula

$$f_1 = 1{,}75S_0, \qquad (1.7.5.4.1)$$

where S_0 – cross-sectional area of the longitudinal (effective flange excluded), in cm^2.

.2 if one continuous bracket plate welded in the appropriate slot cut in the bulkhead plating is fitted (refer to Fig. 1.7.5.4***b***), the sectional area of the bracket at the bulkhead shall not be less than $1{,}25S_0$.

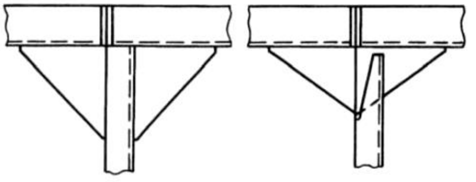


Fig.1.7.5.4

.3 the arm length l_{br}, in mm, of the bracket, in mm, over the longitudinals shall not be less than determined by the formula

$$l_{кн} = \frac{1{,}75 S_0 - S_1}{2a} \cdot 10^2, \quad (1.7.5.4.3)$$

where S_1 – area of weld connecting longitudinal butt ends to transverse bulkheads, in cm^2;

a – accepted design thickness of fillet weld connecting bracket to longitudinal, in mm.

1.7.5.5 Where plate thickness exceeds 18 mm, for connections made by fillet welds in which excessive stress in Z-direction may be caused by welding process or by external loads, Z-steel (refer to 1.2.2.2) shall be used or structural measures shall be taken to prevent lamellar tearing. In all cases, reducing of residual stress level shall be provided.

1.7.5.6 Double continuous welds shall be used in the following regions (refer also to Footnote 1 to Table 1.7.5.1-1):

.1 within 0,25*L* from the forward perpendicular in ships with length $L \geq 30$ m, for connection of framing members to bottom shell, and in case of only a single bottom in this region, also for welding of the webs of centre girder, side girders and floors to face plates of these members;

.2 in region I of ships of ice classes **Ice6, Ice5, Ice4,**, and in region AI of ships of ice class Ice3, for connection of side framing to shell plating;

.3 in way of foundations for machinery and equipment which may constitute a source of vibration (refer to 1.7.1.6), for connection of framing members to bottom and inner bottom platings, deck framing to deck plating;

.4 for the structures in the after peak;

.5 in way of supports and member ends, for connection of framing members to the plating (refer to1.7.5.8);

.6 in tanks (including double bottom tanks), exclusive the tanks for fuel oil or lubricating oil;

.7 for structures providing tightness.

1.7.5.7 Single continuous welds shall not be used:

.1 7.5.7 Single continuous welds shall not be used:

.1 within 0,2*L*, from F.P. for connection of side framing to shell plating, and within 0,25*L*, from F.P. for connection of bottom framing to shell plating;

.2 for structures subject to intense vibration (refer to 1.7.1.6);

.3 in region of ice strengthening of ships;

.4 for welding of side framing in ships mooring alongside other ships at sea or offshore units;

.5 for connections where the angle between a member web and the plating differs by more than 10° from a right angle.

1.7.5.8 For all types of intermittent joints the weld length *l* (refer to Fig. 1.7.5.1-1) shall not be less than 15*a* (for *a*, refer to 1.7.5.1) or 50 mm, whichever is the greater. The spacing of welds (($t - l$) – for chain welds and scalloped framing, and $(t - 2l)/2$ for staggered welds) shall not exceed 15s (s – plate thickness or web thickness, whichever is less). In any case, the spacing of welds or scallop length, where scalloped frames are used, shall not exceed 150 mm.

Intermittent or single continuous welds connecting the framing members to the plating shall be substituted in way of supports and member ends by double continuous welds having the same throat thickness as the intermittent or single continuous welds of the remaining part of the members. The length of joints welded from both sides shall be not less than the sum of bracket arm and the web depth, if a bracket is fitted, and shall be twice the web depth if no bracket is fitted. Where the framing members pass through supporting structures (deck transverses, deck girders, floors, etc.), the aforesaid reinforcement shall be provided on both sides of supporting member. Where single continuous welds are used, back runs at least 50 mm long and spaced not more than 500 mm apart shall be welded on the reverse side of the detail joined. The throat thickness of back weld shall be the same as that of the single continuous weld.

1.7.5.9 Staggered spot welds and single intermittent welds (refer to Fig. 1.7.5.1-1,***d*** and ***e***) may be used in the structures of deckhouses and superstructures of the second tier and above, on decks inside first tier superstructures, casings, enclosures inside the hull, not subject to intense vibration and impact loads and not affected by active corrosion, provided that the maximum plate or member web thickness is not more than 7 mm. The spot diameter *d*, in mm, shall not be less than

$$d = 1{,}12\sqrt{\alpha t s}, \qquad (1.7.5.9)$$

where t – pitch of spot weld (refer to Fig. 1.7.5.1-1);

t_{max} = 80 mm;

for α, s – refer to1.7.5.1.

I f d > 12 mm, as determined by the Formula (1.7.5.9), the weld pitch shall be increased or another type of weld shall be chosen.

1.7.5.10 Scalloped construction shall not be used:

.1 for side framing within 0,2L from F.P. and for connection of framing members to bottom shell plating within 0,25L from F.P.;

.2 in regions with high level of vibration (refer to 1.7.1.6);

.3 for side and bottom framing in region I of ice belt and for side framing in ships mooring at sea alongside other ships or offshore units;

.4 for connection of bottom centre girder to plate keel;

.5 for deck and inner bottom framing in locations where containers, trailers and vehicles may be stowed and for upper deck framing under deckhouses in way of their ends at a distance less than 0,25 of the deckhouse height from the intersection of deckhouse side and end bulkhead.

1.7.5.11 In scalloped construction (refer to Fig. 1.7.5.1-1) the welding shall be carried round the ends of all lugs. The depth of scallop in member web shall not exceed 0,25 of the member depth or 75 mm, whichever is less. The scallops shall be rounded with radius not less than 25 mm. The spacing of lugs *l* shall be not less than the length of the scallop. Scallops in frames, beams, stiffeners and similar structures shall be kept clear of the ends of structures, as well as intersections with supporting structures (decks, side stringers, deck girders, etc.) by at least twice the member depth, and from the toes of the brackets by at least half the member depth.

1.7.5.12 In the framing of tanks (including double-bottom tanks and the tanks of tankers), provision shall be made for openings to ensure free air flow to air pipes, as well as an overflow of liquid.

It is recommended that openings in longitudinals shall be elliptical with a distance from the edge of opening to deck plating or bottom shell plating not less than 20 mm.

In way of air and drain holes, cut-outs for the passage of framing members and welded joints the joints shall be welded as double welds on a length of 50 m on both sides of the opening.

1.7.5.13 Where welding of tee-joints by fillet welds is impracticable, plug welds (refer to Fig. 1.7.5.13 a) or tenon welds (refer to Fig. 1.7.5.13 b) may be used.

The length *l* and pitch *t* shall be determined as for scalloped frames under 1.7.5.11.

For plug welding, the slots shall be of circular or linear form, with throat thickness of weld equal to 0,5 of plate thickness. In general, the ends of slots in plug welding shall be made semicircular. The linear slots shall be arranged with longer side in the direction of the parts to be joined (refer to Fig. 1.7.5.13 *a*).

Complete filling of slot is not permitted.

In regions of high level of vibration (refer to 1.7.1.6) welded joints with complete root penetration and permanent backing ring (refer to Fig. 1.7.5.13 c) are recommended instead of tenon welds or plug welds.

1.7.5.14 Where aluminium alloy structures are welded according to Table 1.7.5.1-1, it is not permitted:

.1 to use intermittent welds (except in scalloped construction);

.2 to use scalloped construction in regions of high level of vibration (refer to 1.7.1.6).

The throat thickness of welds shall be not less than 3 mm, but not more than 0,5*s* (for *s* – refer to 1.7.5.1).

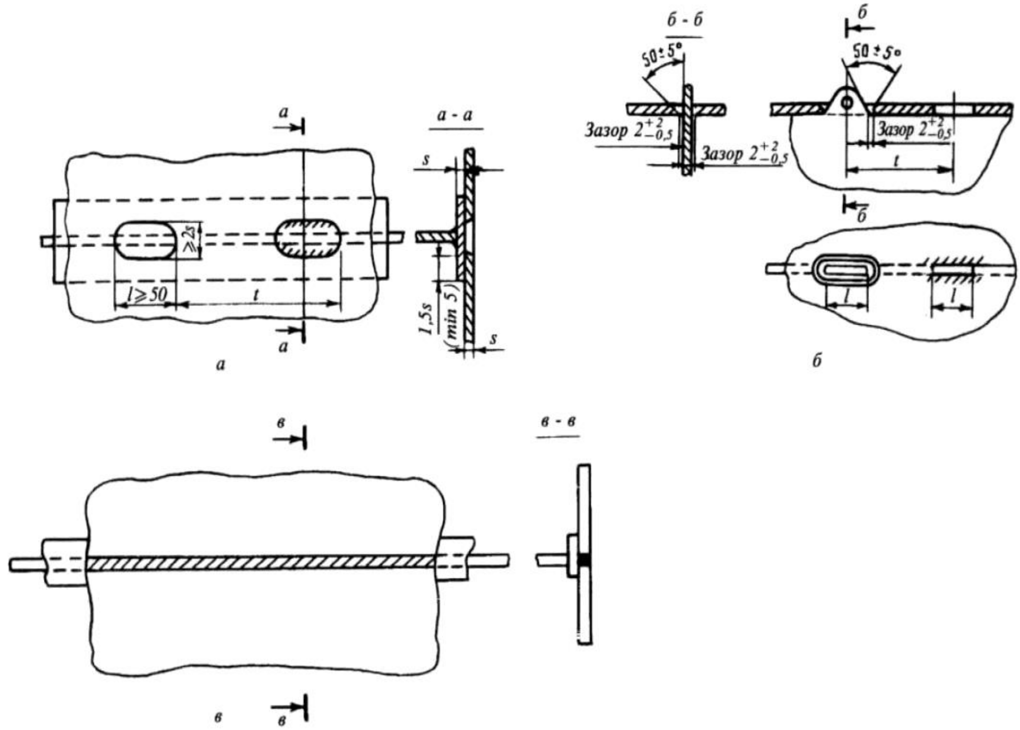


Fig.1.7.5.13

2. GENERAL REQUIREMENTS FOR HULL STRUCTURES

2.1 GENERAL

2.1.1 Application.

The requirements given in this Section apply to sea-going ships of all types and purposes, having regard to additional provisions of Section 3.

The Section contains the requirements for hull structures: shell plating, platings, primary and deep members, pillars, stems, sternframes, seatings, etc.

2.1.2 Symbols.

L_1 – length of the compartment, in m, measured as follows:

with plane bulkheads, as the distance between bulkhead platings;

with corrugated bulkheads, as the distance between corrugation axes or the axes of trapezoidal stools at the inner bottom level;

with cofferdam bulkheads, as the distance between middle cofferdam axes;

B_1 – breadth of the compartment, in m, measured at its mid-length as follows:

for single skin construction, as the distance between the sides or between the side and the longitudinal bulkhead at the upper edge of the floor;

for double skin construction, as the distance between inner skins or between the inner skin and the longitudinal bulkhead;

where hopper side tanks are fitted, as the distance between hopper tanks at the inner bottom level or between the longitudinal bulkhead and the hopper side tank;

where several longitudinal bulkheads are fitted, as the spacing of longitudinal bulkheads or as the distance between the longitudinal bulkhead nearest to the side and the appropriate side;

l – span of the member, in m, defined in 1.6.3.1, unless provided otherwise;

h – depth of the member web, in cm;

a – spacing of primary or deep members concerned (longitudinal or transverse framing); where the spacing varies, a is the half-sum of the distances of adjacent members from the member concerned;

s – plate thickness, in mm;

W – section modulus of members, in cm^3;

I – moment of inertia of members, in cm^4;

Δs – corrosion allowance to the plate thickness, in mm (refer to 1.1.5.1);

ω_k – = factor taking account of corrosion allowance to the section modulus of members (refer to 1.1.5.3);

j_k – factor taking account of mo-memt of inertia allowance to the section modulus of members (refer to 1.1.5.3).

2.2 SHELL PLATING

2.2.1 General and symbols.

Requirements are given in this Chapter for the thickness of bottom and side shell plating, thickness and width of sheerstrake, plate keel, garboard strakes, as well as the requirements for the minimum structural thicknesses of these members and construction of openings therein. The requirements are applicable to all regions over the ship's length and depth unless additional requirements for shell plating thickness are put forward.

Special requirements to reinforcement of the bottom and side plating in the end parts are specified in 2.8, and special requirements to to shell plating of ice class ships – in 3.10.

2.2.1.2 For the purpose of this Chapter the following symbols have been adopted.

p_{st} – design static pressure according to 1.3.2.1;

p_w – design pressure due to the motion of ship hull about wave contour according to 1.3.2.2;

p_c – design pressure from carried liquid cargo, ballast or oil fuel according to 1.3.4.2.1;

r – opening radius, in m.

2.2.2 Construction.

2.2.2.1 No openings shall be cut in the upper edge of sheerstrake or in the side shell plating if the distance between the upper edge of opening and the strength deck is less than half the opening depth.

All other cases shall be specially considered by the Register. Rectangular openings cut in the side shell plating shall have their corners rounded with the radius equal to 0,1 of the opening depth or width, whichever is less, but not less than 50 mm.

In all cases when the openings may result in considerable reduction of longitudinal or local strength of the ship, provision shall be made for reinforcement of such areas.

Reinforcement by means of thickened insert plates is required for openings located within 0,35*L*, from the midship region, the distance from their upper edge to the strength deck being less than the depth of opening. The minimum width of thickened insert plates, as measured from the upper or lower edge of opening, shall be equal to 0,25 of the depth or length of the opening, whichever is less; the total width measured outside the opening shall be greater than the minimum thickness by at least 0,25 of the depth or length of the opening, whichever is less. The minimum distance from the end of the thickened insert plate to the nearest edge of opening, as measured along the length, of the ship shall be equal to at least 0,35 of the depth or length of opening, whichever is less. The corners of the thickened insert plate shall be rounded. The thickness of the thickened insert plate shall not be less than:

1,5 s when $s < 20$ mm;

30 mm when $20 \le s \le 24$ mm;

1,25 s when $s > 24$ mm,

where s — thickness of shell plating in way of the opening.

A thicknened insert plate may be fitted around the perimeter of the opening.

In ships of restricted areas of navigation **R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, **R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS**, with shelter upper decks or deck stringers of a longitudinal cargo hatch coamings or the like, all the top free edges of the above structures, as well as free edges of large cutouts in shell plating shall be smooth in the ship's hull longitudinal direction and rounded in the transverse one.

2.2.2.2 The area of transition from sheerstrake to deck stringer may be rounded. In this case, the radius of curvature of sheerstrake shall not be less than 15 times the sheerstrake thickness.

No openings are permitted in the rounded area.

2.2.3 Loads on shell plating.

The external pressure *p*, in kPa, on the bottom and side shell plating is determined by the formula

$$p = p_{st} + p_w. \qquad (2.2.3\text{-}1)$$

For ships with double bottom and double skin side construction intended for liquid ballast and for tankers with neither double bottom nor double skin side construction, the internal pressure $p = p_c$ shall be determined additionally by Formulae 1.3.4.2.1.

Where $p_{st} > p_w$, counterpressure shall be considered

$$p = p_c - (p_{st} - p_w). \qquad (2.2.3\text{-}2)$$

For ships with double bottom and double skin side construction p_{st} and p_w shall be determined in accordance with 1.3.2 as in the case of the ballasted ships.

As the design pressure, both external and internal pressure may be adopted, whichever is the greater.

The pressure p_w above the summer load waterline shall not be less than p_{min}, , in kPa, determined by the formula

$$p_{min}=0{,}03L+5 \qquad (2.2.3\text{-}3)$$

Where $L > 250$m L shall be taken equal to 250m.

For ships of restricted area of navigation, the value of p_{min} may be reduced by multiplying by the factor φ_r, obtained from Table 1.3.1.5.

2.2.4 Scantlings of plate structures of shell plating.

2.2.4.1 The thickness of bottom and

side shell plating shall not be less than determined by Formula (1.6.4.4) taking:

$m = 22{,}4$ and $k_\sigma = k'_\sigma + k_L \dfrac{x_1}{L}$,

where for k'_σ, k_L – refer to Table2.2.4.1;

x_1 – distance from midsection to the center of the plate considered , in m; where $x_1/L \le 0{,}2$ is taken 0,2; when $x_1 / L \ge 0{,}4$ is taken 0,4.

Table 2.2.4.1

Framing	Bottom		Side	
	k'_σ	k_L	k'_σ	k_L
Longitudinal	0,9	0,75	1,0	0,5
Transverse	0,3	2,25	0,4	2,0

Reducing of side plating thickness toward the distance from the main line shall not exceed 20% of the thickness of the strake above bilge strake.

2.2.4.2 The buckling strength of bottom plating, strake above bilge, sheerstrake and strake below in the midship region of ships shall be verified in accordance with 1.6.5.

2.2.4.3 The thickness of bilge strake shall be adopted equal to that of bottom or side shell plating, whichever is the greater.

2.2.4.4 The width of plate keel $b_к$, in mm, shall not be less than

$$b_к = 800 + 5L, \qquad (2.2.4.4)$$

in this case, $b_к$ need not exceed 2000 mm.

The thickness of plate keel shall be 2 mm greater than that of bottom shell plating.

2.2.4.5 in mm, shall not be less than determined by Formula (2.2.4.4) taking b_s not greater than 2000 mm.

The sheerstrake thickness amidships shall not be less than that of adjoining strakes of side shell or deck plating (stringer plate), whichever is the greater. A t ends, the sheerstrake thickness may be equal to that of side shell plating in this region.

2.2.4.6 The shell plates adjoining the sternframe, as well as the plates to which the arms of propeller shaft brackets are attached, shall have a thickness *s*, in mm, of not less than:

$$s = 0{,}1L + 4{,}4 \text{ for } L < 80 \text{ m}, \qquad (2.2.4.6\text{-}1)$$

$$s = 0{,}055L + 8 \text{ for } L \ge 80 \text{ m}. \qquad (2.2.4.6\text{-}2)$$

Where $L > 200$ m, L shall be taken equal to 200 m.

The aforesaid thickness shall be ensured after hot bending, if applied.

2.2.4.7 The thickness *s* of garboard strakes directly adjoining the bar keel, in mm, within 0,7*L* from F.P., shall not be less than defined by the formula

$$s = 0{,}08L + 6. \qquad (2.2.4.7\text{-}1)$$

The thickness of garboard strakes directly adjoining the bar keel shall not be less than that required for the plate keel, and their width shall not be less than half the width required for the plate keel in accordance with 2.2.4.4.

2.2.4.8 In any case, the thickness of shell plating *s*, in mm, shall not be less than:

$s_{min} = 0{,}12L + 3{,}l$ mm for L < 30 m; (2.2.4.8-1)

$s_{min} = (0{,}04L + 5{,}5)\sqrt{\eta}$ mm for L ≥ 30 m, (2.2.4.8-2)

where for η – refer to1.1.4.3.

Where $L > 300$ m, L shall be taken equal to 300 m.

Where the adopted spacing is less than the standard one (refer to 1.1.3) for ships of unrestricted service **A** and restricted area of navigation **R1** and **A-R1**, a reduction of minimum thickness of shell plating is permitted in proportion to the ratio of adopted spacing to standard spacing but not more than 10 per cent;

For other ships restricted service – refer to1.1.4.6.

2.2.5 Special requirements.

2.2.5.1 The grade of steel used for the sheerstrake shall be the same as that used for the strength deck. The upper edge of sheerstrake shall be smooth, and their corners shall be well rounded in the transverse direction.

Requirement to the edge design covers also free edges of continuous longitudinal structures located above the sheerstrake and ensuring longitudinal strength of the ship's hull.

2.2.5.2 For ships of 65 m and above, within 0. 6*L*, amidships no parts shall be welded to the upper edge of sheerstrake or to the sheerstrake rounding.

2.2.5.3 Bilge keels shall be attached to the shell plating by means of an intermediate member, 1. e. a flat bar welded to the shell plating with an allround continuous fillet weld. Connection of the bilge keel to this member shall be weaker than that of the member to the shell plating. However, the connection shall be strong enough to keep the bilge keels under the ordinary operating conditions of the ship. The intermediate member shall be made continuous over the length of bilge keel.

Bilge keels shall terminate in the stiffened area of shell plating and shall be gradually tapered at ends. The bilge keel and the intermediate member shall be of the same steel grade as the shell plating in this region.

2.2.5.4 In bottom-and-side fittings, the welded branch wall thickness shall not be less than that of shell plating determined according to 2.2.4.8, or 12 mm, whichever is the greater.

2.3 SINGLE BOTTOM

2.3.1 General

2.3.1.1 Requirements are given in this Chapter for the bottom framing of ships having no double bottom and in way where it is omitted, as well as for the floors, centre girder, bottom longitudinals and the brackets by which they are connected.

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

I_f – moment of inertia of the floor cross-section, in cm^4;

I_k – moment of inertia of the keel cross-section, in cm^4;

I_s – moment of inertia of the stringer cross-section, in cm^4.

L_1 – length of the compartment concerned (hold, tank, engine room, etc.), in m;

B_1– breadth of the compartment concerned, in m;

B_x– breadth of ship, in m, in way of considered section at the level of summer load waterline.

2.3.2 Construction.

2.3.2.1 In tankers of 80 m and above, longitudinal framing shall be provided for single bottom.

2.3.2.2 The structure of centre girder shall satisfy the following requirements:

.1 the centre girder shall extend throughout the ship's length as far as practicable. In ships greater than 65 m in length, a continuous centre girder is recommended between transverse bulkheads.

.2 when the bottom is framed longitudinally, the centre girder shall be stiffened on both sides with flanged brackets fitted between the bottom transverses and between bottom transverse and transverse bulkhead.

The distance between brackets, between bracket and bottom transverse or between bracket and transverse bulkhead shall not exceed 1,2 m. The brackets shall be carried to the face plate of the centre girder if the web of the latter is stiffened vertically or to the second horizontal stiffener from below if the centre girder web is stiffened horizontally.

In way of bottom plating, the brackets shall extend to the nearest bottom longitudinal and shall be welded thereto.

2.3.2.3 When the bottom is framed transversely, floors shall generally be fitted at every frame.

Where the floors are cut at the centre girder, their face plates shall be butt-welded to the face plate of the centre girder. I f the actual section modulus of floors exceeds the value required by 2.3.4.1.1 less than 1,5 times, the width of their face plates shall be doubled, where attached to the centre girder face plate, or horizontal brackets of adequate size shall be fitted.

Пояски флорів можуть бути замінені відігнутими фланцями.

The floor face plates may be replaced by flanges. Flanged floors are not permitted in way of engine room, in the after peak, and in ships of 30 m and above; they are not permitted within 0,25*L*, from the fore perpendicular, either.

2.3.2.4 When the bottom is framed longitudinally, brackets shall be fitted in line with the bottom transverse web on both sides of the centre girder where the girder is higher than the bottom transverse at the place of their connection. A bracket shall be welded to bottom transverse face plate and to centre girder web and face plate.

The free edge of the bracket shall be stiffened with a face plate, and the angle of its inclination to bottom transverse face plate shall not exceed 45°.

Similar requirements apply to the connections of the stringer to bottom transverse where the stringer is higher than the bottom transverse at the place of connection.

2.3.2.5 When the bottom is framed longitudinally, the spacing of side girders and the distance from the centre girder or ship's side to the side girder shall not exceed 2,2 m.

The side girder plates shall be cut at floors and welded thereto.

The face plates of side girders shall be welded to those of floors.

2.3.2.6 In tankers, the side girders, if fitted, shall form a ring system together with vertical stiffeners of transverse bulkheads and deck girders.

Deep side girders having the same depth as the centre girder, as well as conventional side girders having the same depth as bottom transverses, shall run continuous from one transverse bulkhead to another with $L_1/B_1 < 1$.

2.3.2.7 In the engine room, the centre girder may be omitted if the longitudinal girders under engine seating extend from the fore to the after bulkhead of the engine room and terminate with brackets beyond the bulkhead according to 2.3.5.1.

2.3.2.8 In ships having a length of 65 m and more, the buckling strength of centre girder and side girders in the midship region shall be ensured in accordance with 1.6.5.

The webs of centre girder, side girders and floors shall be stiffened in accordance with 1.7.3.

2.3.2.9. Connections of bottom longitudinals to transverse bulkheads shall be such that the effective sectional area of the longitudinals is maintained.

2.3.3 Single bottom loads.

2.3.3.1 The design pressure on single bottom structures of dry cargo ships is the external pressure determined by Formula (2.2.3-1) for a ship in the ballast condition. When determining p_{st} in Formula (2.2.3-1), the ballast draught may be taken as 0,6 of the summer draught.

If a dry cargo ship is designed to operate in a fully loaded condition with some holds empty the static pressure p_{st} in Formula (2.2.3-1) for these holds shall be determined at summer draught.

2.3.3.2 As the design pressure on single bottom structures of tankers, external pressure determined by Formula (2.2.3-1) at summer draught is adopted, or the total pressure determined by Formula (2.2.3-2), whichever is the greater.

2.3.4 Scantlings of single bottom members.

2.3.4.1 The bottom with transverse framing shall satisfy the following requirements:

.1 the depth of floors at the centreline shall not be less than $0{,}055B_1$. In any case, B_1 shall not be taken less than $0{,}6B_x$, where B_x – breadth of the ship in the section under consideration.

Allowable reduction of floor depth shall not be more than 10 per cent, the required floor section modulus being maintained.

In the engine room, the height of floor web between longitudinal girders under the seating shall not be less than 0,65 of the required depth at the centreline. A reduction of floor section modulus by more than 10 per cent is not permitted.

At a distance of 3/8 B_x from the centreline, the depth of floors shall not be less than 50 per cent of the required depth of the centreline floors.

at the centreline, the section modulus of floors shall not be less than determined according to 1.6.4.1 and 1.6.4.2 taking:

for p – refer to 2.3.3.1, but it shall not be less than 35 kPa for dry cargo ships and not less than 85 kPa for tankers;

$l = B_1$, but at least $0{,}6B_x$;

$m = 11{,}5$;

k_σ = 0,8 i 0,75 – for floors with flange and face plate.

Floor webs thickness shall not be less than 0,01 their height in the center plane plus 3,5 mm, but they are not to be thicker than the bottom plating.

On portions equal to $0{,}05B_x$ from ship's side, the floor web sectional area $f_{ст}$, cm^2, shall not be less than determined according to the Formula

$$f_{ст} = 0{,}1\, B_x\,(B_x + 7). \qquad (2.3.4.1.1)$$

Bilge brackets sectional area may be included into the value $f_{ст}$.

Floors face plate thickness s, in mm, is not tobe less than determined by the Formula

$$s = s_1 + \Delta s_1,$$

where s_1 – floor web thickness, in mm;

Δs_1 = 2 mm for $L \geq 50$ m; 1 mm for $L < 50$ m and 0 for $L < 30$ m.

Floors face plate thickness is not to be less than 75 мм. In the fore part within $0,2L$ fom F.P., and under engine and boiler foundations floors face plate thickness is to be doubled.

Where bend-up flanges are provided on floors the flange thickness shall be at least 10, but not more than eighteen its thickness.

.2 The center girder web thickness s, in mm, amidships is not to be less than determined by the formula

$$s = 0,06L + 6. \qquad (2.3.4.1.2)$$

The center girder web thickness within $0,1L$ from F.P and A.P. may be taken 1 mm less than is required for the ship's length amidships, but shall not be less than floors thickness within this region.

The center girder face plate thickness shall be 2 mm greater than the center girder web thickness.

In accordance with 2.3.4.1.2, the section modulus of centre girder shall be at least 1,6 times greater than the section modulus of a floor at the centreline. The depth of centre girder shall be equal to that of a floor at the place of their connection.

.3 The side girder web thickness s, in mm, amidships is not to be less than determined by the formula

$$s = 0,05L + 5. \qquad (2.3.4.1.3)$$

The side girder web thickness within $0,1L$ from F.P and A.P. may be taken 1 mm less than is required for the midship's length amidships.

Bottom longitudinals face plate thickness shall be 2 mm greater than the longitudinal web thickness.

the section modulus of a side girder shall not be less than the section modulus of a floor at the centreline in accordance with 2.3.4.1.i.

The depth of side girder shall be equal to that of the floor at the place of their connection.

2.3.4.2 If longitudinal system of framing is adopted, the bottom members in way of the cargo tanks in tankers shall satisfy the following requirements:

.1 the section modulus of bottom longitudinals shall not be less than determined in accordance with 1.6.4.1.

Taking:

p – as defined in 2.3.3;

$m = 12$;

$k_\sigma = 0,2 + (x_1/L)$

where x_1 – the spacing of the longitudinal mid-span from amidships, in m; for $x_1/L \le 0,2$ the value of x_1/L is taken equal to 0,2; for $x_1/L \ge 0,4$ the value of x_1/L is taken equal to 0,4.

In the midship region of ships with $L \ge 60$ m bottom longitudinals bulk strength is to be provided according to 1.6.5.

.2 If longitudinal system of side and bottom framing is adopted and bilge brackets are fitted (refer to Fig. 2.3.4.2.2) the section modulus of longitudinals to which the brackets are connected is to be 30 % more than is required.

Brackets thickness is not to be less of floors, and their effective flange or flange shall be taken as bilge brackets and shall not be welded to longitudinals effective flange.

.3 Floor wed depth is not to be less than $0,13B_1$.

The section modulus of floors shall not be less than determined according to 1.6.4.1 for $l = B_1$ taking:

in the midship tank:

$k_\sigma = 0,6$;

for $m = m_f$ – refer to Tables 2.3.4.2.3-1–2.3.4.2.3-3 depending on the grillage design scheme (refer to Figs. 2.3.4.2.3-1–2.3.4.2.3-3) and the parameters μ and α_c (where $\mu = (L_1/B_1)^3 (I_f/I_k)$ – parameter of the grillage relative stiffness; $\alpha_c = I_c / I_к$ – parameter of the side girder relative stiffness); $\alpha_c = 0$ – where side girders are missing. For intermediate values of μ and α_c factor *m* is determined by linear interpolation;

in wing and centre tanks when installed in the center plane of the third longitudinal bulkhead:

$k_\sigma = 0,7$; $m = 12$.

Where the deep side girder is installed in wing tank floor section modulus is determined as for the centre tank, but in determining the stiffness pararameters μ and α_c the keel sectional moment of inertia I_k is replaced by the stringer sectional moment of inertia I_s.

.4 The floor web sectionnal area f_v, in cm^2, with deduction of openings is not to be less than determined by the Formula (1.6.4.3) for $k_\tau = 0,55$;

In the centre tank:

N_{max} – maximum shear force N_i in the floor outside the bracket region

$N_i = r_i paB_1$;

for r_i – refer to Tables 2.3.4.2.3-1–2.3.4.2.3-3 depending on the grillage design scheme (refer to Figs. 2.3.4.2.3-1–2.3.4.2.3-3) and the parameters μ and α_c (refer to 2.3.4.2.3).

For intermediate values of μ and α_c factor r_i is determined by linear interpolation;

in wing tank $N_{max} = 0,31paB_1$

Table 2.3.4.2.3-1

Value	α_c	Factor μ (grillage with three floors)								
		0,1	0,2	0,3	0,4	0,5	0,7	1,0	1,25	1,5
r_1	0	0,375	0,340	0,315	0,295	0,285	0,260	0,240	0,225	0,205
	0,4	0,265	0,250	0,240	0,225	0,210	0,200	0,185	0,170	0,160
	0,8	0,245	0,225	0,215	0,205	0,195	0,185	0,180	0,175	0,170
	1,0	0,235	0,215	0,205	0,195	0,190	0,180	0,180	0,180	0,175
r_2	0	0,320	0,290	0,260	0,235	0,205	0,170	0,145	0,125	0,105
	0,4	0,250	0,225	0,210	0,185	0,180	0,155	0,135	0,120	0,100
	0,8	0,225	0,205	0,190	0,175	0,165	0,150	0,130	0,115	0,095
	1,0	0,215	0,195	0,180	0,170	0,160	0,150	0,130	0,115	0,095
r_3	0	–	–	–	–	–	–	–	–	–
	0,4	0,145	0,125	0,117	0,115	0,100	0,090	0,085	0,080	0,075
	0,8	0,175	0,160	0,147	0,140	0,133	0,125	0,117	0,110	0,105
	1,0	0,190	0,180	0,160	0,155	0,150	0,145	0,135	0,125	0,120
r_4	0	–	–	–	–	–	–	–	–	–
	0,4	0,115	0,085	0,080	0,070	0,060	0,050	0,040	0,030	0,025
	0,8	0,145	0,123	0,110	0,100	0,090	0,080	0,070	0,060	0,050
	1,0	0,160	0,140	0,125	0,115	0,105	0,095	0,085	0,075	0,065
$m_ф$	0	56	50	44	39	35	29	28	27	26
	0,4	84	65	54	47	42	35	33	31	30
	0,8	98	73	60	53	46	38	35	32	29

Value	α_c	Factor μ (grillage with three floors)								
		0,1	0,2	0,3	0,4	0,5	0,7	1,0	1,25	1,5
	1,0	105	77	63	56	48	40	36	33	29
$m_к$	0	48	54	62	68	74	84	95	104	113
	0,4	31	34	37	41	43	47	53	58	63
	0,8	34	38	41	44	46	50	56	60	65
	1,0	36	40	43	46	48	52	57	61	66
m_c	0	–	–	–	–	–	–	–	–	–
	0,4	63	72	80	85	91	100	110	118	127
	0,8	52	60	67	72	78	87	98	107	116
	1,0	47	54	61	66	72	81	92	102	111

Table 2.3.4.2.3-2

Value	α_c	Factor μ (grillage with four floors)								
		0,1	0,2	0,3	0,4	0,5	0,7	1,0	1,25	1,5
1	2	3	4	5	6	7	8	9	10	11
r_1	0	0,38	0,35	0,33	0,31	0,29	0,28	0,26	0,24	0,23
	0,4	0,27	0,26	0,25	0,24	0,23	0,21	0,20	0,19	0,18
	0,8	0,24	0,23	0,23	0,22	0,21	0,19	0,18	0,17	0,16
	1,0	0,23	0,22	0,22	0,21	0,20	0,18	0,17	0,16	0,15
r_2	0	0,30	0,27	0,24	0,22	0,20	0,16	0,13	0,10	0,08
	0,4	0,24	0,21	0,19	0,18	0,17	0,14	0,12	0,10	0,09
	0,8	0,22	0,19	0,17	0,16	0,14	0,13	0,12	0,11	0,10
	1,0	0,21	0,18	0,16	0,15	0,13	0,13	0,12	0,11	0,11
r_3	0	–	–	–	–	–	–	–	–	–
	0,4	0,14	0,13	0,12	0,11	0,11	0,10	0,17	0,10	0,17
	0,8	0,18	0,16	0,16	0,15	0,14	0,13	0,13	0,13	0,13
	1,0	0,20	0,18	0,18	0,17	0,16	0,15	0,15	0,15	0,15
r_4	0	–	–	–	–	–	–	–	–	–
	0,4	0,09	0,08	0,07	0,06	0,05	0,04	0,04	0,04	0,04
	0,8	0,14	0,12	0,11	0,10	0,08	0,07	0,06	0,06	0,05
	1,0	0,17	0,14	0,13	0,12	0,10	0,09	0,07	0,06	0,05
$m_ф$	0	50	49	49	49	46	35	37	26	20
	0,4	69	47	38	36	34	30	27	25	22
	0,8	80	49	40	37	35	31	30	29	28
	1,0	86	50	41	38	36	32	32	31	31
$m_к$	0	60	68	78	86	94	108	128	145	161
	0,4	38	43	47	52	55	62	68	73	78
	0,8	43	49	54	59	62	69	76	82	88
	1,0	46	52	58	63	66	73	80	87	93
m_c	0	–	–	–	–	–	–	–	–	–
	0,4	90	106	119	146	156	183	197	209	220
	0,8	68	78	87	98	108	122	136	148	159

Value	α_c	Factor μ (grillage with four floors)								
		0,1	0,2	0,3	0,4	0,5	0,7	1,0	1,25	1,5
	1,0	57	64	71	74	84	92	106	118	129

Таблиця 2.3.4.2.3-3

Value	α_c	Factor μ (grillage with five floors)								
		0,1	0,2	0,3	0,4	0,5	0,7	1,0	1,25	1,5
1	2	3	4	5	6	7	8	9	10	11
r_1	0	0,395	0,375	0,355	0,340	0,325	0,300	0,275	0,255	0,235
	0,4	0,250	0,245	0,240	0,235	0.230	0,225	0,205	0,190	0,170
	0,8	0,240	0,235	0,225	0,215	0,210	0,195	0,170	0,150	0,130
	1,0	0,235	0,230	0,220	0,205	0,200	0,180	0,155	0,130	0,120
r_2	0	0,310	0,280	0,245	0,215	0,190	0,160	0,130	0,105	0,080
	0,4	0,240	0,225	0,200	0,180	0,165	0,140	0,110	0,085	0,060
	0,8	0,220	0,200	0,180	0,165	0,150	0,130	0,100	0,075	0,050
	1,0	0,210	0,190	0,170	0,160	0,145	0,125	0,095	0,070	0,045
	0	0,280	0,240	0,205	0,175	0,145	0,110	0,085	0,065	0,045
r_3	0,4	0,230	0,205	0,180	0,155	0,135	0,110	0,080	0,055	0,030
	0,8	0,210	0,180	0,160	0,140	0,130	0,105	0,075	0,050	0,025
	1,0	0,200	0,170	0,150	0,135	0,130	0,105	0,075	0,050	0,025
r_4	0	–	–	–	–	–	–	–	–	–
	0,4	0,165	0,160	0,145	0,135	0,130	0,120	0,100	0,085	0,065
	0,8	0,185	0,180	0,170	0,160	0,155	0,145	0,125	0,110	0,095
	1,0	0,195	0,190	0,185	0,175	0,170	0,160	0,140	0,125	0,110
r_5	0	–	–	–	–	–	–	–	–	–
	0,4	0,110	0,080	0,070	0,060	0,060	0,050	0,040	0,030	0,030
	0,8	0,140	0,120	0,110	0,100	0,090	0,080	0,060	0,040	0,040
	1,0	0,160	0,140	0,130	0,120	0,110	0,100	0,070	0,060	0,050
r_6	0	–	–	–	–	–	–	–	–	–
	0,4	0,090	0,060	0,050	0,040	0,040	0,030	0,030	0,030	0,030
	0,8	0,130	0,100	0,090	0,080	0,070	0,060	0,040	0,040	0,030
	1,0	0,150	0,120	0,110	0,100	0,090	0,080	0,050	0,040	0,030
$m_ф$	0	46	40	35	32	30	27	24	22	19
	0,4	65	52	41	37	34	32	30	28	27
	0,8	72	56	46	40	36	34	34	34	34
	1,0	76	58	49	42	37	36	35	35	35
$m_к$	0	58	64	76	86	96	106	146	179	213
	0,4	39	42	44	49	54	63	81	96	111
	0,8	42	45	48	53	58	69	89	106	122
	1,0	44	47	50	55	60	72	93	111	129
m_c	0	–	–	–	–	–	–	–	–	–
	0,4	84	103	119	132	151	188	207	224	239
	0,8	70	79	88	96	102	122	158	188	218
	1,0	63	67	73	78	78	89	134	170	198

Value	α_c	Factor μ (grillage with five floors)								
		0,1	0,2	0,3	0,4	0,5	0,7	1,0	1,25	1,5

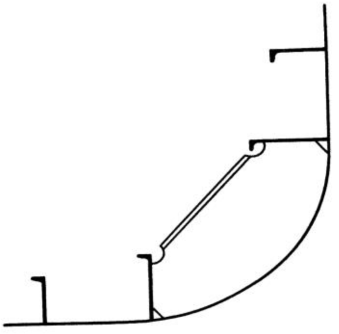


Fig.2.3.4.2.2

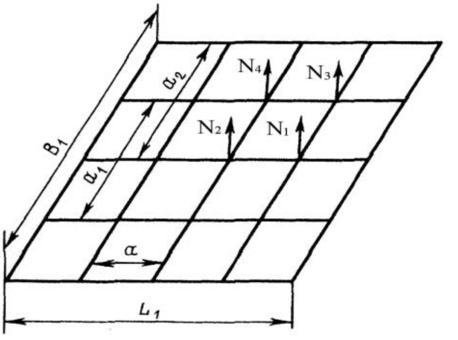


Fig.2.3.4.2.3-1. Three floors grillage

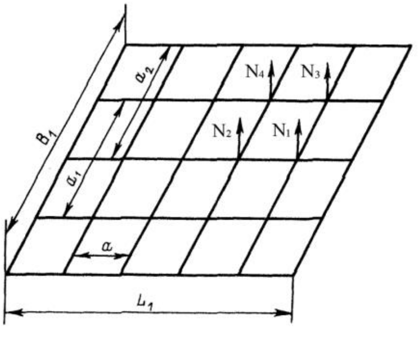


Fig.2.3.4.2.3-2. Four floors grillage

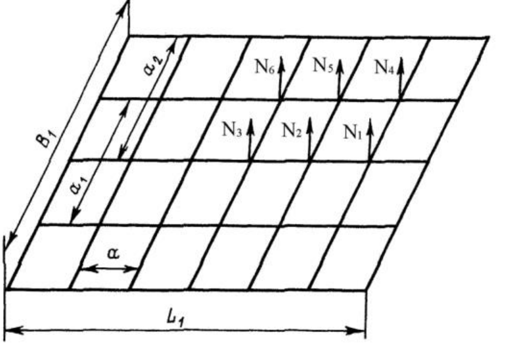


Fig.2.3.4.2.3-3. Five floors grillage

.5 If side girders are omitted, the centre girder section modulus shall not be less than determined from 1.6.4.1.

Taking: $a = B_1/2$;

$l = L_1 - 0{,}3h_c$ (where h_c – dock stay web depth);

$k_\sigma = 0{,}25$;

for $m = m_k$ refer to Tables.2.3.4.2.3-1–2.3.4.2.3-3 depending on the grillage design scheme (refer to Figs.2.3.4.2.3-1–2.3.4.2.3-3) and parameter μ; where $\alpha_c = 0$.

For intermediate values of μ factor m is determined by linear interpolation.

.6 The centre girder with side girders section modulus shall not be less than determined from 1.6.4.1.

Taking:

$a = a_1 / 2$ (refer to Figs. 2.3.4.2.3-1–2.3.4.2.3-3);

l – as defined in 2.3.4.2.5;

$k_\sigma = 0{,}25$;

for $m = m_k$ refer to Tables.2.3.4.2.3-1–2.3.4.2.3-3 depending on the grillage design scheme (refer to Figs.2.3.4.2.3-1–2.3.4.2.3-3) and parameters μ and α_c.

.7 The side girders section modulus shall not be less than determined from 1.6.4.1.

Taking:

$a = a_2/2$ (refer to Figs.2.3.4.2.3-1–2.3.4.2.3-3);

$l = L_1$;

$k_\sigma = 0{,}25$;

for $m = m_c$ refer to Tables 2.3.4.2.3-1–2.3.4.2.3-3.

.8 The thickness, in mm, of single bottom members shall not be less than:

$$\left.\begin{aligned} s_{\min} &= 0{,}035L + 5\,\text{мм} \quad \text{якщо } L < 80\,\text{м},\\ s_{\min} &= 0{,}025L + 6{,}5\,\text{мм} \quad \text{якщо } 80 \le L \le 200\,\text{м},\\ s_{\min} &= 0{,}020L + 7{,}5\,\text{мм} \quad \text{якщо } L > 200\,\text{м}. \end{aligned}\right\} \quad (2.3.4.2.8)$$

$s_{\min}$ may not exceed 13,5 mm for bottom web members і 11,5 mm for longitudinals, transverses and brackets.

.9 In ships of 200 m and above, provision shall be made for side girders midway between longitudinal bulkhead and centre girder, as well as between longitudinal bulkhead and ship's side, in centre and wing tanks.

The section modulus of deep side girders, when fitted in accordance with 2.3.2.6, shall not be less than 0,5 of centre girder section modulus. The centre girder section moduli may be reduced in conformity with 2.3.4.2.5 and those of bottom transverse, in conformity with 2.3.4.2.3 by 15 per cent.

The section modulus of conventional side girders, when fitted in accordance with 2.3.2.6, shall not be less than bottom transverse section modulus;

2.3.4.3 In the engine room, the bottom transverse and side girder web thickness shall not be less than the centre girder web thickness.

If a girder acts as the vertical plate of engine seating, the girder thickness shall not be less than the vertical plate thickness as required by 2.11.4.1.

The depth of bottom transverse shall be increased in proportion to the height at which engine seatings are fitted.

2.3.5 Special requirements.

2.3.5.1 End attachments of bottom members and deep member web stiffening shall satisfy the following requirements:

.1 centre girder and side girders shall be attached to transverse bulkheads by brackets. For size of brackets, refer to 1.7.2.3.

.2 in dry cargo ships, the height of brackets may be reduced to half the centre girder depth if the face plate of centre girder is welded to the transverse bulkhead. In case the centre girder face plate is widened to at least twice the normal value in way of abutting upon the transverse bulkhead, the brackets need not be fitted. If the centre girder is not fitted in the engine room, then at discontinuities beyond bulkheads it shall be terminated in gradually tapered brackets of a length equal to twice the centre girder depth, but not less than three spacings.

.3 in tankers, the bottom transverses shall be attached to side transverses and/or vertical webs of longitudinal bulkheads by brackets. For size of brackets, refer to 1.7.2.3.

The bottom transverses shall be attached to the center girder by brackets, extended to center gireder face plate and welded to it.

.4 In dry cargo ships with length up to 40 m, excluding the 0,25L region from F.P., допускаються side girders without vertical plates, made of T or other profile, welded to floors face plates.

In this case, the cross-sectional area f, in cm^2, of profiles replacing side girders is not to be less than determined by the formula

$$f = 0{,}8\,(B + 10). \qquad (2.3.5.1.4)$$

Profiles which are face plates of side girders witout vertical plates, shall be welded to bulkheads with fitting of brackets of at least the profile depth.

2.3.5.2 If transverse system of framing is adopted, the holes cut in floors shall have a diameter not exceeding half the floor depth in this location. The distance between the hole edge and floor face plate shall not be less than 0,25 times the floor depth in this location. The distance between the edges of adjacent holes shall not be less than the floor depth. Floor plates provided with holes shall be strengthened with vertical stiffeners.

2.3.5.3 The webs of side girders and floors shall be provided with drain holes.

2.4 DOUBLE BOTTOM

2.4.1 General.

Requirements are given in this Chapter for double bottom structures including bottom framing up to the top of bilge rounding, inner bottom plating and framing, centre girder and duct keel, side girders and half-height girders, margin plate with stiffeners, brackets, knees and intermediate vertical stiffeners in the double bottom space, sea chests and drain wells.

Additional requirements for double bottoms are given in 1.1.6.3 (passenger ships), 1.1.6.4 (cargo ships, other than tankers), 3.1 (container ships), 3.3 (bulk carriers and oil/bulk dry cargo carriers), 3.4 (ore carriers and ore/oil carriers), 3.11 (icebreakers).

2.4.2 Construction.

2.4.2.1 In tankers of 80 m in length, bulk carriers and ore carriers, as well as in oil/bulk dry cargo carriers and ore/oil carriers, the double bottom shall be framed longitudinally.

2.4.2.2 The centre girder shall extend fore and aft as far as practicable to the stem and sternframe and shall be attached to them whenever possible. The centre girder shall generally be continuous within at least 0,6L amidships. Where longitudinal framing is adopted in the double bottom, brackets shall be fitted on both sides of centre girder, extended to the nearest longitudinal or ligthened side girder and welded thereto. The distance between brackets shall not exceed 1,2 m.

2.4.2.3 In lieu of centre girder, a duct keel may be fitted consisting of two plates arranged on both sides of the centreline. The spacing between duct keel webs b_k, m, can be determined by the formula

$$b_k = 0{,}004L + 0{,}7. \quad (2.4.2.3)$$

The duct keel shall be wide enough for the access to all its structures to be ensured.

A duct keel of more than 1,9 m in width is subject to special consideration by the Register.

Transverse members with brackets shall be fitted at every frame in way of the bottom and inner bottom plating between the side plates of the duct keel.

If longitudinal system of framing is adopted, brackets shall be fitted at every frame on both sides of the duct keel, similar to those used for the centre girder.

Where the duct keel fitted only over a part of the ship's length terminates and is transformed into the centre girder, the duct keel and centre girder plates shall overlap over a length of at least one frame spacing and shall terminate in brackets with face plates. In this case, the length of the brackets shall not be less than three spacings if the transition areas lie within 0,6L amidships, and not less than two spacings elsewhere.

2.4.2.4 The design of side girders and margin plate shall satisfy the following requirements:

.1 the number of side girders from each side in the middle region of the ship is not to be less than specified in Table 2.4.2.4.1.

the distance between a side girder and centre girder or margin plate, as measured at the level of the double bottom plating, shall not exceed 4,0 m for transversely framed double bottom and 5,0 for longitudinally framed double bottom.

.2 if longitudinal framing is adopted in the double bottom, lightened side girders may be fitted on bottom and double bottom instead of longitudinals (for panels with large openings, refer to 2.4.2.7.2 and 2.4.2.7.4).

Table 2.4.2.4.1

Framing	Ship breadth B, in m	The number of side girders
Longitudinal	$8 \le B < 16$	1
	$16 \le B < 25$	2
	$25 \le B$	3
Transverse	$10 \le B < 18$	1
	$18 \le B < 28$	2
	$28 \le B$	3

.3 where there are two tunnels symmetrical with regard to the centreline, their design is subject to special consideration by the Register.

.4 in the engine room, the arrangement of side girders shall be consistent with that of the engine, boiler and thrust block seatings, so that at least one of the longitudinal girders under the seating is fitted in line with the side girder. In this case, an additional side girder shall be provided under the seating in line with the second longitudinal.

Where side girders cannot be arranged under the seatings in line with longitudinal girders, additional side girders shall be fitted under each longitudinal girder.

Additional side girders may be replaced by half height side girders welded to the inner bottom plating and floors only, if approved by the Register.

.5 inclined margin plate, if fitted, shall extend throughout the double bottom length and have a width, in m, not less than

$b = 0{,}0035L + 0{,}40$.

Horizontal margin plate width is to be (at least 50 mm) more than the amount of the bilge bracket width and the frame profile depth.

2.4.2.5 The arrangement and design of floors shall satisfy the following requirements:

.1 if transverse framing is adopted in the double bottom, plate floors shall be fitted at every frame:

in engine and boiler rooms;

at the fore end within 0,25L from the fore perpendicular;

in the holds intended for the carriage of heavy cargo and ore, as well as in holds from which cargo is regularly discharged by grabs;

in ships which may happen to be aground due to the ebb-tide in ports.

In other regions, plate floors may be fitted five spacings or 3,6 m apart, whichever is less. In this case, provision shall be made for open floors (bracket or lightened).

Bracket floors consist of bottom and reverse frames connected with brackets at centre girder, side girders and margin plate (refer to Fig. 2.4.2.5.1-1).

Lightened floors consist of plate panels having large openings of a smooth shape between side girders (refer to Fig. 2.4.2.5.1-2).

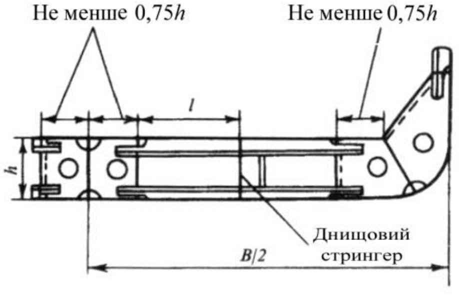
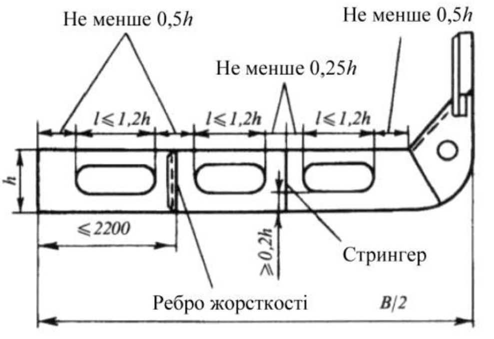


Fig.2.4.2.5.1-1



F.2.4.2.5.1-2

.2 if longitudinal framing is adopted in the double bottom, plate floors shall generally be fitted at a distance not exceeding two spacings from each other:

in engine and boiler rooms;

in the holds intended for the carriage of heavy cargo and ore, as well as in holds from which cargo is regularly discharged by grabs;

at the fore end within 0,25*L* from the fore perpendicular;

in ships which may happen to be aground due to the ebb-tide in ports.

In other regions, plate floors may be fitted five spacings or 3,6 m apart, whichever is less. Where lightened side girders are fitted in lieu of bottom and double bottom longitudinals (refer to 2.4.2.4.2), the above spacing may be increased, but not more than twice.

When the ship's side is framed transversely and double bottom is framed longitudinally, brackets shall be fitted at every frame between plate floors to stiffen the margin plate, which shall be carried to the nearest bottom and inner bottom longitudinals or to the nearest additional side girder, and welded thereto (refer to Fig. 2.4.2.5.2).

Under the seating of main engine, plate floors shall be fitted at every frame and carried to the nearest side girder outside the main engine seating.

Рис.2.4.2.5.2

.3 irrespective of the requirements of 2.4.2.5.1 and 2.4.2.5.2, plate floors shall be fitted:

under pillars and ends of longitudinal partial bulkheads;

under bearers and boiler bearer ends;

under transverse bulkheads and sloping plates of low trapezoidal stools of corrugated bulkheads;

under bracket toes of deep tank bulkhead stiffeners in transversely framed double bottom;

under block bearing seatings.

In the above cases, the floors need not be fitted throughout the ship's breadth. Partial floors may be fitted and carried to the side girder nearest to the structure being stiffened.

2.4.2.6 Arrangement of stiffeners on centre girder and duct keel, side girders and floors shall satisfy the following requirements:

.1 stiffeners shall be provided where transverse system of framing is adopted and plate floors are more than 900 mm in depth. The spacing of stiffeners shall not exceed 1,5 m. The spacing of stiffeners of lightened floors shall not exceed 2,2 m.

If longitudinal system of framing is adopted, the stiffeners on plate floors shall be fitted in line with bottom and inner bottom longitudinals. The stiffeners shall be carried to the longitudinals and welded thereto.

The stiffeners shall be fitted under the pillars, at bracket toes of end stiffeners of longitudinal partial bulkheads, etc поздовжніх напівперего-родок тощо.

.2 watertight floors shall be fitted with vertical stiffeners spaced not more than 0,9 m apart.

2.4.2.7 Holes (manholes) shall satisfy the following requirements.

.1 an adequate number of holes (manholes) shall be provided in the inner bottom plating, side girders and floors for access to all portions of double bottom. The size of the holes, including lightening holes, shall satisfy the requirements of standards or other normative documents recognized by the Register. Air and drain holes, cut-outs for the passage of welded joints, refer to 1.7.5.12.

.2 the holes in centre girder, side girders and floors shall have a smooth rounded shape. The minimum allowable height of the plate adjoining bottom shell plating or inner bottom plating is indicated in Table 2.4.2.7.2.

Besides, the minimum height of the plate in way of the hole shall not be less than l /s of the length of the hole.

The plate height indicated in Table 2.4.2.7.2 may be reduced if suitable stiffening is provided.

Besides, lightened side girder and floor plates shall satisfy the requirements of 2.4.4.5.5, and if the plate height h_0, in mm $h_0 = 25s\sqrt{\eta}$, the free edge of the plate shall be stiffened.

Where: s – lightened side girder or floor height, in mm;

for η – refer to 1.1.4.3;

Table 2.4.2.7.2

Member	Minimum allowable plate height (in parts of member height)
Centre girder	0,3
Side girders	0,25
Lightened side girders	0,15
Floors:	
plate	0,25
lightened	0,2

.3 the distance between the edges of adjacent openings in centre girder, side girders and plate floors shall not be less than half the length of the largest opening.

The distance of the edges of openings in the floors from longitudinal bulkheads, centre girder, side girders, inclined margin plate and inner edges of hopper side tanks shall not be less than half the centre girder depth in this region. The distance of the edge of opening in a lightened floor from the side girder shall not be less than one-quarter of centre girder depth.

In exceptional cases, deviation from the above requirements is permitted.

.4 one or more consecutive openings may be permitted in a lightened side girder web between adjacent floors or in a lightened floor web between adjacent side girders. In the latter case, vertical stiffeners shall be fitted between openings. The length of one opening shall not exceed 1,2 times the accepted depth of centre girder or 0,7 times the distance between floors (side girders) or between a floor (side girder) and vertical stiffener, whichever is less (refer to Fig. 2.4.2.5.1-2). The distance of the edges of openings in lightened side girders and floors from each other shall not be less than half the centre girder depth in this region.

Where the plate height h_0, in mm, in the area of opening in lightened side girders is more than

$$h_0 = \frac{390s}{\sqrt{R_{eH}}}, \qquad (2.4.2.7.4)$$

where s – side girder web thickness, in mm,

horizontal stiffeners are to be insalled near the upper and lower edges of the opening.

.5 normally, openings are not permitted:

in centre girder over a length of 0,751, from the fore perpendicular;

in centre girder and side girders (lightened side girders) under pillars and in sections adjoining transverse bulkheads (between the bulkhead and extreme floor for double bottom with transverse framing and on a length equal to the depth of double bottom with longitudinal framing);

in floors under pillars and in way of partial longitudinal bulkheads; in floors at the toes of brackets transversely supporting main machinery seatings;

in floors between the side (inner side) and the nearest lightened side girder, provided the spacing of floors is increased in accordance with 2.4.2.5.2.

In exceptional cases, openings are permitted in the above members provided the webs in way of the openings are suitably stiffened.

.6 circular lightening openings are permitted for brackets, having a diameter not greater than l / 3 of the width or height of the bracket, whichever is less.

2.4.2.8 За наявності подвійного борту настил другого дна повинний проходити через обшивку внутрішньо-го борту до зовнішньої обшивки.

Where double skin side construction is provided, the inner bottom plating shall extend through the inner skin as far as the shell plating. A side girder shall be fitted in line with the inner skin. Festoon plates may be fitted in lieu of the inner bottom plating inside the double skin side or additional side girder in line with the inner skin.

2.4.2.9 Connections of bottom and inner bottom longitudinals to watertight floors shall be such that the effective sectional area of these members is maintained.

2.4.3 Double bottom loads.

2.4.3.1 The external pressure on double bottom structures is determined by Formula 2.2.3-1.

For design ballast condition, the value of z_i according to 1.3.2.1-2 shall be counted from the design ballast waterline.

2.4.3.2 Double bottom loads from inside:

.1 design pressure on the double bottom from general cargo is determined according to 1.3.4.1;

.2 design pressure on the double bottom from liquid cargo or ballast is determined according to 1.3.4.2;

.3 design pressure on the double bottom from bulk cargo is determined according to 1.3.4.3;

.4 test loads

$$p = 7{,}5h_p, \qquad (2.4.3.2.4)$$

where h_p – vertical distance, in m, from inner bottom plating to the top of air pipe;

.5 loads due to the emergency flooding of double bottom compartments

$$p = 10{,}5\,(d - h), \qquad (2.4.3.2.5)$$

where h - actual depth of double bottom, in m.

2.4.3.3 The total design pressure on the double bottom is defined as a difference between the external pressure p and the cargo (ballast) pressure from inside p_c.

In this case, the value of p_c is defined as the smallest value of counterpressures determined from 2.4.3.2.1–2.4.3.2.3 with $p > p_c$, and as the greatest of the above values with $p < p_c$.

If a hold may be empty during service, the external pressure p shall be taken as the design pressure.

2.4.4 Scantlings of double bottom members.

2.4.4.1 At centre girder, the depth of double bottom h, м, in m, shall not be less than

$$h = \frac{k_m}{k_\sigma \sigma_n} \frac{mpL_1^2}{s}, \qquad (2.4.4.1\text{-}1)$$

where k_m – factor equal to:

1,0 – for dry cargo ships and tankers;

0,8 – for bulk carriers;

m – factor determined by the Formula

$$m = a_1\left(\frac{L_1}{B_1}\right)^2 + b_1\frac{L_1}{B_1} + c_1;$$

for k_σ, a_1, b_1, c_1 – refer to Table 2.4.4.1;

p – as defined in 2.4.3.3;

$$s = \frac{\sum_{i=1}^{n} s_i b_i}{\sum_{i=1}^{n} b_i},$$

where s – the average thickness of the bottom plating, in mm;

b_i – width of the i-th portion of the plating, having the thickness s_i between the cntre girder and the first side girder;

n – number of plating portions.

Table 2.4.4.1

Structural type of ship	a_1	b_1	c_1	k_σ
Dry cargo ship:				
With one side	0,0056	–0,082	0,170	0,7

With double side and tankers	0,0330	–0,153	0,201	0,7
Bulk cargo:				
alternate holds with heavy cargo and empty holds;	0,0880	–0,272	0,217	0,4
sequential location of two or more holds with heavy cargo	–0,0200	–0,018	0,109	0,7

Double bottom depth h_{min}, in m, in all cases shall be taken no less than determined by the formula

$h_{min} = 0{,}0078L + 0{,}13$,   (2.4.4.1-2)

but not less than 0,76 m.

2.4.4.2 Scantling of centre girder and girders are to comply with the following requirements:

.1 Sectional area $f_{ст}$, in cm^2, of centre girder web and girders (with the deduction of openings) is not to be less than determined by the Formula (1.6.4.3) for $k_\tau = 0{,}9$ and maximum shear force value:

$N_{max} = n_0\, n_1\, n_2\, pL_1\, a$,   (2.4.4.2.1)

where n_0 – factor determined by the formula:

$$n_0 = a_2\left(\frac{L_1}{B_1}\right)^2 + b_2\frac{L_1}{B_1} + c_2$$

where a_2, b_2, c_2 – refer to Table 2.4.4.2.1;

n_1 – ractor determined by the Formula (depending on position considered ml area of centre girder (girder) determined by the Formula:

$n_2 = 1 – 0{,}25y_1/B_1 – 3{,}5\,(y_1/B_1)^2$,

wher y_1 – distance, in m, between considered sectional area of centre girder and middle of the hold;

p – in accordance with 2.4.3.3.

.2 The web thickness, in mm, of centre girder (duct keel) s_{min} shall not be less than

$s_{min} = 0{,}035L + 6{,}5$ mm.   (2.4.4.2.2-1)

If transverse system of framing is adopted, the web thickness of side girder is not to be less than determined by the Formula

$s_{min} = 0{,}035L + 5$ мм.   (2.4.4.2.2-2)

If longitudinal system of framing is adopted, the minimum web thickness of side girder is to be determined in accordance with 2.4.4.9.

Таблиця 2.4.4.2.1

Structural type of ship and double bottom grillage	Memeber	a_2	b_2	c_2
Dry cargo ship with one side	centre girder	0,044	–0,387	0,811
	girders	0,022	–0,303	0,675
	floors	–0,061	0,378	–0,161
Dry cargo ship with double side and tankers	centre girder	0,094	–0,514	0,847
	girders	0,044	–0,353	0,660
	floors	–0,050	0,338	–0,059
For bulk cargoes	centre girder	0,180	–0,670	0,820
	girders	0,160	–0,600	0,670
	floors	–0,240	0,780	–0,100

.3 the buckling strength of centre girder web and of side girders, as well as of longitudinal stiffeners fitted along them shall be ensured in accordance with 1.6.5.

.4 at ends within 0,11, from the fore and after perpendiculars, the centre girder web thickness may be 10 per cent less than that in the midship region, as determined for steel used at ends, but not less than the minimum thickness stipulated under (2.4.4.2.2-1).

Товщина непроникних ділянок вертикального кіля і стрингерів повинна бути не менше необхідної для непроникних флорів у даному районі (див.2.4.4.3.3), але може не перевищувати товщину прилеглих до них листів зовнішньої обшивки.

The thickness of side plates of the duct keel shall not be less than 0,9 of that required for the centre girder in this region.

2.4.4.3 Floors shall satisfy the following requirements:

.1 Cross-sectional area $f_{ст}$, см^2, of watertight floors web (excluding openings) is not to be less than determined by Formula (1.6.4.3) with $k_\tau = 0,9$ and maximum shear force value:

$$N_{max} = n_0\, n_1\, n_2\, p\, B_1\, a\,, \quad (2.4.4.3.1)$$

for n_0 – refer to 2.4.4.2.1;

$n_1 = 2y_1/B_1$;

y_1 – spacing of the floor, under consideration, cross-section from the middle of the width of the hold (compartment), in m;

$n_2 = 1 – 0,25x_1/L_1 – 3,5\,(x_1/L_1)^2$;

x_1 – calculated floor spacing from the middle of the length of the hold, in m;

p – as defined in 2.4.3.3.

.2 the floors shall be stiffened in accordance with 1.7.3.2.

the thickness of plate floors s_{min}, in mm, in all ship regions shall not be less than:

for transverse framing system

$$s_{min} = 0,035L + 5 \text{ мм}; \quad (2.4.4.3.2\text{-}1)$$

for longitudinal framing system

$$s_{min} = 0,035L + 6 \text{ мм}. \quad (2.4.4.3.2\text{-}2)$$

.3 the thickness of watertight floors shall not be less than determined by Formula (1.6.4.4) taking:

$p = p_p$ as determined by 2.4.3.2.4 for the middepth of the floor;

$k_\sigma = 0,8$;

$m = 15,8$.

In any case, the thickness of watertight floors shall not be less than that required for plate floors in this region.

2.4.4.4 Inner bottom plating and margin plate shall satisfy the following requirements.

.1 the thickness of inner bottom plating, including margin plate, shall not be less than determined by Formula (1.6.4.4) taking:

$m = 22,4$;

p – maximum design pressure as stipulated under 2.4.3.2.1–2.4.3.2.4;

$k_\sigma = 1,2$ і 1,0 for longitudinal m and transverse framing system accordingly.

.2 in any case, the thickness of inner bottom plating s_{min}, in mm, shall not be less than:

$$s_{min} = 0,05L + 3,8 \text{ mm for } L < 80 \text{ m}, \quad (2.4.4.4.2)$$

$$s_{min} = 0,035L + 5 \text{ mm for } L \geq 80 \text{ m}.$$

The thickness of inner bottom plating in holds into which water ballast may be taken, as well as in the cargo (ballast) tanks of tankers shall not be less than stipulated under 3.5.4.

In the engine room and holds under cargo hatches where no wood sheathing is provided, s_{min} shall be increased by 2 mm.

In holds where no wood sheathing is provided and cargo is discharged by grabs, s_{min} shall be increased by 4 mm.

.3 in the midship region of ships of 65 m and greater in length, the buckling strength of inner bottom plating and margin plate shall be ensured in accordance with 1.6.5.

2.4.4.5 Primary members of bottom and inner bottom shall satisfy the following requirements:

.1 the section modulus of bottom and inner bottom longitudinals, as well as of the bottom and reverse frames of bracket floors and duct keel shall not be less than stipulated under 1.6.4.1 taking:

p – design pressure, in kPa, determined for bottom longitudinals and the bottom frames of bracket floors and duct keel in accordance with 2.4.3.1, and for inner bottom longitudinals and the reverse frames of bracket floors and duct keel, in accordance with 2.4.3.2.1–2.4.3.2.4;

$m = 12$;

l – design span, in m, of longitudinal, defined as the spacing of floors for bottom and inner bottom longitudinals, as the distance betwen bracket toes or between a bracket toe and side girder for the bottom and reverse frames of bracket floors, as the spacing of webs for duct keel;

k_σ – is taken as follows:

for bottom longitudinals $k_\sigma = 0{,}3+x_1/L$;

for inner bottom longitudinals $k_\sigma = 0{,}4+x_1/L$,

where x_1 – longitudinall midspan spacing from midships, in m; for $x_1/L \le 0{,}2$ value of x_1/L is taken equal to 0,2; for $x_1/L \ge 0{,}4$ value of x_1/L is taken equal to 0,4;

for bottom frames of bracket floors and duct keel $k_\sigma = 0{,}8$.

.2 if intermediate struts are fitted at mid-span between bottom and inner bottom longitudinals, the section modulus of such longitudinals may be reduced by 35 per cent.

.3 if the ratio of the span of a bottom or inner bottom longitudinal to its depth is less than 10, the sectional area of the longitudinal web shall not be less than determined by Formula (1.6.4.3-1) taking $N_{max} = 0{,}5pal$ (*p*, *l* – design pressure and design span of longitudinal as stipulated under 2.4.4.5.1), $k_\tau = 0{,}70$.

.4 in the midship region of ships of 65 m in length and above, the buckling strength of bottom and inner bottom longitudinals shall be ensured in accordance with 1.6.5;

.5 at the centre of openings in lightened side girders and floors, the section modulus of the plate adjoining the shell plating or inner bottom plating shall comply with the requirements of 2.4.4.5.1 for bottom and inner bottom longitudinals and transverses respectively. In this case, the design span / shall be taken equal to the greatest opening length minus its rounding-off radius. The plate section shall 56 Rules for the Classification and Construction of Sea-Going Ships include the effective flange of shell plating (inner bottom plating), as described under 1.6.3.2 and 1.6.3.3, as well as the flange or horizontal stiffener of the free edge of the plate, if these are fitted.

2.4.4.6 The stiffeners on the watertight sections of centre girder (duct keel), side girders and floors shall satisfy the following requirements:

.1 the section modulus of vertical stiffeners on the watertight sections of centre girder (duct keel), side girders and floors shall not be less than stipulated under 1.6.4.1 taking:

$p = p_p$ – as determined by 2.4.3.2.4 for mid-height of vertical stiffener;

l – span, in m, of stiffener, defined as the spacing of longitudinals to which the stiffener is welded or as double bottom depth if the stiffener is not in line with bottom or inner bottom longitudinals;

m = 8 and 10 for stiffeners sniped at ends and welded to the bottom and inner bottom longitudinals respectively;

$k_\sigma = 1$.

.2 the section modulus of horizontal stiffeners on the centre girder (duct keel) and side girders shall not be less than stipulated under 1.6.4.1 taking:

$p = p_p$ – as determined by 2.4.3.2.4 for the level of the horizontal stiffener considered;

l – distance, in m, between floors or between floors and brackets (refer to 2.4.2.2);

$m = 12$;

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

.3 in the midship region of ships of 65 m and greater in length buckling strength of horizontal stiffeners on the centre girder (duct keel) and side girders shall be ensured in accordance with 1.6.5.

2.4.4.7 The intermediate struts between bottom and inner bottom longitudinals, as well as between bottom and reverse frames of bracket floors shall satisfy the following requirements:

.1 the sectional area f, in cm^2, of intermediate struts shall not be less than

$$f = \frac{10pal}{k_\sigma \sigma_n} + 0{,}1h\Delta s\,, \qquad (2.4.4.7.1)$$

where p – design pressure, in kPa, defined as the greater of the values of p or p_c according to 2.4.3.1 or 2.4.3.2, whichever is the greater;

l – design span, in m, of stiffened longitudinals;

$k_\sigma = 0{,}5$;

h – height, in cm, of the strut cross section;

for Δs – refer to 1.1.5.1.

.2 the inertia moment i, in cm^4, of intermediate struts shall not be less than

$$i = 0{,}012\, f\, l^2 R_{eH}, \qquad (2.4.4.7.2)$$

where f – sectional area of intermediate struts as given in 2.4.4.7.1;

l – length, in m, of intermediate strut.

2.4.4.8 The thickness of brackets of centre girder (duct keel) and margin plate, as well as of the brackets of bracket floors and the brackets connecting bottom and inner bottom longitudinals to watertight floors, if the longitudinals are cut at the floors, shall not be less than the thickness of plate floors adopted in this region.

In way of centre girder and margin plate, the thickness of brackets fitted in line with the bracket floor shall not be less than 0,75 of the centre girder depth. The free edges of brackets shall be provided with flanges or face plates.

The side girder fitted in line with the bracket floor shall be provided with a vertical stiffener whose profile shall be selected in the same way as that of the reverse frame of the floor.

The arm length of brackets connecting longitudinals on the bottom and inner bottom plating to watertight floors shall not be less than 2,5 times the bottom longitudinal depth (refer to Fig. 2.4.4.8).

The scantlings of knees by which bottom and reverse frames of the duct keel are secured shall be determined in accordance with 1.7.2.2.

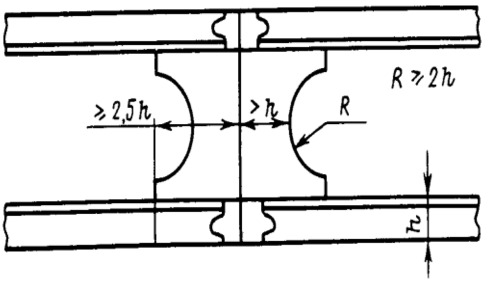


Fig.2.4.4.8

2.4.4.9 Structural members inside the double bottom shall have a thickness s_{min}, in mm, not less than:

$$s_{min} = 0{,}045L + 3{,}9 \text{ mm for } L<80 \text{ m}, \quad (2.4.4.9)$$

$$s_{min} = 0{,}025L + 5{,}5 \text{ mm for } L\geq80 \text{ m}.$$

Where L > 250 m, L shall be taken equal to 250 m.

For centre girder, s_{min} shall be increased by 1,5 mm.

2.4.4.10 When carrying out updated calculations of bottom grillage, as a rule, the following basic provisions are to be met:

the load on the double bottom shall be determined in accordance with 2.4.3;

as the basic method of idealizing the design, rod idealization is to be used, with the specification of the width of the members face plates;

the limiting conditions for the framing members are to be determined depending on the distribution of the cargo along the length and breadth of the vessel and the type of structures adjcent to the calculated grillage construction, or from the calculation of the double bottom within the compartment or group of compartments;

safety factors are to be determined taking into account those given in 2.4.4, but they may be refined in agreement with the Register.

In the area of holds intended for the transport of heavy loads, the strength of the double bottom members is to be checked by calculating the strength of the bottom grillage for the effect of design loads according to 2.4.3 in accordance with the requirements of 3.3.4.1.1.

2.4.5 Special requirements.

2.4.5.1 Partial double bottom and stiffening in way of variable double bottom depth shall satisfy the following requirements:

.1 where the double bottom terminates, gradual transition from longitudinal members of double bottom to those beyond it shall be ensured.

The inner bottom plating shall be gradually tapered (on a length of at least three frame spaces) into the face plates of centre girder and side girders of single bottom. In way of the double bottom boundary, the width of these face plates shall be not less than half the distance between adjacent side girders.

The margin plate shall extend beyond the double bottom as a bracket with the height equal to the margin plate width and the length equal to at least three frame spaces, with a face plate or flange along its free edge.

.2 where the double bottom depth changes in the form of a knuckle, one end of the knuckle shall be in way of a transverse bulkhead and the other, on the fplate floor. However, both the knuckles may be arranged on plate floors in which case the structure is subject to special consideration by the Register.

.3 where the double bottom depth changes in the form of a step, the latter shall normally be arranged on a transverse bulkhead.

At the step, the inner bottom plating of the lower section should extend for a length of three frame spaces when $L \geq 80$ m and for two frame spaces when $L < 80$ m.

Forward (or aft) of the end of the extension the general requirements for partial double bottom shall be complied with.

If the step is arranged beyond 0,5*L*, amidships or if the height of the step is less than 660 mm, the double bottom structure in way of the extension is in each case subject the special consideration by the Register.

.4 continuity and reduction of stress concentrations shall be ensured in way of the step where a variation of the depth of centre girder, side girders, margin plate and inner bottom longitudinals takes place (if longitudinal system of framing is adopted).

2.4.5.2 Bilge wells, sea chests and ice boxes shall satisfy the following requirements:

.1 in cargo ships, the bilge wells shall, as far as practicable, satisfy the requirements of 1.1.6.5.3 and 1.1.6.6.3.

The capacity of bilge wells is specified in Part VIII "Systems and Piping".

The thickness of the walls and bottom plates of a bilge well shall exceed that of watertight floors by not less than 2 mm.

.2 the thickness of the floors, side girders and inner bottom plating forming the walls of sea chests shall be 2 mm greater than that required by 2.4.4.2 – 2.4.4.4.

In any case, the thickness of sea chest and ice box walls shall be not less than that required by 2.2.4.1 for the shell plating in the region under consideration.

2.4.5.3 When oil fuel tanks are arranged in the double bottom, the manholes in the tank tops arranged within the engine and boiler rooms for access to the tanks shall be provided with coamings not less than 0,1 m in height, besides the general provisions for the arrangement of fuel oil tanks.

2.4.5.4 Where the bed plate of main engine and the thrust block are seated directly on the inner bottom plating, insert plates having a thickness not less than stipulated under 2.11.3. shall be welded to the plating under the supporting parts of bed plate and thrust block. The size of welded inserts shall be such as to ensure an adequate arrangement of supports and the attachment of machinery, and shall in any case be not less than that of the supporting parts of bed plate. Where the engine bed plate and thrust block are fitted on the inner bottom plating, two girders, or one girder and a half-height girder shall be provided in way of their arrangement along each welded insert plate. The upper part of the girder webs shall have the same thickness as the welded insert for at least 0,2 of the girder depth, or alternatively, the thickness of the webs throughout their depth shall be as required by 2.11.4 for the vertical plates of seatings.

Between the girders, a horizontal stiffener of the size required in the foregoing for the upper part of girder webs shall be fitted, account being taken of the holes for the holddown bolts of the bed plate.

On agreement with the Register, only one side girder may be fitted under the welded insert plate for small power engines.

2.4.5.5 The plating of the recess under the engine crankcase, as well as the side girders and floors by which it is confined, shall have a thickness 2 mm greater than that of the inner bottom plating in this region.

The minimum distance from the recess plating to the bottom shell plating shall not be less than 460 mm.

2.5 SIDE FRAMING

2.5.1 General.

2.5.1.1 Requirements are given in this Chapter for side frames, web frames (side transverses), side longitudinals, side stringers, cross ties connecting side transverses to vertical webs on longitudinal bulkheads in tankers, as well as for specific structures of double skin side.

2.5.1.2 By the double skin side construction, a side structure is meant which consists of watertight side shell plating and inner skin, both either strengthened with frames and longitudinals or not, and connected with plate structures perpendicular thereto: vertical (diaphragms) and/or horizontal (platforms). I f no diaphragms or platforms are fitted, the inner skin together with framing shall be considered as longitudinal bulkhead and shall comply with the requirements of 2.7.

2.5.1.3 Symbols:

l – span of side longitudinal, measured:

.1 in dry cargo ships:

between upper edge of inner bottom or floor and lower edge by the side (Fig. 2.5.1.3.1-1and 2.5.1.3.1-2);

For hold frames l is not to be adopted less than 3m for single deck ships,

3,5 m for deckers;

between decks for tweendeck frames but not less than 2,6 m;

.2 in tankers:

between girders or between girder and mid-height of bilge bracket for the frames;

between deep frames or deep frame and transverse bulkhead, whichever the greater, for side longitudinals;

between inner edges of floor and deck transverses for deep frame (refer to Fig. 2.5.1.3.2);

between transverse bulkheads including knees for girders; between deep frames or between deep frame and transverse bulkhead where deep frames are used.

The calculation of design span of vertical and horizontal diaphragms of double skin side is subject the special consideration by the Register.

2.5.2 Construction.

2.5.2.1 When the ship's side is framed transversely, side stringers may be provided.

Side stringers shall be fitted at a distance of not more than 3.5 m from each other, from the deck or from the main line.

In tankers with two or more longitudinal bulkheads, fitting of cross ties is recommended between the side stringers and horizontal girders of longitudinal bulkheads.

Web frames may be fitted if the ship's side is framed transversely, and they shall be fitted, if the ship's side is framed longitudinally.

They shall be fitted in line with plate floors, as well as with deep beams, if any.

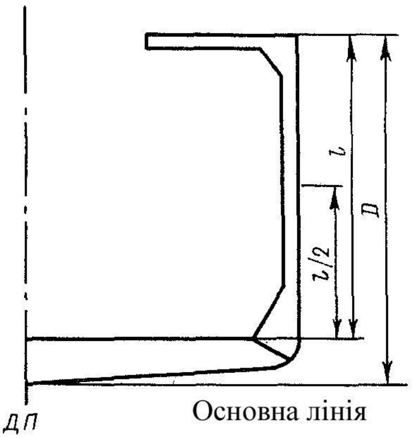


Fig. 2.5.1.3.1-1. Single deck ships

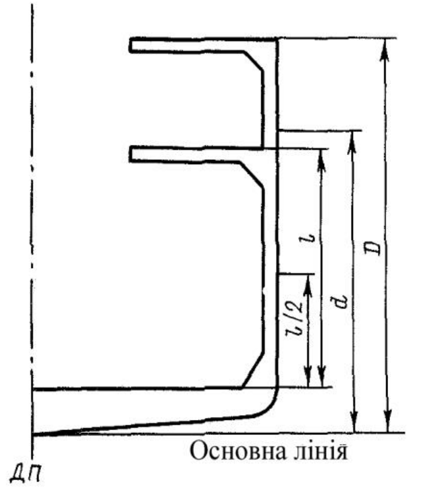


Fig. 2.5.1.3.1-2. Multi deck ships

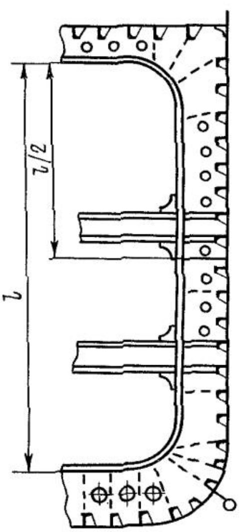


Fig.2.5.1.3.2

In tankers with two or more longitudinal bulkheads, fitting of cross ties is recommended between side transverses and vertical webs of longitudinal bulkheads.

2.5.2.2 Structures of double skin side shall satisfy the following requirements~~Конструкція подвійного борту повинна відповідати наступним вимогам~~:

.1 if the same framing system is adopted for side shell and inner skin, fitting of frames or longitudinals of both side shell and inner skin in line with each other is recommended. In this case, cross ties may be fitted between the frames or longitudinals of the side shell and inner skin, which shall be arranged at midspan of relevant members~~при однаковій системі набору зовнішнього і внутрішнього бортів рекомендується розташовувати шпангоути або поздовжні балки обох бортів в одній площині. При цьому між шпангоутами або го-~~

~~ризонтальними балками зовнішнього і внутрішнього бортів відповідно допускається установлення розпірок, що розташовуються посередині прогону відповідних балок~~;

.2 diaphragms or platforms shall be stiffened in accordance with 1.7.3.2. In this case, the shorter side, in mm, of panel of the diaphragm or platform being stiffened shall not exceed ~~діафрагми або платформи повинні бути підкріплені ребрами жорсткості згідно 1.7.3.2. При цьому менша сторона панелі діафрагми, що підкріпляється, або платформи, мм, не повинна перевищувати~~

$100s\sqrt{\eta}$ -,

where *s* is the thickness, in mm, of the diaphragm or platform~~Тут: s – товщина діафрагми чи платформи, мм~~;

for η – ~~див.~~refeer to 1.1.4.3;

.3 an appropriate number of openings (manholes) shall be provided in the diaphragms and platforms for access to all the structures of double skin side.

The total breadth of openings in a diaphragm or platform section shall not exceed 0,6 of the double skin side breadth.

The edges of openings in diaphragms and platforms, arranged within l/4 of the span from their supports, shall be reinforced with collars or stiffeners.

The distance between the edges of adjacent openings shall not be less than the length of the openings. Normally, openings are not permitted, with the exception of air and drain holes:

in platforms on a length not less than three frame spaces or 1,5 times the double skin side breadth, whichever is less, from transverse bulkheads or partial bulkheads, which serve as platform supports;

in diaphragms on a length not less than 1,5 times the double skin side breadth from deck plating and/or double bottom, which serve as diaphragm supports~~для доступу до всіх частин подвійного борту в діафрагмах і платформах повинна бути передбачена необхідна кількість вирізів (лазів). Сумарна ширина вирізів у одному перерізі діафрагми або платформи не повинна перевищувати 0,6 ширини подвійного борту.~~

~~Кромки вирізів в діафрагмах і платформах, розташованих на ділянках в межах 1/4 прогону від їх опор, повинні бути підкріплені поясками або ребрами жорсткості.~~

~~Відстань між кромками суміжних вирізів повинна бути не менше довжини цих вирізів.~~

~~Вирізи, крім шпігатів для перетоку рідини і повітря, як правило, не допускаються:~~

~~у платформах – на ділянках довжиною не менше трьох шпацій або 1,5 ширини подвійного борту, залежно від того що менше, від поперечних перегородок або напівперегородок, які є опорами платформи;~~

~~у діафрагмах – на ділянках довжиною не менше 1,5 ширини подвійного борту від настилу палуб та/або подвійного дна, які є опорами діафрагми.~~

~~Вирізи в діафрагмах і платформах повинні бути розташовані довгою віссю паралельно бортовій обшивці~~.

2.5.2.3 In the engine room, the side framing shall be strengthened by fitting of web frames and side stringers~~У машинному відділенні бортовий набір~~

~~повинний бути підсилений встановленням рамних шпангоутів і стрингерів~~.

The web frames shall be fitted not more than 5 standard spacings or 3 m apart, whichever is the greater. The web frames shall be arranged taking into account the location of main engine, i.e. they shall be fitted at the extremities of the engine at least. In the engine room, the web frames shall be carried to the nearest continuous platform.

Deep beams shall be fitted in line with web frames. In the engine room, the side stringers shall be fitted so that the vertical distance between them, as well as between a side stringer and deck or tank top (upper edge of floor) at side does not exceed 2,5 m~~Рамні шпангоути повинні бути встановлені на відстані, що не перевищує 5 нормальних шпацій або 3 м залежно від того, що більше. Розташування рамних шпангоутів повинно бути погоджене з положенням двигуна: вони повинні бути бути встановлені принаймні у площині кожного з торців двигуна. За висотою борту рамні шпангоути повинні бути доведені до найближчої безперервної в районі машинного відділення платформи. У площині рамних шпангоутів повинні бути передбачені рамні бімси.~~

~~Бортові стрингери в машинному відділенні повинні розташовуватися таким чином, щоб виміряна по вертикалі відстань між ними, а також між бортовим стрингером і палубою або настилом другого дна (верхньою кромкою флора) не перевищувала 2,5 м~~.

2.5.3 Side loads~~Навантаження на кон-струкції борту~~.

2.5.3.1 The design pressure on the side shell shall be determined in accordance with~~Розрахунковим тиском на конструкції зовнішнього борту є зовнішній тиск *p*, визначений за формулою~~ (2.2.3-1). In way of tanks, the pressure determined in accordance with ~~В районі цистерн додатково необхідно враховувати тиск, визначений згідно з~~ 1.3.4.2 shall additionally be taken into consideration.

The design pressure on the side shell shall be take at least ~~Розрахунковий тиск на конструкції внутрішнього борту повинний братися не менше~~ 25 ~~кПа~~kPa. The design pressure on the superstructures side shell shall not be taken less ~~Розрахунковий тиск на конструкцію борту надбудов повинний бути не менше того, що вимагається згідно з~~than required under 2.12.3.1 ~~для бокових перегородок рубок~~for deck house side shell.

2.5.3.2 The design pressure on double skin side structures shall be determined as follows~~Розрахунковий тиск на конструкції подвійного борту повинний визначатися наступним чином~~:

.1 the design pressure on the inner skin and framing shall be determined in accordance with 1.3.4.2 or 1.3.4.3 depending on the kind of cargo carried and on whether the double side space is used as tank space, but shall not be less than the design pressure on watertight bulkhead structures, as stipulated under 2.7.3.1~~розрахунковий тиск на обшивку і набір внутрішнього борту повинний визначатися згідно 1.3.4.2 чи 1.3.4.3 залежно від виду вантажу, який пере-~~

возиться, і використання міжбортового простору як цистерн, але повинний бути не менше розрахункового тиску на конструкції водонепроникних перегородок згідно з 2.7.3.1;

.2 the scantlings of cross sections of diaphragms and platforms are determined using the design pressure specified in розрахунковий тиск на діафрагми і платформи при визначенні розмірів їх поперечного перерізу, визначають згідно з 2.2.3;

.3 the design pressure on the watertight sections of diaphragms and platforms bounding the tanks in the double side space shall be determined in accordance with 1.3.4.2. розрахунковий тиск на непроникні ділянки діафрагм і платформ, що обмежують цистени в міжбортовому просторі, визначають згідно з 1.3.4.2. However, it shall not be taken less than the test pressure specified in accordance with AnnexПроте не повинний братися менше ніж випробувальний напір, визначений відповідно до Додатка 1.

2.5.4 Member scantlings of side structuresРозміри в'язей бортових конструкцій.

2.5.4.1 If transverse system of framing is adopted, the section modulus of hold frames in dry cargo ships and of side frames in tankers shall not be less than determined from 1.6.4.1 takingМомент опору трюмних шпангоутів суховантажних суден і шпангоутів наливних суден при поперечній системі набору повинний бути не менше визначеного за 1.6.4.1. При цьому:

p – as defined in 2.5.3.1; the value of p for the side shell shall not be less thanзгідно з 2.5.3.1, але не менше ніж гідростатичний напір від середини прогону шпангоута до верхньої палуби біля борту;

m – коефіцієнт, що дорівнюєfactor equal to:

14,5; 16,0 і 17,5 – for frames of dry cargo ships with one, two and three or more decks accordinglyдля шпангоутів суховантажних суден відповідно з однією, двома, і трьома і більше палубами відповідно;

11,0 – for frames of tankersдля шпангоутів наливних суден;

k_σ – factor equal toкоефіцієнт, що дорівнює:

1,0 – for dry cargo ships hold framesдля трюмних шпангоутів суховантажних суден;

0,7 – for frames of tankersдля шпангоутів наливних суден.

2.5.4.2 The section modulus of 'tween deck frames shall not be less than determined from 1.6.4.1 takingМомент опору шпангоутів у міжпалубних приміщеннях і надбудові повинний бути не менше визначеного за 1.6.4.1. При цьому:

p – design pressure, as stipulated under 2.5.3.згідно з 2.5.3.1 (for tweendeck frames not less than hydrostatic pressure from frame midspan to the upper deck at the sideдля шпан-гоутів твіндека не менше ніж гідростатичний напір від середини прогону шпангоута до верхньої палуби біля борту);

m – factor which is takenкоефіцієнт, який приймається:

4,2 – for two-decked ships tweendeckдля твіндека двопалубних суден;

6,4 – for lower tween-deck of multi decked shipsдля нижніх твіндеків багатопалубних суден;

4,7 – for upper tween-deck ~~для верхнього твіндека багатопалубного судна~~of multi decked ship and superstructure~~і надбудови~~;

k_σ – factor equal to~~коефіцієнт, що дорівнює~~: 0,8 – for lower tween-deck of multi decked ships~~для нижніх твін-деків багатопа-лубних суден~~; 1,2 – ~~для твіндека дво-палубного судна~~for double-decled ship twin-deck, for upper tween-deck of multi decked ship and superstructure~~верхнього твіндека багатопалубного судна і надбудови~~;

ω_k = 1 – ~~для~~ for superstructures~~надбудов~~.

The above applies in case the lower end of 'tween deck frame is not stiffened by a bracket. I f the lower end of the frame is stiffened by a bracket of a height not less than ~~Зазначене вище стосується випадку, коли нижній кінець шпангоута у твіндеку не підсилений кницею. Якщо нижній кінець шпангоута підкріплений кницею висотою не менше~~ $0,1l$ and the section modulus of the frame in way of deck is not less than 1,75 of the section modulus determined above, taking the bracket into consideration, the section modulus of 'tween deck frame may be reduced by 30 per cent~~і момент опору перерізу шпангоута біля палуби з урахуванням книці складає не менше 1,75 моменту опору, визначеного вище, момент опору шпангоута у твіндеку може бути зменшений на 30 %~~.

The section modulus of tween deck and superstructure frames shall not be less than ~~У будь-якому випадку момент опору шпангоутів у міжпалубному приміщенні або надбудові повинний братися не менше~~ 12 ~~см³~~cm³.

2.5.4.3 The section modulus of side longitudinals of all ships shall not be less than determined according to ~~Момент опору поздовжніх бортових балок усіх суден повинний бути не менше визначеного за~~ 1.6.4.1 taking~~.~~

~~При цьому~~:

p – as defined in ~~відповідно до~~ 2.5.3.1;

m = 12;

for k_σ – ~~за табл.~~refer to Table2.5.4.3.

The buckling strength of three upper and three lower longitudinals in the midship region of ships 65 m and greater in length shall be ensured in accordance with ~~Стійкість трьох верхніх і трьох нижніх балок в середній частині судна довжиною $L \geq 65$ м повинна бути забезпечена у відповідності до~~ 1.6.5.

~~Таблиця~~ Table 2.5.4.3

Position of longitudinals on side height~~Положення балок за висотою борту~~	k_σ	
	dry cargo ships~~суховантажні судна~~	~~наливні судна~~tankers
~~Від палуби в межах~~Within 0,25*D* from deck	0,45	0,45
~~Посередині висоти між~~In the midheight within 0,25*D* ~~від палуби і~~from deck and 0,25*D* ~~від днища~~from bottom	0,55	0,50
Within 0,25*D* from bottom ~~Від днища в межах 0,25*D*~~	0,45	0,45

2.5.4.4 In a transversely framed side, the section modulus of side stringers shall not be less than stipulated under 1.6.4.1 taking~~Момент опору бортових стрингерів при поперечній системі набору борту повинний бути не менше визначеного за 1.6.4.1. При цьому~~:

$k_\sigma = 0{,}5$;

p – as defined in ~~відповідно до~~ 2.5.3;

m – ~~коефіцієнт, що дорівнює~~ with cross ties: 18,4 – without cross ties~~за відсутності розпірок~~; 29,0 і 37,0 – with one, two or more cross ties~~за наявності однієї, двох і більше розпірок відповідно~~.

If web frames and cross ties are fitted (refer to 2.5.4.5), the scantlings of side stringer section may taken ~~За наявності рамних шпангоутів (див.2.5.4.5) і перев'язки розпірками з поздовжньою перегородкою момент опору бортового стрингера повинний визначатися при~~for m = 8,9.

~~Висота стінки стрингера~~The stringer web height ~~повинна бути в цьому разі не менше~~ is not to be less than 0,08*l* .

2.5.4.5 The section modulus of web frames (side transverses) fitted in the holds of dry cargo ships ~~Момент опору рамних шпангоутів (якщо вони установлені) суховантажних суден у трюмі повин-ний визначатися відповідно до~~shall be determined according to 2.5.4.1, and in tween decks~~а в міжпалубних приміщеннях~~ according to ~~– за~~ 2.5.4.2 with compulsory increase of values obtained by ~~з обов'язковим збільшенням отримуваних значень на~~ 30 %.

The section modulus of web frames ~~Момент опору рамних шпангоутів наливних суден~~of tankers повинний shall not be less than stipulated under 1.6.4.1 taking~~бути не менше визначеного за 1.6.4.1. При цьому~~:

p – as defined in ~~відповідно до~~ 2.5.3;

m equal to~~– коефіцієнт, що дорівнює~~:

21 – without cross ties~~за відсутності розпірок~~;

29, 35 ~~і~~ and 42 – with ~~за наявності~~ one, two and three ~~однієї, двох і трьох~~ cross ties accordingly~~розпірок відповідно~~;

$k_\sigma = 0{,}5$.

The cross-sectional area $f_{ст}$, in cm~~Площа поперечного перерізу стінки рамного шпангоута $f_{ст}$~~, considering ~~см², –~~openings, shall not be less than stipulated under 1.6.4.3 taking

~~з урахуванням вирізів повинна бути не мен-ше визначеної за формулою (1.6.4.3) при~~

$$N_{max} = npal, \qquad (2.5.4.5)$$

де *n* – with cross ties ~~коефіцієнт, що дорівнює~~ 0,33 – without cross ties~~за відсутності розпірок~~, 0,23 і 0,21 – with one, two or more cross ties~~за наявності однієї, двох і більше розпірок~~;

k_τ = 0,65 ~~для наливних суден і~~for tankers and 0,8 ~~для суховантажних~~dry cargo ships;

p – as defined in ~~відповідно до~~ 2.5.3.

The depth ~~Висота стінки рамного шпангоута~~of web frame ~~– за наявності розпірок~~with cross ties, ~~що з'єднують рамні шпангоути~~connecting web frame ~~з~~ with the longitudinal bulkhead ~~рамними стояками~~web cross ties~~ поздовжньої перегородки~~, ~~повинна бути не менше~~shall not be less than 0,08*l*, ~~за відсутності розпірок~~without cross ties 0,12*l*.

The depth of web frame (side transverse) webs may be taken variable over the ship's depth with reducing at the top end and increasing at the bottom end. Variation of web depth shall not exceed 10 per cent of its mean value.~~Висота стінки рамного шпангоута може бути прийнята змінною за висотою зі зменшенням її у верхньому кінці і збільшенням у нижньому. Ця зміна висоти може становити 10 % її середнього значення.~~ For stiffening of web frames refer to ~~Вимоги до підкріплень рамних шпангоутів — див.~~1.7.3.2.

2.5.4.6 The sectional area~~Площа поперечного перерізу розпірки~~ f, ~~см²~~ in cm², of a cross tie fitted between deep members of side framing and of longitudinal bulkhead shall not be less than ~~повинна бути не менше визначеної за формулою~~

$$f = \frac{40}{\sigma_n} p a a_i + 0{,}05\sum h_i \Delta s, \quad (2.5.4.6\text{-}1)$$

where~~де~~ p – design pressure, in kPa, at mid-length of a cross tie, as determined from ~~розрахунковий тиск на рівні центра розпірки, визначений відповідно до~~ 2.5.3.1 ~~або~~ or 2.7.3.2 whichever is the greater~~залежно від того, що більше~~;

a – spacing of web frames connected with cross ties, in m;~~відстань між рамними шпангоутами з розпірками, м~~;

a_i – mean depth, in m, of side area supported by a cross tie~~середня висота площі борту судна, яка підтримується розпірками, м~~;

Σh_i – perimeter of cross section, in cm, of a cross tie~~периметр поперечного перерізу розпірки, см~~.

Minimum moment of inertia I, in~~Момент інерції поперечного перерізу розпірки~~ ~~I~~, см^4, ~~повинний бути не~~ shall not be less than determined by the Formula~~менше визначеного за формулою~~

$$I = 1{,}2 R_{eH} l_1^2 f \cdot 10^{-2}, \quad (2.5.4.6\text{-}2)$$

~~де~~ where l_1 – cross tie length, in m, as measured between the inner edges of deep members of side framing and of longitudinal bulkhead~~довжина розпірки, виміряна між внутрішніми кромками рамних в'язей борту і подовжньої перегородки, м~~.

2.5.4.7 The side framing of the engine room and tanks shall satisfy the following requirements~~Бортовий набір у машинному відділенні та цистернах повинний задовольняти наступним вимогам~~.

.1 The web frames section modulus ~~Момент опору рамних шпангоутів~~ W, ~~см³~~in cm³, shall not be less than determined by the Formula~~повинний бути не менше визначеного за формулою~~

$$W = \left(250 + \frac{10^3}{m k_\sigma \sigma_n} p a l^2\right) + \Delta W, \quad (2.5.4.7.1)$$

~~де~~ where $m = 17{,}5$;

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

p – ~~відповідно до~~as defined in 2.5.3, but not less than ~~але не менше ніж~~ pressure to the upper deck level~~напір до рівня верхньої палуби~~;

for ΔW – ~~див.~~refer to 1.6.4.1.

.2 in the engine room of ships less than 30 m in length, the web frames and side stringers required by 2.5.2.3 may be omitted on condition that the main frame has a section modulus ~~Для суден довжиною L < 30 м у машинному відділенні допускається не встановлювати рамні шпангоути і бортові стрингери, необхідні відповідно до 2.5.2.3, за умови, що момент опору основного шпангоута~~ W, ~~см³~~in cm³, not be less than determined by the Formula~~буде не менше визначеного за формулою~~

$$W = W_1 + 0{,}5\, W_2/(n + 1), \quad (2.5.4.7.2)$$

де W_1 – section modulus of main frame, as stipulated under ~~момент опору основного шпангоута відповідно до~~ 2.5.4.1, ~~см³~~ in cm³ ;

W_2 – section modulus of web frame, as stipulated under~~момент опору рамного шпангоута відповідно до~~ 2.5.4.7.1 for maximum spacing between web frames~~для максимально допустимої відстані між рамними шпангоутами~~, ~~см³~~in cm³;

n – ~~кількість~~ the number of main frames ~~основних шпангоутів між~~between web frame~~рамни~~s~~ми~~.

.3 in way of the ballast and fuel oil tanks of dry cargo ships 30 m and greater in length ~~У районі баластних і наливних цистерн суховантажних суден довжиною $L \geq 30$ м~~ side the framing shall~~бортовий набір повинний бути посилений встановленням~~be reinforced with ~~бортових стрингерів~~side stringers fitted in ~~в одній площині з~~one plane with ~~горизонтальними рамами перегородок~~bulkheads horizontal webs. ~~У цьому разі~~ In this case when ~~при встановленні одного бортового стрингера~~a stringer is fitted ~~допускається зменшення моменту опору шпангоутів на~~ frames section modulus may be reduced by 10 %, ~~а при~~and when when two side stringers are fitted ~~встановленні двох бортових стрингерів — на~~ by 20 % compared to the required in ~~порівняно з необхідним у~~ 2.5.4.1.

~~Момент опору бортових стрингерів~~Side stringers section modulus, ~~а також висота і товщина їх стінок~~as well as height and thickness of their webs ~~визначаються як~~is determined as for the ~~для горизонтальних рам перегородок цистерн~~tanks' bulkheads horizontal webs.

.4 in the engine room, the web frames shall have a depth not less than 0,1 of the span, and a web thickness not less than 0,01 of the web depth plus 3,5 mm~~Рамні шпангоути повинні мати висоту профілю не менше 0,1 прогону і товщину стінки не менше 0,01 висоти стінки плюс 3,5 мм~~. The flange ~~Товщина вільного~~ thickness~~пояска~~ shall be at least 2 mm more ~~повинна бути принаймні на 2 мм більше товщини стінки~~than the web thickness.

.5 in the engine room, the web depth of a side stringer shall be equal to that of a web frame~~Висота стінки бортового стрингера повинна дорівнювати висоті стінки рамного шпангоута~~. The web thickness of a side stringer may be 1 mm less than that of a web frame. The side stringer face plate thickness shall be equal to the face plate thickness of a web frame~~Товщина стінки бортового стрингера може бути на 1 мм менше товщини рамного шпангоута. Товщина вільного пояска бортового стрингера повинна дорів-нювати товщині вільного пояска рамного шпангоута~~.

.6 ~~Мінімальні товщини~~Minimum thickness s_{min} ~~бортового набору в цистернах ви-значаються за формулою~~of side framing in tanks is determined by the Formula (2.7.4.1-2).

2.5.4.8 The section moduli and cross-sectional areas of diaphragms and platforms shall~~Момент опору вертикальних діафрагм шпангоутів подвійного борту і площа їх поперечного перерізу повинні бути~~ ~~не менше зазначених у~~not be less than specified in 2.5.4.4 ~~та~~ and 2.5.4.5 ~~відповідно~~accordingly.

2.5.4.9 I f there are large openings (exceeding 0,7 times the ship's breadth in width) in the deck, stiffening of the diaphragms and frames of the side shell and inner skin may be required on agreement with the Register in connection with the upper deck pliability, which shall be determined by calculation (refer also to ~~За наявності великих вирізів у палубі (ширина яких понад 0,7 ширини судна) за погодженням із Регістром може бути необхідним підкріплення шпангоутів зовнішнього і внутрішнього бортів, а також вертикальних діафрагм-шпангоутів, пов'язане з податливістю верхньої палуби і визначене розрахунком (див. також~~ 3.1.4).

2.5.4.10 The thickness of inner skin shall comply with the requirements for the thickness of longitudinal bulkhead plating in tankers, as specified in 2.7.4.1, using the design pressure determined in accordance with ~~Товщина обшивки внутрішнього борту повинна відповідати вимогам до товщини обшики поздовжніх перегородок наливних суден згідно з 2.7.4.1 при розрахунковому тиску, що визначається згідно з~~ 2.5.3.2.1. In any case, this thickness shall not be less than determined by Formula~~У будь-якому випадку ця товщина повинна бути не менше товщини, яка визначається за формулою~~ (2.7.4.1-1).

2.5.4.11 The cross ties between frames and longitudinals of side shell and inner skin, as mentioned under ~~Розпірки між шпангоутами або поздовжніми балками зовнішнього і внутрішнього бортів згідно з~~ 2.5.2.2.1 shall comply with the requirements for the intermediate struts of double bottom, as mentioned in ~~повинні відповідати вимогам до проміжних стійок подвійного дна згідно з~~ 2.4.4.7 using the design pressure determined from 2.5.3.1 or 2.5.3.2.1, whichever is the greater~~при при розрахунковому тиску, що визначається згідно з 2.5.3.1 чи 2.5.3.2.1, в залежності від того, що більше~~.

If cross ties are fitted, the section modulus of frames complying with 2.5.4.1 and 2.5.4.2, as well as of longitudinals complying with 2.5.4.3, may be reduced by 35 per cent~~При установленні розпірок момент опору шпангоутів згідно з 2.5.4.1 і 2.5.4.2 та поздовжніх балок згідно з 2.5.4.3 може бути зменшений на 35%~~.

2.5.4.12 In the cargo and ballast tanks of tankers, in holds into which water ballast can be taken and in tanks, the thickness of structural members of side framing shall not be less than that required by ~~Елементи конструкці бортового набору в танках (вантажних і баластних) наливних суден і трюмах, у які може прийматися водяний баласт, і цистернах повинні мати товщини не менше тієї, що вимагається~~ 3.5.4.

2.5.5 Special requirements~~Спеціальні вимоги~~.

2.5.5.1 If transverse system of framing is adopted, efficient connection of lower ends of frames to bottom structures shall be ensured by means of bilge brackets or other structures of equivalent strength. The bilge brackets shall comply with the following requirements~~При поперечній системі набору борту повинне бути забезпечене надійне з'єднання нижніх кінців шпангоутів з днищевими конструкціями за допомогою скулових книць або інших еквівалентних до них по міцності конструкцій. Скулові книці повинні відповідати наступним вимогам~~:

.1 the depth of bilge brackets shall not be less than that of the bilge as a whole. The free edge of a bilge bracket shall be flanged or stiffened with a face plate the dimensions of which shall be in compliance with По висоті скулові книці повинні повністю перекривати скулу. Вільна кромка скулової книці повинна мати фланець чи повинна бути підкріплена пояском, розміри яких вибираються згідно з 1.7.2.2.2.

The thickness of a bilge bracket is taken equal to that of plate floors in the hull region under consideration, but it need not exceed the frame web thickness more than 1,5 times.

Holes cut in bilge brackets shall be such that the width of plating outside the hole is nowhere less than Товщина скулової книці приймається рівна товщині суцільних флорів у розглянутому районі корпусу, але може не перевищувати товщину стінки шпангоута більше ніж у 1,5 рази.

Розміри вирізів у скулових кницях повинні бути такими, щоб у жодному місці ширина листа з одного боку вирізу була не менше ⅓ of the bracket width.

In any case, the size of bilge brackets shall not be less than that required by ширини книці.

У будь-якому випадку розміри скулових книць повинні бути не менше визначених згідно з 1.7.2.2.

.2 the end attachments of a frame to bilge bracket shall be designed so that at no section the section modulus is less than required for a frameКонструкція кріплення кінця шпангоута до скулової книці повинна бути такою, щоб у жодному перерізі момент опору не був менше необхідного для шпангоуту.

.3 where an inclined margin plate is fitted in the double bottom, the bilge bracket shall be carried to the inner bottom plating, and its face plate (flange) shall be welded to the platingПри похилому міждонному листі подвійного дна скулова книця повинна бути доведена до настилу подвійного дна, а її поясок (фланець) повинний бути приварений до цього настилу.

.4 where a horizontal margin plate is fitted in the double bottom or transverse system of framing is adopted in the single bottom, the width of bilge brackets shall be determined proceeding from the condition that their section moduli at the point of connection to the inner bottom plating or upper edge of floor shall be at least twice those of the frame.

The face plate (flange) of a bilge bracket may be welded to either the inner bottom plating or the face plate (flange) of a floor, or it may be sniped at ends. I f the face plate (flange) is welded, the floor web shall be stiffened with a vertical stiffener or a bracket at the point of welding, also welded to the inner bottom plating or to the floor face plate (flange)При горизонтальному міждонному листі подвійного дна чи при поперечній системі набору одинарного дна, ширина скулової книці повинна вибиратися за умови, щоб момент опору її перерізу в місці з'єднання з настилом другого дна чи верхньою кромкою флора перевищував, не менше ніж у два рази, момент опору шпангоуту.

Вільний поясок (фланець) скулової книці може бути приварений до настила другого дна або до вільного пояска (фланця) флора, або зрізаний “на вус”. У випадку приварки вільного пояска (фланця), у місці приварки стінка флора повинна бути підкріплена вертикальним ребром жорсткості або кницею, також привареними до насти-

~~ла другого дна чи пояска (фланця) флора~~.

The depth of a bilge bracket shall not be less than its width~~Висота скулової книці повинна бути не менша її ширини~~.

.5 if longitudinal system of framing is adopted in the single bottom, the bilge bracket shall be carried at least to the bottom longitudinal nearest to the side and shall be welded thereto. The section modulus of the bracket at the section perpendicular to the shell plating where the bracket width is the greatest shall be at least twice the section modulus of the frame~~При поздовжній системі набору одинарного дна скулова книця повинна бути доведена принаймні до найближчої до борту поздовжньої балки днища і приварена до неї. Момент опору книці в перерізі, перпендикулярному зовнішній обшивці, де книця має найбільшу ширину, повинний перевищувати момент опору шпангоуту не менше ніж у два рази~~.

.6 If transverse system of framing is adopted on tankers ~~На наливних суднах при поперечній системі набору борту кінці шпангоутів~~frame brackets, ~~що знаходяться не в площині~~which are outside the plane of floos and web beam s~~флорів і рамних бімсів~~, ~~повинні кріпитися до палуби і днища~~are to be secured to deck and webs ~~кницями~~by brackets.

~~Протяжність скулових книць~~Bilge brackets extent by height ~~за висотою повинна бути у цьому разі не менше~~is not to be less than:

l = 0,08D + 0,35 ~~м~~ m ~~при~~ for $D \le$ 10 ~~м~~m;

l = 0,04D + 0,75 ~~м~~ m for~~при~~ $D >$ 10 ~~м~~m,

but not greater than ~~але не більше~~ 1,5 ~~м~~m.

~~Скулові книці~~Bilge brackets shall cover the bilge completely~~повинні цілком перекривати скулу~~.

Brackets shall be welded to the nearest ~~Книці повинні приварюватися до найближчої подовжньої балки палуби і днища~~deck or bottom longitudinal. ~~Протяжність палубних книць~~The length of deck brackets l, ~~м~~in m, ~~за висотою повинна бути не менше~~in height shall not be less than

l = 0,04D + 0,3, ~~але не більше~~but not greater than 1,1 ~~м~~m.

2.5.5. In all the spaces, the upper ends of frames shall be carried to the decks (platforms) with minimum gaps if they are cut at the decks (platforms)~~2 Верхні кінці шпангоутів у міжпалубних приміщеннях і надбудовах повинні бути доведені до палуби з мінімальним зазором, а бімси – до внутрішньої кромки шпангоута~~. Scantling of brackets connecting the upper ends of the beams to the of frames, shall meet the requirements of~~Розміри книць, що з'єднують верхні кінці шпангоутів з бімсами, повинні відповідати вимогам~~ 1.7.2.2 ~~якщо~~ for n = 1,8.

The uppermost decks of ships (except for those secured alongside other ships at sea) may be designed with beams carried to the shell plating with minimum gaps, and frames carried to the beams~~Для верхніх палуб (за винятком суден, що швартуються у морі) може бути застосована конструкція, в якій бімси доводяться до зовнішньої об-шивки з мінімальним зазором, а шпан-гоути – до бімса~~.

Where sides are framed transversely ~~При поперечному наборі бортів~~ and decks are framed longitudinally ~~і поздовжньому наборі палуб книці~~deck brackets, ~~що кріплять верхні кінці шпангоутів~~stiffening upper frame brackets, ~~повинні доводитися до найближчої~~are to be extended to the nearest ~~по-довжньої палубної балки~~deck longitudinal ~~і приварюватися до неї~~and welded to it.

~~При цьому висота книці~~Breacket height, measured from deck~~виміряна від палуби~~, shall be at least a two-time height of the frame web~~повинна бути не менше дворазової висоти стінки шпангоута~~.

2.5.5.3 If the frame is cut at deck, its lower end shall be attached by a bracket~~Якщо шпангоути розрізані на палубі, кріплення їх нижніх кінців повинно здійснюватися за допомогою книць~~. The height and width of the brackets are determined by the formula ~~Висота і ширина книць визначаються за формулою~~ (1.7.2.2) ~~якщо~~ for n = 1,8 (~~див. також~~also refer to 2.5.4.2).

2.5.5.4 Side stringers shall be attached to web frames by brackets carried to the web frame face plate and welded thereto~~Бортові стрингери повинні кріпитися до рамних шпангоутів кницями, що доходять до вільного пояска рамного шпангоута і приварені до нього~~.

2.5.5.5 If cross ties are fitted in the wing tanks of tankers, the side transverse and side stringer webs in way of the cross tie attachments shall be provided with stiffeners which shall be an extension of the cross tie face plates. Cross tie attachments to side transverse (side stringer) shall comply with the requirements of ~~При наявності розпірок у бортових танках наливних суден, стінки рамних шпангоутів чи бортових стрингерів у місцях кріплення розпірок повинні бути підкріплені ребрами жорсткості, що є продовженням вільних поясків розпірок. Кріплення розпірки до рамного шпангоута (бортового стрингеру) повинне відповідати вимогам~~ 1.7.2.3.

2.5.5.6 In the region of connection of double skin side with double bottom the plating of the second bottom is to be extended (not to be cut) through the skin of inner bottom till outer skin. In the line of inner side is to be side girder or scalloped plates are to be filled.

2.6 DECKS AND PLATFORMS~~ПАЛУБИ І ПЛАТФОРМИ~~

2.6.1 General~~Загальні положення~~.

Requirements are given in this Chapter for the deck and platform structures of ships where the width of opening for a single cargo hatch does not exceed 0,7 times the ship's breadth abreast of the opening. Additional requirements for the decks and platforms of ships having greater width of openings and their length exceeding 0,7 times the spacing of centres of transverse deck strips between the openings, as well as for the decks and platforms of ships with twin or triple hatch openings, are specified in 3.1~~У підрозділі наводяться вимоги до конструкцій палуб і платформ суден, у яких ширина одиночних люкових вирізів не перевищує 0,7 ширини судна в районі вирізу. Додаткові вимоги до палуб і платформ суден з більшою шириною вирізів і довжиною~~

~~вирізів, що перевищує 0,7 відстані між центрами поперечних перемичок між вирізами, а також суден з парними і потрійними люковими вирізами наводяться в 3.1~~.

For decks and platforms of ro-ro ships, refer to 3.2.

Requirements for the cargo hatch coamings of bulk carriers are given in 3.3~~Вимоги до палуб і платформ суден з горизонтальною системою завантаження наводяться в 3.2.~~

~~Вимоги до комінгсів вантажних люків суден для навалювальних вантажів наводяться в 3.3~~.

Requirements of this Chapter cover plating and framing members of decks and platforms: deck longitudinals, beams, deck transverses, deck girders, hatch end beams, hatch side coamings and hatch end coamings, wash plate in the tanks of tankers~~Підрозділ містить у собі вимоги до настилу, балок основного і рамного набору палуб і платформ: поздовжніх підпалубних балок, бімсів, рамних бімсів, карлінгсів, кінцевих люкових бімсів, поздовжніх і поперечних комінгсів вантажних люків, відбійного листа в танках наливних суден~~.

Additional requirements for the areas of upper deck situated below the superstructures are given in 2.12.5.1 to 2.12.5.3~~Додаткові вимоги до ділянок верхньої палуби, розташованих під надбудовами, наводяться в 2.12.5.1 – 2.12.5.3~~.

2.6.1.2 ~~Позначення~~ Symbols (~~рис.~~Fig. 2.6.1.2):

l_0 – maximum deck girder span, in m, measured between supports (end hatch beams and pillars)~~найбільший прогін карлінгса, виміряний між опорами (кінцевими люковими бімсами, пілерсами), м~~;

l_1, l_2 – deck girder span, in m, ~~прогін карлінгса від пере-городки~~ from bulkhead to end hatch beam~~до кінцевого люкового бімса, м~~;

$l_0^б$ – end hatch beam span~~прогін кінцевого люкового бімса~~ in the section of the hatch opening~~на ділянці вирізу люка~~, м;

$l_1^б$ – end hatch beam span, in m, ~~прогін кінцевого люкового бімса від борту до карлінгса, м~~from side to deck girder;

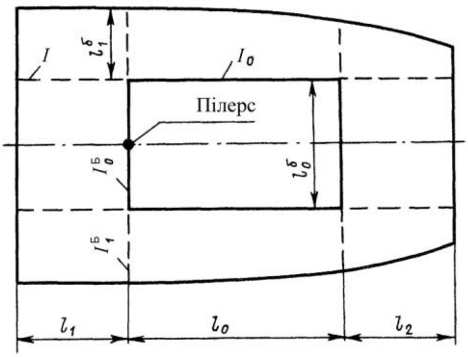
I – ~~момент інерції карлінгса~~moment of inertia of deck girder, ~~см~~^{4}in cm^4;

$I_0^б$ – moment of inertia of end hatch beam~~момент інерції кінцевого люкового бімса на ділянці вирізу люка~~in the section of the opening, ~~см~~^{4}in cm^4;

W, $W_d^ф$ – required under these Rules for ~~той, що вимагається цими Правилами при~~ η = 1 ~~і фактичний моменти опору корпусу~~and actual hull section modulus ~~для палуби~~for deck ~~згідно з~~under 1.4.5 ~~і~~ and 1.4.7 ~~відповідно~~respectively;

$I_1^б$ – moment of inertia of end hatch beam ~~момент інерції кінцевого люкового бімса~~ in the section ~~на ділянці від борту~~from side ~~до вирізу люка~~to hatch opening, ~~см~~^{4}in cm^4;

I_0 – moment of inertia of ~~момент інерції поздовжнього комінгса люка~~longitudinal hatch coaming, that is both a deck girder~~що є одночасно і карлінгсом~~, ~~см~~^{4}in cm^4.



~~Рис~~Fig. 2.6.1.2

2.6.2 Construction~~Конструкція~~.

2.6.2.1 In tankers of 80 m and above, bulk carriers and ore carriers, as well as in oil/dry bulk cargo carriers, and ore/oil carriers, longitudinal system of framing shall be adopted for the strength deck in way of cargo holds (tanks).

Where longitudinal system of framing is adopted, the spacing of deck transverses shall not exceed that of bottom transverses~~На наливних суднах з $L \geq 80$ м, суднах для навалювальних вантажів і рудовозах, а також нафто-навалювальних і нафторудовозах повинна застосовуватися поздовжня система набору розрахункової палуби у районі вантажних трюмів (танків).~~

~~Відстань між рамними бімсами при поздовжній системі набору не повинна перевищувати відстань між флорами~~.

2.6.2.2 Provision shall be made for the structural continuity of deck girders of the strength deck in the midship region. If the deck girders are cut at transverse bulkheads, their web plates shall be welded to the transverse bulkheads and attached thereto by brackets.

The web plates of hatch end coamings, deck transverses, hatch end beams and wash plates shall be strengthened by stiffeners and brackets (refer to ~~Повинна бути забезпечена конструктивна безперервність карлінгсів розрахункової палуби в середній частині довжини судна. Якщо карлінгси розрізаються на поперечних перегородках, їхні стінки повинні приварюватися до поперечних перегородок і кріпитися до них кницями.~~

~~Стінки поперечних комінгсів, рамних і кінцевих люкових бімсів, а також поперечних відбійних листів повинні бути підкріплені ребрами жорсткості і кницями (див.~~1.7.3).

The face plates of deck girders shall be connected to the face plates of hatch end beams by means of diamond plates (refer to 1.7.4.5) whose thickness shall be equal to the greater face plate thickness~~З'єднання поясків карлінгсів і кінцевих люкових бімсів повинно виконуватися хрестовинами (див.1.7.4.5), товщина яких повинна дорівнювати більшій товщині цих поясків~~.

2.6.2.3 On the strength deck, the ends of side coamings at the corners of hatchways shall be either bent along the line of hatch corner rounding and buttwelded to the hatch end coaming or extended, in the form of a bracket, beyond the corner of the hatchway. Provision shall be made for a gradual termination of the bracket above the deck girder web.

The upper edges of coamings acting as deck girders shall be stiffened with face plates and the lower edges of the coamings shall be rounded.

The upper edge of hatch side coaming shall be smooth and their corners shall be well rounded in the transverse direction~~У кутах люків, розташованих на розрахунковій палубі, кінці подовжніх комінгсів повинні бути загнуті по лінії заокруглення вирізу кута люка і зварені встик з поперечним комінгсом або продовжені за кут люка у вигляді книці. Повинно бути забезпечене плавне закінчення книці над стін-кою розташованого під палубою карлінгса.~~

~~Верхні кромки комінгсів-карлінгсів повинні бути підкріплені поясками, а нижні кромки повинні мати оброблення, що забезпечує заокругленість кромок.~~

~~Верхня кромка вертикального подовжнього комінгса вантажного люка повинна бути гладкою, а її кути заокруглені в поперечному напрямку~~.

2.6.2.4 The deck girders and deck transverses in way of pillars shall be strengthened by stiffeners or tripping brackets.

Where deck girders are connected to deck transverses and their web height is different, the deck girder web shall be strengthened by brackets fitted in line with the deck transverse. The brackets shall be welded to the face plate of deck transverse, to the web and face plate of deck girder.

Where deck girders are attached to conventional beams, the web of deck girder shall be strengthened by vertical stiffeners~~Карлінгси і рамні бімси в місцях встановлення пілерсів повинні бути підкріплені кницями або бракетами~~

~~У місцях з'єднання рамних бімсів з карлінгсами, при різній висоті їх стінок, стінка карлінгса повинна бути підкріплена кницями, установленими в площині рамного бімса. Книці повинні бути приварені до вільного пояска рамного бімса, стінки і вільного пояска карлінгса.~~

~~У місцях з'єднання карлінгсів із звичайними бімсами стінка карлінгса повинна бути підкріплена вертикальними ребрами жорсткості~~.

2.6.2.5 In the case of connection of deck longitudinals to transverse bulkheads, the effective sectional area of the longitudinals shall be maintained~~З'єднання поздовжніх підпалубних балок з поперечними перегородками повинне забезпечувати збереження ефективної площі перерізу зазначених балок~~.

2.6.2.6 In tankers with two effective longitudinal bulkheads, provision shall be made for a wash plate at the centreline~~На наливних суднах, при наявності двох поздовжніх перегородок, повинний бути установлений відбійний лист у діаметральній площині~~.

2.6.3 Deck loading.

2.6.3.1 The design pressure on the weather deck ~~Розрахунковим тиском на верхні відкриті палуби~~ is a wave pressure ~~є хвильовий тиск~~ p_w ~~відповідно до~~ as defined in 1.3.2.2.

2.6.3.2 For weather decks intended to carry deck cargo (except timber and coke), the design pressure shall be taken equal to the cargo pressure~~Для верхніх відкритих палуб, які призначені для перевезення палубного вантажу (за винятком лісу і коксу), розрахунковий тиск приймається таким, що дорівнює тиску вантажу~~ $p_в$, determined by Formula ~~визначеному за формулою~~ (1.3.4.1).

For weather decks intended to carry timber and coke, the value of ~~Для верхніх відкритих палуб, призначених для перевезення лісу і коксу, величина~~ h in

Formula (1.3.4.1) shall be taken equal to 0,7 times the stowage height of timber and coke on deckв формулі (1.3.4.1) приймається рівною 0,7 висоти укладання лісу і коксу на палубу.

For lower decks and platforms, the design pressure shall be taken according to 1.3.4.1. For decks where cargo is suspended from beams or deck longi tudinals, the design pressure value shall be suitably increasedДля нижніх палуб і платформ розрахунковий тиск необхідно приймати відповідно до 1.3.4.1. Для палуб, у яких знизу до бімсів або подовжніх підпалубних балок підвішується вантаж, розрахунковий тиск повинний бути відповідно збільшений.

For decks and platforms intended for the crew, passengers and equipment, the design pressure shall be determined by Formula (1.3.4.1) while the product Для палуб і платформ, призначе-них для розміщення екіпажа, пасажирів і обладнання, розрахунковий тиск визначається за формулою (1.3.4.1), при цьому добуток $h p_{Bc} g$ shall not be less than 3,5 kPaповинний бути не менше 3,5 кПа.

For platforms in the engine room, the minimum design pressure shall be 18 kPa.

Watertight lower decks and platforms shall be additionally calculated using the test loads, in kPa, as follows:Для платформ у машинному відділенні мінімальний розрахунковий тиск 18 кПа.

Водонепроникні нижні палуби і платформи додатково розраховуються на навантаження при випробуваннях,

$$p = 7{,}5\, h_p \text{, кПаin kPa} \qquad (2.6.3.2)$$

де where h_p — vertical distance, in m, from deck (platform) plating to air pipe topвідстань по вертикалі від настилу палуби (платформи) до верху повітряної труби, м.

2.6.3.3 The design pressure on the structures of decks and platforms forming boundaries of compartments intended for the carriage of liquids shall be determined in accordance withРозрахунковий тиск на конструкції палуб і платформ, що обмежують відсіки, призначені для перевезення рідин, визначається відповідно до 1.3.4.2.

2.6.4 Scantlings of deck membersРозміри палубних в'язей.

2.6.4.1 Thickness of deck platingТовщина настилу палуби.

.1 The thickness of strength deck plating outside the line of hatch openings, taking deck longitudinals into account, shall be that necessary to give the hull section modulus for strength deck, as required by Товщина настилу розрахункової палуби поза лінією люкових вирізів з урахуванням поздовжніх підпалубних балок основного і рамного набору повинна забезпечувати одержання необхідного згідно з 1.4.5 моменту опору поперечного перерізу корпусу для розрахункової палуби.

The adopted thickness of strength deck plating within midship region shall be in accordance with the requirements for buckling strength (refer to Прийнята товщина настилу розрахункової палуби в середній частині довжини судна повинна задовольняти вимозі стійкості (див.1.6.5).

.2 In the end portions withinВ кінцевих частинах в межах 0,1L від носового і кормового перпендикулярівfrom F.P. and A.P. of ships of 65 meters and more суден довжиною 65 м і більше площа поперечного перерізу розрахункової палубиdesign deck cross section F_1, см²in cm², shall not be less than determined by Formula~~повинна бути не менше визначеної за фор-мулою~~

$$F_1 = 4Bs_{min}, \qquad (2.6.4.1.2)$$

~~де~~where for s_{min} – ~~див. табл~~refer to~~.~~ Table 2.6.4.2.

.3 If the engine room is located aft, the plating thickness and the scantlings of deck longitudinals, at the poop (aft deckhouse) front shall be maintained abaft the poop (deckhouse) front for a length of at least the width of machinery casing opening~~При кормовому розта-шуванні машинного відділення тов-щини нас-тилу і розміри поздовжніх балок палуби перед ютом і кормовою рубкою не повинні зменшуватися на ділянці довжиною не менше ширини вирізу для машинної шахти в напрям-ку до корми від носової перегородки юта (кормової рубки)~~.

.4 If the distance from the fore edge of casing opening to the poop (deckhouse) front is less than the width of the opening, additional strengthening of deck may be required in this region~~Якщо носова кромка вирізу ма-шинної шахти розташована від носо-вої перегородки юта (кормової рубки) на відстані, менший ніж ширина вирі-зу, може бути необхідним додаткове підсилення палуби в цьому районі~~.

.5 If the thickness of strength deck plating is taken less than the side plating thickness, a deck stringer plate shall be provided~~Якщо товщина настилу розра-хункової палуби береться менше тов-щини обшивки борту, повинний бути передбачений палубний стрингер~~. The width *b*, in mm, of the strength deck stringer plate shall not be less than~~Ши-рина палубного стрингера верхньої палуби *b*, мм, повинна бути не менше визначеної за формулою~~

$$b = 5L + 800 \le 1800, \qquad (2.6.4.1.5)$$

and the thickness of stringer plate shall not be less than that of side shell plating (sheerstrake)~~а товщина палубного стрингера повинна бути не менше то-вщини бортової обшивки (ширстреку)~~.

.6 ~~Товщина листів настилу палуб~~The thickness of deck plating ~~і платформ~~and platforms in a way ~~у рай-оні цистерн~~of tanks ~~повинна визнача-тися як~~shall be determined ~~для обшив-ки перегородок~~as for bulkhead plating, ~~що обмежують цистерни~~forming boundaries of tanks (~~див.~~refer to 2.7.4.1). However, it shall not be less than ~~При цьому вона не по-винна бути менше~~ necessary for appropriate deck plating~~не-обхідної для настилу відповідної па-луби~~.

2.6.4.2 In any case, the thickness of the decks and platforms plating shall not be less than specified in Table 2.6.4.2~~У будь-якому випадку тов-щини листів настилів палуб і платформ повинні бути не менше зазначених у табл.2.6.4.2~~.

The thickness of plating ~~Товщина листів настилу і конст-руктивних еле-ментів палуб~~and structural deck ele-ments s_{min}, ~~мм~~in mm, (including perforated~~у тому числі перфорованих~~) ~~у районі цистерн~~in the way of tanks ~~по-винна бути не менше~~shall not be less than

$$s_{min} = 0,03L + 4,5, \qquad (2.6.4.2)$$

$$6,0 \le s_{min} \le 7,5.$$

~~Таблиця~~ Table 2.6.4.2

~~Палуба і платформ~~Deck and platforma	s_{min}, mm	
	~~між бортом~~between the side ~~і лінією великих вирізів~~and line of large openings[1]	~~в середині лінії великих вирізів~~in the middle of large openings line ~~і в кінцевих частинах~~and in end portions
~~Розрахункова палуба~~Strength deck:		
~~якщо~~ for $L < 80$	$0{,}055L + 3{,}8$	$0{,}055L + 3.3$
for~~якщо~~ $L \geq 80$	$0{,}04L + 5{,}0$	$0{,}015L + 6{,}5$
~~Друга палуба~~Second deck:		
for~~якщо~~ $L < 80$	$0{,}055L + 3.3$	$0{,}04L + 3{,}5$
for ~~якщо~~ $L \geq 80$	$0{,}015L + 6.5$	$0{,}015L + 5{,}5$
~~Третя палуба і платформи~~Third deck and platforms:		
for~~якщо~~ $L < 80$	$0{,}04L + 3{,}5$	
for~~якщо~~ $L \geq 80$	$0{,}015L + 5{,}5$	

~~Примітка~~Note. ~~При розмірах шпації~~With scantling of spacings more/less~~більших/менших~~, than normal spacing~~ніж нормальна шпація~~, specified thicknesses of deck plating~~зазначені товщини палубного настилу~~ s_{min} ~~повинні~~shall/~~можуть~~ may ~~бути~~ be changed proportionally to the adopted spacing ratio to ~~змінені пропорційно відношенню прийнятої шпації до~~ a_0.

[1]~~Для наливних суден~~ For tankers– ~~настил палуби в районі танків~~deck plating in the way of tanks.

2.6.4.3 For ships with L<65 m in the midship region the cross section area of the longitudinals of design deck F_0, in cm^2, is not to be less than determined by the Formula

$$F_0 = Bs_{min}\,(1{,}4 + 0{,}06L)\,c_1c_2\eta, \quad (2.6.4.3\text{-}1)$$

where s_{min} – minimum thickness of deck plating at the ands of the ships which determined by the formula

$$s_{min} = 0{,}055L + 3{,}3;$$

$$c_1 = 1 + 0{,}022\sqrt{L}\left(\frac{L}{D} - 12\right);$$

$$c_2 = 1 + 12\left(\frac{d}{L} - 0{,}06\right).$$

Where transverse framing is fitted the thickness of design deck plating in the midship region s for ships with L<65 m is not to be less than determined by the formula

$$s = \frac{1000a}{(90 - 0{,}35L)\sqrt{\eta}}\sqrt{\frac{F_0}{F}}, \quad (2.6.4.3\text{-}2)$$

where F_0 – required, in accordance with Formula (2.6.4.3-1) cross sectional area where $\eta = 1$, in cm^2;

F – actual cross sectional area of longitudinals of design deck, in cm^2.

2.6.4.4 The section modulus of cross section area of underdeck longitudinals is not to be less than determined in accordance with 1.6.4.1 taking:

p – in accordance with 2.6.3;

$m = 12$;

k_σ – factor which equal:

for design deck $k_\sigma = 0{,}2 + x_1/L$, where x_1 – distance, in m, between middle of frame span and midship; for $x_1/L \le 0,2$ the value x_1/L is to be equal to 0,2; for $x_1/L \ge 0,4$ the value x_1/L is to be equal to 0,4;

for second deck and other lower decks and platforms $k_\sigma = 0,6$.

Buckling strength of longitudinals of design deck in the midship region is to be in accordance with1.6.5.

2.6.4.5 Where transverse framing of decks and platforms is fitted the action modulus of beams is not to be less than determined according to 1.6.4.1 taking:

p – in accordance with 2.6.3;

$m = 10$;

$k_\sigma = 0,7$.

Where transverse framing is fitted the moment of inertia i_b, in cm^4, of • the midship region for ships with L≥65 m is not to be less than

$$i_б = 3,76\left(\frac{s}{a}\right)^3 l^4 \varphi \frac{\lambda^2}{4-1,5\lambda^4} \cdot 10^{-3}, \qquad (2.6.4.5)$$

where l – beam span, in m;

$\varphi = 1$ for $\sigma_c \le 0,5R_{eH}$;

$$\varphi = \frac{10\sigma_c}{3,1R_{eH}}\left(1,13 - \frac{\sigma_c}{R_{eH}}\right) \text{ for } \sigma_c > 0,5R_{eH};$$

$$\lambda = \frac{4\sigma_c}{\varphi}\left(\frac{a}{s}\right)^2,$$

but not more than 1,0;

σ_c – compression determined in accordance with 1.6.5.1;

s – accepted thickness, in mm, of design deck plating.

2.6.4.6 The scantling of deck transverses are to satisfy the following requirements:

.1 For dry cargo ships where longitudinal framing of deck is used the section modulus of cross section of deck transverse is not to be less than determined in accordance with 1.6.4.1 taking:

p – in accordance with 2.6.3;

$m = 10$;

$k_\sigma = 0,7$.

.2 or tankers the section modulus of cross section W, in cm^3, of deck transverse in the central tank (where wash plate in the central line is fitted) is not to be less than determined in accordance with 1.6.4.1 taking:

$$Q = paL_1, \quad l = B_1;$$

$m = 40$ – where four and less beams are fitted in the tank;

$m = 35$ – where more than four beams are fitted in the tank;

$k_\sigma = 0,5$;

p – in accordance with 2.6 3;

.3 In wing tanks of tankers and in underdeck tanks of ships for bulk cargoes the section modulus of cross section of deck transverse is not to be less than determined in accordance with 1.6.4.1 taking:

p – in accordance with 2.6.3;

$m = 12$;

$k_\sigma = 0,5$.

.4 of deck transverse of dry cargo ships with the deduction of openings, is not to be less than determined by the Formula (1.6.4.3) where

$$N_{max} = 0,73pal; \; k_\tau = 0,8;$$

p – in accordance with 2.6.3.

.5 Where longitudinal framing is used the moment of inertia I_b, in cm^4, of deck transverses of design deck in the midship region is not to be less than determined by the Formula

$$I_б = 0,76\left(\frac{l}{c}\right)^3 \frac{l}{a_1} i\varphi \frac{\lambda^2}{4-1,5\lambda^4}. \qquad (2.6.4.6.5)$$

Where l, φ – in accordance with 2.6.4.5;

c – distance, in m, between deck transverses;

a_1 – distance, in m, between underdeck longitudinals;

i – actual moment, in cm ^{4} of inertia of underdeck longitudinals with effective flange;

$$\lambda = \frac{\sigma_c\left(f + 10sa_1\right)c^2}{203i\varphi},$$

but not more than 1,0,

where σ_c – compression determined in accordance with 1.6.5.1;

f – section area of inertia of underdeck longitudinals without effective flange, in cm ^{2};

s – thickness, in mm, of design deck plating.

2.6.4.7 Deck girders and hatch end coamings are to satisfy following requirements:

.1 The section modulus *W*, in cm^3, of deck girders is not to be less than mtined in accordance with 1.6.4.1 taking:

$Q = p\,a_2\,l, \quad l = l_0$;

p – in accordance with 2.6.3;

a_2 – deck breadth, in m, (including loads hatch), supported by deck and measured in the section on the distance $(l_1 + l_0 + l_2)/2$ from bulkhead, in m;

k_σ = 0,6 i 0,7 – or the deck girder of design and deck and lower decks respectively;

m – factor which determined in accordance with Table 2.6.4.7.1-1 depending on design plan of grillage (refer to Fig. 2.6.1.2) and on parameter of comparative buckling strength α, as well as on ratio of spans l_1/l_0 (for $l_1 \neq l_2$ the greatest value of deck girder span l_1 or l_2 is to be taken);

$$\alpha = k\,\frac{I}{I_0^{6}}\left(\frac{l_0^{6}}{l_1}\right)^3;$$

there the pillars are fitted in the points of crossing of hatch end beam and deck girder α = 0;

k – actor determined in accordance with Table 2.6.4.7.1-2 depending on the accepted structure.

Outside the region of load hatches the section modulus of deck girder is determined in accordance with 1.6.4.1 where *m* = 12, k_σ = 0,6 i 0,7 for deck girder of design and and lower deck respectively. During the setting of scantling of deck girder the following conditions is to be carried out:

The web height is not to be less than 0,05 of deck girder span in the ship with length of 80m and greater and not less than 0,04 of deck girder span in the ship with length of 65 m and less. Intermediate values are determined by liner interpolation;

web thickness *s*, in mm, is not to be less than

$$s = 0{,}01h_c + 5, \qquad (2.6.4.7.1)$$

where h_c – accepted web height, in mm.

For ships of length less than 30 m the web thickness may not 'be greater than deck plating. The webs of deck girders are to be strengthened by stiffeners in accordance with 1.7.3.2.

In midship region of ships with length 65 m and greater buckling strength of deck girders webs are to be checked in accordance with 1.6.5.

Table 2.6.4.7.1-1

l_1/l_0	*m* where α equal to,									
	0	0,05	0,10	0,25	0,50	1,00	1,50	2,00	2,50	3,00

0,2	13,14	13,32	13,50	13,97	14,67	15,79	15,40	14,87	14,49	14,20
0,4	13,95	14,54	15,15	15,09	13,23	11,32	10,35	9,77	9,38	9,10
0,6	14,08	15,38	15,27	12,54	10,21	8,22	7,32	6,81	6,48	6,25

N o t e . The linear interpolation is possible for the intermediate values α.

Table 2.6.4.7.1-2

Deck	Hatch beam structure	k where $l_1^б / l_0^б$, equal to		
		0,25	0,50	0,75
uppermost deck	without pillars	0,139	0,640	1,626
	pillar in the centre line	0,033	0,065	0,098
lower deck and platforms	without pillars	0,022	0,150	0,478
	pillar in the centre line	0,009	0,031	0,053

N o t e . The linear interpolation is possible for the intermediate values of $l_1^б / l_0^б$.

.2 The section modulus of the hatch side coamings is to be greater than necessary one in accordance with 2.6.4.7.1 by 20 per cent.

The thickness of vertical plate of uppermost deck hatch coamings s is not to be less than

for dry cargo ships with length less than 30m

$$s = 0{,}2L + 3, \qquad (2.6.4.7.2)$$

but it is to be greater than thickness of deck plating at least by 1mm;

for dry cargo ships with length 65 m and greater s = 11mm.

For ships with intermediate length the thicknesses is to be determined by linear interpolation.

The webs of the hatch side coamings are to be strengthened by stiffeners in accordance with 1.7.3.2.

In midship region of ships with length 65 m and greater buckling strength of the hatch side coamings webs are to be checked in accordance with 1.6.5.

.3 If the side coamings of strength deck hatches terminate in brackets, the length l_c, in m, of these brackets on the deck is to be:

$$l_c \geq 0{,}75h_c \quad \text{where } R_{eH} \leq 315 \text{ MPa};$$

$$l_c \geq 1{,}50h_к \text{ where } R_{eH} = 390 \text{ МПа},$$

where h_c – height of coamings above deck, in m.

For the intermediate values of R_{eH} the bracket length is to be determined by linear interpolation.

.4 If containers or other cargo are stowed on cargo hatch covers, the scantlings of stiffeners for vertical coamings plates are to be so chosen as to consider both the horizontal and vertical components of inertia forces acting upon the stiffeners in the event of rolling.

.5 In the tankers (where two longitudinal bulkheads are fitted) wash plate is to be fitted in the centre line. The height of wash plate is not less than two heights of deck transverses and the thickness is not to be less than that of deck transverse web.

Along the free edge, the wash plate is to be strengthened with a face plate the sectional area of which is not to be less than that of the deck transverse face plate.

.6 The section modulus of strengthened underdeck longitudinals (when they are fitted in wings and central tanks of tankers) is not to be less than 0,9 of the value of deck transverse section modulus.

2.6.4.8 The section modulus *W*, in cm^3, of the hatch ends beams is not to be less than determined in accordance with 1.6.4.1

$$Q = pa_3\,(l_1 + l_0); \qquad l = l_1^{б};$$

m – factor which determined in accordance with Table 2.6.4.8;

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

p – in accordance with 2.6.3;

a_3 – deck breadth, in m, supported by deck girders in the line of the hatch ends beams.

where the pillars are fitted in the points of crossing of hatch end beam and deck girder the section modulus of the hatch ends beams is to be determined in accordance with 2.6.4.6.1.

Table 2.6.4.8

Deck	Hatch beam structure	$I_0^{б}/I_1^{б}$	*m* where $l_0^{б}/l_1^{б}$, equal to		
			0,25	0,50	0,75
uppermost deck	without pillars	1,0	3,1	3,1	3,1
		5,0	4,9	6,2	7,2
		10,0	7,1	10,2	12,4
		15,0	9,3	14,0	17,5
	pillar in the centre line	1,0	3,0	4,8	5,6
		5,0	7,7	19,1	31,7
		10,0	13,6	35,5	60,5
		15,0	19,6	52,4	89,3
lower deck and platforms	without pillars	1,00	5,1	6,5	8,2
		1,25	6,0	7,0	9,3
		1,50	6,5	8,8	10,0
	pillar in the centre line	1,00	6,3	7,9	10,5
		1,25	6,9	8,3	12,1
		1,50	7,4	10,0	13,7

N o t e . The linear interpolation is possible for the intermediate values of $l_0^{б}/l_1^{б}$.

2.6.4.9 The section modulus of deck girder is to be increased in case when deck pillars which are located above are not fitted over each other.

In this case the value *p* in accordance with 2.6.4.7.1 is added to the value Δp, is to determined by the Formula

$$\Delta p = kP/l_0a_2, \quad (2.6.4.9)$$

where k = 1,15 i 1,65 – if pillar is fitted not further than 1/8 of deck girder span from its bearing in the length and within 1/4 and 1/2 of the deck girder span respectively;
k is determined by linear interpolation for intermediate pillar;

P – pillar load, kN, in accordance with 2.9.3.1.

2.6.4.10 Structural members of deck framing which bound tanks (load and ballast) of tankers and holds which can be filled up by water ballast are not to have thickness less than determined by the Formula (2.3.4.2.8). In this case minimum thickness of beams webs and underdeck longitudinals may not to be greater than 11,5 mm.

2.6.5 Special requirements.

2.6.5.1 The requirements for hatch openings as given below apply to single hatches whose scantlings do not exceed those stipulated under 2.6.1.

The openings are supposed to be arranged in the fore-and-aft direction with their greater side. Otherwise, the corner design of openings will be subject to special consideration by the Register.

.1 For the strength deck within 0,6L amidships, if L≥65 m, and 0,5L, if 40 ≤ 65 m, the corner radii of openings in cargo hatches and engine and boiler casings shall comply with the following requirements:

If adjacent and continuous in-line arranged openings are on the distance c from each other which is not greater than scantling determined by the Formula

$$c_0 = B\frac{b}{l_1}\left(\frac{2}{\sqrt{b/B}} - 1\right), \quad (2.6.5.1.1\text{-}1)$$

where b, l_1 – breadth and length of opening, in m,

radius of rounding r, in m, along the circumferential arc with is not to be less than determined by the Formula

$$r = 0{,}1cW/W_d^{\Phi}. \quad (2.6.5.1.1\text{-}2)$$

If the corners of adjacent openings are strengthened by thickened insert plates scantling of which are complied to Fig. 2.6.5.1.1 radius of rounding is not to be less than determined by the Formula

$$r = 0{,}07cW/W_d^{\Phi}. \quad (2.6.5.1.1\text{-}3)$$

When the corners are rounded along the elliptical arc with the ratio of the length of longitudinal half-axis to the length of transverse half-axis being equal to 2, the following condition are to complied

$$n \geq 0{,}05cW/W_d^{\Phi}. \quad (2.6.5.1.1\text{-}4)$$

Where the distance between transverse edges of adjacent openings are greater than value of c_0 the openings are separated.

For the corners of separated openings radius of rounding is to be determined from the condition

$$r \geq 0{,}1bW/W_d^{\Phi}. \quad (2.6.5.1.1\text{-}5)$$

If the corners of separated openings are strengthened by thickened insert plates radius of rounding is not to be less than determined by the Formula

$$r = 0{,}07bW/W_d^{\Phi}. \quad (2.6.5.1.1\text{-}6)$$

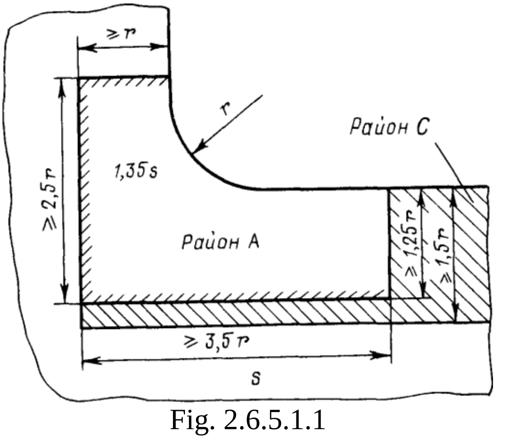


Fig. 2.6.5.1.1

When the corners are rounded along the elliptical arc the scantling of transverse half-axis are to comply the following condition.

$$n \geq 0{,}05bW/W_d^{\phi}. \qquad (2.6.5.1.1\text{-}7)$$

The corners of fore (respectively after) edges of end openings from adjacent openings of load hatches are considered as corners of separated openings.

If $40 \leq L < 65$ m instead of ratio of W/W_d^{ϕ} the ratio of F_0/F is to be accepted (refer to 2.6.4.3).

If $L <$ 40 m as well as within $l < 0{,}2L$, the scantlings of rounding are to be determined in accordance with 2.6.5.1.2.

In any case the corner radii of deck openings may not be accepted greater than 0,04 *B*.

.2 For the strength deck outside the area indicated in 2.6.5.1.1 and for the second continuous deck situated above 0,75*D* from the base line, the corner radii of openings, as required by 2.6.5.1.1, may, in accordance with 1.1.3.5, be reduced by half in the midship region.

The minimum radius shall not be taken less than 0,2 m. For other regions, other decks and platforms, as well as for ships less than 40 m in length, the minimum corner radius of openings in cargo hatches and engine and boiler casings may be taken equal to 0,15 m.

.3 At corners of openings in the cargo hatches of decks (irrespective of their location over the length and depth of the hull) exposed to low temperatures, the radii of curvature shall comply with the requirements for similar structures of the strength deck, situated in the midship region (refer to 2.6.5.1.1).

.4 In the area A (refer to Fig. 2.6.5.1.1), butts of deck plating and coaming plates, butt welds of primary and deep longitudinal members, openings welding of shackles, frames, etc., as well as mounting parts, to deck plating are not permitted..

In the area C (refer to Fig. 2.6.5.1.1), only small openings generally of a round or elliptical shape with a minimum size not exceeding 20*s* (*s* – deck plating thickness, in mm) are permitted. Penetration of welds to longitudinal edges of openings shall be avoided as far as practicable.

I f the deck plating is terminated at a hatch coaming (or engine casing) and welded thereto, full penetration welds shall be used. Where the deck plating extends inside a hatch coaming, the free edges of plating shall be smooth within the hatch and free of weld attachments.

If the hatch side coaming terminates in a bracket, the bracket the shall not coincide with the butt joint of the deck plating.

.5 If the lost cross-sectional area of deck shall be compensated in way of an isolated opening, reinforcement shall be applied as shown in Fig. 2.6.5.1.5. The value of factor k shall be selected proceeding from the relationship between the deck plating thickness s, insert plate thickness *s* and opening width *b*, but shall not be taken less than $k = 0{,}35s/s_1$.

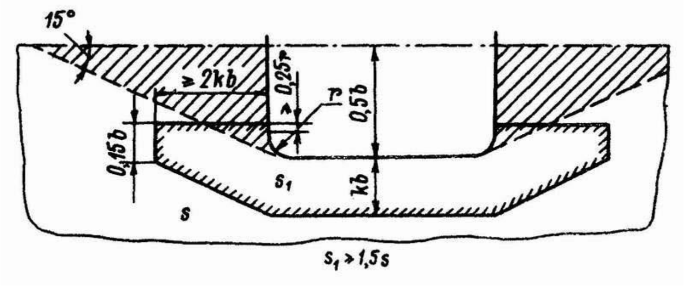


Fig.2.6.5.1.5

.6 The deck plating thickness between transverse edges of adjacent successive openings in cargo hatches and engine casings (refer to 2.6.5.1.1) within their width except for the transverse dimensions of rounding shall not be less than stipulated under 2.6.4.2.

The thickness s_{min} is permitted in way of transverse edges of isolated openings in the area shown in Fig. 2.6.5.1.6.

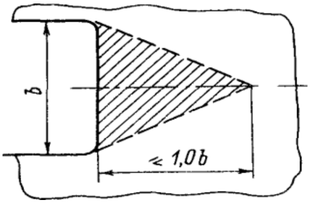


Рис.2.6.5.1.6

If longitudinal system of framing is adopted, the deck plating between hatch end coamings shall be additionally strengthened by fitting of transverse intercostal stiffeners at every frame.

.7 Single openings in the strength deck and in the second continuous deck situated above 0,75D from the base line, in areas within the midship region, as mentioned in 2.6.5.1.1 and and between the ship's side and the line of hatch openings in ships of 40 m and greater in length shall be as small as practicable and be arranged well clear of the corners of openings in cargo hatches and engine and boiler casings, as well as of the ends of superstructures. Rectangular and circular openings in the above areas need not be reinforced, if their width (diameter) is less than 20 times the deck plating thickness in way of the opening, or 300 mm, whichever is less.

No openings are permitted in the thickened insert plates by which the corners of cargo hatches and engine and boiler casings are reinforced, as well as in the thickened deck stringer plates at the ends of superstructures and at the toes of brackets in which side coamings terminate.

Openings (including rectangular ones) shall not be reinforced when located inside the line of large hatchway openings not more than 0,25b from the centreline and 0,5b from the transverse edges of a cargo hatchway opening (where b – is the width of cargo hatch, in m).

For isolated openings in the area indicated in Fig. 2.6.5.1.6, reinforcement is not required.

If the distance between the edge of an opening in the strength deck and ship's side (or a hatch side coaming) is less than twice the opening width, appropriate reinforcement shall be provided irrespective of the width and shape of opening. The aforesaid distance shall not be less than 75 mm..

The corners of rectangular openings shall be rounded with a radius.

In general, r_{min} = 0,1b (where b is the width of opening, in m). In any case, the minimum radius of curvature shall not be taken less than twice the plating thickness in way of the opening or 50 mm, whichever is the greater.

2.6.5.2 The thickness s, in mm, of the coamings of ventilators (ventilating tubing, ducts, trunks, etc.) on the freeboard deck and quarter deck, as well as on the open decks of superstructures within 0,25L from the forward perpendicular shall not be less than

$$s = 0{,}01d_к + 5, \qquad (2.6.5.2)$$

where $d_к$ – internal diameter or length of the greater side of a coaming section, in mm.

The thickness s shall not be less than 7 mm, but it need not be greater than 10 mm.

In ships of restricted areas of navigation **R2, A-R2, R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS, C-R3-S**, **C-R3-RS, R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** less than 24 m in length, the thickness s, in mm, of ventilator coamings shall not be less than:

$$s = 0{,}01d + 4;$$
$$s = s_{pal} + 1,$$

where d – internal diameter or length of the greater side of a coaming section, in mm;

$s_{пал}$ – thickness of deck plating, in mm

whichever is the greater.

The thickness of coamings on decks of the first tier superstructures situated outside 0,25L, from the forward perpendicular may be reduced by 10 per cent as compared to that required for coamings on freeboard deck and raised quarter deck.

Where the thickness of deck plating is less than 10 mm, a welded insert or doubling plate shall be fitted in way of the coaming, having a thickness equal to at least 10 mm, length and breadth not less than twice the diameter or twice the length of the greater side of the coaming section.

In case of an efficient connection of the coaming to the deck framing, fitting of welded insert or doubling plate is not required.

Where the height of a ventilator coaming is greater than 0,9 m and the coaming is not supported by adjacent hull structures, brackets shall be fitted to attach the coaming to the deck.

The height of ventilator coamings shall be determined in accordance with 7.8, Part III "Equipment, Arrangements and Outfit". The structure of companionway and skylight coamings shall have strength equivalent to that of cargo hatches, whereas the thickness of the coamings shall not be taken less than 7 mm, but need not exceed the thickness of deck plating in way of the coaming.

2.7 BULKHEADS, PROPELLER SHAFT TUNNEL

2.7.1 General and definitions.

2.7.1.1 Requirements are given in this Chapter for various types of bulkheads, propeller shaft tunnel and cofferdams.

2.7.1.2 Definitions and symbols.

.1 Definitions:

T i g h t b u l k h e a d is a bulkhead proof against water and other liquids.

C o f f e r d a m b u l k h e a d is a bulkhead having two parallel tight platings, either strengthened with vertical or horizontal stiffeners or not, which are connected to each other by plate structures perpendicular to the platings: vertical structures (diaphragms) and/or horizontal structures (platforms). If no diaphragms and platforms are fitted, the structure shall be considered as two bulkheads bounding the cofferdam.

Watertight (emergency) bulkhead – a bulkhead restricting the flow of water through ship spaces in the case of emergency.

Tank/cargo tank bulkhead is a bulkhead bounding a ballast, fuel or other tank, as well as a cargo tank of tanker.

Wash bulkhead is a bulkhead with openings, fitted inside a compartment in order to reduce impact pressure due to the movement of liquid therein.

Partial bulkhead – is a bulkhead fitted in a compartment or part thereof, which shall ensure additional support for deck structures.

.2 Symbols:

Z_b – distance, in m, measured in the centre line from design load application point to its upper level;

The upper level of loading is:

bulkhead deck for watertight bulkheads and propeller shaft tunnel; upper edge of forepeak bulkhead for forepeak bulkhead; top of the tank (deck which bound the tank) - for the tank bulkheads (load tanks of tankers);

l_c – the vertical web length, in m, measured between inner edges of floors or web beams;

l_h – the horizontal girder length, in m, measured between inner edges of deep frames or horizontal girders;

I_c – the moment of inertia of vertical web, in cm^4;

I_h – the moment of inertia of horizontal girder, in cm^4.

2.7.1.3 The total number of transverse watertight bulkheads, including fore and after peak bulkheads, shall not be less than specified in Table 2.7.1.3.

These requirements apply to cargo ships only and are minimum.

Where compliance with subdivision requirements shall be ensured, the number and disposition of watertight bulkheads (and of partial watertight bulkheads) shall be determined proceeding from the requirements of Part V "Subdivision".

Table 2.7.1.3

Length of the ship, in m	Total number of bulkheads	
	Machinery amidships	Machinery aft [1]
Up to 65	4	3
65 to 85	4	4
85 " 105	5	5
105 " 125	6	6
125 " 145	7	6
145 " 165	8	7
165 " 185	9	8

Length of the ship, in m	Total number of bulkheads	
	Machinery amidships	Machinery aft [1]
Above 185	On agreement with the Register	

[1] With after peak bulkhead forming after boundary of the engine room.

In special cases, a reduction in number of bulkheads may be permitted by the Register.

In this case, two adjacent watertight bulkheads shall be spaced not more than 30 m apart. Increase of this distance shall be a matter of the special consideration of the Register in each case.

All the transverse watertight bulkheads located between fore and after peak bulkheads shall generally be carried to the freeboard deck.

2.7.1.4 Peak and engine room bulkheads, shaft tunnels shall also comply with the requirements 1.1.6.1, 1.1.6.2 or 1.1.6.3.

2.7.1.5 Compartments intended for the carriage of liquid cargoes and ballast, for which $l > 0,13L$ and/or $b > 0,6B$ (l and b are the length and breadth, in m, of a compartment, as measured in the middle of its height), are subject to special consideration by the Register.

Where the tank's length is more than $0,1L$ or 15 m, whichever is greater, wash bulkhead is to be fitted in the middle of tank's length.

Where the tank's length and/or or breadth more than 9 m wash longitudinals and/or transverse bulkheads (plates) are to be fitted.

2.7.2 Construction.

2.7.2.1 Tight bulkheads may be either plane or corrugated. Wash bulkheads with openings shall be plane bulkheads.

For the construction of longitudinal tight bulkheads, as well as for the tight bulkheads of log and depth sounder wells, escape trunks, propeller shaft tunnel, etc., the same requirements apply as for transverse tight bulkheads.

In bulkheads, watertight steps and recesses are permitted.

In tankers, the longitudinal bulkheads shall be tight throughout the cargo tank region (including pump rooms and cofferdams) with the exception of the third bulkhead at the centreline which may be constructed as a wash bulkhead.

At intersections of longitudinal and transverse bulkheads, structural continuity of longitudinal bulkheads shall be ensured. The termination of longitudinal bulkheads shall be smooth.

Partial bulkheads shall be plane bulkheads.

2.7.2.2 In corrugated longitudinal bulkheads, the corrugations shall generally be arranged horizontally, while in transverse bulkheads the arrangtement of corrugations may be both horizontal and vertical.

Plane bulkheads shall be strengthened by vertical or horizontal stiffeners. The vertical and horizontal stiffeners of plane bulkheads as well as the vertical and horizontal corrugations of corrugated bulkheads may be supported by horizontal girders or vertical webs respectively.

The horizontal girders and vertical webs shall be stiffened in accordance with the requirements of 1.7.3.

Partial bulkheads shall be strengthened by vertical webs.

2.7.2.3 The end attachments of bulkhead framing members shall comply with the following requirements:

.1 the ends of vertical webs and horizontal stiffeners of bulkheads shall generally be attached by brackets complying with the requirements of 1.7.2.2. Bracket attachments are required for the ends of main framing of forepeak bulkhead below the freeboard deck.

.2 if transverse system of framing is adopted, the brackets by which the vertical webs of transverse bulkheads are attached to deck plating and inner bottom plating (bottom plating) shall be carried to the beam or floor nearest to the bulkhead and welded thereto.

Where transverse framing system is adopted, the brackets by which the horizontal stiffeners of bulkheads are attached to the side or other bulkhead shall be carried to the frame or vertical stiffener nearest to the bulkhead and welded thereto.

.3 when the vertical stiffeners of bulkheads are cut at decks, platforms or horizontal girders and no brackets are fitted, the stiffener ends shall be welded to deck or platform plating, to horizontal girder web, or sniped at ends.

.4 the end attachments of vertical webs and horizontal girders shall comply with the requirements of 1.7.2.3.

Where there are no horizontal girders on longitudinal bulkheads and/or side stringers at the level of the horizontal girder brackets of transverse bulkheads, the brackets shall be carried to the nearest vertical web on longitudinal bulkhead and/or the nearest frame and welded thereto.

If the vertical web on a transverse bulkhead is not in line with the centre girder or side girder, a bracket shall be fitted in the double bottom under the bracket by which the lower end of the vertical web is attached.

2.7.2.4 The attachments of corrugated bulkheads shall comply with the following requirements:

.1 where a horizontally corrugated bulkhead is attached to deck and bottom (inner bottom) or a vertically corrugated bulkhead is attached to ship's sides and longitudinal bulkheads, provision shall be made for flat transition areas whose structure, thickness and stiffening shall be in compliance with the requirements for plane bulkheads;

.2 attachment of corrugation ends shall be effected by welding them directly to the inner bottom plating (bottom plating), side plating, deck plating, etc. In so doing, attention shall be given to eliminating hard spots (refer to 1.7.1.4) in the above structures.

.3 requirements for the attachments of corrugated bulkheads in bulk carriers are given in 3.3.2.

2.7.2.5 Shaft tunnel stiffeners ends are to be attached by brackets in a way similar to attachment of watertight and tanks bulkheads stiffeners.

2.7.3 Bulkhead loads.

2.7.3.1 The design pressure *p*, in kPa, on watertight bulkhead structures and propeller shaft tunnel shall be taken equal to

$$P = \alpha \cdot z_b, \quad (2.7.3.1)$$

where α = 10 for forepeak bulkhead structure;

α = 7,5 elsewher.

Z_b − distance, in m, as measured at the centreline, from the point of design load application to its upper level; the upper load level is: the bulkhead deck for watertight bulkheads and propeller shaft tunnel, the upper edge of forepeak bulkhead for the forepeak bulkhead.

If partial watertight bulkheads are fitted on the bulkhead deck in line with the watertight bulkheads or in close vicinity to them, z_b shall be measured to the upper edge of the watertight partial bulkheads.

In any case, the design pressure shall be not less than 12 kPa for watertight bulkhead structures and not less than 16 kPa for forepeak bulkhead structures.

2.7.3.2 The design pressure on the bulkheads of tanks, cargo tanks and water ballast holds shall be determined in accordance with 1.3.4.2.

bulkheads of tanks shall be additionally tested for design pressure, corresponding to the pressure up to the tank top and test pressure according to Appendix 1.

The design pressure on the wash bulkheads and plates shall be determined by Formulae (1.3.4.2.2-1) and (1.3.4.2.2-2), but shall not be less than p_{min} = 25 kPa.

The design pressure on bulkheads bounding heavy bulk cargo holds shall be determined in accordance with 1.3.4.3.

2.7.4 Scantlings of bulkhead members.

2.7.4.1 The thickness of bulkhead plating shall be not less than determined by Formula (1.6.4.4) taking:

p – as defined in 2.7.3;

m =15,8;

for k_σ – refer to Table2.7.4.1.

In ships of 50 m in length, the thickness of watertight bulkhead plating may be reduced by 0,5 mm, and in ships of 40 m in length or below, by 1 mm. For intermediate ship lengths, the reduction in thickness shall be determined by linear interpolation.

Table 2.7.4.1

Bulkheads	k_σ
Watertight (emergency)	0,85
Fore peak	0,60
Tank/cargo tank and ballast water tank bukhead	0,80
Bulkheads of the tanks where the pressure is:	
up to the top of overflow	0,90
To the top of tank	0,50
Bulkheads of the holds of bulk carrier ship	0,70

In tankers, the thickness of top and bottom strakes of longitudinal bulkheads shall comply with the requirements for side plating, as given in 2.2.4, with regard for the liquid cargo pressure.

The plating thickness s_{min}, in mm, of watertight bulkheads and bulkheads of lubricating oil tanks shall not be less than

$$s_{min} = 4 + 0{,}02L, \qquad (2.7.4.1\text{-}1)$$

Where L > 150 m, *L* shall be taken equal to 150 m. The thickness of bottom plates of bulkheads shall exceed the above value specified in 2.7.4.1-1 by 1 mm, but shall not be less than 6 mm.

For tank bulkheads (except lubricating oil tanks), the thicknes s_{min}, in mm, of plating, face plates and webs of framing members shall not be less than

$$s_{min} = 5 + 0{,}015L, \qquad (2.7.4.1\text{-}2)$$

$$6{,}0 \le s_{min} \le 7{,}5 \text{ mm}.$$

In tankers, the minimum bulkhead plating thickness in way of cargo and ballast tanks shall not be less than that required by 3.5.4.

Bulkhead plating may have a thickness not exceeding that of relevant shell plating strakes and deck plating, where the spans and yield stress values are identical.

The same applies to the thickness relationship of bulkhead bottom plating and inner bottom plating (bottom plating).

The breadth of top and bottom strakes of bulkheads shall be determined in accordance with 2.7.5.1.

Where sterntubes penetrate through bulkhead plating, the thickness of the latter shall be doubled.

The thickness of corrugated bulkheads shall be determined in accordance with 1.6.4.5 with regard for the requirements for the section moduli of vertical and horizontal stiffeners, as specified in 2.7.4.2.

2.7.4.2 The section modulus of vertical and horizontal stiffeners of bulkheads shall not be less than stipulated under 1.6.4.1 taking:

p – as defined in 2.7.3;

k_σ – as obtained from Table 2.7.4.2;

m – factor equal to:

21 for vertical webs and horizontal stiffeners whose ends are attached by the brackets;

13 for vertical webs and stiffeners whose ends are extended without cutting through supporting structure (web, deck and bulkhead) or welded thereto (brackets are not fitted). As well as for the stiffeners whose ends are fitted by brackets and extended along the stiffener from each side from support less than 1/12 of stiffener span;

10 – for vertical webs and stiffeners whose ends sniped at end.

Table 2.7.4.2

Bulkheads and primary members	k_σ
Watertight (emergency)[1]	0,85
Fore peak bulkhead	0,65
Tank / cargo tank , ballast water tank,bulk cargo tanks bulkhead:	
horizontal stiffeners of longitudinal bulkheads in the midship region within 0,15 D from deck and bottom	0,75
others horizontal stiffeners of longitudinal bulkheads as well as vertical webs of longitudinal and transverse bulkheads	0,80
Bulkheads of the tanks[1] where the pressure is:	
up to the top o overflow	0,80
to the top of tank	0,45

[1] Vertical webs and horizontal stiffeners.

Horizontal stiffeners of longitudinal bulkheads fitted at a distance of 0,15D from deck and bottom shall comply with the buckling strength requirements of 1.6.5.

The scantlings of the brackets measured from lower or upper ends of vertical webs, from the end of the horizontal stiffener are not to be less than determined by the Formula (1.7.2.2), taking n equal to:

2,0 and 2,2 for the brackets in a way of lower or upper ends of vertical webs;

1,6 for the bracket of horizontal stiffener.

The extending of lower bracket along the vertical web is not to be less than the 1/2 of vertical web span. For the brackets of bulkheads vertical webs of tanks with horizontal stiffeners stated size is not to be less than the 1/7 of vertical web span.

2.7.4.3 The section modulus and cross section area of web (with the exception of opening) of bulkheads deep members taking in to account web which suit to the plans in the Fig. 2.7.4.3-1 - 2.7.4.3-4 are not to be less than determined in according with 1.6.4.1 and 1.6.4.3 respectively taking:

$$N_{max} = npal \text{ kN};$$

p – as defined in 2.7.3;

m, n – in accordance with Table 2.7.4.3-1 - 2.7.4.3-5 depending on parameter of strength

$\mu = \dfrac{I_c}{I_г}\left(\dfrac{l_г}{l_c}\right)^3$, for the intermediate values of μ the linear interpolation is permitted;

k_σ, k_τ – in accordance with Table 2.7.4.3-1;

a – the breadth, in m, of section of bulkhead supported by the considered member of deep framing;

$l = l_c$ – for the vertical web;

$l = l_г$ – for the horizontal stiffener (refer to 2.7.1.3).

The members of deep framing of bulkheads of structural plans which are different from stated in Table 2.7.4.3-1 - 2.7.4.3-5 are to be determined by the direct calculation.

2.7.4.4 Profile height of vertical webs and horizontal girders of watertight (emergency) bulkheads is not to be less than l/l0 of the their span length.

Profile height of vertical webs and horizontal girders of tank bulkheads is not to be less than 1/8 of their span length.

Table 2.7.4.3-1

Bulkheads and primary members	k_σ	m	k_τ	n
Watertight (emergency)	0,85	21	0,70	0,5
Fore peak bulkhead	0,65	21	0,55	0,5
Of tank / cargo tank , ballast water tank transverse bulkheads				
for vertical webs	0,60	in accordance with Table 2.7.4.3-2–2.7.4.3-4	0,90	in accordance with Table 2.7.4.3-2–2.7.4.3-4
of horizontal girder in centre tank	0,35		0,60	
of horizontal girder in wing tank	0,35	50	0,60	0,5
of tanks [1,2]	0,65/0,50	21	0,55/0,40	0,5
of holds for bulk cargoes [1]	0,60	21	0,50	0,5

[1] Vertical webs and horizontal stiffeners.

[2] In the numerator - where the pressure is up to the top o overflow, in the denominator where the pressure is to the top of tank for factor of k_σ and k_τ.

Table 2.7.4.3-2

Structure	Parameter of rigidity μ								
	1	2	3	4	5	6	7	8	9
Vertical web	34,8	28,5	22,2	20,9	19,1	18,5	18,5	18,3	18,1
	0,115	0,145	0,180	0,204	0,204	0,215	0,215	0,219	0,222
Horizontal girder	52,6	62,0	71,4	81,2	90,9	90,9	90,9	90,9	90,9
	0,219	0,187	0,154	0,142	0,130	0,125	0,119	0,116	0,112

N o t e s : 1. In the numerator – factor *m*, in the denominator – *n*

2. For the intermediate values of μ linear interpolation is permitted.

Table 2.7.4.3-3

Structure	Parameter of rigidity μ								
	1	2	3	4	5	6	7	8	9
Vertical web	35,7	24,4	22,5	20,8	19,6	18,9	18,5	18,2	17,9
	0,245	0,335	0,390	0,427	0,452	0,470	0,482	0,490	0,495
First horizontal girder	45,5	62,5	76,9	89,3	93,5	98,0	100,0	105,2	111,1
	0,275	0,235	0,210	0,190	0,175	0,170	0,162	0,155	0,150
Second horizontal girder	47,6	64,5	83,3	95,2	100,0	100,0	100,0	100,0	100,0
	0,260	0,220	0,195	0,180	0,165	0,160	0,155	0,150	0,145

N o t e s : 1. In the numerator – factor *m*, in the denominator – *n*

2. For the intermediate values of μ linear interpolation is permitted.

Таблиця 2.7.4.3-4

Конструкція	Parameter of rigidity μ								
	1	2	3	4	5	6	7	8	9
Vertical web	50,0	31,8	27,0	24,4	22,5	21,3	20,4	19,9	19,6
	0,225	0,320	0,370	0,405	0,435	0,455	0,470	0,480	0,490
First horizontal girder	43,5	54,0	64,5	69,0	74,1	75,8	76,9	80,0	83,3
	0,270	0,230	0,205	0,190	0,180	0,175	0,165	0,160	0,160
Second horizontal girder	35,7	46,5	56,8	62,5	69,0	73,5	76,9	80,0	83,3
	0,305	0,260	0,230	0,212	0,200	0,190	0,180	0,175	0,170
Third horizontal girder	51,3	66,7	76,9	83,3	87,0	90,9	90,9	95,2	95,2
	0,260	0,220	0,200	0,185	0,175	0,167	0,160	0,155	0,152

N o t e s : 1. In the numerator – factor *m*, in the denominator – *n*

2. For the intermediate values of μ linear interpolation is permitted.

Table 2.7.4.3-5

Structure	Parameter of rigidity μ								
	1	2	3	4	5	6	7	8	9
1	2	3	4	5	6	7	8	9	10
Vertical web	69,0	43,5	33,9	30,3	27,8	28,0	24,0	34,1	23,5
	0,205	0,295	0,345	0,380	0,410	0,430	0,445	0,455	0,465
First horizontal girder	57,1	66,7	74,1	80,0	83,3	84,0	84,7	84,7	87,0
	0,240	0,210	0,190	0,175	0,170	0,160	0,155	0,151	0,150

Second horizontal girder	37,5 / 0,310	47,6 / 0,265	57,1 / 0,235	66,7 / 0,215	74,1 / 0,205	80,0 / 0,195	83,3 / 0,190	90,9 / 0,182	90,9 / 0,175
Third horizontal girder	37,5 / 0,315	47,6 / 0,270	57,1 / 0,245	66,7 / 0,225	74,1 / 0,210	80,0 / 0,195	83,3 / 0,190	90,9 / 0,180	90,9 / 0,175
4-а горизонтальна рама	50,0 / 0,250	62,5 / 0,220	74,1 / 0,200	83,3 / 0,185	87,0 / 0,180	90,9 / 0,165	90,9 / 0,155	93,5 / 0,152	93,5 / 0,150

N o t e s : 1. In the numerator – factor *m*, in the denominator – *n*
2. For the intermediate values of μ linear interpolation is permitted.

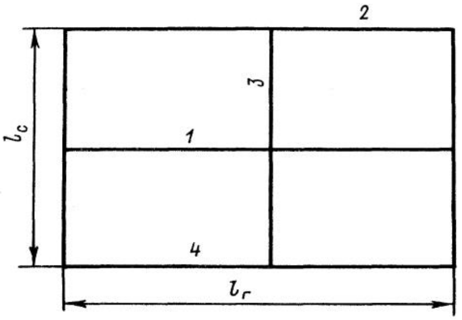


Fig.2.7.4.3-1. Plan of the grillage with one horizontal girder:
1 – horizontal girder; 2 – deck;
3 – wertical web; 4 – bottom

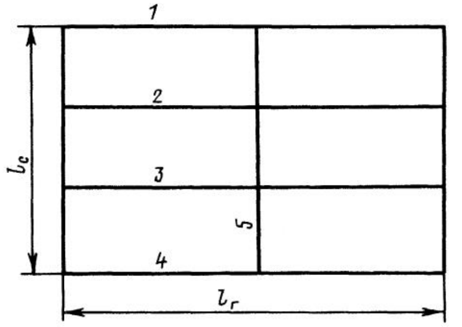


Fig.2.7.4. 3-2. Plan of the grillage with two horizontal girders:
1 – палуба; 2 – first horizontal girder;
3 – second horizontal girder; 4 –bottom;
5 – wertical web

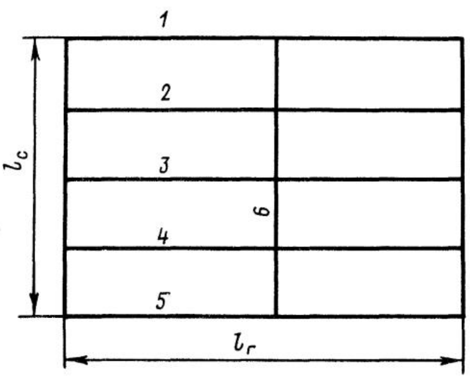


Fig.2.7.4.3-3. Plan of the grillage with three horizontal girders:
1 – deck; 2 –first horizontal girder;
3 – second horizontal girder; 4 – third horizontal girder ; 5 – bottom; 6 – wertical web

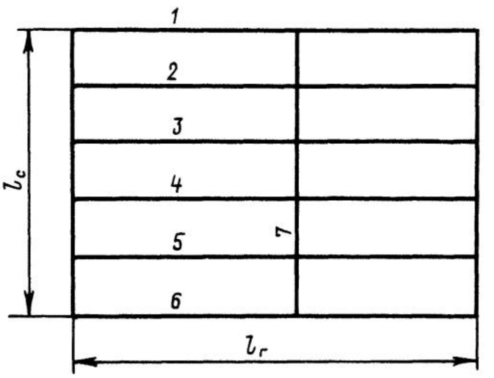


Fig.2.7.4.3-4. Plan of the grillage with three horizontal girders:
1 – deck; 2 – first horizontal girder;
3 – second horizontal girder; 4 – third horizontal girder; 5 – fourth horizontal girder;
6 – bottom; 7 – wertical web

Where the vertical web is fitted in the centre line profile height of horizontal girders of transverse bulkheads in the load tanks is not to be less than l/lO of the horizontal girders span length.

Profile height of vertical webs may be variable decreasing in a way of upper end and increasing in a way of lower end. This change may be up to 10 per cent of the mid-height of vertical web.

2.7.5 Special requirements.

2.7.5.1 The breadth of the bottom strake of bulkhead, as measured from inner bottom plating, or, where double bottom is omitted, from the bottom shell, shall be not less than 0,9 m for ships of 40 m and greater in length, and not less than 0,4 m for ships of 12 m in length. For intermediate ship lengths, the breadth of this strake shall be determined by linear interpolation. I f the double bottom extends to the bulkhead on one side only, the bottom strake of bulkhead plating shall extend for at least 0,3 m above the inner bottom plating.

In the boiler room, the bottom strake of the bulkhead shall extend for at least 0,6 m above the flooring.

The upper edge of bottom strake of transverse bulkheads in the cargo tanks of tankers shall be at least 100 mm above the upper toes of brackets of bottom longitudinals. The top and bottom strake breadth of longitudinal bulkhead plating shall not be less than 0,1-D, but need not exceed 1,8 m.

2.7.5.2 Cofferdams and the bulkheads forming their boundaries shall comply with the following requirements:

.1 unless expressly provided otherwise in the other Parts of the Rules, the breadth of vertical cofferdams stipulated under 2.4.7, Part V I "Fire Protection", 4.3.4, Part VI I "Machinery Installations" and 13.7.5, 14.5.2, 17.3, Part VII I "Systems and Piping" shall be equal to one spacing, but not less than 0,6 m, and the height of horizontal cofferdams shall not be less than 0,7 m.

In any case, cofferdam dimensions shall be so selected as to make the cofferdams accessible for inspection and repair.

Instead of cofferdams, cofferdam bulkheads may be fitted in accordance with 3.3 unless expressly provided otherwise by the Rules.

.2 cofferdams adjoining cargo tanks and fuel tanks shall be watertight.

Bulkheads separating cofferdams from tanks shall comply with the requirements for the bulkheads of those tanks.

The bulkheads of cofferdams filled with water shall comply with the requirements for tank bulkheads.

The bulkheads of cofferdams which shall ensure tightness, but which are not filled with water, shall comply with the requirements for watertight bulkheads. The bulkheads of cofferdams which are non-tight shall comply with the requirements for partial bulkheads as stipulated under 2.7.5.3, except the requirement for vertical webs supporting deck transverses and hatch end beams. They may have openings provided the corners of the openings are rounded and the edges are suitably reinforced. Such openings shall not generally be arranged in the top and bottom strakes of longitudinal bulkheads.

2.7.5.3 The scantling of the partial bulkheads members is to comply the following requirements:

.1 The thickness of partial bulkhead plating is not to be less than 7 mm in the hold and 6 mm' in the 'tween deck spaces, but not greater than the thickness of the adjacent watertight transverse bulkheads, where the distance between primary members (stiffeners) are equa.

.2 Partial bulkhead stiffeners supporting deck trans-verses and hatch end beams are to be in accordance with the requirements for relevant pillars (refer to 2.9).

.3 Where diametrical partial bulkheads may be used for separating bulk cargo, the scantlings of the stiffeners are to comply with 3.3.

.4 Under the last hatch beams as well as under the last bulkheads of superstructure two-sided stiffeners which attached to deck and bottom by flanged brackets or by other equal tool are to be fitted.

2.7.5.4 In tankers the scantlings of members of wash bulkheads and wash plates are to comply with the following additional requirements:

.1 In the wash bulkheads, the total area of openings is not to be greater than 10 per cent of the bulkhead area as a whole. The number and size of openings in the top and bottom strakes should be as small as possible.

The thickness and breadth of the top and bottom plates of wash bulkheads are to comply with the requirements for the bulkhead plating of tanks.

The section modulus of framing members of wash bulkheads (stiffeners, bulkhead stringer, horizontal girders, vertical webs) is not to be less than 50 per cent of necessary for members of tank bulkheads.

The ends of framing members are to be attached by brackets (refer to 2.7.2.3).

.2 The height of wash plate measured" from the top of the tank is not to be less the half of the tank height for fuel tanks and not less than 1/3 of height for other tanks. The thickness of the wash plate is not to be less than the thickness of upper face plate of bulkheads shell plating which bound the tank. Along the free edge of wash plate horizontal stiffener or face plate are to be fitted. The section modulus of the stiffener W, in cm^3, (face plate) is not to be less than determined by the Formula

$$W = 3hl^2, \quad (2.7.5.4.2)$$

where h – wash plate thickness, in m;
l – free span of plate, in m.

Wash plates are to be to be stiffened by vertical or horizontal stiffeners fitted not father than 0,75 from each other.

2.7.5.5 In watertight bulkheads corrugated structures may be used. The arrangement of corrugations may be both horizontal and vertical (refer to 1.6.4.5).

.1 The thickness of corrugations determined in accordance with 1.6.4.5.

.2 The section modulus of corrugation is not to be less than determined in accordance with 2.7.4.2 where m = 13 for non cutting corrugations and m = 10 for corrugations which are cut on frame members. In this case 1.6.4.5.3 should be taken into account.

.3 Requirements to the web girders of corrugated bulkheads are the same as for plane bulkheads. In this case the lowest cross sectional area of web girder is taken as a calculation one and the breadth of effective flange is to be taken in accordance with 1.6.3.6.

.4 Attachment of corrugated bulkheads is to comply with the following requirements:

In a way of attaching corrugated bulkheads to the bottom and deck (for horizontal corrugations) and to the ship sides and longitudinal bulkheads (for vertical corrugations) transition plane sections are to be fitted, the thickness and stiffening of which are to comply requirements to plane bulkheads.

Attachment of corrugated bulkheads ends is to be carried out directly by their welding to double bottom plating (or bottom plating), side plating, deck plating etc. Attention is to be paid to exclusion of "hard spots" (refer to 1.7.1.4) in structures considered.

Requirements to attachment of corrugated bulkheads of bulk cargo ships are specified in 3.3.2.

2.7.5.6 The thickness of vertical webs and plating of propeller shaft tunnel is to be the same as for watertight bulkheads in accordance with 2.7.4.1.

If the top plating is well curved, the thickness may be reduced by 10 per cent.

The recess of the shaft tunnel is to comply the requirements to watertight bulkheads in accordance with 2.7.4.1 and beams to comply the requirements in accordance with 2.6 and the section modulus is not to be less than for watertight bulkheads.

Under hatchways the thickened of top plating is to comply the requirements of 2.4.4.4.

The section modulus of vertical web of propeller shaft tunnel is not to be less than determined in accordance with 2.7.4.2 for the watertight vertical webs.

For the tunnels and passage which pass trough the tanks the thickness of the shell plating and profile of the vertical webs are not to be less than necessary for tank bulkheads (refer to 2.7.4.1 i 2.7.4.2).

2.8 FORE AND AFTER ENDS

2.8.1 General.

2.8.1.1 Requirements are given in this Chapter for the following structures:
fore peak and bulb (if any);

bottom within 0,25*L*, aft of the fore perpendicular;

side within 0,15*L*, aft of the fore perpendicular;

structures located aft of the after peak bulkhead, as well as strengthening of bottom and side forward in the region of impact pressure.

It is assumed in this Chapter that the upper boundary of the fore and after peak is formed by a tight deck or platform arranged directly above the summer load waterline.

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

D_f – minimum design draught, in m, in way of forward perpendicular;

α_x – angle, in deg., between a vertical and the straight line connecting the intersection points of summer load waterline and weather deck with the ship's side at a cross section within 0,05*L* from the forward perpendicular (refer to Fig.2.8.1.2-1);

β_x – angle, in deg., between a tangent to the waterline at vertical mid-distance between the summer load waterline and weather deck on forward perpendicular, and a line parallel to the centreline at a cross section within 0,05L from the forward perpendicular (refer to Fig. 2.8.1.2-2).

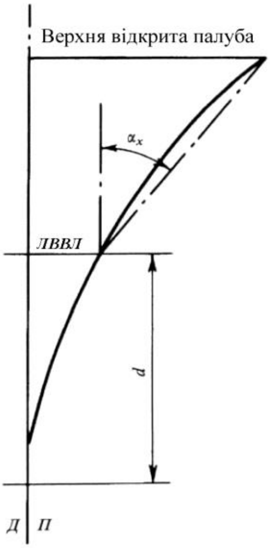


Fig.2.8.1.2-1.
Determination of angle α_x

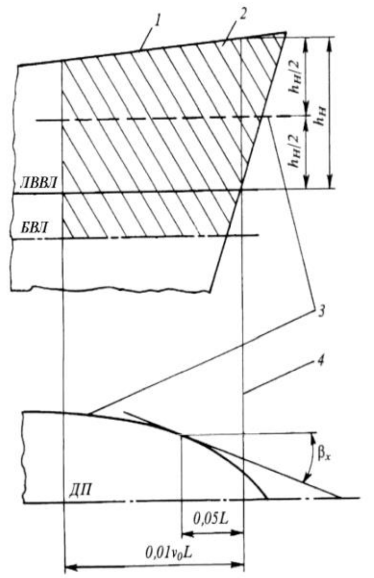


Рис.2.8.1.2-2.
Diagram for determining the angle β_x and the area (lined) to which the move impact pressure is applied:
1 – open upper deck; 2 – impact pressure area; 3 – water line for determining the angle β_x; 4 – forward perpendicular; h_H– vertical distance between the loadline and the open upper deck at forward perpendicular.

2.8.2 Construction.

2.8.2.1 The following framing systems are adopted at ends:

transverse system of framing for bottom in peaks;

transverse or longitudinal system of framing for other structures.

2.8.2.2 Fore peak floors shall be fitted at every frame. Their height shall not be less than stipulated under 2.8.4.5.

Floor webs shall be strengthened with vertical stiffeners to be spaced not more than 0,6 m apart.

A t the centreline an intercostal side girder with a face plate shall be fitted as an extension of centre girder in way of the holds.

The height and thickness of girder plates as well as the thickness and width of girder face plate shall be equal to those of the floors.

Where the webs of the girder cannot be arranged, the floor face plates shall be interconnected at the centreline by an angle, tee section, etc. the flanges of which have the same width and thickness as the floor face plates.

2.8.2.3 I f transverse system of framing is adopted in the fore peak side, the side stringers shall be fitted at least up to the deck directly above the summer load waterline. Side stringers shall be so fitted that the distance measured vertically between them does not, in general, exceed 2 m.

Side stringers shall be supported by panting beams fitted at alternate frames and shall, where possible, be supported at the centreline by a longitudinal bulkhead.

The free edge of the side stringers shall be stiffened by a face plate having a thickness not less than that of a stringer web and a breadth in accordance with 1.7.3.1.

A t every frame, the stringer web shall be stiffened by brackets having the side dimensions not less than half the stringer web height, and where panting beams are fitted, these shall be not less than required by 1.7.2.2 The thickness of brackets shall not be less than that of the stringer web.

Instead of panting beams, the side stringers may be supported by web frames spaced not more than 3 m apart.

It is recommended that non-tight platforms be fitted instead of side stringers with panting beams or web frames. In this case, the distance between the platforms may be increased to 2,5 m. The beams of non-tight platforms shall be fitted at every frame.

If in the structure with panting beams or web frames the distance from the base line to the nearest deck or platform exceeds 9 m, a non-tight platform shall be fitted at the middle of this length, in which the total area of openings shall not exceed 10 per cent of its area.

With longitudinally framed fore peak side, the spacing of web frames shall not exceed 2,4 m. Deck transverses shall be fitted in way of the web frames passage through or attachment to decks and platforms.

Floors without web frames fitted in line with them shall be attached to the nearest side longitudinals by brackets..

If the forepeak is a tank, a longitudinal wash bulkhaed or plate is to be fitted in the centre plane.

In tanks within 0.15*L* from the forward perpendicular (including the forepeak tank), whose length exceeds 0.06*L* or 6 m, whichever is greater, a transverse wash plate is to be fitted.

2.8.2.4 The bulb shall be strengthened by platforms spaced not more than 2 m apart. Beams of the platform shall be fitted at every frame.

If the length of the bulb forward of the forward perpendicular exceeds 0,03*L*, a non-tight bulkhead shall be fitted at the centreline, with stiffeners arranged at every frame.

If the length of the bulb is less than 0,03*L*, the bulb may be strengthened by a girder fitted at the centreline in continuation of the centre girder.

The construction of the fore end shall provide for the anchor to be lowered freely past the bulb with the ship listed 5° either side.

In way of eventual touching of the bulb, the shell plating thickness shall be increased and intermediate frames fitted.

2.8.2.5 In ships with single bottom, the bottom structure in way of the fore end outside the fore peak shall comply with the requirements of 2.3.2, 2.3.4 and, besides, with those given below.

.1 if transverse system of framing is adopted, the spacing of side girders, as well as the distance from the centre girder or the ship's side to a side girder, shall not exceed 1,1m within 0,25*L*, from the forward perpendicular.

If longitudinal system of framing is adopted and minimum draught is less than 0,035*L*, in way of the forward perpendicular, in cargo tanks of tankers an additional transverse with a face plate along its free edge shall be fitted midway between the bottom transverses. The depth of this transverse shall not be less than that of bottom longitudinals;

.2 forward of cargo tanks:

if transverse system of framing is adopted, intercostal side girders with face plates along their free edges shall be fitted in continuation of every second bottom longitudinal, extending forward as far as practicable. The depth and thickness of the side girder webs, as well as the scantlings of the face plates, shall be taken the same as for the floors.

if longitudinal system of framing is adopted, the spacing of floors shall not exceed 2,8 m. A n intercostal side girder having the same scantlings as the floors shall be fitted on either side of the ship between the centre girder and longitudinal bulkhead.

2.8.2.6 In way of the fore end, the double bottom structure outside the fore peak shall comply with the requirements of 2.4.2 and those given below. Within 0,25*L*, from the forward perpendicular the distance between side girders shall not exceed 2,2 m.

If transverse system of framing is adopted, in this region half-height side girders shall be fitted additionally and welded to the bottom and floors.

The distance between side girders and half-height girders shall not exceed 1,1m. These half-height girders shall be extended as far forward as practicable, whereas their free edges shall be reinforced with flanges or face plates.

If longitudinal system of framing is adopted, the floors shall be strengthened with stiffeners in line with each half-height side girder and each bottom longitudinal.

In ships greater than 80 m in length with a minimum draught less than 0,25*L*, in way of the forward perpendicular, the edges of openings in floor, side girder and centre girder webs shall be stiffened within 0,25*L*, from the forward perpendicular.

2.8.2.7 If transverse framing system is adopted, intercostal side stringers shall be fitted within 0,15*L*, from the forward perpendicular, outside the fore peak, at the level of the fore peak side stringers.

The depth and thickness of a stringer plate shall be equal to those of the frame. The intercostal brackets fitted as stringer plates shall be welded to the webs of frames at both ends and to the shell plating. On the free edge of a stringer, a face plate shall be fitted with the thickness not less than that of the web and the breadth in accordance with 1.7.3.1.

The intercostal side stringer may be of the same profile as the frames.

The stringer face plate (flange) shall not be welded to the face plate of frame.

Intercostal stringers shall be attached to the bulkheads by brackets.

The face plates (flanges) of intercostal stringers may be omitted where the spacing of frames does not exceed their double depth. In this case, their thickness s, in mm, shall not be less than

$$s = l/4s_c + \Delta s \text{ чи } s = 0,05\,h,$$

whichever is the greater,,

where l — is the length of the free edge of stringer between frames, in mm;
h — is the stringer depth, in mm;
s_c— the stringer web thickness, in mm, as defined in 1.6.5;
Δs— value in mm, as obtained from 1.6.5.5.

In ships having the characteristic $(v_0/\sqrt{L}) > 1,5$ or a large bow flare, provision shall be made for web frames and side stringers supported thereby. The spacing of web frames shall not exceed 5 frame spaces.

Where longitudinal framing is adopted in the ship's side forward outside the fore peak, the spacing of side transverses shall not exceed 3 m. In the holds of any ship, as well as in 'tween decks and superstructures of ships with the characteristic $(v_0/\sqrt{L}) > 1,5$ or with a large bow flare, provision shall be made for a vertical intercostal member having the same scantlings as side longitudinals, to be fitted between side transverses. The structure of the member shall be similar to that of the intercostal side stringers required by transverse framing system. The intercostal member can terminate at the upper and lower side longitudinals of the hold, 'tween decks and superstructure. Every second side longitudinal shall be attached to the side transverses by brackets extended to the frame face plate.

2.8.2.8 Within 0,1L, from the forward perpendicular, the span of weather deck transverses shall not exceed 3 m, and the deck girder span shall not exceed 3,6 m.

Within 0,2L, from the forward perpendicular, the section modulus of weather deck transverses shall not be less than required for deck girders with equal spans and spacing of members.

2.8.2.9 The structure located aft of the after peak bulkhead shall be sufficiently rigid in the vertical and horizontal plane. For this purpose, fitting of additional longitudinal bulkheads or platforms, thickening of deck plating and shell plating, as well as connection of bottom and upper deck longitudinals with pillars or struts may be required. If the stern overhang is large or the after peak width exceeds 20 m at any section, fitting of additional longitudinal non-tight bulkheads is recommended port or starboard.

Where there is a flat of the bottom, additional strengthening may be required to take up the loads due to impact pressure.

2.8.2.10 Floors in the after peak shall comply with the requirements of 2.8.4.6. In single screw ships, the floors shall be extended above the sterntube, but in any case to a height of not less than 0,8 m. If this is impracticable, tie plates with face plates on both edges shall be fitted transversely at every frame above the sterntube. The thickness of the tie plates shall not be less than that of the floor.

Tie plate exceeding 1,5 m in length shall be provided with a stiffener fitted in the middle of its length.

Floors with flanged edges are not permitted.

In ships greater than 200 m in length, floors shall be extended to the platform located above the sterntube. Longitudinally, the floors shall be stiffened with brackets fitted at the centreline and, if practicable, supporting the floor for a full depth.

Brackets above the sterntube are necessary. The brackets shall be carried to the propeller post. They need not be fitted where a wash plate is located above the floors, with its lower edge extending at least 0,8 m below the face plates of the floors.

The opening in floors for the sterntube shall be reinforced with face plate along the edges. Below the sterntube, the openings shall be reinforced with face plates or stiffeners.

2.8.2.11 If transverse framing is adopted in the after peak side, panting beams and side stringers, beam knees, frame to side stringer attachments, arrangement and structure of web frames and non-tight platforms shall comply with the requirements of 2.8.2.3. The vertical distance between side stringers shall not exceed 2,5 m, and the frame span, as measured on the side plating, shall not exceed 3,5 m.

In 'twin- and multi-screw ships having a cruiser or transom stern, the distance between stringers, as measured on the side plating, shall not exceed 2 m, with one of the stringers being fitted in way of the top edge of propeller shaft bossing or in line with the shaft bracket. Where web frames are fitted, their spacing shall not exceed 2,4 m.

If longitudinal framing is adopted in the after peak side, relevant requirements of 2.8.2.3 shall be complied with.

2.8.2.12 The ends of after peak members (including deck, platform and bulkhead framing), as well as the ends of horizontal and, where practicable, vertical stiffeners of floors shall be secured (refer to 1.7.1.4).

The face plates of the after peak floors and deck transverses shall be sniped in way of their attachments to longitudinal bulkheads. Bulkhead stiffeners shall be attached to the floor face plates by brackets fitted on either side of the bulkhead.

This also applies to deck girder and side girder attachments to transverse bulkheads.

2.8.2.13 The spacing of ordinary and bevel frames may be the same as in the midship region, but shall not exceed 750 mm. A side girder of the same depth as that of floors shall be fitted at the centreline.

In case of transom stern and/or flat of the bottom, the side girders shall be spaced not more than 2 m apart.

In full cruiser sterns and where the frame span from the upper edge of floors to the nearest deck exceeds 2,5 m, additional strengthening shall be provided by means of web frames and a side stringer.

2.8.2.14 Side stringers in fore and after peak tanks shall be fitted with flanged edge or face plate.

If peaks are used as tanks, fitting of a wash bulkhead or plate is recommended at the centreline.

2.8.2.15 In impact pressure area (refer to 2.8.3.2) in centre girder, stringers and floors minimum number of openings are to be provided.

Where L > 80 the openings are to be strengthened by member along the edge or stiffening rib.

2.8.3 Loads on structures at ends.

2.8.3.1 The design pressure on the structures at ends is determined using the design loads specified in 2.2 to 2.7 and the extreme loads specified in 2.8.3.2 and 2.8.3.3.

The scantlings of fore end members subject to impact pressure shall be verified by applying extreme loads:

- in accordance with 2.8.3.2 for ships greater than 65 m in length with a minimum draught of 0,045L, in way of the forward perpendicular;

in accordance with 2.8.3.3 for ships having the characteristic ($v_0/\sqrt{L}$) > 1,5, or a considerable bow flare.

2.8.3.2 Under the wave impact upon the bottom of the fore end, the extreme values of the design hydrodynamic pressure p_{SL}, in kPa, shall be determined by the formula

$$P = 5{,}5c_1c_2\,\varphi_r\,(b_x/B)(1\text{-}5d_f/L)\times$$
$$\times(1\text{-}x_1/l_b)10^3, \qquad (2.8.3.2\text{-}1)$$

where $c_1 = \sqrt{L}$ for $L \le 200$ m;

$c_1 = 5\sqrt{(10 - L/100)}$ for L > 200 m;

$c_2 = 0{,}134\,v_0\,(1\text{-}17{,}1\,d_f/L)/\sqrt{L}$;

$l_b = (0{,}22 + 1{,}5c_2)L$,

for v_0 – refer to 1.1.3;

φ_r – as obtained from 1.3.1.5 (φ_r = 1 for ships of unrestricted service);

b_x – ship breadth, in m, in the considered cross section at the level of 0,04B above the base line, but not greater than 0,8B;

x – distance, in m, from the considered cross section to the forward perpendicular, but not greater than l_b;

d_f – lowest moulded draft at forward prpendicular , in m.

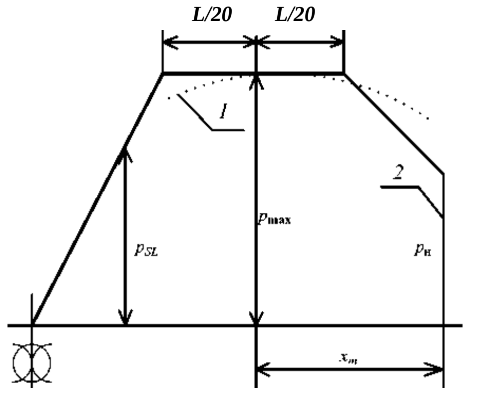


Fig.2.8.3.2 Determination of design pressure p_{SL}.

1- value of p determined by Formula (2.8.3.2-1);

2- forward perpendicular.

Formula (2.8.3.2-1) is used for derivation of p values in a number of sections within the portion l_d from which the maximum value of p (hereinafter — symbol – p_{max}) and the value of x_1 (hereinafter symbol – x_{max}) corresponding to p_{max} are chosen.

The design pressure p_{SL} (refer to Fig. 2.8.3.2) is determined by the formula.

$$p_{SL} = p_f + (p_{max} - p_f)\,x_1/(x_{max} - 0{,}05L)$$

when $0 \le x_1 < x_{max} - 0{,}05\,L$

$p_{SL} = p_{max}$, when

$x_{max} - 0{,}05\,L \le x_1 \le x_{max} + 0{,}05\,L$

$$p_{SL} = p_{max}\,(0{,}5L - x_1)/(0{,}45L - x_{max}),$$

when

$$x_{max} + 0{,}05L \le x_1 \le 0{,}5\,L\,. \quad (2.8.3.2\text{-}2)$$

where p_H = 0,5 – with bulb;

p_H = 0 – without bulb.

The hydrodynamic pressure as determined by Formula (2.8.3.2-2) is distributed over a height of 0,04*L* above the base line.

2.8.3.3 Under the wave impact upon the bottom of the fore end, the extreme values of the design hydrodynamic pressure p_{SL}, in kPa, shall be determined by the formula

$$p_{SL} = 0{,}9\, c_3\, c_4^2, \qquad (2.8.3.3)$$

where $c_3 = 2{,}2 + 1{,}5\ \mathrm{tg}\ \alpha_x$;

$$c_4 = v_0 \left(0{,}6 - \frac{20}{L}\right)\left(1{,}2 - 0{,}2\beta_x / 60\right)\ \sin\beta_x + 0{,}6\sqrt{L};$$

for v_0 – refer to1.1.3;

α_x, β_x – as defined in 2.8.1.2.

Depthwise the impact pressure is distributed over the part of the side above the ballast waterline, and lengthwise — over the part of the side extending as far aft as the cross section at $0{,}01 v_0 L$ from the forward perpendicular and as far forward as the intersection of the upper deck with the stem (refer to Fig. 2.8.1.2-2).

2.8.4 Scantlings of structural members at ends.

2.8.4.1 The scantlings of structural members using the service loads given in 2.8.3.1 are not to be less than determined in accordance with 1.6.4.1 -1.6.4.4 taking:

$N_{max} = npal$ кН;

m, k_σ, n – in accordance with Tables 2.8.4.1-1, 2.8.4.1-2 and 2.8.4.1-3 respectively;

$k_\tau = 0{,}8$ – for web frames and web beams of dry cargo ships;

$k_\tau = 0{,}65$ – for web frames of tankers;

k_τ – in accordance with 2,3 and 2,4 for bottom framing members.

In this case the thickness of shell plating and scantlings of members which support shell plating is to be determined as for steel with R_{eH} = 235 MPa without regard to the liquid limit of used steel.

Table 2.8.4.1-1

Structure	Framing members	Factor *m*
Deck	Longitudinals	12
	Beams	10
	Deck transverce (exept for web beams in the load tanks of tankers)	11
	Deck transverce in the load tanks of tankers	in accordance with 2.6
	Deck girders	in accordance with 2.6
Side	Peaks frames	12
	Longitudinals	12
	Hold frames of dry cargo ships	
	one deck	24
	two decks	26
	three and more decks	28
	Hold frames of tankers	13
	'tween deck frames:	
	in upper 'tween deck	8
	in other 'tweendecks	10

Structure	Framing members	Factor *m*
	Web frames of dry cargo ships	
	in hold	18
	in 'tween deck	6
	Web frames in the load tanks of tankers:	
	where struts are ommited	20
	where one strut are fitted	24
	where two strut are fitted	30
	where three strut are fitted	35
	Stringers if transverse framing is fitted:	
	where struts are ommited	16
	where one strut are fitted	24
	where two or more strut are fitted	30
	where web frams are fitted	8
Bottom	All members of framing	in accordance with 2.3, 2.4

Table 2.8.4.1-2

Structural members	Factor k_σ
Plate	1,2
Draming members of deck and side (exept for web beams in the load tanks of tankers and deck girders)	0,6
Deck transverce in the load tanks of tankers and deck girders	in accordance with 2.6
Framing members of bottom	in accordance with 2.3 and 2.4

Table 2.8.4.1-3

Structure	Framing members	Коефіцієнт *n*
Палуба	Deck transverse of **dry** cargo ships	0,73
Side	Deck transverse of dry cargo ships	0,50
	Deck transverse of tankers where truts are ommited	0,33
	where one strut are fitted	0,23
	where two and more struts are fitted	0,21
Bottom	All members of framing	in accordance with 2.3 and 2.4

2.8.4.2 Where exposed to extreme loads to be determined in accordance with 2.8.3.2 and 2.8.3.3, the scantlings of bottom and sides members at the fore end are to comply with the following requirements

.1 The thickness of shell plating *s*, in mm, is not to be less than determined by the Formula

$$s = 13k_1 a\sqrt{p/R_{eH}} + \Delta s, \quad (2.8.4.2.1)$$

where $k_1 = 1{,}25 - 0{,}5a/b$ for $a/b > 0{,}5$;
$k_1 = 1$ for $a/b \le 0{,}5$;
a, *b* – the thickness, in m, of smaller and bigger side of the pate respectively.

.2 The section modulus W, in cm^3, of framing members is not to be less than

$$W = 47\frac{pa_1 l^2}{k_2 R_{eH}} k_3 \omega_k, \qquad (2.8.4.2.2)$$

where p - design pressure in accordance with 2.8.3.2 and 2.8.3.3;

$$k_2 = \frac{3}{3-(a_1/l)^2};$$

k_3 = 1,0 if the members are continuous through the webs of supporting structures;

1,75 - if the members are cut at supports;

0,55 - if the supporting sections of the member are reinforced with brackets on both sides of the supporting structure; the depth and length of brackets are not less than 1,5 of the member depth;

.3 The cross-sectional area f, in cm^2, of a primary member or of welds by which intercostal members are connected to supporting structures is not to be less than determined by the Formula

$$f = \frac{8{,}7k_4 pa_1 l}{R_{eH}} + 0{,}05h_1\Delta s, \quad (2.8.4.2.3)$$

where $k_4 = 1 - 0{,}5(a_1/l)$;

h_1 – perimeter of the member section;

for p – refer to2.8.4.2.2.

The cross-sectional area of a member includes the web area, as well as the portion of the sectional area of shell plating, having a breadth $b_1 = 3s$ (де s – is the thickness, in mm, of face plate). If the face plate is of bulb profile, the whole of its face plate is included in the cross-sectional area. In the case of face plate of T-section, a portion of its breadth is included in the cross-sectional area similarly to face plate.

2.8.4.3 The web thickness s_f, in mm, of floor, side girder and centre is not to be less than determined by the Formula

$$s_ф = \frac{0{,}76p(L_0 - 50)}{(6{,}1 - a_2)(1{,}2h_к + nh_ф + 2\sum h_с + 2\sum h_{пс})R_{eH}} + \Delta s, \quad (2.8.4.3)$$

where p – in accordance with 2.8.3 2;

$L_0 = L$ – is not to be less than 80 and greater than 160;

$h_к$ – centre girder height in the given region of ship length;

$n = 0{,}01L(3 + a_2)/a_2 – 0{,}6(1 – 2/a_2)$;

h_f – floor height in the given region of ship length within *L/40* from centreline to ship side, but not less than the height of the nearest to the side girder, with the deduction of opening height (if any is in this plate of floor between girder and half-height side girders;

Σh_s i Σh_{hs} – the sum of the heights, in m, of side girder and half-height side girders in the given region of ship length which are within *L/40* from centreline to ship side with the deduction of opening height (if any).

The thickness of the web of girder, of web and face plate of half-height side girders (see 2.8.2.6) is to be equal to the thickness of floor and the thickness of centre girder is to be greater than thickness of the floors by 20 per cent.

2.8.4.4 Where transverse framing is used the height of floors h, in mm, within the region from load tanks to forward, is not to be less than determined by the formula

$$h = 7L + 100;$$

the thickness of face plates of floors is to be greater than thickness of web by 2 mm. The breadth of face plate is not to be taken less than 10 thicknesses of face plate.

2.8.4.5 In the fore peak the height of floors is not to be less than $B_x/8$ and the thickness is to be equal to 0,01 of floors' height but no need to take it thicker than bottom plating in the considered region . The thickness of face plate of floors is not to be less than web thickness.

The breadth of face plate (flange) is to comply with the requirements 1.7.3.1.

Flor webs are to be strengthened with with vertical stiffeners, spaced 0,6 m apart.

2.8.4.6 Within the area of the stern counter, the scantlings of frames are to be not less than those of the after peak frames, unless their span exceeds 2,5 m. With a greater span, the frame scantlings should be increased accordingly. The thickness of floors and side girders is not to be less than required by 2.8.4.5.

2.8.4.7 Where the transverse framing is used the scantlings of the side stringers of fore and after peaks are not to be less than (*b* - breadth, *s* -thickness):

$b = 0{,}005L + 0{,}24$ m for $L \le 80$ m;
$b = 0{,}003L + 0{,}4$ m for $L > 80$ m;
$s = 0{,}025L + 5{,}75$ mm.

2.8.4.8 The scantlings of panting beams as well as scantlings of penetrated platforms which are fitted instead of panting beams are determined in accordance to 2.9.4.1. In this case area and section modulus of penetrated platforms beams is determined taking into account the face plate.

2.8.4.9 The thickness of shell plating in way of the bulb is not to be less than $0{,}08L + 6$, але може братися не більше 25 мм. but it need not be taken greater than 25 mm. In this case, the shell plating thickness at the lower part of the bulb is not to be less than stipulated under 2.8.4.2.1 for the hull section in way of the forward perpendicular.

2.8.5 Special requirements.

2.8.5.1 Visor-type bow doors [6].

.1 The present requirements apply to the construction of visor-type bow doors which form a component part of the fore end of the ship, being mechanically connected with the side and deck structures and capable of moving in the vertical direction to provide access for motor vehicles and/or other transport means.

.2 The thickness of visor-type bow door plating is not to be less than that required by 2.8.4.2.1 for the appropriate sections of shell plating.

.3 The section modulus of primary members is not to be less than that for the appropriate fore end regions.

The sectional area, *f*, in cm², of member web is not to be less than

$f = 12pal/R_{eH}$,

where *p* - load, in kPa, on shell plating of fore end part in accordance with 2.8.3.3 but not less than

$$p_{\min} = 0{,}8(0{,}15v_0 + 0{,}6\sqrt{L})^2.$$

.4 Structural measures are to be taken to ensure rigid attachment of primary members and support members of bow doors.

.5 The scantlings of support members are to be obtained by strength calculation using the design loads given in 2.8.3.3, and the following permissible stresses:

shearing stress $\tau = 80/\eta$;
normal stress $\sigma = 120/\eta$;
combined stress $\sigma_{eq} = 150/\eta$.

.6 The construction of support members is to comply with the requirements of 1.7.3.

2.8.5.2 In ships provided with fixed propeller nozzles, transverse bulkheads or support members are to be fitted in way of the nozzle attachment to the hull.

2.8.5.3 In hull curvilinear sections (deadrise, flare), it is recommended that the framing be fitted at an angle of approximately 90° to the shell plating.

[6] The requirements apply to Visor-type bow doors.

2.8.5.4 In multi-screw ships, the structural strength and rigidity in way of sterntube, shaft bracket and shaft bossing attachments are subject to special consideration by the Register.

2.9 PILLARS AND PANTING BEAMS

2.9.1 General.

2.9.1.1 Requirements are given in this Chapter for the scantlings of pillars fitted in the hull, superstructures and deckhouses and for the panting beams in peaks.

2.9.1.2 Symbols:

l – length of pillar (panting beam), in m, measured:

for the pillar between the face plate of the deck girder (or the deck transverse, if the latter is supported by the pillar) and the deck plating (or the inner bottom plating);

for the panting beam between the inner edges of the starboard and port frames or from the inner edge of the frame to a strong support at the centerline;

f – sectional area of the pillar (panting beam), in cm^2;

I – the least value of moment of inertia of the pillar (panting beam), in cm^4;

$i = \sqrt{\frac{I}{f}}$ – the least moment of inertia of the pillar (panting beam), in см;

$\lambda = \frac{l}{i}$ – flexibility of pillar (panting beam);

s – the thickness, in mm, of pillar web;

d_0 – outer diameter of the pillar, in mm.

2.9.2 Construction.

2.9.2.1 The pillar axes in 'tween deck spaces and holds are generally to be fitted in the same vertical line.

The pillars are to be fitted on plate floors and side girders (see also 2.4.2.5.3).

With the load P>250 kN the pillars are to be fitted at the intersection of plate floors and side girders, otherwise the plate floor (side girder) is to be strengthened with vertical brackets attached to the adjacent floors (side girders).

Where d_0 > 125 under the heel of pillar on the plating of inner bottom or deck (where brackets, cones or inserted plate for load distribution) doubling plate, which welded along the contour by continuous welding seam is to be fitted (refer also to 2.9.4.3).

In tanks pillars, as a rule, are to be open proftte shaped.

2.9.2.2 The pillars shall be attached at their heads and heels by brackets or other arrangements approved by the Register, in order to effectively transmit the loads to the hull structures below:

in the holds of ships of ice classes **Ice6** and **Ice5;**

in the tanks under watertight platforms, deckhouses, ends of superstructures, windlasses, winches, capstans, etc.;

at the fore end of ships with the specified speed $v_0 > 1{,}5\sqrt{L}$ (where for v_0 refer to 1.1.3.6) or large bow flare.

2.9.3 Design loads.

2.9.3.1 Loads on the pillar P, in kN, is determined by the formula

$$P = pl_m b_m + \sum_i \left(pl_m b_m\right)_i , \qquad (2.9.3.1)$$

where p – design pressure on the above deck specified in 2.6.3, in kPa;

l_m – distance measured along the deck girders between midpoints of their spans, in m;

b_m – mean breadth of deck area (including the hatchways in the region concerned) supported by the pillar, in m;

$\sum_i (pl_m b_m)_i$ – sum of loads from the pillars fitted above, determined having regard to 2.6.3, which may be transmitted to the pillar considered, in kN.

2.9.3.2 Loads on the panting beam *P,* in kN, is determined by the formula

$$P = pac, \qquad (2.9.3.2)$$

where $p = p_{st} + p_w$ – design pressure on the ship's side in way of installation of the panting beam, determined from 1.3.2.1 and 1.3.2.2, in kPa;

a – spacing of frames on which panting beams are fitted, in m;

c – half-sum of frame spans measured vertically above and under the beam considered, in m.

2.9.4 Scantlings of pillars and panting beams.

2.9.4.1 The sectional area of pillalrs and panting beams f, in cm^2, shall not be less than determined by the iterative method according to the formula

$$f = 8Pk\,(2 + \lambda)/\sigma_{cr}, \qquad (2.9.4.1)$$

where P – as determined in accordance with;

k =1,0 and 1,15 for pillars and panting beams respectively;

σ_{cr} – critical stress according to 1.6.5.3 at Euler stress depending on $\sigma_e = 203/\lambda^2$;

It is recommended to take $\lambda = 0{,}4/\eta$ in the first approximation.

2.9.4.2 The wall thickness s, in mm, of tubular pillars is not to be taken less than:

$$s = (d_0/50) + 3{,}5. \qquad (2.9.4.2\text{-}1)$$

The wall thickness of built-up pillars (box-shaped, made of channels or I-beams, etc.) s, in mm, is not to be less than:

$$s = h_п/50, \qquad (2.9.4.2\text{-}2)$$

where h_p - width of the pillar wall, in mm.

The wall thickness of a pillar, in general, is not to be taken less than 6 mm.

In small ships the thickness of the pillar walls may, on agreement with the Register, be reduced to 5 mm, provided the required sectional area of the pillar is maintained.

2.9.4.3 The thickness of inserted plate under the heel of pillar (see 2.9.2.1) s, in mm, is not to be less than:

$$s = 3{,}3 \cdot 10^{-3}P + 10, \qquad (2.9.4.3)$$

where P – in accordance with 2.9.3.1.

The diameter of inserted plate is to be greater than diameter of pillar ≈ 6s.

2.9.5 Special requirements.

The thickness of face plate of section members of compound profile pillar measured from web is not to exceed determined in 1.7.3.

2.10 STEMS, KEELS , RUDDER HORN, PROPELLER SHAFT BRACKETS, FIXED NOZZLES OF PROPELLER

2.10.1 General.

Requirements are given in this Chapter for the construction and scantlings of the stem, sternframe (rudder post, propeller post), solepiece of the sternframe, rudder horn of semi-spade rudders, propeller shaft brackets, bar keel, fixed nozzles of propellers.

2.10.1.2 Symbols:

l_s – the length of section area of stem, in mm;

b_s – the breadth of section area of stem, in mm;

h_s – the height of section area of stem, in mm;

x_s – the distance, in m, of design section of rudder horn of semi-spade rudders from lower bearing of rudder blade;

R_4 – reaction force of lower support of the rudder, in kN (refer to 2.10.3);

R_p– radius of propeller, in mm;

D_n – outer diameter of the nozzles of propellers, in m.

2.10.2 Construction.

2.10.2.1 Stem is to be efficiently connected to the bar or plate keel and, whenever possible, to the centre girder.

The welded stem plates are to be stiffened with transverse brackets. Arrangement of transverse brackets of the stem should, as far as possible, be consistent with the hull framing. Transverse brackets stiffening the stem plate are fitted not more than 1 m apart below and not more than 1,5 m above the summer load line. The brackets are to overlap the joints of the stem with the shell plating and are to be extended and welded to the nearest frames.

The brackets which cannot be extended to the framing, except for the brackets in way of ice belt in ships with ice categories, should have their rear edge made along a smooth curve.

In case where the small sharpness of hull configuration or the radius of curvature of the stem in the summer load line level is larger than 200 mm , it is recommended to fit a c'enterline girder with a face plate along the free edge in the centreline of fore stem from keel to the level which higher than summer load line by 0,15d .

In cast stem for connection with centre girder the special rib is to be fitted in a way of solepiece of sternframe. Along the height cast stem is to be provided with transverse. Arrangement of transverse ribs in should be consistent with the hull framing.

2.10.2.2 The construction of sternframe of a single screw ship shall comply with the following requirements:

.1 the sternframe shall have such dimensions as to provide the clearances between sternframe and propeller, and between propeller and rudder (refer to Fig. 2.10.2.2) not less than indicated in Table 2.10.2.2;

.2 the solepiece shall be made with a smooth rise in the aft direction;

Table 2.10.2.2

Dimensions	*a*	*b*	*c*	*d*	*e*
Clearances, in mm	0,2$R_{г}$	0,42$R_{г}$	0,36$R_{г}$	0,08$R_{г}$	200 – 250

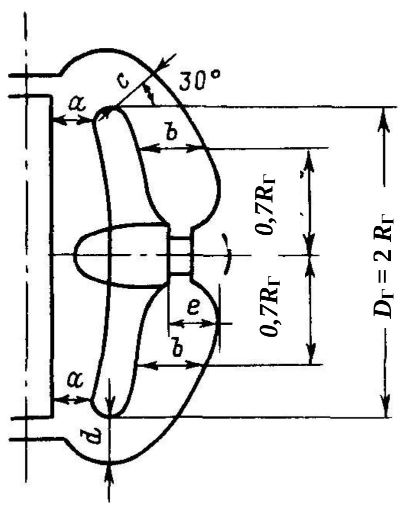


Fig.2.10.2.2

.3 the propeller post shall be provided with transverse brackets in the case of welded sternframe and webs in the case of cast sternframe. The brackets and webs shall be spaced at least 1 m apart; their arrangement shall be consistent with the hull framing.

.4 the sternframe shall be efficiently attached to the hull.

The lower part of the sternframe shall be extended forward from the propeller post and shall be attached by its brackets (webs) to at least three floors in ships with a length $L > 120$ m and at least two floors in ships with a length $L \le 120$ м. In small ships the sternframe may be attached to one floor only.

The rudder post shall extend over the counter to a height sufficient for its attachment to the transom floor.

In ships of 80 m and above and in ships with cruiser stern, the propeller post shall also be extended upwards to a distance sufficient for its attachment to the additional transom floor.

The thickness of transom floor and additional transom floor shall be increased as compared to that of the floors in the after peak. In general, the above floors shall be extended to the nearest deck or platform.

Propeller post of a single screw ship where it forms a single whole with rudder-post is to be extended to the aft from the axis of rudder spindle at distance not less than three normal spacing.

2.10.2.3 The sternframe in twin screw ships shall comply with the requirements for the sternframe in single screw ships, as specified in 2.10.2.2.

The lower part of the sternframe to be extended forward, may be attached to at least two main floors.

2.10.2.4 The sternframe of triple screw ships shall comply with the requirements for the sternframe of single screw ships, as specified in 2.10.2.2 and 2.10.4.2.

2.10.2.5 The rudder horn of semi-spade rudder shall be efficiently connected to the respective floors of the after peak and its centreline wash bulkhead.

The welded rudder horn shall be provided inside with transverse brackets; its main supporting structures shall be extended to the nearest deck or platform; the thickness of the floors to which the rudder horn is connected shall be increased as compared to that of the floors in the after peak.

2.10.2.6 The struts of two-strut shaft brackets shall form an angle of approximately 90° to each other. Their axes shall intersect at the axis of the propeller shaft.

The construction of propeller shaft brackets with struts arranged at an angle less than 80° and greater than 100°, additional strengthening of the hull within the region of shaft brackets are subject to special consideration by the Register.

The propeller shaft brackets shall be so arranged in relation to the ship's hull that the clearance between the blade tip and the ship's hull is as large as possible and, but, not less than 25 per cent of the propeller diameter.

2.10.2.7 The outer and inner plating of propeller nozzle shall be strengthened by stiffeners whose arrangement and size as well as connection with outer and inner plating of the propeller nozzle shall be determined according to 2.4.2.2, Part

II I "Equipment, Arrangements and Outfit".

In general, the transverse web plates shall be arranged in line with the floors of the after peak.

In way of attachment of the nozzle to the hull smooth transition from the nozzle to the ship's hull shall be provided. The bottom part of the nozzle shall be connected to the hull. I f the propeller nozzle is attached to the hull by shaft brackets, provision shall be made for an efficient connection of the brackets with the framing in the aft region of the hull and the framing inside the nozzle.

The construction of shaft brackets shall satisfy the requirements of 2.10.2.6.

Drain plugs of non-corrosive material shall be fitted in the top and bottom parts of outer plating.

2.10.3 Design loads.

Design loads for the structures of the solepiece and rudder horn of semi-spade rudders is taken equal to the reaction force of lower support of the rudder R_4 according to 2.2.4.12, Part III "Equipment, Arrangements and Outfit".. In the Formulae (2.2.4.7-2) to (2.2.4.7^) the coefficient α_4 shall be taken equal to zero.

2.10.4 Scantlings of stem, sternframe, rudder horn and propeller shaft brackets, bar keel and fixed nozzle of propeller.

2.10.4.1 The stem shall satisfy the following requirements:

.1 The sectional area l_s and b_s, in mm, of a bar stem from the keel to the summer load water line is not to be less than determined by the Formula

$$l_s = 0{,}95L + 100;$$

$$b_s = 0{,}40L + 15, \text{ but not more than 100 mm.} \quad (2.10.4.1)$$

The sectional area may be reduced for ships of restricted areas of navigation:
R2, **A-R2, R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS** – by 10 per cent;
B-R3-S, **B-R3-RS, C-R3-S**, **C-R3-RS, R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** – by 20 per cent.

Above the summer load waterline the sectional area may be gradually reduced to 70 per cent of the area stated above.

.2 the plate thickness *s*, in mm, of welded stem shall not be less than $s = 0{,}1L + 4$, but not less than 7 mm.

Where $L > 220$ m, L shall be taken equal to 200 m.

Where $d/L \geq 0{,}065$ the thickness of the plate of welded stem is to be multiply by factor $0{,}35 + 10\, d/L$.

The plate thickness of the stem may be reduced for ships of restricted areas of navigation:
R2, **A-R2, R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS** – by 5 per cent;
B-R3-S, **B-R3-RS, C-R3-S**, **C-R3-RS, R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** – by 10 per cent

The plate thickness of the stem above the summer load waterline may be gradually reduced to that of shell plates adjoining the stem. The thickness and width of the stem plates in way of attachment to the plate keel shall not be less than the thickness and width of the latter.

When the distance between the brackets strengthening the stem is reduced by 0,5 m, as compared to stated above, the reduction of plate thickness of stem by 20 per cent may be permitted.

It is recommended to take the length of section area of welded stem equal to two length of section area of bar stem.

.3 The thickness of transverse brackets of welded after stern is to be greater than the thickness of shell plating by 20 per cent.

The thickness of brackets strengthening the stem shall not be less than that of shell plating adjoining the stem.

The thickness of web and face plate of the girder stiffening the stem at the centreline shall not be less than that of the brackets.

In this case the thickness of plates is not to be less than the thickness of plates of shell plating adjoining to stem.

The thickness of the ribs which strengthen cast after stern is to be greater than shell plating adjoining to after stern by 50 per cent.

2.10.4.2 The sternframe of a single screw ship shall satisfy the following requirements:

.1 the length l_s and b_s, in mm, of rectangular solid propeller post section, from the keel to the counter, shall not be less than:

$l_s = 1,30\,L + 95$; $b_s = 1,60L + 20$ for $L < 120$ m;

$l_s = 1,15L + 110$; $b_s = 0,675L + 130$ for $L \geq 120$ m. (2.10.4.2.1)

The scantlings of the propeller post may be reduced for ships of restricted areas of navigation:

R2, A-R2, R2-S, **R2-RS**, **A-R2-S**, **A-R2-RS** – by 5 per cent;

B-R3-S, **B-R3-RS, C-R3-S**, **C-R3-RS, R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** – by 10 per cent.

Above the counter the sectional area of sternframe may be gradually reduced. And nowhere its sectional area shall be less than 40 per cent of the required area of the propeller post, corresponding to the scantlings determined by the following formulae (2.10.4.2.1).

The solepiece of after stern is to be greater by 10 per cent along the height and by 40 per cent along the breadth than the length and breadth of sectional area of propeller post.

.2 the scantlings of the propeller post cross section of a cast sternframe with the rudder having top and bottom supports shall be established in accordance with Fig. 2.10.4.2.2 depending on the value s_0, in mm, determined by the following formulae:

$s_0 = 0,1\,L + 4,4$ for $L < 200$ m;

$s_0 = 0,06L + 12,4$ for $L \geq 200$ m. (2.10.4.2.2)

The thickness of the sternframe free edges s, which are welded to the plating, and the length of the transition to plating thickness a_s shall be taken in accordance with existing regulations on the construction of places of transition for welding of various thicknesses.

The thickness of webs shall be at least 50 per cent greater than that of the shell plating adjoining the sternframe.

.3 the scantlings of the propeller post cross section of a welded sternframe with the rudder having top and bottom supports shall be established according to Fig. 2.10.4.2.3,

where s_0 – shall be determined in accordance with 2.10.4.2.2.

The thickness of transverse brackets shall be at least 20 per cent greater than that of the shell plating adjoining the sternframe.

Welded propeller post of other construction may be used, provided that its strength is equivalent to that of the abovementioned construction.

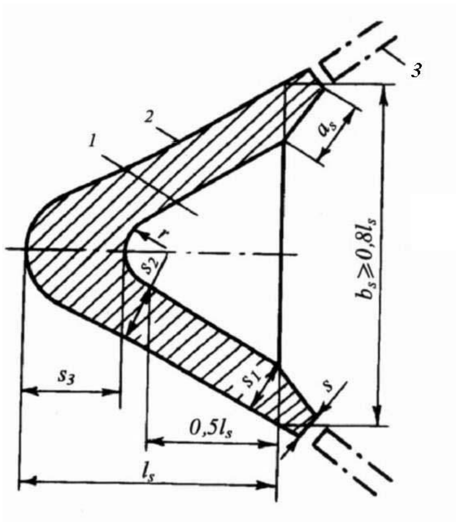


Fig.2.10.4.2.2:
1– web; 2 – along hull counters;
3 – adjoining plate of shell;
$s_1 = 1{,}5s_0$; $s_2 = 2{,}5s_0$; $s_3 = 3{,}5s_0$;
$l_s \geq 1{,}9L + 135$mm for $L < 200$ m;
$l_s \geq 1{,}4L + 235$mm for $L \geq 200$ m;
r – cast radius.

.4 the finished thickness of propeller boss shall be not less than 60 % of the sterm frame cross-section width or 30 % of the shaft diameter, whichever is greater.

.5 the section modulus W_s, in cm^3, of the solepiece about the vertical axis shall not be less than

$$W_s = 8\,\alpha\, R_4\, x_s \eta. \qquad (2.10.4.2.5\text{-}1)$$

The section modulus of the solepiece about the horizontal transverse axis shall not be less than specified in 2.10.4.2.1.

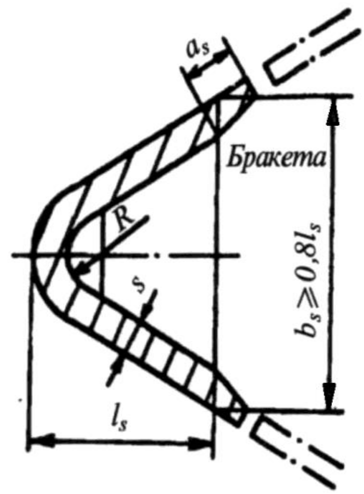


Fig.2.10.4.2.3:
$s = 1{,}65s_0$ for $L < 150$ m;
$s = 1{,}5s_0$ for $L \geq 150$ m;
$l_s = 2{,}5L + 180$ mm for $L < 200$ m;
$l_s = 1{,}4L + 400$ mm for $L \geq 200$ m;
R – bending radius.

The section modulus $W_{r.p.}$, in cm^3, of the rudder post about the horizontal longitudinal axis shall not be less than

$$W_{r.p.} = 8(1-\alpha)\, R_4\, l_p \eta. \qquad (2.10.4.2.5\text{-}2)$$

where $\alpha = 0{,}85$ if there is a rudder pos;

$\alpha = 1{,}0$ 1 if there is no rudder post or a bolted rudder post is fitte;

x_s – distance from the solepiece section concerned to the centre of the rudder stock (x_s shall not be taken less than 0,5 l_s and more than l_s)

l_s – span of the solepiece, measured from the centre of the rudder stock to the beginning of rounding of the propeller post, in m;

$l_{r.p.}$ – span of the rudder post, measured vertically from the mid-thickness of solepiece at the centre of the rudder stock to the beginning of rounding in the upper part of the rudder post, in m;

η – as determined according to 1.1.4.3.

The section modulus of the solepiece about the horizontal transverse axis shall not be less than 0,5 W_s

where W_S shall be determined by Formula (2.10.4.2.5-1).

The section modulus of the rudder post about the horizontal transverse axis shall not be less than 0,5$W_{r.p.}$

where $W_{r.p.}$ shall be detennined by Formula (2.10.4.2.5-2.

.6 the scantlings of the sternframe structural members may be determined on the basis of direct strength calculation taking the permissible stress factor k_σ = 0,55 and external loads according to 2.2, Part II I "Equipment, Arrangements and Outfit".

2.10.4.3 Sternframes of multi screw ships.

2.10.4.3.1 The scantlings of the sternframe of twin screw ships shall satisfy requirements for the scantlings of propeller post in single screw ships as given in 2.10.4.2 with the following amendments:

.1 the section width of the sternframe of a solid rectangular cross section may be reduced by 50 per cent as compared with that required by 2.10.4.2.1;

.2 the scantlings of the cast or welded sternframe may be reduced as compared with those required by 2.10.4.2.2 and 2.10.4.2.3 respectively, so that their section moduli about the horizontal longitudinal and transverse axes, are reduced by not more than 50 per cent. The thickness of the sternframe wall shall be at least 7 mm.

2.10.4.3.2 The scantlings of the sternframe of three screw ships shall satisfy requirements for the scantlings of propeller post in single screw ship of the same size.

2.10.4.4 For semi-spade rudders with one gudgeon upon the horn, the section modulus, in cm ^{3} , of the rudder horn about the horizontal longitudinal axis shall not be less than

$$W = 12R_4 z_s \eta. \qquad (2.10.4.4)$$

where z_s – vertical distance for the mid-thickness of the horn gudgeon to the section concerned, in m (z_s shall not be taken less than 0,5 l_h and more than l_h);

l_h – horn span measured vertically from the mid-thickness of the horn gudgeon to the point of intersection of the horn axis with shell plating, in m;

η – as defined in 1.1.4.3.

R_4 – as defined in 2.10.3.

Where the rudder horn is welded of plates, the thickness of the plates, in all cases, shall be at least 7 mm.

The scantlings of the rudder horn may be determined on the basis of direct strength calculation taking the permissible stress factor k_σ = 0,55 and external loads according to 2.2, Part II I "Equipment, Arrangements and Outfit".

2.10.4.5 The sectional area of either strut of twostrut shaft brackets shall be equal to not less than 60 per cent of the propeller shaft section in the bracket plane, the strut thickness — to not less than 45 per cent, and the boss thickness — to not less than 35 per cent of the propeller shaft diameter.

The length of the boss shall be in accordance with 5.6.1, Part VI I "Machinery Installations".

The strength of the welded shaft brackets shall not be less than that specified above. The plate thickness shall not be less than 7 mm.

The weld area of rivets attaching each strut to the hull shall not be less than 25 per cent of the propeller shaft sectional area. Where the struts are attachhed by means of flanges, the thickness of the latter shall be not less than 25 per cent of the propeller shaft diameter.

2.10.4.6 The height h_s and width b_s, in mm, of the bar keel cross section shall not be less than:

$$h_s = 1{,}30L + 100;$$
$$b_s = 0{,}70L + 8 \quad \text{for } L < 60 \text{ m};$$
$$b_s = 0{,}40L + 26 \quad \text{for } L \geq 60 \text{ m}. \qquad (2.10.4.6)$$

The height and width of the bar keel cross section may be reduced for ships of restricted areas of navigation:

R2, **A-R2, R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS** – by 5 per cent;

B-R3-S, **B-R3-RS, C-R3-S**, **C-R3-RS, R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** – by 10 per ment.

2.10.4.7 The thickness of outer and inner plating of fixed propeller nozzle shall comply with the requirements of 2.4.2, Part III "Equipment, Arrangements and Outfit" taking the following into consideration:

width of middle belt of inner plating shall be not less than the distance from $0{,}03D_o$ forward of the propeller blade tips and $0{,}07D_o$ aft of the propeller blade tips;

thickness of forward part of the inner and outer plating shall be not less than required for side shell plating (refer to 2.2.4.1 for transverse framing system).

The width of attachment shall be at least $0{,}15D_o$.

The cross-sectional area of the joint shall be not less than required by 2.10.4.2.5 for the solepiece. If the solepiece serves as support of the rudder, the connection of the nozzle to the solepiece is subject to special consideration by the Register.

For twin screw ships when the propeller nozzle is not attached to the hull at its bottom part, the width of attachment at the top part shall be not less than $0{,}3D_o$.

If the propeller nozzle is attached to the hull by shaft brackets, their strength shall comply with the requirements of 2.10.4.5.

In way of attachment of the nozzle to the hull the thickness of framing members shall not be less than required by Formula (2.4.2.2-2), Part III "Equipment, Arrangements and Outfit".

2.10.5 Special requirements.

2.10.5.1 The thickness of the floors to which rudder post and propeller post of single screw ship are attached is to be greater than thickness of the floors of sternframe by 3 - 5 mm depending on the scantling of the ship (for double screw - 2 mm). Floors are to be extended to the nearest deck or platform.

2.10.5.2 The thickness of floors to which rudder horn is joined is to be increased by 50 per cent in comparison with thickness of the floors s_{min} in accordance with 2.4.4.3.2.

2.10.5.3 Buckling strength of sternframe of any construction when bending and cutting shall not be less than buckling strength of a solid cross-section sternframe, manufactured according to 2.10.4.2; where sternframe longitudinal stiffener is not included in standardized cros-section area.

2.11 SEATINGS OF MACHINERY AND BOILERS

2.11.1 General.

2.11.1.1 Requirements are given in this Chapter for the construction and dimensions of the seatings intended for main machinery and boilers, deck machinery, fishing installations, cargo handling gear, auxiliary machinery, etc.

Requirements concerning construction and dimensions of structural components of a seating, which are contained in the technical documentation of the machinery, unit or device to be installed on the seating concerned, shall also be complied with.

2.11.1.2 Symbolsя:

Q – mass of machinery (boiler) in working condition, in t;

N – specified power of engine, in kW.

2.11.1.3 For dimensions of the structural components of the seatings intended for mooring and towing appliances — refer to 4.3 and 5.3, Part III "Equipment, Arrangements and Outfit".

2.11.2 Construction of seatings.

2.11.2.1 The construction of seatings shall satisfy the following requirements:

.1 the seating shall be of substantial construction to ensure efficient attachment of machinery, gear or device and transmission of forces to the hull framing, which shall be sufficiently strong (refer to 2.3.2.7, 2.4.5.4 i 2.4.5.5);

.2 the seating shall be so constructed that the resonance vibration of the seating as a whole and of its structural components can be avoided under all specified running conditions;

.3 where the seating in ships with a length L>65 m is installed on the continuous longitudinals of strength deck and double bottom (bottom) within 0,5*L*, amidships, the height of the vertical plates of the seating at the ends shall be gradually reduced.

If the length of the vertical plate is more than six times its height, the vertical plate and its top plate shall be made of the same steel grade as the deck or double bottom (bottom) structural member on which it is installed.

The structural components of the seating shall not terminate at the unsupported portions of plating.

Attachment of the seating to the upper edge of sheerstrake is subject to special consideration by the Register.

.3 the seating shall be so designed that the plating beneath is accessible for inspection. Measures shall be taken to prevent water from accumulating under the seating.

In particular cases agreed with the Register, a hermetic construction of the seating is permitted, the inner space of the seating being filled with some chemically neutral material with good adhesion properties.

2.11.2.2 In general, a seating of main machinery and boilers shall comprise two vertical plates (girder webs) (for medium-speed and high power engines — four vertical plates (two — either side of the engine)) and horizontal face plates (top plates) to which the machinery (boiler) shall be attached directly.

The vertical plates shall be strengthened with brackets (knees) having face plates (flanges) along the free edges.

Where the seating comprises four vertical plates, the top plate is attached to two vertical plates fitted on one side of the machinery; the outer plates shall have openings to provide access into the seating.

In the case of medium-speed engines, such openings shall not extend to the top plate.

The outer plates may be made sloped.

All the vertical plates shall be fitted in line with the main or additional side girders.

2.11.2.3 Machinery and equipment may be installed on shell plating of the hull, tight bulkheads, decks and platforms (including tank bulkheads and crown), inner bottom and shaft-tunnel platings on condition they are attached to the framing members and stiffeners (refer to 1.7.1.4), or on cantilevers connected to framing members or stiffeners.

Attachment of small-sized machinery and equipment directly to the above-mentioned structure with the help of welded pads is not permitted.

2.11.3 Dimensions of structures of seatings.

2.11.3.1 The thickness *s*, in mm, of structural components of a seating of main machinery or boiler shall not be less than

$$s = k_0 \sqrt[3]{Q} + k_1, \qquad (2.11.3.1)$$

where k_0 – factor given in Table 2.11.3.1-1;
k_1 – factor given in Table 2.11.3.1-2.

2.11.3.2 The thickness *s*, in mm, of structural components of a seating of main internal combustion engine shall not be less than $s = k_2 \sqrt[3]{N} + k_3$, (2.11.3.2)

де k_2, k_3 – factors given in Table 2.11.3.2,

but not less than required by 2.11.3.1.

2.12 SUPERSTRUCTURES, DECKHOUSES AND QUARTER DECKS

2.12.1 General provisions, definitions and symbols.

2.12.1.1 Requirements are given in this Chapter for short and long bridges extending from side to side of the ship as well as to short bridges which do not extend to the sides of the ship, forecastle, poop, long forecastle and poop extending to ship's sides, short deckhouses and quarter decks.

The applicability of the requirements contained in this Chapter to long superstructures not extending from side to side of the ship as well as to long deckhouses shall be specially agreed with the Register.

Table 2.11.3.1-1

Seating of machinery (boiler)	k_0		
	Top plates	Vertical plates [1]	Brackets, knees
Main internal combustion engine	4,65	3,0	2,5
Main geared turbine set, main diesel generator and propulsion motor	4,15	2,7	2,7
Boiler	3,65	2,4	2,4

[1] In a seating with four vertical plates the thickness of the plates may be taken equal to the thickness of brackets and knees.

Table 2.11.3.1-2

Mass of machinery (boiler), in t	≤ 20	> 20 ≤ 50	> 50 ≤ 100	> 100 ≤ 200	> 200
k_1	4	3	2	1	0

Table 2.11.3.2

N, in kW	Number of vertical plates	Factor	Top plates	Vertical plates	Brackets, knees
≤ 1000	2	k_2	1,7	1,1	0,9
		k_3	6	4	3
	4	k_2	1,4	0,9	0,9
		k_3	5	3	3
> 1000	2	k_2	1,0	1,0	0,7
		k_3	13	5	5
	4	k_2	0,8	0,7	0,7
		k_3	11	5	5

2.12.1.2 For the purpose of this Chapter the following definitions have been adopted.

Long deckhouse is a deckhouse of a length not less than that determined by Formula (2.12.1.2-1), but not less than 0,20 *L*, having no expansion or sliding joints .

Long bridge is a superstructure having a length not less than:

$$l_1 = 2\,l_e, \qquad (2.12.1.2\text{-}1)$$

but not less than 0,15 *L* .

Quarter deck is the after part of upper deck stepped up to a portion of 'tween deck height.

Ends of superstructur s and deck-houses are the ends of the length measured from the end bulkheads, in m,

$$L_e = 1{,}5\,(B_2/2 + h). \qquad (2.12.1.2\text{-}1)$$

Short deckhouse is any deckhouse which is not a long deckhouse.

Deckhouses of ships less than 65 m in length are considered as short deckhouses.

Short bridge is any bridge which is not a long bridge.

Superstructures of ships less than 65 m in length are considered as short superstructures.

Transition area of quarter deck – is an area measured from the forward edge of break to the after edge of upper deck plating and extending below the quarter deck.

Long forecastle (poop) is a forecastle (poop) having a length not less than

$$l_1 = 0{,}1L + l_e, \qquad (2.12.1.2\text{-}3)$$

in ships of 65 m and greater in length

Deck step up is a stepped up or lowered part of the deck upon side depth, (may be vertical or inclined).

2.12.1.3 Symbols:

B_2 – breadth of superstructure deck measured at its mid-length, excluding the breadth of openings of cargo hatches, machinery casings, if any, in m; helicopter deck (platform), which is part of the upper deck or the superstructure or deckhouse top;

B_x – ship's breadth at the level of the upper deck at the section considered, in m;

b – breadth of the deckhouse, in m;

b_1 – half-breadth of continuous region of deckhouse between its side webs;

c_1 – the breadth of side overhang of deckhouse;

l – pole span measured as distance between decks;

h – height of the first tier of superstructure or deckhouse, in m;

l_2 – the section of upper deck length in the midship region in accordance with Formula:

$l_2 = (0,9 - 0,5 W_d^{\phi} / W)L$;

l_1 – length of superstructure (deckhouse) measured between the end bulkheads along the side in the superstructure and long the side bulkhead in deckhouse; the length of forecastle (poop) measured from the fore or after perpendicular to the end bulkhead of the forecastle (poop), in m;

$c = l_1/(B_2/2 + h)$ – relative length of superstructure;

W and W_d^{ϕ} – required by the Rules for $\eta = 1$ and actual section modulus of hull for the deck in accordance with 1.4.5 and 1.4.7 respectively.

2.12.2 Construction.

2.12.2.1 The short bridge are to be made with equal thicknesses of side shell plating and deck plating along the length.

For the bottom strake of side plating the grade of steel and yield stress are to be the same as required for the strength deck in this region.

2.12.2.2 The long bridge are to be made with different thicknesses of side shell plating and deck plating for the end regions and for the mid part of the bridge length.

In this case the bottom strake of side plating in the end regions is to have thickness equal to the thickness of side plating of bridge in the mid part of its length, and the breadth is not to be less than 0,5 of bridge height.

The change of thickness from the mid part of the bridge to the end regions is to be gradual.

For the bottom strake of side plating and for the longitudinal bulkheads plating of bridges in the end section regions the grade of steel and yield stress are to be the same as required for the strength deck in this region.

2.12.2.3 The deckhouse (or its part) which are situated on the design deck within the section l_2 in the midship region and with length $l_1 < 6(b_1+c_1) W_d^{\phi}/W$, is to have bottom strake of side bulkheads plating with the same the grade of steel and yield stress as required for the strength deck in this region.

Where the length of deckhouse $l_1 \geq 6(b_1 + c_1) W_d^{\phi}/W$ this requirement is only for end parts of the deckhouse.

2.12.2.4 The lower ends of vertical stiffeners of the end bulkheads of the 1st tier superstructures and deckhouses shall be welded to the deck.

The lower ends of side vertical stiffeners of 1st tier houses shall be attached to the deck by brackets.

But if inside of the deckhouse partial bulkhead are fitted, as defined in 2.12.2.5.1, at the distance not more than

8m the ends of the vertical stiffeners may be welded to the deck.

2.12.2.5 The bulkheads of deckhouses and superstructures are to be strengthened by web structure and partial bulkhead in accordance with stated below requirements.

.1 In the deckhouses and superstructures web frames and web stiffeners or partial bulkheads fitted in the line of web members or bulkheads below are to be provided.

The distance between partial bulkheads or web frames and vertical stiffeners in the deckhouses and superstructures is not to be greater than 10 m.

Stated requirement is also for arrangement of web stiffeners on the end bulkheads of deckhouses and superstructures.

.2 Where the superstructure end bulkhead is not in line with the transverse bulkhead of the hull, partial bulkheads or pillars are to be fitted in 'tweendeck spaces the end bulkhead, or frames and beam knees are to be strengthened і збільшення бімсових книць.

.3 Where the end of long deckhouse is within the length l_2 of midship region and the end bulkhead of deckhouse is not in line with the transverse bulkhead below, short-deck girders are to be fitted in line with deckhouse sides under the house deck so as to extend further for three frame spaces forward and aft of the deckhouse end bulkhead.

.4 Where the end bulkheads of superstructures and deckhouses abut on the undeck longitudinal structures and the sides of deckhouses on the transverse underdeck structures fitted below (bulkheads, partial bulkheads, undeck girders, deck transverses, etc.), the webs of these underdeck structures are to be stiffened with brackets or knees in the line of bulkheads of superstructures and deckhouses below for the purpose of excluding of hard points.

.5 Adequate strengthening is to be provided for the side bulkheads and deckhouse decks where cockboats and sloops acre fitted.

2.12.3 Design loads.

2.12.3.1 Pressure on the end bulkheads of superstructures and deckhouses as well as on sides of deckhouses *p*, in kPa, is determined by the formula

$$p = 9{,}8nc_2\,(kz_0 - z_1), \qquad (2.12.3.1)$$

where n – factor determined from Table 2.12.3.1-1;

$c_2 = 0{,}3 + 0{,}7b/B_x$, in this case $c_2 \geq 0{,}5$;

$$k = 1{,}0 + \left(\frac{x_1/L - 0{,}45}{C_b + 0{,}2}\right)^2 \text{ for } x_1/L \leq 0{,}45;$$

$$k = 1{,}0 + 1{,}5\left(\frac{x_1/L - 0{,}45}{C_b + 0{,}2}\right)^2 \text{ яfor } x_1/L > 0{,}45;$$

for the sides of deckhouses the factor *k* is assumed to vary for the length of bulkhead. F.or this purpose the deckhouse is subdivided into parts of approximately equal length not exceeding $0{,}15L$ each, and x_1 is taken as the distance between the after perpendicular and the middle of the part considered;

C_b – shall be taken as not less than 0,6, nor greater than 0,8; for the aft end bulkheads forward of amidships $C_b = 0{,}8$;

z_0 – as given in Table 2.12.3.1-2,

z_1 – vertical distance, in m, from the summer load waterline to the mid-point of the plate panel considered or the midpoint of span of the bulkhead stiffener.

The above-stated varus of factor *n* apply to a ship having the freeboard equal to minimum tabular freeboard of Type "B" ships, and a standard height of superstructures according to Section 4 of the Load Line Rules for Sea-Going Ships.

If the deck of the tier considered is situated higher than the standard position due to an increase of freeboard, as against the tabular value, then the appropriate factor n may be determined by linear interpolation between the values of that factor for superstructures with standard and actual positions of decks under the superstructures.

2.12.3.2 In any case, the design pressure shall not be taken less than indicated in Table 2.12.3.2.

Table 2.12.3.1-1

Bulkhead	Structure		*n*
Front	Unprotected	1st tier	$2 + L_0/120$
		2nd tier	$1 + L_0/120$
		3rd tier	$0,5 + L_0/150$[1]
	Protected		
Aft end	Aft of amidships		$0,7 + \frac{L_0}{1000} - 0,8\frac{x_1}{L}$
	Forward of amidships		$0,5 + \frac{L_0}{1000} - 0,4\frac{x_1}{L}$

L_0 – length of ship, in m (to be taken not greater than 300 m for the purpose of calculation);
x_1 – distance, in m, between the after perpendicular and the bulkhead under consideration.
[1] formula is also used for the deckhhouses sides.

Table 2.12.3.1-2

L, in m	z_0, in m	*L*, in m	z_0, in m
20	0,87	180	9,85
40	2,59	200	10,25
60	4,07	220	10,55
80	5,42	240	10,77
100	6,60	260	10,92
120	7,69	280	11,00
140	8,63	300	11,03
160	9,35	350	11,05

2.12.4 Scantlings of structures of superstructures, deckhouses and quarter decks.

2.12.4.1 The thickness *s*, in mm, of side plating of short bridges, forecastle and poop shall not be less than $s = (mL + n)\alpha$ (2.12.4.1)

where m, n – obtained from Table 2.12.4.1-1;
α – obtained from Table 2.12.4.1-2.

Table 2.12.3.2

L, m	Design pressure *p*, in kPa	
	for 1st tier unprotected fronts	elsewhere

≤ 50	30	15
50 < *L*< 250	25 + (*L*/10)	12,5 + (*L*/20)
≥ 250	50	25

Table 2.12.4.1-1

Ship region	Side plating		Deck plating	
	m	*n*	*m*	*n*
Forecastle	0,045	4,0	0,03	3,5
Poop	0,040	4,0	0,03	3,5

Table 2.12.4.1-2

d/D	α
≥ 0,8	1
0,65 ≤ *d/D* < 0,8	*d/D* + 0,2
< 0,65	0,85

For ships with length less than 40 m the thickness of plates of side plating and deck plating is determined as for ships with length 40 m.

Where distance between strengthening girders $a>(<)a_0$ which determined in accordance with 1.1.3.7, the plate thickness of side plating and deck plating is (may) to be increased (decreased) by $\Delta s = s(a - a_0)/a_0$. But the reducing of plate thickness is not to be greater than 15 per cent of the value in accordance with Formula (2.12.4.1).

The reducing of plate thickness where $a < a_0$ is not permitted in the regions within 0,2 L and less from fore perpendicular and above the after peak

The thickness of the side plating of the superstructure may not be taken greater than the thickness of side framing of hull in considered region.

The thickness of the side plating of forecastle and poop in all cases is not to be less than necessary in accordance with 2.2.4.1.

Where the steal of increased strength is used the reducing of plate thickness of side plating and deck plating is a subject special consideration by the Register.

The thickness of steal deck plating may be decreased according to special agreement with the Register.

Extended forecastle (poop) is to be considered as bridge with length equal to

$$2\left(l_1 - \frac{L - l_2}{2}\right) \text{m.}$$

In this case the thickness of side plating and deck plating of forecastle (poop) within the region l_2 is to be taken in accordance with 2.12.4.2 and outside stated boundaries is to gradually decrease to the end parts with scantling given in 2.12.4.1.

2.12.4.2 The thickness of side plating and deck plating in mid part of the long bridge between end parts *s*, in mm, is not to be less than determined by the Formulae

$s = s_1$ for $c \leq 3$;

$s = s_2$ for $c \geq 4{,}5$;

$$s = \left(3 - \frac{c}{1{,}5}\right)s_1 + \left(\frac{c}{1{,}5} - 2\right)s_2 \quad (2.12.4.2)$$

for $3 < c < 4{,}5$,

where s_1 = the thickness of side plating or deck plating determined as for the forecastle in accordance with 2.12.4.1, in mm;

s_2 = the thickness of side plating in accordance with 2. 2.4.1 and 2.2.4.2 and deck plating respectively to 2.6.4.1.

The thicknesses of side plating and deck plating of end part of long bridge are determined as for forecastle in accordance with 2.12.4.1.

The thicknesses of side plating and deck plating of end part of short bridge are determined as for forecastle in accordance with 2.12.4.1.

2.12.4.3 The plate thickness *s*, in mm, of the end bulkheads plating of forecastle, bridge side and end bulkheads of deck houses is not to be less than determined by the Formula

$$s = 14{,}7a\sqrt{p / R_{eH}} \qquad (2.12.4.3)$$

where *p* - in accordance with 2.12.3.1.

The thickness of bottom plates of end bulkheads in superstructures (deckhouses) of 1-st tier is to be increased by 1 mm as compared with the design thickness. The width of bottom plate is to be not less than 0,5 mm.

If the deckhouse front extends in a fair convex form beyond the intersection with the deckhouse sides, the thickness of plating may be taken 0,5 mm less as compared with the design value.

2.12.4.4 The thickness of side plating and end bulkheads of superstructures as well as the thickness of deckhouse bulkheads is not to be less than 0,01L+5 for bottom tier and 0,01L +4 for upper tiers, but not less than 5 mm.

The minimum thickness is not to be less than 5 mm for ships of length L>50 m. The minimum thickness may be reduced to 4 mm for ships of length L<20 m and to 3 mm for ships of length $L < 20$ m, subject to an agreement with the Register. Reduction of the minimum thickness is not permitted for fronts of bridge and unprotected front of poop in ships of length $L \geq 20$ m.

2.12.4.5 Framing of the sides, decks and end bulk heads of the forecastle, poop and bridge, quarter deck and deckhouse is to satisfy the following requirements:

.1 Side framing of forecastle, poop and bridge are to fulfill requirements of 2.5.4.2 and requirements of 2.8.

Beams are to be fitted in every frame. The section modulus *W*, in cm^3, of framing members of deckhouses and superstructure decks is to fulfill the requirements of 2.6.4 where $\omega_k = 1$.

.2 The section modulus *W*, in cm^3 , of cross section area of end bulkheads girders forecastle, poop and bridge and deckhouse, side bulkheads of deckhouses is not to be less than determined by the Formula

$$W = 85apl^2 / R_{eH}, \qquad (2.12.4.5.2)$$

where *p* - in accordance with 2.12.3.1.

.3 The value of section modulus in accordance with Formula (2.12.4.5.2) relates to structure with welding of the ends of members to the deck.

Where the lower ends of members are attached to the undeck framing by knees whose scantling are fulfill the requirements of 2.7.2.3, the section modulus of members may be reduced by 20 per cent.

2.12.5 Special requirements.

2.12.5.1 The minimum thickness of upper deck plating within l_2 of midship region under the superstructure with length more than $2(0{,}5B_2 + h)$ in the region between sections by $2(0{,}5B_2 + h)$ from the end of superstructure may be reduce from $s'_{\min}$, in accordance with Table 2.6.4.2, for design deck to $s''_{\min}$ in accordance with Table 2.6.4.2 for second deck by the value

$$s'_{\min} - k\left(s'_{\min} - s''_{\min}\right), \qquad (2.12.5.1)$$

where $k = 0$ for $c \geq 2$; $k = 1{,}0$ for $c \geq 5$.

Note. For the intermediate values c the value k is determined by linear interpolation.

The reducing of design deck plating under the long deck house is a subject of special consideration of the Register.

2.12.5.2 The structure at the ends of superstructures within the length l_2 of the midship region is to satisfy the following requirements:

.1 At the ends of bridge, the side plating is to be extended beyond the end bulkhead with smooth tapering to the ship's side on a length d in m, , determined by the formula (2.12.5.2.1) The blunted ends of projecting side plates are to be machined flush with the deck. (Fig. 2.12.5.2.1):

$$d_1 \geq 0{,}2(W/W_d^{ф})^2\,(0{,}5B_2 + h). \quad (2.12.5.2.1)$$

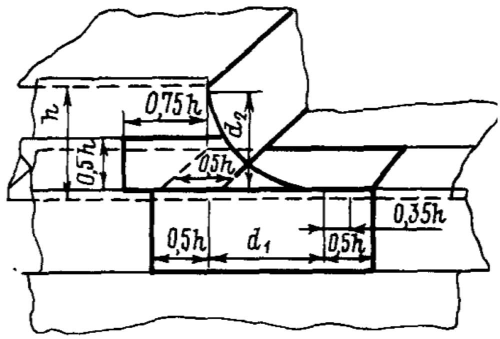
The value d_1 is not taken greater than $1{,}5h$. Where $L < 60$ m instead the ratio $W/W_d^{ф}$ the ratio F_0/F is to be taken (refer to 2.6.4.3).

.2 The plates of the upper side plating of superstructure which overflow its ends is to have thickness which exceed the thickness of side plating in the mid part of the superstructure Δ, %, determined by the Formula

$$\Delta = 10(2c - 3)\,W/W_d^{ф} \leq 35. \quad (2.12.5.2.2)$$

The free edge of side plating is to be stiffened by flat bar carried down for 50 mm from the edge. The ends of that bar are to be sniped. The plates are to be attached to the bulwark by means of flexible joints. The members of flexible joints are not to be welded to the plate projecting beyond the edges of superstructures.

Openings in side plating projecting beyond the ends of a superstructure are normally not permitted. But in case when the openings are necessary, their arrangements are the subject of the special consideration of the Register.



$0{,}5h \leq d_2 = 0{,}65d_1 \leq 0{,}75h$

Рис.2.12.5.2.1

.3 If the value d_1 determined by the Formula (2.12.5.2.1) is greater than 1.5h (taking into account 2.12.5.2.1) $d_1 = 1.5h$, is to be taken. The thickness of sheerstrake in a way of the end of the bridge is to be increased in comparison with its thickness outside the borders of superstructure by Δ_1, %, determined by the Formula

$$\Delta_1 = 25(c - 1{,}5) \leq 30. \quad (2.12.5.2.3)$$

Where $c < 2$ the value $\Delta_1 = 0$. Fractional increase of thickness of deck girder is not to be taken than 70% of value Δ_1. he extension and arrangement of thickened plates of sheerstrake and deck girder are present in the Fig. 2.12.5.2.1.

.4 At the ends of extended forecastle and poop the plate of side plating projecting beyond the ends of a superstructure are to be made as stated for the end of bridge taking

$$c = \frac{2\left(l_1 - \dfrac{L - l_2}{2}\right)}{B_2/2 + h}. \quad (2.12.5.2.4)$$

Where the distance between end bulkheads of forecastle (poop) and bridge less than $3(0{,}5B_2 + h)W/W_d^{\phi}$, the thickening of sheerstrake and deck stringer of upper deck in a way of the adjoining ends of the superstructures and thickening of the plating projecting beyond the ends of the superstructures their side plating is the subject of special consideration by the Register.

.5 At the ends of short bridge not extending from side to side of ship the, attachment of the side to the deck should be made similarly to the attachment required by 2.12.5.3 for deckhouses, otherwise gussets are to be used to provide smooth transition from the side to a short deck girder strengthening the deck under that side with simultaneous strengthening of the deck stringer plate in accordance with 2.12.5.2.3.

2.12.5.3 The structure at the ends of superstructures which are outside the length 1_2 of the mid ship region is to satisfy the following requirements.

If the end of superstructure (forecastle, poop) is located within 0,1*L*, from the fore or after perpendicular the thickening of the side plating of the superstructure in a way of the ends is not necessary. But it is necessary to fulfill the requirements 2.12.5.2.1 concerning the packaging of the lower plate projecting beyond the ends of the superstructures taking $d_1 \geq 0{,}1(0{,}5B_2 + h)$ or $d_1 \geq 0{,}5$ m, whichever the greater.

If the end of a superstructure (forecastle, poop) is located between the end of the length l_2 of midship region and 0,1L from fore or after perpendicular the value d_1 and the scantling of thickening of plates are to be determined by linear interpolation based on the requirements of 2.12.5.2.1 and this paragraph.

2.12.5.4 Attachment of sides of the deckhouse, situated on the upper deck within the length l_2 of midship region, to the end bulkhead (fore and after) should be performed by rounding with a radius *r*, in m, determined by the formula

$$r = l_1/100\,(1{,}5 + 0{,}1\,l_1/b) \leq 1{,}4. \qquad (2.12.5.4)$$

2.12.5.5 Rectangular openings in outer sides and top plating of long deckhouses with length $l_1 > 6(b_1 + c_1)W/W_d^{\phi}$ should have their corners well rounded and should be substantially framed. In the deckhouse or its part with length $l_1 > 6(b_1 + c_1)W/W_d^{\phi}$, which are situated on the design deck within the length l_2 of midship region door openings should be addition ally reinforced with thickened plates above and below. Where the length of deckhouse is less or the deckhouse is situated outside the length l_2 of midship region door openings should be addition ally reinforced with thickened plates only below. The structure of reinforcement are presented in the Fig. 2.12.5.5.

Where the distance between the expansion or sliding joints is less than a triple height of the deckhouse, it is sufficient to provide the rounding of the corners of openings. Openings for side scuttles should have the upper and lower edges reinforced with horizontal stiffeners.

In side webs of deckhouse or its part, with length $l_1 > 6(b_1 + c_1)W/W_d^{\phi}$ within the region with length not less than the height of deckhouse measured froni, the end located on the design deck within the length l_2

of midship region, rectangular openings are not permitted.

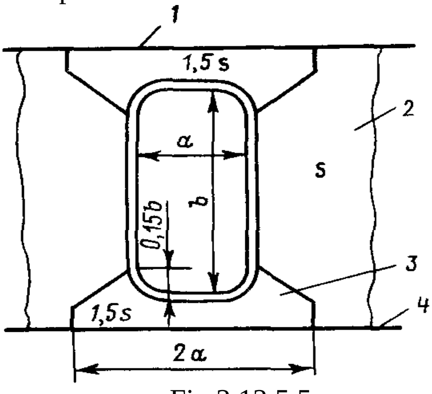


Fig.2.12.5.5:
1 – deckhouse top; 2 – deckhouse side;
3 – thinckened plate;
4 – strength deck

2.12.5.6 The structures in way of the break at connection of the upper deck to quarter deck in ships of 90 m and under are to satisfy the following requirements.

.1 The upper deck plating in way of the break is to extend abaft the break for three frame spaces in ships of 60 m in length and above, and for two frame spaces in ships less than 60 m in length. The upper deck plating of ships less than 40 m in length need not extend abaft the break.

.2 The upper deck stringer plate is to extend abaft the steel plating for three frame spaces, where $L \geq 60$ m, and for two frame spaces, where $L < 60$ m.

The stringer plate so arranged should be tapered from its full width to a width equal to the depth of frame to which it is welded.

.3 The stringer plate of quarter deck should extend forward in the form of a bracket gradually tapered to ship's side on a length of three frame spaces. The quarter deck stringer plate projecting beyond the break is to be adequately stiffened and its free edge should have a face plate or flange.

.4 The sheerstrake of quarter deck should extend forward of the deck stringer plate projecting beyond the break bulkhead for at least 1,5 times the height of break and should be smoothly tapered into the upper edge of ship's side sheerstrake. For other structural requirements refer to 2.12.5.2.

.5 Diaphragm plates spaced not more than 1,5 m apart are to be fitted over the ship's breadth between the overlapping decks in way of the break. The thickness of diaphragms is not to be less than the thickness of the break bulkhead plating.

The diaphragm plates are to be strengthened by vertical stiffeners.

Vertical stiffeners with effective flange are to have a moment of inertia not less than that obtained from Formula (1.6.5.6-1).

Continuous welds are to be used to attach the horizontal edges of diaphragm plates to the decks, and the vertical edges to break bulkhead on one side, and on the other side to an extra supporting bulkhead made of continuous plate welded to the decks over the ship breadth. The plate thickness of that bulkhead is to be not less than the thickness of break bulkhead plating and may have openings between diaphragms.

.6 Where a supporting bulkhead is fitted, the diaphragm plates should be stiffened with brackets fitted to their ends (Fig. 2.12.5.6.6).

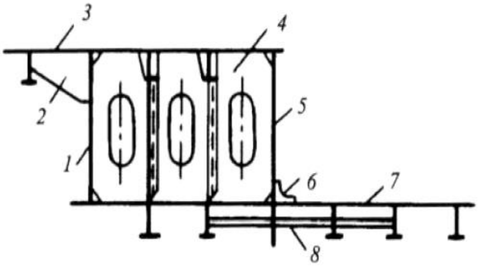


Fig. 2.12.5.6.6:
1 – supporting bulkhead; 2, 6 – brackets,
3 – quarter deck; 4 – diaphragm,
5 – break bulkhead,
7 –upper deck,
8 – stiffener in the line with bracket

.7 Where a raised quarter deck is adjoining the bridge, it should extend into that superstructure for two frame spaces beyond the break, the extension being, in any case, not less than the elevation of superstructure above the quarter deck.

The quarter deck stringer plate should extend forward for two frame spaces with the width gradually reduced as required by 2.12.5.6.2.

Strengthening of the overlapping decks in way of break is to comply with requirements of 2.12.5.6.5 and 2.12.5.6.6 depending on the location of the break along the length of the ship.

The superstructure side plates extending aft of the superstructure are to be smoothly tapered into the sheerstrake on a length of at least 1,5 times the height of break (refer also to 2.12.5.2.1).

.8 Strengthening in case where the break bulkhead is located within *0,25L* from the after perpendicular should comply with the following requirement:

in ships greater than 60 m in length, the supporting bulkhead fitted over the breadth the ship may be omitted. The free edges of diaphragm plates are, in this case, to be stiffened with face plates or flanges of a width equal to at least ten thicknesses of the diaphragm plate;

in ships of 60 m in length and below, the upper deck plating need not extend aft of the break over the ship breadth, however, the upper deck stringer and the raised quarter deck stringer and sheerstrake should be extended forward and aft as provided in 2.12.5.6.3 and 2.12.5.6.4.

Strengthening in position of a break in ships with the length L>90 m is subject to special consideration by the Register.

2.12.5.7 The use of aluminium alloys for the construction of deckhouses is permitted. Decks of accommodation and service spaces situated above the machinery and cargo spaces should be made of steel.

The scantlings of aluminium deckhouses should be determined according to 1.6.6. The minimum scantlings are to be the same as those required for steel deckhouses.

The degree to which the deckhouse of aluminium alloys contributes to longitudinal bending of the hull and stresses in ship's hull and deckhouse should be determined according to the procedure approved by the Register.

2.12.6 Helicopter deck.

2.12.6.1 The design of the Helicopter Deck, which is the upper deck or the superstructure or deckhouse top.

.1 The main members of the deck framing should be installed parallel to the axis of the helicopter during its take-off and landing.

.2 The helicopter deck, in accordance with its location along the length and depth of the ship, shall comply with the requirements for an open deck for the carriage of goods in accordance with 2.6 or the superstructure or deck house tops in accordance with 2.12.4.2 and 2.12.4.5.2.

The design load is determined in accordance with 1.3.4.1 as the maximum type load of helicopters and equipment to be placed on this deck in operation and an additional pressure of 0.5 kPa, as a result of snow or ice.

.3 The helicopter deck members shall meet the requirements to Ro-Ro ships deck members in accordance with 3.2. The design load in the conditions of helicopter landing is determined, taking:

Q_0 – the nominal (static) load on the wheel axle of the helicopter is assumed to be equal to the take-off weight of the helicopter, in kN;

n_0 = 2 – the notional amount of the wheels on the axle;

n = 1 – number of wheels that form a group;

$u \times v_1 = 0,3 \times 0,3$, m²

u – wheel print size, perpendicular to the axis of rotation, in m;

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

$k_д$ =1,5 – dynamic factor.

.4 Scantling of web members and pillars, as well as the thickness of the deck for a helicopter, having skids instead of wheels, shall be determined by direct calculation.

2.12.6.2 The design of the Helicopter Deck (platform), which is not the upper deck or the superstructure or deckhouse top.

.1 Plating thickness, section modulus cross-section area of the deck main and web members webs is determined in accordance with 2.12.6.2 and 2.12.4.2 and 2.12.4.5.2 as for the short deck house or deck house of corresponding tier.

.2 Scantling of stiffeners and panting beams is determined in accordance with 2.9 as for pillars and/or half bulkheads in accordance with 2.7.4.5.

.3 Scantling of members, pillars, as well as cross stays and panting beams, are to be determined taking into account forces of inertia of the mass of deck structures. Acceleration to determine the inertial forces are determined according to 1.3.3.1 and 1.3.4.4.

.4 If the Helicopter Deck (platform) has structures protruding beyond the side line, the Helicopter Deck (platform) construction and the setting of permissible stresses are subject to special consideration by the Register.

.5 Use of aluminum alloys is allowed. Strength and stability of the Helicopter decks made of aluminum alloys are allowed to be determined by the method of model tests, which is to be carried out in the presence of a representative of the Register under an agreed program.

.6 The Helicopter Deck (platform) construction is to take into account the provisions of paragraphs 11.2.6.3 ÷ 11.2.6.5 of Part III "Equipment, Arrangements and Outfit".

2.13 MACHINERY CASINGS

2.13.1 General.

2.13.1.1 Openings in decks and

platforms over engine rooms shall be protected by strong casings.

The casings may be omitted only in cases where the space on the deck or platform is a part of the engine room.

2.13.1.2 If the part of machinery casing which located lower than the bulkhead deck where it is included in subdivision calculation as watertight construction the strength of the machinery casing is not to be less than suitable along the height parts of transverse watertight bulkhead.

2.13.2 Construction.

2.13.2.1 Where there are large openings in the deck in way of machinery space, additional pillars and deck transverses are to be fitted for strengthening of the deck in way of machinery casing. For the lower strake of the casing longitudinal wall plating, adjoining the strength deck within the midship region of ships with a length L>60 m the steel are to be the same as for the strength deck plating in this region.

2.13.2.2 Where machinery casing are located along the whole length of machinery space and support decks the structure of the machinery casing in this region are to be strengthened. The range of this strengthening is a subject of the special consideration of the Register.

2.13.2.3 Where the opening for machinery casing is arranged in the strength deck, the requirements of 2.6.5.1 regarding the design of corners and compensation for openings shall be complied with.

2.13.2.4 For the lower strake of the casing longitudinal wall plating, adjoining the strength deck within the 0,6*L*, midship region of ships with a length L≥65 m of steel grade and yield stress shall be the same as for the strength deck plating in this region.

2.13.3 Loads.

Design loads for plating and framing of machinery casing are the similar to loads on suitable along the height members of watertight bulkheads (refer to 2.7.3.1) or the webs of deckhouse in given region (refer to 2.12.3.1) for $c_2 = 1$.

2.13.4 Scantlings of machinery casing structures.

2.13.4.1 The plating thickness of machinery casing which located on the upper open deck or on quarterdeck is to be greater than necessary for deckhouse in the same place by 15 per cent and section modulus of struts greater by 50 per cent.

The plating thickness of part of machinery casing located on open, deck at the level of second and upper tiers of deckhouse is to be greater than necessary for deckhouse of this tier by 10 per cent and section modulus of struts greater by 20 per cent.

The lower plate of casing which adjoined to the upper deck is to be increased by 1 mm.

2.13.4.2 If the part of machinery casing which located lower than the bulkhead deck where it is not included in subdivision calculation as watertight construction, the plating thickness of casing in 'tweendeck spaces is to be equal to 6 mm and the thickness of coamings - 7 mm. In same cases for ships with $L \leq 100$ the plate thickness may be reduced but not more than by 5 mm and the thickness of coamings - up to 6 mm.

The webs of casing are to be strengthened by struts located on the distance not more than 0,9 mm from each other. The scantlings of the struts is to be enough in order that section modulus is not to be less than 70 per cent of necessary for the suitable on height strut transverse watertight bulkheads (refer to 2.7.4.2).

Where *d/D* ≤ 0,70, the scantling of struts of casing in upper 'tweendeck space may be reduced counting that the section modulus is not to be less than 55 % for the suitable strut transverse watertight-bulkheads (refer to.2.7.4.2).

The plating thickness of casing in the bridge, poop or deckhouse may be less than casing plating in 'tween deck spaces by 0.5 mm, but not less than 4,5 mm and for coamings - not less than 5,5 mm. Struts may have scantlings which are necessary for the casing in 'tweendeck spaces where *d/D* ≤ 0,7.

2.14 BULWARK

2.14.1 General.

Bulwarks of strong construction shall be provided in places specified in 8.6, Part III "Equipment, Arrangements and Outfit".

The construction of bulwarks in the midship region of ships of 65 m and above shall be such that the bulwark does not contribute to longitudinal bending of the hull.

2.14.2 Construction.

2.14.2.1 The height of the bulwark as measured from the upper edge of the deck plating or from that of planking, if any, to the upper edge of the rail section shall comply with the requirements of 8.6.2, Part III "Equipment, Arrangements and Outfit".

2.14.2.2 The bulwark plating within the 0,6*L*, midship region of ships of 65 m and above shall not be welded to the upper edge of sheerstrake. Outside the above-mentioned region as well as in ships less than 65 m in length, the openings cut in bulwarks shall be so designed as to ensure a smooth transition (with a radius not less than 100 mm) from the bulwark plate to the sheerstrake.

Within 0,07*L*, from the fore perpendicular the welding of bulwark plating to the sheerstrake is necessary.

2.14.2.3 The bulwark shall be supported by stays spaced not more than 1,8 m apart. In the region of uprights for timber deck cargo, fastening to bulwarks, as well as at the fore end within 0,07 *L*, from the fore perpendicular, the spacing of stays shall be not more than 1,2 m. In the ships with large flare of sides and in ships with minimum assigned freeboard, stays may be required to be fitted at every frame within the region considered.

2.14.2.4 The stays shall be fitted in line with deck beams, brackets and other structures and shall be welded to the rail section, bulwark plate and deck. The attachment of stays to bulwark shall be ensured on a length not less than half the height of the bulwark.

In welding the stays to the deck, holes sufficient in size to allow free passage of water to the scuppers shall be provided in the stays. The welded connection of the beam (bracket) to deck plating under the stay shall not be weaker than the attachment of stay to deck.

Directly under the lower ends of stays no cut-outs in the deck beams and no gaps between frame ends and deck are permitted.

The dimensions of tightening holes in stays shall not exceed half the stay width in any section of the stay.

The free edges of stays shall be stiffened with face plates or flanges. In general, the flanges (face plates) of stays shall not be welded to deck plating and rail section.

The flanges (face plates) on the outer edge of the stay shall not be welded to horizontal stiffener (flange) of lower edge of the bulwark in way of continuous cut-out.

2.14.2.5 The rail section shall have a flange (face plate) or shall be of bulb profile.

The lower edge of bulwark shall be stiffened with horizontal stiffener or flange in way of continuous cut-out.

Bulwarks shall be adequately strengthened in way of mooring pipes, fairleads and eyeplates for cargo gear.

2.14.2.6 Requirements for the design of freeing ports in bulwarks are given in 1.1.6.7.

2.14.3 Loads on bulwarks.

The external pressure determined by the Formula (1.3.2.2-2) is the design pressure p, in kPa, acting on the bulwark. The design pressure shall be taken not less than:

$$p_{min} = 0{,}02L + 14 \text{ kPa}, \quad (2.14.3)$$

but not less than 15 kPa.

Where L > 300 m L shall be taken equal to 300 m.

For ships of restricted area of navigation the value of p_{min} may be reduced by multiplying by the factor φ_r, obtained from Table 1.3.1.5.

2.14.4 Scantlings of bulwark structures.

2.14.4.1 The thickness of the bulwark plating shall not be less than:

$$s = 0{,}065L + 1{,}75 \text{ for } L \le 60 \text{ m and}$$
$$s = 0{,}025L + 4{,}0 \text{ for } L > 60 \text{ m}, \quad (2.14.4.1)$$

but not less than 3,0, nor greater than 8,5 mm.

The thickness of bulwark plating of a superstructure located beyond 1/ of the ship's length from the fore perpendicular, as well as that of bulwark plating of 2nd tier deckhouses or superstructures may be reduced by 1 mm. For 3rd and above tiers of the deckhouses the thickness of the bulwark plating need not exceed the thickness required for the plating of sides of 3rd tier deckhouse.

The thickness of gunwale of bulwark is to be greater by 1 mm than the plate thickness of bulwark. The breadth of gunwale is not to be less than 75 mm where the thickness of bulwark is 3 mm and not less than 150 mm where the thickness of bulwark is 8,5 mm. The intermediate values of the breadth of gunwale is to be determined by linear interpolation.

2.14.4.2 The section modulus of bulwark stay adjoining the deck plating shall not be less than determined according to 1.6.4.1 taking:

P – as defined in 2.14.3;

$m = 2$;

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

Where the bulwarks are cut to form a gangway or provision is made for expansion joints, the section modulus of stay at the ends of the openings or expansion joints shall be increased by 25 per cent .

The thickness of struts is to be greater by 1 mm than the thickness of plates of bulwark.

The breadth of the lower end of the strut b, in mm, measured along the welding seam, is not to be less than $b = (0{,}65L + 190)\sqrt{a}$ (where a – spacing between struts, in m). However b may be taken not more than 360 mm.

Where the height of a bulwark is greater than 1 m the breadth of the lower end of the strut shall be increased in proportion to height.

The width of stay at the upper end shall be equal to that of the rail section.

2.14.4.3 Where the deck cargo effect on the bulwark is contemplated, the scantlings of the bulwark stays shall be determined by strength calculation involving effect of the said cargo, with regard for heel of the ship determined by Formula (1.3.3.1-5) and acceleration in the horizontal-transverse direction, determined by Formulae (1.3.3.1-2); the permissible stress factor is determined according to 2.14.4.2.