RULES
FOR THE CLASSIFICATION AND CONSTRUCTION OF INLAND WATERWAYS VESSELS

PART II
HULL

July
2019

GDAŃSK

RULES FOR CLASSIFICATION AND CONSTRUCTION OF INLAND WATERWAYS developed and edited by Polski Rejestr Statków S.A., hereinafter referred to as PRS, consist of the following Parts:

Part I – Classification Regulations
Part II – Hull
Part III – Hull Equipment
Part IV – Stability and Freeboard
Part V – Fire Protection
Part VI – Machinery and Piping Systems
Part VII – Electrical Equipment and Automation,

whereas the materials and welding are to comply with the requirements specified in *Part IX – Materials and Welding* of the *Rules for Classification and Construction of Sea-going Ships*.

Part II – Hull – July 2019, was approved by PRS Executive Board on 28 June 2019 and comes into force on 1 July 2019.

Upon the entry into force of this *Part II*, its requirements apply to new vessels to the full scope.

For the existing vessels, the requirements specified in the *Rules* being in force during their construction remain in force, unless the subsequent editions of the *Rules* or amendments thereto provide otherwise.

The requirements of *Part II – Hull* are extended by the below-listed Publications:

Publication No. 121/P – Use of LNG as a fuel on inland waterways vessels.

PRS/RP, 02/2024

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1 GENERAL PROVISIONS

1.1 Application and General Requirements

1.1.1 *Part II – Hull* applies to the vessels specified in paragraph 1.1.1 of *Part I – Classification Regulations*, with the welded steel hull. The use of other materials than steel for the hull structure is subject to PRS approval in each particular case.

1.1.2 In particular the requirements contained in *Part II – Hull* apply to the following types of craft:

.1 vessels and barges intended for the carriage of dry cargo;
.2 tankers;
.3 pontoons;
.4 passenger vessels;
.5 ferries;
.6 tugs and pushers;
.7 floating cranes and dredgers;
.8 ice-breakers;
.9 vessels intended for the carriage of hazardous cargo (materials).

1.1.3 The requirements concerning the design load values applied during the design, concern the operating areas defined in *Part I – Classification Regulations*.

1.1.4 The requirements specified in Chapter 2 apply to all vessels.

1.1.5 The requirements specified in Chapter 3 apply to assess the hull strength by direct calculations. Determining of the minimum scantlings of the hull by direct calculations is required in the following cases:

.1 where any of the conditions specified in .1 to .3 given in sub-chapter 1.1.7 is not fulfilled;
.2 the loads resulting from the intended service of a vessel may produce significant stress values in the hull structure;
.3 progress of the vessel hull structure corrosion has been considered by PRS as excessive (this applies to existing vessels).

The requirements contained in Chapter 3 may also be applied for strength analysis of hull structure elements in other cases than those specified above.

Where the limitations on hull dimensional proportions specified in paragraph 1.1.7 are not complied with, PRS may require direct calculations for the dynamic loads on wave (wave bending moments, dynamic pressures and accelerations) applied in the strength analysis as required in Chapter 3 of this *Part*.

Analysis of hull bending in the horizontal plane may also be required.

1.1.6 The requirements specified in Chapter 4 apply to all vessels.

1.1.7 The requirements specified in Chapter 5 are applicable to determining the minimum scantlings of hull structure elements, where the following conditions are fulfilled:

.1 $L : H \le 32$ and $L : B \le 10$ (L, B, H – see paragraph 1.2.4);
.2 Length $L \le 40$ m;
.3 The sequence of cargo handling operations set in the *Vessel Loading Plan* (see sub-chapter 1.4.2) fulfils the requirements specified in sub-chapter 1.1.12.

For vessels intended for service in operating area 3 or 4 (see paragraph 3.6.3 in *Part I – Classification Regulations*), concessions specified in paragraph 1.1.11 may apply.

1.1.8 The requirements specified in Chapter 6 apply to vessels which are assigned additional ice strengthening mark **L1** or **L2** in the symbol of class (see *Part I – Classification Regulations*).

1.1.9 The requirements specified in Chapter 7 apply to different types of vessels; these requirements are of supplementary nature and are related to additional marks in the symbol of class.

1.1.10 PRS may accept application of structure elements of the scantlings smaller than those resulting from the requirements specified in Chapters 5, 6 and 7 provided it is justified by the hull strength analysis conducted in accordance with the requirements contained in Chapter 3.

1.1.11 Relaxations Concerning Vessels Navigating in Operating Area 3

1.1.11.1 Vessels intended for the service in operating area 3, who fulfil the requirements specified in sub-chapter 1.1.12 are permitted to have reduced scantlings or section modulus of members against those required in Chapter 5 or Chapter 7 to the following extent:

.1 section modulus of transverse members– by no more than 10%;
.2 section modulus of longitudinal members– by no more than 15%;
.3 plating thickness except the fore part and deck– by no more than 10%;
.4 section of stem, sternframe and keel– by no more than 15%;
.5 section modulus of rudder horns– by no more than 25%;
.6 section modulus of forefoot arm– by no more than 25%;
.7 forefoot boss wall thickness– by no more than 10%.

The above relaxations do not, however, apply to ice-strengthened vessels, double hull pushed barges and ferries.

1.1.12 Loading Method Limitations

1.1.12.1 Cargo vessels with the engine room situated aft who meet the condition $L : H \geq 25$, the following cargo handling operations' sequence applies:

.1 First, the aft hold shall be charged with half of the cargo to be loaded, then the successive holds shall be loaded similarly. The remaining cargo shall be loaded in the holds in the reversed order, i.e. from fore to aft.
.2 The cargo shall be discharged by unloading the first half of the cargo from all the successive holds from aft to fore, and the remaining cargo shall be discharged from the holds in the reversed order, i.e. from aft to fore.

The principle of charging and discharging successive holds with half of the cargo – however, beginning from either fore or aft – also applies to vessels having no motive power and length to moulded depth ratio $L : H \geq 25$.

1.1.12.2 Cargo handling principles specified in paragraph 1.1.12.1 also apply to those vessels intended for the service in operating areas 3 or 4 with the length to moulded depth ratio $L : H < 25$ to whom relaxations provided in sub-chapter 1.1.11 have been applied.

1.1.12.3 Where the vessel is loaded to a draught lesser than maximum design draught, which applies to the transition between different operating areas of different requirements concerning freeboard (see *Part IV – Stability and Freeboard*), then the moulded depth (actual or corrected as provided in sub-chapter 1.2.4) increased by the actual freeboard reserve may be taken for the calculation of the length to moulded depth ratio L/H.

1.1.13 Requirements Concerning Structures Made of Higher Strength Steel

1.1.13.1 Where higher strength structural steel is used (see sub-chapter 2.1) the minimum scantlings of members resulting from Chapters 5 and 7 may be decreased as follows:

.1 Plate thickness may be obtained using the following formula:

$$t_0 = 1 + (t-1)\frac{15.8}{\sqrt{R_e}} \quad \text{[mm]} \tag{1.1.13.1-1}$$

provided that:

$$t_0 \geq 3 \text{ mm} \tag{1.1.13.1-2}$$

where:

t – thickness of normal strength structural steel plate [mm];
t_0 – thickness of higher strength steel plate [mm];
R_e – lower standard yield stress of higher strength structural steel [MPa].

.2 Section moduli of members may be obtained using the following formula:

$$W_0 = \left(0.1 + 0.9\frac{235}{R_e}\right)W \quad \text{[cm}^3\text{]} \tag{1.1.13.1-3}$$

where:

W_0 – section modulus for higher strength structural steel, [cm^3];
W – section modulus for normal strength structural steel, [cm^3].

1.1.13.2 Where higher strength structural steel is applied, scantlings shall not be reduced for the following hull elements which are subject to check for buckling strength:

– supports,
– struts and strutting beams,
– deck plating exposed to dynamic load.

1.1.13.3 Strength of structural elements of higher strength structural steel is subject to assessment through direct calculations, as provided in Chapter 3.

1.2 Definitions

Definitions commonly used in the *Rules* are given in *Part I – Classification Regulations*. In this *Part* of the *Rules* additional definitions and symbols related to the hull are introduced.

1.2.1 Main Dimensions

L – Length of the vessel (length L) – the distance measured on the summer load waterline from the fore side of the stem to the axis of the rudder stock, or 96% of the length on summer water line, whichever is greater.

L_k – Length of the vessel (length L_k) – the maximum length of the vessel's hull (exclusive of the rudder, bowsprit and fenders).

B – Moulded breadth of the vessel (breadth B) – the greatest breadth measured between the outer edges of frames.

H – Moulded depth – the vertical distance measured amidships from the base plane to the lower edge of the upper deck stringer plate at side.

For the calculation of L/H ratio (see paragraph 1.1.7 and sub-chapter 1.1.12) in trunk deck vessels, the corrected moulded depth shall be taken:

$$H_1 = H + h\frac{b}{B} \tag{1.2.1}$$

where:
h – trunk height;
b – trunk breadth.
T – *Moulded draught* – the vertical distance measured amidships from the base plane to the summer load waterline.

Such quantities as L, B, H and T are taken in metres.

1.2.2 Parts of Vessel Length

Intermediate portions of the vessel – the portions of vessel situated between the vessel' ends and midship portion.

Midship portion – the vessel portion of length equal 0.5 L (within –0.25 L < x < 0.25 L), unless otherwise provided in the *Rules* (L – see sub-chapter 1.2.1).

Fore and after peaks – fore and stern portions of a vessel within 0.1L from the after perpendicular and forward perpendicular, respectively, towards midship section.

1.2.3 Decks

Closed-in deck – a deck protected by a deck erection.

Lower deck – the deck situated below the upper deck.

Strength deck – the upper deck or a complex of decks forming the uppermost continuous structural hull member. Where a superstructure having more than 0.2L in length is situated amidships, then its deck may be considered as strength deck, depending on the particular design.

Superstructure (deckhouse) deck – the deck forming the top of a superstructure (deckhouse). Where the superstructure (deckhouse) is divided into several tiers, the superstructure (deckhouse) decks are named: the first tier superstructure (deckhouse) deck, the second tier superstructure (deckhouse) deck, etc. continuing from the upper deck.

Upper deck – the uppermost continuous deck extending over the full length of the vessel. Upper deck may have steps.

Weather deck – the upper deck or the superstructure deck exposed to the effect of weather.

1.2.4 Deck Erections

Deckhouse – deck erection on the weather deck, or partially recessed into the weather deck, with the sides being inboard of the vessel sides by more than by 0.05B.

Superstructure – deck erection on the upper deck, or partially recessed into the upper deck, which extends from side to side of a vessel. Superstructure may consist of one or more tiers.

1.2.5 Other Definitions

ADN Rules – the requirements for construction of vessels specified in the European Agreement on International Carriage of Dangerous Goods by Inland Waterway.

After perpendicular – the perpendicular at the intersection of the summer waterline with the axis of the rudder stock or the after end of the vessel's length L – for a vessel without a rudder.

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

Double-side width – minimum distance between the side shell plating and the longitudinal bulkhead plating measured at frame planes in the direction parallel with the base plane.

Forward perpendicular – the perpendicular at the intersection of the summer waterline with the fore side of the stem.

Girders – a general name for structural members supporting the stiffener systems or other girders.

Design thickness – the thickness of a hull structural component intended to be used in the process of hull construction.

Load waterline – the waterline to which a vessel is drawn into fresh water with full load, cargo, stores and possible fixed ballast.

Midship section – hull cross-section at the middle of the distance between the forward perpendicular and the after perpendicular.

Net thickness – the design thickness decreased by the corrosion addition.

Note: Unless in any part of the text of the *Rules* it is otherwise stated, the term "thickness" shall be understood as the design thickness.

Stiffeners – a general name for structural members supporting the plating.

Stiffener span – a segment between the neighbouring girders supporting this stiffener (or between a girder and a bulkhead/division).

Zone R – those of the waterways belong to zone 1, 2, 3 and 4 for which certificates are to be issued in accordance with Article 22 of the *Revised Convention for Rhine Navigation*.

1.3 Scope of Survey

Survey and classification are conducted in compliance with the provisions of *Part I – Classification Regulations*.

1.4 Documentation Required

1.4.1 Hull Documentation of Vessel under Design

Prior to beginning the construction of the vessel's hull, the following documentation shall be submitted, in triplicate, to PRS Head Office for consideration and approval:

.1 Midship section with characteristic cross-sections, including main dimensions of vessel, propulsion power, full requested symbol of class and other data such as number of crew and passengers.

.2 Longitudinal section with specified frame spacings, location of watertight bulkheads, pillars, superstructures and deckhouses.

.3 Drawings of the decks and double bottom (if any), including the arrangement and dimensions of the openings.

.4 Shell expansion, including the particulars concerning welded joints, frame spacing, arrangement of girders, stiffeners, sea chests, bulkheads, decks and platforms, as well as the arrangement and dimensions of the openings.

.5 Drawings of longitudinal and transverse bulkheads, as well as the tank bulkheads, including the height of tank overflow and air pipes.

.6 Drawings of engine room region, including foundations of main engines and boilers, as well as the bottom structure under the foundations, tanks, pillars, strengthenings, e.g. for upper fastening the engine; type and rating of the engine shall be given, the guidelines of the engine manufacturer concerning the foundation shall be considered; the height of tank overflow and air pipes should be specified.

.7 Drawings of aft portion and stern indicating the distance from the propeller to stern and rudder.

.8 Drawings of forward portion and stem.
.9 Drawings of supports and exits of propeller shafts, suspension of rudder and fixed propeller nozzles.
.10 Drawings of foundations for cranes, windlasses and reinforcements under mooring bitts.
.11 Drawings of superstructures and deckhouses.
.12 Tables of hull welding unless all data and dimensions concerning the welding are specified in the design drawings.
.13 Information on hull loads as required in sub-chapter 1.4.2.

In the case of vessels of atypical design, PRS may extend the scope of the required documentation.

1.4.2 Vessel Load and Loading Plan

1.4.2.1 In the case of cargo vessels intended for the carriage of dry cargo and tankers, for which direct strength calculations are required (see sub-chapter 1.1.5), a document called Loading Plan shall be prepared and submitted to PRS for approval.

Loading Plan shall be developed based on the stability calculations as well as hull structure calculations and shall include the following:

.1 Allowable service load conditions and service ballast states of the vessel, specifying the conditions where the following cases occur, either in combination or separately:
- the vessel is not fully loaded, i.e. below the design deadweight,
- the vessel is loaded unevenly fore-and-aft (in particular holds),
- the vessel is loaded unevenly athwartships.

.2 The sequence of loading and unloading operations.

The maximum allowable weights of single cargo portions to be loaded into (or unloaded from) particular holds (or in the particular areas of holds) and the due sequence of filling (emptying) of the holds. During loading (unloading) operations, application of water ballast is permitted in order to reduce the stress in the hull structure due to the cargo loads.

The method and sequence of ballasting (deballasting) shall be unambiguously indicated in the Loading Plan.

.3 The allowable values of cargo pressure on the bottom and decks, including the cases described in .2 as well as allowable values of concentrated forces acting on the bottom and decks while carrying homogeneous cargoes and heavy cargoes.

.4 Limitations concerning the carriage of liquid cargo (applies to tankers):
- the sequence of filling tanks,
- maximum mass density of liquid allowed for filling cargo tanks and, for closed-type tanks, the value of pressure opening the relief valve,
- allowable values of the differences in the liquid cargo level in the adjacent tanks,
- required methods of cargo level control in particular tanks for different vessel draughts.

.5 Limitations concerning cargo handling in open harbours in waving conditions.
.6 Limitations concerning the carriage of dry goods (particularly grain).
.7 Recommended methods of cargo securing.
.8 Applied special reinforcement of the structure (e.g. thickened bottom plating) enabling cargo handling operations with the specific equipment characterised by high cargo-handling capacity;
.9 Recommendations on the possibility and methods of the hull loads' minimisation in emergencies, under the conditions of flooding of particular watertight compartments.

1.4.2.2 Every cargo vessel designed in accordance with the requirements specified in Chapters 5 and 7 (without application of direct strength calculations in accordance with Chapter 3) shall be provided with the Loading Plan containing a clear description of the loading and unloading operations, as defined in paragraph 1.1.12.1.

1.4.3 Classification Documentation of Vessel under Alteration

Prior to beginning the alteration of the vessel, the documentation of those parts of hull which are intended to be altered shall be submitted to PRS Head Office for consideration and approval:

1.4.4 Workshop Documentation of Vessel

Upon approval of classification documentation by PRS Head Office, the following workshop documentation shall be submitted to the competent PRS Branch Office or Survey Station for consideration and approval:

- diagram of hull subdivision into sections and blocks, as well as the plan of assembling sequence,
- plan of welding sequence,
- plan of testing of the welded joints,
- plan of hull tightness tests,
- drawings showing passage of pipelines, ventilation ducts and cables through hull plating, bottom, decks, bulkheads, girders, etc.,
- drawings of local strengthenings under gear and machinery not shown in classification documentation.

Note: Descriptions, drawings and programmes of innovative manufacturing procedures, structural designs and applied materials are subject to approval by PRS Head Office in each particular case.

2 MATERIALS AND WELDING. CORROSION ADDITIONS

2.1 Materials

2.1.1 Materials intended for hull construction are specified in the *Rules for* Construction *and Classification of Sea-going Ships*, *Part IX – Materials and Welding*. Also general-purpose carbon constructional steels fulfilling the requirements specified in Chapter 9 of *Part I – Classification Regulations* are permitted to be used for hull construction.

2.1.2 In general, hulls of the vessels intended for the service in operating area 1 and for the service in ice conditions, irrespective of the operating area, shall be made of normal strength hull structural steels of grade A and B, in accordance with the requirements contained in the *Rules for Classification and Construction of Sea-going Ships, Part IX – Materials and Welding*. Application of higher strength hull structural steels is permitted (see paragraph 2.1.4).

2.1.3 Deckhouses in the second and higher tier, platforms, divisions, ducts and protections which do not form hull strength units are permitted to be made of general purpose structural steels with steelworks' certificate.

2.1.4 Where higher strength hull structural steel is used for the construction of hull or its particular members, the steel shall fulfil the requirements specified in the *Rules for Classification and Construction of Sea-going Ships, Part IX – Materials and Welding*.

2.2 Welded Joints

2.2.1 General Requirements

2.2.1.1 Welded joints shall be made in accordance with the *Rules for Classification and Construction of Sea-going Ships, Part IX – Materials and Welding* and with the requirements contained in this sub-chapter.

2.2.1.2 In the local hull structure strengthenings, higher thickness plates are recommended to be used avoiding doubling plates. If doubling plates are indispensable, their edges shall be joined with a continuous weld, and in the case or larger surfaces – also with slot welds.

The distance between the continuous weld and slot welds as well as between the slot welds shall not be greater than 40-times as much as the doubling plate thickness.

2.2.1.3 Concentration of welds, too little distance between parallel butt welds and fillet welds, as well as intersection of welds at too acute angle shall be avoided.

The distance between parallel welds shall be at least:

.1 $10t$ (where t – design thickness of a thinner plate) between butt welds, but not less than 100 mm;

.2 $5t$ between a butt weld and a fillet weld, not less than 50 mm ;

.3 $4t$ between a butt weld and a fillet weld (within the distance not exceeding 2 m), not less than 30 mm.

Butt welds shall not intersect at an angle lesser than 60°.

2.2.1.4 Distance between the lines of contact between the side shell plating and deck plating as well as web frames parallel with these contact lines shall not be less than 100 mm. For field joints, this distance shall not be less than 200 mm.

2.2.1.5 In the locations where a stiffener intersects with the butt weld, scallops in the stiffener are recommended.

The length of scallops shall not be less than 50 mm and not more than 150 mm, whereas their depth shall not be greater than 0.25 of the stiffener height and not greater than 75 mm. The rounding radius of a scallop shall be equal to its height. The scallops shall be all-round welded.

Scallops shall not be applied:
- within the distance of $0.2L$ from the forward perpendicular,
- in areas subjected to increased vibration, such as the after peak and engine room,
- within the ice strengthening,
- in areas subjected to large concentrated forces, e.g. under and over pillars,
- within the bilge of the radius less than 300 mm,
- within brackets and stiffener ends.

If a scallop is waived, the butt weld shall be equalised with the plate surface in way of contact with the stiffener, and where the butt weld intersects with the stiffener, it shall not be welded to plates throughout the distance of 60 mm, i.e. 30 mm into both directions from the butt weld. In the case of automatic welding, the weld need not be interrupted.

2.2.1.6 Butt weld shall be applied to connect plates. PRS may permit application of lap welds or welds with connection lug if:

.1 a butt weld is impracticable to be made in the particular conditions;

.2 the designed vessel has no motive power or, the vessel is of a limited service time and not intended to undergo major repairs.

2.2.2 Butt Welds

2.2.2.1 Butt welds shall be so made to achieve through penetration. Where double side welded joints are applied, the weld root shall be removed before the weld is made on the other side. Where a sealing run is impracticable, the penetration run shall be correct and free from imperfections, e.g. performed with backing which facilitates the correct forming of the weld root.

2.2.2.2 Where two butt-welded plates are different, the thickness of the thicker plate shall be reduced by bevelling not exceeding 1:3 i.e. the tangent of the slop angle of bevelled edge shall be not grater than 1/3.

2.2.3 Fillet Welds

2.2.3.1 For tight joints, double continuous welds shall be applied, whereas for other joints continuous or intermittent welds shall be applied, as specified in Table 2.2.3.3.

2.2.3.2 The distance between portions of intermittent fillet welds shall be measured on one side of the welded component, as shown in Fig. 2.2.3.2-1 and Fig. 2.2.3.2-2.

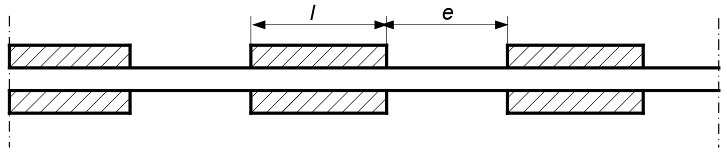


Fig. 2.2.3.2-1. Chain welds

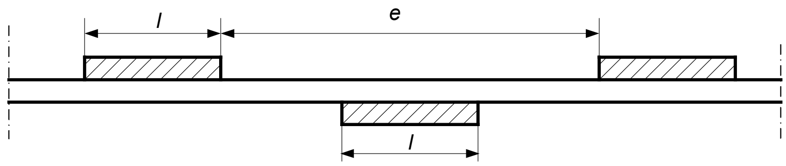


Fig. 2.2.3.2-2. Staggered welds

Distance e shall be so selected that it is not greater than that obtained using the following formulae:

– for chain welds (see Fig. 2.2.3.2-1)

$$e = 15t \ \text{[mm]}, \qquad (2.2.3.2\text{-}1)$$

– for staggered welds (see Fig. 2.2.3.2-2)

$$e = l + 10t \ \text{[mm]}, \qquad (2.2.3.2\text{-}2)$$

where:
l – weld length [mm];
t – design thickness of thinner component [mm].

Length l shall not be less than 75 mm.

2.2.3.3 Weld thickness a (see Fig. 2.2.3.3) shall not be less than determined using the following formula:

$$a = kt \quad \text{[mm]} \qquad (2.2.3.3)$$

where:
k – coefficient taken from Table 2.2.3.3,
t – thickness of thinner component, [mm],

and shall not be less than 2.5 mm, regardless of the weld type and welding procedure.

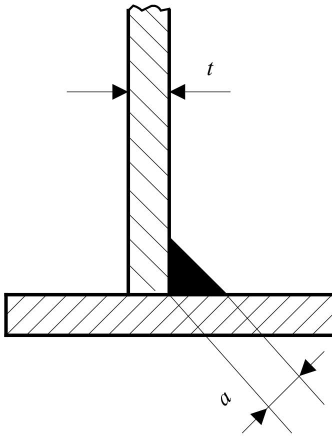


Fig. 2.2.3.3

Where there is a significant difference in thickness of the joined components, PRS' approval is required in each particular case.

Table 2.2.3.3
Values of coefficient *k* and required type of fillet weld

Item	Joined components	Weld type	Coefficient *k* (in formula 2.2.3.3)
1	Bar keel, stem and bar sternframe or web sternframe to shell	c	0.7
2	Plate stem to stiffeners	c	0.5
3	Pusher's bow plating to stiffeners and bumpers	c	0.5
4	Rudder plating to rudder webs	s	0.5
5	Single bottom		
5.1	Floors:		
	–to flat keel	c	0.5
	–to bottom shell	s	0.5
	–to bilge plating	c	0.4
	–to face plates	p	0.5
5.2	Tight floors		
	–to shell	c	0.5
5.3	Bottom girders:		
	– to floors	c	0.6
	– to bulkhead plating	c	0.6
	– to flat keel	s	0.6
	– to bottom shell	s	0.6
	– to face plates	s	0.5
6	Double bottom		
6.1	Floors:		
	– to outer bottom shell	s	0.5
	– to flat keel	c	0.5
	– to bilge plating	c^2	0.5
	– to inner bottom plating	s	0.5
	– to stiffeners	s	0.4
6.2	Bottom girders:		
	– to flat keel	c	0.6
	– to inner bottom plating	s	0.5
	– to outer bottom shell	s	0.6
	– to floors	c^2	0.6

Item	Joined components	Weld type	Coefficient *k* (in formula 2.2.3.3)
7	Engine seating		
7.1	Seating girders:		
	– to outer bottom shell	c	0.5
	– to bed plate	c	0.6
	– to bed plate, adjoining foundation bolts	c	0.7
	– to inner bottom plating	c	0.5
	– to floors	c	0.5
	– to bulkheads	c	0.5
7.2	Floors:		
	– between girders, to inner bottom plating	c	0.6
	– in way of girders, to outer bottom shell	s	0.5
8	Side girders:		
	– to shell	s	0.5
	– to face plates	p	0.5
9	Frames		
9.1	Transverse frames:		
	– to shell	p	0.5
	– to shell in tanks	s	0.5
9.2	Intermediate frames to shell	p	0.5
9.3	Deck erection frames to shell	p	0.5
9.4	Bottom longitudinals to plating	s	0.5
9.5	Longitudinal side frames to plating	s[3]	0.5
9.6	Web frames to plating and their face plates	s	0.5
10	Sea chests:		
	– to plating and upper plate, on water side	c	0.6
	– ditto on opposite side	c	0.4
11	Decks		
11.1	Stringer plate:		
	– to sheer strake, upper side	c	0.5
	– to sheer strake, lower side	c	0.4
	– to shell	c	0.4
11.2	Stringer plate at hatch trunk:		
	– to thick sheer strake, upper side	c	0.6
	– to thick sheer strake, lower side	c	0.5
11.3	Coamings of casings, partitions and ventilators to deck plating	c	0.5
12	Deck beams		
12.1	Beams:		
	– to decks	p	0.5
	– to tank decks	s	0.5
12.2	Deck longitudinals to decks	s[3]	0.5
12.3	Deck transverse to deck (if the deck is framed longitudinally):		
	– to decks	s	0.5
	– to face plates	s	0.5
13	Deck girders:		
	– at pillars and bulkheads to decks	c	0.4
	– to decks	s	0.5
	– to face plates	s[3]	0.5
14	Pillars to decks, face plates, and intermediate plates	c	0.5
15	End bulkheads and sides of deck erections:		
	– to decks, watertight	c	0.4
	– to decks, non-watertight	s[3]	0.5
	– to stiffeners	p	0.5

Item	Joined components	Weld type	Coefficient k (in formula 2.2.3.3)
16	Watertight bulkheads, tank bulkheads and cofferdam bulkheads		
16.1	Plating:		
	– to shell and other bulkheads	c	0.5
	– to bulkhead stiffeners	s[3]	0.5
	– to horizontal and vertical girders at bulkheads	as for tankers	
17	Wash bulkheads:		
	– to plating	s[3]	0.5
	– to stiffeners	s[3]	0.5
18	Hatchways and hatch covers		
18.1	Longitudinal hatch coamings:		
	– to stringer plate	c	0.5
	– to longitudinal stiffeners, upper side	c	0.4
	– to vertical stays and brackets	s[3]	0.4
	– to strutting beams	c	0.5
18.2	Transverse coamings:		
	– to deck plating, upper side	c	0.5
	– to deck plating, lower side	c	0.3
	– to horizontal stiffener, upper side	c	0.4
	– to horizontal stiffener, lower side	s	0.4
	– to vertical stays	s[3]	0.4
18.3	Strutting beams		
	– to plates with face plates	s	0.5
18.4	Hatch covers		
	– to plates with stiffeners	s[3]	0.5
19	Primary supporting members of tankers		
19.1	Floors:		
	– to bottom plating	s	0.5
	– to bilge strake and longitudinal bulkhead	c	0.4
	– to face plates	s	0.5
19.2	Deck transverses:		
	– to deck	s	0.5
	– to shell and longitudinal bulkhead	c	0.4
	– to face plates	s	0.5
19.3	Web frames:		
	– to shell	s	0.5
	– to floors and deck transverses	c	0.7
	– to face plates	s	0.5

Where:

c – double continuous welds;
s – chain welds;
p – staggered welds[1];
k – throat thickness coefficient (see formula 2.2.3.3).

[1] Chain welds may be applied instead of staggered welds.
[2] In double bottom of more than 750 mm in height, chain welds may be applied.
[3] In vessels intended to navigate in operating area 3, staggered welds may be applied.

2.2.3.4 If double continuous welds are intended to be applied, instead of intermittent welds in accordance with Table 2.2.3.3, then their thickness shall be determined using the following formula:

$$a_{red} = a\left(0.4 + 0.6\frac{l}{l+e}\right) \quad [\text{mm}] \qquad (2.2.3.4)$$

where:
a – intermittent weld thickness, [mm];
l – weld length, [mm] (see Fig. 2.2.3.2-1 and 2.2.3.2-2);
e – distance between weld portions, [mm] (see Fig. 2.2.3.2-1 and 2.2.3.2-2).

2.2.3.5 In vessels intended to navigate in operating area 3, instead of chain welds, single continuous welds with the same weld thickness a may be applied, whereas instead of staggered welds, single intermittent welds with the value $l+e$ reduced by 50% and the same value l (l, e see Fig. 2.2.3.2-2) may be applied.

Single welds shall not be applied:

.1 within the distance of 0.2L from the forward perpendicular;
.2 in areas subjected to increased vibration, such as the after peak and engine room;
.3 within the ice strengthening;
.4 in areas subjected to large concentrated separating forces and bending moments, e.g. in way of pillars;
.5 in those joints where the angle between the added component and the plate is less than 80°;
.6 in vessels intended for the carriage of ores.

2.2.3.6 Where elements containing scallops are to be welded (see paragraph 2.2.1.5), the weld dimensions shall be determined as for chain welds. The welds shall be continuous at the perimeter.

2.2.3.7 Where welds are made with an automatic welding machine, the weld thickness obtained using formula 2.2.3.3 or 2.2.3.4 may be reduced by 25%, however the throat of a fillet weld shall never be less than 2.5 mm.

2.2.3.8 Intermittent or single welds joining structural members with the plating shall be substituted at their ends by double continuous welds which:

.1 reach at least the bracket end, if applied to join the members;
.2 have a length equal to double height of the member, if brackets have not been applied; this also refers to the joints between webs and face plates at the members' ends.

2.2.3.9 In longitudinally framed tankers such members as: frames, beams, bulkhead stiffeners, etc., shall have their ends welded to the stiffened plating throughout the length equal to triple height of the member with a double continuous weld of the thickness equal k = 0.7 (see formula 2.2.3.3).

2.2.3.10 If longitudinal and transverse stiffeners of hull, such as frames, beams, bulkhead stiffeners intersect with the web frames, then those members shall be welded together.

2.2.4 Lap Welds

In lap joints permitted for application in accordance with paragraph 2.2.1.6, the overlap width shall not be less than quadruple thickness of the thinner component, however no more than 40 mm. The joints shall be made with double continuous welds of the thickness obtained from formula 2.2.3.3 for k = 0.7.

2.2.5 Slot Welds

2.2.5.1 Where application of a fillet weld is impossible, pin slot weld (Fig. 2.2.5.1-1) or slot weld with backing (Fig. 2.2.5.1-2) may be applied. Pin slot welds may be applied only in those joints where, as a result of great thickness of plating and its possible deformation, it is difficult to bring the plate to contact with the backing (face plate) on the stiffener.

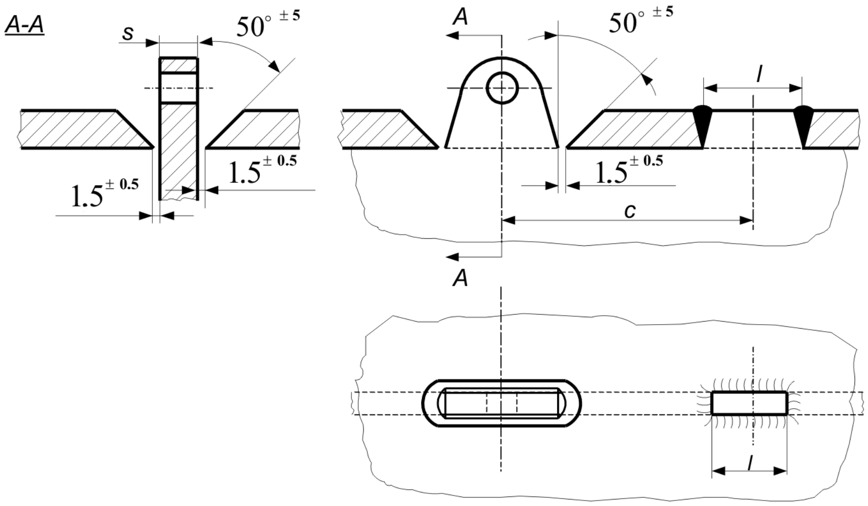


Fig. 2.2.5.1-1. Pin slot weld

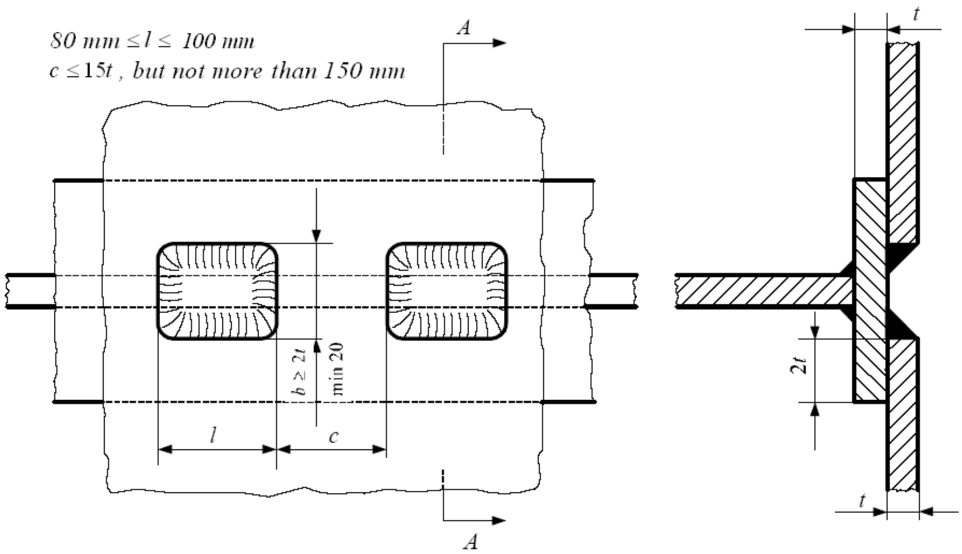


Fig. 2.2.5.1-2. Slot weld with backing

2.2.5.2 The slots for welds shall be situated with their longitudinal axes parallel with the stress direction and shall have rounded edges.

The length of the holes shall not be less than 80 mm and not be more than 100 mm, their spacing along the longitudinal axis shall not be more than 15 times as much as thickness of the plate welded with backing or web (rib), but not more than 150 mm.

The width of the hole for weld with backing shall be at least double thickness of the plate welded with backing, however not less than 20 mm. The edges of the backing flat bar shall stand out of the weld hole edges on each side by double thickness of the joined plate, however they need not stand out by more than 20 mm on each side. The backing thickness shall be at least equal to thickness of the joined plate.

Weld thickness within the hole shall be determined as for the lap weld (see sub-chapter 2.2.4).

2.2.5.3 The space remaining after making a slot weld shall be filled with pitch or similar material carefully. The hole shall not be fully filled with weld.

2.2.5.4 Pin slot welds shall be applied where application of a slot weld is impracticable. Single pin slot welds may particularly be applied to bring the plate to contact with the backing. The slot width shall be so determined to suit the pin thickness (see Fig. 2.2.5.1-1), and the edges shall be bevelled at the angle of 50°. The groove so created shall be fully filled with the weld.

2.2.6 Inspection of Welded Joints

Welded joints are subject to inspection in accordance with the requirements specified in the *Rules for Classification and Construction of Sea-going Ships*, *Part IX – Materials and Welding*, sub-chapters 2.5 and 2.11.

2.3 Corrosion Additions

2.3.1 Corrosion additions specified in paragraph 2.3.2 are applicable to those vessels whose hulls are designed on the basis of direct strength analysis, as required in Chapter 3 and regard to the assumed 25-year period of service.

2.3.2 The values of corrosion additions for shell plating as well as walls, stiffeners and girders are given in Table 2.3.2.

Table 2.3.2
Corrosion additions

Vessel type and space	Type and location of members	Corrosion addition [mm]
1. Vessel not intended for the carriage of bulk cargo, oil – all vessel	1. Bottom plating, as well as bottom primary members and stiffeners (including double bottom)	1.5
	2. Inner bottom plating	1.5
	3. Side shell as well as side primary members and stiffeners	1.5
2. Bulk carrier – vessel areas beyond the area of cargo holds (including the spaces in double side and double bottom, in cargo spaces)	4. Plating as well as primary members and stiffeners of longitudinal and transverse bulkheads, in the location of the lowest strakes	1.5
3. Oil tanker – other than cargo tank spaces (including the spaces in double side and double bottom, in cargo spaces)	5. As in 4, in other spaces	1.0
	6. Plating as well as primary members and stiffeners of decks and hatchway coamings	1.0
Bulk carrier – cargo spaces	1. Inner bottom plating, the lowest strakes of sides (or longitudinal bulkheads, if any) and bulkheads as well as their primary members and stiffeners	2.5
	2. Plating of double sides (or longitudinal bulkheads, if any) and bulkheads as well as their primary members and stiffeners in spaces other than specified in 1	2.0
	3. Plating of cargo decks	2.5
	4 Plating of decks other than cargo decks	2.0
Oil tanker – cargo tank spaces	1. Deck plating, primary members and stiffeners of decks as well as the spaces with uppermost side shell strakes (or longitudinal bulkheads of double sides, if any) and bulkheads in vessels intended for the carriage of crude oil	3.0
	2. As in 1, for oil tankers	2.0
	3 Other structural members in contact with liquid cargo: – in vessels intended for the carriage of crude oil – in oil tankers	 2.5 1.5

2.3.3 Corrosion additions shall also be taken into account while determining throat thickness of fillet welds, which is required for the hull designed based on the direct strength analysis. The values of such additions shall be taken as halves of the values given in Table 2.3.2. To calculate the net thickness of welds, as required in sub-chapter 2.2.3, the net thickness of plates may be taken.

2.3.4 PRS may accept lower values of corrosion additions than those specified in sub-chapter 2.3.2 if the Owner submits reliable data on corrosion of the existing similar vessels in the service similar to that intended for the vessel to be classified.

2.3.5 The adopted values of corrosion additions shall be stated on the drawings included in the classification documentation.

3 HULL STRUCTURE STRENGTH

3.1 General Provisions

3.1.1 Scope of Strength Analysis

3.1.1.1 Hulls of vessels designed with the direct strength analysis (see paragraph 1.1.5) shall fulfil the general strength criteria specified in sub-chapter 3.3, the criteria for combined stress – in the hull longitudinal members – caused by general bending and local loads, as specified in sub-chapter 3.5, as well as the local strength criteria specified in sub-chapter 3.4. Independent criteria for the structures with members of the design thickness (see sub-chapter 3.3.5 and paragraph 3.3.6.1) and for the structures with members of the net thickness, i.e. the reduced corrosion additions (see paragraph 3.3.6.2 and sub-chapters 3.4 and 3.5) apply.

3.1.1.2 Criteria of structural members' buckling strength, as specified in sub-chapter 3.6, apply to the net thicknesses of structural members, i.e. the design thicknesses reduced by the corrosion additions, as specified in sub-chapter 2.3.

3.1.1.3 If during the service of the hull of a designed vessel in accordance with the principles specified in paragraph 1.1.5, the values of corrosion diminution exceed those specified in sub-chapter 2.3, and the corroded structure no longer fulfils the requirements specified in sub-chapters 3.3 to 3.6, then it may prove necessary to apply restrictions in the form of e.g. reduction of deadweight, the change of the allowable operating area, deleting some loading conditions from the vessel Stability Information, etc. However, the above is subject to the condition that the actual plating thickness will not be less than the thickness specified in 3.1.2.

3.1.2 Minimum Plating Thickness

3.1.2.1 The actual thickness of the bottom, bilge and side plates, measured at any stage of steel hull vessel, other than a passenger vessel, shall be not less than the greatest of the values determined from formulae 3.1.2.1-1 to 3.1.2.1-3:

– vessels with the length $L > 40$ m:

$$t_{\min} = fbc(2.3 + 0.04L) \quad [\text{mm}] \qquad (3.1.2.1\text{-}1)$$

– vessels with the length $L \le 40$ m:

$$t_{\min} = fbc(1.5 + 0.06L) \quad [\text{mm}], \text{ however not less than 3 mm} \qquad (3.1.2.1\text{-}2)$$

– irrespective of the vessel's length:

$$t_{\min} = 0.005a\sqrt{T} \quad [\text{mm}] \qquad (3.1.2.1\text{-}3)$$

where:
a – frame spacing [mm];

f – frame spacing factor:
f = 1.0 – for $a \leq 500$ mm;
$f = 1.0 + 0.0013\ (a - 500)$ – for $a > 500$ mm;
when calculating t_{min} of the side pates, f = 1.0 may be taken;
b = 1.0 for the bottom plates and side plates;
b = 1.25 for the bilge plates;
c – factor for the type of structure:
c = 0.95 – for vessels with double bottom and wing voids, where the partition between the wing void and holds is located vertically in line with the hatch coaming:
c = 1.0 – for other types of structure.

The value of t_{min} for the bilge plates shall be not less than that required for the bottom plates and side plates.

The actual net thickness of the bottom, bilge and side plating shall be not less than minimum required net thickness based on the direct calculation – see Chapter 3. The loads of the sea pressure, wind pressure and cargo loads shall be taken into account in this calculation.

3.1.2.2 For passenger vessels, the minimum plating thickness, specified in 7.6.5, applies.

3.1.2.3 In the case of steel hull vessels with double bottom and wing voids, the values of t_{min}, determined in accordance with 3.1.2.1, may be reduced to the values which satisfy the hull strength criteria, specified in the present Part of the *Rules,* for plates with net thickness (see also 3.1.1.3).

3.1.2.4 The thickness of plates, calculated according to 3.1.2.1 and 3.1.2.3, may be considered acceptable, provided that the following conditions are satisfied:
- the vessel's hull is constructed of shipbuilding steel complying with the requirements specified in *Part IX – Materials and Welding* of the *Rules for the Classification and Construction of Sea-going Ships*;
- the plates thickness reduction due to corrosion is uniform;
- the internal structural elements (frames and other stiffeners of the plating, floors, principal members, bulkheads and partitions) are in good condition, i.e. do not show excessive corrosion or permanent deformations;
- the hull shows no indication of damage due to general bending (e.g. permanent deformations, cracks, etc.).

3.1.2.5 Plates not complying with the criteria specified in 3.1.2.1 and 3.1.2.3 shall be repaired or replaced, without delay.

However, the values of the plates thickness lesser, by not more than 10%, than the values calculated in accordance with 3.1.2.1 and 3.1.2.3, may be permitted locally.

3.1.2.6 Where a material other than steel is used for the construction of the hull, the minimum plating thickness shall be such as to ensure that the hull longitudinal, zone and local strength will equal at least the strength of a steel hull having the minimum plating thickness determined in accordance with 3.1.2.1 or 3.1.2.3.

3.2 Design Loads

3.2.1 General Notes

The design loads determined as required in sub-chapter 3.2 shall be applied to assess the hull general strength (sub-chapter 3.3), local strength (sub-chapter 3.4) as well as buckling strength of structural members (sub-chapter 3.6).

Bending moments and shear forces in the general bending conditions shall be calculated as required in sub-chapter 3.2.2.

The values of pressure and loads imposed by the cargo or equipment on the hull structure as well as the values of pressure imposed by the outside water shall be determined as required in sub-chapter 3.2.3.

3.2.2 Bending Moments and Shear Forces Due to General Bending of Hull

3.2.2.1 The design values of the wave bending moments and shear forces shall be determined as required in paragraph 3.2.2.9, taking account of the still water as well as wave conditions.

3.2.2.2 Still water bending moments and shear forces shall be determined for the most adverse loading conditions.

The applied calculation methods and software shall ensure adequate accuracy of the calculations. The values of the curve of weight and curve of buoyancy shall be given, in general, for 21 compartments along the vessel.

3.2.2.3 In the calculations of still water bending moments and shear forces, the following loading conditions shall be taken into account for the most popular types of vessels listed below:

.1 tankers, dry cargo carriers and barges intended for the carriage of dry cargo:
- vessel without cargo or ballast carrying 100% of stores and 10% of stores;
- ballasted vessel carrying 100% of stores and 10% of stores;
- fully loaded vessel, according to the vessel Loading Plan;
- intermediate loading conditions, according to the vessel Loading Plan;
- loading conditions, where significant differences in the hull general bending stress values may occur (e.g. transport of individual pieces of heavy cargo, incomplete use of carrying capacity, etc.);

.2 passenger vessels:
- vessel without passengers and cargo, carrying 100% of stores and 10% of stores;
- vessel with the maximum allowable number of passengers and maximum allowable mass of cargo, carrying 100% of stores and 10% of stores;

.3 other vessels:
- typical service conditions, vessel carrying 100% of stores and 10% of stores.

3.2.2.4 For all types of vessels designed to have one-compartment subdivision, additional calculation of the still water bending moments and shear forces shall be performed for each loading or service condition determined in accordance with the requirements specified in paragraph 3.2.2.3 at the assumption of emergency flooding one watertight compartment up to the equilibrium waterline. The allowable structure response characteristics are specified in paragraphs 3.3.5.4 and 3.3.6.3.

3.2.2.5 For vessels whose dimensions L and H meet the condition L/H>25, hull deflection may be taken into account in the calculations of the still water bending moment and shear strength. Application of a calculation model in the form of a variable-section beam resting on the elastic foundation (water buoyancy) is permitted.

3.2.2.6 The values of still water bending moments for cargo vessels and barges applied to determine the design values of the bending moments as required in paragraph 3.2.2.9 shall not be less than those obtained from the following formula:

$$M_s(x) = k_s(x) \cdot M_0 \ \text{[kNm]} \qquad (3.2.2.6)$$

where:

$M_0 = 0.07BHL^2$ [kNm];

B, H, L – main dimensions of hull defined in sub-chapter 1.2.1;

$k_s(x)$ – dimensionless coefficient, of the value dependent on coordinate x of the transverse section, measured along the vessel, obtained from Fig. 3.2.2.6.

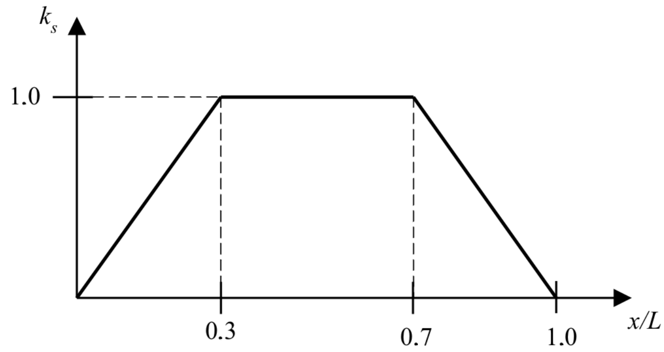


Fig. 3.2.2.6. Values of coefficient $k_s(x)$

$M_s(x)$ shall be considered as absolute values, i.e. they apply to the bending moments of any sign (deck subjected to compression and deck subjected to tension).

Minimum values of $M_s(x)$ for vessels found by PRS atypical shall be considered by PRS in each particular case.

3.2.2.7 The design values of wave bending moment M_w and wave shear force Q_w shall be calculated using the following formulae:

$$M_w = k_1 k_2 A_1 h \delta B L^2 \text{ [kNm]} \quad (3.2.2.7\text{-}1)$$

$$Q_w = k_1 k_2 A_2 h \delta B L \text{ [kN]} \quad (3.2.2.7\text{-}2)$$

where:

k_1 – dimensionless coefficient depending on the operating area, having the values given in Table 3.2.2.7-1;

k_2 – dimensionless coefficient depending on the vessel's moulded draught T, having the values given in Table 3.2.2.7-2 (for intermediate values of T linear interpolation shall apply);

A_1, A_2 – dimensionless coefficients of the values depending on the operating area and vessel's length L, given in Table 3.2.2.7-3; for intermediate values of L, the values of A_1 and A_2 shall be determined by linear interpolation;

δ – block coefficient $\left(\delta = \frac{V}{LBT}\right)$;

L, B, T – length, breadth and moulded draught, [m] (see sub-chapter 1.2.1);

V – volume of underwater part of hull at draught T, [m^3];

h – wave height, depending on the operating area, given in Table 3.2.2.7-1, [m].

Table 3.2.2.7-1
Values of coefficient k_1

Operating area	Wave height h [m]	k_1
1	2.0	0.85
2	1.2	0.78
3	0.6	0.60

Table 3.2.2.7-2
Values of coefficient k_2

T [m]	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.25	1.5	1.75	2.0	2.25	2.5	≥3.0
k_2	0.74	0.67	0.61	0.55	0.50	0.45	0.41	0.37	0.29	0.22	0.17	0.14	0.11	0.082	0.05

Table 3.2.2.7-3
Values of coefficients A_1 and A_2 as function of L

Operating area						
1	L [m]	≤ 25	50	75	≥ 100	–
	A_1	0.31	0.25	0.19	0.13	–
	A_2	1.00	1.00	0.74	0.38	–
2	L [m]	≤ 15	30	45	60	≥ 80
	A_1	0.31	0.25	0.19	0.13	0.09
	A_2	1.00	1.00	0.74	0.38	0.30
3	L [m]	≤ 10	25	40	≥ 60	–
	A_1	0.31	0.25	0.19	0.13	–
	A_2	1.00	1.00	0.74	0.38	–

3.2.2.8 The design values of the wave bending moment M_w(x) and wave shear force Q_w(x) shall be calculated using the following formulae:

$$M_w(x) = M_w k_M(x) \text{ [kNm]} \quad (3.2.2.8\text{-}1)$$

$$Q_w(x) = Q_w k_Q(x) \text{ [kN]} \quad (3.2.2.8\text{-}2)$$

where:

x – coordinate along the vessel hull (x = 0 at the after perpendicular);
M_w – wave bending moment, obtained from formula 3.2.2.7-1;
Q_w – wave shear force, obtained from formula 3.2.2.7-2;
$k_M(x)$ – dimensionless coefficient taking values shown in Fig. 3.2.2.8-1;
$k_Q(x)$ – dimensionless coefficient taking values shown in Fig. 3.2.2.8-2.

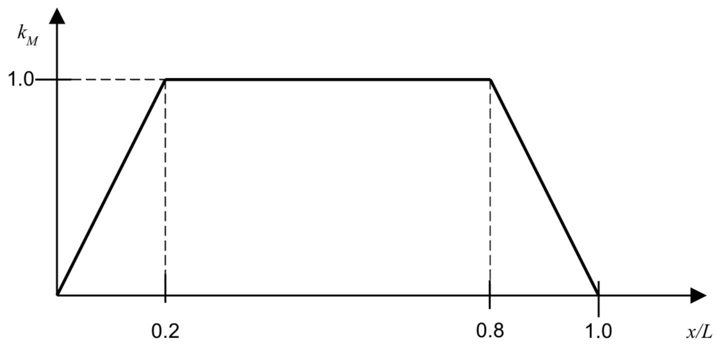


Fig. 3.2.2.8-1. Values of coefficient k_M

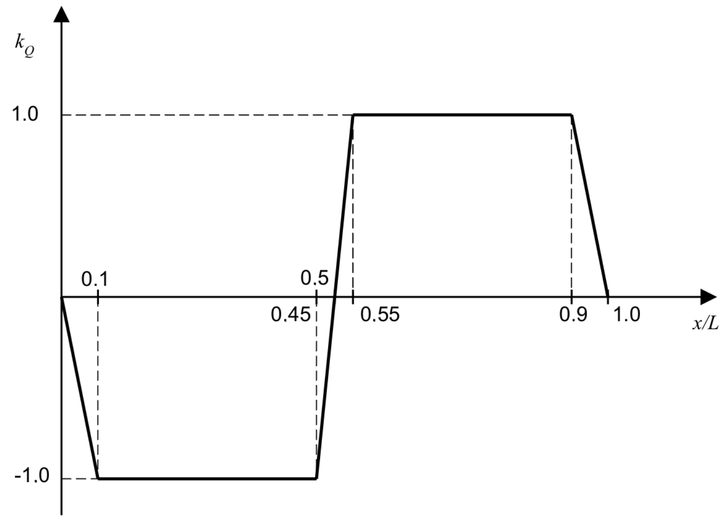


Fig. 3.2.2.8-2. Values of coefficient k_Q

3.2.2.9 The design values of bending moments and shear forces in particular transverse sections of the hull shall be determined by adding up their maximum still water values obtained in accordance with paragraphs 3.2.2.2 ÷ 3.2.2.6 and their design wave moments obtained in accordance with paragraphs 3.2.2.7 and 3.2.2.8. The values of $M_w(x)$ and $Q_w(x)$ (see paragraph 3.2.2.8) shall be taken for the same sign as the values of $M_s(x)$ and $Q_s(x)$ (bending moment and shear force) in still water.

For the cargo handling operations $M_w(x) = 0$, $Q_w(x) = 0$ may be taken.

3.2.3 Local Loads on Structure

3.2.3.1 The stress in the longitudinal members of the hull or shell plating which are exposed to general bending determined within the analysis of the structure local strength, as required in sub-chapter 3.4 for the loads defined in this sub-chapter 3.2.3, shall be combined with the general bending stress, as required in sub-chapter 3.5.

The stress in the transverse members are subject to assessment as required in paragraphs 3.4.2.7 and 3.4.3.6, whereas the stress in the shell plating not exposed to the general bending – as required in paragraph 3.4.4.4.

The structure local strength shall be checked for those combinations of inner and outside loads (paragraphs 3.2.3.2÷3.2.3.8) which impose the maximum values of stress in the shell plating and stiffeners.

3.2.3.2 The loads to be used for local strength analysis shall be determined in the loading conditions specified in paragraph 3.2.2.3.

Also the loads occurring in the following conditions shall be taken into account:
– processes of loading and unloading of the vessel;
– emergency flooding of a watertight compartment;
– hull tightness tests.

3.2.3.3 The local loads of structure occur in the form of the design pressures (outside water pressure, ballast pressure, pressure of stores and liquid cargo inside the hull, bulk cargo pressure) or concentrated forces (loads imposed by individual pieces of cargo, containers, vessel equipment, etc.).

3.2.3.4 The design pressure from the water ballast, stores or liquid cargo shall be determined taking the greater of the following two values:

$$p = \rho g h_c \text{ [kPa]} \qquad (3.2.3.4\text{-}1)$$

$$p = \rho g h_a + p_v \text{ [kPa]} \qquad (3.2.3.4\text{-}2)$$

where:

ρ – mass density of liquid (for water to be taken $\rho = 1.0$ t/m³);
g = 9.81 – acceleration of gravity, [m/s²];
h_c – vertical distance from the air pipe top, whose position shall not be taken lower than 1 m from the uppermost point of tank top [m];
h_a – vertical distance from the uppermost point of tank top, [m];
p_v – pressure (relief valve setting), [kPa], ($p_v = 0$ for ballast tanks).

3.2.3.5 For the emergency flooding of a watertight compartment, loads shall be taken in the form of hydrostatic pressure whose value shall be calculated using the method adequate to location of the vessel's equilibrium waterline in damaged condition.

3.2.3.6 The loads imposed by the bulk cargo on the bottom, sides and bulkheads shall be calculated using the following formula:

$$p = \rho_c h_c g K \text{ [kPa]} \qquad (3.2.3.6\text{-}1)$$

where:

ρ_c – mass density of bulk cargo, [t/m³];
h_c – thickness of the cargo layer above the point for which p is calculated, [m];
$g = 9.81$ – acceleration of gravity, [m/s²];
K – dimensionless coefficient obtained from the following formula:

$$K = \sin^2\alpha \,\mathrm{tg}^2(45^\circ - 0.5\gamma) + \cos^2\alpha \qquad (3.2.3.6\text{-}2)$$

α – angle between the plating under consideration and the horizontal plane [deg];
γ – cargo angle of repose, [deg], the following values of γ may be taken:
$\gamma = 20°$ – for light bulk cargoes (coal, grain),
$\gamma = 25°$ – for cement ($\rho_c = 1.35$ t/m³),
$\gamma = 35°$ – for heavy bulk cargoes (ores).

When using formula 3.2.3.6-1, the actual height h_c which takes into account the shape of the bulk cargo free surface including the angle of repose γ (either the cone surface or the sloping planes, of the slope angle relative to the horizontal γ) shall be applied if such a method of the carriage of cargo has been assumed to develop the vessel Loading Plan required in sub-chapter 1.4.2.

3.2.3.7 The design (minimum) loads of decks shall be taken in accordance with paragraphs 5.6.7.1 and 5.6.7.2.

3.2.3.8 Scantlings of the plating and plating stiffeners shall be determined taking into account the following two values of pressure imposed by outside water on the hull plating:

– the maximum value of hydrostatic pressure corresponding to the vessel draught $T + 0.5h$ (T – vessel draught at the loading condition under consideration, h – wave height depending on the operating area, taken in accordance with paragraph 3.2.3.9);
– the minimum value of hydrostatic pressure corresponding to the vessel draught $T - 0.5\,h$ (T, h – as above).

In general, the draught $T + 0.5h$ shall be taken for scantling of these structure fragments which are not subjected to the loads imposed from the hull inside whereas the draught $T - 0.5\ h$ – for scantling of the bottom and side areas which are subjected to the loads imposed from the hull inside.

3.2.3.9 If stresses are necessary to be determined in the complex system of girders or stiffeners by direct calculations, the load shall be determined using the models described in paragraph 3.4.3.1 in accordance with the following algorithm:

a) it shall be assumed that the hull is statically positioned on front waves (the wave direction is parallel with the hull plane symmetry), and the position of the vessel against still water is constant;
b) taking account of several wave positions against the hull (i.e. moving a wave along the hull), such a wave position against the hull shall be taken in which the greatest stresses are generated in the analysed structure region, where the pressures imposed from the structure inside have been determined in accordance with paragraphs 3.2.3.3÷3.2.3.7, and the outside pressures are hydrostatic pressures, corresponding to the wave in the particular frame sections of hull.

Wave height h and wave length λ take the following values depending on the operating area:

- operating area 1: $h = 2.0$ m, $\lambda = 20$ m;
- operating area 2: $h = 1.2$ m, $\lambda = 12$ m;
- operating area 3: $h = 0.6$ m, $\lambda = 6$ m.

3.3 General Strength

3.3.1 Scope of Calculations

The stresses imposed by the general bending of hull shall be calculated for the extreme values of the design bending moments and shear forces determined in accordance with sub-chapter 3.2.2 causing sagging or hogging type of hull deflection.

Calculations shall be performed for those frame sections of hull, where extreme values of combined stresses for the general bending of hull and local bending of plating, stiffeners or girders as well as in those sections where the extreme values of shear forces occur.

3.3.2 Members Stressed by General Bending

3.3.2.1 When calculating normal stress – caused by the bending moment in general bending conditions – in the hull cross-sections, it may be assumed that they are born by all the longitudinal members of hull in the particular section, extending over the length not less than double moulded depth.

Reduced effectiveness of compressed members shall be taken into account in accordance with the provisions of sub-chapter 3.3.4. Hull openings and intermittent longitudinal members shall also be taken into account in accordance with the provisions of paragraphs 3.3.2.2 and 3.3.2.3, respectively.

3.3.2.2 Openings in the hull section under consideration shall be taken into account.

In those hull sections which are located near openings, cross-sectional areas of the members shall not be taken into account in the area determined as shown in Fig. 3.3.2.2-1.

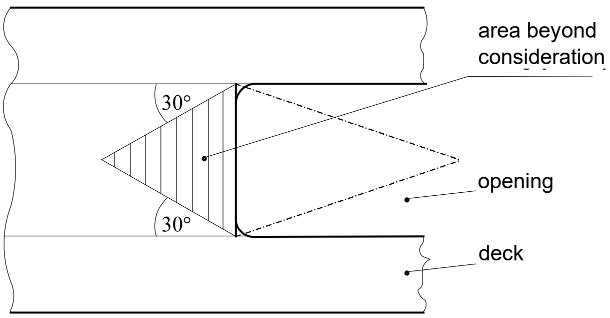


Fig. 3.3.2.2-1. Principle of consideration of deck openings

3.3.2.3 In way of their ends, longitudinal members of hull structure (e.g. hatch coamings, sides and superstructure decks, etc.) shall be taken into account as shown in Fig. 3.3.2.3-1.

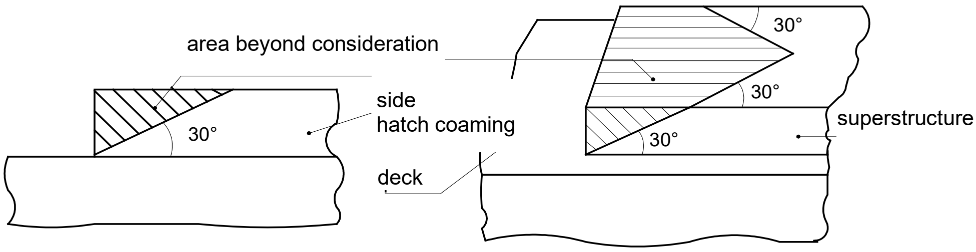


Fig. 3.3.2.3-1. Principle of consideration of hatch side coamings and superstructures

3.3.3 Calculation Method

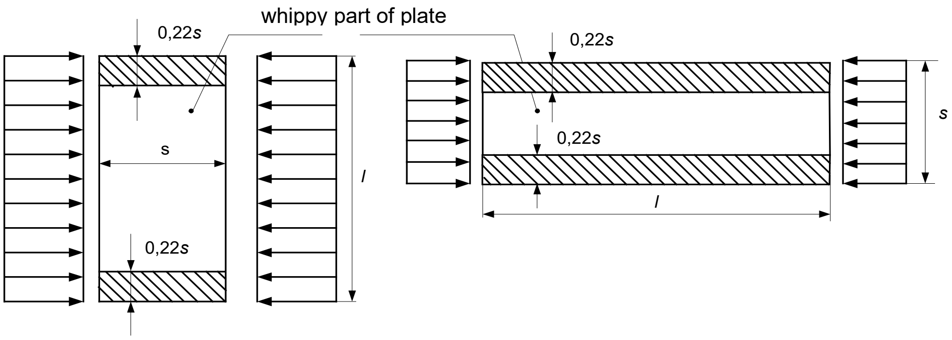
In the general bending conditions, the values of normal stress σ in the transverse hull section shall be calculated using an iterative method, taking into account the reduced values of the cross-sectional areas of the plating of the bottom, decks, side and longitudinal bulkheads obtained in accordance with sub-chapter 3.3.4 or in other way accepted by PRS.

The calculations' results may be considered sufficiently accurate if the maximum values of the normal stresses determined in the subsequent iterative steps differ no more than by 3%.

3.3.4 Reducing Transverse Section of Plates

3.3.4.1 The following elements of hull cross-section are not subject to reduction:

.1 elements, in which normal stress is tensile;
.2 stiffeners and longitudinal members;
.3 curved bilge plating;
.4 rounded strakes;
.5 portions of compressed plating of the bottom, decks, sides, bulkheads and longitudinal bulkheads located at longitudinal edges of plates (determined by stiffeners or longitudinal members, edges of the connection between deck and side, etc.) of the width equal 22% of the shorter side of the plate (Fig. 3.3.4.1).



a) transverse framing system $(s / l \le \sqrt{2})$ b) longitudinal framing system $(l / s > \sqrt{2})$

Fig. 3.3.4.1. Plate portions which are not subject to reduction

3.3.4.2 Normal stresses in the hull cross-section which are not subject to reduction (in the so called rigid parts) shall be calculated in accordance with the beam bending theory. The beam cross section consists of the rigid portions and of the plating portions which are subject to reduction (the so called whippy parts) whose reduced cross-sectional area is considered as the area of rigid portions, shall be calculated using the following formula:

$$A = \varphi A_p \ \ [\text{cm}^2] \tag{3.3.4.2}$$

where:

A_p – shell plate cross-sectional area which is subject to reduction, as shown in Fig. 3.3.4.1, [cm^2];
φ – reduction coefficient, obtained in accordance with paragraph 3.3.4.3, 3.3.4.4 or 3.3.4.5 or using any other method accepted by PRS.

3.3.4.3 Reduction coefficient of the whippy portion, of the plate in the transverse framing system, which is not loaded with the buoyancy pressure or cargo pressure, shall be calculated using the following formula:

$$\varphi = \frac{\sigma_w}{\sigma_s} = \frac{\alpha}{m} \tag{3.3.4.3-1}$$

where:

σ_w – average normal stress in the whippy portion of the plate ($\sigma_w > 0$ for tensile stress; $\sigma_w < 0$ for compressive stress), [MPa];
σ_s – normal stress in the rigid portions of the plate ($\sigma_s > 0$ for tensile stress; $\sigma_s < 0$ for compressive stress), [MPa];
α, m – dimensionless coefficients fulfilling equation 3.3.4.3-2:

$$m = \alpha - 3\frac{1-v^2}{K}\left(\frac{b_1}{t}\right)^2\left[\frac{1}{(1+\alpha)^2} - 1\right] \tag{3.3.4.3-2}$$

v – Poisson's ratio (for steel $v = 0.3$);

$$m = \frac{\sigma_s}{\sigma_E}$$

$$\alpha = \frac{\sigma_w}{\sigma_E}$$

σ_E – ideal critical stress calculated using formula 3.3.4.3–3, [MPa];
t – plate thickness, [mm];

$$\sigma_E = \frac{\pi^2 E}{12(1-v^2)}\left(\frac{t}{1000s}\right)^2 K \ \ [\text{MPa}] \tag{3.3.4.3-3}$$

E – Young modulus (for steel $E = 2.06 \cdot 10^5$ MPa);

s, l – plate width and length (see Fig. 3.3.4.1), [m];

K – dimensionless coefficient taking the following values:

$K = 1$, where $\frac{l}{s} > 5$

$$K = \left(1 + \frac{s^2}{l^2}\right)^2, \text{ where } 5 \geq \frac{l}{s} > \frac{1}{\sqrt{2}}$$

b_1 – maximum value of the initial (technological) plate deflections according to Table 3.3.4.3-1. For intermediate values of t, the values of b_1 shall be calculated by linear interpolation.

Table 3.3.4.3-1
Values of b_1/s as function of t

t [mm]	b_1/s
≤ 3	0.015
4	0.014
5	0.013
6	0.012
≥ 7	0.011

To make the calculations easier, the values of $\varphi = \alpha/m$ corresponding to m and α which fulfil condition 3.3.4.3-2 and $\nu = 0.3$ are given in Table 3.3.4.3-2, as a function of m and $\frac{1}{K}\left(\frac{b_1}{t}\right)^2$.

The values of φ for intermediate values of m and $\frac{1}{K}\left(\frac{b_1}{t}\right)^2$ shall be determined by linear interpolation.

Table 3.3.4.3-2
Values of φ as a function of m and $\frac{1}{K}\left(\frac{b_1}{t}\right)^2$

m \ $\frac{1}{K}\left(\frac{b_1}{t}\right)^2$	0.00	0.05	0.10	0.15	0.20	0.30	0.40	0.50	0.60	0.80	1.00
+12	1.00	0.99	0.98	0.96	0.95	0.93	0.90	0.88	0.85	0.80	0.75
+10	1.00	0.99	0.97	0.96	0.94	0.91	0.88	0.85	0.82	0.76	0.70
+8	1.00	0.98	0.96	0.95	0.93	0.89	0.85	0.82	0.78	0.71	0.64
+6	1.00	0.98	0.95	0.93	0.90	0.85	0.81	0.76	0.71	0.62	0.53
+4	1.00	0.96	0.93	0.89	0.86	0.79	0.72	0.65	0.59	0.47	0.37
+3.0	1.00	0.95	0.91	0.86	0.82	0.73	0.65	0.57	0.50	0.38	0.29
+2.0	1.00	0.93	0.87	0.81	0.75	0.64	0.54	0.46	0.38	0.29	0.22
+1.5	1.00	0.92	0.84	0.77	0.70	0.57	0.47	0.39	0.33	0.25	0.20
+1.0	1.00	0.89	0.79	0.70	0.63	0.50	0.41	0.34	0.29	0.22	0.17
+0.5	1.00	0.85	0.72	0.62	0.54	0.42	0.34	0.29	0.25	0.19	0.16
0	1.00	0.77	0.63	0.53	0.45	0.36	0.29	0.25	0.22	0.17	0.14
-0.5	1.00	0.65	0.51	0.43	0.38	0.30	0.25	0.22	0.19	0.16	0.13
-1.0	1.00	0.51	0.42	0.36	0.32	0.26	0.22	0.19	0.17	0.14	0.12
-1.5	0.67	0.41	0.34	0.30	0.27	0.23	0.20	0.17	0.16	0.13	0.11
-2.0	0.50	0.34	0.29	0.26	0.23	0.20	0.18	0.16	0.14	0.12	0.10
-3.0	0.33	0.25	0.22	0.20	0.19	0.16	0.14	0.13	0.12	0.10	0.09
-4	0.25	0.20	0.18	0.16	0.15	0.14	0.12	0.11	0.11	0.09	0.08
-6	0.17	0.14	0.13	0.12	0.11	0.10	0.10	0.09	0.08	0.07	0.07
-8	0.13	0.11	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.06	0.06
-10	0.10	0.09	0.08	0.08	0.08	0.07	0.07	0.06	0.06	0.05	0.05
-12	0.08	0.07	0.07	0.07	0.06	0.06	0.06	0.05	0.05	0.05	0.04

3.3.4.4 Reduction coefficient of the whippy portion of the plate, in the transverse framing system, loaded with the displacement pressure or cargo pressure shall be calculated using the following formulae:

$$\varphi = \frac{\alpha}{m}, where\ \alpha > -1 \qquad (3.3.4.4\text{-}1)$$

$$\varphi = -\frac{1}{m}, where\ \alpha = -1 \qquad (3.3.4.4\text{-}2)$$

where:

α, m – dimensionless coefficients defined in paragraph 3.3.4.3, fulfilling condition 3.3.4.4-3.

If for m and α fulfilling condition 3.3.4.4-3 $\varphi > 1$ is obtained, then $\varphi = 1$ shall be taken for reduction of the whippy portion. Similarly, where $\varphi < 0$ is obtained, then $\varphi = 0$ shall be taken.

The values of φ resulting from equation 3.3.4.4-3 which fulfil the limitations resulting from 3.3.4.4-2 and $0 \le \varphi \le 1$, are given in *Annex 1*, as a function of m, l/s, b_1/t and h_1/t, in the tabular form.

Values of φ for intermediate values of m, l/s, b_1/t and h_1/t may be determined by linear interpolation.

Coefficients m and α fulfil the following condition:

$$m = \alpha - 3\frac{1-v^2}{t^2K}\left[\left(\frac{h_1+b_1}{1+\frac{\alpha}{K_1}}\right)^2 - b_1^2\right] \qquad (3.3.4.4\text{-}3)$$

where:

v, t, K, b_1 – see paragraph 3.3.4.3;

K_1 – dimensionless coefficient taking the following values:

$$K_1 = 4, where\ \frac{l}{s} > 5 \qquad (3.3.4.4\text{-}4)$$

$$K_1 = 4 - 2.81\frac{s}{l} + 1.34\frac{s^2}{l^2}, where\ 5 \ge \frac{l}{s} > \frac{1}{\sqrt{2}} \qquad (3.3.4.4\text{-}5)$$

h_1 – plate deflection as a result of acting pressure p, [kPa], (determined in accordance with sub-chapter 3.2.3), obtained using the following formula:

$$h_1 = k\frac{ps^4}{Et^3}\frac{(1-v^2)}{0.91}\cdot 10^9\ \ [\text{mm}] \qquad (3.3.4.4\text{-}6)$$

where:

s, t, E, v – as defined in paragraph 3.3.4.3,

k – dimensionless coefficient, taken in accordance with Table 3.3.4.4, as a function of l/s. For intermediate values of l/s, the value of k shall be calculated by linear interpolation.

Table 3.3.4.4
Values of *k* as a function of *l/s*

l/s	1	1.1	1.2	1.3	1.4	1.5	1.6	1.8	2.0	4.0	>4.0
k	0.0138	0.0165	0.0191	0.0210	0.0227	0.0241	0.0251	0.0267	0.0276	0.0282	0.0284

3.3.4.5 Reduction coefficient of the whippy portion of the plate in the longitudinal framing system shall be calculated in accordance with 3.3.4.3-1 for the following values of σ_w and σ_s:
$\sigma_w = \sigma_s$, where $\sigma_s > -\sigma_E$ is obtained in an iterative step in accordance with 3.3.4;
$\sigma_w = -\sigma_E$, where $\sigma_s < -\sigma_E$ is obtained in the calculations as above;
σ_E – to be calculated in accordance with formula (3.3.4.3-3), taking $K = 4$.

3.3.5 Shear Stress in Hull

3.3.5.1 Maximum values of shear stress τ in the side shell plating, in the analysed frame section of the hull, shall be calculated using the following formula:

$$\tau = 100 \frac{(Q_s + Q_w) S_n}{I_n t} \text{ [MPa]} \qquad (3.3.5.1\text{-}1)$$

where:

Q_s – still water shear force, [kN], determined in accordance with paragraph 3.2.2;
Q_w – wave shear force, [kN], determined in accordance with paragraph 3.2.2.7;
S_n – first moment of area of the longitudinal structure members situated above or below the horizontal neutral axis, taken about this axis, [cm^3];
I_n – moment of inertia of the hull cross-section taken about the horizontal neutral axis, [cm^4];
t – combined thickness of both sides' plating in way of the neutral axis, [mm].

The values of Q_s and Q_w shall be determined in accordance with paragraph 3.2.2.9.

The values of S_n and I_n may be calculated for the hull cross-section without the reduction of whippy portions of the hull section. The values of S_n , I_n and t shall be determined for the design thicknesses of the hull structure members.

3.3.5.2 For the vessel with longitudinal bulkheads or double-side skin construction, the shear stress in plating shall be calculated in accordance with the theory of thin-walled beam bending. The values of Q_s and Q_w shall be determined in accordance with paragraph 3.3.5.1.

3.3.5.3 The allowable value of stress τ obtained in accordance with paragraph 3.3.5.1 or 3.3.5.2 is $0.35R_e$.

3.3.5.4 In the damage condition as defined in paragraph 3.2.2.4, the allowable value of stress τ obtained in accordance with paragraph 3.3.5.1 and 3.3.5.2 is 0.40 R_e.

3.3.6 Criteria for General Bending Normal Stress

3.3.6.1 Allowable values of normal stress σ due to general bending of hull calculated for the design thicknesses of hull structure members as required in paragraphs 3.3.2÷3.3.4, are as follows:

– 0.60 R_e – in the longitudinal members which are additionally subjected to local bending by transverse load;
– 0.70 R_e – in the longitudinal members which are not subjected to local bending by transverse load.

3.3.6.2 Hull structure of net scantlings (i.e. the design scantlings reduced by the corrosion additions determined as required in sub-chapter 2.3), as well as the hull structure of the actual scantlings (i.e. measured at the survey of a vessel in service) shall fulfil the following condition:

$$M_{gr} \geq cM \qquad (3.3.6.2)$$

where:

$M_{g\gamma}$ – bending moment causing the maximum value of stress $|\sigma| = R_e$ in the hull cross-section elements which are not subject to reduction (see paragraph 3.3.4.1). Calculations of value σ in the hull cross-section elements shall be performed taking into account the reduction of whippy portions in accordance with paragraphs 3.3.3 ÷ 3.3.4;
$M = M_s + M_w$ – design value of the hull bending moment, determined in accordance with paragraph 3.2.2.9, [kNm];
c – coefficient, to be taken as follows:

$c = 1.1$ if the rigid elements, where $|\sigma| = R_e$ are not subjected to transverse load due to displacement or cargo load;
$c = 1.25$ if the above mentioned elements are subjected to transverse load.

3.3.6.3 In the damage conditions as defined in paragraph 3.2.2.4, a criterion in the form (3.3.6.2) shall be fulfilled using the following values of c:
$c = 1.0$ if the rigid elements, where $|\sigma| = R_e$ are not subjected to transverse load due to displacement or cargo load;
$c = 1.15$ if the above mentioned elements are subjected to transverse load.

3.4 Local Strength

3.4.1 General Requirements

3.4.1.1 Checking of the hull structure local strength criteria as required in this chapter shall be performed for net scantlings of the structure members, i.e. after deduction of corrosion additions from the design values, as specified in sub-chapter 2.3.

3.4.1.2 Design loads for checking the local strength criteria are specified in sub-chapter 3.2.3.

3.4.2 Strength of Stiffeners

3.4.2.1 Stiffener span together with the effective width of plating shall be considered as a portion of a multi-span beam or a portion of a flat framework. The beam or frame is supported on girders, bulkheads, etc. which in general may be regarded as hinged immovable supports.

3.4.2.2 If in the structure there are stiffeners of similar heights situated transversely against each other, a calculation model analogous to the one defined in sub-chapter 3.4.3 for girders shall be applied.

3.4.2.3 The effective width of plating shall be taken as the lesser value out of b_1 and b_2:

$$b_1 = 0.44\, s \quad [\text{m}] \tag{3.4.2.3-1}$$

$$b_2 = 0.056 \sqrt{\frac{235}{R_e}}\, t \quad [\text{m}] \tag{3.4.2.3-2}$$

where:

s – spacing of stiffeners [m];
t – plating thickness [mm];
R_e – plating material yield point [MPa].

3.4.2.4 Stiffeners' span l shall be determined as shown in Fig. 3.4.2.4. The span of curvilinear stiffeners l is measured as the length of chord connecting the points of their ends' support.

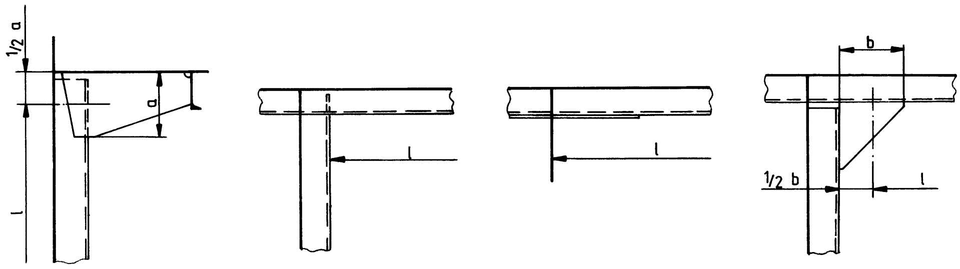


Fig. 3.4.2.4. Stiffener span determination pattern

3.4.2.5 Construction and scantlings of brackets connecting the stiffeners with girders or stiffeners between each other shall fulfil the requirements specified in Chapters 4, 5 and 7.

3.4.2.6 The maximum value of the bending moment in a stiffener span shall be calculated using the following formula:

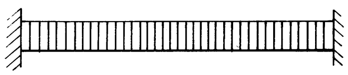
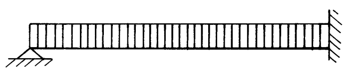
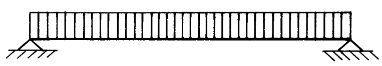
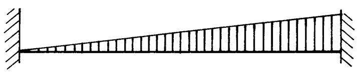
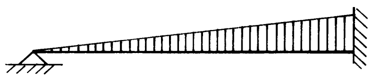
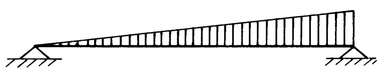
$$M = \frac{psl^2}{m} \quad [\text{kNm}] \qquad (3.4.2.6)$$

where:

p – design pressure at midspan of l, [kPa];
s – spacing of stiffeners, [m];
l – span determined as specified in paragraph 3.4.2.4, [m];
m – bending moment coefficient.

For longitudinal stiffeners of hull shell plating, decks and longitudinal bulkheads, m = 12 shall be taken. For other boundary conditions than fixing and loads variable along the stiffener, the data given in Table 3.4.2.6 may be used. In other cases direct calculations shall be performed using models defined in paragraph 3.4.2.2.

Table 3.4.2.6
Coefficients *m*

Load and boundary conditions	Bending moments' coefficients		
Location	1	2	3
1 support; 2 extreme between supports; 3 support	m_1	m_2	m_3
	12.0	24.0	12.0
	–	14.2	8.0
	–	8.0	–
	15	23.3	10
	–	16.8	7.5
	–	7.8	–

3.4.2.7 The maximum value of normal stresses in stiffeners shall fulfil the following condition:

$$\sigma = 1000\frac{M}{W} \leq \sigma_{\text{dop}} \ [\text{MPa}] \qquad (3.4.2.7)$$

where:

M – bending moment obtained in accordance with paragraph 3.4.2.6, [kNm];

W – section modulus of a stiffener together with the effective strake of plating, [cm^3];

$\sigma_{all} = 0.85\ R_e$ – allowable stress;

R_e – yield point [MPa].

For longitudinal stiffeners, the requirements specified in sub-chapter 3.5 shall also be fulfilled.

3.4.3 Strength of Girders

3.4.3.1 In general, strength of girders shall be checked by direct calculations using the models of flat frameworks, three-dimensional frameworks or grillages.

Finite element method calculations of the structure using membrane or shell elements are subject to PRS acceptance in each particular case.

Loads for structure model shall be taken as required in sub-chapter 3.2.3.

3.4.3.2 Where the boundary conditions at the girder ends are known, a single-span beam model may be used. The design length l of beam shall be determined as shown in Fig. 3.4.3.2.

The span l of curvilinear girders shall be measured as the length of chord connecting the points of their ends' support.

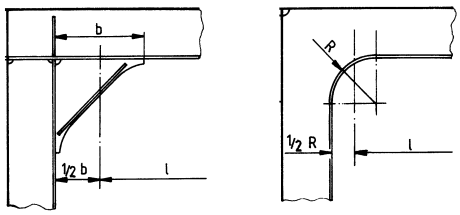


Fig. 3.4.3.2. Girder span determination pattern

3.4.3.3 The effective width of plating b_e for girders situated transversely to the plating stiffeners shall be calculated using the following formula:

$$b_e = 0.44s + (d - 0.44s)\frac{\sigma_E}{R_e}\ \text{[m]} \qquad (3.4.3.3)$$

where:

s – spacing of stiffeners [m];
σ_E – ideal critical stress calculated using formula 3.3.4.3 [MPa]; $\sigma_E \le R_e$ shall be taken in the formula;
d – the lesser value out of the spacing of girders and $\frac{1}{6}l$ (l – girder span) [m].

3.4.3.4 For girders situated in parallel with the stiffeners, sectional areas of the stiffeners on both sides of the girder in the distance not greater than d_1 may be included in the effective sectional area of plating. The distance d_1 shall be determined using the following formula:

$$d_1 = Min\left(\frac{1}{2}d, \frac{1}{12}l\right)\ \text{[m]} \qquad (3.4.3.4\text{-}1)$$

where:

Min – the lesser value;
d – spacing of girders [m];
l – girder span determined in accordance with paragraph 3.4.3.2 [m].

The effective width of plating shall be calculated using the following formula:

$$b_e = 0.44d_1 + 0.56d_1 \frac{\sigma_E}{R_e} \text{ [m]} \quad (3.4.3.4\text{-}2)$$

where:

d_1 – to be calculated using formula 3.4.3.4-1 [m];
σ_E – ideal critical stress in plates, to be calculated using formula 3.3.4.3-3 (for a plate compressed along the longer side K = 4 shall be taken), [MPa]; in formula 3.4.3.4-2 $\sigma_E \le R_e$ shall be taken.

3.4.3.5 Shear stress in girder webs shall be calculated for the effective sectional area of web in accordance with the following formula:

$$A_s = 0{,}01 h_s t_s \quad [\text{cm}^2] \quad (3.4.3.5)$$

where:

t_s – web thickness [mm];
h_s – web net thickness [mm].

Web net thickness h_s shall be determined deducting cuts and holes in the section under consideration. If the edge of a web hole is closer than $h/3$ from the section under consideration, then the lesser value, out of the following two: h_3 and ($h_1 + h_2$) shown in Fig. 3.4.3.5, shall be taken as h_s.

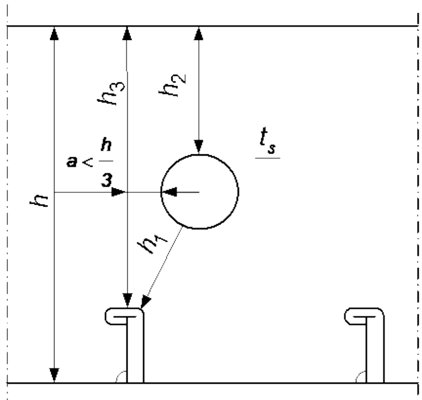


Fig. 3.4.3.5. Determining of web net height

3.4.3.6 Allowable stress values in girders due to local bending are as follows:

– $\tau_{all} = 0.45R_e$,
– $\sigma_{all} = 0.75R_e$,
– $\sigma_{eq,all} = \sqrt{\sigma^2 + 3\tau^2} = 0.95R_e$.

Longitudinal girders participating in general bending shall also fulfil the conditions specified in sub-chapter 3.5.3.

3.4.4 Strength of Plating of Bottom, Sides, Decks and Bulkheads

3.4.4.1 Required net thickness of plating with longitudinal stiffeners shall be calculated in accordance with the following formula:

$$t = 22.4s\sqrt{\frac{p}{R_e}} \quad [\text{mm}] \quad (3.4.4.1\text{-}1)$$

where:

s – spacing of stiffeners [m];
p – water or cargo pressure [kPa], determined in accordance with sub-chapter 3.2.3;

R_e – yield point [MPa].

If t, [mm], calculated using formula 3.4.4.1-1 fulfils the following condition:

$$t < 10s \qquad (3.4.4.1\text{-}2)$$

where: s – spacing of stiffeners, [m],

then the required plating net thickness may be determined by an analysis of normal stress values in plates, calculated in accordance with paragraph 3.4.4.2, which shall not be greater than the allowable values specified in paragraph 3.4.4.4.

The plating with transverse stiffeners shall fulfil the criterion for combined allowable stresses due to general bending and local bending, as required in sub-chapter 3.5.4.

The strength of bulkheads' plating shall be checked as required in paragraphs 3.4.4.5 to 3.4.4.7.

3.4.4.2 Stresses in the extreme fibres of plating with longitudinal stiffeners, subjected to constant pressure p determined in accordance with sub-chapter 3.2.3, [kPa], shall be calculated using the following formulae:

– in the middle of the plate (towards the shorter side):

$$\sigma = \sigma_w \mp \left[250p\left(\frac{s}{t}\right)^2 \chi_1 - \frac{3b_1\sigma_w}{(1+0{,}25\alpha)t}\right] \text{ [MPa]} \qquad (3.4.4.2\text{-}1)$$

– on the plate edges supported by longitudinal stiffeners (towards the shorter side):

$$\sigma = \sigma_w \pm \left[500p\left(\frac{s}{t}\right)^2 \chi_2 - \frac{3b_1\sigma_w}{(1+0{,}25\alpha)t}\right] \text{ [MPa]} \qquad (3.4.4.2\text{-}2)$$

The upper mark ("–", "+") directly following σ_w in formulae 3.4.4.2-1 and 3.4.4.2-2 applies to the value of σ on the plate surface loaded directly by pressure p, whereas the lower mark – on the opposite surface.

The symbols in formulae 3.4.4.2-1 and 3.4.4.2-2 have the meaning as follows:

σ_w – membrane stress in plate, calculated in accordance with paragraph 3.4.4.3 (positive, where tensile), [MPa];
t – plate thickness, [mm];
b_1 – initial (technological) plate deflections, determined in accordance with paragraph 3.3.4.3, [mm];

$\alpha = \frac{\sigma_w}{\sigma_E}$;

σ_E – ideal critical stress calculated using formula 3.3.4.3-3 [MPa];

$$\chi_1(u) = \frac{6}{u^2}\left(1 - \frac{u}{\sin h\,(u)}\right)$$

$$\chi_2(u) = \frac{3}{u^2}\left(\frac{u}{\text{tg}h\,(u)} - 1\right);$$

$$u = 500s\sqrt{\sigma_w \cdot t/D};$$

s – spacing of stiffeners [m];

$D = \frac{Et^3}{12(1-\nu^2)}$;

E – Young modulus, [MPa];

ν – Poisson ratio.

The values of $\chi_1(u)$ and $\chi_2(u)$ are specified in Annex 2, in the tabular form. For intermediate values of u, values of these functions may be determined by linear interpolation.

Calculations of σ using formulae 3.4.4.2-1 and 3.4.4.2-2 shall be performed for the values of b_1 determined in accordance with paragraph 3.3.4.3 and for $b_1 = 0$, and the obtained value of greater magnitude shall be taken as a result in each plate section (the edges supported by stiffeners and the middle of the plate on both surfaces of plate).

3.4.4.3 Stress σ_w shall be calculated using the following formula:

$$\sigma_w = \alpha \sigma_E \quad \text{[MPa]} \qquad (3.4.4.3\text{-}1)$$

where:

σ_E – ideal critical stress calculated using formula 3.3.4.3-3, [MPa];
α – parameter which fulfils the following condition:

$$\alpha = K_\emptyset \frac{3(1-v^2)}{t^2 K_2}\left[\left(\frac{h_1+b_1}{1+\frac{\alpha}{K_1}}\right)^2 - b_1^2\right] \qquad (3.4.4.3\text{-}2)$$

v, t, b_1 – see paragraph 3.4.4.2;

h_1 – plate deflection caused by pressure p, calculated in accordance with paragraph 3.3.4.4 [mm];

$$K_\emptyset = \frac{A + 4.4st}{A + 10lt}$$

A – half value of the sum of sectional areas of the girders supporting shorter sides of the plate (with the plating neglected), [cm^2];

l, s – dimensions of the plate sides (see Fig. 3.3.4.1), [m].

$$K_1 = 4, \text{where } \frac{l}{s} > 5$$

$$K_1 = 4 - 2.81\frac{s}{l} + 1.34\left(\frac{s}{l}\right)^2, \text{where } 5 \geq \frac{l}{s} \geq \frac{1}{\sqrt{2}}$$

$$K_2 = 1, \text{where } \frac{l}{s} > 5$$

$$K_2 = \left(1 + \frac{s^2}{l^2}\right)^2, \text{where } 5 \geq \frac{l}{s} \geq \frac{1}{\sqrt{2}}$$

The values of α resulting from equation 3.4.4.3-2 are specified in Annex 3, as a function of $K_\emptyset$, $\frac{b_1}{t}$ and $\frac{h_1}{t}$. For intermediate argument values, the values of α may be determined by linear interpolation.

3.4.4.4 The magnitude of stress σ calculated in accordance with paragraph 3.4.4.2 shall not be greater than:
$1.0R_e$ – on the edges of a plate supported by a stiffener,
$0.85R_e$ – in the middle of the plate.

3.4.4.5 Where a side or longitudinal bulkhead is stiffened longitudinally, the value of p in the middle of the plate shall be taken for the calculations required in paragraph 3.4.4.1.

3.4.4.6 Plating of transverse bulkheads stiffened horizontally shall be calculated as required in paragraph 3.4.4.1.

3.4.4.7 Plating of transverse bulkheads stiffened vertically shall be checked in accordance with paragraph 3.4.4.1, by separate calculations for the value of p at the level of both ends of the longer side of plate or in the location of the plating thickness change.

The end of the longer side of plate is located at the level of the bottom, deck, horizontal girder of bulkhead, etc.

3.5 Combined Normal Stress in Longitudinal Hull Members

3.5.1 General Requirements

In sub-chapters 3.5.2 to 3.5.4, criteria are specified for the combined normal stress caused by hull general bending in the vertical plane and by local bending of stiffeners and girders situated longitudinally (this also applies to the deck, in way of cargo hatches, bent in its plane due to the load acting on the side and bottom) as well as plating in the transversely framed system.

Adding up the stresses shall be done directly for the components corresponding to the extreme values of the hull bending moment, determined in accordance with paragraph 3.2.2.9 and local load acting on the hull, determined in accordance with sub-chapter 3.2.3.

The stresses shall be calculated for the net scantlings, i.e. after deduction of corrosion additions from the design scantlings determined in accordance with sub-chapter 2.3.

3.5.2 Stiffeners

3.5.2.1 Stress values σ_s calculated for the plating as required in sub-chapters 3.3.1÷3.3.4 as well as the values of stress caused by local bending σ calculated as required in sub-chapter 3.4.2 shall be added up.

If a stiffener is situated within the effective longitudinal girder strake, then the component of stress resulting from the girder bending shall also be taken into account.

3.5.2.2 The allowable value of combined stresses determined at the ends and in the midspan is:

$$\sigma_{\text{all}} = 0.95R_e$$

3.5.3 Girders

3.5.3.1 Stress values σ_s calculated for the plating as required in sub-chapters 3.3.1÷3.3.4 as well as the values of stress caused by local bending σ calculated as required in sub-chapter 3.4.3 shall be added up.

3.5.3.2 The allowable value of combined stresses determined at the ends and in the midspan is:

$$\sigma_{\text{all}} = 0.90R_e$$

Reduced stress $\sqrt{\sigma^2 + 3\tau^2}$ calculated for the values of combined stresses σ and stresses τ calculated as required in sub-chapter 3.4.3 shall not exceed $1.0 \cdot R_e$.

3.5.4 Plating

3.5.4.1 Combined stresses σ shall be calculated in accordance with formulae 3.4.4.2-1 and 3.4.4.2-2, using the value of σ_w determined as specified in paragraphs 3.3.4.2÷3.3.4.4.

3.5.4.2 The allowable value of stresses σ calculated as required in paragraphs 3.4.4.2 and 3.5.4.1 is:

– at the plate edges supported by a stiffener: $1.0\ R_e$,
– in the middle of the plate: $0.85R_e$.

3.6 Buckling Control of Structure Elements

3.6.1 Structure Elements Subject to Buckling Control

The following structure elements shall fulfil the stability criteria, specified in this Chapter, for the critical stress determined in accordance with paragraph 3.6.2.7 or sub-chapter 3.6.8:

- longitudinal stiffeners of: deck, continuous fore-to-aft coamings, bottom and longitudinal bulkheads – in the scope of flexural buckling (in accordance with paragraph 3.6.2.2) and torsional buckling (in accordance with paragraph 3.6.2.3), local buckling of web (in accordance with paragraph 3.6.2.4) and flange (in accordance with paragraph 3.6.2.5) as well as the critical value of the cross-sectional moment of inertia (in accordance with paragraph 3.6.2.6);
- deck pillars and other elements subjected to compressive axial forces (in accordance with sub-chapter 3.6.4)
- girders – in the scope of local buckling of web and flange (in accordance with paragraph 3.6.3.2) as well as the critical value of the cross-section moment of inertia (in accordance with paragraph 3.6.3.3);
- side shell plating and longitudinal bulkheads' plating (in accordance with sub-chapters 3.6.5 to 3.6.9).

3.6.2 Buckling Strength of Stiffeners

3.6.2.1 The values of the ideal critical stress calculated in accordance with paragraph 3.6.2.2, 3.6.2.3 or 3.6.2.4, shall be transformed to the critical values – in accordance with paragraph 3.6.2.7.

The critical stress values shall be greater than the design compressive stress, due to the hull general bending and girders' bending, by at least 10% (see paragraph 3.5.2.1).

The requirements specified in paragraph 3.6.2.5, regarding the buckling strength of stiffeners' flanges, and in paragraph 3.6.2.6, ensuring the maximum possible values of the critical stress in the plating, shall also be fulfilled.

3.6.2.2 Ideal critical stress σ_E at the flexural buckling of compressed stiffeners may be calculated using the following formula:

$$\sigma_E = 0.001E \frac{I_\alpha}{Al^2} \text{ [MPa]} \quad (3.6.2.2)$$

where:

E – Young modulus [MPa];
l – span of stiffener [m];
I_α – cross-sectional moment of inertia of the stiffener, without the corrosion addition, relative to the axis perpendicular to the expected buckling direction, i.e. perpendicularly to the plating, [cm^4];
A – stiffener cross-sectional area [cm^2].

In the calculations of the values of I_α and A, the effective sectional area of plating with 44% of stiffeners spacing in width and of the net thickness may be taken into account.

The value of σ_E obtained using formula 3.6.2.2 concerns the case of axial compression and free support of both stiffener ends.

Where a stiffener is fixed at one end, the calculated value of σ_E may be doubled, whereas for a stiffener fixed at both ends the calculated value of σ_E may be quadrupled.

It may be considered that the conditions of fixing of the ends of a supporting element (stiffener) occur if ends of a supporting element are joined with the girders of considerable bending rigidity in two perpendicular directions.

3.6.2.3 Ideal critical stress causing torsional buckling of stiffeners shall be calculated using the following formula:

$$\sigma_E = \frac{\pi^2 E I_w}{10^4 I_0 l^2}\left(m^2 + \frac{K}{m^2}\right) + 0.385E\frac{I_t}{I_0} \quad \text{[MPa]} \qquad (3.6.2.3\text{-}1)$$

where:

E – Young modulus, [MPa] (for steel E = 206 000 MPa);

$$K = \frac{cl^4}{\pi^4 E I_w}10^6 \qquad (3.6.2.3\text{-}2)$$

m – number of half-waves of stability loss which may be determined using the following formula:

$$(m-1)^2 m^2 < K \le m^2(m+1)^2 \qquad (3.6.2.3\text{-}3)$$

where:

$m = 1$ for $0 < K \le 4$,
$m = 2$ for $4 < K \le 36$,
$m = 3$ for $36 < K \le 144$,
$m = 4$ for $144 < K \le 400$;

I_w – sectorial moment of inertia of the stiffener cross-section related to the point of connection of stiffener to plating, [cm^6]:

– for flat bars

$$I_w = \frac{h_s^3 t_s^3}{36}10^{-6} \qquad (3.6.2.3\text{-}4)$$

– for T-sections

$$I_w = \frac{t_m b_m^3 h_s^2}{12}10^{-6} \qquad (3.6.2.3\text{-}5)$$

– for angles and bulb flats

$$I_w = \frac{b_m^3 \cdot h_s^2}{12(b_m + h_s)^2}[t_m(b_m^2 + 2b_m h_s + 4h_s^2) + 3t_s b_m h_s]10^{-6} \qquad (3.6.2.3\text{-}6)$$

h_s – web height [mm];
t_s – web net thickness [mm];
b_m – flange width [mm];
t_m – flange net thickness [mm]; for bulb flats, the mean thickness of bulb shall be taken;

l – span of stiffener, [m];

I_0 – polar moment of inertia of stiffener cross-section related to the point of connection of stiffener to plating, [cm^4]:

– for flat bars

$$I_0 = \frac{h_s^3 t_s}{3}10^{-4} \qquad (3.6.2.3\text{-}7)$$

– for flanged stiffeners

$$I_0 = [\frac{h_s^3 t_s}{3} + h_s^2 b_m t_m]10^{-4} \qquad (3.6.2.3\text{-}8)$$

I_t – Saint Venant's moment of inertia of stiffener cross-section (without effective width of plating), [cm^4]:

– for flat bars

$$I_t = \frac{h_s t_s^3}{3} 10^{-4} \qquad (3.6.2.3\text{-}9)$$

– for flanged stiffeners

$$I_t = \frac{1}{3}[h_s t_s^3 + b_m t_m^3 \left(1 - 0.63 \frac{t_m}{b_m}\right)]10^{-4} \qquad (3.6.2.3\text{-}10)$$

c – elasticity coefficient of the stiffener and attached strake of plating:

$$c = \frac{k_p E t_p^3}{3s(1 + \frac{1{,}33 k_p h_s t_p^3}{1000 s t_s^3})} 10^{-3} \qquad (3.6.2.3\text{-}11)$$

k_p = 1 – r, however not less than k_p = 0, (3.6.2.3-12)

$$r = \frac{\sigma_r}{\sigma_{Ep}} \qquad (3.6.2.3\text{-}13)$$

σ_r – design compressive stress, [MPa]; for deck longitudinals, bottom and side frames, as well as stiffeners of longitudinal bulkheads this is general bending stress calculated in accordance with sub-chapter 3.3;

σ_{Ep} – ideal critical stress in the supporting strake of plating, [MPa], determined as σ_E in accordance with paragraph 3.6.7.1;

t_p – plating net thickness [mm].

For flanged stiffeners, the value of k_p need not be taken less than 0.1.

3.6.2.4 For checking the local buckling strength of a web, the value of σ_E may be determined using the following formula:

$$\sigma_E = 3.8E \left(\frac{t_s}{h_s}\right)^2 \text{ [MPa]} \qquad (3.6.2.4)$$

where:

h_s – web height, [mm];
t_s – web net thickness, [mm].

3.6.2.5 Buckling strength of the flange of a longitudinal stiffener made of an angle or T-section may be considered sufficient provided the following condition is fulfilled:

$$t_m \geq \frac{1}{15} b_m \qquad (3.6.2.5)$$

where:

b_m – flange width for an angle or flange half-width for a T-section, [mm];
t_m – flange thickness, [mm].

3.6.2.6 For stiffeners supporting plating panels subjected to compression in the direction perpendicular to the stiffeners (e.g. transverse deck beams, vertical side frames and stiffeners of longitudinal bulkheads), the moment of inertia of the stiffener cross-section, including the effective width of plating, shall not be less than the value calculated using the following formula:

$$I = \frac{0.09 \sigma_r \sigma_E l^4 s}{t} \text{ [cm}^4\text{]} \qquad (3.6.2.6\text{-}1)$$

where:

t – plating net thickness, [mm];
σ_r – compressive stress, [MPa], acting on the plate panels in the direction perpendicular to the stiffener;

σ_E =1.18 σ_r [MPa] – where $\sigma_E \leq 0.5 R_e$ (3.6.2.6-2)

$\sigma_E = \frac{R_e^2}{4(R_e - 1{,}18\sigma_r)}$ [MPa] – in other cases; (3.6.2.6-3)

l – span of stiffener [m];
s – spacing of stiffeners [m].

3.6.2.7 Critical stress in stiffeners under the conditions of flexural or torsional buckling or local buckling of web shall be determined using the following formula:

$$\sigma_c = \sigma_E \text{ [MPa], if } \sigma_E \le \frac{R_e}{2} \quad (3.6.2.7\text{-}1)$$

$$\sigma_c = R_e\left(1 - \frac{R_e}{4\sigma_E}\right) \text{ [MPa], if } \sigma_E > \frac{R_e}{2} \quad (3.6.2.7\text{-}2)$$

where:

σ_E – ideal critical stress, [MPa], determined in accordance with paragraph 3.6.2.2, 3.6.2.3 or 3.6.2.4;
R_e – yield point [MPa].

3.6.3 Buckling Strength of Girders

3.6.3.1 Buckling strength of girders subjected to axial loads (pillars and cross-ties) shall be checked as required in sub-chapter 3.6.4.

3.6.3.2 Checking of buckling strength of the girders subjected to axial loads due to the hull general bending need not, in general, be performed.

The face plates of girders, however, shall fulfil the requirements specified in paragraph 3.6.2.5 (as flanges of stiffeners).

The girder webs shall fulfil the requirements specified in sub-chapters 3.6.5÷3.6.9 concerning the buckling strength of plates.

3.6.3.3 For girders supporting longitudinal stiffeners (deck beams, frames, longitudinal bulkhead stiffeners) or girders supporting other stiffeners subjected to axial compression stress, the moment of inertia of girder cross-section (including the effective width determined in accordance with paragraph 3.4.3.3 or 3.4.3.4) shall not be less than:

$$I = 0.3\frac{l_w^4 I_u}{b^3 s} \text{ [cm}^4\text{]} \quad (3.6.3.3\text{-}1)$$

where:

l_w – span of girder [m];
b – spacing of girders [m];
s – spacing of stiffeners [m];

$I_u = \frac{\sigma_E A l^2}{0.001E}$ [cm^4] – moment of inertia of the compressed stiffener cross-section, resulting from the requirements specified in paragraph 3.6.2.2;

$\sigma_E = 1.18\,\sigma_r$ [MPa] – where $\sigma_E \le 0.5R_e$ (3.6.3.3-2)

$\sigma_E = \frac{R_e^2}{4(R_e - 1.18\sigma_r)}$ [MPa] – in other cases; (3.6.3.3-3)

σ_r – compressive stress in the stiffener [MPa];
A – cross section area of stiffener, determined in accordance with paragraph 3.6.2.2 [cm^2];
l – span of stiffener [m].

3.6.4 Buckling Strength of Pillars, Struts and Supporting Stiffeners

3.6.4.1 Critical buckling stress σ_c of pillars, cross-ties and panting beams, determined in accordance with paragraphs 3.6.2.2 and 3.6.2.7, shall not be less than:

$$\sigma_c = \frac{10P}{Ak_1} \text{ [MPa]} \qquad (3.6.4.1\text{-}1)$$

where:

P – axial load, determined by zone strength analysis of the structure, as required in paragraph 3.4.3.1 [kN];

$$k_1 = \frac{0.7}{1+\frac{l}{i}} \qquad (3.6.4.1\text{-}2)$$

l – span of a pillar , cross-tie or panting beam, [m],

$i = \sqrt{\frac{I_\alpha}{A}}$ – radius of gyration of cross-section of the supporting member, [cm];

I_α, A – see 3.6.2.2 – as for stiffeners.

3.6.5 Scope of Buckling Control for Plates

Buckling strength criteria for plates specified in sub-chapter 3.6.9 which regard the critical stress values determined in accordance with sub-chapters 3.6.7 and 3.6.8 apply to the plating of side shell, longitudinal bulkheads, transverse bulkheads and to girder webs.

For deck and bottom plating, elastic buckling of plates may be accepted.

3.6.6 Buckling Control Method for Plates

3.6.6.1 The buckling strength criteria for plates subjected to combined in-plane load shall be fulfilled as required in paragraphs 3.6.7.3, 3.6.7.4, 3.6.8.3 and 3.6.9.3. In most cases, it may be assumed that $\sigma_y = 0$ (see Fig. 3.6.7.3).

Within the zones of the extreme values of hull bending moment (general bending) or in the girder (zone strength), it is sufficient to fulfil the criterion for uni-axial compression – see paragraphs 3.6.8.1 and 3.6.9.1.

Within the zones of the extreme values of shear forces, it is sufficient to fulfil the criterion for pure shearing – see paragraphs 3.6.8.2 and 3.6.9.2.

3.6.6.2 To assess the buckling strength of plates, the values of ideal critical stress shall be calculated first, in accordance with sub-chapter 3.6.7, and then value of critical stress shall be calculated in accordance with sub-chapter 3.6.9.

3.6.6.3 Where a circular or oval opening has been cut out in the centre of plate, the value of ideal critical stress shall be calculated in accordance with the *Rules for Classification and Construction of Sea-going Ships, Part II – Hull*, Chapter 13.

Then, the critical stress shall be determined in accordance with sub-chapter 3.6.8 and the buckling strength criterion shall be checked in accordance with sub-chapter 3.6.9.

3.6.7 Ideal Elastic Buckling Stress of Plates

3.6.7.1 Ideal critical stress σ_E at uni-axial compression of the plate fields within the adjacent supporting contour shall be determined using the following formula:

$$\sigma_E = 0.9mE\left[\frac{t_n}{1000s}\right]^2 \text{ [MPa]} \qquad (3.6.7.1\text{-}1)$$

For plate fields stiffened longitudinally (parallel to the compressive stress):

$$m = \frac{8.4}{k_2 + 1.1} \tag{3.6.7.1-2}$$

For plate fields stiffened transversely (perpendicularly to compressive stress):

$$m = c\left[1 + \left(\frac{s}{l}\right)^2\right]^2 \frac{2.1}{k_2 + 1.1} \tag{3.6.7.1-3}$$

where:

E – Young modulus, [MPa];
t_n – plating net thickness, [mm];
s – length of the plate field shorter side, [m];
l – length of the plate field longer side, [m];
c = 1.30 – where plating is stiffened with bottom floors or deep girders,
c = 1.21 – where stiffeners are angles or T-sections,
c = 1.10 – where stiffeners are bulb flats,
c = 1.05 – where stiffeners are flat bars;
k_2 – ratio of the smallest to the largest compressive stress σ (see Fig. 3.6.7.1).

The assumed value of k_2 shall meet the condition that $0 \le k_2 \le 1$.

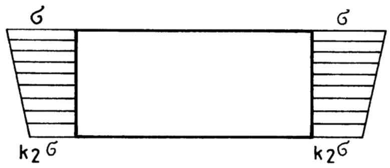


Fig. 3.6.7.1. Definition of coefficient k_2

3.6.7.2 Ideal critical shear stress τ_E of plate fields within the adjacent supporting contour shall be determined using the following formula:

$$\tau_E = 0.9 k_t E \left[\frac{t_n}{1000s}\right]^2 \text{ [MPa]} \tag{3.6.7.2}$$

where:

$k_t = 5.34 + 4\left[\frac{s}{l}\right]^2$
E, t_n, s, l – see 3.6.7.1.

3.6.7.3 For plate field subjected to combined in-plane load, as in Fig. 3.6.7.3, the values of ideal critical stress shall be determined using the following formula:

$$\frac{\sigma'_{xE}}{\sigma_{xE}} + \frac{\sigma'_{yE}}{\sigma_{yE}} + \left(\frac{\tau'_E}{\tau_E}\right)^2 = 1 \tag{3.6.7.3}$$

where:

σ'_{xE} – ideal critical stress value at compression along axis x for combined in-plane load, as shown in Fig. 3.6.7.3, [MPa];
σ_{xE} – ideal critical stress value at uni-axial compression along axis x (Fig. 3.6.7.1), calculated as σ_E in accordance with paragraph 3.6.7.1;
σ'_{yE}, σ_{yE} – as σ'_{xE} and σ_{xE}, however at compression along axis y;
τ'_E – ideal critical shear stress value for combined in-plane load, as shown in Fig. 3.6.7.3, [MPa];
τ_E – ideal critical shear stress value for pure shearing calculated in accordance with paragraph 3.6.7.2.

While calculating the values of σ'_{xE}, σ'_{yE} and τ'_E in accordance with formula 3.6.7.3, they shall be assumed to be directly proportional to the values of stresses σ_x, σ_y, τ determined in accordance with sub-chapters 3.3 and 3.4.3. Compressive stresses shall be taken as positive. If σ_x or σ_y are tensile, then σ'_{xE}/σ_{xE} or σ'_{yE}/σ_{yE} shall be taken equal to 0 in formula 3.6.7.3.

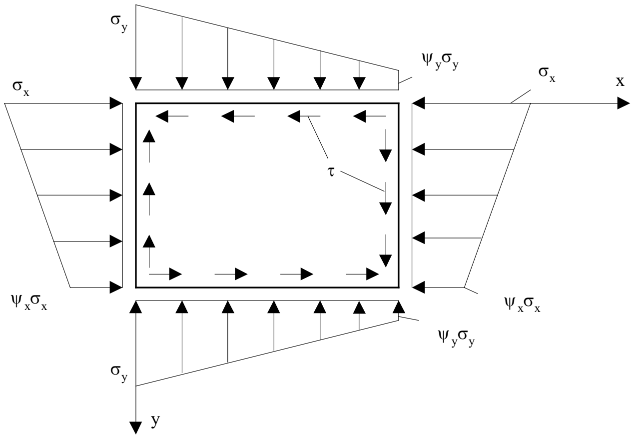


Fig. 3.6.7.3. Plate subjected to combined in-plane load

3.6.7.4 The design value of equivalent ideal critical stress for combined in-plane load shall be determined using the formula below:

$$\sigma_{zE} = \sqrt{(\sigma'_{xE})^2 + (\sigma'_{yE})^2 - \sigma'_{xE}\sigma'_{yE} + 3(\tau'_E)^2} \quad \text{[MPa]} \qquad (3.6.7.4)$$

where:

σ'_{xE}, σ'_{yE}, τ'_E – ideal critical stress values calculated in accordance with paragraph 3.6.7.3; shall be taken as non-negative numbers.

3.6.8 Critical Stress of Plates

3.6.8.1 Critical stress at uni-axial compression of plates shall be determined using the following formula:

$$\sigma_c = \sigma_E \quad \text{[MPa]}, \quad \text{if} \quad \sigma_E \le \frac{R_e}{2} \qquad (3.6.8.1\text{-}1)$$

$$\sigma_c = R_e\left(1 - \frac{R_e}{4\sigma_E}\right) \quad \text{[MPa]}, \quad \text{if} \quad \sigma_E > \frac{R_e}{2} \qquad (3.6.8.1\text{-}2)$$

where:

σ_E – ideal critical stress at compression, [MPa], determined in accordance with paragraph 3.6.7.1

3.6.8.2 Critical stress τ_c at plate pure shearing shall be determined using the following formula:

$$\tau_c = \tau_E \quad \text{[MPa]} \quad \text{if} \quad \tau_E \le 0.5\tau_{pl} \qquad (3.6.8.2\text{-}1)$$

$$\tau_c = \tau_{pl}\left(1 - \frac{\tau_{pl}}{4\tau_E}\right) \quad \text{[MPa]} \quad \text{if} \quad \tau_E > 0.5\tau_{pl} \qquad (3.6.8.2\text{-}2)$$

$$\tau_{pl} = \frac{R_e}{\sqrt{3}} \quad \text{[MPa]} \qquad (3.6.8.2\text{-}3)$$

where:

τ_E – ideal critical stress value at shearing, [MPa], determined in accordance with paragraph 3.6.7.2.

3.6.8.3 The design value of critical equivalent stress for combined in-plane load shall be determined using the following formula:

$$\sigma_{zc} = \sigma_{zE}, \quad \text{if} \quad \sigma_{zE} \le \frac{R_e}{2} \qquad (3.6.8.3\text{-}1)$$

$$\sigma_{zc} = R_e\left(1 - \frac{R_e}{4\sigma_{zE}}\right), \quad \text{if } \sigma_{zE} > \frac{R_e}{2} \qquad (3.6.8.3\text{-}2)$$

where:

σ_{zE} – critical equivalent stress for combined in-plane load, [MPa], determined in accordance with 3.6.7.4.

3.6.9 Criterion for Buckling Strength of Plates

3.6.9.1 For plates subject to the check for buckling strength at uni-axial compression, the following condition shall be fulfilled:

$$\sigma_c \ge \sigma_r \qquad (3.6.9.1)$$

where:

σ_c – critical stress calculated in accordance with paragraph 3.6.8.1 [MPa];
σ_r – compressive stress determined for the design loads [MPa].

3.6.9.2 For plate panels subject to the check for buckling strength at pure shearing, the following condition shall be fulfilled:

$$\tau_c \ge \tau_r \qquad (3.6.9.2)$$

where:

τ_c – critical shear stress of plate panel determined in accordance with paragraph 3.6.8.2 [MPa];
τ_r – design compressive shear stress of plate panel, [MPa], determined for the design loads.

3.6.9.3 For plate panels subjected to combined in-plain load (uni-axial or bi-axial compressive stresses combined with shear stresses), the following condition shall be fulfilled:

$$\sigma_{zc} \ge \sigma_{eq} \qquad (3.6.9.3\text{-}1)$$

where:

σ_{zc} – critical equivalent buckling stress determined in accordance with paragraph 3.6.8.3 [MPa],
σ_{eq} – design equivalent buckling stress determined using the following formula:

$$\sigma_{eq} = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x\sigma_y + 3\tau^2} \quad \text{[MPa]} \qquad (3.6.9.3\text{-}2)$$

σ_x, σ_y, τ – stresses in panel [MPa], as shown in Fig. 3.6.7.3, determined for the design loads.

Compressive stresses σ_x or σ_y shall be taken as positive.

If σ_x or σ_y is tensile stress, then 0 values are to be taken in formula 3.6.9.3-2.

4 GENERAL PARTICULARS OF STRUCTURE

4.1 Rounding of Scantlings

4.1.1 Section modulus and moments of inertia shall be rounded up. Rounding down is acceptable where it is not more than 3% of the required value of a modulus or moment.

4.1.2 When rounding plate thickness, millimetre fractions lesser than 0.25 may be neglected, whereas the fractions equal 0.25 and above shall be rounded up. Plates thinner than 3 mm shall not be applied, unless other provisions of the *Rules* state otherwise.

4.2 General Provisions

4.2.1 All parts of the hull shall be accessible for inspection and maintenance. The requirements concerning the access to confined spaces are specified in *Part I – Classification Regulations*; in doubtful cases the procedure and type of inspection is subject to PRS acceptance in each particular case.

4.2.2 Stiffeners and girders of hull shall be so arranged that frames are created in the frame planes and in the longitudinal planes. This means that, e.g. the longitudinal stiffeners of the bottom and deck shall be situated in a common plane. A similar principle applies to girders situated in the frame planes.

4.2.3 Smooth change of thickness of the structure members shall be provided. In general, thicknesses of the adjacent plate panels situated in one plane shall not differ by more than 30% of the thicker panel thickness – except for local strengthening of the plating, e.g. such as in way of hawse-holes.

4.2.4 The change of web height of stiffeners or girders shall be achieved throughout the length not less than five times as much as the height difference of the joined webs. Scantlings of the above mentioned girders' flanges shall change smoothly.

4.2.5 Changes in the hull structure fore-and-aft shall be as smooth as possible. In one frame section, no more than 1/3 of all stiffeners or longitudinal girders shall end.

The places where consecutive portions of longitudinal girders are cut shall not be at the shorter distance than 2 frame spacings.

The change from the longitudinally to transversely framed system of hull shall be gradual.

4.2.6 Longitudinal stiffeners of hull shall not be cut in the places of local stress concentration, e.g. near the shell openings.

4.2.7 In way of ends of decks or inner bottom or longitudinal bulkheads, the stress concentration shall be reduced by the use of smoothly shaped brackets coplanar with the planes of those structures' plating. Examples of recommended designs are shown in Fig. 4.2.7.

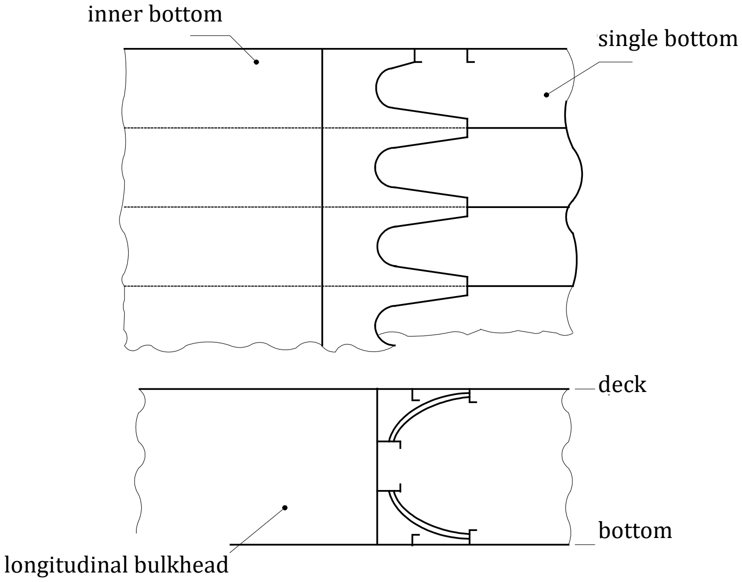


Fig. 4.2.7. Recommended design patterns for reduction of stress concentration

4.3 Construction of Stiffeners and Girders

4.3.1 Ends of stiffeners of the plating of the hull, decks and bulkheads, except those specified in sub-chapter 4.3.2, shall be connected, with brackets, to the girders or plating panels situated transversely to the stiffeners.

4.3.2 Where fulfilment of the requirements specified in paragraph 4.3.1 is impossible or impracticable, the ends of stiffeners shall be bevelled. Such a solution is acceptable for the following elements:

– stiffeners of girder webs;
– stiffeners of bulkhead plating if the plating is strong enough to equilibrate, in the form of shear stress perpendicular to the plating, the shear forces imposed on the bulkhead. Such a solution, however, is not permitted for collision bulkheads, afterpeak bulkheads as well as the bulkheads forming the machinery space boundaries.

4.3.3 Stiffeners and girders whose webs are coplanar shall be joined with a bracket. That bracket shall be coplanar with the webs of the joined beams. Only in connections between stiffeners as well as stiffeners and girders overlap brackets are permitted.

Webs and flanges of girders shall be joined by welding.

4.3.4 Connections of stiffener ends to girders or brackets shall be made as shown in Fig. 4.3.4.

Where section thickness t_1 of web is greater than plate thickness t, then the weld length l shall be increased in proportion to ratio t_1/t. The required weld thickness shall be determined in accordance with formula 2.2.3.3 applying weld height coefficient k = 0.6.

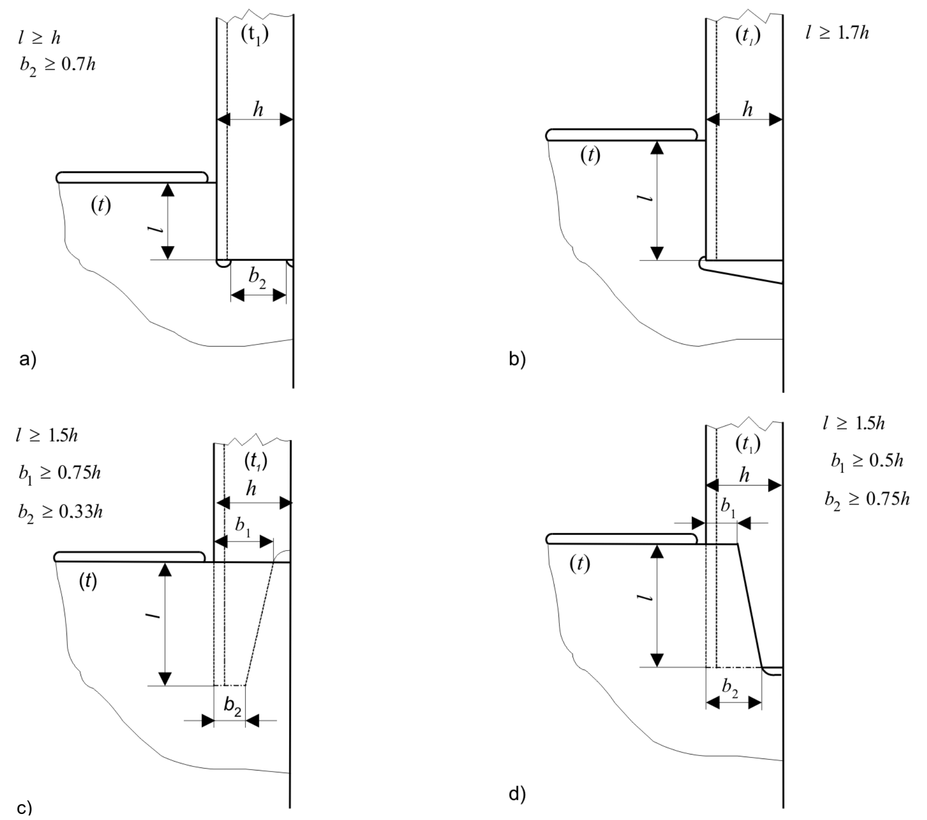


Fig. 4.3.4. Required design patterns for connection of stiffener ends to girders or brackets

4.3.5 The length of sides of a bracket connecting stiffeners, measured at the stiffener flanges, shall not be less than double height of the lower stiffener web, unless required otherwise in Chapters 5 and 7. For connections of girders, the above defined bracket side length shall not be less than the web height of the lower girder connected.

4.3.6 Where the ratio of the free edge length to its thickness is greater than 50, a bracket shall be flanged or face plate shall be fitted.

The ratio of the flange width (or face plate width on one side of the bracket plane) to the flange thickness (or face plate thickness) shall range from 8 to 12.

4.3.7 A girder crossing a bulkhead shall be connected to the bulkhead structure member with brackets situated on both sides of the bulkhead.

4.3.8 Stiffeners may be cut in the places where they cross girders, divisions or bulkheads. In those cases brackets shall be applied on both sides of the transverse wall (girder web or plating of a division or bulkhead). The brackets shall be coplanar with the webs of stiffeners.

The brackets shall be connected to the stiffener of the transverse wall.

Recommended design patterns are shown in Fig. 4.3.8.

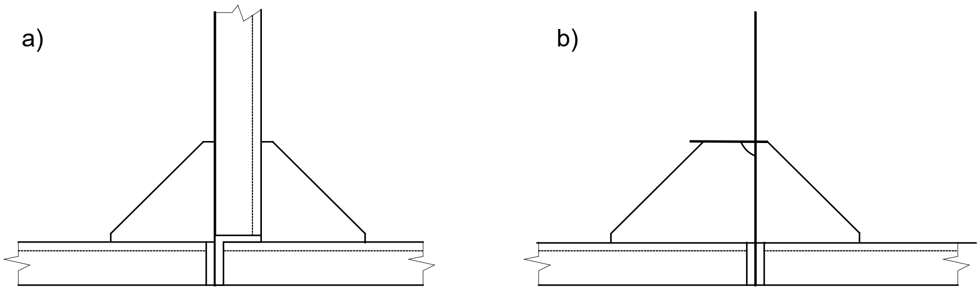


Fig. 4.3.8.
Recommended design patterns for connections of stiffeners to girders, divisions or bulkheads

4.3.9 Stiffeners crossing transverse walls (girder web or plating of a division or bulkhead) shall be welded to the edges of the wall openings.

4.3.10 Bent flanges and bracket face plates shall not be welded to the plating of the sides, bottom, decks as well as to the face plates of longitudinals, deck beams and web frames.

4.3.11 Bracket corners shall be cut as shown in Fig. 4.3.11. In corners of an obtuse angle, circular cuts shall be made with the radius greater than 20 mm (Fig. 4.3.11).

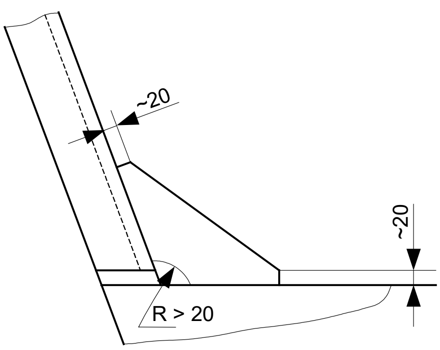


Fig. 4.3.11. Bracket design pattern

4.3.12 In the areas where the planes of the three mutually perpendicular plates intersect (e.g. the area of connection of transverse bulkhead, longitudinal bulkhead and platform), brackets shall be applied to reduce stress concentration. The brackets shall be situated coplanar with that plate whose outer edge is in the above mentioned area.

4.3.13 Webs of the girders with the ratio of height to thickness greater than 80 shall be stiffened vertically or horizontally to fulfil the buckling strength criteria specified in sub-chapter 3.6.3.

4.3.14 Stiffeners of girders mentioned in paragraph 4.3.13 may be made of flat bars. The flat bar's ratio of height to thickness shall not exceed 10.

Stiffener thickness shall not be less than 80% of the stiffened web thickness.

4.4 Openings in Structural Elements

4.4.1 Rectangular openings in the longitudinal members of hull shall have their corners rounded with the radius not less than 10% of the opening width. The opening edges shall be smooth.

Application of not-rounded corners is subject to PRS acceptance in each particular case.

4.4.2 Openings in the longitudinal members of hull are recommended to have their longer sides situated fore-and-aft.

4.4.3 Where several openings in the plating or girder web are necessary to be made in close proximity, they shall be preferably arranged fore-and-aft in line.

4.4.4 Stiffener ends in way of shell openings shall be welded to the dedicated transverse stiffeners.

The design pattern is shown in Fig. 4.4.4.

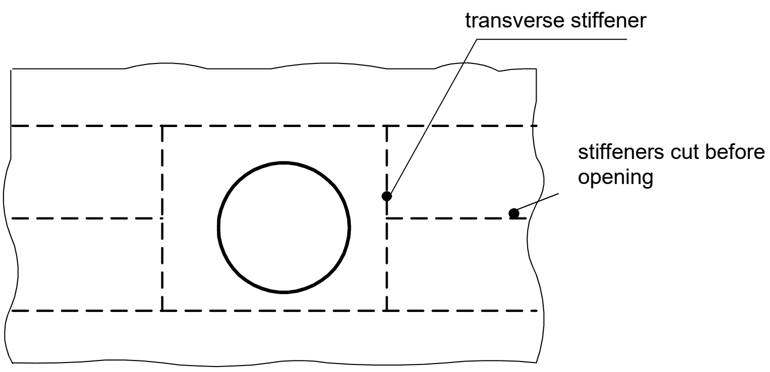


Fig. 4.4.4. Stiffening of plating in way of opening

4.4.5 Openings in webs of stiffeners or girders are not permitted in the distance less than 50% of the web height from:

.1 bracket end;

.2 transverse wall (web of a transverse member, bulkhead, etc.), unless the bracket has been applied.

4.4.6 The height of cut-outs in a girder web, for stiffeners, shall not exceed 40% of the member depth.

The total height of lightening holes and cut-outs in girder webs shall not exceed 50% of a web depth and their length shall not exceed 75%.

The distance between the edges of cut-outs for plating stiffeners and the edges of other openings shall not be less than the stiffener depth.

4.4.7 In girder webs and stiffeners supporting the bottom plating as well as top and bottom walls (horizontal or virtually horizontal) of integral tanks, drain holes or vent holes shall be made for effective drainage on the bottom or air flow in the top part of the tank. The holes shall fulfil the minimum requirements for scallops specified in paragraph 2.2.1.5.

4.5 Corrugated Plate Structures

4.5.1 Watertight and oiltight bulkheads may be constructed as corrugated ones of undulated or trapezoidal cross-sections (Fig. 4.5.1).

The bulkhead corrugation may be orientated vertically or horizontally.

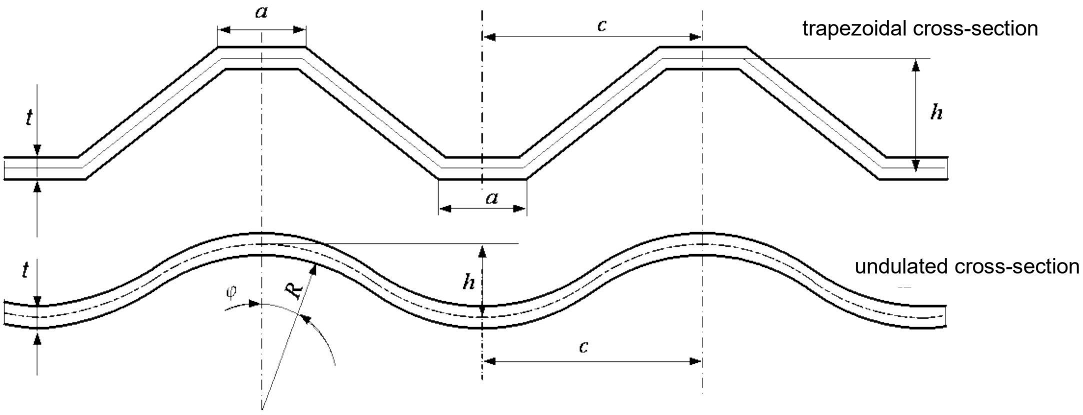


Fig. 4.5.1. Trapezoidal and undulated cross-sections

4.5.2 Walls of non-essential structural fragments which are not subjected to the hull general bending (e.g. transverse divisions, walls and deckhouse covers) may be constructed of corrugated sheets as shown in Fig. 4.5.2.

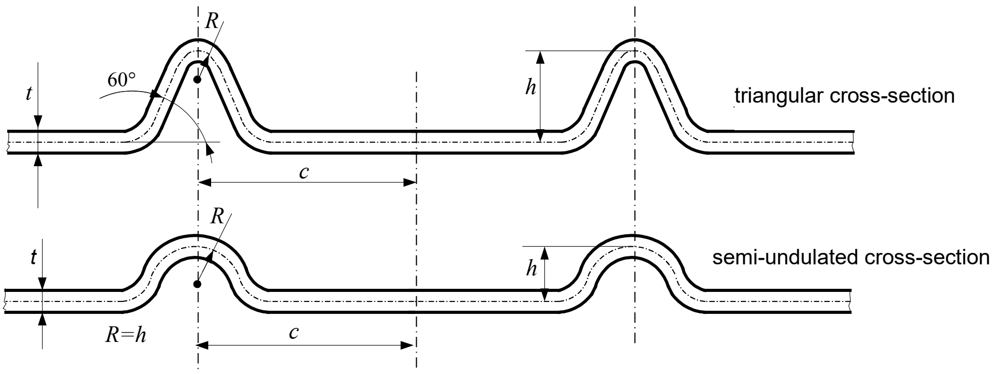


Fig. 4.5.2. Corrugated sheets

4.5.3 Recommended parameters of waves shown in Fig. 4.5.2, applied for constructions defined in sub-chapter 4.5.2, are as follows:

– triangular cross-sections: c = 150 ÷ 200 mm, R = 15 ÷ 20 mm,
h = 30 ÷ 40 mm, t = 3 ÷ 5 mm;

– semi-undulated cross-sections: h = 20 ÷ 30 mm, c = 120 ÷ 170 mm, t = 3 ÷ 5 mm.

4.5.4 If transverse stiffeners are fixed, with brackets, to a corrugated bulkhead, then the brackets shall be fixed to the stiffener of the bulkhead corrugation. The design pattern for such a connection is shown in Fig. 4.5.4.

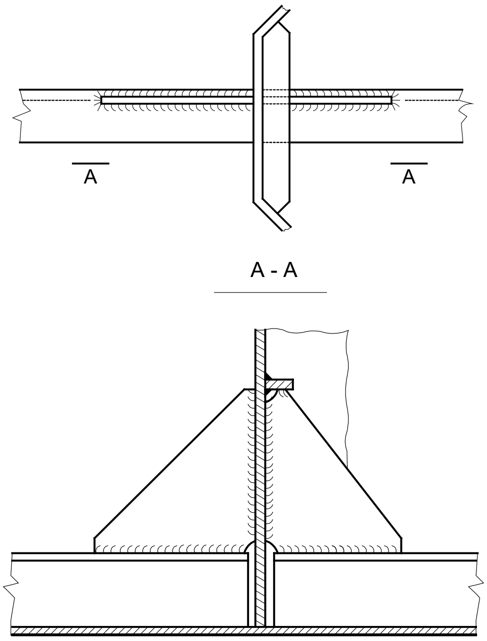


Fig. 4.5.4. Fixing of plating stiffeners to corrugated bulkhead

5 HULL STRUCTURE OF DRY CARGO CARRIERS

5.1 General

5.1.1 In Chapter 5, the requirements included in box brackets do not apply to those vessels whose hulls are designed by direct strength calculations, i.e. in compliance with the requirements specified in Chapter 3.

5.1.2 The requirements specified in Chapter 5 directly concerning the strength of structure (thickness of plates, section modulus and web area of plating stiffeners or girder stiffeners, etc.) directly apply to hulls of the vessels constructed of normal strength steel (R_e = 235 MPa). The other requirements also apply to structural elements of higher-strength steel. The structural elements of higher-strength steel shall also fulfil the requirements specified in sub-chapter 1.1.13.

5.1.3 Where a vessel is also intended to operate as a pusher, the structure of her forebody shall fulfil the requirements specified in paragraphs 7.9.2.2 to 7.9.2.4.

5.2 Single Bottom Structures

5.2.1 Floors

5.2.1.1 Where transverse framing system has been applied beyond the forepeak, application of floors on each frame with the spacing of a = 500 mm is recommended. [*The maximum floor pitch in the transverse framing system shall be determined using the following formula:*

$$a = 2L + 500 \ \ [mm].\ ] \quad (5.2.1.1)$$

5.2.1.2 *[Beyond the engine room, the floor section modulus shall not be less than calculated using the following formula:*

– *for vessels loaded in a single passage*

$$W = 8aB^2T \quad [cm^3] \qquad (5.2.1.2\text{-}1a)$$

– *for vessels loaded in several passages*

$$W = 6{,}5aB^2T \quad [cm^3] \qquad (5.2.1.2\text{-}1b)$$

where:

a – floor pitch, [m].

The floor thickness shall not be less than determined using the following formula:

$$t = \frac{h}{60} \quad [mm] \qquad (5.2.1.2\text{-}2)$$

where:

h – floor height, [mm].]

Floor thickness shall not be less than 4 mm.

5.2.1.3 Upper edges of floors shall be flanged or face plate shall be fitted. The recommended width of a face plate or flange is 10t (t – web thickness); whereas the thickness of a face plate or flange t_m shall not be less than t +1mm.

The following condition shall be fulfilled:

$$t_m \geq \frac{1}{15} b_m \qquad (5.2.1.3)$$

where:

b_m – flange width or half the width of T-bar's face plate.

[*For transverse framing system, the cross-sectional area of the face plates of the bottom floors in the web frame planes is recommended to be twice as much as the cross-sectional area of the face plates of other bottom floors.*]

Flanged bottom floors shall not be applied:

.1 in the engine room;
.2 in the web frame planes.

Where bottom floors are cut at the bottom centre girder, their proper connection to the girder shall be provided. Face plates of the bottom floors and the bottom centre girder shall be joined with a butt weld.

5.2.1.4 *[Where the width of deck strake at the hatch trunk is lesser than resulting from formula 5.6.1.1-2, the minimum value of the section modulus of bottom floors in the web frame planes shall be determined in accordance with the following formula:*

$$W_1 = W\frac{b}{b_1} \quad [cm^3] \qquad (5.2.1.4)$$

where:

W – section modulus in accordance with paragraph 5.2.1.2, [cm³];
b – design width of the deck strake, in accordance with formula 5.6.1.1-2, [mm];
b_1 – actual width of the deck strake, [mm].]

5.2.1.5 In vessels with great rise of floors, the floor height – at the distance of 0.4B from the plane of symmetry – shall not be less than 45% of the floor height in the plane of symmetry.

In vessels with a propeller screw, the upper edge of bottom floors shall be situated above the stern tube.

The height of bottom floors in fore and after peaks shall gradually rise towards the stem and sternframe.

5.2.1.6 Drain holes shall be provided in bottom floors for good drainage of water into suction strums (for hole dimensions – see 2.2.1.5).

5.2.2 Bottom Centre Girder

5.2.2.1 In vessels with ratio $L/H > 25$, the bottom centre girder shall be continuous. The depth shall not be less than the bottom floor height.

[*Amidships, the girder thickness shall be greater than the thickness of bottom floors by 1 mm; beyond that region, the girder thickness may be equal to the thickness of bottom floors*.

In ore carriers, the girder thickness shall be greater than the thickness of bottom floors by 1 mm throughout the vessel length.

The girder face plate width shall not be less than 12t, whereas the thickness – not less than t +1 mm (t – girder thickness, [mm]).]

5.2.2.2 The bottom centre girder shall extend fore-and-aft as far as possible; it need not, however, be led through the engine room.

5.2.2.3 *[In flat bottomed vessels not exceeding 6 m in breadth, a girder made of rolled section may be applied, instead of the plate bottom centre girder, and placed on the bottom floors. The sectional area of the rolled section shall not be less than 50% of the plate bottom girder.*

Two longitudinals placed on the bottom floors may be applied instead of the bottom centre girder made of a rolled section. Scantlings of the longitudinals shall be determined in accordance with paragraph 5.2.3.2.]

5.2.3 Bottom Side Girders

5.2.3.1 *[In vessels with the breadth from 6 to 10 m, one longitudinal shall be applied on each side of the centre girder, whereas in vessels with a breadth over 10 m – at least two longitudinals shall be applied.]*

5.2.3.2 *[Where two longitudinals made of a rolled section are applied, the cross-sectional area of each longitudinal shall not be less than 40% of the plate centre girder cross-sectional area, whereas in the case of four longitudinals – not less than 30% of the plate centre girder cross-sectional area.]*

5.2.3.3 *[Where two side longitudinals made of plates inserted between the bottom floors are applied, their thickness shall not be less than that of the bottom floors. Face plates of the longitudinals shall have the same scantlings as the bottom floor face plates, and the face plates may be either continuous or cut.]*

5.2.3.4 Any possible changes in the arrangement of longitudinals shall be gradual, throughout the length of at least two frame spacings.

5.2.4 Bottom Floors in Engine Room

5.2.4.1 Seating girders under the propelling engines shall be continuous throughout the length of the machinery space; they shall be extended by at least two frame spacings beyond bulkheads of that space.

Height of the girders outside the machinery space bulkhead shall decrease gradually to the height of bottom floors.

5.2.4.2 In the afterbody, PRS may require extension of the seating girders aftwards or application of additional members in that area, and – if deemed necessary – strengthening of the girders situated along the shafting.

5.2.4.3 Seating girders shall be connected to the machinery space bulkhead with brackets.

5.2.4.4 Thickness of seating girders for gearless engines shall be not less than 1/50 of their height and not less than the design thickness of the centre girder in a cargo hold. For geared engines, thicknesses not less than 1/80 of their height shall apply.

5.2.4.5 Thickness of bottom floors in the engine room shall be greater than that determined in accordance with formula 5.2.1.2-2 by 1 mm. Flanged bottom floors are not permitted. Bottom floor lowering and cut-outs under the engine crankcases shall be reduced to the indispensable minimum maintaining transverse continuity of the structure. Under the engine, the bottom floor sectional modulus shall not be less than 70% of that determined in paragraph 5.2.4.6. In the case where this requirement is impracticable, intermediate bottom floors shall be applied. Where a bottom floor and a girder form a sea chest, they shall be locally thickened in accordance with paragraph 5.5.5.4.

5.2.4.6 Section modulus of floors in machinery room shall be not less than given in formulae 5.2.1.2-1a or 5.2.1.2-1b.

5.3 Double Bottom

5.3.1 Double Bottom Depth

5.3.1.1 Double bottom depth shall enable welding and internal maintenance of double bottom tanks. The minimum depth shall be taken 600 mm.

5.3.1.2 Application of a double bottom with lesser height is subject to PRS acceptance in each particular case.

5.3.2 Bottom Structure Continuity

If practicable, in way of transition of the single bottom into the double bottom or double bottom tank, uniform height of bottom floors shall be maintained and there shall be applied horizontal brackets or widenings of longitudinals' face plates with transition into the inner bottom plating – as required in paragraph 4.2.7.

In a stepped bottom structure, vertical brackets coplanar with the longitudinals shall be applied.

5.3.3 Bottom Centre Girder

5.3.3.1 Bottom centre girder shall be continuous, and its height shall be equal to the double bottom depth.

5.3.3.2 *[Bottom centre girder thickness shall not be less than that determined using the following formula:*

$$t = \frac{h}{80} \quad [mm] \qquad (5.3.3.2)$$

where:

h – height of girder, [mm].]

5.3.4 Bottom Side Girders

5.3.4.1 *[The required number of longitudinals shall be determined as required in paragraph 5.2.3.1. Bottom floors may be made of insert sheets or rolled sections.]*

5.3.4.2 *[Thickness of insert longitudinals may be lesser than the bottom centre girder thickness by 1 mm. Section modulus of the longitudinal's profile shall be the same as that calculated for plate floors in accordance with formula 5.3.5.4.]*

5.3.5 Non-watertight Floors

5.3.5.1 Non-watertight floors may be made as solid or open ones. Within the double bottom beyond the engine room, solid floors shall be applied no more rarely than every 6 frame spacings, whereas in the engine room – no more rarely than every 3 frame spacings. In the web frame planes, solid floors shall be applied.

5.3.5.2 *[Solid floor thickness shall not be less than the greater value out of the following ones: the thickness of outer bottom plating and the thickness determined using in accordance with the following formula:*

$$t = \frac{h}{100} \; [mm] \qquad (5.3.5.2)$$

where:

h – height of bottom floor, [mm].]

5.3.5.3 Open bottom floors shall not be applied:
- **.1** in locations where concentrated forces occur (pillars, bulkheads, etc.);
- **.2** in those planes where web frames are applied;
- **.3** in cargo holds intended for the carriage of ores;
- **.4** under the seatings of heavy machinery
- **.5** nowhere in vessels with ice strengthening L1.

5.3.5.4 *[Section modulus of bottom stiffeners being a part of open floor shall not be less than determined in accordance with the following formula:*

$$W = 5aHl^2 \; [cm^2] \qquad (5.3.5.4)$$

where:

a – spacing of stiffeners under consideration, [m];
l – span of stiffener between side girders (or edges of brackets situated at side girders or longitudinal members) or span of the stiffener between the side girder and side, [m].]

5.3.5.5 *[Section modulus of reverse frames being portions of open bottom floors may be reduced by 20% against the value required in paragraph 5.3.5.4 for plate floors.]*

5.3.5.6 *[At the intersections of opened bottom floors and rolled-section side girders, vertical stiffeners made of rolled sections with the dimensions not less than those of plate floors shall be applied.]*

5.3.5.7 Bottom floors and reverse frames of open bottom floors shall be connected to the centre girder and margin plate with flanged supporting plates. The width of the supporting plates shall not be less than 0.6 of the actual height of the bottom centre girder, whereas the thickness – not less than that of the bottom centre girder. In great-radius bilges, supporting panels shall overlap the flat part of the bottom.

5.3.5.8 If bottom floors and reverse frames of the bottom floors are cut at the side girder, then vertical rectangular brackets of the width equal 0.4 of the actual height of the bottom centre girder shall be fitted on both sides of the longitudinal.

5.3.5.9 Diameter of lightening holes in the supporting plates at the bottom centre girder and margin plate shall not be greater than 50% of the bracket width.

5.3.6 Tight Floors

5.3.6.1 Tight floors shall be fitted under or adjacent to bulkheads as well as between the double bottom tanks.

5.3.6.2 *[Thickness of watertight and oiltight floors shall be greater by 0.5 mm than that of the non-watertight solid floors determined in accordance with formula 5.3.5.2 and not less than the plating thickness of the tight bulkhead of the tank, at the proper level of the bottom floor (taking account of the air pipe).]*

5.3.7 Inner Bottom Plating

5.3.7.1 Inner bottom plating thickness shall be not less than 5 mm and not less than determined in accordance with the following formula:

$$t = a(0.1L+4.5) \text{ [mm]} \qquad (5.3.7.1)$$

where:
a – frame spacing [m].

5.3.7.2 Unless the inner bottom, below the cargo hold hatches, is protected by wood, then the inner plating thickness determined in accordance with paragraph 5.3.7.1 shall be increased by at least 30%, and for the hold intended to be loaded and unloaded with grabs, the increase shall not be less than 2 mm.

5.3.8 Margin Plates

Thickness of margin plates shall not be less than the inner bottom plating determined in accordance with paragraph 5.3.7.1.

5.3.9 Manholes and Lightening Holes

5.3.9.1 To provide access to all double bottom spaces, manholes shall be provided in the inner bottom plating and holes shall be cut in the plate floors and longitudinals.

Manholes and lightening holes shall have their corners rounded with the radius not less than 100 mm. The height of holes in the bottom floors and longitudinals shall not exceed 0.7 of the floor height. The width of holes in floors shall not exceed 1.5 the floor height, whereas in the longitudinals – 0.7 of the floor spacing.

5.3.9.2 Holes shall not be cut in floors or longitudinals in way of occurrence of the concentrated forces (e.g. under pillars).

5.3.9.3 Covers of manholes in the inner bottom plating shall be protected by lining or by other effective means.

5.4 Side Structures

5.4.1 Frame Spacing

5.4.1.1 *[Throughout the vessel length, beyond the forepeak, frame spacing of 500 mm is recommended. The maximum frame spacing shall not exceed (2L + 500) mm.*

In the forepeak, the frame spacing shall not exceed 400 mm, unless intermediate frames are applied throughout the length B from the fore perpendicular.]

5.4.1.2 *[Where cant frames are applied, their spacing at the deck level shall not exceed 500 mm.]*

5.4.1.3 *[Where hull ends are cut to form transoms, their stiffeners shall be applied with the spacing not exceeding 600 mm.]*

5.4.2 Frame Scantlings

5.4.2.1 *[Section modulus of a dry cargo carrier frames shall not be less than determined in accordance with the following formula:*

$$W = kaH^3 + 3 \quad [cm^3] \qquad (5.4.2.1\text{-}1)$$

where:

$k = 2 + 0.1\frac{B}{H}$;

a – *frame spacing [m].*

For other types of vessels (pushers, tugs, passenger vessels, auxiliary vessels etc.), section modulus of frames shall not be less than determined in accordance with the following formula:

$$W = kaTH^2 + 3 \ [cm^3].] \qquad (5.4.2.1\text{-}2)$$

5.4.2.2 *[Where the compartment length exceeds 0.25L, then the minimum required section modulus shall be determined in accordance with paragraph 5.4.2.1, taking the following factor:*

$$k = 0.65 + 1.4\frac{d}{L} \qquad (5.4.2.2)$$

where:

d – *length of cargo hold (compartment), [m].*

Compartment means a portion of the cargo hold bounded by the structural members connecting the opposite sides at the deck level (e.g. struts).]

5.4.2.3 *[In integral deep tanks throughout the hull height, the minimum section modulus of frames shall be greater than that determined in accordance with formulae 5.4.2.1-1 and 5.4.2.1-2 by 10%.*

Where the tank does not extend to the deck height, the minimum value of the frame section modulus shall be taken either in accordance with formulae 5.4.2.1-1 and 5.4.2.1-2, or in accordance with formula 5.9.3.1 – whichever is greater.]

5.4.2.4 *[Section modulus of transom stiffeners shall be the same as that of the watertight bulkheads' stiffeners (see sub-chapter 5.7). The stiffeners shall be connected to the bottom girders with brackets.]*

5.4.3 Web Frames

5.4.3.1 Web frames in the engine room shall be arranged no more rarely than every 4 frame spacings. Web frames shall be situated at the ends of propulsion equipment.

5.4.3.2 In cargo holds, web frames shall be applied where the distance between transverse bulkheads exceeds 10 m. For the distance between transverse bulkheads ranging from 10 to 13 m, one web frame shall be applied, whereas for the distance ranging from 13 to 18 m – two web frames. For the distance between bulkheads exceeding 18 m, web frames shall be so arranged that their spacing and the distances between them and the bulkhead is not greater than 5.5 m.

5.4.3.3 Web frame section modulus in the bottom floor upper edge plane shall not be less than the floor section modulus in the particular location (see paragraph 5.2.1.2).

5.4.3.4 *[The minimum value of web frame section modulus at the deck level may be 80% of the value determined in accordance with formula 5.2.1.2-1. Where the length of a compartment (cargo hold) exceeds 0.25L, the minimum value of the web frame section modulus shall be taken as the greater one out of the following values: determined in accordance with formula 5.2.1.2-1 and determined in accordance with the formula below:*

$$W_1 = 25\frac{d}{L}uH^3 \ [cm^3] \qquad (5.4.3.4)$$

where:
d – length of compartment (cargo hold), [m], however no more than L/2;
u – spacing of web frames, [m].]

5.4.3.5 *[Where the deck strake width is less than that resulting from formula 5.6.1.1-2, the minimum value of web frame section modulus shall be determined in accordance with the formula below:*

$$W_2 = W\frac{b}{b_1} \ [cm^3] \qquad (5.4.3.5)$$

where:
W – section modulus resulting from formula 5.2.1.2-1;
b – design deck strake width resulting from formula 5.6.1.1-2, [mm];
b_1 – actual deck strake width, [mm].]

5.4.3.6 *[The minimum value of web frame section modulus need not be greater than W_1 determined in accordance with formula 5.4.3.4 for $d = L/2$.]*

5.4.4 Frames in Deck Erections of over 0.2*L* in Length

5.4.4.1 Minimum value of frames' section modulus between the upper deck and superstructure deck shall not be less than 80% of the modulus determined in accordance with formula 5.4.2.1-2.

5.4.5 Frame End Fixing

5.4.5.1 In vessels with single bottom, the lower ends of frames may be welded to bottom floors directly (see 4.3.4). In that case the length of the connection of the frame to the floor shall be at least 1.5 times the frame height.

Other lap welds than shown in Fig. 4.3.4 c and d are subject to PRS acceptance in each particular case.

For the connection of a frame to floor with bracket, the bracket shall be as thick as the floor, and its sides shall be at least 2.5 times the frame height. Where the frame section modulus is more than 30 cm^3, than the bracket free edge shall be flanged; the flange width shall be equal to the frame face plate or floor flange.

5.4.5.2 In vessels with double bottom, frames shall be connected to the margin plate with bilge brackets. The height of the brackets, from the inner bottom level, shall not be less than:

$$h = 100\, l \ [mm] \qquad (5.4.5.2)$$

where:
l – frame span, [m].

Where horizontal margin plates are applied, the bracket sides connected to them shall not be less than the frame height.

Bilge bracket thickness shall not be less than the floor thickness determined in accordance with formula 5.3.5.2.

The bilge bracket free edge shall be flanged; the flange width shall be equal to the frame profile face plate width.

5.4.5.3 Web frames shall be connected to bottom floors or inner bottom plating with brackets. The bracket shall be as thick as the web of a web frame, whereas its sides shall be equal 1.5 times the web frame height.

Direct connection of the web frame to the bottom floor is permitted. In that case the web of a web frame shall be extended below the floor flange by at least half the floor height.

5.4.5.4 Frames shall be connected to deck beams with brackets. The length of each bracket side shall not be less than the greater value out of the following ones:

$$l_1 = 27\sqrt{W_1} + 60 \text{ [mm]} \qquad (5.4.5.4)$$

and l_2 = 100 mm

where:

W_1 – arithmetic mean of frame section modulus and floor section modulus.

The brackets' thickness shall not be less than frame thickness.

If the bracket side length is greater than 250 mm, then the bracket free edge shall be flanged; the flange width shall be 10 times the bracket thickness.

5.4.5.5 Web frames shall be connected to deck beams with brackets. The bracket shall be as thick as the web of a web frame, whereas the sides shall be equal 1.5 times the web frame height.

5.4.6 Side Stringers

5.4.6.1 [Where the frame span exceeds 2.7 m, side stringers shall be applied.]

5.4.6.2 In self-propelled cargo vessels, side stringer shall be applied in the forebody regardless of the frame span.

The side stringer shall be led throughout at least two frame spacings into the straight portion of the side and, if practicable, ended at the web frame.

5.4.6.3 Side stringer shall be situated at the height of around 0.6*H*. Its web height shall not be less than 1.6 the frame height, whereas its thickness shall not be less than that of the frame. The stringer's flange shall have the cross-sectional area not less than that of the web frame.

5.4.6.4 Side stringer shall be connected to transverse bulkheads with brackets. The brackets' sides shall have the length equal to the stringer height.

5.5 Hull Plating

5.5.1 Bottom and Side Plating

5.5.1.1 *[Thickness of the bottom and sides' plating amidships shall not be less than determined in accordance with the formula below:*

$$t = a(0.1L+6.5)\ [mm] \qquad (5.5.1.1)$$

where:
a – frame spacing, [m], however not less than 0.4 m.]

5.5.1.2 Bilge strake thickness amidships shall be increased by at least 1 mm against the bottom plating thickness.

5.5.1.3 Outside amidships, the bilge strake thickness may be equal to the bottom plating.

5.5.1.4 In cargo vessels with the mark of operating area 3, the bilge strake thickness shall be increased by 1 mm (against the bottom plating) throughout the vessel length.

5.5.1.5 Bilge strake width shall be such that the upper seam is located at least 100 mm above the upper edge of the floors and outside the turn of bilge, whereas the lower seam – 100 mm and outside the turn of bilge.

5.5.1.6 In vessels with bar keel, garboard strake thickness shall be greater than the bottom plating by 0.5 mm. In vessels with the mark of operating area 3, this applies to the whole length of the vessel, whereas in vessels with other mark of operating area this applies to amidships only.

5.5.1.7 *[Outside amidships, the bottom and sides' plating thickness may be gradually reduced by 10%; this does not apply to the forebody of the cargo vessels with mark of operating area 3. Plating thickness shall not, however, be less than 3 mm.]*

5.5.1.8 *[Where hull ends are cut to form transoms, the thickness of their plating shall be taken not less than the bottom thickness amidships.]*

5.5.2 Sheer Strake

5.5.2.1 *[Sheer strake thickness amidships shall not be less than determined in accordance with the formula below:*

$$t = a(0,1L+9)\ [mm] \qquad (5.5.2.1)$$

where:
a – frame spacing, [m], however not less than 0.4 m.]

5.5.2.2 *[Sheer strake width amidships shall not be less than 0.3H.]*

5.5.2.3 *[Sheer strake thickness in fore and after peaks where the deck breadth is less than B need not exceed the side shell plating thickness. In the case of 'step' in the deck, the sheer strake thickness near the step shall not be less than that determined in accordance with formula 5.5.2.1.]*

5.5.2.4 *[Instead of the sheer strake with the dimensions determined in paragraphs 5.5.2.1 and 5.5.2.2, a thickened strake of plating of the width not less than 0.1H constituting side protection may be applied throughout the vessel length. The side protection thickness shall not be less than that determined using the formula below:*

$$t = a(0,1L+17)\ [mm].] \qquad (5.5.2.4)$$

5.5.2.5 *[In vessels intended for loading and unloading with grabs, the sheer strake (or side protection) thickness shall be increased by 2 mm.]*

5.5.3 Fenders

5.5.3.1 Where steel fenders, e.g. made of half-round bars or pipes, are applied, they shall be fixed to the plating with watertight double continuous weld.

5.5.3.2 Where wooden fenders are applied, they shall not be through-bolted to the shell plating.

5.5.4 Shell Openings

5.5.4.1 Shell openings shall have rounded corners; the fillet radius shall not be less than 50 mm.

5.5.4.2 Openings with more than 300 mm in diameter, made in plating amidships, require full compensation of the loss by increasing the plating thickness in way of such an opening.

5.5.4.3 In way of valves' and pipelines' fixing, strengthening flanges shall be installed.

Shell penetration by bolts or direct welding of bolts to the shell plating are not permitted.

5.5.4.4 Where scuttles or other openings reducing the sectional area by more than 20% are made in the sheer strake, equivalent strengthening shall be provided.

5.5.5 Plating Strengthening

5.5.5.1 In the machinery space, bottom plating under the seating girders shall be thickened by at least 1 mm against the values determined in accordance with formula 5.5.1.1.

5.5.5.2 Thickness of plating panels connected to the propeller post, propeller shaft brackets or shell bossing, and to ducted propeller shell shall not be less than shell plating thickness amidships.

Where combined power of main propulsion engines is more than 360 kW, the plating panels shall be additionally thickened by 1 mm, and for the combined power exceeding 550 kW – by 2 mm.

5.5.5.3 Local thickening of plating panels by 50% shall be applied in the following locations:
.1 in way of hawse-hole mouth and contact of anchor with the plating;
.2 in way of outlets of paddle wheel shafts;
.3 on the bottom of skipper pump wells and under sounding pipes of more than 3 m in length;
.4 in rounded corners of transoms;
.5 in way of deck 'steps' at the sides.

5.5.5.4 Thickness of plating panels in way of outlet openings to sea chests and sea chest walls shall not be less than determined in accordance with the formula below:

$$t = 50c\sqrt{p}\ [\text{m}] \qquad (5.5.5.4)$$

where:
c – maximum span of non-stiffened wall of sea chest, [m];
p – pressure of compressed air (or steam) supplied to sea chest, [MPa]; however not less than 0.2 MPa; where compressed air is not supplied, the value of p = 0.1 MPa shall be taken.

5.6 Decks

5.6.1 Deck Strake of Vessel with Hatch Trunk

5.6.1.1 *[In a vessel with continuous hatch trunk (see sub-chapter 5.10.3), deck strake scantlings shall not be lesser than determined in accordance with the formula below:*

$$t = 0.1L + 0.5B\ \ [mm], \qquad (5.6.1.1\text{-}1)$$

$$b = (6.5L + 300)\left(0.6 + 4\frac{B}{L}\right)\quad [mm] \qquad (5.6.1.1\text{-}2)$$

where:
t – deck strake thickness, [mm];
b – deck strake breadth, [mm].]

5.6.1.2 *[Where the ratio of the cargo hold length d to the vessel length is greater than 0.25, the deck strake breadth shall be increased using the following multiplier:*

$$k = 0.75 + \frac{d}{L} \qquad (5.6.1.2)$$

whereas ratio d/L may be taken not greater than 0.4.]

5.6.1.3 *[Where the deck strake breadth is less than the value determined in accordance with formula 5.6.1.1-2, its thickness shall be so increased that the design cross-sectional area* $t \times b$ *is maintained. In that case scantlings of the web frames and connected to them bottom floors shall also be increased (see 5.4.3.5).]*

5.6.1.4 *[Where the deck strake breadth is greater than the value determined in accordance with formula 5.6.1.1-2, its thickness may be reduced in proportion to the ratio of the actual breadth to the design breadth. The deck strake thickness, however, shall not be less than the strake thickness for the deck with separate hatches (see 5.6.2.1).]*

5.6.1.5 In self-propelled cargo vessels with continuous hatch trunks, the deck strake shall be thickened by 30% in way of hatch ends on the after and fore superstructure sides. The thickening shall be welded as a plate extending 2.5 frame spacings beyond the hatch ends.

5.6.2 Sheer Strake of Vessel with Separate Hatches

5.6.2.1 *[In a vessel with separate hatches, scantlings of the deck strake (see 5.10.2) shall not be less than determined in accordance with the formulae below:*

$$t = \sqrt{L} \quad [mm] \qquad (5.6.2.1\text{-}1)$$

$$b = 5L+300 \ [mm] \qquad (5.6.2.1\text{-}2)$$

where:
t – thickness of deck strake
b – breadth of deck strake.

5.6.2.2 Deck strake thickness shall not be less than the deck plating determined in accordance with sub-chapter 5.6.3.

5.6.3 Strength Deck Plating

5.6.3.1 *[Strength deck plating thickness amidships shall not be less than determined in accordance with the formulae below:*

– *for the deck outside separate hatches:*

$$t = a(0.1L+4) \ [mm] \qquad (5.6.3.1\text{-}1)$$

– *for the deck between separate hatches:*

$$t = a(0{,}1L+5) \ [mm] \qquad (5.6.3.1\text{-}2)$$

where:
a – beam spacing, [m].]

5.6.3.2 *[Strength deck plating thickness outside amidships, beyond hatches or machinery fixing locations, may be less than determined in accordance with formula 5.6.3.1-1 by 1 mm, however not less than 3 mm.]*

5.6.4 Decking

5.6.4.1 *[Where the deck strength is lined with wood, the plating thickness determined in accordance with formulae 5.6.3.1-1 and 5.6.3.1-2 may be decreased by 10%.]*

5.6.4.2 Wood used for the deck lining shall be dry and of good quality. Pinewood lining in cargo vessels' decks shall not be less than 40 mm, whereas in passenger vessels – not less than 30 mm.

5.6.4.3 Deck coating mass approved by PRS may be used instead of wood.

5.6.5 Deck Strengthening in Way of Hatch Corners

5.6.5.1 Openings in the strength deck shall have rounded corners; the fillet radius shall not be less than 5% of the opening width or 50 mm, whichever is greater.

5.6.5.2 Hatch corners need not be rounded where continuous coamings are applied, except the end corners where the requirement specified in paragraph 5.6.5.1 shall be fulfilled.

5.6.5.3 Thickness of plating panels embracing corners of large openings with more than 0.5B in width shall not be less than specified in paragraph 5.6.1.5. The panels shall embrace the corners extending at least 1 frame spacing beyond the transition of the fillet radius in the straight part of hatch.

5.6.6 Strength Deck of Superstructure

[*Where strength superstructure is applied in the vessel, the deck shall fulfil the requirements concerning the strength deck specified in subchapters 5.6.3 and 5.6.4 in way of this superstructure*.]

5.6.7 Deck Beams

5.6.7.1 Deck beam section modulus shall not be less than determined in accordance with the formula below:

$$W = 0.6apl^2 \text{ [cm}^3\text{]} \qquad (5.6.7.1)$$

where:

a – spacing of beams [m];
p – design pressure, to be taken:
4.5 kPa –for upper deck and passenger deck,
3 kPa – for accommodation spaces' decks;
l – span of beam between the inside edges of frames or between the inside edge of frame and the longitudinal structure supporting the beam, however not less than 0.1B+0.4 [m].

5.6.7.2 *[In way of permanent location of heavy weights and machinery subjected to large external loads, the required section modulus of a beam shall be determined in accordance with formula 5.6.7.1, increasing the design pressure p by ratio P/F (where: P – weight, [kN]; F – surface subjected to that weight, [m*^{2}*]).]*

In vessels loaded and unloaded with grabs, section modulus W determined in accordance with paragraph 5.6.7.1 shall be increased by 20%.

5.6.7.3 Short beams in way of hatches shall be connected to hatch coamings or deck girders.

5.6.7.4 Brackets properly connected to the hatch coamings may be substituted for short beams.

5.6.8 Transverse Deck Girders

5.6.8.1 Transverse deck girders shall be applied in the web frame planes as well as at the hatch ends where the transverse hatch coaming is at the distance of 4 or more frame spacings from a bulkhead.

5.6.8.2 *[Transverse deck girder section modulus shall not be less than 80% of that of the web frame.]*

5.6.9 Deck Girders

5.6.9.1 Deck beams shall rest on deck girders supported by bulkheads, pillars or transverse beams.

5.6.9.2 Application of deck girders which form an extension of the lower part of longitudinal hatch coamings is recommended.

5.6.9.3 Deck girder section modulus shall not be less than determined in accordance with the formula below:

$$W = 0.5bpl^2 + 10 \quad [\text{cm}^3] \tag{5.6.9.3}$$

where:

l – length of deck girder, [m], measured between their supports; the supports include pillar centres, bulkhead plating, hatch-end beam web or transverse girder web (exclusive of the bracket);
b – average breadth of deck and hatch supported by a girder, [m];
p – design pressure (see 5.6.7.1).

5.6.9.4 In way of permanent location of heavy weights, girders shall be properly strengthened taking into account those additional loads to determine the design pressure – as in paragraph 5.6.7.2.

5.6.10 Structure of Girders

5.6.10.1 Girder web height shall not be less than 1.6 the height of deck beams.

5.6.10.2 Girder web thickness shall not be less than the thickness of deck beams.

5.6.10.3 Girder face plate width shall not be greater than the web height, and its thickness – not less than the web thickness increased by 1 mm, however not greater than double web thickness.

5.6.10.4 Deck girder shall be stiffened with tripping brackets, if the difference between its web height and deck beam web height exceeds 60 mm.

Thickness of brackets shall be equal to the web thickness.

The distance between brackets shall be equal to double spacing of deck beams – if the face plate or flange is asymmetrical, and four spacings – if the face plate or flange is symmetrical.

5.6.11 Longitudinal Hatchway Coamings as Deck Girders

5.6.11.1 Longitudinal coaming of a separate hatchway (see 5.10.2) shall be considered as a deck girder segment if the closest deck girder is situated at the distance greater than 500 mm from the hatch edge. In that case the section modulus of the longitudinal hatchway coaming shall be increased by 20% against the value determined using formula 5.6.9.3; longitudinal hatchway trunk coamings need not calculation in accordance with that formula.

5.6.11.2 While determining section modulus of a separate hatchway longitudinal coaming, the part of coaming above the deck – up to the height of its horizontal stiffener, including that stiffener – may be taken into account.

5.6.11.3 Separate hatchway longitudinal coamings which play the role of deck girders shall fulfil the structural requirements specified in sub-chapter 5.10.3.

5.6.12 Girder End Brackets

5.6.12.1 Girders shall be connected to a bulkhead or hatch-end beam web by brackets with flanged free edge or face plate whose width is equal to the girder face plate width.

5.6.12.2 Thickness of brackets shall be equal to the girder web thickness. The length of the bracket horizontal side shall not be less than the girder web height.

5.6.13 Hatchway End Beams

Hatchway end beams shall be applied where the hatch end is situated at the distance greater than 4 frame spacings from a bulkhead. Scantlings of hatchway end beams shall be taken in accordance with paragraph 5.10.5.4.

5.6.14 Pillars

5.6.14.1 Where deck erections, engine room casings, wheelhouse trunks, heavy deck machinery etc., are not seated on the strong deck members, they shall be supported by pillars positioned on bottom floors.

5.6.14.2 If practicable, pillars shall run in one perpendicular at the particular tier. Hull structure under and above the pillars shall be so stiffened that the pillars can bear the load by their whole cross-sectional area. In way of their connection to girders, deck beams and floors, the pillars shall be strengthened with vertical brackets.

5.6.14.3 *[Cross-sectional area of a pillar shall fulfil the following condition:*

$$f \geq \frac{P}{0.01k_c} \text{ [cm}^2\text{]} \qquad (5.6.14.3)$$

where:

$P = abp + P_1$, *axial load on pillar, [kN];*
- a – *distance between midspan points of deck girders, [m];*
- b – *average breadth of deck supported by deck girder within length a, [m];*
- p – *design pressure for particular deck – see 5.6.7.1;*
- P_1 – *axial loads imposed from pillars situated above, [kN];*

$k_c = 1430 - 5\lambda$ *for* $\lambda \leq 40$;

$k_c = 1570 - 8{,}5\lambda$ *for* $40 < \lambda \leq 120$;

$k_c = \frac{40\,500}{\lambda - 50} - 95$ *for* $\lambda \geq 120$;

- $\lambda = \frac{l}{i}$ – *slenderness ratio*;
  - l – *height of pillar, [cm]*;
- $i = \sqrt{\frac{J}{f}}$ – *radius of gyration, [cm]*;
  - J – *minimum moment of inertia of pillar cross-section, [cm⁴];*
  - f – *pillar cross-sectional area, [cm²].*]

5.6.14.4 Where the pillar is situated inside a tank, verification analysis shall be done to tension caused by the liquid pressure on tank walls.

5.7 Watertight Bulkheads

5.7.1 Arrangement of Bulkheads

5.7.1.1 A collision bulkhead shall be fitted at a suitable distance from the forward perpendicular in such a manner that the vessel complies with the buoyancy criteria, specified in *Part IV – Stability and Freeboard,* having the watertight compartment ahead of the collision bulkhead flooded..

As a general rule, the buoyancy criteria, specified in *Part IV*, shall be considered to have been met if the collision bulkhead has been installed at a distance of 0.04 L to 0.04L +2, [m], measured from the forward perpendicular in the load waterline plane.

The fitting of the collision bulkhead at a distance greater than 0.04L + 2, [m], from the forward perpendicular is acceptable, provided that the buoyancy calculations made according to *Part IV – Stability and Freeboard* prove compliance with the criteria, specified in *Part IV*, for the vessel having the compartment ahead of the collision bulkhead flooded.

The distance of the collision bulkhead from the forward perpendicular may be reduced to 0.03L, provided that the above criteria, specified in *Part IV*, are complied with for simultaneous flooding of the compartment ahead of the collision bulkhead and the adjacent compartment.

5.7.1.2 Accommodation spaces or installations essential for the vessel operation and safety shall not be situated ahead of the collision bulkhead.

This requirement shall not apply to anchor gear or steering apparatus.

Accommodation spaces shall be separated from the engine room and boiler room with gastight bulkheads and directly accessible from the deck. Unless such access is provided, means of escape directly to the deck shall be arranged.

5.7.1.3 After peak bulkhead shall be provided. An aft-peak bulkhead at a suitable distance from the stern where the vessel length exceeds 25 m in such a way that the buoyancy of the laden vessel is ensured, with a residual safety clearance of 100 mm if water enters the watertight compartment aft of the aft peak bulkhead. As a general rule, the requirement referred to in the first subparagraph shall be considered to have been met if the aft peak bulkhead has been installed at a distance of between 1,4 m and 0,04 L + 2 measured from the aft point of the intersection of the hull with the maximum draught line. If this distance is greater than 0,04 L + 2, the requirement referred to in the first subparagraph must be proved by calculation. The distance may be decreased to 1 m. In this case, the requirement referred to in the first subparagraph must be substantiated by calculation on the assumption that the compartment aft of the aft peak bulkhead and the immediately adjacent compartments have been filled with water.

In self-propelled vessels, the bulkhead shall separate a watertight compartment containing the stern tube and rudder casing.

In slender vessels, stern tube flange may be fixed to a strengthened bottom floor in the cargo hold.

Where stern tube is situated in a watertight compartment other than after peak, the after peak bulkhead need not be applied provided one of the following conditions is fulfilled:
- length of vessel $L < 25$ m;
- fore bulkhead of the machinery space is situated within the distance of 0.07L from the after perpendicular;
- fore bulkhead of the machinery space is situated within the distance of 0.20L from the after perpendicular and the vessel draught is not greater than 0.46H.

5.7.1.4 Accommodation spaces, engine room, boiler room and all workshops being a part of these rooms shall be separated from the holds by watertight transverse bulkheads that extend up to the deck. If the machinery space is located in the afterbody, the after bulkhead of this space may also form the after peak bulkhead.

5.7.1.5 Bulkheads forming the boundaries of fore and after peak shall be led to the lowest level of the bottom. In vessels with significant undercutting of the bow or stern, application of bulkheads extending to the bottom above the base plane is permitted. In that case, however, protection arrangements shall be provided in the bow to reduce the risk of the plating piercing from the movement direction above the base plane, such as tanks adjacent to the collision bulkhead or strengthening of plating and bottom members.

5.7.1.6 Transverse bulkheads, referred to in paragraphs 5.7.1.1, 5.7.1.2 and 5.7.1.4, shall not in general contain any openings

However, watertight doors in the after peak bulkhead, as well piping or shafts penetrations in watertight bulkheads may be permitted, provided the relevant requirements, specified in *Part III – Hull Equipment*,. are complied with.

5.7.2 Number of Bulkheads

5.7.2.1 *[The distance between transverse bulkheads shall not be greater than 22 m. This distance may be increased where framework structure – with a solid floor, frames in accordance with sub-chapter 5.4.3, deck girder throughout the breadth in accordance with sub-chapter 5.6.8, or coaming strutting beams in accordance with sub-chapter 5.10.4 connected to the transverse deck girder – is applied between the bulkheads. Such a structure is considered as a bulkhead when determining the distance.]*

5.7.3 Plating of Bulkheads

5.7.3.1 Thickness of the collision bulkhead plating and after peak bulkhead plating shall not be less than determined in accordance with the formula below:

$$t = 5.5a\sqrt{h} \text{ [mm]}, \quad (5.7.3.1\text{-}1)$$

whereas the thickness of other bulkheads shall not be less than:

$$t = 4.5a\sqrt{h} \text{ [mm]}, \quad (5.7.3.1\text{-}2)$$

where:

a – spacing of stiffeners, [m];
h – height measured in the plane of symmetry from the lower edge of the strake of bulkhead plating to the deck, [m].

5.7.3.2 Thickness of bulkhead plating need not exceed the thickness of the adjacent side plating, it shall not, however, be less than 3 mm.

5.7.3.3 Thickness of the lowest strake of bulkhead plating shall be greater than determined in accordance with formulae 5.7.3.1-1 and 5.7.3.1-2 by 1 mm and extend at least 200 mm above the upper edges of the adjacent bottom floors.

5.7.3.4 Thickness of the lower strake of the plating of the machinery space bulkhead to which machinery foundations are fitted shall not be less than determined in accordance with the formula below:

$$t = 0{,}007N+5 \text{ [mm]} \quad (5.7.3.4)$$

where:
N – rated power of propelling engines, [kW].

This strake shall extend at least 100 mm above the upper edge of the seating girders.

5.7.4 Stiffening of Bulkheads

5.7.4.1 Section modulus of the bulkhead stiffeners shall not be less than determined in accordance with the formula below:

$$W = kahl^2 + 3 \ [\text{cm}^3] \quad (5.7.4.1)$$

where:
a – spacing of stiffeners, [m];
h – distance between the midspan of stiffener to the upper edge of bulkhead measured in the plane of symmetry, [m];
l – span of stiffener, [m];
k = 5 for collision bulkhead,
k = 4 for other bulkheads.

Where stiffener ends are fixed with brackets, the stiffener section modulus may be reduced by 25%.

5.7.4.2 Upper edge of bulkhead requires horizontal stiffening by:
.1 connection to the deck plating, where the bulkhead is led to the deck;
.2 strutting beam in the case of continuous hatch trunk (see sub-chapter 5.3.4).
.3 horizontal stiffener in the case of bulkhead not extending the deck or girder.

[*Option 3 is acceptable where the upper portion of the bulkhead structure is not subjected to compressive forces imposed by the continuous hatch coamings. In that case the horizontal stiffener section modulus shall not be less than determined in accordance with the formula below:*

$$W = l^2 b^2 \ [\text{cm}^3] \quad (5.7.4.2)$$

where:

l – *span of vertical stiffeners, [m];*
b – *not supported length of horizontal stiffener, [m]*.]

5.7.4.3 Spacing of stiffeners of the collision bulkhead is recommended to be not greater than 500 mm, and in the case of stiffeners of other bulkheads – not greater than 700 mm.

5.7.5 Brackets

5.7.5.1 If bulkhead stiffeners are connected to the bottom with brackets, then the bracket height shall not be less than 0.1 of the stiffener span, and the brackets shall be led to the closest transverse member.

5.7.5.2 Thickness of bracket shall not be less than that of the bullhead stiffener web.

5.7.5.3 In the case of connection of bulkhead stiffeners of more than 3 m in length and the collision bulkhead stiffeners without brackets – butt welding of both ends of stiffeners to the bottom plating and deck is required. For stiffeners of other bulkheads than collision bulkhead of less than 3 m in length, only such a connection to the bottom is required.

5.7.6 Stepped Bulkheads

5.7.6.1 Thickness of horizontal portions of bulkheads shall be greater than determined in accordance with formulae 5.7.3.1-1 and 5.7.3.1-2 by 1 mm.

5.7.6.2 Horizontal stiffeners of bulkheads shall be equivalent, in respect of their strength, to the stiffeners calculated in accordance with formula 5.7.4.1.

5.7.7 Longitudinal Bulkheads

Watertight longitudinal bulkheads shall fulfil the requirements concerning transverse bulkheads in respect of both thickness and strength.

5.7.8 Corrugated Bulkheads

5.7.8.1 Thickness of corrugated bulkheads' plating shall not be less than that of a flat bulkhead, determined in accordance with formulae 5.7.3.1-1 and 5.7.3.1-2.

5.7.8.2 Section modulus of a corrugated bulkhead member of trapezoidal cross-section member with trapezoidal cross-section and width equal to u shall fulfil the following condition:

$$W \geq 0.1kupl^2 \frac{a}{80t} \quad [\text{cm}^3] \qquad (5.7.8.2)$$

where:

k = 9 for bulkheads of cargo holds;
k = 12 for other bulkheads,
k = 15 for collision bulkhead,
u – width of bulkhead member, [m];
p – pressure of water column extending from the midspan of not supported portion of member to the bulkhead deck, [kPa]; in vessels with continuous hatch trunk, water column extends to the upper edge of hatch coamings;
l – not supported length of member, (usually length of corrugated members), [m];
a, t – dimensions indicated in Fig. 5.7.8.2; to be taken to formula 5.7.8.2 in the same units.

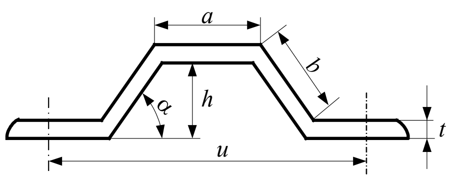


Fig. 5.7.8.2. Scantlings of corrugated bulkhead member with trapezoidal cross-section

5.7.8.3 For corrugated bulkhead member of trapezoidal cross-section and width equal to u, section modulus shall be determined in accordance with the formula below:

$$W = th(a + \frac{b}{6}) \quad [\text{cm}^3] \qquad (5.7.8.3)$$

where all the scantlings are in cm; for symbols – see Fig. 5.7.8.2.

5.7.9 Watertight Doors and Penetrations in Bulkheads

5.7.9.1 The number of doors in watertight bulkheads below the freeboard deck shall be limited to the minimum resulting from the design conditions and necessary for the safe operation of the vessel.

5.7.9.2 In watertight bulkheads, doors operated from both sides of a bulkhead shall be applied. The strength of doors shall be equal to that of the bulkhead.

5.7.9.3 Doors or manholes in the collision bulkhead are not permitted.

5.7.9.4 Doors closed by their own weight or by the falling mass are not permitted.

5.7.9.5 Penetrations through bulkheads, e.g. for pipes and electric cable transits shall be watertight. Transition of tiller ropes through watertight bulkheads shall be avoided. Where it is necessary, such penetrations shall be so made to maintain watertight integrity of the bulkhead.

5.8 Keel, Stem and Sternframe

5.8.1 Structure

Keel, stem and sternframe may be of welded construction, as well as cast steel, rolled steel or forged steel construction.

5.8.2 Bar Keel

5.8.2.1 Dimensions of the rectangular cross-section of bar keel shall not be less than determined in accordance with the following formulae:

– in self-propelled vessels

$$h = L+65 \text{ [mm] [mm]} \quad (5.8.2.1\text{-}1)$$

$$a = 0.4L+8 \text{ [mm] [mm]} \quad (5.8.2.1\text{-}2)$$

– in vessels with no motive power

$$h = L+50 \text{ [mm]} \quad (5.8.2.1\text{-}3)$$

$$a = 0.4\,L+5 \text{ [mm]} \quad (5.8.2.1\text{-}4)$$

where:
h – height of keel, [mm];
a – thickness of keel, [mm].

5.8.2.2 Bar keel segments shall be connected by butt welding.

5.8.3 Flat Keel

Thickness of flat keel in flat-bottomed vessels need not exceed the bottom shell thickness unless the vessel has slack bilge or significant rise of the bottom – in that case the flat keel thickness shall be increased by 1 mm against the bottom shell thickness.

In the case of keel thickening, keel width shall not be less than 0.1B.

5.8.4 Bar Stem

The dimensions of bar stem shall not be less than those of the bar keel. The stem connection to the bar keel or connection of its parts shall be made with butt weld.

5.8.5 Plate Stem

5.8.5.1 Plate stem of welded construction may be made from bent plates, whose thickness after processing shall not be less than determined in accordance with the formula below:

$$t = 0.05L+4 \text{ [mm]} \quad (5.8.5.1)$$

In the lower part, the stem shall extend at least 1 frame spacing into the straight portion of the bottom and – in each particular case – beyond the fore peak bulkhead.

5.8.5.2 The stem shall be strengthened with transverse brackets up to the height of 0.5 m above the waterline; spacing of the brackets shall not be greater than 0.6 m.

Thickness of the brackets shall be at least 75% of the thickness determined in accordance with formula 5.8.5.1. The brackets shall extend to the closest frame to which they shall be connected.

5.8.5.3 Butt welds shall be applied for mutual connection of the stem segments as well as to their connection to the plating.

5.8.6 Cast Steel Stem

5.8.6.1 Dimensions of a cast steel stem with solid cross-section shall not be less than those of the bar keel.

5.8.6.2 Thickness of stem with thin-walled cross-section, stiffened with brackets, at the connection to the plating shall not be less than calculated for the plate stem. Stem brackets shall be made as required in paragraph 5.8.5.2.

Stem construction shall have adequately large fillet radius and flare angle to enable easy access to connect it to the plating and hull longitudinal members.

5.8.6.3 In the plane of symmetry, stem thickness shall not be less than determined in accordance with the formula below:

$$t = 0.4L \quad \text{[mm]} \tag{5.8.6.3}$$

however need not be more than 20 mm.

5.8.7 Sternframe of Single-propeller Vessel

5.8.7.1 Dimensions of the propeller post specified in paragraphs 5.8.7.2 to 5.8.7.7 apply to the sternframe sole piece supporting the rudder stock bearing.

The dimensions of the propeller post of other sternframes may be reduced by 10%.

5.8.7.2 Above the boss plate, propeller post of the sternframe with solid rectangular cross-section shall not have less dimensions than determined in accordance with the following formulae:

$$a = 0.6L+10 \quad \text{[mm]} \tag{5.8.7.2-1}$$

$$b = L+60 \quad \text{[mm]} \tag{5.8.7.2-2}$$

where:
a – thickness of propeller post (measured perpendicularly to the plane of symmetry);
b – width of propeller post (measured parallel to the plane of symmetry).

Below the boss plate, propeller post with solid rectangular cross-section shall gradually transform into the sternframe sole piece.

5.8.7.3 Cross-section dimensions of a streamlined propeller post (Fig. 5.8.7.3) measured above the boss plate shall not be less than determined in accordance with the following formulae:

$$b = 30\sqrt{L} \quad \text{[mm]} \tag{5.8.7.3-1}$$

$$g = 0.4L+4 \quad \text{[mm]} \tag{5.8.7.3-2}$$

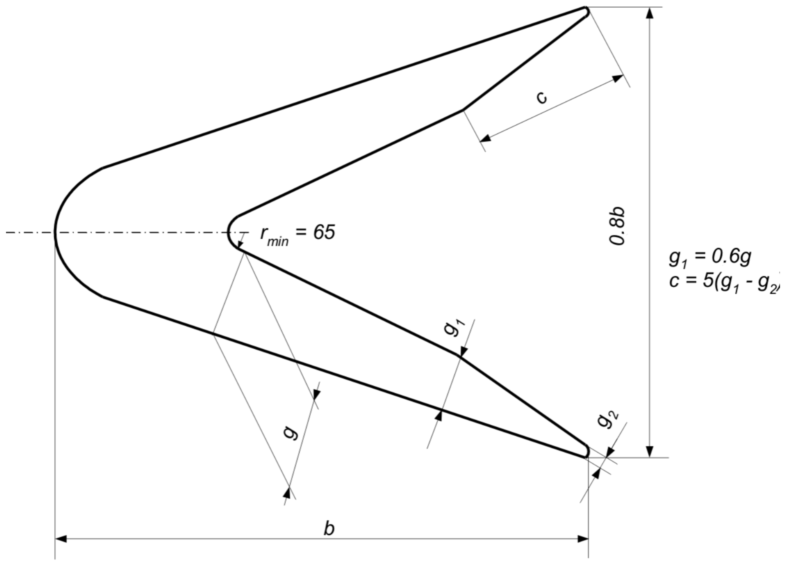


Fig. 5.8.7.3. Cross-section dimensions of propeller post

Length *c* of transition into the plating thickness shall be taken in accordance with the relevant requirements for transition in welding of elements with different thicknesses.

5.8.7.4 Cross-section dimensions of a streamlined propeller post measured above the boss plate shall ensure achievement of the section moduli greater than for the rectangular cross-section by at least by 20% (see paragraph 5.8.7.2).

5.8.7.5 Dimensions of a propeller post made by welding of plates (Fig. 5.8.7.5) shall not be less than determined in accordance with the following formulae:

$$b = 40\sqrt{L} \text{ [mm]} \qquad (5.8.7.5\text{-}1)$$

$$t = 1.4\sqrt{L} \text{ [mm]} \qquad (5.8.7.5\text{-}2)$$

Construction of the propeller post shall be as simple as possible, stiffened with brackets and have large fillet radii.

After the assembly, closed parts of the propeller post shall be subjected to tightness test and the inner surfaces shall be anti-corrosion treated.

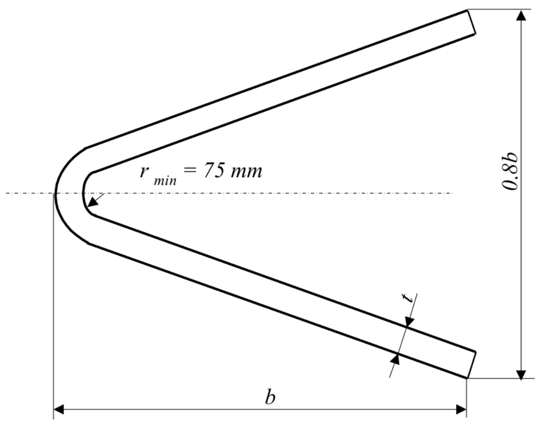


Fig. 5.8.7.5. Propeller post made by welding of plates

5.8.7.6 Where the round-bar construction is applied (Fig. 5.8.7.6), the bar diameter shall not be less than determined in accordance with the formula below:

$$d = 10\sqrt{L} \text{ [mm]} \quad (5.8.7.6)$$

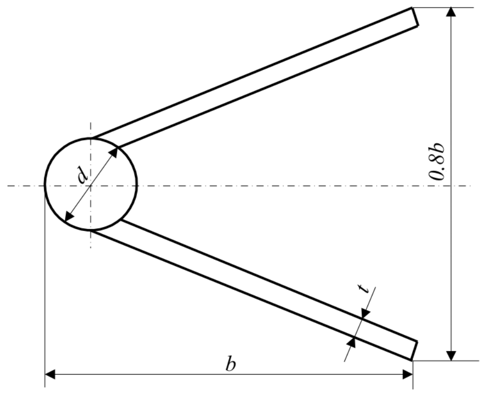


Fig. 5.8.7.6. Propeller post with round bar construction

Dimensions b and t shall be determined in accordance with formulae 5.8.7.5-1 and 5.8.7.5-2.

5.8.7.7 Section modulus of sternframe sole piece (Fig. 5.8.7.7) related to the vertical axis shall not be less than determined in accordance with the formula below:

$$W_y = 0{,}3Flv^2 \text{ [cm}^3\text{]} \quad (5.8.7.7)$$

where:

F – surface of projection of rudder and rudderpost, [m²];
l – distance from the axis of the rudder stock to the cross-section under consideration, however not less than half of the distance between the rudder axis and the after edge of the stern boss, [m];
v – loaded vessel speed, however not less than 10 km/h.

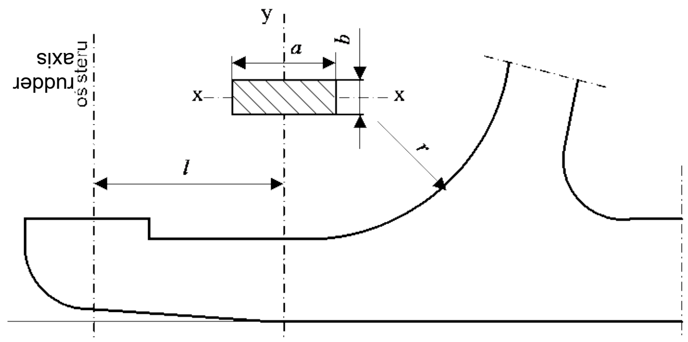


Fig. 5.8.7.7. Sternframe sole piece

Section modulus of the sternframe sole piece related to axis x–x shall not be less than $0.4W_y$. The sole piece height shall not be less than the thickness of propeller post with rectangular cross-section determined in accordance with formula 5.8.7.2-1.

5.8.7.8 Where sternframe with a sole piece is applied, the sole piece with the propeller aperture between the propeller post and the rudder post shall be as short as possible, whereas its lower edge is advisable to be so lifted that it runs above the lower edge of the keel.

The radius of fillet of the sternframe sole piece into the propeller post shall be as large as possible.

5.8.7.9 Lower part of the sole piece shall be extended fore, and its stiffeners shall be connected to at least three bottom floors – in the case of a sternframe with propeller aperture, and to at least two bottom floors or bulkhead – in the case of sternframe without propeller aperture.

5.8.7.10 Thickness of propeller post boss wall after machining shall be at least 60% of the propeller post cross-section width or 30% of the propeller shaft diameter, whichever is greater.

5.8.7.11 Dimensions of a rudder post with rectangular cross-section and with the propeller aperture shall not be less than determined in accordance with the following formulae:

$$a = 0.5L + 10 \quad \text{[mm]} \tag{5.8.7.11-1}$$

$$b = L + 45 \quad \text{[mm]} \tag{5.8.7.11-2}$$

In vessels with no motive power, the dimensions of a rudder post shall not be less than determined in accordance with the following formulae:

$$b = L + 35 \quad \text{[mm]} \tag{5.8.7.11-3}$$

$$a = 0.4L + 10 \quad \text{[mm]} \tag{5.8.7.11-4}$$

where:

a – thickness of rudder post, measured perpendicularly to the plane of symmetry;
b – breadth of rudder post, measured parallel with the plane of symmetry.

5.8.8 Sternframe of Twin-propeller Vessel, Propeller Shaft Brackets and Propeller Nozzle Brackets

5.8.8.1 Dimensions of sternframe with solid rectangular cross-section shall not be less than determined in accordance with formulae 5.8.7.11-3 and 5.8.11-4.

5.8.8.2 Lower part of sternframe shall be extended fore, and its stiffeners shall be connected to at least two bottom floors or bulkhead.

5.8.8.3 Propeller brackets may be of cast steel construction or steel welded construction.

5.8.8.4 Arms of two-armed brackets of propeller shafts shall form the angle 70°÷110°.

The axes of arms shall intersect on the propeller shaft axis. Cross-sectional area of each cast steel bracket arm shall be at least 60% of the propeller shaft cross-sectional area at the bracket plane, whereas the arm thickness – at least 45%, and the boss thickness – at least 35% of the shaft diameter.

Strength of the brackets of welded construction shall not be less than the strength of the above mentioned cast steel brackets.

5.8.8.5 Brackets shall be connected to bottom floors and girders inside the hull. Cross-sectional area of the weld fixing the arm to the hull shall not be less than double cross-sectional area of the arm.

Plating thickness in way of intersection of brackets shall be increased in accordance with paragraph 5.5.5.2.

5.8.8.6 Where propeller nozzles are applied, their supports shall be connected to bottom floors and girders.

Section modulus of the sternframe sole piece behind the nozzle shall not be less than determined in accordance with formula 5.8.7.7.

5.9 Deep Tanks

5.9.1 General Requirements

5.9.1.1 Domestic water and boiler water tanks shall be separated by cofferdams from fuel and lubricated oil tanks as well as from cargo tanks.

5.9.1.2 Fuel oil tanks shall be separated from refrigerated spaces and refrigerating machinery rooms by cofferdams. Cofferdam, however, may be waived provided that an air-gap of minimum 50 mm is arranged between the insulation and bulkhead plating.

5.9.1.3 Where fuel oil with the ignition temperature below 60°C is intended to be carried in deep tanks, their construction and arrangement is subject to PRS acceptance in each particular case.

5.9.1.4 Tanks intended for the carriage of vegetable oil shall be separated by cofferdams from tanks intended for any other liquids.

5.9.1.5 Cofferdam width shall not be less than frame spacing, however not less than 400 mm.

5.9.1.6 Fuel tanks, oil tanks and their fittings shall not be located directly above engines or exhaust pipes.

5.9.1.7 No fuel tanks and oil tanks may be located forward of the collision bulkhead.

5.9.1.8 The liquid-fuel or lubricant bunkers and passenger areas and accommodation may not have any common surfaces which are under the static pressure of the liquid when in normal service.

5.9.2 Wall Plating

5.9.2.1 Thickness of tank wall plating shall not be less than determined in accordance with the formula below:

$$t = 1.25a\sqrt{p} + 1 \ \text{[mm]} \qquad (5.9.2.1)$$

however not less than 4 mm;

where:

p – pressure determined according to 3.2.3.4 at the level of the lower edge of the plating;
a – frame spacing [m].

Formula 5.9.2.1 is also applicable to the corrugated bulkhead plating – in that case face plate width or web width shall be substituted for a (i.e. dimension a or b, see Fig. 5.7.8.2), whichever is greater.

5.9.2.2 Thickness of horizontal walls topping the tank shall not be less than the plating thickness in accordance with paragraph 5.9.2.1 and not less than the deck thickness required in sub-chapter 5.6.

5.9.2.3 If tank horizontal plating forms a part of deck, then the deck thickness in way of tank shall be increased by 1 mm over the values required in paragraph 5.9.2.1 and sub-chapter 5.6.

5.9.2.4 Tank walls shall be connected to the plating and to weather deck with double weld; deviation from this principle is subject to PRS acceptance in each particular case.

5.9.3 Stiffeners

5.9.3.1 Section modulus of tank wall stiffeners shall not be less than:
– for vertical stiffeners:

$$W = 0.4apl^2+3 \ \ [\text{cm}^3] \qquad (5.9.3.1\text{-}1)$$

– for horizontal stiffeners:

$$W = 0.5apl^2+3 \ \ [\text{cm}^3] \qquad (5.9.3.1\text{-}2)$$

where:
a – spacing of stiffeners, [m];
p – pressure determined according to 3.2.3.4 at the level of the midspan of vertical stiffener or axis of horizontal stiffener;
l – span of stiffener, [m].

Where stiffener ends cannot be considered as clamped, value W determined in accordance with formulae 5.9.3.1-1 and 5.9.3.1-2 shall be increased by 50%.

Formulae 5.9.3.1-1 and 5.9.3.1-2 are also applicable to corrugated bulkheads – in that case bulkhead element width shall be substituted for a (i.e. dimension u, see Fig. 5.7.8.2.).

5.9.3.2 Stiffeners shall be fixed at both ends, either by direct welding to the plating of the bottom, sides, longitudinal bulkheads or deck, or by brackets. Bracket side height shall not be less than 1/10 of the stiffener span, whereas the length shall be equal to frame spacing or stiffener spacing.

5.9.4 Girders

5.9.4.1 Vertical stiffeners of deep tanks whose height exceeds 2.7 m shall be strengthened with one horizontal girder situated at the midheight of the tank.

The span of horizontal stiffeners shall also not be greater than 2.7 m. To fulfil this condition, vertical girders connected to the bottom members or stiffeners of the bottom and deck.

Height of the girder web shall not be less than double height of frames or vertical stiffeners of bulkheads, whereas its thickness – not less than that of stiffeners.

5.9.4.2 Girders shall be provided with brackets at their corners; thickness of brackets shall be equal to that of stiffener web. Bracket arm length shall be equal to the web height.

5.9.4.3 In the lower portion of girders inside tanks, limber holes shall be provided.

5.9.5 Tank Beams

5.9.5.1 Section modulus of the deck beam of tank upper horizontal cover shall not be less than determined in accordance with the formula below:

$$W = 5ahl^2+3 \ \ \ [\text{cm}^3] \qquad (5.9.5.1)$$

where:
a – spacing of deck beams [m];
l – span of deck beam [m];
h – vertical distance between tank upper horizontal cover and spill pipe top, [m], however not less than 0.5 m.

5.9.5.2 Where the tank upper horizontal cover forms a part of deck, section modulus of the deck beam shall not be less than determined in accordance with formula 5.6.7.1.

5.10 Hatchways, Machinery Casings and Deck Openings

5.10.1 General

All cuts in decks shall be framed with coamings or walls of trunks, companionways, skylights etc. Coamings and closing appliances of hatches, manholes and doors shall fulfil the requirements specified in *Part III – Hull Equipment* and *Part IV – Stability and Freeboard*. Deck openings shall be so arranged as not to hamper movement of the crew.

5.10.2 Types of Cargo Hatchways

The following types of cargo hatches are distinguished: separated and concentrated, whose coamings form one common hatch trunk above all the cargo holds. The trunk, as a continuous fore-and-aft structure is a counterpart of the strength superstructure.

5.10.3 Cargo Hatchway Coamings

5.10.3.1 Height of continuous fore-and-aft coamings of the hatch trunk measured from the upper edge of deck (deck strake) shall not be less than:
250 mm for vessels with length $L \le 25$ m,
700 mm for vessels with length $L \ge 50$ m.

For intermediate lengths, the coaming height shall be determined by linear interpolation. [*Thickness of side coamings shall not be less than the greater out of the following values:*
– *deck strake thickness as required in paragraph 5.6.1.1, increased by 1 mm,*
– *thickness determined in accordance with the formula below:*

$$t = (2.50 - 2.14n)(9\delta - 6.98)(0.1L + 0.5B) \quad [mm] \qquad (5.10.3.1)$$

where:
n – *ratio of combined length of all cargo holds to the length of vessel L;*
δ – *block coefficient.]*

Lower edges of cargo hatch coamings shall be so arranged to avoid tripping of the cargo handling gear tackle.

5.10.3.2 *[Design thickness of the hatch side coaming in self-propelled vessels shall be maintained throughout the distance of 0.7L from the aft perpendicular; outside that region it may be gradually reduced to 80% of the design thickness.]*

5.10.3.3 *[Where the hatch side coaming height is less than required in paragraph 5.10.3.1, its thickness shall be so increased that the cross-sectional area of the hatch side coaming will fulfil the requirements specified in paragraph 5.10.3.1.]*

5.10.3.4 *[Increasing the hatch side coaming height above the value required in paragraph 5.10.3.1 cannot justify reduction of its thickness.]*

5.10.3.5 *[Where the hatch side coaming height is 700 mm or more, the upper strake of coaming (with at least 250 mm in height) shall have its thickness increased by 50% against the value required in paragraph 5.10.3.1.]*

5.10.3.6 *[Upper part of the coaming shall be stiffened with a rolled profile with the cross-sectional area not less than determined in accordance with the formula below:*

$$A = \frac{Lt}{15} \quad [cm^2] \qquad (5.10.3.6)$$

where:
t – *thickness of coaming as determined in paragraph 5.10.3.1*.]

5.10.3.7 In the place of each web frame and each transverse bulkhead as well as between these structural elements, plate supports connecting the deck to the coaming and to its horizontal stiffener shall be applied with the spacing not greater than 6 frame spacings. The support web thickness shall not be less than 0.7 of the coaming thickness [*determined in accordance with paragraph 5.10.3.1.]* The face plate width shall not be less than 15 thicknesses of the coaming and the thickness not less than the coaming thickness. In way of a bulkhead ended, at its top, with a case structure situated within the hatch trunk, coaming supports need not be applied.

5.10.3.8 Hatch trunk side coamings shall be led, with their ends, into the walls of deck houses maintaining their full height.

Where this is impracticable, girders – whose dimensions are determined in paragraph 5.6.11 – shall be made under the deck in the planes of coamings; particularly in self-propelled vessels attention shall be paid to the continuity of longitudinal members in way of the hatch after end.

5.10.3.9 *[Transverse end coamings of trunk hatches not penetrating a deck house shall be made from plates of the thickness not less than determined in accordance with the formula below:*

$$t = 0.5B + 3 \quad [mm] \qquad (5.10.3.9\text{-}1)$$

Transverse coamings shall be stiffened with the horizontal angle bar [of the cross-sectional area not less than determined in accordance with the formula below:

$$A = \frac{Bt}{4} \quad [cm^2] \qquad (5.10.3.9\text{-}2)$$

where:
t – thickness of transverse coaming determined in accordance with formula 5.10.3.9-1.]

Pillars supporting the transverse coaming shall be situated with the spacing not exceeding 4 m.

5.10.4 Sheer Strake Beams and Supporting Beams

5.10.4.1 Individual hatches within the hatch trunk shall be separated by beams strutting hatch side coamings. For this purpose, the following elements may be applied:

- **.1** transverse casing structures;
- **.2** permanent beams;
- **.3** portable beams.

These elements shall be situated in planes of watertight bulkheads or equivalent frameworks, preferably so that their lower horizontal plate elements are situated as extension of the deck strake.

5.10.4.2 *[Section modulus in the midspan of the strutting beam, related to the horizontal axis, shall not be less than determined in accordance with the formula below:*

$$W_x = apb^2 \quad [cm^3] \qquad (5.10.4.2)$$

where:

a – spacing of strutting beams, [m];
b – hatch breadth, [m].
p – design load of hatch covers, [kPa], however not less than 1.5 kPa.

Section modulus of the strutting beam, related to the vertical axis, shall not be less than $0.8W_x$.]

5.10.4.3 *[For hatch longitudinal girders supporting loose hatch covers, the section modulus of the strutting beam, related to the horizontal axis, shall not be less than determined in accordance with the formula below:*

$$W_x = 0.25apb^2 \ [cm^3] \qquad (5.10.4.3)$$

where:

a – *spacing of strutting beams, [m];*
p – *design load of hatch covers, [kPa], however not less than 1.5 kPa;*
b – *hatch breadth, [m].*]

5.10.4.4 *[Thickness of the strutting beam walls or webs shall not be less than calculated in accordance with the formula below:*

$$s = 0.7\sqrt{L} \ [mm] \qquad (5.10.4.4)$$

however not less than 4 mm.]

5.10.4.5 Hatch sockets shall be carefully connected to the members of both hatch as well as deck and so arranged that the interface pressure does not exceed 90 MPa.

5.10.4.6 *[Where only one supporting girder is applied in the hatch axis of symmetry, its section modulus shall not be less than determined in accordance with the formula below:*

$$W = 0.4pbl^2 \ [cm^3] \qquad (5.10.4.6)$$

where:

p – *as in paragraph 5.10.4.3;*
b – *as in paragraph 5.10.4.3;*
l – *not supported length of the supporting girder, [m].*]

5.10.5 Separate Hatchways' Coamings

5.10.5.1 Height of the separate cargo hatch coamings (measured from the deck) shall not be les than 250 mm in vessels engaged on voyages in operating areas 2 and 3, and 300 mm – in vessels engaged on voyages in operating area 1.

5.10.5.2 *[Thickness of hatch coamings shall not be less than that of deck strake.]*

5.10.5.3 The upper edge of hatch coamings shall be stiffened with a rolled profile, and the coamings themselves – with vertical cantilevers.

5.10.5.4 *[Where hatch side coamings are supported by hatch end beams, the section modulus of that beam shall not be less than determined in accordance with the formula below:*

$$W=0.4pl(B^2-b^2) \ [cm^3] \qquad (5.10.5.4)$$

where:

p – *design pressure on the deck and hatch cover, not less than 3 kPa;*
l – *length of hatch, [m];*
b – *breadth of hatch, [m].*]

5.10.5.5 Hatch coamings which play the role of deck girders in accordance with sub-chapter 5.6.11 as well as hatch end coamings situated in the planes of transverse deck girders or hatch-end beams shall extend under the deck as deep as required for deck girders and shall be provided with the horizontal stiffener in the form of flange or face plate.

5.10.5.6 Hatch side coamings, situated amidships, whose lower portion does not form a deck girder shall extend under the deck to the depth not less than the deck beam depth, and they shall also extend under the deck for the distance at least two frame spacings beyond the hatch end coaming and be provided with a horizontal stiffener in the form of flange or face plate. Hatch end coamings situated beyond the planes of transverse deck girders or hatch-end beams shall extend under the deck as deep as at least the depth of deck beams and shall be provided with the horizontal stiffener as required above for hatch side coamings.

5.10.6 Coaming Hatchway Covers

5.10.6.1 Steel hatch covers in the form of segments with their axis orientated transversely to the plane of symmetry and supported by the side hatch coamings shall be made from plates with at least 2.0 mm in thickness. The cover section modulus shall not be less than determined in accordance with the formula below:

$$W = 1.3bpl^2 \ \text{[cm}^3\text{]} \qquad (5.10.6.1\text{-}1)$$

whereas the moment of inertia shall not be less than:

$$I = 1.5bpl^3 \ \text{[cm}^4\text{]} \qquad (5.10.6.1\text{-}2)$$

where:
b – breadth of cover, [m];
l – not supported length of cover, [m];
p – design specific load of covers, not less than 1.5 kPa.

In the calculation of the section modulus, the whole breadth of the covers b may be taken into account as the effective strake of plating.

5.10.6.2 Covers made from corrugated galvanised plate shall have a thickness not less than 1.5 mm and fulfil the requirements specified by formulae 5.10.6.1-1 and 5.10.6.1-2.

5.10.6.3 Covers shall be protected against shifting and they shall protect the cargo hold from rain, snow and water splashes.

5.10.7 Flush Deck Hatchways

Hatches without coamings may be applied on the upper deck for bunkers and store-rooms. Covers of such hatches shall have closing arrangements ensuring watertightness and operating comfort. Construction of the hatch cover shall ensure the same local strength as the deck in way of the hatch.

5.10.8 Trunks, Skylights, Companionways and Manholes

5.10.8.1 Coamings of trunks, skylights, companionways and manholes shall fulfil the construction requirements concerning coamings of separate cargo hatches specified in paragraphs 5.10.5.1, 5.10.5.4, 5.10.5.5 and 5.10.5.6 whereas closing appliances – the requirements specified in paragraph 5.10.6 or 5.10.7, respectively. Additionally, particular requirements contained in *Part IV – Stability and Freeboard* shall be taken into account.

5.10.8.2 The requirements specified in 5.10.5.5 and 5.10.5.6 need not be applied for deck openings whose area does not exceed 2 m^2, and the coamings do not cut deck girders or transverse girders and the coamings are not tangential to those girders.

Coamings of such openings shall be led to the lower edge of transverse girders.

Section modulus of stiffeners shall not be less than determined in accordance with the formula below:

$$W = 2.8al\sqrt{L} \ \text{[cm}^3\text{]} \qquad (5.10.8.2)$$

where:
a – spacing of stiffeners, [m];
l – not supported length of trunk, [m].

5.10.9 Side Openings

5.10.9.1 Where side openings are applied for communication and cargo handling, they shall be properly framed and provided with steel watertight doors, side ports or lids possible to be operated and secured from inside the hull.

5.10.9.2 Construction of side doors, ports and lids shall fulfil the requirements specified in *Part IV – Stability and Freeboard* and shall be of type approved by PRS. Their strength shall not be less than the side strength in that region.

5.11 Superstructures and Deckhouses

5.11.1 General

The requirements specified in sub-chapter 5.11 apply to superstructures and deckhouses with the length not exceeding 0.2L.

5.11.2 Deck Plating

5.11.2.1 *[Thickness of deck plating of a single-tier superstructure and the plating of the lowest deck of a multi-tier superstructure shall not be less than specified in paragraph 5.6.3.2.]*

5.11.2.2 *[Thickness of plating of the higher decks of a multitier superstructure shall not be less than determined in accordance with the formula below:*

$$t = \sqrt[3]{L} + 1 \text{ [mm]} \qquad (5.11.2.2)$$

The applied thickness need not be greater than the required in paragraph 5.6.3.1 for the strength deck (formula 5.6.3.1-1).

Thickness of weatherdecks covered in accordance with sub-chapter 5.6.4, lower decks and closed decks may be less than determined in accordance with formula 5.11.2.2 by 1 mm, however not less than 3 mm.]

5.11.2.3 In way of fixing deck machinery and equipment, local strengthenings of both deck plating and stiffeners shall be provided.

5.11.3 Deck Beams

The required section moduli of deck beams shall be determined in accordance with formula 5.6.7.1.

5.11.4 Deck Girders

Section moduli of deck girders shall be taken not less than determined in accordance with formula 5.6.9.3, taking values of p in accordance with 5.6.7.1.

5.11.5 Superstructure Walls and Deckhouse Walls

5.11.5.1 Thickness of walls of superstructures and deckhouses specified in paragraph 5.11.1 shall not be less than determined in accordance with the formula below:

$$t = a(0.05L+4) \text{ [mm]} \qquad (5.11.5.1)$$

where: a – spacing of stiffeners, [m]

and shall not be less than 3 mm.

Thickness of walls and internal divisions may be less by 1 mm, however it shall not be less than 2.0 mm.

5.11.5.2 Section modulus of stiffeners of the outside walls shall not be less than 70% of the modulus determined in accordance with formula 5.4.2.1-2.

Thickness of stiffeners shall be greater than the thickness of walls of the superstructures by at least 0.5 mm.

5.11.5.3 It is recommended that the spacing of stiffeners not exceed 600 mm.

5.11.5.4 Doorsteps and external doors shall fulfil the requirements specified in *Part IV – Stability and Freeboard*.

5.11.6 Aluminium Alloy Deckhouses

5.11.6.1 Aluminium alloys used for construction of deckhouses shall fulfil the requirements specified in the *Rules for Classification and Construction of Sea-going Ships, Part IX – Materials and Welding.*

5.11.6.2 Thickness of plating may be the same as that of steel deckhouses. For the spacing of stiffeners and deck beams greater than 500 mm, the thickness of plating shall be increased in proportion to their actual spacing.

5.11.6.3 Section modulus of each vertical stiffener and deck beam shall not be less than determined in accordance with the formula below:

$$W_{Al} = \frac{190}{R_{eAl}} W \qquad (5.11.6.3)$$

where:
$W_{Al.}$ – section modulus of aluminium alloy structural member;
$R_{eAl.}$ – yield point of aluminium alloy in soft condition (recristalised or hot rolled), [MPa]; taken value shall not exceed $0.7R_m$ (R_m – tensile strength);
W – modulus required for structural member from steel with yield point R_e = 235 MPa.

5.11.6.4 Aluminium alloy structures subjected to concentrated compressive forces are subject to PRS acceptance in each particular case.

5.11.7 Connection of Aluminium Alloy Structures with Steel Structures

5.11.7.1 On surfaces of contact between steel structures and aluminium alloy structural members an insulating material or other arrangement shall be provided to prevent corrosion.

5.11.7.2 Insulating material and connecting method are subject to PRS acceptance in each particular case.

5.11.8 Superstructures and Deckhouses over Engine Room

Section moduli of deck beams and wall stiffeners in superstructures and deckhouses situated over the machinery room shall be increased by 20% against the values resulting from the requirements specified in the previous paragraphs of sub-chapter 5.11.

6 ICE STRENGTHENING

6.1 Ice Class L1

6.1.1 Stem

6.1.1.1 Dimensions of bar stem determined in accordance with sub-chapter 5.8.4, shall be increased by at least 15%.

6.1.1.2 If the stem is made from bent plates, then thickness of the plates shall be increased, against the bottom shell plating amidships by 30%, up to the height of 500 mm above the load waterline. Stem construction shall be such that its transverse brackets required in paragraph 5.8.5.2 can be connected to the side stringers required in paragraphs 5.4.6.1, 5.4.6.3 and 6.1.6.1.

6.1.2 Rudder Stock

6.1.2.1 Cross sectional area of the rudder stock shall be greater than determined in *Part III – Hull Equipment* by 15%. Strength of all steering gear components shall correspond to that of the strengthened rudder stock.

6.1.2.2 In single-propeller vessels without shaft tunnel, ram shall be provided on the rudderpost or in way of the lower part of the buttocks to protect the rudder stock.

6.1.3 Plating

6.1.3.1 Thickness of plating panels from the stem aftwards, up to the place where the load waterline reaches its maximum, shall be increased against the plating thickness amidships by 25%; this increase, however, shall not be less than 2 mm.

6.1.3.2 The strake of thickened side shell plating shall extend from at least 500 mm below the light vessel waterline to at least 500 mm above the load waterline.

6.1.3.3 If any portion of the bottom is at the distance less than 500 mm below the light vessel waterline, then the bottom plating thickness shall be increased in accordance with paragraph 6.1.3.1, and the bottom members shall be strengthened respectively.

6.1.3.4 Plating thickness shall decrease gradually, and the difference in thickness between the adjacent panels shall not exceed 2 mm.

6.1.4 Frames

Frames of fore and after peaks shall have the same section moduli as the frames amidships.

6.1.5 Intermediate Frames

6.1.5.1 Intermediate frames shall be applied from the stem up to the place where the load waterline reaches its maximum breadth.

6.1.5.2 Section modulus of intermediate frames shall not be less than 75% of that of frames amidships. Lower ends of intermediate frames shall extend below the upper ends of bottom floors, whereas the upper ends of intermediate frames shall extend at least 600 mm above the load waterline and be connected to the frames by an appropriate longitudinal strengthening. If intermediate frames extend to the deck, their connection to the deck is not required.

6.1.5.3 Intermediate frames are not required where the frame spacing does not exceed 0.7 of the frame spacing amidships.

6.1.6 Side Stringers

6.1.6.1 Vessels with single deck shall have a side stringer at the height 200÷300 mm below the load waterline. The side stringer shall extend from the stem to the place situated at the distance of four frame spacings aftwards behind the point where the vessel reaches its maximum breadth on the load waterline. Scantlings of the side stringer shall be determined in accordance with sub-chapter 5.4.6.

6.1.6.2 Where the side stringer required in sub-chapter 5.4.6 fulfils the requirements specified in paragraph 6.1.6.1 in respect of its position, application of the additional side stringer for ice strengthening is not required.

6.1.6.3 Side stringer may extend only to the collision bulkhead if intermediate frames have the same section modulus as the frames amidships.

6.2 Ice Class L2

6.2.1 Stem

6.2.1.1 Scantlings of the bar stem determined in accordance with the requirements specified in sub-chapter 5.8.4 shall be increased by at least 10%.

6.2.1.2 Up to the height of 500 mm above the load waterline, thickness of stem made from bent plates shall not be less than plating thickness in way of the strengthened bow determined in accordance with paragraph 6.1.3.1.

6.2.1.3 Stem shall be strengthened by brackets in accordance with paragraph 6.1.1.2.

6.2.2 Plating

6.2.2.1 Thickness of plating panels in the forebody shall be greater than plating thickness amidships by 25%; thickening of plating is required in the region extending from the stem aftwards for the distance equal at least the breadth of vessel.

Strengthened plating shall include the strake of the width specified in paragraph 6.1.3.2. The scope of strengthening need not be greater than required for mark L1.

6.2.3 Intermediate Frames

6.2.3.1 Intermediate frames shall be applied from the stem to the place where the load waterline reaches its maximum breadth.

6.2.3.2 Section modulus of intermediate frames shall not be less than 75% of the section modulus of the frames amidships.

7 ADDITIONAL REQUIREMENTS CONCERNING PARTICULAR VESSEL TYPES

In Chapter 7, as a rule the requirements written within square brackets do not apply to ships whose hulls are designed using direct strength calculations, i.e. according to the requirements of Chapter 3.

7.1 Double Hull Pushed Barges

7.1.1 Application

7.1.1.1 Requirements specified in sub-chapter 7.1 apply to pushed barges with double-side skin and double bottom construction where transverse framing system or combined framing system – i.e. transverse for the bottom and longitudinal for other walls (design patterns are shown in Fig. 7.1.1.1) – is applied.

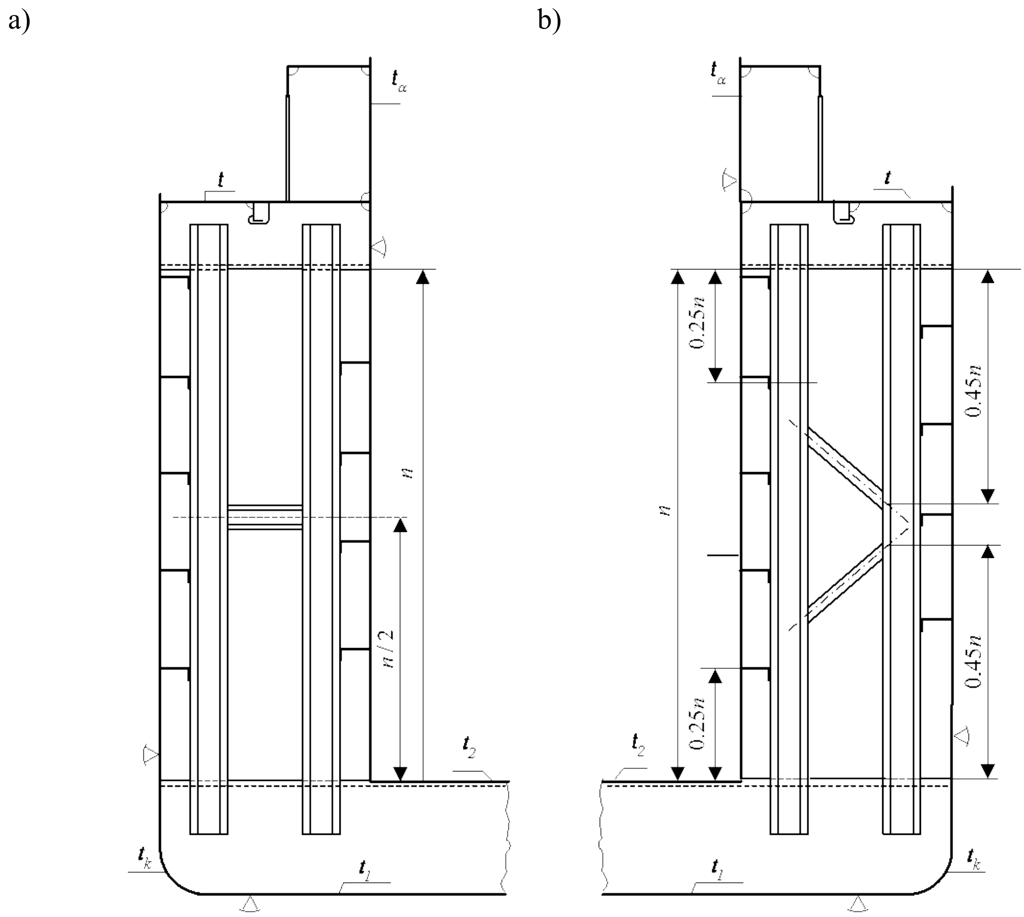


Fig. 7.1.1.1. Typical stiffening system in double-hull barges

Hulls with longitudinally stiffened bottom are subject to PRS approval in each particular case – on the basis of direct strength calculations as required in Chapter 3.

The requirements included in box brackets do not apply to those barges whose hulls have been designed by direct strength calculations, i.e. in compliance with the requirements specified in Chapter 3.

7.1.1.2 [The formulae specified in sub-chapter 7.1 apply to the values of block coefficient $\delta = 0.85 \div 0.92$ and the ratio of cargo hold length measured at the deck to the length of barge $l/L \geq 0.85$.

Application of the members' scantlings resulting from those formulae generally enables the design of a barge with the strength which is possible to be loaded and unloaded continuously, beginning from either end.]

7.1.2 Hull Shell Plating

7.1.2.1 [Thickness of outer bottom plating amidships shall not be less then determined in accordance with the formula below:

$$t_1 = \frac{a}{43}(0.1L + 5.5)(36 + B)\ [mm] \qquad (7.1.2.1)$$

where:

a – frame spacing, [m], however not less than 0.4 m.]

7.1.2.2 *[Thickness of side shell plating amidships shall not be less than the inner bottom plating thickness determined in accordance with paragraph 7.1.2.1 – for longitudinal side framing system, and not less than determined in accordance with paragraph 7.1.2.1 increased by 10% – for the transverse system.]*

7.1.2.3 *[Thickness of outer bottom plating and side shell plating outside amidships shall not be less than determined in accordance with the formula below:*

$$t = 6.5\sqrt{T_1}\ [mm] \qquad (7.1.2.3)$$

where:

T_1 – maximum draught of strake of plating under consideration, [m]
a – see paragraph 7.1.2.1.]

7.1.2.4 Scantlings of the bilge strake shall be determined in accordance with paragraphs 5.5.1.4 and 5.5.1.5.

7.1.2.5 *[Thickness of bottom plating and side shell plating outside amidships may be reduced in accordance with paragraph 5.5.1.7.]*

7.1.2.6 Thickness of [*transom plating shall be taken in accordance with paragraph 5.5.1.8, and*] their rounded edges – in accordance with paragraph 5.5.5.3.

7.1.2.7 *[Scantlings of the sheer strake shall be taken for the whole longitudinal perimeter of the barge as not less than resulting from the formulae below:*

$$b = 0{,}1H\ \ [m] \qquad (7.1.2.7\text{-}1)$$

$$t = 2{,}2\sqrt{L}\ \ [mm] \qquad (7.1.2.7\text{-}2)$$

where:
b – breadth of sheer strake, [m];
t – thickness of sheer strake, [mm].

Thickness of sheer strake may be equal to the side shell plating thickness, if the side is stiffened, by the side stringer with the section modulus twice as great as determined in accordance with formula 7.1.5.5, at the distance not exceeding 300 mm from the sheer strake.]

7.1.3 Deck Plating

7.1.3.1 [Thickness of the deck stringer with the deck longitudinal, amidships, shall not be less than determined in accordance with the formula below:

$$t = \frac{(0{,}12L+4{,}5)(48+B)(28{,}5-H)}{1850}\ \ [mm] \qquad (7.1.3.1)$$

and this formula applies to the deck stringer with 0.105B in breadth.]

7.1.3.2 *[Thickness of the deck stringer transversely stiffened shall be increased by 15% against the value determined in accordance with formula 7.1.3.1.]*

7.1.3.3 *[Thickness of the deck stringer outside amidships may be gradually reduced to:*

$$t = 0.95\sqrt{L}\ [mm].] \qquad (7.1.3.3)$$

7.1.3.4 *[If the breadth of deck stringer is less than 0.105B, its thickness shall be so increased that the cross-sectional area determined by breadth 0.105B and by thickness determined in accordance with paragraph 7.1.3.1 is maintained. Deck stringer with less than 0.08B in breadth shall not be applied.]*

7.1.3.5 *[For breadth of deck stringer exceeding 0.105B, its thickness may be reduced in proportion to the coefficient below:*

$$K = \sqrt{\frac{b}{b_1}} \qquad (7.1.3.5)$$

where:
b_1 – *actual breadth of sheer strake [m];*
b – *0.105B [m].*]

7.1.4 Inner Plating

7.1.4.1 Thickness of inner bottom shall not be less than outer bottom thickness determined in accordance with paragraph 7.1.2 taking into account additions specified in paragraph 5.3.7.2.

7.1.4.2 *[Thickness of transverse and longitudinal walls of cargo holds shall not be less than determined in accordance with the formula below:*

$$t = 1.77a(0.082L + 2.5) \text{ [mm]} \qquad (7.1.4.2)$$

where:
a – *spacing of stiffeners, [m], however not less than 0.5 m.*]

If loading operations are intended to be performed with heavy grabs, the value of t determined in accordance with the above formula shall be increased by 1.5 mm.

7.1.5 Watertight Bulkheads

7.1.5.1 Inner transverse walls of cargo holds may be considered as collision bulkheads or after peak bulkheads, where their distance from the fore or after perpendicular is not greater than 0.1L in the case of raised outer bottom, and not greater than 0.05L in the case of horizontal outer bottom.

End bulkheads (collision bulkhead and after peak bulkhead required in paragraphs 5.7.1.1 and 5.7.1.3) of barge may be waived where the forebody and afterbody are strengthened properly.

The fore end bulkhead shall be so located as to ensure compliance with the buoyancy criteria specified in 5.7.1.1.

Strengthened forebody or afterbody shall endure a head-on collision with the energy 2.5 times as great as the equivalent barge, provided with the collision bulkhead and after peak bulkhead, constructed in accordance with the requirements contained in these Rules.

7.1.5.2 In order to consider the end walls of cargo holds as collision bulkheads or after peak bulkheads, additional watertight bulkheads in their interside and interbottom spaces shall be constructed. Members of such an equivalent combined collision bulkhead shall fulfil the requirements specified in sub-chapter 5.7.

7.1.5.3 Intermediate bulkheads separating cargo holds, as required in sub-chapter 5.7.2, need not be constructed. However, partial watertight bulkheads, dividing interside and interbottom spaces at the distance of 0.15L from the ends of the cargo holds, shall be constructed.

7.1.5.4 Where the bulkheads separating cargo holds are constructed, the bulkheads shall fulfil the requirements specified in sub-chapter 5.7 taking into account the dimensions between the inner plating.

The applied thickness of plating shall also fulfil the requirements specified in paragraph 7.1.4.2, whereas the section modulus of stiffeners – the requirements specified in paragraphs 7.1.5.5 to 7.1.5.7.

7.1.5.5 *[Section modulus of longitudinal stiffeners of the side walls of cargo holds shall not be less than determined in accordance with the formula below:*

$$W = 10al^2(1 + \frac{L}{200})\ [cm^3] \qquad (7.1.5.5)$$

where:
a – spacing of stiffeners, [m];
l – span of stiffeners, [m].]

Where cargo loading operations are performed with heavy grabs, the value of *W* shall be twice as great as determined in accordance with the above formula.

7.1.5.6 *[Section modulus of transverse stiffeners of the side walls of cargo holds shall be greater than determined in accordance with formula 7.1.5.5 by 50%.]*

7.1.5.7 *[Section modulus of vertical stiffeners of the bulkheads between cargo holds and end walls of cargo holds shall not be less than determined in accordance with the formula below:*

$$W = 10al^2\ [cm^3].] \qquad (7.1.5.7)$$

Where cargo loading operations are performed with heavy grabs, the value of *W* shall be twice as great as determined in accordance with the above formula.

7.1.6 Hatchway Coamings

7.1.6.1 [It is recommended that the height of hatch trunk coamings be not less than 700 mm.]

7.1.6.2 *[Thickness of the hatch trunk coaming shall not be less than 90% of the deck strake thickness determined in accordance with paragraph 7.1.3.1 and not less than thickness of the internal walls of the cargo holds determined in accordance with paragraph 7.1.4.2.]*

7.1.6.3 *[Where the height of coaming is greater than 700 mm, its thickness shall be increased against the value required in paragraph 7.1.6.2 using the coefficient below:*

$$k = \frac{h}{700} \qquad (7.1.6.3)$$

where:
h – actual height of coaming, [mm].]

7.1.6.4 Where the height of coaming is less than 700 mm, its thickness shall not be less than the value required in paragraph 7.1.6.2.

7.1.6.5 *[Upper edge of the hatch coaming shall be stiffened by the continuous profile or profiles with the combined cross-sectional area A not less than determined in accordance with the formula below:*

$$A = \frac{0.58Bt}{h}\ [cm^2] \qquad (7.1.6.5)$$

where:
t – thickness of coaming, [mm];
h – height of coaming, [m].]

7.1.7 Ice Strengthening

7.1.7.1 In hulls with ice strengthening marked with L1, the shell plating shall be thickened by 40%, against the shell plating thickness amidships, in the region specified in paragraphs 6.1.3.1 and 6.1.3.2.

7.1.8 Double Bottom Members

7.1.8.1 [Thickness of the bottom centre girder shall not be less than specified in paragraph 5.3.3.2 and not less than determined in accordance with the formula below:

$$t = 0.85\sqrt{L}\ [mm].] \qquad (7.1.8.1)$$

7.1.8.2 *[Thickness of the bottom floors shall not be less than specified in paragraph 5.3.5.2 and not less than determined in accordance with the formula below:*

$$t = 0.3\sqrt{h}\ [mm] \qquad (7.1.8.2)$$

where:
h – *height of bottom floor, [mm].*

In barges intended for the carriage of ores, bottom floors shall be stiffened, with the pitch not greater than 2 m, by flat bars with the dimensions $t \times \frac{h}{6}$ *(t – thickness of floor: h – height of floor). Ends of those stiffeners shall be welded to the outer bottom plating and – if practicable – also to the inner bottom plating.*]

7.1.9 Bottom in Fore Peak and After Peak

7.1.9.1 In fore and after peaks, single bottom members shall be connected to the collision bulkhead and the inner bottom structure by brackets coplanar with the longitudinal members of the bottom or inner bottom plating.

7.1.9.2 Bottom floors or bottom longitudinals in fore and after peaks shall have the section modulus not less than determined in accordance with the formula below:

$$W = 10aHl^2\ [cm^3] \qquad (7.1.9.2)$$

where:
l – not supported span of member, [m], however not less than $B/4$;
a – spacing of bottom members, [m].

7.1.10 Frames

7.1.10.1 [Section modulus of transverse frames shall not be less than determined in accordance with the formula below:

$$W = 2{,}8a(H^3+0{,}13B^2)\ [cm^3].] \qquad (7.1.10.1)$$

7.1.10.2 *[Section modulus of longitudinal frames shall not be less than determined in accordance with the formula below:*

$$W = 15al^2\left(1+\frac{L}{200}\right)\ [cm^3] \qquad (7.1.10.2)$$

where:
a – *spacing of longitudinal frames, [m];*
l – *span of longitudinal frames, [m].*]

7.1.11 Transverse Frames

7.1.11.1 Where longitudinal framing system is applied for sides and side walls of cargo holds, it is recommended that the divisions in the form of transverse frames with manholes supporting the stiffeners of the sides and side walls of cargo holds be applied.

Application of the structure supporting longitudinal stiffeners of the sides and side walls of cargo holds in the form of transverse frames with the construction formed by rolled profiles adherent to the frames or stiffeners (Fig. 7.1.1.1) is permitted. Spacing of such divisions or frames shall not be greater than 3 m.

7.1.11.2 *[Section modulus of the vertical element of frame, mentioned in paragraph 7.1.11.1, shall not be less than determined in accordance with the formula below:*

$$W = 9u(H-h)^2 \frac{T}{H} \ [cm^3] \qquad (7.1.11.2)$$

where:
u – *spacing of transverse frames, [m];*
h – *height of bottom floor, [m].*]

7.1.11.3 In the middle of height H, web profiles supporting frames and longitudinal stiffeners mentioned in paragraph 7.1.11.1, shall be connected by a horizontal strut [*with the cross-sectional area not less than determined in accordance with the formula below:*

$$f = uH^2 \ [cm^2] \qquad (7.1.11.3)$$

]

(see Fig. 7.1.1.1a).

7.1.11.4 *[Under the deck, vertical members of the frames mentioned in paragraph 7.1.11.1, shall be connected by the transverse girder with the section modulus not less than determined in accordance with the formula below:*

$$W = 8ubH^2 \ [cm^3] \qquad (7.1.11.4)$$

where:
b – *breadth of deck strake, [m].*]

7.1.11.5 *[Where transverse bulkheads (or strutting beams) are not applied in accordance with paragraph 5.7.2, the section modulus of the cross-section of the vertical member of frame determined in accordance with formula 7.1.11.2 shall be increased by 50% and the vertical members of frame shall be connected by diagonal strutting beams in accordance with Fig. 7.1.1.1b. The cross-sectional area of diagonal strutting beam shall not be less than determined in accordance with formula 7.1.11.3.]*

7.1.12 Deck Beams

7.1.12.1 Section moduli of deck beams shall not be less than determined in accordance with sub-chapter 5.6.7 at the assumption that grabs are used for loading and unloading operations.

7.1.13 Other Members

7.1.13.1 Minimum scantlings of other members not mentioned in this Chapter shall be determined in accordance with the requirements specified in Chapter 5.

7.2 Fully-decked Barges

7.2.1 Application and General Requirements

7.2.1.1 The requirements specified in sub-chapter 7.2 apply to the hull of fully-decked barges (intended to carry deck cargo), with single-bottom and single side skin and small deck openings.

7.2.1.2 Construction of fully-decked barges with the transverse framing system shall fulfil the requirements specified in Chapter 5 for dry cargo carriers. The strength criteria specified in Chapter 3 shall also be fulfilled.

7.2.1.3 Construction of fully-decked barges with the longitudinal framing system applied to the bottom, sides, deck and watertight bulkheads shall fulfil the requirements specified in Chapter 3.

7.2.1.4 Basic survey documentation submitted to PRS Head Office for consideration shall contain information on the assumed allowable loads imposed on deck.

7.2.1.5 Longitudinal strength shall fulfil the requirements specified in sub-chapter 3.3.

7.2.1.6 The forepeak and after peak bulkheads shall comply with the requirements of sub-chapter 5.7.1.

7.2.2 Hull Structure

7.2.2.1 On barges with more than 50 m in length, it is recommended that the longitudinal framing system be applied to the deck and bottom.

7.2.2.2 Longitudinal bulkhead or longitudinal division is recommended for the support of the bottom and deck structures.

7.2.2.3 To ensure adequate transverse strength of hull, it is recommended that additional bulkheads or transverse divisions be applied.

7.2.2.4 Net thickness of plating panels shall not be less than thickness of inner bottom panels determined in accordance with paragraph 5.3.7 and not less than resulting from the formula below:

$$t = \frac{15.8a\sqrt{p}}{\sqrt{\sigma}} \quad \text{[mm]} \qquad (7.2.2.4\text{-}1)$$

$$t = 10a \quad \text{[mm]} \qquad (7.2.2.4\text{-}2)$$

where:
a – spacing of stiffeners [m];
p – deck load [kN/m^2];
$\sigma = 0.60R$ – allowable stress [MPa].

7.2.2.5 Where the deck is not lined with wood, thickness of the plating panels shall be increased by 30%, and where grabs are used for loading and unloading operations – by 50%, however not less than 2 mm.

7.2.2.6 In the longitudinal framing system, transverse girders of the bottom, sides and deck shall be fitted with the spacing not exceeding 3.5 m.

7.2.2.7 It is recommended that the longitudinal framing members be led continuously through the transverse bulkheads and transverse girders.

7.2.2.8 In the case of longitudinal framing system in the bottom and deck, and transverse framing system in the sides, frame end brackets shall be led to this stiffener of the bottom or deck that is closest to the side and the brackets shall be connected to them.

7.3 Ore Carriers

7.3.1 General Requirements

Vessels fulfilling the requirements specified below may be assigned additional mark „rud" in the symbol of class.

Allowable bottom load caused by the pressure of ore shall be specified in the *Vessel Loading Plan* (see 1.4.2).

The structure of the hull cargo portion shall fulfil the strength criteria specified in Chapter 3, checked by direct strength analysis.

General requirements specified in Chapters 4 and 5 shall also be fulfilled.

The requirements specified in Chapter 5 apply to the structure regions located outside the cargo space.

7.3.2 Ore Carriage by Vessels without „rud" Class Notation

Dry cargo vessels constructed in accordance with the requirements specified in Chapter 5 may be used for the carriage of ores:

.1 at the limited draught not bringing the risk of exceeding the allowable stresses;
.2 at the maximum draught with the properly stowed cargo.

In both cases, the structure calculations shall be performed to check compliance with the requirements specified in Chapter 3; the calculations shall be submitted to PRS. Allowable loads caused by the ore pressure shall be specified in the *Vessel Loading Plan* (see sub-chapter 1.4.2).

7.4 Tankers

7.4.1 Application and General Requirements

7.4.1.1 The requirements specified in sub-chapter 7.4 apply to the hulls of oil tankers, assigned an additional class notation **zb**. The requirements for tankers intended for the carriage of hazardous cargoes are specified in sub-chapter 7.12.

7.4.1.2 Taking into account the hull structure, the following two categories are introduced for the purposes of sub-chapter 7.4:
category I – tankers with fixed cargo tanks;
category II – tankers with independent tanks, i.e. removable saddleback tanks.

7.4.1.3 Cargo spaces intended for the liquid cargo shall be separated from other spaces by cofferdams.

7.4.1.4 For the construction of the vessel, flame-resistant materials shall be used. Application of wood shall be reduced to the minimum.

7.4.1.5 Tankers intended for the carriage of inflammable liquids and oil tankers shall not have steel side protection arrangements.

7.4.2 Size of Cargo Tanks

7.4.2.1 Length of Tanks

Length of integral cargo tanks shall not be greater than determined in accordance with the formula below:

$$l = 7 + 0.1L \ \ [\text{m}] \qquad (7.4.2.1)$$

7.4.2.2 Number of Longitudinal Bulkheads in Cargo Tanks

Tankers with breadth B less than 6 m need not have a longitudinal bulkhead. For the breadth ranging from 6 to 12 m, one longitudinal bulkhead is required, whereas above 12 m – two longitudinal bulkheads are required, regardless of the fact whether or not the vessel has the double bottom and double side-skin.

7.4.3 Structural Requirements Concerning Vessels of Category I with Longitudinal System of Girders

7.4.3.1 The requirements specified in this sub-chapter apply to tankers with the power plant located aft and longitudinal framing system applied to the bottom and deck in way of cargo tanks. They are also applicable to tankers with the longitudinally stiffened inner bottom and longitudinal bulkhead if such a construction is required by the Flag state administration or by the safety rules in force. The requirements specified in Chapter 5 are applicable to the structural members not mentioned in this sub-chapter.

The requirements specified in particular paragraphs of sub-chapter 7.4.7 included in box brackets are not applicable to vessels whose hulls have been designed by direct strength calculations, i.e. in accordance with the requirements specified in Chapter 3.

7.4.3.2 Framing system of the longitudinal bulkhead, sides, longitudinal bulkheads and transverse bulkheads may be longitudinal or transverse. Different framing systems shall not, however, be applied for the longitudinal bulkhead and sides.

7.4.3.3 *[Spacing of bottom longitudinals shall not be greater than determined in accordance with the formula below:*

$$a = 2L + 420 \ [mm] \qquad (7.4.3.3)$$

and not greater than 100 thicknesses of the bottom plating. Spacing less than 500 mm is not required.]

7.4.3.4 *[Section modulus of bottom longitudinals shall not be less than determined in accordance with the formula below:*

$$W = 4al^2(H + h + 0{,}02L) \ [cm^3] \qquad (7.4.3.4)$$

where:

a – *spacing of bottom longitudinals, [m];*
l – *not supported span of bottom floor, [m];*
h – *the vertical distance from the upper edge of the expansion trunk coaming to the deck edge at side, to be not less than 1 m and not less than the value* $p_v/10$*, [m];* p_v *– see 3.2.3.4.*]

7.4.3.5 It is recommended that bottom longitudinals and longitudinal stiffeners of the inner bottom be led continuously through transverse bulkheads of tanks. If bottom longitudinals and inner bottom stiffeners do not penetrate bulkheads, they shall be connected to the bulkheads with flanged brackets (see Fig. 7.4.3.5).

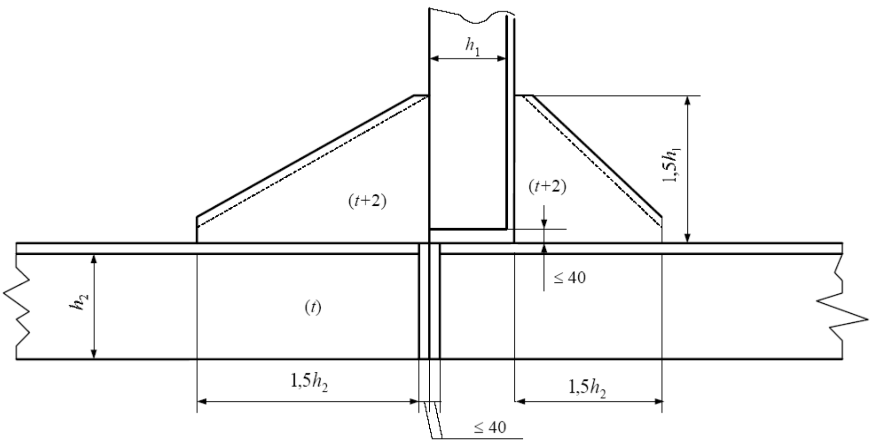


Fig. 7.4.3.5. Recommended construction of bottom longitudinal connection to bulkhead

7.4.3.6 *[Section modulus of deck longitudinals shall not be less than determined in accordance with the formula below:*

$$W = 3,5al^2(h+0.02L)\ [cm^3] \qquad (7.4.3.6)$$

Definitions of symbols specified in paragraph 7.4.3.4 apply.]

7.4.3.7 *[Section modulus of side-shell longitudinals shall not be less than determined in accordance with the formula below:*

$$W = 5al^2(h_1+0.02L)\ [cm^3] \qquad (7.4.3.7)$$

where:

h_1 – the vertical distance from the upper edge of the expansion trunk coaming to the level of the side-shell longitudinal under consideration, [m], increased by 0.5 m, but by not less than $p_v/10$, [m];
p_v – see 3.2.3.4.

For other symbols – see paragraph 7.4.3.4.]

7.4.3.8 Floors shall be arranged with a spacing not greater than 3.5 m. Floors shall form a framework with the side members, longitudinal bulkhead members (where applied) transverse deck girders (see Fig. 7.4.3.8). Other design patterns equivalent to those shown in Fig. 7.4.7.8 are permitted.

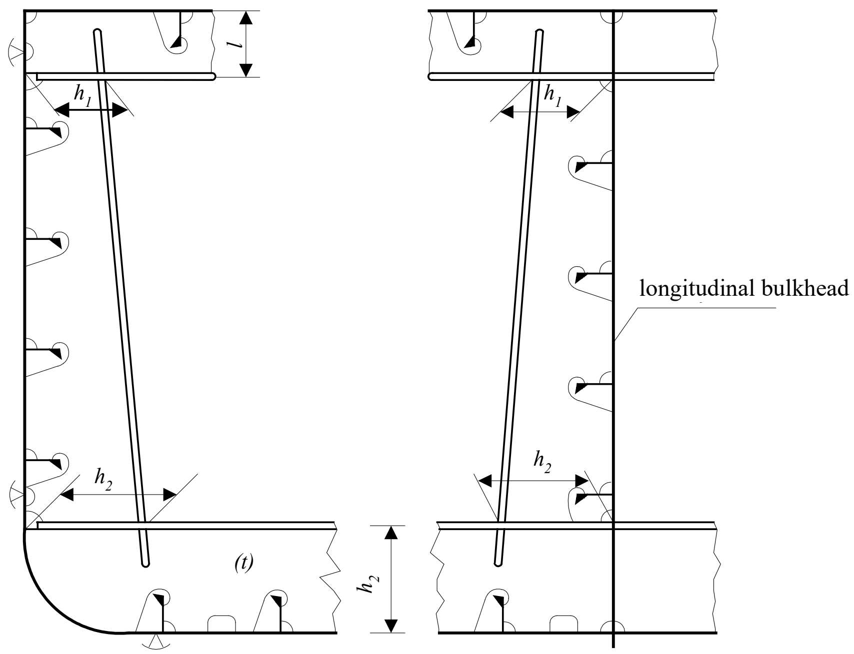


Fig. 7.4.3.8. Construction of framework in frame planes with bottom floors applied

7.4.3.9 *[Section moduli of floor and web frame at the level of the floor upper edge shall not be less than determined in accordance with the formula below:*

$$W = 4.5al^2(H+h)\ [cm^3] \qquad (7.4.3.9)$$

where:

a – spacing between floors or between floors and bulkhead, [m];
h – as defined in paragraph 7.4.7.4;
l – not supported part of floor, [m].]

7.4.3.10 *[Web frames at the lower edge of deck girder and transverse deck girders shall have their webs of the height not less than 2/3 of the floor height.]*

7.4.3.11 Where longitudinal bulkhead is applied, bulkhead girder [*with the cross-sectional area not less than the cross-sectional area of transverse deck girder*] shall be provided. The above requirement does not apply to corrugated bulkheads.

7.4.3.12 Plating thickness of transverse bulkheads in cargo tanks shall not be less than determined in accordance with the formula below:

$$t = 5a\sqrt{h} \quad \text{[mm]} \tag{7.4.3.12}$$

where:
a – spacing of stiffeners, [m];
h – the height of bulkhead, [m], increased by 0.5 m, but by not less than $p_v/10$, [m];
p_v – see 3.2.3.4.

The plating thickness, however, shall not be less than 5 mm.

7.4.3.13 Section modulus of the vertical stiffeners of transverse bulkheads shall not be less than determined in accordance with formula 5.7.4.1, whereas coefficient k = 4 and h equal to the distance between the upper edge of the expansion trunk coaming and the stiffener midspan [m], increased by 0.5 m shall be taken for calculations.

Section modulus of the horizontal stiffeners of transverse bulkheads shall not be less than determined in accordance with formula 5.7.4.1, whereas coefficient k = 6 and h_1 defined in paragraph 7.4.3.7 shall be taken for calculations.

Where brackets with their sides equal to the spacing of stiffeners are applied at both ends of stiffeners, the section modulus of the stiffeners may be reduced by 25%.

7.4.3.14 The minimum thickness of plating of longitudinal bulkheads, including those in cargo tanks, shall be determined in accordance with formula 7.4.7.12 and increased by 1 mm amidships, whereas outside amidships – by 0.5 mm.

7.4.3.15 *[Section modulus of horizontal stiffeners of longitudinal bulkheads, including those with brackets at both ends, shall not be less than determined in accordance with the formula below:*

$$W = 4al^2h_1 \ [cm^3] \tag{7.4.3.15}$$

For symbols – see paragraph 7.4.3.7.]

7.4.3.16 Stiffeners of cofferdam bulkheads shall be taken in accordance with paragraph 7.4.7.13.

7.4.3.17 *[Thickness of bottom plating shall not be less than determined in accordance with the formula below:*

$$t_1 = t + \frac{0{,}05f}{a} \ [mm] \tag{7.4.3.17}$$

where:
t – *thickness of bottom plating determined in accordance with formula 5.5.1.1 [mm];*
f – *cross-sectional area of bottom longitudinal [cm²];*
a – *spacing of bottom longitudinals, [m].*]

7.4.3.18 *[Bottom plating thickness shall not be less than determined in accordance with formula 7.4.7.17, however not less than 0.01a.]*

7.4.3.19 Deck plating thickness shall be determined in accordance with sub-chapter 5.6, [*it shall not, however, be less than 0.01a (a – spacing of deck beams).*]

7.4.3.20 Thickness of the side-shell plating and deck plating in way of the cargo tanks and cofferdams shall not be less than:
5.0 mm – in vessels with $L \leq 40$ m in length intended for the carriage of K and K2 liquids,
4.0 mm – in vessels with $L \leq 40$ m in length intended for the carriage of K3 liquids,
6.0 mm – in vessels with $L > 40$ m in length intended for the carriage of K1 and K2 liquids,
5.0 mm – in vessels with $L > 40$ m in length intended for the carriage of K3 liquids.

7.4.4 Structural Requirements Concerning Vessels of Category I with Transverse System of Girders

7.4.4.1 The requirements specified in paragraphs 7.4.7.1 to 7.4.7.9 and Chapter 5 are applicable to the structural members not mentioned in this sub-chapter.

The requirements included in box brackets do not apply to those vessels whose hulls have been designed by direct strength calculations, i.e. in compliance with the requirements specified in Chapter 3.

7.4.4.2 *[Section modulus of floors shall not be less than determined in accordance with the formula below:*

$$W = 5al^2(H + h)+12 \ [cm^3] \qquad (7.4.4.2)$$

where:
a – spacing of floors, [m].

For other symbols – see paragraph 7.4.7.4.]

Bottom floors shall be connected to the longitudinal bulkhead by brackets (see paragraph 7.4.7.5)

7.4.4.3 *[In each tank, one bottom longitudinal with the dimensions determined in accordance with sub-chapter 5.2.2 shall be applied between the longitudinal bulkhead and the ship side.]*

7.4.4.4 *[Section modulus of frames shall not be less than determined in accordance with the formula below:*

$$W = 2{,}5aH^2(H + 2h)+4 \ [cm^3] \qquad (7.4.4.4)$$

For symbols – see paragraph 7.4.7.4.

Where side stringer is applied in the midspan of frames, the section modulus of frames may be determined in accordance with sub-chapter 5.4.2.

Frames may be connected to floors by brackets (see sub-chapter 5.4.5).

Where brackets have not been applied, the section modulus of frames shall be increased by 20%.]

7.4.4.5 *[Where side stringer has been applied, its section modulus shall not be less than determined in accordance with the formula below:*

$$W = H(l^2(H + 2h)+5) \ [cm^3] \qquad (7.4.4.5)$$

where:
l – not supported span of side stringer, [m].

For other symbols – see paragraph 7.4.7.4.]

Side stringer shall be connected to the transverse bulkheads by brackets.

7.4.4.6 *[Section modulus of the vertical stiffeners of longitudinal bulkheads shall not be less than determined in accordance with the formula below:*

$$W = 2.1al^2(l + 2h) \ [cm^3] \qquad (7.4.4.6)$$

where:
a – *spacing of stiffeners, [m];*
l – *span of stiffeners, [m];*
h – *distance from the upper edge of the expansion trunk to deck, however not less than 1 m.*]

Stiffeners shall be connected to floors by brackets.

7.4.4.7 *[Where horizontal stiffeners are applied in the midheight of the longitudinal bulkhead, the section modulus of vertical stiffeners shall not be less than determined in accordance with the formula below:*

$$W = 0.52al^2(1.5l + 2h) \ [cm^3] \qquad (7.4.4.7)$$

For symbols – see paragraph 7.4.4.6.]

7.4.4.8 *[Section modulus of the horizontal stiffeners of longitudinal bulkheads or inner sides (see paragraph 7.4.4.7) shall not be less than that of the side stringer (see paragraph 7.4.4.5).]*

7.4.5 Structural Requirements Concerning Vessels of Category II (with Independent Tanks)

7.4.5.1 The requirements specified in paragraphs 7.4.7.1 to 7.4.7.9 and Chapter 5 apply to the structural members not mentioned in this sub-chapter.

The requirements included in box brackets do not apply to those vessels whose hulls have been designed by direct strength calculations, i.e. in compliance with the requirements specified in Chapter 3.

7.4.5.2 End bulkheads of cargo holds and spaces shall be constructed as in vessels of category I.

7.4.5.3 Between the sides and tanks, adequate space shall be provided for inspection, maintenance and ventilation of tanks. The same space shall be provided under the deck.

7.4.5.4 Cargo tanks seated on floors shall be secured against shifting due to horizontal forces; for heated tanks, thermal expansion shall be taken into account.

7.4.5.5 Bilge wells shall be applied in cargo space.

7.4.5.6 *[It is recommended that transverse bulkheads be applied with the spacing not greater than:*

$$l = 0.15L + 6.5 \ [m] \qquad (7.4.5.6)$$

If bulkheads are not applied with the above mentioned spacing, then frame girders with struts shall be provided.]

7.4.5.7 Web frames shall be connected to tank stiffeners by ties.

7.4.5.8 *[Within the cargo space, floors shall be strengthened by at least two girders extending by three frame spacings beyond the end bulkheads of cargo holds.]*

7.4.5.9 Plating thickness of cargo tanks shall not be less than determined in accordance with formula below:

$$t = 20a\sqrt{\frac{p}{R_e}} \ [\text{mm}] \qquad (7.4.5.9)$$

where:
a – spacing of stiffeners, [m];

p – test pressure, [kPa], equal to hydrostatic pressure in a fully filled tank (mass density of liquid not less than 1.0 t/m³), increased by a value not less than 10 kPa and not less than p_v;
p_v – see 3.2.3.4;
R_e – plating material yield point, [MPa].

Plating thickness of tanks shall not be less than 5.0 mm.

7.4.5.10 Stiffeners of tank plating may be fitted outside or inside the tanks and they may be either transverse or longitudinal.

Scantlings of tank stiffeners shall fulfil the requirements specified in sub-chapter 5.9.

7.4.5.11 Cargo tanks shall be subjected to tightness test before they are installed on board.

7.5 Pontoons

7.5.1 General Requirements

Construction of pontoon hull shall, to the maximum possible extent, fulfil the requirements for fully decked barges specified in sub-chapter 7.2.

7.5.2 General Strength

Depending on the ratio L/B and expected loads imposed on the pontoon deck, PRS may require an analysis of hull general bending in the transverse direction.

In that case, the pontoon hull shall fulfil the identical criteria as for the longitudinal bending, i.e. specified in sub-chapters 3.2, 3.3, 3.5 and 3.6.

7.6 Passenger Vessels

7.6.1 The requirements specified in sub-chapter 7.6 apply to passenger vessels assigned an additional mark : **pas**, affixed to the symbol of class.

Passenger ships engaged on domestic voyages in sea areas, in accordance with sub-chapter 3.6.3 of *Part I – Classification Regulations*, shall additionally comply with the requirements of *Council Directive 98/18/EC* of 17 March 1998 as amended by *Commission Directive 2002/25/EC* of 5 March 2002, related to bulkheads, double bottom and stern tubes (see also *Publication No. 76/P – Stability, Subdivision and Freeboard of Passenger Ships Engaged on Domestic Voyages – 2006*).

7.6.2 Adequate strengthening shall be applied to the hull structure of vessels intended for the service throughout the year, including ice conditions, who frequently berth either the quay or other vessels.

7.6.3 Vessels shall have watertight bulkheads so arranged that the vessel remains afloat after watertight compartments have been flooded in accordance with requirements of Chapter 3, *Part IV – Stability and Freeboard*.

Passengers rooms shall, on all decks, be located aft of the level of the collision bulkhead and, as long as they are below the bulkhead deck, forward of the level of the aft-peak bulkhead.

7.6.4 Local strengthenings of the hull structure, due to installation of special equipment in the spaces and on decks available to passengers, shall be taken into account.

7.6.5 The thickness of the bottom and side plates, measured at any stage of the vessel service, shall be not less than the thickness determined from formulae 7.6.5-1 and 7.6.5-2 and in no case can be less than 3 mm:

$$t = 0.006a\sqrt{T} \text{ [mm]} \quad (7.6.5\text{-}1)$$

$$t = f \cdot 0.55\sqrt{L_{WL}} \text{ [mm]} \quad (7.6.5\text{-}2)$$

where:
a – spacing of plating stiffeners (longitudinal or transverse), [mm].

If longitudinal framing system is applied, the value of a, taken for the calculations, shall be not less than 400 mm.

$f = 1 + 0.0013\ (a – 500)$, where $a \geq 400$ mm shall be entered.

L_{WL} – the length of the vessel measured on the waterline corresponding to draught T, [m].

The exemption from the above requirements may be permitted, provided that direct calculations of general, zone and local strength made according to Chapter 3 show that the strength criteria, as specified in this Chapter, are complied with for the plating thickness values lesser than those determined from formulae 7.6.5-1 and 7.6.5-2. The plating thickness shall not, however, be less than 3 mm.

Plates not complying with the above requirements shall be replaced.

7.6.6 The height of the double bottom shall be not less than 0.60 m. The width of the double-skin side shall be not less than 0.60 m.

7.6.7 The number and position of bulkheads shall be selected such that, in the event of flooding, the vessel remains buoyant according to *Part IV – Stability and Freeboard*. Every portion of the internal structure which affects the efficiency of the subdivision of such vessels shall be watertight, and shall be of a design which will maintain the integrity of the subdivision.

7.6.8 For determining the positioning of the collision bulkhead and aft-peak bulkhead, the provisions of 5.7.1.1 shall apply, but the reference value to be used shall be the length of waterline rather than the length.

7.6.9 A transverse bulkhead may be fitted with a bulkhead recess, if all parts of this recess lie within the safe area.

7.6.10 The bulkheads, which are taken into account in the damage stability calculation according to *Part IV – Stability and Freeboard*, shall be watertight and be installed up to the bulkhead deck. Where there is no bulkhead deck, these bulkheads shall extend to a height at least 0,20 m above the margin line.

7.6.11 The number of openings in these bulkheads shall be kept as low as is consistent with the type of construction and normal operation of the vessel. Openings and penetrations shall not have a detrimental effect on the watertight function of the bulkheads.

7.6.12 Collision bulkheads shall have no openings and no doors.

7.6.13 Bulkheads separating the engine rooms from passenger rooms or crew and shipboard personnel accommodation shall have no doors.

7.7 Ferries

7.7.1 General Requirements

7.7.1.1 The requirements specified in sub-chapter 7.7 apply to hulls of cable ferries assigned an additional class notation: **pr**.

7.7.1.2 Ferries shall be constructed as fully decked vessels with the watertight deck lined with wood or covered with deck coating plastic approved by PRS.

7.7.1.3 Local strengthenings of the hull structure, due to installation of special equipment on ferries such as: guiding appliances, ro-ro ramps, winches, bitts, etc., shall be taken into account.

7.7.2 Hull Structure

7.7.2.1 Collision bulkheads shall be located at the distance not greater than 0.15L from the outer points of the hull in forebody and afterbody.

The distance between other bulkheads shall not exceed 0.35L. Collision bulkheads shall be so located as to ensure compliance with the buoyancy criteria specified in 5.7.1.1.

7.7.2.2 Thickness of outer plating in fore and after peaks shall be increased by at least 1 mm against the requirements specified in sub-chapter 5.5.

7.7.2.3 Plating thickness of bulkheads shall not be less than the thickness of adjacent plating of the bottom and side shell.

7.8 Tugs

7.8.1 General Requirements

7.8.1.1 The requirements specified in sub-chapter 7.8 apply to hulls of the vessels assigned an additional class notation: **hol**.

7.8.1.2 Local strengthenings of the deck and sides, due to installation of towing equipment shall be taken into account.

7.8.1.3 Transverse bulkheads shall comply with the requirements of sub-chapter 5.7.1.

7.8.2 Hull Structure

7.8.2.1 Stern frame dimensions shall be increased by 15% against those specified in sub-chapters 5.8.7 and 5.8.8.

7.8.2.2 Section modulus of floors in the machinery room shall be increased by 50% against that determined in accordance with paragraph 5.2.1.2. Outside the machinery space, floors with the section modulus increased by 20% against that required in paragraph 5.2.1.2 shall be applied.

7.8.2.3 Thickness of members of the main engine seatings shall be increased by 10% against that required in sub-chapter 5.2.4.

7.8.2.4 Seatings of tow hook, towing winch or capstan, rope grip and towing bollards shall be properly connected to the stiffeners of the structure of hull or deck erections.

Deck plating in way of such seatings shall be thickened by at least 20%.

7.8.2.5 In tugs with main motive power ranging from 145 to 360 kW, plating thickness shall be increased against the requirements specified in sub-chapter 5.5 by 1 mm, and in tugs with main motive power above 360 kW – by 1.5 mm.

7.8.2.6 Adequate strengthening of the upper part of shell sides and deck rim shall be provided depending on the fender type.

7.8.2.7 If the tug is intended to play also the role of pusher, the forebody structure shall fulfil the requirements specified in paragraphs 7.9.2.2 to 7.9.2.4.

7.9 Pushers

7.9.1 General Requirements

7.9.1.1 The requirements specified in sub-chapter 7.9 apply to the hulls of vessels assigned an additional class notation: **pch**.

7.9.1.2 Local strengthenings of the hull structure, due to installation of special equipment on pushers such as: winches, bitts, rollers and arrangements necessary for the coupling of trains, bow bumpers, before-propeller rudders etc., shall be taken into account. These requirements also apply to self-propelled cargo vessels used for pushing.

7.9.1.3 Transverse bulkheads shall fulfil the requirements of sub-chapter 5.7.1.

7.9.1.4 The collision bulkhead in accordance with paragraph 5.7.1.1 can be dispensed with the for pushers intended to form part of a pushed convoy.

7.9.2 Hull Structure

7.9.2.1 The requirements specified for tugs in paragraphs 7.8.2.1, 7.8.2.2 and 7.8.2.3 shall be taken into account.

7.9.2.2 Thickness of transom plating and flat or unidirectionally bent plating panels in the forebody shall be increased by at least 1 mm against the requirements specified in sub-chapter 5.5. Thickness of transom bow shall not be less than sheer strake thickness amidships.

7.9.2.3 Forebody structure shall be strengthened due to the loads imposed by the train coupling ropes. Particularly, the entire fore deck shall be strengthened and seatings for coupling appliances shall be robustly connected to the hull stiffeners.

7.9.2.4 Fore deck shall be so formed to enable the crew easy and safe passage from one vessel to the other from the beginning of coupling activities. Bow bumpers shall be arranged as box or semi-box structure stiffened horizontally with the spacing around 0.4 m and robustly connected to the deck, upper part of transom bow and girders in the fore peak.

Construction of deck and bumpers shall be such as to enable a pusher to take the intended position against the pushed vessels – especially to enable relative side movements.

7.9.2.5 Tunnel stern shall be stiffened inside by the bottom framework structure properly fixing stern tubes, nozzles and shaft brackets as well as tubes of before- and after-screw rudders.

7.9.2.6 Construction of the rounded corners of hull is recommended.

7.10 Floating Cranes and Dredgers

7.10.1 The requirements specified in sub-chapter 7.10 apply to the hulls of vessels assigned an additional class notation: **dp** or **pg**.

7.10.2 Minimum thicknesses of hull members shall not be less than specified in Chapter 5, unless required otherwise in this sub-chapter.

7.10.3 In the general and local strength analysis in accordance with the requirements specified in Chapter 3 and in the structure vibration analysis, loads resulting from the specific operating conditions of the vessel and from the operation of special machinery and equipment installed on board the vessel shall be taken into account.

7.10.4 In way of the seating of masts of cranes and dredging appliances, the hull structure shall be strengthened. The mast of crane or dredging appliance column shall be continuously led through the deck structures and connected to bottom members and stiffeners, unless transverse bulkhead is applied to support those elements.

7.10.5 In the locations adjacent to the crane masts or columns of dredging appliances, deck plating thickness shall be increased by at least 25%.

7.10.6 In way of connections of suction pipes of dredgers to the hull structure, transverse framing system shall be applied. In that region, hull shall be strengthened by web frames and plating thickness shall be increased by 25%.

7.10.7 Lifting-pump room shall be separated from the hull structure by the system of tight divisions – to ensure that the dredger will remain afloat after that room has been flooded.

7.10.8 The forepeak and after peak bulkheads shall fulfil the requirements of sub-chapter 5.7.1.

7.11 Ice-breakers and Flood-control Ice-breakers

7.11.1 Application and General Requirements

7.11.1.1 The requirements specified in sub-chapter 7.11 apply to the hulls of vessels assigned an additional class notation: **ld** or **ldp**. They shall be applied to ice-breakers which fulfil the conditions from 7.11.1.1-1 to 7.11.1.1-7:

$$D^{1/4} N^{1/3} < 230 \qquad (7.11.1.1–1)$$

$$\frac{L_w}{B_w} = 3.3 \div 5.0 \qquad (7.11.1.1\text{-}2)$$

$$\frac{B_w}{T_w} = 4.4 \div 6.5 \qquad (7.11.1.1\text{-}3)$$

$$\varphi = 15° \div 35° \qquad (7.11.1.1\text{-}4)$$

$$\alpha = 11° \div 25° \qquad (7.11.1.1\text{-}5)$$

$$\beta = 30° \div 50° \qquad (7.11.1.1\text{-}6)$$

$$\beta_M = 10° \div 25° \qquad (7.11.1.1\text{-}7)$$

where (see also Fig. 7.11.1.1):

D – vessel displacement corresponding to draught to load waterline, [kN];
N – total motive power of propulsion system, [kW];
L_w – length on load waterline, [m];
B_w – breadth of vessel amidships, at the height of load waterline, [m];
T_w – draught of vessel (to load waterline), [m];
φ – angle between the line tangent to stem and base plane, at the height of load waterline (see Fig. 7.11.1.1);
α – angle between the line tangent to the load waterline and the plane of symmetry, in the frame section located at the distance of 0.15 L from fore perpendicular;
β – angle between the perpendicular and the line tangent to the frame section located at the distance of 0.15 L from fore perpendicular drawn in the point located on the load waterline;

β_M – angle between the perpendicular and the line tangent to the frame section amidships, drawn in the point located on the load waterline.

Construction of ice-breaker hull, who does not fulfil the conditions from 7.11.1.1-1 to 7.11.1.1-7 is subject to special consideration by PRS in each particular case.

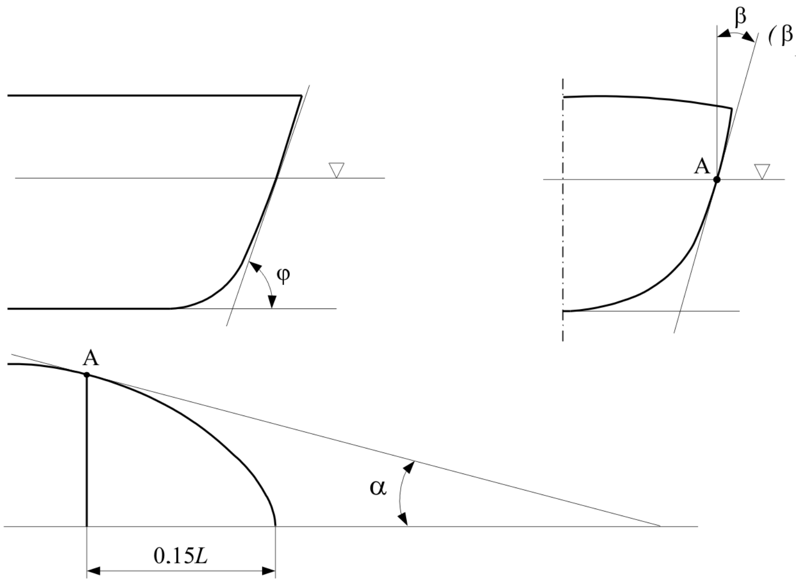


Fig. 7.11.1.1. Definition of angles φ, α, β, β_M

7.11.1.2 In sub-chapter 7.11 the following definitions of hull regions apply:

afterbody region – hull portion with frame sections located at the distance not greater than 0.2L from after-perpendicular;

forebody region – hull portion with frame sections located at the distance not greater than 0.3L from fore perpendicular;

amidship region – hull portion of length 0.5L, located between forebody and afterbody.

7.11.1.3 Ice-breaker hulls shall be constructed from at least Grade D and Grade E steels. Hull shell plating shall be constructed from Grade E steel.

7.11.1.4 Ice-breaker hull structure shall fulfil general structural requirements specified in Chapters 4 and 5, and the strength and buckling strength of structural members – the requirements specified in Chapter 3, unless special requirements are specified in sub-chapter 7.11.

7.11.2 Allowable Stress

7.11.2.1 In the hull structure local strength calculations, combined allowable stresses equal $\sigma_{all} = \sqrt{\sigma^2 + 3\tau^2} = 0.95R_e$, where σ – normal stress, τ – shear stress, shall be applied when considering ice loads.

7.11.2.2 When considering ice loads, the stresses resulting from the general bending and local bending of hull shall not be added up in the strength analysis of bottom girders and side shell stringers.

7.11.3 Ice Load

7.11.3.1 The design value of ice pressure on the ice belt in the forebody shall be determined in accordance with the formula below:

$$p_{dz} = (1.4 + 0.004 D^{1/4} N^{1/3}) \times C_{pdz}, \ [\text{MPa}] \qquad (7.11.3.1)$$

where:

D, N – see paragraph 7.11.1.1;

C_{pdz} – coefficient of pressure reduction in forebody, depending on ice-breaker type:

- C_{pdz} = 1.0 – for ice-breakers assigned additional mark **Id** in the symbol of class;
- C_{pdz} = 0.7 – for ice-breakers assigned additional mark **Idp** in the symbol of class performing as front-column ice-breakers;
- C_{pdz} = 0.5 – for ice-breakers assigned additional mark **Idp** in the symbol of class performing as mid-column ice-breaker.

Ice belt is defined in paragraphs 7.11.4.3 to 7.11.4.5.

7.11.3.2 The design value of ice pressure on the ice belt outside the forebody shall be determined in accordance with the following formulae:

– amidships in the region from 0.3L aft of the forward perpendicular to the midship section:

$$p_s = C_{ps} \times p_{dz} \ [\text{MPa}] \qquad (7.11.3.2\text{-}1)$$

where C_{ps} = 0,60;

– amidships in the region aft of the midship section to 0,2 L from the after perpendicular:

$$p_s = C_{ps} \times p_{dz} \ [\text{MPa}] \qquad (7.11.3.2\text{-}2)$$

where:

C_{ps} = 0.60 – for icebreakers assigned additional mark **Id** in the symbol of class.
C_{ps} = 0.23 – for icebreakers assigned additional mark **Idp** in the symbol of class;

– in the afterbody:

$$p_r = C_{pr} \times p_{dz} \ [\text{MPa}] \qquad (7.11.3.2\text{-}3)$$

where:

C_{pr} = 0.75 – for icebreakers assigned additional mark **Id** in the symbol of class;
C_{pr} = 0.60 – for icebreakers assigned additional mark **Idp** in the symbol of class.

The value of p_{dz} shall be determined in accordance with formula 7.11.3.1.

Ice belt is defined in paragraphs 7.11.4.3. to 7.11.4.5.

7.11.3.3 The design value of ice pressure on the bottom plating outside the ice belt shall be determined in accordance with the formula below:

$$p_d = p_{dz} D^{1/4} N^{1/3} / 400 \ [\text{MPa}] \qquad (7.11.3.3\text{-}1)$$

and the following condition shall be fulfilled:

$$p_d \le p_s \qquad (7.11.3.3\text{-}2)$$

where:

D, N – see paragraph 7.11.1.1;
p_{dz} – see paragraph 7.11.3.1;
p_s – see paragraph 7.11.3.2.

7.11.3.4 The design value of continuous ice load used for the calculations of hull principal members and stiffeners in the ice belt – in way of the forebody, at the ice impact – shall be determined in accordance with the formula below:

$$q_{dz} = 12.6k\sqrt[3]{Dv^2p_{dz}^2} \text{ [kN/m]} \quad (7.11.3.4)$$

where:

D – see sub-chapter 7.11.1;

v – design speed at ice impact, to be taken as 60% of the maximum speed of vessel v_0 at calm water, [m/s];

p_{dz} – see paragraph 7.11.3.1;

k – dimensionless coefficient depending on angles α and β (see paragraph 7.11.1.1), determined in accordance with diagrams shown in Fig. 7.11.3.4.

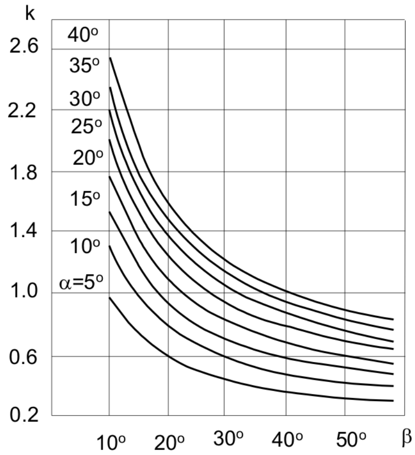


Fig. 7.11.3.4. Value of k as function of angles α and β

7.11.3.5 The design values of continuous ice load acting on side-shell stiffeners and members in the ice belt outside the forebody shall be determined in accordance with the following formulae:

– amidships in the region from 0.3L aft of the forward perpendicular to the midship section:

$$q_s = C_{qs} \times q_{dz} \text{ [kN/m]} \quad (7.11.3.5\text{-}1)$$

where:

$C_{ps} = 0.60$

Additionally, for icebreakers assigned additional mark **Id** in the symbol of class, the following condition shall be fulfilled:

$$q_s = \frac{0{,}028}{\sin\beta_M} L^2 \text{ [kN/m]} \quad (7.11.3.5\text{-}2)$$

– amidships in the region aft of the midship section to 0,2 L from the after perpendicular:

$$q_s = C_{qs} \times q_{dz} \text{ [kN/m]} \quad (7.11.3.5\text{-}3)$$

where:

$C_{ps} = 0.60$ – for icebreakers assigned additional mark **Id** in the symbol of class,

$C_{ps} = 0.30$ – for icebreakers assigned additional mark **Idp** in the symbol of class;

– in the afterbody:

$$q_r = C_{qr} \times q_{dz} \text{ [kN/m]} \quad (7.11.3.5\text{-}4)$$

however not less than q_s,

q_{dz} – see paragraph 7.11.3.4;

$C_{qr} = 0.75$ – for icebreakers assigned additional mark **Id** in the symbol of class,

$C_{qr} = 0.60$ – for icebreakers assigned additional mark **Idp** in the symbol of class.

The design value of continuous ice load acting on bottom longitudinals or intermediate longitudinals outside the ice belt shall be determined in accordance with the following formula:

$$q_d = 10\, p_d L \quad [\text{kN/m}] \qquad (7.11.3.5\text{-}5)$$

The value of q_d shall not exceed q_s (see 7.11.3.5), for p_d – see 7.11.3.3.

7.11.3.6 The design value of the continuous ice load acting on bottom longitudinals or intermediate longitudinals outside the ice belt shall be determined in accordance with the formula below:

$$q_d = 10\, p_d L \quad [\text{kN/m}] \qquad (7.11.3.6)$$

The value of q_d shall not be greater than q_s (see paragraph 7.11.3.5), for p_d – see paragraph 7.11.3.3.

7.11.4 General Structural Requirements and Plating Thickness

7.11.4.1 Frame spacing in the forebody shall not be greater than 300 mm, and where intermediate frames are applied – not greater than 600 mm.

7.11.4.2 Frame spacing amidships and in the afterbody shall not be greater than 500 mm, and where intermediate frames are applied – not greater than 650 mm.

7.11.4.3 Ice belt in the form of thickened plating shall be applied throughout the length of vessel.

7.11.4.4 The upper edge of the ice belt shall be located at the level not lower than 0.6 m above the maximum load waterline.

The lower edge of the ice belt shall be located below the light waterline at the distance not less than $0.02L$, however not less than 0.8 m.

For flood-control ice-breaker performing as mid-column ice-breaker, the ice belt upper edge may be situated at the level not less than 0.5 m above the maximum draught waterline and the lower edge – not higher than 0.6 m below the light ship waterline.

7.11.4.5 Throughout the distance of $0.2L$ abaft the forward perpendicular and $0.15L$ forward of the after perpendicular, the lower edge of the ice belt shall extend to the hull plane of symmetry.

7.11.4.6 Thickness of ice belt shell plating shall not be less than determined in accordance with the formula below:

$$t = 720s\sqrt{p/R_e} \ [\text{mm}] \qquad (7.11.4.6)$$

not less, however, than 8 mm,

s – spacing of stiffeners in ice belt [m];

p – design ice-pressure, [MPa], determined in accordance with formulae 7.11.3.1÷7.11.3.3, depending on location of the plating panels in the ice belt, along the vessel;

R_e – yield point of material [MPa].

7.11.4.7 Thickness of plating panels outside the ice belt shall be determined in accordance with the formula below:

$$t = (L + 100)/30 + \Delta t \ [\text{mm}] \qquad (7.11.4.7)$$

where:

$\Delta t = 0$ for $N_e < 330$ kW

$\Delta t = 0{,}06\sqrt{1.36N_e - 450}$ [mm], for $N_e > 330$ kW;

N_e – total horsepower of vessel [kW].

7.11.4.8 Thickness of plating shall gradually reduce outside the ice belt. The difference in thickness between the adjacent plating panels shall not be greater than 30% of the thinner panel thickness.

7.11.4.9 Thickness of deck plating shall not be less than:

– in weather deck areas:

$$t = (220 + L)/60 + \Delta t \text{ [mm]} \quad (7.11.4.9\text{-}1)$$

– in areas below superstructures and deckhouses:

$$t = (180 + L)/60 + \Delta t \text{ [mm]} \quad (7.11.4.9\text{-}2)$$

where: Δt – to be determined in accordance with paragraph 7.11.4.7.

7.11.5 Frames and Side Stringers

7.11.5.1 Spacing of web frames shall not be greater than 1.2 m in the forebody, and 2.0 m outside the forebody.

Web thickness of web frames shall not be less than 10 mm in the forebody, and 8 mm outside the forebody for an icebreaker assigned an additional mark **ld** in the symbol of class.

Web thickness of web frames shall not be less than: 8 mm in the forebody, 6 mm in the midship portion and 7 mm in the afterbody of icebreaker assigned an additional mark **ldp** in the symbol of class.

7.11.5.2 Throughout the length of vessel, side stringer or platform shall be applied in the region between the load waterline and the level 250 mm below the load waterline.

7.11.5.3 Within the ice belt, the distance between side stringers or the side stringer and deck, bottom or platform, shall not be greater than 1.2 m. Web thickness of side girders and thickness of platform plating panels connected to the side-shell plating shall not be less than web thickness of side frames in that region.

7.11.5.4 In way of connection of side frames to side stringers, brackets shall be applied.

7.11.5.5 Strength of regular frames shall be checked applying the model of multi-span beam supported by the side stringers, deck, platforms and bilge. The beam is loaded by the concentrated transverse force Q:

$$Q = qs \text{ [kN]} \quad (7.11.5.5)$$

where:

q – design value of the continuous load in the structure region under consideration, determined in accordance with paragraphs 7.11.3.4 and 7.11.3.5;

s – frame spacing, [m].

Force Q shall be applied in the middle of the longest span of frame in way of the ice belt.

If intermediate frames are applied, then the value of s in formula 7.11.5.5 represents the distance between regular frames and intermediate frames.

Strength of intermediate frames shall be checked in the same way as the strength of regular frames.

The effect of side stringers and web frames on the values of internal forces in regular frames and intermediate frames shall be taken into account.

7.11.5.6 Strength calculations for side stringers and web frames shall be performed using either the grillage model or 3-dimiensional framework model formed by those members.

Length of the loaded parts of shell-side in the forebody and afterbody shall be determined in accordance with the formula below:

$$l = 0.01\, q/p \ \ [\mathrm{m}] \qquad (7.11.5.6)$$

where:

q, p – continuous load q_{dz} or q_r and design pressure p_{dz} or p_r determined in accordance with paragraphs 7.11.3.1 to 7.11.3.6.

7.11.5.7 Webs of web frames and regular frames – in way of ice belt throughout the length of vessel – shall be connected to the plating by continuous double fillet weld.

7.11.5.8 Side frames in the fore and after peaks shall be positioned approximately perpendicular to the hull plating in the ice belt.

7.11.6 Floors

7.11.6.1 In the forebody and afterbody, solid floors shall be applied at each frame.

Spacing of solid floors amidships shall not be greater than 2.0 m.

7.11.6.2 Strength of solid floor and bottom longitudinals shall be checked using either the grillage model or 3-dimiensional framework model with even distribution of ice pressure of the value of 0.3 p_d, where p_d shall be determined in accordance with formula 7.11.3.3-1.

7.11.6.3 Strength of bottom stiffeners in the planes of regular open floors shall be checked using the model of a single-span beam fixed at both ends.

The span of beam is equal to the maximum spacing between the bottom longitudinals, or between the longitudinals and shell-sides or longitudinal bulkheads.

The beam is loaded, at the midspan, by the concentrated force equal:

$$Q = q_d\, s \qquad (7.11.6.3)$$

where:

q_d – continuous pressure imposed by ice determined in accordance with formula 7.11.3.6;
s – spacing between regular floors or between regular floor and solid floor.

Strength of the longitudinal stiffeners of bottom shall be checked in the same way as specified above. In that case, the value of s represents spacing of stiffeners, whereas the beam span equals to the spacing of floors.

7.11.7 Bulkheads

7.11.7.1 Transverse bulkheads shall be designed flat. The requirements specified in sub-chapter 5.7 shall be fulfilled.

7.11.7.2 Thickness of plating panels connected to the side-shell plating and bottom plating shall not be less than thicknesses of the webs of web frames and solid floors, respectively.

7.11.7.3 Horizontal stiffeners shall be applied in flat bulkheads in areas adjacent to side-shell of width not less than 10% of the bulkhead width.

The horizontal stiffeners shall be connected to the vertical girders.

Section modulus of the horizontal stiffener, including the effective width of plating, shall not be less than determined in accordance with the formula below:

$$W = 6kd^2 \quad [\text{cm}^3] \qquad (7.11.7.3\text{-}1)$$

where:

$k = \sqrt{2 + 0.085L}$
d – distance between vertical members or between member and shell-side [m].

Also the following conditions shall be fulfilled:

.1 Spacing of stiffeners shall not be greater than determined in accordance with the formula below:

$$a = 0.88t/\sqrt{R_e} \quad [\text{m}] \qquad (7.11.7.3\text{-}2)$$

and not greater than 500 mm,

t – thickness of bulkhead plating at shell-sides, [mm];

.2 moment of inertia of the stiffener cross-section, including the effective sectional area of plating with the thickness equal to 1/6 of the span of stiffeners, shall not be less than:

$$i = 190\, psal^2 \ [\text{cm}^4] \qquad (7.11.7.3\text{-}3)$$

where:
p – design pressure of ice, MPa, imposed on the ice belt plating in way of the bulkhead under consideration;
s – spacing of frames in the above mentioned region, [m];
l – span of stiffener, [m];
a – spacing of stiffeners, determined in accordance with formula 7.11.7.3–2;

.3 moment of inertia of the vertical member of bulkhead to which horizontal stiffeners are connected, including the effective width of plating shall not be less than:

$$I = 0.32\left(\frac{l_1}{l}\right)^3 i \quad [\text{cm}^4] \qquad (7.11.7.3\text{-}4)$$

where:
l_1 – span of member [m];
l – span of stiffener [m];
i – moment of inertia of stiffener cross-section, including effective strake of plating.

7.11.7.4 Horizontal stiffeners and other strengthening arrangements of transverse bulkheads in way of the ice belt shall be connected to the plating by continuous double fillet weld.

7.11.7.5 Transverse bulkheads shall fulfil the criteria for strength and buckling strength in the conditions of simultaneous load of the shell-side in way of the ice belt, and the hydrostatic pressure on the bulkhead in the condition of emergency flooding of the watertight compartment up to the deck level.

7.11.7.6 It is recommended that the longitudinal bulkhead be applied above the stem in the vessel plane of symmetry, throughout the length not less than stem length. Thickness of such a bulkhead shall not be less than plating thickness of the fore peak bulkhead.

7.11.8 Stem and Sternframe

7.11.8.1 It is recommended that both stem and stern be made of forgings or castings.

Stem welded construction from steel plates with the thickness at least twice as much as the ice belt plating panels connected to the stem is permitted.

7.11.8.2 Stem shall have special cog or other equal construction to protect the plating panels connected to it against direct ice impact.

7.11.8.3 Stem shall extend from the fore end of the upper deck to the closest transverse bulkhead situated outside the region of the bottom rise in the forebody in the plane of symmetry.

7.11.8.4 The plating of hull and longitudinal division which fulfils the requirements specified in paragraph 7.11.7.6 shall be welded to the stem with full penetration.

7.11.8.5 Transverse brackets strengthening the stem in way of the ice belt shall be applied.

The spacing of brackets shall not be greater than 0.5 m. The height and thickness of the bracket plates and the scantlings of their webs shall not be less than the corresponding scantlings required for the web frames in the fore peak.

The brackets of stem shall be connected to the side frames.

7.11.8.6 Cross-sectional area of stem in way of the ice belt shall not be less than determined in accordance with the formula below:

$$F = 2L \text{ [cm}^2\text{]} \qquad (7.11.8.6)$$

Outside the ice belt, the cross-sectional area may be reduced gradually to 70% of the value of F determined in accordance with formula 7.11.8.6.

7.11.8.7 Thickness of sternframe above the stern tube shall not be less than:

$$t = 24 + 0.38L + 1.2H^2 \text{ [mm]} \qquad (7.11.8.7\text{-}1)$$

Sternframe plate thickness in the above mentioned location shall not be less than determined in accordance with the following formulae:

$$a = 80 + 3L \text{ [mm]} \qquad (7.11.8.7\text{-}2)$$

where $L < 20$ m;

$$a = 100 + 2.3L \text{ [mm]} \qquad (7.11.8.7\text{-}3)$$

where $20 \text{ m} \leq L \leq 50$ m;

$$a = 135 + L \text{ [mm]} \qquad (7.11.8.7\text{-}4)$$

where $L > 50$ m.

7.11.8.8 In the afterbody, proper construction shall be provided to protect propellers and rudders against ice when vessel is going astern.

7.12 Vessels for Carriage of Hazardous Materials

7.12.1 Application and General Requirements

7.12.1.1 The requirements of sub-chapter 7.12 apply to vessels for the carriage of hazardous materials whether one of the following additional marks: **ADN, zb ADN-G, zb ADN-C, zb ADN-N** (see 3.7.5.3 and 3.7.5.4, *Part I – Classification Regulations*) is assigned or not.

7.12.1.2 Specific requirements concerning the hull structure are relevant to the vessel type (for vessel types – see sub-chapter 7.12.2.

7.12.1.3 The vessels for carriage of hazardous materials shall fulfil all requirements specified by *ADN Rules*.

In particular, this applies to the following aspects which influence the hull structure significantly:

– arrangement of accommodation spaces and service spaces;
– arrangement, allowable quantities and proportions of the dimension of cargo tanks;
– seating and fixing of cargo tanks to the hull;
– means of closing and openings in cargo tanks;
– insulation of cargo tanks;
– cofferdams between cargo tanks and other functional spaces of the hull;
– arrangement of water ballast and fuel oil tanks;
– means of protection against gas penetration into the accommodation spaces and service spaces (doorsteps, hatch coamings, etc.);
– double-bottom, double shell-side, shell-side stiffening pattern, deck and bulwark structure;
– material applicable for construction of hull and cargo tanks, tank insulation, materials banned from the application on board the vessel;
– required installations (piping, ventilation, etc.).

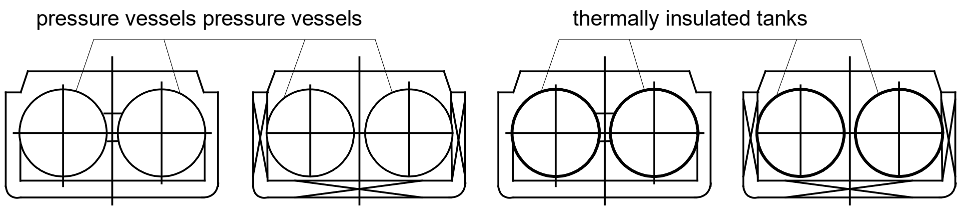
7.12.1.4 Additional requirements concerning the hull structure and strength are specified in sub-chapter 7.12.2 to 7.12.6 in accordance with *ADN Rules.*

7.12.2 Vessel Types

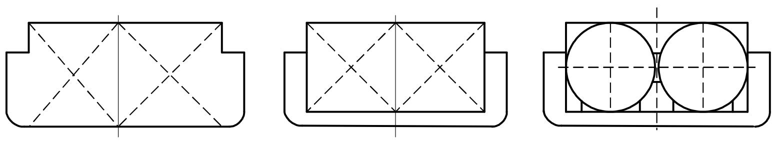
7.12.2.1 There are the following vessels distinguished: vessels intended for the carriage of hazardous bulk or packed cargo and tankers.

Tankers can be of type „G", „C" or „N" – see Fig. 7.12.2.1.

Type „G"



Type „N"



Type „C"

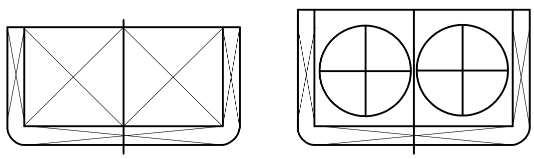


Fig. 7.12.2.1. Types of tankers for carriage of hazardous cargoes

7.12.2.2 Types of vessels mentioned in sub-chapter 7.12.2.1 which are required for the carriage of particular hazardous cargoes (chemicals) are specified in detail in ADN Rules.

7.12.3 Vessels for Carriage of Packed or Dry Bulk Hazardous Cargo

7.12.3.1 The requirements of sub-chapter 7.12.3 apply to vessels for carriage of dangerous goods in packages or in bulk whether an additional mark **ADN** is assigned or not.

7.12.3.2 In the cargo space double-side skin and double bottom are required. Each cargo hold shall be bounded by metal transverse watertight bulkheads. The cargo holds shall not be separated from oil fuel tanks by a common bulkhead.

7.12.3.3 The width of the double-side skin in cargo holds shall generally not be less than 0.8 m.

7.12.3.4 The width of the double-side skin in cargo holds may be reduced to 0.6 m, provided that the following additional conditions are fulfilled:

.1 in the case of longitudinally stiffened sides, spacing of those stiffeners shall not be greater than 0.60 m and web frames shall be arranged with the spacing not grater than 1.80 m. These intervals may be increased if the construction is correspondingly reinforced;

.2 in the case of transversely stiffened sides, either:

a) two longitudinal side shell stringers shall be fitted. The distance between the two stringers and between the uppermost stringer and the gangboard shall not exceed 0.80 m. The depth of the stringers shall be at least equal to that of the transverse frames and the cross-section of the face plate shall be not less than 15 cm^2.

The longitudinal stringers shall be supported by web frames with lightening holes similar to plate floors in the double bottom and spaced not more than 3.60 m apart. The transverse shell frames and the hold bulkhead vertical stiffeners shall be connected at the bilge by a bracket plate with a height of not less than 0.90 m and a thickness equal to the thickness of the floors; or

b) web frames with lightening holes similar to the double bottom plate floors shall be arranged on each transverse frame;

.3 the gangboards shall be supported by transverse bulkheads or cross-ties spaced not more than 32 m apart.

As an alternative to compliance with the requirement specified in .3 above, a proof by calculation, issued by a recognized classification society, confirming that additional reinforcements have been fitted in the double-hull spaces and that the vessel's transverse strength may be regarded as satisfactory, may be accepted.

7.12.3.5 As an alternative to the design pattern mentioned in 7.12.3.4-2, the construction consisting of all solid frames, i.e. connecting the side to the longitudinal bulkhead, is permitted.

7.12.3.6 The depth of the double bottom shall be not less than 0.50 m. The depth below a suction well may, however, be locally reduced, but the space between the bottom of the suction well and the bottom of the vessel floor shall be at least 0.40 m. If the spaces are between 0.40 m and 0.49 m, the surface area of the suction well shall not exceed 0.5 m^2.

The capacity of the suction well must not exceed 0.120 m^3.

7.12.4 Tankers of Type „G"

7.12.4.1 The requirements of sub-chapter 7.12.4 are applicable to tankers which according to *ADN Rules* are required to be type G tank vessels whether an additional mark **zb ADN-G** is assigned or not.

7.12.4.2 The index of all hazardous cargoes (materials) approved to be carried by the vessel shall be included in the Certificate of Class or annexes thereto.

The design pressure applied for scantling of the cargo tanks and test pressure for those tanks shall also be stated there.

7.12.4.3 Hull and cargo tanks shall be constructed of a steel which fulfils the requirements specified in sub-chapter. 2.1.

Cargo tanks may be constructed from the materials other than steel, subject to PRS approval in each particular case.

7.12.4.4 The maximum allowable volumetric capacities of cargo tanks are specified in Table 7.12.4.4.

Table 7.12.4.4
Maximum allowable volumetric capacities of cargo tanks

LBH [m³]	Maximum allowable volumetric capacities of cargo tanks [m³]
< 600	$0.3LBH$
600 ÷ 3750	180 + (LBH – 600) 0.0635
> 3750	380

where:
L – length of vessel [m],
B – breadth of vessel [m],
H – moulded depth of vessel [m].

In trunk deck vessels (with heightened deck in a portion of vessel breadth) quantity H' determined in accordance with the formula below:

$$H' = H + h\frac{b}{B}\frac{l}{L} \qquad (7.12.4.4)$$

shall be substituted for H,

where:
h – height of trunk [m] (distance between the trunk deck and main deck measured at the side wall of trunk in the midspan of L);
b – breadth of trunk [m];
l – length of trunk [m].

7.12.4.5 Application of pressure cargo tanks with the ratio of length to diameter greater than 7 is not permitted. The pressure tanks shall be designed for a cargo temperature of +40 °C.

7.12.4.6 Hull may have either single-side skin construction or double-side skin construction in the cargo space.

Hull with single-side skin construction shall fulfil the requirements specified in paragraph 7.12.4.7, whereas with double-side skin construction – in paragraph 7.12.4.8.

PRS may accept the structure of hulls not fulfilling formally the requirements specified in paragraph 7.12.4.7 or 7.12.4.8, where credible calculations demonstrate that the hull structure in the cargo space will absorb the energy of the impact against the side by other vessel's bow (straight bow) of the magnitude 22 MJ, without the loss of tightness of cargo tanks or cargo piping system.

7.12.4.7 In the cargo space, the hull with a single-side skin shall fulfil the following requirements:
- sides shall be longitudinally stiffened with the spacing not greater than 0.6 m;
- sided stiffeners shall be supported by the web frames with the spacing not greater than 2 m;
- side stringers and web frames shall not have the height less than 10% of the side height, and not less than 0.3 m;
- webs of stiffeners and web frames shall have cross-sectional areas not less than 7.5 cm^2 and 15 cm^2, respectively;
- distance between the side-shell plating and cargo tank shall be at least 0.8 m, whereas the distance between the bottom and cargo tank – at least 0.6 m;
- distance between the vessel bottom and the bottom of cargo tank suction well shall be at least 0.5 m;
- distance between the edge of suction well and the side shell plating or bottom structure longitudinal member shall be at least 0.1 m.

7.12.4.8 In the cargo space, the double-side shell hull shall fulfil the following requirements:
- double bottom with a height not less than 0.6 m shall be applied;
- distance between the side plating and longitudinal bulkhead plating shall not be less than 0.8 m.

7.12.4.9 Refrigerated cargo tanks may be installed only in the cargo holds with double-side skin and double bottom construction.

7.12.4.10 Cargo tanks in vessels with double-side skin construction shall be supported by special seatings whose apexes extend so high that the angle between the transverse horizontal line drawn through the tank centre and the segment connecting the tank centre with the seating apex in the frame plane is not greater than 20°. Side-struts linking or supporting the load bearing components of the sides of the vessel with the load-bearing components of the longitudinal walls of cargo tanks and side-struts linking the load bearing components of the vessel's bottom with the tank bottom are prohibited.

7.12.4.11 Supports of cargo tanks in vessels with single-side skin construction shall fulfil the following requirements:
- supports shall have the form of beds, whose apexes extend so high that the angle between the transverse horizontal line drawn through the tank centre and the segment connecting the tank centre with the seating apex in the frame plane is not greater than 10°;
- between the adjacent cylindrical cargo tanks, spacers having the area of the surface of contact with the tank not less than 500 mm × 450 mm shall be installed in the planes of the beds, and in the midspan between the beds – spacers having the surface area not less than 2000 mm × 450 mm;
- spacers shall be made from an energy absorbing material.

7.12.4.12 Construction of hull and fixing arrangements of tanks shall be such that the cargo tanks will not come afloat in the cargo hold flooding condition.

7.12.4.13 Volume of suction wells shall not be greater than 0.10 m^3. In pressure cargo tanks, the volume of suction well may be increased up to 0.20 m^3.

7.12.4.14 Bulkheads bounding the cargo holds shall be watertight. The possibility for application of openings and manholes in bulkheads is determined by the detailed requirements specified in *Part III – Hull Equipment* and *Part V – Fire Protection*.

7.12.4.15 Distance not less than 0.2 m shall be maintained between cargo tanks and cargo hold end bulkheads. If end bulkheads of the cargo tanks are flat, then the above defined distance shall not be less than 0.5 m.

7.12.4.16 Double-hull spaces and double bottoms in the cargo area shall be arranged for being filled with ballast water only. Double bottoms may, however, be used as oil fuel tanks, provided their depth is not less than 0.60 m.

7.12.4.17 A space in the cargo area below deck may be arranged as a service space, provided that the bulkhead bounding the service space extends vertically to the bottom and the bulkhead not facing the cargo area extends from one side of the vessel to the other in one frame plane. Such service space shall only be accessible from the deck and shall be watertight with the exception of its access hatches and ventilation inlets.

7.12.4.18 In hold spaces and other accessible spaces within the cargo area (except those double-hull spaces and double bottoms which do not have a wall adjoining the cargo tanks), the distance between the reinforcements shall not be less than 0.50 m. In double bottoms this distance may be reduced to 0.45 m.

7.12.5 Tankers of Type „C"

7.12.5.1 The requirements of sub-chapter 7.12.5 are applicable to tankers which according to *ADN Rules* are required to be type C tank vessels whether an additional mark **zb ADN -C** is assigned or not.

7.12.5.2 The index of all hazardous cargoes (materials) approved to be carried by the vessel shall be included in the Certificate of Class or annexes thereto.

The value of the maximum mass density of cargo, applied when designing the cargo tanks, shall also be stated there.

If the vessel is provided with pressure cargo tanks, then the working pressure not less than 400 kPa shall be taken for their design.

7.12.5.3 Hull as well as cargo tanks shall be constructed from the steel fulfilling the requirements specified in sub-chapter 2.1.

Saddleback cargo tanks may be constructed from materials other than steel, provided that they are at least equal to steel in respect of mechanical properties as well as resistance to high temperature and fire endurance.

7.12.5.4 Maximum allowable volumetric capacities of cargo tanks are specified in Table 7.12.5.4.

Table 7.12.5.4
Maximum allowable volumetric capacities of cargo tanks

LBH [m^3]	Maximum allowable volumetric capacities of cargo tanks [m^3]
< 600	$0.3LBH$
600÷3750	$180 + (LBH - 600)\ 0.0635$
> 3750	380

where:
L – length of vessel [m],
B – breadth of vessel [m],
H – moulded depth of vessel [m].

7.12.5.5 Length of cargo tanks shall not be greater than 10 m in the case of vessel with the length not greater than 50 m, and not greater than 0.2L in the case of a vessel with the length greater than 50 m. This provision does not apply to the vessels with cylindrical saddleback tanks with the ratio of length to diameter ≤ 7.

The relative density of the substances to be carried shall be taken into consideration in the design of the cargo tanks. The maximum relative density shall be indicated in the certificate of approval.

When the vessel is provided with pressure cargo tanks, these tanks shall be designed for a working pressure of 400 kPa (4 bar).

7.12.5.6 In the cargo space (except for cofferdams), hull may have the form of flush deck vessel (i.e. without trunk) with the double-side skin and double bottom construction (see Fig. 7.12.2.1).

7.12.5.7 Saddleback cargo tanks shall be so fixed to the hull that they will not come afloat in the cargo hold flooding condition.

7.12.5.8 Volumetric capacity of suction wells shall not be greater than 0.1 m^3.

7.12.5.9 Cargo tanks shall be separated, by cofferdams with the breadth not less than 0.60 m, from the accommodation spaces, machinery spaces and service spaces located under the deck outside the cargo space, and in the case of a lack of such spaces – from fore and after peaks.

7.12.5.10 The distance between the walls of saddleback tanks and cargo hold end bulkheads shall not be less than 0.5 m.

In the case of pressure tanks, this distance may be reduced down to 0.2 m.

7.12.5.11 Bulkheads bounding cargo tanks, cofferdams and cargo holds shall be watertight. Openings and manholes are not permitted in those bulkheads – except for the manholes in the bulkheads separating such cargo holds.

7.12.5.12 In vessels with fixed cargo tanks, the width of the double side shall not be less than 1.0 m.

The width may be reduced down to 0.8 m, provided that the following additional requirements are fulfilled:

a) thickness of deck strake shall be greater than the thickness fulfilling the criteria specified in Chapter 3 and sub-chapter 5.6 by 25%;
b) thickness of side plating shall be greater than the thickness fulfilling the criteria specified in sub-chapter 5.5 by 15%;
c) where longitudinal framing system is applied to the side, the height of side stiffeners shall not be less than 150 mm, and the cross-sectional area of the stiffener webs – not less than 7 cm^2. Longitudinal stiffeners shall be supported by web frames, in the form of plates with lightening holes, connecting the side to the longitudinal bulkhead and arranged with the spacing not greater than 1.8 m. Those distances may be increased where side stringers are properly strengthened;
d) if transverse framing system is applied to the side, then side stringers shall be applied with the spacing not greater than 0.8 m. The height of side stiffeners shall be greater than the height of cuts for the frames by 150 mm. The height of side stiffeners may be 150 mm where the cuts for frames are closed. Side stringers shall be supported by web frames arranged with the spacing not greater than 1.8 m; cross-sectional area of the webs of web frames shall not be less than 7 cm^2.

7.12.5.13 Average height of the double bottom shall not be less than 0.7 m, and in no place it shall be less than 0.6 m, except for the double bottom portions under bilge wells, where the height may be reduced down to 0.5 m.

7.12.5.14 In vessels with saddleback cargo tanks or refrigerated tanks, the width of the double side-skin shall not be less than 0.8 m, whereas the double bottom height – not be less than 0.6 m.

7.12.5.15 Cargo tanks independent of the vessel's hull and refrigerated cargo tanks may only be installed in a hold space which is bounded by double-hull spaces and double bottoms in accordance with the requirements of paragraph 7.12.5.12. The cargo tanks shall not extend beyond the deck.

7.12.5.16 Side-struts linking or supporting the load bearing components of the sides of the vessel with the load-bearing components of the longitudinal walls of cargo tanks and side-struts linking the load bearing components of the vessel's bottom with the tank bottom are prohibited.

7.12.5.17 A local recess in the cargo deck, contained on all sides, with a depth greater than 0.1 m, designed to house the loading and unloading pump, is permitted if it fulfils the following conditions:
– the recess shall not be greater than 1 m in depth;
– the recess shall be located at a minimum distance from the side plating equal to one quarter of the vessel's breadth;
– the recess shall be located not less than 6 m from entrances and openings to accommodation and service spaces outside the cargo area.

7.12.5.18 Double-hull spaces and double bottoms in the cargo area shall be arranged for being filled with ballast water only. Double bottoms may, however, be used as oil fuel tanks, provided their depth is not less than 0.60 m.

7.12.5.19 A cofferdam, the centre part of a cofferdam or another space below deck in the cargo area may be arranged as a service space, provided that the bulkheads bounding the service space extend vertically to the bottom. Such service space shall only be accessible from the deck and shall be watertight with the exception of its access hatches and ventilation inlets.

7.12.5.20 In cofferdams, double-hull spaces, double bottoms, cargo tanks, hold spaces and other accessible spaces within the cargo area (except those double-hull spaces and double bottoms which do not have a wall adjoining the cargo tanks), the distance between the reinforcements shall not be less than 0.50 m. In double bottoms this distance may be reduced to 0.45 m.

7.12.6 Tankers of Type „N"

7.12.6.1 The requirements of sub-chapter 7.12.6 are applicable to tankers which according to *ADN Rules* are required to be type N tank vessels whether an additional mark **zb ADN-N** is assigned or not.

7.12.6.2 The index of all hazardous cargoes (materials) approved to be carried by the vessel shall be included in the Certificate of Class or annexes thereto.

The value of the maximum mass density of cargo, applied when designing the cargo tanks, shall also be stated there.

If the vessel is provided with pressure cargo tanks, then the working pressure not less than 400 kPa shall be taken for their design.

7.12.6.3 Hull as well as cargo tanks shall be constructed from the steel fulfilling the requirements specified in sub-chapter 2.1.

Saddleback cargo tanks may be constructed from materials other than steel, provided that they are at least equal to steel in respect of mechanical properties as well as resistance to high temperature and fire endurance.

7.12.6.4 Maximum allowable volumetric capacities of cargo tanks are identical to those specified in Table 7.12.4.4 – for tankers of type **G**.

The relative density of the substances to be carried shall be taken into consideration in the design of the cargo tanks. The maximum relative density shall be indicated in the certificate of approval.

When the vessel is provided with pressure cargo tanks, these tanks shall be designed for a working pressure of 400 kPa (4 bar).

7.12.6.5 Length of cargo tanks shall not be greater than 10 m in the case of a vessel with the length not greater than 50 m, and not greater than 0.2L in the case of a vessel with the length greater than 50 m. This provision does not apply to the vessels with cylindrical saddleback tanks with the ratio of length to diameter ≤ 7.

7.12.6.6 Saddleback cargo tanks shall be so fixed to the hull that they will not come afloat in the cargo hold flooding condition.

7.12.6.7 Volumetric capacity of suction wells shall not be greater than 0.1 m^3.

7.12.6.8 Cargo tanks shall be separated, by cofferdams with the breadth not less than 0.60 m, from the accommodation spaces, machinery spaces and service spaces located under the deck outside the cargo space, and in the case of a lack of such spaces – from fore and after peaks.

7.12.6.9 The distance between the walls of saddleback tanks and cargo hold end bulkheads shall not be less than 0.5 m.

In the case of pressure tanks, this distance may be reduced down to 0.2 m.

7.12.6.10 Bulkheads bounding cargo tanks, cofferdams and cargo holds shall be watertight. Openings are not permitted in those bulkheads – except for the manholes in the bulkheads separating such cargo holds.

7.12.6.11 Double-hull spaces and double bottoms in the cargo area shall be arranged for being filled with ballast water only. Double bottoms may, however, be used as oil fuel tanks, provided their depth is not less than 0.60 m.

7.12.6.12 A cofferdam, the centre part of a cofferdam or another space below deck in the cargo area may be arranged as a service space, provided that the bulkheads bounding the service space extend vertically to the bottom. Such service space shall only be accessible from the deck and shall be watertight with the exception of its access hatches and ventilation inlets.

7.12.6.13 In the case of vessels:
– of double-hull construction with the tanks integrated in the vessel's structure or where hold spaces contain cargo tanks which are independent of the structure of the vessel; or
– where independent cargo tanks are used; or
– of double hull construction where the cargo tanks are integrated in the vessel's structure

the space between the wall of the vessel and the wall of the cargo tanks shall be not less than 0.60 m.

The space between the bottom of the vessel and the bottom of the cargo tanks shall not be less than 0.50 m. The space may be reduced to 0.40 m under the pump sump. The vertical space between the suction well of a cargo tank and the bottom structures shall be not less than 0.10 m.

When a hull is constructed in the cargo area as a double hull with independent cargo tanks located in hold spaces, the above values are applicable to the double hull. If, in this case, the minimum values for inspections of independent tanks, referred to in 7.12.6.14, are not feasible, it shall be possible to remove the cargo tanks easily for inspection.

7.12.6.14 In hold spaces and other accessible spaces within the cargo area (except those double-hull spaces and double bottoms which do not have a wall adjoining the cargo tanks), the distance between the reinforcements shall not be less than 0.50 m. In double bottoms this distance may be reduced to 0.45 m.

7.13 Vessels Adapted for Carriage of Containers

7.13.1 Application

The requirements specified in this sub-chapter apply to the vessels intended for the carriage of containers in certain positions in cargo holds or on deck and also to the vessels intended for the carriage of other cargoes who are adapted for the carriage of containers.

Cargo holds may be provided with guides or containers may be secured by special securing devices which fulfil the requirements specified in *Part III* of the *Rules*.

7.13.2 Documentation

Technical documentation, as specified in sub-chapter 1.4, shall be submitted to PRS for consideration and approval.

7.13.3 Materials and Welding

7.13.3.1 Fixed securing devices (permanently connected to the hull structure) for containers shall be constructed from the steel fulfilling the requirements specified in sub-chapter 2.1.

Application of other materials is subject to PRS acceptance in each particular case.

7.13.3.2 Castings which form fixed securing devices for containers which are connected to hull shall fulfil the requirements specified in *Part IX – Materials and Welding* of PRS *Rules for Construction and Classification of Sea-going Ships*.

7.13.3.3 Welding of the components of fixed securing devices for containers to the hull structure shall fulfil the requirements specified in sub-chapter 2.2 of this *Part* of the *Rules*.

7.13.4 Structure

7.13.4.1 Generally, in those hull cross-sections where container sockets (or cross sockets) are located, transverse hull members (bottom floors, deck girders and web frames) shall be situated.

PRS may accept the location of cross sockets above intercoastal girders if effectiveness of such a solution is justified by the results of strength calculations performed in accordance with the requirements specified in Chapter 3.

7.13.4.2 Hull structure in way of cross sockets shall be locally strengthened to ensure proper transmission of the reactive forces to the principal member webs.

7.13.5 Hull Strength Analysis

Hull strength in general bending conditions and strength of the framing system in way of cargo space shall be checked by direct calculations in accordance with the requirements specified in Chapter 3.

The loads resulting from the weight of containers shall be determined in accordance with the requirements specified in sub-chapter 7.13.6.

7.13.6 Load Imposed by Containers

7.13.6.1 Loads imposed by containers shall be assumed in the form of reactive forces under the container corners caused by the weight of containers determined in accordance with the requirements specified in paragraph 7.13.6.2.

It shall be assumed that the total weight of container is counterbalanced by four vertical reactive forces of equal magnitudes acting under the container corners.

7.13.6.2 If limits concerning the allowable weights of containers in particular loading conditions have not been specified in the vessel's *Loading Plan*, then the following maximum container weights shall be taken to calculations:
– 24.0 t – for 20-foot container,
– 30.48 t – for 40-foot container.

7.14 Vessels Adapted for Carriage of Vehicles

7.14.1 Application

The requirements specified in this sub-chapter apply to the vessels with the deck or bottom intended for the carriage of ro-ro cargoes (including vehicles and rail cars). They supplement the requirements specified in Chapter 5 and sub-chapters 7.6 and 7.7.

7.14.2 Documentation

Technical documentation, as specified in sub-chapter 1.4, shall be submitted to PRS for consideration and approval.

In the vessel's *Loading Plan* allowable characteristics of the vehicles permitted to be carried, such as the maximum weight, axle loads, configuration of wheels and dimensions of wheel prints shall be included.

7.14.3 General Requirements

7.14.3.1 Movable decks, unloading platforms, platforms for vehicle rolling and cargo doors shall fulfil the requirements specified in *Part III – Hull Equipment*.

7.14.3.2 General arrangement and hull structure of a vessel simultaneously carrying passengers and vehicles shall also fulfil the requirements specified in sub-chapter 7.6.

7.14.3.3 Hulls of ferries shall also fulfil the requirements specified in sub-chapter 7.7.

7.14.3.4 In general, vehicles and rail cars may be lashed to the deck only by proper securing of their wheels.

The lashing system is subject to PRS acceptance in each particular case.

7.14.3.5 Application of limitation on the vessel operation pattern which consists in imposing the movement of vehicles within the clearly defined region of the vessel deck or bottom is permitted.

The methods imposing the above mentioned pattern of vessel operation are subject to PRS acceptance in each particular case.

7.14.4 Structure

7.14.4.1 In the points of connection of structural members and stiffeners to the plating of deck or bottom adjusted to the carriage of vehicles, cuts shall not be applied, and double continuous welds shall be applied.

7.14.4.2 In vessels intended for the carriage of rail vehicles, deck longitudinal or bottom longitudinal shall be applied under each rail.

7.14.5 Strength of Girders, Stiffeners and Plating

7.14.5.1 Strength of the framing system of the deck or bottom adjusted to the carriage of vehicles shall be checked by direct calculations in accordance with the requirements specified in sub-chapter 3.4.3.

7.14.5.2 Strength of plating and stiffeners of the deck or bottom adjusted to the carriage of vehicles shall be checked by direct calculations in accordance with the requirements specified in Chapter 19 of the *Rules for Construction and Classification of Sea-going Ships, Part II – Hull* taking the loads for harbour conditions.

7.15 Craft suitable for being pushed

7.15.1 Ship-borne lighters whose length L does not exceed 40 m shall meet the requirements given in paragraph 7.15.2.

7.15.2 Collision bulkhead in accordance with paragraph 5.7.1.1, can be dispensed with if lighters' front faces are able to bear a load at least 2,5 times that set for the collision bulkheads on inland waterway vessels with the same draught and built in accordance with *the Present Rules*.

7.16 Vessels with a length L_k > 110 m

7.16.1 General

7.16.1.1 Sufficient hull strength (longitudinal, lateral and local strength) shall be confirmed by certificate issued by PRS and be base of approval of technical documentation for vessels with a length L_k > 110 m.

7.16.1.2 For craft which are built in accordance with the AND, it shall be entered in item 52 of the Community certificate that they comply with requirements of ADN.

7.16.1.3 Passenger vessels with a length L_k > 110 m shall:
– have a double bottom with a height of at least 600 mm and subdivision to ensure that, in the event of flooding of any two adjacent watertight compartments, the vessel does not immerse lower than the margin line and a residual safety clearance of 100 mm remains; or
– have a double bottom with a height of at least 600 mm and double hull with a distance of at least 800 mm between the side wall of the vessel and the longitudinal bulkhead.

7.16.1.4 If passenger vessels with a length L_k > 110 m are built or converted under the supervision of PRS for the highest class in their category, in such a case their compliance with the requirements shall be confirmed by means of a certificate issued by PRS, with no necessity of entering information about the current class; compliance with the requirements given in paragraphs 7.16.1.3 and 7.16.1.4 shall be entered in item 52 of the Community certificate.

7.16.2 The separated parts of a vessel

7.16.2.1 For cargo vessels with a length L_k > 110 m, which in addition comply with the following condition:

.1 are capable of being separated, in the event of accident in the middle third of the vessel without the use of heavy salvage equipment while the separated parts of the vessel shall remain afloat after separation,

.2 are provided with a special certificate, issued by PRS, regarding the buoyancy, trim and stability of the separate parts of the vessel, indicating the degree of loading above which buoyancy of the two parts is no longer ensured,

it shall be entered in item 52 of the Community certificate that they comply with the requirements of paragraphs .1 and .2.

7.16.2.2 The trim and stability shall fulfil requirements given in paragraphs 4.2.2.5 and 4.2.2.6 of *Part IV – Stability and Freeboard*.

7.17 Towed barge

7.17.1 General

7.17.1.1 For barges which are exclusively towed, the inspection body may allow minor deviations from paragraph 3.1.2.1 with respect to the minimum thickness of the shell plating of the hull. The deviation shall not be more than 10% and the minimum hull thickness shall not be less than 3 mm.

7.17.1.2 The deviations in accordance with paragraph 7.17.1.1 shall be entered in the Community certificate.

8 TIGHTNESS TESTS

8.1 General Requirements

8.1.1 Watertight components of hull such as plating, bulkheads, tanks, deck and superstructures shall be subjected to tightness test in accordance with the requirements specified in this Chapter.

8.1.2 Hydraulic tests shall not be performed at an ambient temperature below 2 °C (275 °K).

8.1.3 Tests shall be performed after watertight welded components have been fixed to the structure, however before cementing and painting.

8.1.4 If any work which may impair the structure watertightness was performed after the tightness test, the test shall be repeated.

8.1.5 In special cases, PRS may accept compressed air tests or paraffin and chalk tests instead of hydraulic tests.

8.1.6 Central bottom girder need not be watertight, unless it bounds a watertight compartment.

8.2 Hose Tests

The following parts of hull shall be subjected to hose tests:
- shell plating,
- weatherdecks, deckhouse walls, coamings and superstructure end walls,
- watertight bulkheads.

The test shall be performed with a fire hose nozzle with the outlet diameter not less than 12 mm. The pressure of water supplied by the nozzle shall not be less than 0.2 MPa. The water jet shall be directed perpendicularly to the plane of welds from the distance not greater than 3 m. The hose test may be performed from any side of the welded joint. Tightness test of vertical joints shall be performed upwards. The construction is considered as tight if no leak of water occurs on the observed side of the joint.

8.3 Leak Proof Tests

8.3.1 Double bottom tanks shall be tested by flooding with water up to the upper edge of the air pipe.

8.3.2 Other tanks than those specified in sub-chapter 8.3.1 as well as cofferdams shall be tested by flooding with water in accordance with the following requirements:
- fore and after peaks intended for the water tanks shall be flooded up to the upper edge of the air pipe, however at least 0.6 m above the bulkhead deck, whereas fore and after peaks not intended for tanks – up to the upper edge of its manhole coaming,
- cargo tanks in tankers – 1 m above the tank deck,
- oil fuel, oil and water tanks – up to the air pipe top, however at least 0.5 m above the tank deck,
- cofferdams – up to the upper edge of the hatch coaming, however at least 0.3 m above the compartment deck.

8.3.3 Where the vessel is docked, single bottom shall be filled with water up to 100 mm above the upper edge of bottom floors; tanks may be filled only to the light waterline. Further parts of tests shall be performed in accordance with the requirements specified in sub-chapters 8.3.1 and 8.3.2 when the vessel is afloat.

8.3.4 Compartments on the decks where water may retain shall be tested by filling with water up to the doorstep level.

8.3.5 Blades of streamlined rudders and sea chests shall be subjected to the test by the water column pressure equal to the draught of vessel up to the load waterline, increased by 2 m.

8.4 Paraffin Tests

8.4.1 Paraffin tests may be performed at an ambient temperature below 0 °C (273 °K).

8.4.2 The test duration shall not be less than:
- for weld thickness not greater than 6 mm:
  - flat welds40 minutes,
  - other welds60 minutes;
- for weld thickness greater than 6 mm:
  - flat welds60 minutes,
  - other welds90 minutes.

The weld is considered as tight if no traces of paraffin occur on the inspected side of the joint during the test.

8.4.3 Tanks intended for domestic water and oil fuel shall not be subjected to paraffin test.

8.5 Compressed Air Tests

8.5.1 Performance of tightness test by this method requires PRS acceptance in each particular case.

8.5.2 Pressure of air supplied to the nozzle shall not be less than 0.4 MPa. The air jet shall be directed perpendicularly to the contact surfaces of joints. The outlet nozzle shall have the diameter 10 ÷ 20 mm and shall be positioned at the distance not greater than 100 mm from the tested joint.

The other side of the tested joint shall be covered with a layer of foaming emulsion. The joint is considered as tight unless the emulsion is foaming on the inspected side.

ANNEX 1

REDUCTION COEFFICIENTS FOR PLATES IN TRANSVERSE FRAMING SYSTEM LOADED WITH PRESSURE

In the tables below, the values of reduction coefficients φ for plates resulting from the solution to equation 3.3.4.4-3 and fulfilling the limits resulting from equation 3.3.4.4-2 and $0 \le \varphi \le 1$.

The subsequent columns correspond to the following values: h_1/t = 0.3, h_1/t = 0.7, h_1/t = 1.0, h_1/t = 1.5 and h_1/t = 2.0.

l/s = 0.75

b_1/t = 0.75

m=-10	0.100	0.100	0.100	0.100	0.100
m=-8	0.125	0.125	0.125	0.125	0.125
m=-6	0.166	0.166	0.166	0.166	0.130
m=-4	0.250	0.250	0.250	0.184	0.104
m=-3	0.333	0.333	0.282	0.163	0.053
m=-2	0.500	0.374	0.259	0.081	0
m=-1.5	0.566	0.354	0.205	0	0
m=-1	0.566	0.273	0.062	0	0
m=-0.5	0.461	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	1	1	1	1	1
m= 1	1	1	1	1	1
m= 1.5	0.974	1	1	1	1
m= 2	0.965	1	1	1	1
m= 3	0.963	0.988	1	1	1
m= 4	0.966	0.980	0.993	1	1
m= 6	0.973	0.978	0.984	0.994	1
m= 8	0.978	0.980	0.983	0.989	0.995
m= 10	0.981	0.983	0.984	0.988	0.991

b_1/t = 1

m=-10	0.100	0.100	0.100	0.100	0.100
m=-8	0.125	0.125	0.125	0.125	0.113
m=-6	0.166	0.166	0.166	0.158	0.110
m=-4	0.250	0.250	0.234	0.152	0.074
m=-3	0.333	0.308	0.236	0.122	0.016
m=-2	0.464	0.307	0.197	0.026	0
m=-1.5	0.480	0.276	0.132	0	0
m=-1	0.468	0.177	0	0	0
m=-0.5	0.340	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	1	1	1	1	1
m= 1	0.966	1	1	1	1
m= 1.5	0.934	1	1	1	1
m= 2	0.926	0.989	1	1	1
m= 3	0.929	0.959	0.986	1	1
m= 4	0.937	0.954	0.969	0.998	1
m= 6	0.950	0.957	0.964	0.976	0.991
m= 8	0.960	0.964	0.967	0.973	0.981
m= 10	0.967	0.969	0.971	0.974	0.979

$b_1/t = 1.5$

m=-10	0.100	0.100	0.100	0.100	0.089
m=-8	0.125	0.125	0.125	0.119	0.088
m=-6	0.166	0.166	0.166	0.121	0.076
m=-4	0.250	0.222	0.174	0.098	0.025
m=-3	0.319	0.227	0.160	0.055	0
m=-2	0.345	0.202	0.101	0	0
m=-1.5	0.345	0.155	0.020	0	0
m=-1	0.316	0.035	0	0	0
m=-0.5	0.156	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	1	1	1	1	1
m= 1	0.856	1	1	1	1
m= 1.5	0.823	0.950	1	1	1
m= 2	0.819	0.903	0.969	1	1
m= 3	0.835	0.877	0.912	0.973	1
m= 4	0.855	0.879	0.899	0.936	0.976
m= 6	0.888	0.898	0.906	0.922	0.940
m= 8	0.910	0.915	0.919	0.927	0.937
m= 10	0.926	0.928	0.931	0.935	0.941

$b_1/t = 2$

m=-10	0.100	0.100	0.100	0.094	0.071
m=-8	0.125	0.125	0.125	0.096	0.066
m=-6	0.166	0.161	0.134	0.090	0.047
m=-4	0.233	0.172	0.127	0.056	0
m=-3	0.250	0.165	0.104	0.006	0
m=-2	0.258	0.127	0.032	0	0
m=-1.5	0.249	0.072	0	0	0
m=-1	0.208	0	0	0	0
m=-0.5	0.035	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	0.900	1	1	1	1
m= 1	0.731	0.965	1	1	1
m= 1.5	0.696	0.842	0.950	1	1
m= 2	0.693	0.794	0.870	0.995	1
m= 3	0.717	0.771	0.814	0.886	0.959
m= 4	0.748	0.781	0.807	0.852	0.899
m= 6	0.803	0.816	0.827	0.848	0.870
m= 8	0.841	0.848	0.853	0.864	0.875
m= 10	0.868	0.872	0.875	0.881	0.888

$l/s = 1.0$

$b_1/t = 0.75$

m=-10	0.100	0.100	0.100	0.099	0.068
m=-8	0.125	0.125	0.125	0.102	0.060
m=-6	0.166	0.166	0.159	0.096	0.035
m=-4	0.250	0.226	0.159	0.056	0
m=-3	0.333	0.228	0.136	0	0
m=-2	0.395	0.192	0.053	0	0
m=-1.5	0.397	0.131	0	0	0
m=-1	0.360	0	0	0	0
m=-0.5	0.161	0	0	0	0

m= 0	1	1	1	1	1
m= 0.5	1	1	1	1	1
m= 1	1	1	1	1	1
m= 1.5	0.949	1	1	1	1
m= 2	0.932	1	1	1	1
m= 3	0.928	0.974	1	1	1
m= 4	0.934	0.960	0.984	1	1
m= 6	0.947	0.958	0.968	0.987	1
m= 8	0.957	0.962	0.967	0.977	0.989
m= 10	0.964	0.967	0.970	0.976	0.983

b_1/t = 1

m=-10	0.100	0.100	0.100	0.086	0.055
m=-8	0.125	0.125	0.125	0.085	0.044
m=-6	0.166	0.166	0.134	0.073	0.014
m=-4	0.250	0.185	0.122	0.022	0
m=-3	0.300	0.176	0.089	0	0
m=-2	0.316	0.125	0	0	0
m=-1.5	0.306	0.053	0	0	0
m=-1	0.255	0	0	0	0
m=-0.5	0.030	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	1	1	1	1	1
m= 1	0.933	1	1	1	1
m= 1.5	0.877	1	1	1	1
m= 2	0.862	0.973	1	1	1
m= 3	0.866	0.922	0.969	1	1
m= 4	0.879	0.912	0.939	0.991	1
m= 6	0.905	0.918	0.930	0.953	0.979
m= 8	0.924	0.930	0.936	0.948	0.961
m= 10	0.936	0.940	0.943	0.950	0.958

b_1/t = 1.5

m=-10	0.100	0.100	0.092	0.063	0.034
m=-8	0.125	0.119	0.095	0.056	0.017
m=-6	0.166	0.127	0.092	0.035	0
m=-4	0.200	0.121	0.063	0	0
m=-3	0.209	0.098	0.020	0	0
m=-2	0.202	0.031	0	0	0
m=-1.5	0.178	0	0	0	0
m=-1	0.111	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	1	1	1	1	1
m= 1	0.766	1	1	1	1
m= 1.5	0.707	0.907	1	1	1
m= 2	0.693	0.832	0.936	1	1
m= 3	0.706	0.783	0.843	0.943	1
m= 4	0.734	0.781	0.818	0.883	0.949
m= 6	0.788	0.808	0.825	0.855	0.888
m= 8	0.829	0.838	0.847	0.863	0.880
m= 10	0.857	0.863	0.868	0.877	0.887

b_1/t = 2

m=-10	0.100	0.088	0.0722	0.044	0.017
m=-8	0.123	0.093	0.070	0.033	0
m=-6	0.136	0.092	0.060	0.008	0
m=-4	0.147	0.075	0.023	0	0
m=-3	0.146	0.047	0	0	0
m=-2	0.128	0	0	0	0
m=-1.5	0.100	0	0	0	0
m=-1	0.030	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	0.843	1	1	1	1
m= 1	0.611	0.930	1	1	1
m= 1.5	0.549	0.758	0.909	1	1
m= 2	0.530	0.683	0.794	0.971	1
m= 3	0.538	0.631	0.700	0.812	0.921
m= 4	0.568	0.629	0.676	0.753	0.828
m= 6	0.639	0.668	0.691	0.731	0.772
m= 8	0.702	0.717	0.729	0.750	0.773
m= 10	0.749	0.758	0.764	0.777	0.791

l/s = 1.5

b_1/t = 0.75

m=-10	0.100	0.100	0.097	0.052	0.009
m=-8	0.125	0.125	0.098	0.038	0
m=-6	0.166	0.143	0.089	0.003	0
m=-4	0.250	0.130	0.042	0	0
m=-3	0.270	0.096	0	0	0
m=-2	0.263	0	0	0	0
m=-1.5	0.229	0	0	0	0
m=-1	0.136	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	1	1	1	1	1
m= 1	1	1	1	1	1
m= 1.5	0.929	1	1	1	1
m= 2	0.894	1	1	1	1
m= 3	0.878	0.969	1	1	1
m= 4	0.884	0.937	0.983	1	1
m= 6	0.904	0.926	0.947	0.986	1
m= 8	0.921	0.932	0.943	0.964	0.989
m= 10	0.933	0.940	0.946	0.958	0.973

b_1/t = 1

m=-10	0.100	0.100	0.080	0.036	0
m=-8	0.125	0.112	0.076	0.018	0
m=-6	0.166	0.111	0.059	0	0
m=-4	0.203	0.086	0.003	0	0
m=-3	0.205	0.043	0	0	0
m=-2	0.181	0	0	0	0
m=-1.5	0.140	0	0	0	0
m=-1	0.036	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1

m= 0.5	1	1	1	1	1
m= 1	0.924	1	1	1	1
m= 1.5	0.824	1	1	1	1
m= 2	0.788	0.983	1	1	1
m= 3	0.777	0.886	0.970	1	1
m= 4	0.791	0.857	0.911	1	1
m= 6	0.828	0.857	0.882	0.928	0.978
m= 8	0.858	0.873	0.886	0.911	0.940
m= 10	0.881	0.889	0.897	0.912	0.929

b_1/t = 1.5

m=-10	0.100	0.075	0.011	0.011	0
m=-8	0.118	7.411	0.041	0	0
m=-6	0.127	6.352	0.017	0	0
m=-4	0.128	2.575	0	0	0
m=-3	0.117	0	0	0	0
m=-2	0.079	0	0	0	0
m=-1.5	0.032	0	0	0	0
m=-1	0	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	1	1	1	1	1
m= 1	0.715	1	1	1	1
m= 1.5	0.614	0.910	1	1	1
m= 2	0.575	0.792	0.948	1	1
m= 3	0.559	0.695	0.794	0.952	1
m= 4	0.575	0.667	0.735	0.847	0.956
m= 6	0.632	0.678	0.714	0.776	0.838
m= 8	0.689	0.714	0.734	0.770	0.807
m= 10	0.736	0.750	0.762	0.783	0.807

b_1/t = 2

m=-10	0.083	0.052	0.030	0	0
m=-8	0.087	0.047	0.017	0	0
m=-6	0.088	0.032	0	0	0
m=-4	0.080	0	0	0	0
m=-3	0.065	0	0	0	0
m=-2	0.025	0	0	0	0
m=-1.5	0	0	0	0	0
m=-1	0	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	0.859	1	1	1	1
m= 1	0.551	0.965	1	1	1
m= 1.5	0.456	0.734	0.933	1	1
m= 2	0.415	0.624	0.774	1	1
m= 3	0.387	0.527	0.627	0.787	0.939
m= 4	0.390	0.493	0.567	0.685	0.798
m= 6	0.431	0.492	0.538	0.611	0.683
m= 8	0.490	0.528	0.557	0.605	0.652
m= 10	0.552	0.575	0.593	0.624	0.656

l/s = 2.0

b_1/t = 0.75

m=-10	0.100	0.100	0.080	0.026	0
m=-8	0.125	0.118	0.073	0.002	0
m=-6	0.166	0.115	0.051	0	0
m=-4	0.228	0.081	0	0	0
m=-3	0.229	0.028	0	0	0
m=-2	0.200	0	0	0	0
m=-1.5	0.149	0	0	0	0
m=-1	0.024	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	1	1	1	1	1
m= 1	1	1	1	1	1
m= 1.5	0.932	1	1	1	1
m= 2	0.883	1	1	1	1
m= 3	0.8549	0.978	1	1	1
m= 4	0.8566	0.932	0.994	1	1
m= 6	0.8772	0.910	0.940	0.995	1
m= 8	0.8973	0.914	0.930	0.961	0.996
m= 10	0.9130	0.923	0.932	0.950	0.972

b_1/t = 1

m=-10	0.100	0.092	0.060	0.009	0
m=-8	0.125	0.092	0.049	0	0
m=-6	0.165	0.081	0.020	0	0
m=-4	0.172	0.036	0	0	0
m=-3	0.163	0	0	0	0
m=-2	0.120	0	0	0	0
m=-1.5	0.062	0	0	0	0
m=-1	0	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	1	1	1	1	1
m= 1	0.942	1	1	1	1
m= 1.5	0.815	1	1	1	1
m= 2	0.764	1	1	1	1
m= 3	0.737	0.882	0.991	1	1
m= 4	0.744	0.837	0.910	1	1
m= 6	0.781	0.825	0.861	0.925	0.993
m= 8	0.816	0.839	0.859	0.896	0.936
m= 10	0.844	0.858	0.869	0.8921	0.917

b_1/t = 1.5

m=-10	0.099	0.059	0.030	0	0
m=-8	0.104	0.052	0.014	0	0
m=-6	0.107	0.033	0	0	0
m=-4	0.097	0	0	0	0
m=-3	0.078	0	0	0	0
m=-2	0.027	0	0	0	0
m=-1.5	0	0	0	0	0
m=-1	0	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1

m= 0.5	1	1	1	1	1
m= 1	0.719	1	1	1	1
m= 1.5	0.595	0.943	1	1	1
m= 2	0.542	0.801	0.985	1	1
m= 3	0.507	0.675	0.795	0.986	1
m= 4	0.509	0.629	0.715	0.854	0.987
m= 6	0.552	0.618	0.668	0.751	0.832
m= 8	0.608	0.646	0.676	0.728	0.781
m= 10	0.660	0.683	0.701	0.734	0.769

b_1/t = 2

m=-10	0.072	0.036	0.010	0	0
m=-8	0.072	0.026	0	0	0
m=-6	0.069	0.042	0	0	0
m=-4	0.054	0	0	0	0
m=-3	0.032	0	0	0	0
m=-2	0	0	0	0	0
m=-1.5	0	0	0	0	0
m=-1	0	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	0.902	1	1	1	1
m= 1	0.552	1	1	1	1
m= 1.5	0.441	0.755	0.982	1	1
m= 2	0.389	0.627	0.798	1	1
m= 3	0.347	0.507	0.623	0.807	0.983
m= 4	0.336	0.458	0.544	0.683	0.816
m= 6	0.353	0.432	0.489	0.580	0.667
m= 8	0.394	0.448	0.487	0.552	0.614
m= 10	0.446	0.482	0.510	0.556	0.601

l/s = 3.0
b_1/t = 0.75

m=-10	0.100	0.100	0.064	0	0
m=-8	0.125	0.103	0.050	0	0
m=-6	0.166	0.090	0.015	0	0
m=-4	0.206	0.036	0	0	0
m=-3	0.196	0	0	0	0
m=-2	0.146	0	0	0	0
m=-1.5	0.078	0	0	0	0
m=-1	0	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	1	1	1	1	1
m= 1	1	1	1	1	1
m= 1.5	0.950	1	1	1	1
m= 2	0.884	1	1	1	1
m= 3	0.840	0.999	1	1	1
m= 4	0.835	0.936	1	1	1
m= 6	0.853	0.900	0.941	1	1
m= 8	0.874	0.899	0.922	0.965	1
m= 10	0.892	0.907	0.920	0.947	0.978

b_1/t = 1

m=-10	0.100	0.081	0.043	0	0
m=-8	0.125	0.074	0.024	0	0
m=-6	0.152	0.054	0	0	0
m=-4	0.148	0	0	0	0
m=-3	0.128	0	0	0	0
m=-2	0.068	0	0	0	0
m=-1.5	0	0	0	0	0
m=-1	0	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	1	1	1	1	1
m= 1	0.981	1	1	1	1
m= 1.5	0.824	1	1	1	1
m= 2	0.757	1	1	1	1
m= 3	0.712	0.894	1	1	1
m= 4	0.710	0.832	0.924	1	1
m= 6	0.741	0.802	0.851	0.936	1
m= 8	0.777	0.811	0.839	0.890	0.944
m= 10	0.809	0.828	0.845	0.878	0.913

b_1/t = 1.5

m=-10	0.092	0.045	0.011	0	0
m=-8	0.094	0.033	0	0	0
m=-6	0.092	0.058	0	0	0
m=-4	0.074	0	0	0	0
m=-3	0.046	0	0	0	0
m=-2	0	0	0	0	0
m=-1.5	0	0	0	0	0
m=-1	0	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	1	1	1	1	1
m= 1	0.745	1	1	1	1
m= 1.5	0.599	0.999	1	1	1
m= 2	0.532	0.832	1	1	1
m= 3	0.480	0.678	0.819	1	1
m= 4	0.469	0.614	0.718	0.883	1
m= 6	0.493	0.580	0.644	0.747	0.847
m= 8	0.540	0.595	0.636	0.705	0.773
m= 10	0.591	0.625	0.652	0.699	0.747

b_1/t = 2

m=-10	0.064	0.022	0	0	0
m=-8	0.062	0.008	0	0	0
m=-6	0.055	0	0	0	0
m=-4	0.033	0	0	0	0
m=-3	0.059	0	0	0	0
m=-2	0	0	0	0	0
m=-1.5	0	0	0	0	0
m=-1	0	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	0.969	1	1	1	1

m= 1	0.574	1	1	1	1
m= 1.5	0.445	0.799	1	1	1
m= 2	0.384	0.652	0.846	1	1
m= 3	0.330	0.511	0.642	0.851	1
m= 4	0.310	0.448	0.547	0.706	0.857
m= 6	0.309	0.402	0.468	0.575	0.676
m= 8	0.332	0.400	0.448	0.527	0.602
m= 10	0.368	0.419	0.455	0.515	0.572

l/s = 6.0
b_1/t = 0.75

m=-10	0.100	0.100	0.052	0	0
m=-8	0.125	0.096	0.026	0	0
m=-6	0.166	0.068	0	0	0
m=-4	0.202	0	0	0	0
m=-3	0.177	0	0	0	0
m=-2	0.100	0	0	0	0
m=-1.5	0.006	0	0	0	0
m=-1	0	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	1	1	1	1	1
m= 1	1	1	1	1	1
m= 1.5	1	1	1	1	1
m= 2	0.932	1	1	1	1
m= 3	0.859	1	1	1	1
m= 4	0.838	0.981	1	1	1
m= 6	0.842	0.915	0.974	1	1
m= 8	0.858	0.899	0.934	0.999	1
m= 10	0.876	0.901	0.922	0.965	1

b_1/t = 1

m=-10	0.100	0.075	0.025	0	0
m=-8	0.125	0.061	0	0	0
m=-6	0.154	0.026	0	0	0
m=-4	0.136	0	0	0	0
m=-3	0.103	0	0	0	0
m=-2	0.017	0	0	0	0
m=-1.5	0	0	0	0	0
m=-1	0	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	1	1	1	1	1
m= 1	1	1	1	1	1
m= 1.5	0.899	1	1	1	1
m= 2	0.806	1	1	1	1
m= 3	0.731	0.970	1	1	1
m= 4	0.711	0.877	0.999	1	1
m= 6	0.722	0.812	0.882	1	1
m= 8	0.750	0.803	0.846	0.922	0.999
m= 10	0.780	0.812	0.840	0.890	0.944

b_1/t = 1.5

m=-10	0.094	0.034	0	0	0
m=-8	0.093	0.014	0	0	0
m=-6	0.085	0	0	0	0
m=-4	0.055	0	0	0	0
m=-3	0.017	0	0	0	0
m=-2	0	0	0	0	0
m=-1.5	0	0	0	0	0
m=-1	0	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	1	1	1	1	1
m= 1	0.856	1	1	1	1
m= 1.5	0.670	1	1	1	1
m= 2	0.582	0.955	1	1	1
m= 3	0.504	0.752	0.928	1	1
m= 4	0.477	0.661	0.792	1	1
m= 6	0.477	0.593	0.676	0.810	0.938
m= 8	0.505	0.583	0.641	0.735	0.826
m= 10	0.544	0.598	0.638	0.706	0.773

b_1/t = 2

m=-10	0.062	0.009	0	0	0
m=-8	0.057	0	0	0	0
m=-6	0.045	0	0	0	0
m=-4	0.014	0	0	0	0
m=-3	0	0	0	0	0
m=-2	0	0	0	0	0
m=-1.5	0	0	0	0	0
m=-1	0	0	0	0	0
m=-0.5	0	0	0	0	0
m= 0	1	1	1	1	1
m= 0.5	1	1	1	1	1
m= 1	0.670	1	1	1	1
m= 1.5	0.508	0.946	1	1	1
m= 2	0.430	0.761	0.999	1	1
m= 3	0.356	0.580	0.741	1	1
m= 4	0.325	0.495	0.617	0.813	0.999
m= 6	0.307	0.422	0.505	0.637	0.762
m= 8	0.314	0.401	0.462	0.561	0.656
m= 10	0.335	0.402	0.450	0.528	0.602

ANNEX 2

VALUE OF FUNCTIONS χ_1 (u) AND χ_2 (u) IN PARAGRAPH 3.4.4.2

u	χ_1	χ_2
0.1	0.999	0.999
0.2	0.995	0.997
0.3	0.989	0.994
0.4	0.981	0.989
0.5	0.972	0.984
0.6	0.960	0.977
0.7	0.946	0.969
0.8	0.930	0.960
0.9	0.913	0.950
1	0.894	0.939
1.1	0.875	0.928
1.2	0.854	0.916
1.3	0.832	0.903
1.4	0.811	0.890
1.5	0.788	0.876
1.6	0.765	0.862
1.7	0.742	0.848
1.8	0.719	0.834
1.9	0.696	0.820
2	0.673	0.806
2.1	0.650	0.792
2.2	0.628	0.778
2.3	0.606	0.764
2.4	0.584	0.750
2.5	0.563	0.736
2.6	0.543	0.723
2.7	0.523	0.710
2.8	0.504	0.697
2.9	0.485	0.684
3	0.467	0.672
3.1	0.450	0.660
3.2	0.433	0.648
3.3	0.417	0.636
3.4	0.401	0.625
3.5	0.386	0.614
3.6	0.372	0.603
3.7	0.358	0.593
3.8	0.345	0.583
3.9	0.332	0.573
4	0.320	0.563
4.1	0.308	0.554
4.2	0.297	0.545
4.3	0.287	0.536
4.4	0.276	0.527
4.5	0.267	0.519
4.6	0.257	0.511
4.7	0.248	0.503
4.8	0.240	0.495
4.9	0.231	0.487
5.0	0.224	0.480
5.1	0.216	0.473
5.2	0.209	0.466

5.3	0.202	0.459
5.4	0.196	0.453
5.5	0.189	0.446
5.6	0.183	0.440
5.7	0.178	0.434
5.8	0.172	0.428
5.9	0.167	0.422
6	0.162	0.417

ANNEX 3

VALUES OF COEFFICIENT α IN PARAGRAPH 3.4.4.3

The tables below contain the values of coefficient α fulfilling condition 3.4.4.3-2 for the pre-defined values of K_0, b_1/t and h_1/t.

The subsequent columns of the values of α correspond to the following values: h_1/t = 0.3, h_1/t = 0.7, h_1/t = 1.0, h_1/t = 1.5 and h_1/t = 2.0.

l/s =0.75

b_1/t = 0

K_0 = 0.1	0.003	0.017	0.034	0.075	0.129
K_0 = 0.2	0.006	0.034	0.067	0.143	0.238
K_0 = 0.3	0.009	0.050	0.099	0.206	0.334
K_0 = 0.4	0.013	0.066	0.129	0.263	0.421
K_0 = 0.5	0.016	0.082	0.158	0.317	0.500
K_0 = 0.6	0.019	0.097	0.185	0.368	0.573
K_0 = 0.7	0.022	0.112	0.212	0.416	0.641
K_0 = 0.8	0.025	0.126	0.238	0.461	0.705
K_0 = 0.9	0.028	0.141	0.263	0.505	0.765

b_1/t = 0.25

K_0 = 0.1	0.008	0.029	0.051	0.098	0.157
K_0 = 0.2	0.0172	0.057	0.098	0.185	0.287
K_0 = 0.3	0.025	0.083	0.143	0.262	0.399
K_0 = 0.4	0.033	0.109	0.184	0.333	0.498
K_0 = 0.5	0.041	0.134	0.224	0.398	0.588
K_0 = 0.6	0.049	0.157	0.261	0.458	0.670
K_0 = 0.7	0.056	0.180	0.297	0.515	0.746
K_0 = 0.8	0.064	0.203	0.331	0.569	0.817
K_0 = 0.9	0.071	0.224	0.364	0.619	0.884

b_1/t = 0.5

K_0 = 0.1	0.014	0.041	0.067	0.121	0.184
K_0 = 0.2	0.027	0.078	0.127	0.223	0.331
K_0 = 0.3	0.039	0.114	0.182	0.313	0.456
K_0 = 0.4	0.052	0.147	0.233	0.393	0.565
K_0 = 0.5	0.064	0.179	0.281	0.467	0.662
K_0 = 0.6	0.075	0.209	0.325	0.534	0.751
K_0 = 0.7	0.087	0.238	0.367	0.597	0.832
K_0 = 0.8	0.098	0.265	0.407	0.655	0.908
K_0 = 0.9	0.108	0.292	0.445	0.711	0.979

b_1/t = 0.75

K_0 = 0.1	0.019	0.052	0.082	0.141	0.209
K_0 = 0.2	0.036	0.099	0.153	0.257	0.371
K_0 = 0.3	0.053	0.141	0.217	0.357	0.505
K_0 = 0.4	0.069	0.180	0.275	0.444	0.621
K_0 = 0.5	0.084	0.217	0.328	0.523	0.723
K_0 = 0.6	0.098	0.252	0.377	0.595	0.816
K_0 = 0.7	0.111	0.284	0.423	0.661	0.900
K_0 = 0.8	0.125	0.315	0.466	0.723	0.978
K_0 = 0.9	0.137	0.344	0.506	0.780	1.051

b_1/t = 1

K_0 = 0.1	0.023	0.062	0.096	0.161	0.233
K_0 = 0.2	0.045	0.116	0.177	0.288	0.407
K_0 = 0.3	0.065	0.165	0.248	0.395	0.548
K_0 = 0.4	0.083	0.209	0.311	0.488	0.668
K_0 = 0.5	0.100	0.249	0.367	0.570	0.774
K_0 = 0.6	0.116	0.286	0.419	0.644	0.868
K_0 = 0.7	0.131	0.321	0.467	0.711	0.953
K_0 = 0.8	0.146	0.353	0.511	0.773	1.032
K_0 = 0.9	0.159	0.383	0.552	0.831	1.104

b_1/t = 1.5

K_0 = 0.1	0.032	0.082	0.122	0.196	0.275
K_0 = 0.2	0.059	0.147	0.218	0.340	0.466
K_0 = 0.3	0.084	0.203	0.297	0.455	0.615
K_0 = 0.4	0.105	0.252	0.364	0.552	0.739
K_0 = 0.5	0.124	0.294	0.422	0.635	0.844
K_0 = 0.6	0.141	0.332	0.474	0.708	0.937
K_0 = 0.7	0.15	0.366	0.521	0.774	1.019
K_0 = 0.8	0.171	0.397	0.563	0.833	1.094
K_0 = 0.9	0.184	0.425	0.602	0.887	1.162

b_1/t = 2

K_0 = 0.1	0.040	0.098	0.144	0.226	0.311
K_0 = 0.2	0.072	0.171	0.248	0.379	0.511
K_0 = 0.3	0.098	0.229	0.329	0.496	0.660
K_0 = 0.4	0.119	0.278	0.396	0.590	0.781
K_0 = 0.5	0.137	0.318	0.452	0.670	0.881
K_0 = 0.6	0.153	0.353	0.500	0.738	0.967
K_0 = 0.7	0.167	0.384	0.542	0.797	1.043
K_0 = 0.8	0.179	0.411	0.579	0.850	1.110
K_0 = 0.9	0.191	0.435	0.612	0.897	1.169

l/s =1.0

b_1/t = 0

K_0 = 0.1	0.006	0.033	0.065	0.138	0.229
K_0 = 0.2	0.012	0.064	0.125	0.253	0.405
K_0 = 0.3	0.018	0.093	0.179	0.354	0.551
K_0 = 0.4	0.024	0.122	0.229	0.444	0.678
K_0 = 0.5	0.030	0.149	0.277	0.526	0.791
K_0 = 0.6	0.036	0.175	0.322	0.601	0.894
K_0 = 0.7	0.042	0.201	0.365	0.671	0.988
K_0 = 0.8	0.047	0.226	0.406	0.736	1.075
K_0 = 0.9	0.053	0.249	0.444	0.798	1.156

b_1/t = 0.25

K_0 = 0.1	0.016	0.055	0.094	0.178	0.276
K_0 = 0.2	0.032	0.105	0.177	0.320	0.479
K_0 = 0.3	0.047	0.151	0.251	0.441	0.645
K_0 = 0.4	0.062	0.195	0.319	0.547	0.786
K_0 = 0.5	0.076	0.236	0.381	0.643	0.912
K_0 = 0.6	0.090	0.275	0.439	0.729	1.024
K_0 = 0.7	0.103	0.311	0.493	0.809	1.127
K_0 = 0.8	0.116	0.346	0.543	0.884	1.222
K_0 = 0.9	0.129	0.380	0.591	0.953	1.310

b_1/t = 0.5

K_0 = 0.1	0.026	0.076	0.122	0.214	0.319
K_0 = 0.2	0.050	0.142	0.224	0.378	0.543
K_0 = 0.3	0.073	0.201	0.313	0.514	0.722
K_0 = 0.4	0.094	0.255	0.392	0.631	0.874
K_0 = 0.5	0.114	0.305	0.463	0.734	1.006
K_0 = 0.6	0.134	0.352	0.528	0.827	1.124
K_0 = 0.7	0.152	0.395	0.588	0.912	1.231
K_0 = 0.8	0.170	0.435	0.644	0.991	1.329
K_0 = 0.9	0.187	0.473	0.696	1.063	1.420

b_1/t = 0.75

K_0 = 0.1	0.035	0.095	0.148	0.248	0.357
K_0 = 0.2	0.066	0.174	0.265	0.428	0.598
K_0 = 0.3	0.095	0.243	0.364	0.573	0.786
K_0 = 0.4	0.120	0.303	0.449	0.696	0.942
K_0 = 0.5	0.144	0.358	0.524	0.803	1.077
K_0 = 0.6	0.166	0.408	0.592	0.898	1.196
K_0 = 0.7	0.187	0.453	0.654	0.984	1.304
K_0 = 0.8	0.207	0.495	0.711	1.063	1.402
K_0 = 0.9	0.225	0.534	0.764	1.135	1.492

b_1/t = 1

K_0 = 0.1	0.043	0.112	0.171	0.278	0.392
K_0 = 0.2	0.080	0.201	0.299	0.470	0.644
K_0 = 0.3	0.112	0.276	0.404	0.620	0.836
K_0 = 0.4	0.140	0.340	0.492	0.745	0.993
K_0 = 0.5	0.166	0.396	0.568	0.852	1.127
K_0 = 0.6	0.189	0.445	0.636	0.946	1.245
K_0 = 0.7	0.210	0.490	0.696	1.030	1.350
K_0 = 0.8	0.229	0.531	0.751	1.106	1.444
K_0 = 0.9	0.247	0.568	0.802	1.175	1.531

b_1/t = 1.5

K_0 = 0.1	0.058	0.142	0.210	0.327	0.449
K_0 = 0.2	0.101	0.242	0.350	0.531	0.711
K_0 = 0.3	0.136	0.320	0.457	0.682	0.902
K_0 = 0.4	0.165	0.382	0.542	0.802	1.053
K_0 = 0.5	0.189	0.434	0.613	0.901	1.178
K_0 = 0.6	0.209	0.479	0.674	0.986	1.284
K_0 = 0.7	0.227	0.518	0.726	1.060	1.377
K_0 = 0.8	0.243	0.552	0.773	1.125	1.460
K_0 = 0.9	0.257	0.582	0.814	1.183	1.534

b_1/t = 2

K_0 = 0.1	0.069	0.165	0.239	0.365	0.492
K_0 = 0.2	0.114	0.267	0.381	0.568	0.751
K_0 = 0.3	0.147	0.340	0.481	0.710	0.931
K_0 = 0.4	0.173	0.395	0.557	0.817	1.067
K_0 = 0.5	0.193	0.440	0.618	0.904	1.177
K_0 = 0.6	0.209	0.476	0.668	0.975	1.268
K_0 = 0.7	0.223	0.506	0.710	1.035	1.345
K_0 = 0.8	0.234	0.532	0.746	1.087	1.412
K_0 = 0.9	0.244	0.555	0.777	1.133	1.471

l/s =1.5

b_1/t = 0

K_0 = 0.1	0.012	0.061	0.120	0.247	0.398
K_0 = 0.2	0.023	0.117	0.223	0.437	0.672
K_0 = 0.3	0.034	0.170	0.315	0.594	0.891
K_0 = 0.4	0.046	0.219	0.398	0.731	1.075
K_0 = 0.5	0.057	0.266	0.474	0.853	1.237
K_0 = 0.6	0.067	0.310	0.545	0.963	1.381
K_0 = 0.7	0.078	0.351	0.610	1.064	1.513
K_0 = 0.8	0.088	0.391	0.672	1.158	1.634
K_0 = 0.9	0.099	0.430	0.731	1.246	1.747

b_1/t = 0.25

K_0 = 0.1	0.031	0.101	0.172	0.313	0.472
K_0 = 0.2	0.059	0.190	0.312	0.541	0.782
K_0 = 0.3	0.087	0.268	0.432	0.725	1.024
K_0 = 0.4	0.113	0.340	0.537	0.881	1.226
K_0 = 0.5	0.138	0.406	0.632	1.019	1.402
K_0 = 0.6	0.162	0.467	0.718	1.143	1.558
K_0 = 0.7	0.185	0.524	0.798	1.256	1.699
K_0 = 0.8	0.207	0.577	0.872	1.360	1.829
K_0 = 0.9	0.229	0.628	0.941	1.456	1.950

b_1/t = 0.5

K_0 = 0.1	o.048	0.137	0.219	0.372	0.537
K_0 = 0.2	0.091	0.250	0.386	0.626	0.872
K_0 = 0.3	0.130	0.346	0.523	0.826	1.128
K_0 = 0.4	0.166	0.430	0.640	0.993	1.338
K_0 = 0.5	0.199	0.506	0.744	1.137	1.520
K_0 = 0.6	0.230	0.574	0.837	1.266	1.680
K_0 = 0.7	0.259	0.637	0.921	1.382	1.823
K_0 = 0.8	0.286	0.694	0.998	1.488	1.954
K_0 = 0.9	0.312	0.748	1.070	1.586	2.075

b_1/t = 0.75

K_0 = 0.1	0.064	0.170	0.260	0.422	0.593
K_0 = 0.2	0.117	0.299	0.444	0.694	0.943
K_0 = 0.3	0.164	0.404	0.590	0.900	1.205
K_0 = 0.4	0.204	0.493	0.712	1.070	1.417
K_0 = 0.5	0.240	0.571	0.817	1.215	1.597
K_0 = 0.6	0.273	0.640	0.909	1.341	1.754
K_0 = 0.7	0.302	0.701	0.991	1.454	1.893
K_0 = 0.8	0.329	0.757	1.066	1.556	2.019
K_0 = 0.9	0.354	0.809	1.134	1.649	2.134

b_1/t = 1

K_0 = 0.1	0.078	0.197	0.295	0.465	0.640
K_0 = 0.2	0.138	0.337	0.490	0.745	0.998
K_0 = 0.3	0.187	0.445	0.637	0.953	1.259
K_0 = 0.4	0.229	0.533	0.757	1.119	1.466
K_0 = 0.5	0.264	0.608	0.858	1.258	1.639
K_0 = 0.6	0.294	0.673	0.945	1.377	1.788
K_0 = 0.7	0.321	0.729	1.021	1.482	1.919
K_0 = 0.8	0.345	0.780	1.089	1.576	2.036
K_0 = 0.9	0.367	0.825	1.150	1.661	2.141

b_1/t = 1.5

K_0 = 0.1	0.100	0.240	0.348	0.530	0.712
K_0 = 0.2	0.164	0.383	0.545	0.810	1.066
K_0 = 0.3	0.211	0.485	0.683	1.003	1.309
K_0 = 0.4	0.247	0.562	0.788	1.150	1.494
K_0 = 0.5	0.275	0.623	0.872	1.268	1.643
K_0 = 0.6	0.298	0.674	0.941	1.366	1.768
K_0 = 0.7	0.318	0.716	1.000	1.449	1.874
K_0 = 0.8	0.334	0.753	1.050	1.521	1.966
K_0 = 0.9	0.348	0.784	1.093	1.584	2.047

b_1/t = 2

K_0 = 0.1	0.114	0.267	0.382	0.571	0.757
K_0 = 0.2	0.175	0.401	0.566	0.832	1.089
K_0 = 0.3	0.214	0.487	0.684	1.000	1.302
K_0 = 0.4	0.241	0.548	0.769	1.121	1.457
K_0 = 0.5	0.262	0.594	0.833	1.214	1.578
K_0 = 0.6	0.278	0.631	0.884	1.288	1.674
K_0 = 0.7	0.290	0.660	0.926	1.350	1.754
K_0 = 0.8	0.301	0.684	0.960	1.401	1.822
K_0 = 0.9	0.310	0.705	0.989	1.445	1.880

l/s = 2.0
b_1/t = 0

K_0 = 0.1	0.016	0.081	0.157	0.319	0.507
K_0 = 0.2	0.031	0.154	0.289	0.555	0.842
K_0 = 0.3	0.046	0.221	0.404	0.748	1.105
K_0 = 0.4	0.060	0.284	0.507	0.913	1.325
K_0 = 0.5	0.075	0.343	0.601	1.059	1.516
K_0 = 0.6	0.089	0.398	0.687	1.191	1.688
K_0 = 0.7	0.102	0.450	0.767	1.312	1.843
K_0 = 0.8	0.116	0.499	0.842	1.424	1.986
K_0 = 0.9	0.129	0.547	0.913	1.528	2.118

b_1/t = 0.25

K_0 = 0.1	0.041	0.133	0.224	0.402	0.598
K_0 = 0.2	0.078	0.246	0.400	0.682	0.974
K_0 = 0.3	0.114	0.345	0.548	0.904	1.262
K_0 = 0.4	0.147	0.434	0.676	1.092	1.502
K_0 = 0.5	0.179	0.515	0.791	1.256	1.709
K_0 = 0.6	0.210	0.590	0.895	1.402	1.893
K_0 = 0.7	0.239	0.659	0.990	1.535	2.059
K_0 = 0.8	0.267	0.723	1.079	1.658	2.211
K_0 = 0.9	0.294	0.784	1.161	1.771	2.351

b_1/t = 0.5

K_0 = 0.1	0.063	0.179	0.283	0.474	0.676
K_0 = 0.2	0.119	0.321	0.489	0.783	1.079
K_0 = 0.3	0.168	0.439	0.656	1.021	1.381
K_0 = 0.4	0.213	0.541	0.797	1.219	1.629
K_0 = 0.5	0.254	0.632	0.920	1.389	1.840
K_0 = 0.6	0.292	0.713	1.029	1.539	2.027
K_0 = 0.7	0.327	0.787	1.128	1.674	2.193
K_0 = 0.8	0.360	0.856	1.218	1.797	2.345
K_0 = 0.9	0.390	0.919	1.302	1.911	2.484

b_1/t = 0.75

K_0 = 0.1	0.084	0.219	0.333	0.534	0.742
K_0 = 0.2	0.151	0.379	0.558	0.860	1.159
K_0 = 0.3	0.208	0.506	0.732	1.104	1.466
K_0 = 0.4	0.257	0.612	0.875	1.302	1.712
K_0 = 0.5	0.300	0.703	0.997	1.469	1.919
K_0 = 0.6	0.338	0.782	1.104	1.615	2.100
K_0 = 0.7	0.373	0.853	1.198	1.744	2.259
K_0 = 0.8	0.403	0.917	1.283	1.860	2.403
K_0 = 0.9	0.432	0.975	1.360	1.966	2.534

b_1/t = 1

K_0 = 0.1	0.101	0.253	0.374	0.584	0.797
K_0 = 0.2	0.176	0.422	0.608	0.917	1.218
K_0 = 0.3	0.235	0.549	0.782	1.158	1.520
K_0 = 0.4	0.283	0.652	0.920	1.349	1.758
K_0 = 0.5	0.323	0.737	1.034	1.507	1.954
K_0 = 0.6	0.358	0.810	1.132	1.642	2.123
K_0 = 0.7	0.388	0.873	1.217	1.760	2.270
K_0 = 0.8	0.414	0.929	1.293	1.864	2.401
K_0 = 0.9	0.438	0.979	1.360	1.958	2.519

b_1/t = 1.5

K_0 = 0.1	0.126	0.301	0.434	0.656	0.875
K_0 = 0.2	0.203	0.469	0.664	0.979	1.283
K_0 = 0.3	0.256	0.584	0.820	1.197	1.557
K_0 = 0.4	0.295	0.669	0.936	1.360	1.763
K_0 = 0.5	0.326	0.735	1.027	1.489	1.927
K_0 = 0.6	0.350	0.789	1.101	1.595	2.063
K_0 = 0.7	0.370	0.834	1.163	1.684	2.178
K_0 = 0.8	0.387	0.872	1.216	1.761	2.276
K_0 = 0.9	0.401	0.904	1.262	1.828	2.363

b_1/t = 2

K_0 = 0.1	0.141	0.330	0.469	0.697	0.920
K_0 = 0.2	0.210	0.481	0.677	0.991	1.293
K_0 = 0.3	0.252	0.574	0.805	1.174	1.527
K_0 = 0.4	0.281	0.638	0.895	1.304	1.693
K_0 = 0.5	0.302	0.686	0.961	1.401	1.821
K_0 = 0.6	0.318	0.723	1.013	1.478	1.922
K_0 = 0.7	0.330	0.752	1.055	1.541	2.005
K_0 = 0.8	0.341	0.776	1.090	1.593	2.074
K_0 = 0.9	0.349	0.796	1.119	1.637	2.133

l/s = 4.0

b_1/t = 0

K_0 = 0.1	0.021	0.111	0.213	0.428	0.672
K_0 = 0.2	0.042	0.210	0.389	0.734	1.100
K_0 = 0.3	0.063	0.299	0.539	0.980	1.432
K_0 = 0.4	0.083	0.382	0.672	1.190	1.707
K_0 = 0.5	0.102	0.459	0.793	1.374	1.947
K_0 = 0.6	0.121	0.531	0.903	1.540	2.160
K_0 = 0.7	0.140	0.598	1.005	1.691	2.353
K_0 = 0.8	0.158	0.662	1.100	1.831	2.531
K_0 = 0.9	0.176	0.723	1.190	1.961	2.695

b_1/t = 0.25

K_0 = 0.1	0.056	0.181	0.303	0.536	0.789
K_0 = 0.2	0.107	0.331	0.533	0.895	1.265
K_0 = 0.3	0.155	0.461	0.723	1.177	1.628
K_0 = 0.4	0.200	0.576	0.887	1.413	1.926
K_0 = 0.5	0.242	0.680	1.032	1.618	2.183
K_0 = 0.6	0.283	0.775	1.163	1.801	2.411
K_0 = 0.7	0.321	0.863	1.283	1.966	2.617
K_0 = 0.8	0.357	0.945	1.394	2.118	2.804
K_0 = 0.9	0.392	1.022	1.497	2.259	2.978

b_1/t = 0.5

K_0 = 0.1	0.087	0.242	0.379	0.627	0.887
K_0 = 0.2	0.161	0.427	0.646	1.020	1.394
K_0 = 0.3	0.226	0.579	0.857	1.319	1.771
K_0 = 0.4	0.284	0.709	1.034	1.565	2.077
K_0 = 0.5	0.337	0.823	1.187	1.776	2.338
K_0 = 0.6	0.385	0.925	1.323	1.961	2.567
K_0 = 0.7	0.429	1.017	1.445	2.127	2.771
K_0 = 0.8	0.470	1.101	1.557	2.278	2.957
K_0 = 0.9	0.508	1.178	1.659	2.416	3.127

b_1/t = 0.75

K_0 = 0.1	0.113	0.294	0.442	0.703	0.968
K_0 = 0.2	0.202	0.499	0.729	1.113	1.490
K_0 = 0.3	0.275	0.659	0.947	1.416	1.868
K_0 = 0.4	0.337	0.791	1.124	1.659	2.169
K_0 = 0.5	0.390	0.903	1.273	1.863	2.423
K_0 = 0.6	0.437	1.000	1.403	2.040	2.641
K_0 = 0.7	0.479	1.086	1.517	2.196	2.835
K_0 = 0.8	0.516	1.163	1.619	2.336	3.008
K_0 = 0.9	0.550	1.232	1.712	2.463	3.165

b_1/t = 1

K_0 = 0.1	0.135	0.336	0.494	0.763	1.034
K_0 = 0.2	0.232	0.550	0.788	1.178	1.557
K_0 = 0.3	0.305	0.707	1.001	1.473	1.925
K_0 = 0.4	0.364	0.832	1.169	1.704	2.213
K_0 = 0.5	0.413	0.935	1.306	1.894	2.449
K_0 = 0.6	0.454	1.021	1.423	2.056	2.651
K_0 = 0.7	0.489	1.096	1.524	2.195	2.826
K_0 = 0.8	0.520	1.162	1.612	2.319	2.981
K_0 = 0.9	0.547	1.220	1.691	2.429	3.120

b_1/t = 1.5

K_0 = 0.1	0.167	0.394	0.565	0.847	1.124
K_0 = 0.2	0.261	0.600	0.845	1.241	1.619
K_0 = 0.3	0.324	0.735	1.030	1.500	1.946
K_0 = 0.4	0.369	0.834	1.166	1.691	2.189
K_0 = 0.5	0.404	0.911	1.271	1.841	2.380
K_0 = 0.6	0.432	0.971	1.355	1.963	2.536
K_0 = 0.7	0.454	1.022	1.425	2.064	2.668
K_0 = 0.8	0.472	1.064	1.484	2.151	2.781
K_0 = 0.9	0.488	1.100	1.535	2.225	2.879

b_1/t = 2

K_0 = 0.1	0.183	0.424	0.601	0.889	1.169
K_0 = 0.2	0.265	0.603	0.847	1.238	1.612
K_0 = 0.3	0.313	0.710	0.995	1.450	1.884
K_0 = 0.4	0.344	0.782	1.096	1.597	2.074
K_0 = 0.5	0.367	0.834	1.169	1.706	2.218
K_0 = 0.6	0.384	0.874	1.226	1.791	2.330
K_0 = 0.7	0.408	0.931	1.309	1.916	2.498
K_0 = 0.9	0.417	0.952	1.340	1.963	2.562

l/s = 6.0

b_1/t = 0

K_0 = 0.1	0.024	0.125	0.242	0.487	0.768
K_0 = 0.2	0.048	0.238	0.442	0.839	1.262
K_0 = 0.3	0.071	0.340	0.615	1.123	1.644
K_0 = 0.4	0.094	0.435	0.768	1.365	1.964
K_0 = 0.5	0.116	0.523	0.907	1.578	2.242
K_0 = 0.6	0.137	0.605	1.034	1.770	2.489
K_0 = 0.7	0.159	0.683	1.151	1.945	2.713
K_0 = 0.8	0.179	0.756	1.262	2.107	2.919
K_0 = 0.9	0.200	0.826	1.365	2.258	3.110

b_1/t = 0.25

K_0 = 0.1	0.063	0.205	0.344	0.611	0.902
K_0 = 0.2	0.121	0.377	0.608	1.025	1.453
K_0 = 0.3	0.176	0.526	0.827	1.350	1.872
K_0 = 0.4	0.227	0.658	1.016	1.623	2.218
K_0 = 0.5	0.276	0.778	1.184	1.861	2.517
K_0 = 0.6	0.322	0.887	1.335	2.073	2.782
K_0 = 0.7	0.365	0.989	1.474	2.265	3.020
K_0 = 0.8	0.407	1.083	1.602	2.442	3.239
K_0 = 0.9	0.447	1.172	1.722	2.605	3.440

b_1/t = 0.5

K_0 = 0.1	0.098	0.275	0.432	0.717	1.016
K_0 = 0.2	0.183	0.488	0.738	1.170	1.602
K_0 = 0.3	0.257	0.663	0.982	1.517	2.040
K_0 = 0.4	0.324	0.813	1.187	1.802	2.396
K_0 = 0.5	0.385	0.944	1.365	2.047	2.699
K_0 = 0.6	0.440	1.062	1.523	2.263	2.966
K_0 = 0.7	0.492	1.169	1.665	2.456	3.204
K_0 = 0.8	0.539	1.267	1.795	2.631	3.420
K_0 = 0.9	0.583	1.357	1.914	2.793	3.618

b_1/t = 0.75

K_0 = 0.1	0.128	0.335	0.505	0.804	1.110
K_0 = 0.2	0.230	0.571	0.836	1.279	1.715
K_0 = 0.3	0.315	0.756	1.088	1.631	2.155
K_0 = 0.4	0.386	0.909	1.294	1.914	2.506
K_0 = 0.5	0.448	1.039	1.468	2.152	2.801
K_0 = 0.6	0.503	1.153	1.619	2.359	3.057
K_0 = 0.7	0.551	1.253	1.753	2.541	3.283
K_0 = 0.8	0.595	1.344	1.873	2.705	3.486
K_0 = 0.9	0.635	1.425	1.982	2.854	3.670

$b_1/t = 1$

K_0 = 0.1	0.154	0.383	0.565	0.875	1.187
K_0 = 0.2	0.265	0.631	0.905	1.356	1.795
K_0 = 0.3	0.350	0.814	1.154	1.700	2.224
K_0 = 0.4	0.419	0.960	1.349	1.970	2.560
K_0 = 0.5	0.476	1.080	1.511	2.193	2.838
K_0 = 0.6	0.525	1.182	1.648	2.382	3.074
K_0 = 0.7	0.566	1.270	1.766	2.547	3.280
K_0 = 0.8	0.603	1.347	1.871	2.692	3.462
K_0 = 0.9	0.635	1.416	1.963	2.822	3.626

$b_1/t = 1.5$

K_0 = 0.1	0.191	0.452	0.648	0.974	1.294
K_0 = 0.2	0.301	0.692	0.976	1.434	1.873
K_0 = 0.3	0.375	0.851	1.193	1.738	2.257
K_0 = 0.4	0.470	1.058	1.477	2.140	2.768
K_0 = 0.6	0.502	1.131	1.578	2.285	2.953
K_0 = 0.7	0.529	1.191	1.661	2.405	3.109
K_0 = 0.8	0.551	1.241	1.732	2.509	3.243
K_0 = 0.9	0.570	1.284	1.793	2.598	3.360

$b_1/t = 2$

K_0 = 0.1	0.211	0.488	0.692	1.026	1.349
K_0 = 0.2	0.307	0.699	0.982	1.436	1.871
K_0 = 0.3	0.363	0.825	1.157	1.687	2.192
K_0 = 0.4	0.401	0.911	1.277	1.861	2.418
K_0 = 0.5	0.429	0.974	1.366	1.991	2.588
K_0 = 0.6	0.449	1.022	1.434	2.093	2.723
K_0 = 0.7	0.465	1.060	1.489	2.175	2.833
K_0 = 0.8	0.478	1.091	1.533	2.243	2.924
K_0 = 0.9	0.489	1.117	1.571	2.301	3.001

SUPPLEMENT – ADJUSTING REQUIREMENTS

1 APPLICATION

1.1 The requirements of Chapters 2 and 3 of the Supplement apply only to craft carrying on 30 December 2008 a valid vessel certificate according to the Rhine Vessel Inspection Regulation in force on 31 December 1994, or which were under construction or undergoing conversion on 31 December 1994.

1.2 The requirements of Chapter 4 of the Supplement apply to craft not covered by paragraph 1.1 of the Supplement.

1.3 The requirements of Chapter 5 of the Supplement apply to craft not navigating on zone R waterways.

2 ADJUSTING REQUIREMENTS FOR CRAFT WHICH ARE ALREADY IN SERVICE

2.1 General

2.1.1 Without prejudice to Chapter 3 of the Supplement, craft shall be adapted to comply with those requirements in accordance with the adjusting requirements of paragraph 2.2 of the Supplement.

2.1.2 Until their adaptation, craft must comply with the Rhine Vessel Inspection Regulation in force on 31 December 1994.

2.2 Adjusting requirements

The adjusting requirements and their deadlines of rules in scope of hull are given in the table 2.2 for craft which are already in service.

Table 2.2

Point of *Part II*	Subject of requirement	Deadline and comments
5.7.1.1	Situation of collision bulkhead	NRC, at latest on issue or renewal of the Community certificate after 1.01.2035
5.7.1.2	Accommodations	NRC, at latest on issue or renewal of the Community certificate after 1.01.2010
5.7.1.2	Safety equipment	NRC, at latest on issue or renewal of the Community certificate after 1.01.2015
5.7.1.2	Gastight separation of accommodations from engine rooms, boilers rooms and holds	NRC, at latest on issue or renewal of the Community certificate after 1.01.2010
5.9.1.7	No fuel tanks located forward of the collision bulkhead	NRC, at latest on issue or renewal of the Community certificate after 1.01.2010
5.9.1.6	No fuel tanks and their fittings above engines or exhaust pipes	NRC, at latest on issue or renewal of the Community certificate after 1.01.2010. Until then, appropriate devices must ensure the safe evacuation of fuels.
7.6.3	Number and position of bulkheads	NRC, at latest on issue or renewal of the Community certificate after 01.01.2045
7.6.3	Margin line if no bulkhead deck	For passenger vessels whose keels were laid down before 1.01.1996, the requirement applies at NRC, at latest on issue or renewal of the Community certificate after 1.01.2045

Point of *Part II*	Subject of requirement	Deadline and comments
7.6.6	Minimum height of double bottoms, width of wing voids	NRC, at latest on issue or renewal of the Community certificate after 1.01.2045
7.6.3	Passenger rooms on all decks aft of the collision bulkhead and forward of the level of the aft-peak bulkhead	NRC, at latest on issue or renewal of the Community certificate after 1.01.2045

Symbols and definitions in the table:

NRC – the provision does not apply to craft which are already operating, unless the parts concerned are replaced or converted, i.e. the requirement applies only to newly-built (N) craft and to the replacement (R) or conversion (C) of the parts or areas concerned. If existing parts are replaced by replacement parts using the same technology and of the same type, this does not constitute replacement (R) within the meaning of the adjusting requirements.

"Issue or renewal of the Community certificate" – the requirement must be complied with by the time of the next issue or renewal of the Community certificate after the date indicated.

3 ADJUSTING REQUIREMENTS FOR CRAFT WHOSE KEEL WAS LAID DOWN ON OR BEFORE 1.04.1976

3.1 General

3.1.1 The requirements of Chapter 2 and Sub-chapter 3.2 of the Supplement apply only to craft whose keel was laid down on or before 1.04.1976.

3.2 Adjusting requirements

The adjusting requirements and their deadlines of rules in scope of hull are given in the table 3.2 for craft whose keel was laid down on or before 1.04.1976.

Table 3.2

Point of *Part II*	Subject of requirement	Deadline and comments
5.7.1.1	Situation of collision bulkhead	RC, at latest on issue or renewal of the Community certificate after 1.01.2035
5.9.1.8	Common surfaces of bunkers and accommodation and passenger areas	RC, at latest on issue or renewal of the Community certificate after 1.01.2035
7.6.3	Margin line if no bulkhead deck	RC, at latest on issue or renewal of the Community certificate after 1.01.2045

Symbols and definitions in the table:

RC – the provision does not apply to craft which are already operating, unless the parts concerned are replaced or converted, i.e. the requirement applies only to the replacement (R) or conversion (C) of the parts or areas concerned. If existing parts are replaced by replacement parts using the same technology and of the same type, this does not constitute replacement (R) within the meaning of the adjusting requirements.

"Issue or renewal of the Community certificate" – the requirement must be complied with by the time of the next issue or renewal of the Community certificate after the date indicated.

4 ADJUSTING REQUIREMENTS FOR CRAFT NOT COVERED BY PARAGRAPH 1.1 OF THE SUPPLEMENT

4.1 General

4.1.1 The requirements of Chapter 4 of the Supplement apply:
– to craft not covered by paragraph 1.1 of the Supplement;

– to craft for which a vessel certificate in accordance with the Rhine Vessel Inspection Regulation was issued for the first time between 1.01.1995 and 30.12.2008, provided they were not under construction or undergoing conversion on 31.12.1994;
– to craft which have obtained another traffic licence between 1.01.1995 and 30.12.2008.

4.1.2 It must be provided that those craft comply with the Rhine Vessel Inspection Regulation as applicable on the date on which the vessel certificate or the other traffic licence is granted.

4.1.3 The craft must be adapted to comply with requirements of Chapter 4 of the Supplement which enter into force following the first issue of the vessel certificate or other traffic licence is granted according to table 4.2 of the Supplement.

4.2 Adjusting requirements

The adjusting requirements and their deadlines of rules in scope of hull are given in the table 4.2 for craft not covered by paragraph 1.1 of the Supplement.

Table 4.2

Point of *Part II*	Subject of requirement	Deadline and comments	Valid for craft with vessel certificate or traffic licence before
7.6.3	Number and position of bulkheads	NRC, at latest on issue or renewal of the Community certificate after 1.01.2045	1.01.2006
7.6.3	Margin line if no bulkhead deck	For passenger vessels whose keels were laid down before 1.01.1996, the requirement applies at NRC, at latest on issue or renewal of the Community certificate after 1.01.2045	1.01.2006
7.6.6	Minimum height of double bottoms, width of wing voids	NRC, at latest on issue or renewal of the Community certificate after 1.01.2045	1.01.2006
7.6.3	Passenger rooms on all decks forward of the level of the aft-peak bulkhead	NRC, at latest on issue or renewal of the Community certificate after 1.01.2045	1.01.2006

Symbols and definitions in the table:

NRC – the provision does not apply to craft which are already operating, unless the parts concerned are replaced or converted, i.e. the requirement applies only to newly-built (N) craft and to the replacement (R) or conversion (C) of the parts or areas concerned. If existing parts are replaced by replacement parts using the same technology and of the same type, this does not constitute replacement (R) within the meaning of the adjusting requirements.

"Issue or renewal of the Community certificate" – the requirement must be complied with by the time of the next issue or renewal of the Community certificate after the date indicated.

5 ADJUSTING REQUIREMENTS FOR CRAFT NOT NAVIGATING ON ZONE R WATERWAYS

5.1 General

5.1.1 The requirements of Chapter 5 of the Supplement apply:
– to craft for which the Community certificate was issued for the first time before 30.12.2008,
– to craft which obtained another traffic licence before 30.12.2008,
– not navigating on zone R waterways.

5.1.2 It must be proved that those craft comply with the requirements of PRS Rules on the date on which the Community certificate or the other traffic licence is issued.

5.1.3 Community certificates delivered before 30.12.2008 remain valid until the date of expiry indicated on the certificate.

5.1.4 If it is difficult in practical terms to apply the requirements of Chapter 5 of the Supplement following the expiry of the adjusting requirements, or if their application gives rise to unreasonably high costs, the inspection body may allow derogations from these requirements subject to recommendations by the Committee. These derogations must be entered in the Community certificate.

5.2 Adjusting requirements for craft already in service

5.2.1 Without prejudice to Sub-chapter 5.3 and paragraph 5.1.4, craft must be adapted to comply with requirements of paragraph 5.2.2 of the Supplement.

5.2.2 The adjusting requirements and their deadlines of rules in scope of hull are given in the table 5.2.2 below for craft already in service.

Table 5.2.2

Point of *Part II*	Subject of requirement	Deadline and comments
5.7.1.1	Location of collision bulkhead	NRC, at latest on issue or renewal of the Community certificate after 30.12.2049
5.7.1.2	Accommodations	NRC, at latest on issue or renewal of the Community certificate after 30.12.2024
5.7.1.2	Safety equipment	NRC, at latest on issue or renewal of the Community certificate after 30.12.2029
5.7.1.2	Gastight separation	NRC, at latest on issue or renewal of the Community certificate after 30.12.2024
5.9.1.7	No fuel tanks forward of the collision bulkhead	NRC, at latest on issue or renewal of the Community certificate after 30.12.2024
5.9.1.6	No fuel tanks and their fittings above engines or exhaust pipes	NRC, at latest on issue or renewal of the Community certificate after 30.12.2024. Until then, appropriate devices must ensure the safe evacuation of fuels.

Symbols and definitions in the table:

NRC – the provision does not apply to craft which are already operating, unless the parts concerned are replaced or converted, i.e. the requirement applies only to newly-built (N) craft and to the replacement (R) or conversion (C) of the parts or areas concerned. If existing parts are replaced by replacement parts using the same technology and of the same type, this does not constitute replacement (R) within the meaning of the adjusting requirements.

"Issue or renewal of the Community certificate" – the requirement must be complied with by the time of the next issue or renewal of the Community certificate after 30.12.2008. If the certificate expires between 30.12.2008 and the day before 30.12.2009, that requirement is, however, only mandatory from 30.12.2009.

5.3 Adjusting requirements for craft whose keel was laid before 01.01.1985

5.3.1 Craft whose keel was laid down before 01.01.1985 must be adapted to comply with requirements of paragraphs 5.2 and 5.3.2 of the Supplement.

5.3.2 The adjusting requirements and their deadlines of rules in scope of hull are given in the table 5.3.2 below for craft whose keel was laid before 1.0.1.1985.

Table 5.3.2

Point of *Part II*	Subject of requirement	Deadline and comments
5.7.1.1	Watertight collision bulkheads	NRC
5.7.1.2	Accommodations, safety installations	NRC
9.3.2	Opening in watertight bulkheads	NRC
9.9.1.8	Surfaces of bunkers	NRC

Symbols and definitions in the table:

NRC – the provision does not apply to craft which are already operating, unless the parts concerned are replaced or converted, i.e. the requirement applies only to newly-built (N) craft and to the replacement (R) or conversion (C) of the parts or areas concerned. If existing parts are replaced by replacement parts using the same technology and of the same type, this does not constitute replacement (R) within the meaning of the adjusting requirements.

List of amendments effective as of 1 April 2019

Item	*Title/Subject*	*Source*
5.7.1.3	After peak bulkhead	ES-TRIN 2017/1
7	Explanation according to the records of chapter 7	PRS
7.6.7 - .13	Number and position of bulkheads for passenger vessel	ES-TRIN 2017/1
5.7.1.2	Anchor gear or steering apparatus.	ES-TRIN 2017/1
