SHIPPING REGISTER OF UKRAINE

RULES

FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS

Volume

2

Kyiv 2020

Shipping Register of Ukraine.
Rules for the Classification and Construction of Sea-going Ships. Volume 2

This edition of the Rules for the Classification and Construction of Sea-Going Ships of has been prepared on the basis of their third edition in 2011, taking into account amendments and additions included in the Bulletins of Amendments №1 (2014), №2 (2016), №3 (2017), №4 (2019), and taking into account amendments to applicable international conventions and codes adopted by relevant resolutions of the International Maritime Organization (IMO), unified requirements and recommendations of the International Association of Classification Societies (IACS) and amendments to the applicable resolutions of the United Nations Economic Commission for Europe and Directives of the European Parliament and of the Council, amendments and additions made as a result of the analysis of the Rules of other Classification Societies, as well as the experience of their application (for more details see Introduction).

The second volume contains parts:
II «Hull»;
III «Equipment, Arrangements and Outfit»;
IV «Stability»;
V «Subdivision»;
XVI «Structure and Strength of Fiber-Reinforced Plastic Ships».

Rules for the Classification and Construction of Sea-Going Ships of the Shipping Register of Ukraine have been approved in accordance with the current regulations and enter into force on 01.01.2020.

The rules have been published in Ukrainian and English. In case of discrepancies between the Ukrainian and English texts and doubt about the interpretation of the Rules, the Ukrainian text will prevail.

The official edition
Shipping Register of Ukraine

Registration of amendments and additions

Lit.amendments	Bulletin of Amendments/ Circular	Date	Signature
1	2	3	4

Introduction

This edition of the Rules for the Classification and Construction of Sea-Going Ships, 2020, as compared to their 2011 edition, as amended, contains the following amendments:

PART II. HULL

1. Para **1.1**: in paras **1.1.6.6.3** and **1.1.6.8** requirements have been specified.

2. Para **1.2**: para **1.2.3.3** has been completed with the requirements for ice class, polar class, Baltic ice class ships;

a new para **1.2.3.13** has been introduced taking into account IACS UR S6;

in para**1.2.5** requirements have been specified.

3. Para **1.4**: numeration of **1.4.5 ÷ 1.4.8** has been replaced by **1.4.6 ÷ 1.4.9**;

A new para **1.4.6.10** has been introduced taking into account longitudinal strength requirements for the abaft part of the hull.

4. Para **1.5**: paras **1.5.4 ÷ 1.5 7** have been canceled.

5. Para **1.6**: in para **1.6.4.5** requirements have been specified.

6. Para **1.7**: in paras **1.7.2.2.1** and **1.7.3.2.1** requirements have been specified to the size of knees and stiffeners;

paras **1.7.2.2.5** and **1.7.5.6.1** have been completed with the requirements for ice class, polar class, Baltic ice class ships.

7. Para **2.2**: paras **2.2.4.1** and **2.2.4.4** have been amended.

8. Para **2.3**: paras **2.3.1.1**, **2.3.4.1** and **2.3.4.3** have been amended;

para **2.3.4.2** have been revised taking into account the analysis of the Rules of other classification societies;

a new para **2.3.4.4** has been introduced with the requirements for minimum single-bottom plates thicknesses;

para **2.3.5.1.4** has been canceled.

9. Para **2.4**: paras **2.4.2.3, 2.4.2.4** and **2.4.2.7.4** have been amended;

paras **2.4.4.2.4**, **2.4.4.4.1**, **2.4.4.5.1**, **2.4.4.6.1 ÷ 2.4.4.6.3** and **2.4.4.10** have been revised taking into account the analysis of the Rules of other classification societies.

10. Para **2.5**: paras **2.5.1.3**, **2.5.4.7.6** and **2.5.5.1.6** have been canceled;

paras **2.5.2.1** and **2.5.3.2.3** have been amended;

paras **2.5.4.1 ÷ 2.5.4.6, 2.5.4.7.1 ÷ 2.5.4.7.3, 2.5.4.8, 2.5.5.3** and **2.5.5.6** have been revised taking into account the analysis of the Rules of other classification societies.

11. Para **2.6**: para **2.6.1.2** has been canceled;

paras **2.6.4.1.3** have been amended;

paras **2.6.4.1.4, 2.6.4.1.5**, **2.6.4.2 ÷ 2.6.4.9** and **2.6.5.1.1** have been revised taking into account the analysis of the Rules of other classification societies.

12. Para **2.7**: paras **2.7.1.2** and **2.7.3.2** have been amended;

para **2.7.1.5** has been canceled;

paras **2.7.4.1 ÷ 2.7.4.4** have been revised taking into account the analysis of the Rules of other classification societies;

new paras **2.7.4.5** and **2.7.4.6** have been introduced;

paras **2.7.5.3 ÷ 2.7.5.6** have been canceled.

13. Para **2.8**: paras **2.8.1.1, 2.8.2.2, 2.8.2.3, 2.8.2.14, 2.8.5.1.1 ÷ 2.8.5.1.5** have been amended;

paras **2.8.5.4, 2.8.2.15, 2.8.4.7 ÷ 2.8.4.9** have been canceled;

paras **2.8.4.1 ÷ 2.8.4.6** have been revised taking into account the analysis of the Rules of other classification societies.

14. Para **2.9**: paras**2.9.1, 2.9.1.1, 2.9.1.2, 2.9.2.1, 2.9.4.1** have been amended;

para **2.9.5** has been canceled.

15. Para **2.10**: paras **2.10.1.2**, **2.10.4.3.2** and **2.10.5** have been canceled;

paras **2.10.2.2, 2.10.2.6** and **2.10.4.2.4** have been amended;

para **2.10.4.1** has been revised taking into account the analysis of the Rules of other classification societies.

16. Para **2.11**: para **2.11.2.2** has been amended.

17. Para **2.12**: paras **2.12.3, 2.12.4.5, 2.12.5.2** and **2.12.5.3** have been revised taking into account the analysis of the Rules of other classification societies;

paras **2.12.4.6** and **2.12.5.5** have been amended.

18. Para **2.13**: paras **2.13.1** and **2.13.2** have been revised taking into account the analysis of the Rules of other classification societies;

Para **2.13.3** has been canceled;

The number of para **2.13.4** has been replaced by **2.13.3**;

Para **2.13.3** (amended) has been revised taking into account the analysis of the Rules of other classification societies.

19. Para **2.14**: paras **2.14.4.1** and **2.14.4.2** have been revised taking into account the analysis of the Rules of other classification societies.

20. Para **3.1:** paras **3.1.1.5** and **3.1.3.6** have been amended;

paras **3.1.2.5**, **3.1.2.7** and **3.1.2.9.3** have been canceled;

numbers of paras have been replaced as follows: **3.1.2.6** by **3.1.2.5**, **3.1.2.8** by **3.1.2.6**, **3.1.2.9** by **3.1.2.7**, **3.1.2.9.4** by **3.1.2.7.3**, **3.1.2.10** by **3.1.2.8**, **3.1.2.11** by **3.1.2.9**.

21. Para **3.2:** paras **3.2.1.2, 3.2.4.5** and **3.2.4.7** have been amended;

paras **3.2.3.2, 3.2.3.4 ÷ 3.2.3.9, 3.2.4.1 ÷ 3.2.4.4** have been revised taking into account the analysis of the Rules of other classification societies;

paras **3.2.3.10 ÷ 3.2.3.13, 3.2.4.8 ÷ 3.2.4.11** have been canceled.

22. Para **3.3:** paras **3.3.4.9.5, 3.3.4.10, 3.3.5.3, 3.3.6.2 ÷ 3.3.6.5** have been amended.

23. Para **3.5:** para **3.5.5.3** has been canceled.

24. Para **3.6:** para **3.6.1.2 4** has been revised taking into account the analysis of the Rules of other classification societies;

paras **3.6.2.8.1, 3.6.4.10** i **3.6.5.5** have been amended;

para **3.6.4.12.1** has been canceled;

numbers of paras: **3.6.4.12.2 ÷ 3.6.4.12.5** have been replaced by **3.6.4.12.1 ÷ 3.6.4.12.4**.

25. Para **3.7:** para **3.7.1.3** has been canceled;

numbers of paras: **3.7.1.4 ÷ 3.7.1.6** have been replaced by **3.7.1.3 ÷ 3.7.1.5**;

paras **3.7.2, 3.7.3.4**, **3.7.4** i **3.7.5** have been revised taking into account the analysis of the Rules of other classification societies.

26. Para **3.8:** para **3.8.4** has been revised taking into account the analysis of the Rules of other classification societies.

27. Para **3.9:** para **3.9.4.7** has been revised taking into account the analysis of the Rules of other classification societies.

28. Paras **3.10** and **3.11:** have been combined into one para **3.10**, revised taking into account the analysis of the Rules of other classification societies.

29. Section **3**: new paras **3.11** «Polar class ships», **3.12** «Baltic ice class ships», **3.14** «Requirements for ice strengthening of ships intended for operation astern» and **3.15** «Ships intended for operation in low air temperatures» have been introduced.

Existing para number **3.12** has been replaced by **3.13**. Para **3.13** (amended) has been revised taking into account the analysis of the Rules of other classification societies.

30. Para **3.13** Existing para number has been replaced by **3.16.**

31. Para **3.14** Existing para number has been replaced by **3.17.**

32. Appendix **1**: has been revised taking into account the analysis of the Rules of other classification societies.

33. Appendix **3**: the text title has been amended;

para **4.1.2** has been amended with Pic. 4.1.2.

34. Appendix **4**: the text title has been amended.

35. Editorial amendments have been made.

PART III. EQUIPMENT, ARRANGEMENTS AND OUTFIT

1. Para **1.1**: paras **1.1.1** and **1.1.4** have been amended;

para **1.1.5** has been canceled.

2. Para **1.3**: para **1.3.2.9** has been amended.

3. Para **2.1**: a new para **2.1.3** has been introduced taking into account IACS UR S10.Rev.5;

numbers of paras **2.1.3 ÷ 2.1.10** have been replaced by **2.1.4 ÷ 2.1.11** and amended taking into account the requirements for polar, Baltic ice class ships.

4. Para **2.2**: paras **2.2.2.2, 2.2.2.3** and **2.2.3.1** have been completed with the requirements for polar class ships, Baltic ice classes.

5. Section **2**: a new para **2.11** «Additional requirements for Baltic ice class ships» has been introduced.

6. Para **3.1**: para **3.1.1** has been amended.

7. Para **3.2:** para **3.2.1** has been amended with Fig. 3.2.1.

8. Para **4.1**: para 4.1.1 has been amended.

9. Para **5.1**: a new para **5.1.4** has been introduced.

10. Para **7.1**: para **7.1.1** has been amended.

11. Para **7.2**: a new para **7.2.1.14** has been introduced.

12. Para **7.7**: para **7.7.1.1** has been amended.

13. Para **7.10**: para **7.10.4.1** has been amended, the number of para has been canceled;

paras **7.10.4.2, 7.10.4.3** and **7.10.7** have been canceled.

14. Para **7.11**: the heading of para has been changed;

paras **7.11.1** and **7.11.2** have been revised taking into account the analysis of the Rules of other classification societies;

paras **7.11.4** ÷ **7.11.6** have been canceled.

15. Para **7.12:** paras **7.12.2.5, 7.12.5.3, 7.12.5.4, 7.12.5.6** and **7.12.5.15** have been amended.

16. Para **7.13**: para 7.13.1 has been amended;

paras **7.13.13** ÷ **7.13.20** have been revised taking into account the analysis of the Rules of other classification societies.

17. Para **7.14:** para **7.14.2** has been amended;

para **7.14.3** has been canceled.

18. Para **8.5:** para **8.5.2.8** has been revised taking into account the analysis of the Rules of other classification societies.

19. Para **8.6:** para **8.6.1** has been amended.

20. Para **8.8**: the heading of para has been changed;

paras **8.8.2** and **8.8.3** have been revised taking into account the analysis of the Rules of other classification societies.

21. Section **9:** the heading of para has been changed.

22. Para **10.2:** para **10.2.2** a new para **10.2.2.3** has been introduced;

the number of para **10.2.1.2** has been replaced by **10.2.3**;

para **10.2.3** (existing) has been canceled.

23. Para **10.3:** para **10.3.5** has been canceled;

numbers of paras **10.3.6** ÷ **10.3.12** have been replaced by **10.3.5** ÷ **10.3.11**;

para **10.3.5** (amended) has been amended.

24. Para **10.5:** para **10.5.1** a new para **10.5.1.8** has been introduced.

25. Section **10:** a new para **10.6** «Testing» has been introduced.

26. Para **11.1:** para **11.1.1** has been amended;

the number of para **11.1.5.2** has been replaced by **11.1.5.3**;

para **11.1.1** a new para **11.1.5.2** has been introduced.

27. Para **11.2:** para **11.2.6.5** has been amended.

28. Section **11:** a new para **11.8** «Testing» has been introduced.

29. Section **13:** the number of Section has been replaced by **12**.

30. Part **III**: a new Section **13** «Ships intended for operation in low air temperatures» has been introduced.

31. Section **12:** the number of Section has been replaced by **15**.

32. Section **15** (amended): para **15.2.5** (amended) has been amended taking into account the requirements for polar, Baltic ice class ships.

33. Appendix **2**: have been revised taking into account the analysis of the Rules of other classification societies.

34. Editorial amendments have been made.

PART IV. STABILITY

1. Para **1.1**: para **1.1.1** has been amended;

para **1.1.4** has been canceled;

the number of para **1.1.5** has been replaced by **1.1.4**.

2. Para **1.4**: paras **1.4.2.1**, **1.4.7.1** and **1.4.11.3** have been amended.

3. Para **1.5**: paras **1.5.1**, **1.5.2.1**, **1.5.5.2** and **1.5.13** have been amended.
4. Section **1**: a new para **1.7** «Passage of ships» has been introduced.
5. Para **2.1**: para **2.1.5.6** has been amended.
6. Para **3.1**: para **3.1.1** has been amended.
7. Para **3.2**: para **3.2.1** has been amended.
8. Para **3.3**: para **3.3.1** has been amended.
9. Para **3.7**: para **3.7.1** a new para **3.7.1.3** has been introduced;
para **3.7.4** a new para **3.7.4.7** has been introduced**.**
10. Para **3.8**: para **3.8.4.7** has been canceled;
the number of para **3.8.4.8** has been replaced by **3.8.4.7**;
paras **3.8.7.2** and **3.8.7.3** have been revised taking into account the analysis of the Rules of other classification societies.
11. Para **3.9**: para **3.9.3** has been canceled;
numbers of paras **3.9.4 ÷ 3.9.11** have been replaced by **3.9.3 ÷ 3.9.10**.
12. Para **3.10:** para **3.10.5** has been revised taking into account the analysis of the Rules of other classification societies.
13. Para **3.11**: the heading of para has been changed;
para **3.11.1** have been revised taking into account the analysis of the Rules of other classification societies;
paras **3.11.8.1.1**, **3.11.8.3.1 ÷ 3.11.8.3.5, 3.11.8.4.1 ÷ 3.11.8.4.4, 3.11.9.2, 3.11.10.4.1.2, 3.11.10.5.1, 3.11.10.6.2 ÷ 3.11.10.6.4, 3.11.10.7.1** and **3.11.10.7.2** have been amended;
paras **3.11.11** and **3.11.12** have been canceled.
14. Para **4**.1**:** para **4.1.1** a new para **4.1.1.5** has been introduced.
15. Para **4.2**: para **4.2.1** has been amended.
16. Para **4.3**: para **4.3.3.9** has been amended.
17. Editorial amendments have been made.

PART V. SUBDIVISION

1. Para **1.1**: para **1.1.1** has been amended;
para **1.1.4** has been canceled.
2. Para **1.4**: para **1.4.6** has been amended;
para **1.4.6.1.4** has been amended taking into account the requirements for polar, Baltic ice class ships.
3. Para **2**.**1**: para **2.1.1** has been amended;
a new para **2.1.2** has been introduced.
4. Para **2**.5: para **2.5.4.1.2** has been amended.
5. Para **3.4**: paras **3.4.2.1, 3.4.2.2, 3.4.2.3.4, 3.4.2.3.5, 3.4.3.1, 3.4.4, 3.4.4.1, 3.4.13** і **3.4.13.1** внесені зміни;
paras **3.4.10, 3.4.10.1 ÷ 3.4.10.3** and Table 3.4.10.5 have been amended taking into account the requirements for polar, Baltic ice class ships.
6. Para **3.4**: a new para **3.4.15** «Ships for handling anchors» has been introduced.
7. . Editorial amendments have been made.

PART XVI. STRUCTURE AND STRENGTH OF FIBER-REINFORCED PLASTIC SHIPS

This part of the Rules has been revised taking into account the analysis of the Rules of other classification societies.

CONTENT

PART II. HULL

PART III. EQUIPMENT, ARRANGEMENTS AND OUTFIT

PART IV. STABILITY

PART V. SUBDIVISION

PART XVI. STRUCTURE AND STRENGTH OF FIBER-REINFORCED PLASTIC SHIPS

PART II. HULL

1. DESIGN PRINCIPLES

1.1 GENERAL

1.1.1 Application.

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

Table 1.1.1.1

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

[1] For vessels of dredging fleet, not more than 3.

[2] For vessels of industrial fleet, not more than 4.

[3] For floating cranes, not less than 4,5.

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

- contracted for construction on or after 1 July 2016;
- in the absence of a contract for construction, which keels were laid or which were at a similar stage of construction on July 1, 2017 or after that date; or
- which were commissioned on July 1, 2020[1] or after that date.

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

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

1.1.1.3 Draft fore of mixed (sea – river) navigation ships, in all load conditions, shall not be less than:

.1 for ships with sign **R2-RS(6,0)** – 2,9 m with $L \geq 60{,}0$ m and not less than 1,6 m with $L \leq 25{,}0$ m;

.2 for ships with sign **R2-RS(4,5)** – 2,2 m with $L \geq 60{,}0$ m and not less than 1,2 m with $L \leq 25{,}0$ m;

.3 for ships with sign **R3-RS** – 1,7 m with $L \geq 60{,}0$ m and not less than 0,9 m with $L \leq 25{,}0$ m;

For the intermediate values of *L* and intermediate wave height values, among specified in **.1** and **.2**, the minimum allowable draft fore is determined by linear interpolation.

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

1.1.1.4 Ships of mixed (sea – river) navigation, having in class notation signs **R2-RS** or **R3-RS,** namely: self-propelled cargo ships, tugs, towed barges, and pushed barges, shall be fitted with double sides and double bottom.

Double sides shall be provided within cargo holds (cargo tanks). Double bottom shall be arranged from collision (forepeak) bulkhead to after peak bulkhead. On towing vessels double sides may not be provided and double bottom shall be arranged from forepeak to after peak bulkhead, as far as practicable and compatible with the design and normal operation of the vessel.

In this case, any part of the towing vessel not fitted with a double bottom shall be capable of withstanding the damage to the bottom referred to in 2, Part V "Subdivision".».

1.1.2 General.

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

1.1.2.2. The structures regulated by this Part shall comply with the requirements of Part XIII "Materials" and Part XIV "Welding" and with the approved technical documentation listed in в **4.2.3** Part I "Classification" of the Rules for the Classification and construction of Sea-going Ships[2].

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

1.1.3 Definitions and explanations**.**

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

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

Moulded depth D is the vertical distance measured amidships from the top of the plate keel or from the point where the inner surface of shell plating abuts upon the bar keel, to the top of the upper deck beam at side. In ships having a rounded gunwale, the depth is measured to the point of intersection of the moulded lines of upper deck and side, the lines extending so as if the gunwale were of angular design.

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

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

Ship's ends are portions of the ship's length beyond the midship region.

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

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

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

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

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

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

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

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

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

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

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

Superstructure deck is a deck forming the top of a tier of superstructure.

Where the superstructure has several tiers, the superstructure decks are called as follows: first tier

[2]Hereinafter – Part I «Classification».

superstructure deck, second tier superstructure deck, etc., counting from the upper deck.

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

Lower decks are the decks located below the upper deck.

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

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

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

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

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

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

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

Midship region is the part of the ship's length equal to 0,4*L* (0,2*L* forward and aft of amidships), unless expressly provided otherwise.

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

$g = 9{,}81$ m/s^2 - acceleration due to gravity;

$\rho = 1{,}025$ t/m^3 - density of sea water.

Moulded breadth B is the greatest moulded breadth, in m, measured amidships from outside of frame to outside of frame.

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

Intermediate frames are additional frames fitted between main frames.

Spacing is the distance between primary members, determined on the basis of the value of standard spacing a_0, in m, determined by the formula

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

Deviation from normal spacing may be permitted. In this case, it is recommended to assume the spacing of more than $0{,}6a_0$ and less than $1{,}25a_0$.

In the fore and after peaks it is not recommended to assume the spacing of more than 0,6 m, between the fore peak bulkhead and 0,2*L* aft of the forward perpendicular - of more than 0,7 m.

1.1.4 Basic provisions for determining the scantlings of hull members.

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

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

1.1.4.3 3 For the purpose of these Rules, the design characteristics of the material used for hull structures shall be as follows:

R_{eH} – upper yield stress, in MPa;

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

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

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

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

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

Table 1.1.4.3

R_{eH}	235	315	355	≥ 390
η	1,0	0,78	0,72	0,68
σ_n	235	301	326	346

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

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

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

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

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

For ships of restricted areas of navigation **R2**, **R2-S**, **R2-RS**, **A-R2**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS, C-R3-S**, **C-R3-RS, R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** a reduction in the thickness of hull members is permitted, but not in excess of the values given in Table1.1.4.6.

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

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

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

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

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

The reduced scantlings as well as scantlings determined in accordance with the requirements of these Rules for the 25-years service life of the ship shall be expressly indicated in the hull structural drawings submitted to the Register for review. A special entry shall be made in the Classification Certificate of such ships (refer to **2.3.1**, Part I "Classification").

1.1.5 Corrosion allowance.

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

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

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

T – planned service life of structure, in years;

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Nos	Structural member	u, in mm per annum	
		Group I	
1	**2**	**3**	**4**
1	**Plating of decks and platforms**		
1.1	Upper deck	0,08	0,13[1]
1.2	Lower deck	0,08	–
1.3	Deck in accommodation and working spaces	0,08	0,08
2	**Side plating**		
2.1	Side (no inner skin is provided):		
2.1.1	freeboard	0,08	0,08
2.1.2	in the region of alternating waterlines	0,12	0,12
2.1.3	below the region of alternating waterlines	0,12	0,12
2.2	Side (inner skin is provided) (compartments of double skin side are not designed to be filled):		
2.2.1	freeboard	0,08	0,08

Nos	Structural member	*u*, in mm per annum	
		Group I	
2.2.2	in the region of alternating waterlines	0,12	0,12
2.2.3	below the region of alternating waterlines	0,12	0,12
2.3	Side (inner skin is provided) (compartments of double skin side are designed for the of carriage cargo, fuel oil or water ballast):		
2.3.1	freeboard:		
	.1 tanks filled with fuel oil	0,15	0,15
	.2 tank for reception of water ballast	0,15	0,15
2.3.2	in the region of alternating waterlines:		
	.1 tanks filled with fuel oil	0,15	0,15
	.2 tank for reception of water ballast	0,15	0,15
2.3.3	below the region of alternating waterlines:		
	.1 tanks filled with fuel oil	0,15	0,15
	.2 tank for reception of water ballast	0,15	0,15
3	**Bottom plating**		
3.1	Bottom (inner bottom is not provided):		
3.1.1	including bilge	0,12	–
3.1.2	in way of cargo tanks	–	0,15
3.1.3	in way of fuel oil tanks	0,15	0,15
3.1.4	in way of ballast compartments	0,15	0,15
3.2	Bottom (inner bottom is provided):		
3.2.1	including bilge	0,12	0,12
3.2.2	in way of cargo tanks	0,15	0,15
3.2.3	in way of ballast compartments	0,15	0,15
4	**Plating of inner bottom, hopper tank and trapezoidal stools under transverse bulkheads**		
4.1	Inner bottom in the area of cargo holds (tanks):		
4.1.1	in way of fuel oil tanks	0,12	0,15
4.1.2	in way of ballast compartments	0,15	0,15
4.1.3	in way of boiler room	0,17	0,17
4.1.4	in way of engine room	0,10	0,17
4.1.5	with no wood sheathing in holds if cargo is expected to be discharged by grabs	0,17	0,17
4.2	Hopper tanks, trapezoidal stools under transverse bulkheads, margin plate:		
4.2.1	plating of hopper tanks and trapezoidal stools:		
	bottom strake	0,17	0,17
	other strakes	0,12	0,15
4.2.2	margin plate (inclined and horizontal)	0,17	0,17
4.2.3	margin plate in boiler room:		
	inclined	0,17	0,17
	horizontal	0,17	0,17
5	**Plating of longitudinal and transverse bulkheads of inner skin**		
5.1	Watertight bulkheads:		
5.1.1	top strake	0,10	–
5.1.2	middle strake	0,12	–
5.1.3	bottom strake	0,13	–
5.2	Bulkheads between holds loaded with bulk cargoes:		
5.2.1	top strake (0,1 *D* from the upper deck)	–	0,13
5.2.2	other strakes	–	0,15
5.3	Bulkheads between holds loaded with oil cargo or bulk cargo:		
5.3.1	top strake (0,1 *D* from the upper deck)	–	0,16
5.3.2	other strakes	–	0,18
5.4	Bulkheads between cargo tanks:		
5.4.1	top strake (0,1 *D* from the upper deck)	–	0,13[1]
5.4.2	middle strake	–	0,10[1]

Nos	Structural member	*u*, in mm per annum	
		Group I	
5.4.3	bottom strake	–	0,13
5.5	Bulkheads between cargo and ballast compartments:		
5.5.1	top strake (0,1 *D* from the upper deck)	0,13	0,15
5.5.2	middle strake	0,15	0,15
5.5.3	bottom strake	0,15	0,17
5.6	Topside tanks	0,12	0,15
6	**Framing of decks and platforms**		
6.1	Deck longitudinals and beams of decks and platforms forming boundaries of:		
6.1.1	holds loaded with general cargoes	0,12	–
6.1.2	holds loaded with bulk cargoes	–	0,15
6.1.3	holds loaded with crude oil and petroleum products or bulk cargoes	–	0,15[1]
6.1.4	cargo tanks	–	0,15
6.1.5	fuel oil tanks	0,15	0,15
6.1.6	ballast compartments	0,15	0,15
6.2	Deck girders, transverses of decks and platforms forming boundaries of:		
6.2.1	holds loaded with general cargoes	0,08	–
6.2.2	holds loaded with bulk cargoes	–	0,12
6.2.3	holds loaded with crude oil and petroleum products or bulk cargoes	–	0,15
6.2.4	cargo tanks	–	0,15[1]
6.2.5	fuel oil tanks	0,10	0,10
6.2.6	ballast compartments	0,10	0,10
6.3	Cargo hatch coamings	0,08	0,10
7	**Framing of sides and bulkheads**		
7.1	Longitudinals, main and web frames, cross ties, vertical stiffeners and horizontal girders of sides and bulkheads forming boundaries of:		
7.1.1	holds loaded with general cargoes	0,10	–
7.1.2	holds loaded with bulk cargoes	–	0,13
7.1.3	holds loaded with crude oil and petroleum products or bulk cargoes	–	0,15
7.1.4	cargo tanks	–	0,15[1]
7.1.5	fuel oil tanks	0,15	0,15
7.1.6	ballast compartments	0,15	0,15
8	**Framing of bottom and inner bottom**		
8.1	Bottom centre girder, side girders, floors and bottom longitudinal girders (inner bottom is omitted):		
8.1.1	in general cargo compartments	0,14	–
8.1.2	in cargo tanks	–	0,15
8.1.3	in ballast compartments	0,15	0,15
8.1.4	under the boilers	0,17	0,17
8.2	Bottom centre girder, side girders, floors, bottom and inner bottom longitudinals in double bottom compartments:		
8.2.1	not intended to be filled	0,12	0,12
8.2.2	in oil fuel tanks	0,15	0,15
8.2.3	in water ballast tanks	0,15	0,17
8.2.4	under the boilers	0,17	0,17
9	**Superstructures, deckhouses and bulwarks**		
9.1	Shell plating	0,06	0,06
9.2	Framing	0,06	0,06

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

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

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

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

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

.2 for band and flat profile members

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

but at least 1,05,

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

Δs – refer to 1.1.5.1;

$j_k \approx \omega_k$

1.1.6 Compliance with statutary requirements (for ships of gross tonnage 500 t and over).

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

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

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

.3 where a long forward superstructure is fitted, the fore peak or collision bulkhead on all passenger ships shall respectively be extended weathertight to the next full deck above the bulkhead deck. The extension shall be so arranged as to preclude the possibility of the bow door causing damage to it in the case of damage to, or detachment of, the bow door.

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

However, in ships constructed before 1 July 1997:

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

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

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

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

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

collision bulkhead.

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

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

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

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

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

.1 a collision bulkhead shall be fitted which shall be watertight up to the freeboard deck. This bulkhead shall be located at a distance from the forward perpendicular of not less than 5 per cent of the length of the ship or 10 m, whichever is the less, in separate cases other value may be permitted, but not more than 8 per cent of the length of the ship.

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

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

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

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

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

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

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

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

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

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

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

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

---

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

bulkhead below the bulkhead deck.

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

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

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

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

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

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

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

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

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

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

.12 The ship shall be so designed that the factor s_i calculated in accordance with **2.5**, Part V is not less than *1* under load conditions at the highest draft of subdivision, under load conditions at trim or any forward trim, if any the part of the ship ahead of the collision bulkhead has been flooded without vertical borders.

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

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

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

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

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

.2 where a double bottom is required to be fitted, its depth shall be in accordance with the requirements of м **2.4.4.1**, and the inner bottom shall be continued out to the ship's sides in such a manner as to protect the bottom to the turn of the bilge. Such protection will be deemed satisfactory if the line of intersection of the outer edge of the margin plate with the bilge plating is not lower at any part than a horizontal plane passing through the point **A** at midship section, as shown in Fig.1.1.6.4.2.

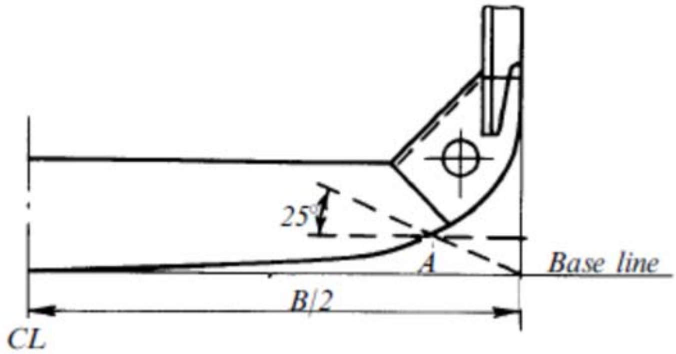


Fig. 1.1.6.4.2

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

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

.5 In ships of restricted navigation area «**B-R3-S**, **B-R3-RS, C-R3-S**, **C-R3-RS** and **D-R3-S**, **D-R3-RS**» the Register may permit not to arrange a double bottom in any part of the ship, with subdivision index less than 0.50 if the arrangement of double bottom in this part of the ship is not compatible with her design and normal operation.

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

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

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

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

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

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

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

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

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

.3 small wells constructed in the double bottom, in connection with the drainage arrangements of holds, etc. shall not extend downward more than necessary.

In no case shall the vertical distance from the bottom of such a well to a plane coinciding with the keel line be not less than *h*/2 or 500 mm whichever is greater, or whether the requirements of 2.9, Part V, for this part of the ship have been established.

.3. Other wells (e.g., for lubricating oil under main engines) may be permitted if the arrangements give protection equivalent to that afforded by a double bottom complying with the present paragraph.

.3.2 For a cargo ship with a length of 80 m and over or for a passenger ship it shall be demonstrated that the ship is capable of withstanding bottom damages as specified in **2.9,** Part **V.**

Alternatively, lubricating oil wells under main engines may extend into the double bottom below the boundary line, which is determined by the distance *h*, provided, the vertical distance from the bottom of such a well to a plane coinciding with the keel line be not less than *h*/2 or 500 mm whichever is greater.

.3.3 For a cargo ship with a length of 80 m such devices shall provide a level of safety satisfactory to the Administration.

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

.5 any part of a passenger ship or a cargo ship that is not fitted with a double bottom in accordance with **1.1.6.6.1** or **1.1.6.6.4** shall comply with the requirements of **2.9**, Part V "Subdivision".

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

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

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

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

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

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

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

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

1.2 MATERIALS

1.2.1 General.

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

1.2.2 Steel grades for hull structures.

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

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

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

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

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

1.2.3 Selection of steel grades for hull structures.

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

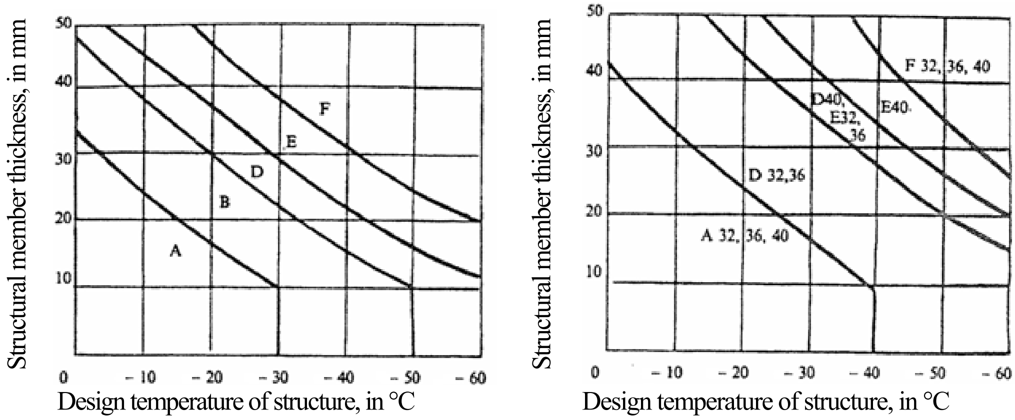


Fig. 1.2.3.1-1 Structural members of Class I

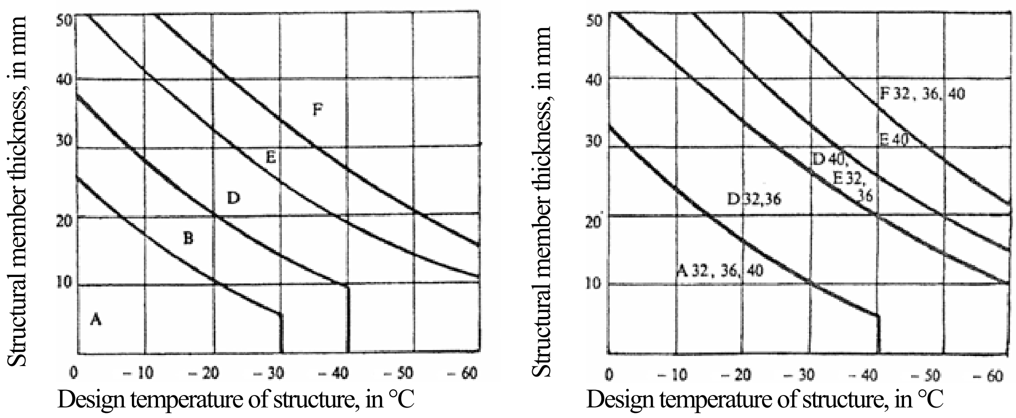


Fig. 1.2.3.1-2 Structural members of Class II

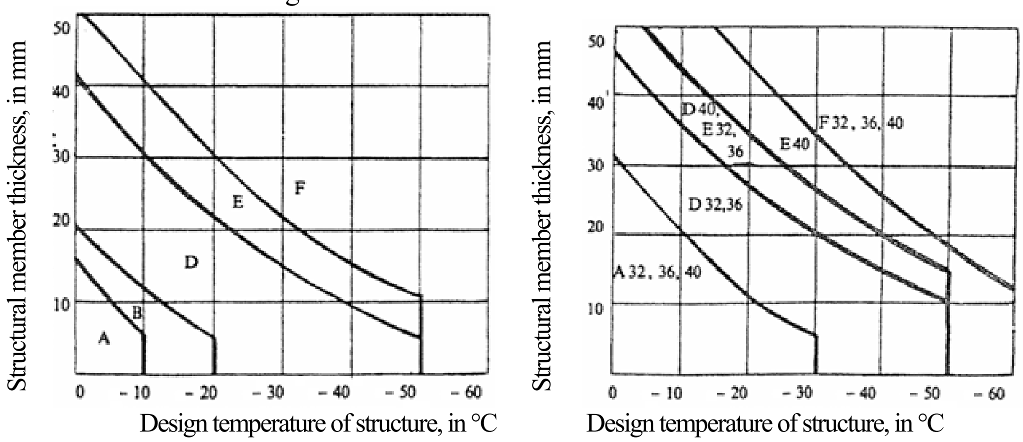


Fig. 1.2.3.1-3 Structural members of Class III

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

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

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

– 40 ºC[5] – for icebreakers of ice classes **Icebreaker2, Icebreaker3, Icebreaker4** and ships of ice classes **Ice6, Ice5**;

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

– 10 ºC – for ships of ice classes **Ice3, Ice2**.

For ships of polar classes, Baltic ice classes **IC ÷ IA Super** and other ice classes equipped to provide continuous operation at low temperatures with assigning **WINTERIZATION(DAT)** sign, the value of T_A is set according to the estimated outside temperature according to the sign (refer to **3.16.2**).

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

Table 1.2.3.4

Hull structure	Operation conditions		Design temperature t_p		
	Insulation	Heating	Cargo space region		Region of spaces other than cargo spaces
			tanks	holds	
Exposed part of strength deck, side plating portion above summer load waterline (for ice class ships — above ice belt) as well as adjacent framing and portions up to 1,0 m wide of bulkhead structures, decks, platforms, topside tanks, etc.	Fitted	Not provided	T_A		
	–	Fitted	0,50 T_A		
	Not provided	Not provided	0,70 T_A	T_A + 5 °C	0,60 T_A
Strength deck portion under unhealed superstructures.	–	Not provided	–10 °C		
External structures of superstructures and deckhouses.	Fitted	Fitted	0,50 T_A		
		Not provided	0,70 T_A		
Structures cooled on both sides with ambient air	Not provided	Not provided	T_A		
Side plating portion in the region of alternating waterline. Ice belt of ice class ships	Fitted	Not provided	0,55 T_A		
	–	Fitted	0,35 T_A		
	Not provided	Not provided	0,40 T_A		

N o t e s t o T a b l e *1.2.3.4* :

1. For external structures of underwater portion of the hull t_p = 0 °C.
2. "–" means that the isolation does not affect the design temperature T_p.

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

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

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

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

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

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

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

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

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

The steel grade of structural members shall not be below the grade specified in Tables 1.2.3.7-1 _ 1.2.3.7-6. Additional requirements:

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

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

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

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

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

Table 1.2.3.7-1

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

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

[1] Single strakes required to be of Class III within 0,4Z amidships shall have breadths not less than 800+ 5*L* mm, need not be greater than 1800 mm, unless limited by the geometry of the ship's design.
[2] The boundaries of areas for members related to this category correspond to Fig. 1.2.3.7.
[3] Not to be less than Grade D/D H

Table 1.2.3.7-2

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

Table 1.2.3.7-3*

Structural member category	Material class/grade
Longitudinal plating of strength deck where contributing	Grade B/AH amidships.

to the longitudinal strength.		
Continuous longitudinal plating of strengt h member s above the strength deck	Trunk deck plating	Class II amidships.
	Inner deck plating. Longitudinal strength member plating between the trunk deck and inner deck	Grade B/AH amidships.

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

Table 1.2.3.7-4

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

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

Table 1.2.3.7-5

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

Table 1.2.3.7-6

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

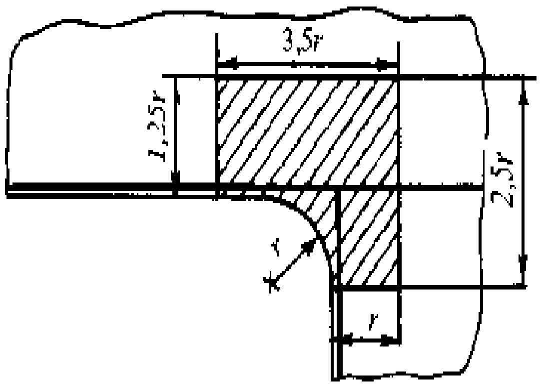


Fig. 1.2.3.7. Areas of cargo hatch corners (lined) belonging to members referred to Class III.

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

The steel grade shall correspond to the as-built plate thickness and material class.

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

Steel grade A is not permitted.

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

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

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

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

1.2.3.13 Steel grades for hull structural members of ships of 90 m in length and above, contributing to the hull strength may be selected in accordance with IACS unified requirement (UR) S6 taking into account **1.2.3.3**.

1.2.4 Aluminium alloys.

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

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

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

1.2.5 Anticorrosive protection and coatings.

1.2.5.1 Effective protective coatings complying with the requirements of **6.5.1.1**, Part XIII "Materials" shall be applied to the inner surfaces of ballast tanks. It is recommended to protect the inner spaces of cofferdams, duct keels, supports of transverse bulkheads and other similar void spaces of oil tankers and bulk carriers with protective coatings in accordance with **6.5.1.2**, Part XIII "Materials".

1.2.5.2 Anti-fouling coatings of ship hulls, in case of their application, shall comply with the requirements of **6.5.2**, Part XIII "Materials".

1.2.5.3 For cargo tanks of oil tankers of 5000 t deadweight and over carrying crude oil, one of the following effective measures on corrosion protection shall be implemented:

applying protective coatings in compliance with IMO resolution MSC.288(87) (refer to **6.5.1.2**, Part XIII "Materials");

using alternative means of protection or corrosion resistant materials to maintain the required structural integrity for 25 years in accordance with IMO resolution MSC.289(87) (refer to **3.16.1.**2, Part XIII "Materials").

1.3 DESIGN LOADS

1.3.1 General..

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

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

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

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

$$c_w = 0{,}0856L \quad \text{for} \quad L \le 90\text{m},$$

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

$$c_w = 10{,}75 \text{ for } 300 \le L \le 350\text{m}.$$

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

Table 1.3.1.5

Area of navigation	Factor φ_r,
1	2
R1, A-R1	1
R2, A-R2	$1,25 - 0,25L \cdot 10^{-2} \le 1$
R2-S**, **R2-RS****, **A-R2-S**, **A-R2-RS**	$1,0 - 0,20L \cdot 10^{-2}$
R2-S (4,5), R2-RS (4,5)	$0,94 - 0,19L \cdot 10^{-2}$
R3-S, **R3-RS**, **B-R3-S***, **B-R3-RS***, **C-R3-S**, **C-R3-RS**	$0,86 - 0,18L \cdot 10^{-2}$
R3, **R3-IN**, **D-R3-S**, **D-R3-RS**	$0,75 - 0,18L \cdot 10^{-2}$
* For ships with a sign **B-R3-S** and **B-R3-RS** subject to the establishment of the area of operation with a wave height of at 3% provided between 3.5 m and 6.0 m, φ_r is determined by linear interpolation between the values for **R2-S** and **R2-RS** and **R3-S** and **R3-RS**, respectively to a specific waves height values. ** For ships with a sign **R2-S** and **R2-RS** subject to the establishment of the area of operation with a wave height of at 3% provided between 4,5 m and 6,0 m, φ_r is determined by linear interpolation between the values for **R2-S** and **R2-RS** and **R2-S(4,5)** and **R2-RS(4,5)**, respectively to a specific waves height values.	

1.3.2 Wave loads.

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

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

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

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

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

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

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

z_i – distance form the point of application of the load to the summer load waterline, in m;
p_w – as defined in **1.3.2.2.**

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

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

$$p_w = p_{w0} \cdot [1 - 4,75 \cdot (d / L + B / 4L) \cdot (z_i / d)] \ge 0,5 \cdot p_{w0}$$
(1.3.2.2-1)

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

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

where: $p_{w0} = 5\, c_w a_v a_x$;
c_w – refer to **1.3.1.4** i **1.3.1.5**;
$a_v = [0,8 \cdot v_0 \cdot (L / 10^3 + 0,4) / \sqrt{L}] + 1,5$;
$a_x = k_x (1 - 2 x_1 / L) \ge 0,267$;
k_x – factor equal to 0,8 and 0,5 for hull sections forward and aft of the midship section respectively;
x_1 – distance of the considered section from the nearest fore or after perpendicular, in m;
for z_i – refer to **1.3.2.1-2;**
v_0 – specific speed of the ship, in knots, see **1.1.3.6.3**.

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

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

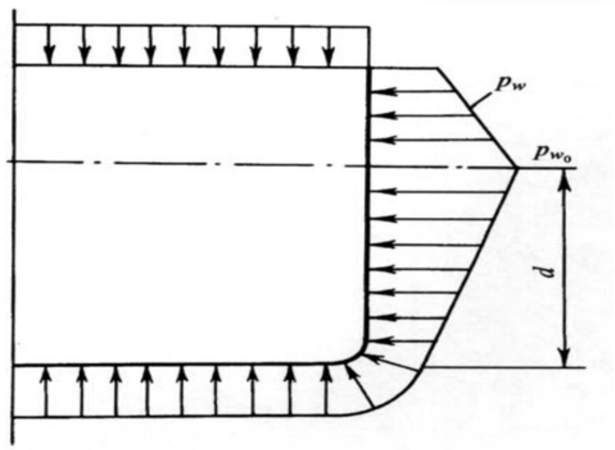


Fig. 1.3.2.2

1.3.3 Acceleration at motions.

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

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

where: $a_с$ – projection of ship's centre of gravity acceleration on the appropriate direction;

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

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

$$a_{cx} = 0,1(100/L)^{1/3} g\varphi_r;$$
$$a_{cy} = 0,2(100/L)^{1/3} g\varphi_r;$$
$$a_{cz} = 0,2(100/L)^{1/3} g\varphi_r;$$
$$a_{px} = (2\pi/T_p)^2 \psi z_0;$$
$$a_{py} = 0;$$
$$a_{pz} = (2\pi/T_p)^2 \psi x_0;$$
$$a_{rx} = 0;$$
$$a_{ry} = (2\pi/T_r)^2 \theta z_0;$$
$$a_{rz} = (2\pi/T_r)^2 \theta y_0$$

(1.3.3.1-2)

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

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

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

T_p and T_r – pitching and rolling periods, in s, determined by the formulae:

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

$$T_r = cB/\sqrt{h}$$

(1.3.3.1-3)

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

h – metacentric height for the most unfavourable conditions of operation; for a ship in fully loaded condition, $h \approx 0,07B$.

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

$$T_r \approx 3\sqrt[3]{B};$$

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

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

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

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

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

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

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

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

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

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

x_1 – refer to 1.3.2.2.

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

1.3.4 Cargo, fuel and ballast loads.

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

$$p_c = h\rho_c g \cdot (1 + a_z/g), \qquad (1.3.4.1)$$

but not less than 20 kPa,

where h – design stowage height, in m;

ρ_c – density of the cargo carried, in t/m^3;

a_z – design acceleration in the vertical direction determined in accordance with **1.3.3.1**, in m/s^2.

1.3.4.2 The design pressure on the structures forming boundaries of the compartments intended for the carriage of liquid cargoes and ballast in tankers, the ballast tanks in dry cargo ships as well as the tanks for ballast and fuel oil is determined depending on their dimensions, the extent of filling and the height of air pipe.

By compartment is meant a tank or a part of a tank confined between the effective bulkheads. Both watertight and wash bulkheads with the total area of openings not over 10 % of the bulkhead area are considered as effective bulkheads.

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

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

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

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

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

$$p_c = \rho_c g\,z_i + p_v, \qquad (1.3.4.2.1\text{-}5)$$

where ρ_c – cargo, ballast or fuel density, in t/m^3, whichever is appropriate;

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

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

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

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

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

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

whichever is the greater.

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

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

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

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

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

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

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

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

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

but not less than 20 kPa.

where for: ρ_c – refer to **1.3.4.1**, t/m^3;

$k_c = \sin^2\alpha \cdot tg^2(45 - \varphi_{i.f}/2) + \cos^2\alpha$, or $k_c = \cos 2\alpha$, whichever is the greater;

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

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

a_z – design acceleration in the vertical direction according to (**1.3.3.1-6**), in m/s^2;

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

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

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

$$a_y = \sqrt{a_{cy}^2 + (a_{ry} + g\sin\theta)^2}; \qquad (1.3.4.4\text{-}1)$$

and in the horizontal-longitudinal direction

$$a_x = \sqrt{a_{cx}^2 + (a_{px} + g\sin\psi)^2}\,, \qquad (1.3.4.4\text{-}2)$$

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

a_{cy}, a_{ry}, a_{cx}, a_{px} – refer to. **1.3.3.1.**

1.4 LONGITUDINAL STRENGTH

1.4.1 General and definitions.

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

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

The requirements of the this Chapter shall not apply to container ships and ships, dedicated primarily to carry their cargo in containers, both of 90 m in length and upwards and operated in unrestricted service. When assessing the longitudinal strength, the requirements of AICS UR S11A «Longitudinal strength standard for container ships» taking into account S34 (May 2015).

1.4.1.2 Hull structures of ships having:

.1 proportion:

$L/B \leq 5$,

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

.2 block coefficient

$C_b < 0{,}6$;

.3 specified speed v_o, exceeding the value of v, in knots, determined by the formula

$$v = k\sqrt{L}\ ,$$

where $k = 2{,}2$ if $L \leq 100$ m;

$k = 2{,}2 - 0{,}25(L-100)/100$ if $L > 100$ m,

as well as of ships carrying heated cargoes and ships of unusual design and/or type shall be subject to direct strength calculation according to the agreed procedur.

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

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

1.4.1.4 Downward shear forces are assumed to be taken as positive values and upward shear forces - as negative values.

The hogging bending moments are assumed to be taken as positive values and sagging bending moments - as negative values.

For the calculation of still water bending moment and shear force, transverse loads shall be integrated in the forward direction from the aft end of L;

in this case, downward loads are assumed to be taken as positive values.

The sign conventions of still water bending moment and shear force are as shown in Fig. 1.4.1.4.

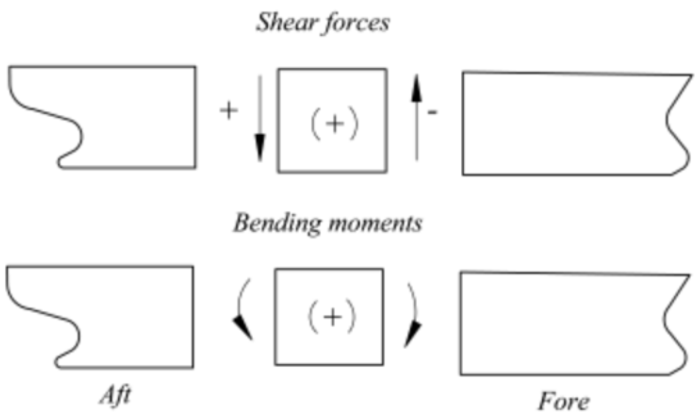


Fig.1.4.1.4

1.4.2 Symbols.

L_1 – length of the compartment considered, in m;

B_1 – breadth of the compartment considered, in m;

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

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

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

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

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

1.4.3 Still water bending moments and shear forces.

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

The bending moments and shear forces in the course of consuming the contents of each tank with ship's stores (fuel oil, water, lubricating oil) during voyage shall be also calculated if the above moments and forces exceed those for departure or arrival of the ship. The same applies to ship's ballasting/ deballasting at sea. In so doing, partially filled ballast tanks, including peak tanks, shall be ignored in the consideration excepting the following cases:

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

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

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

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

homogeneous loading conditions at maximum draught;

ballast condition;

special loading conditions:

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

short voyage, where applicable;

loading and unloading transitory conditions;

docking condition (afloat);

.2 for oil tankers:

homogeneous loading conditions (excluding dry and clean ballast tanks);

partly loaded and ballast conditions for both departure and arrival;

any specified non-uniform distribution of loads;

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

loading and unloading transitory conditions;

docking condition afloat;

.3 for combination carriers:

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

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

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

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

- trim by the stern for 3 % of ship length;
- trim by the bow for 1,5 % of ship length;
- any trim, at which propeller depth axis constitutes 25 % of its diameter.

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

In cargo loading conditions, the requirements of the present paragraph apply to the peak tanks only.

The requirements of the present paragraph do not apply to ballast water exchange at sea using the sequential method. However, bending moment and shear force calculations for each ballasting or deballasting stage in the ballast water exchange sequence shall be included in the Loading Manual or the Guidelines for Safe Ballast Water Exchange at Sea of any ship that intends to employ the sequential ballast water exchange method асту.

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

The values M_{sw} and N_{sw} are regarded further as design values for the section under consideration.

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

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

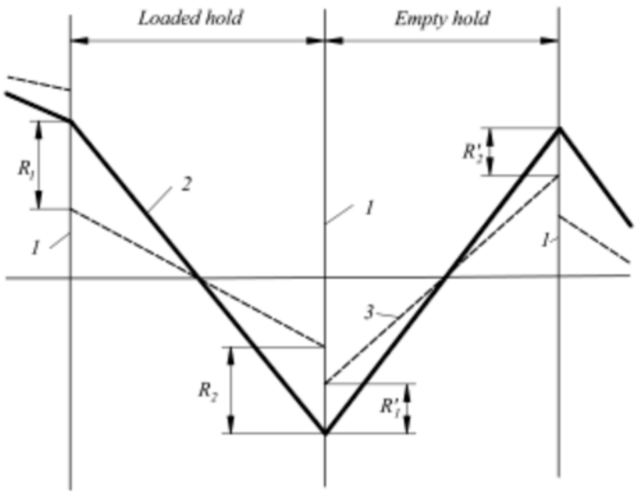


Fig.1.4.3.3. Shear force curve correction diagram
1 – transverse bulkhead; 2 – uncorrected curve; 3 –corrected curve;
R_1 and R_2 – total of bottom longitudinal responses for a loaded hold in way of aft bulkhead and forward bulkhead accordingly;
R'_1 and R'_2 – same for an empty hold.

1.4.3.4 Where provision is made in ship's design for loading conditions resulting in regular change of a sign of the still water bending moment (in fully loaded and ballast conditions on direct and return voyages), its components at the section with the maximum range of bending moment (refer to Fig. 1.4.3.4) shall be determined for use in the calculation under **1.4.6.3**.

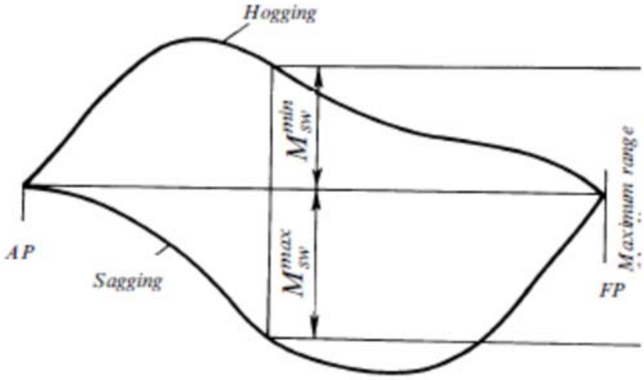


Fig. 1.4.3.4

1.4.4 Wave bending moments and shear forces.

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

hogging bending moment

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

sagging bending moment

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

where: c_w – as determined from **1.3.1.4**;
α – coefficient determined from Table 1.4.4.1 and Fig. 1.4.4.1;
C_b – as defined in 1.1.3, but not less than 0,6.

Table 1.4.4.1

Position of section along the ship's length	α
$x/L < 0{,}4$	$2{,}5\, x/L$
$0{,}4 \le x/L \le 0{,}65$	1
$x/L > 0{,}65$	$(1 - x/L)/0{,}35$

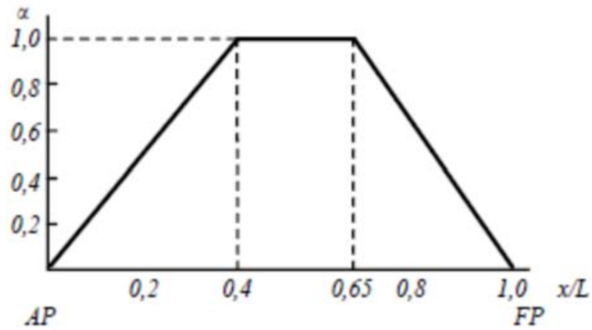


Fig. 1.4.4.1

1.4.4.2 The wave shear force N_w, in kN, at the section concerned shall be determined by the formulae:
positive

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

negative

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

where c_w – as determined from **1.3.1.4**;
C_b – as defined in **1.1.3**, but not less than 0,6;
f_1 and f_2 – coefficients determined from Table 1.4.4.2, Figs. 1.4.4.2-1 and 1.4.4.2-2.

Table 1.4.4.2

Position of section along the ship's length	f_1	f_2
1	2	3
$0 \le x/L < 0{,}2$	$4{,}6\, f_o\, x/L$	$4{,}6\, x/L$
$0{,}2 \le x/L \le 0{,}3$	$0{,}92\, f_o$	0,92
$0{,}3 < x/L < 0{,}4$	$0{,}7 + (9{,}2\, f_o - 7)(0{,}4 - x/L)$	$1{,}58 - 2{,}2x/L$

$0,4 \le x/L \le 0,6$	0,7	0,7
$0,6 < x/L < 0,7$	$0,7 + 3(x/L - 0,6)$	$0,7+(10f_o - 7)(x/L - 0,6)$
$0,7 \le x/L \le 0,85$	1,0	f_o
$0,85 < x/L \le 1,0$	$6,67(1 - x/L)$	$6,67(1 - x/L)f_o$
$f_o = 190C_b / 110(C_b + 0,7)$		

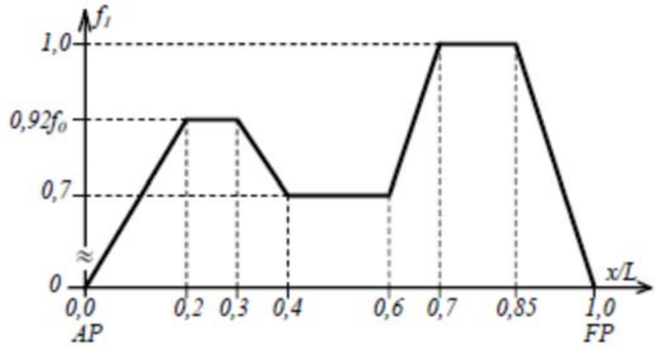


Fig.1.4.4.2-1

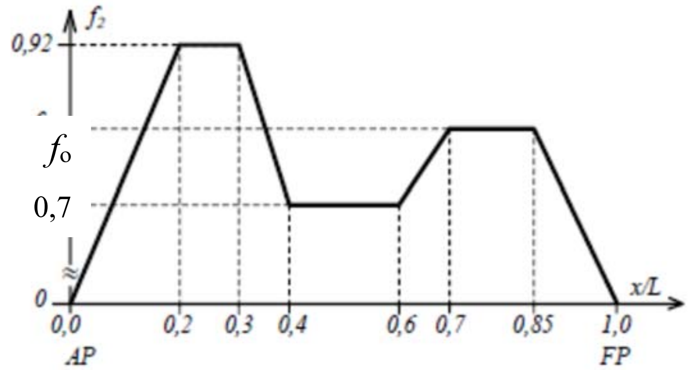


Fig.1.4.4.2-2

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

$\psi = (1 + \rho_n \cdot f \cdot 10^{-2})$; (1.4.4.3-1)

$\nu = 1/(1+\Delta)$, (1.4.4.3-2)

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

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

α – waterplane area coefficient for summer load waterline;

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

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

where: $D_1 = D + h_k$;

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

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

η- refer to **1.1.4.3**;

φ - determined from Table 1.4.4.3.

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

Table 1.4.4.3

Area of navigation	φ
1	2
R1, A-R1	1,1–0,23 $L \cdot 10^{-2} \leq 1$
R2, A-R2	1,0–0,25 $L \cdot 10^{-2}$
R2-S, R2-RS**, A-R2-S, A-R2-RS**	0,94–0,26 $L \cdot 10^{-2}$
R2-S (4,5), R2-RS (4,5)	0,92–0,29 $L \cdot 10^{-2}$
R3-S, R3-RS, B-R3-S*, B-R3-RS*, C-R3-S, C-R3-RS	0,71–0,22 $L \cdot 10^{-2}$
R3, R3-IN, D-R3-S, D-R3-RS	0,60–0,20 $L \cdot 10^{-2}$
*,** refer to Table 1.3.1.5.	

1.4.5 Bending moment due to wave impacts on the flare.

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

A_F and z_F as determined from **1.4.2.**

1.4.5.2 The sagging bending moment due to wave impacts on the flare, M_F, shall be calculated as follows:

$$M_F = -\,k_F \cdot c_w \cdot B \cdot L^2 \cdot (C_b + 0{,}7) \cdot \alpha_F \cdot 10^{-3}, \qquad (1.4.5.2)$$

where: $k_F = 7 \cdot (1 + 1{,}25 \cdot v_o/L) \cdot c_1 \cdot c_2$, but not more than 23;
$c_1 = (L - 100)/30$, for 100m $\leq L <$ 130m;
$c_1 = 1$, for 130m $\leq L <$ 170m;
$c_1 = 1 - (L - 170)/30$, for 170m $\leq L \leq$ 200m;
$c_2 = [5 \cdot A_F/(L \cdot z_F)] - 0{,}5$, at $0{,}1 \leq A_F/(L \cdot z_F) \leq 0{,}3$;
$c_2 = (A_F/L \cdot z_F) + 0{,}7$, at $0{,}3 < A_F/(L \cdot z_F) < 0{,}4$;
$c_2 = 1{,}1$, at $A_F/(L \cdot z_F) \geq 0{,}4$;
for c_w– refer to **1.3.1.4**;
v_o– refer to **1.4.1.2.3**;
α_F – is obtained from Table 1.4.5.2 and Fig. 1.4.5.2.

Table 1.4.5.2

Position of section along the ship's length	α_F
$x/L \leq 0{,}15$	$0{,}667x/L$
$0{,}15 < x/L < 0{,}45$	$0{,}1 + 3(x/L - 0{,}15)$
$0{,}45 \leq x/L \leq 0{,}75$	1
$x/L > 0{,}75$	$1 - 4(x/L - 0{,}75)$

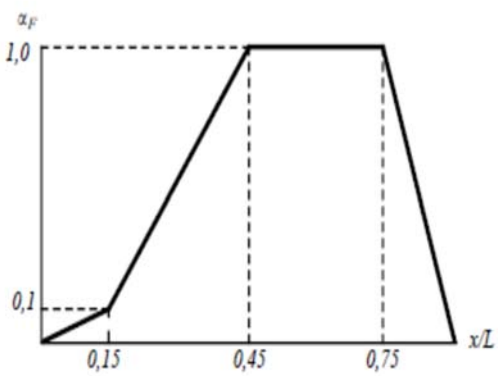


Fig.1.4.5.2

1.4.5.3 For ships of restricted area of navigation, the bending moment due to wave impacts on the flare MF calculated in accordance with 1.4.5.2 shall be multiplied by the reduction factor φ determined from Table 1.4.4.3.

For ships of restricted areas of navigation **R3-S, R3-RS, B-R3-S** and **B-R3-RS** with restricted navigation at a wave height of 3% probability of not more than 3,5 m, **C-R3-S, C-R3-RS, R3, R3-IN, D-R3-S, D-R3-RS** $M_F=0$.

1.4.6 Hull section modulus and moment of inertia.

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

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

$$W = M_T \cdot 10^3 / \sigma \ , \tag{1.4.6.2}$$

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

M_{sw} – referr to **1.4.3**, in kN·m;

M_w – referr to **1.4.4**;

$\sigma = 175 / \eta$, MPa.

1.4.6.3 In cases specified by **1.4.3.4**, the section modulus W, determined in accordance with **1.4.6.2**, shall be multiplied by the factor shall be multiplied by the factor m determined by the formula:

$$m = 1 + \frac{M_{sw}^{\min}}{10 M_{sw}^{\max}} \left(\frac{M_{sw}^{\min} + M_{sw}^{\max}}{0{,}076 c_w B L^2 (C_b + 0{,}7)} - 1 \right), \tag{1.4.6.3}$$

but not less than 1,

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

1.4.6.4 For ships for which the bending moment due to wave impacts on the flare (refer to **1.4.5**) shall be considered the section modulus W, in cm^3, at the section concerned shall not be less than:

$$W = \frac{M_T \cdot 10^{-3}}{\sigma} \ , \tag{1.4.6.4}$$

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

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

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

M_F - as determined from **1.4.5**;

σ - refer to **1.4.6.2**.

1.4.6.5 The hull section modulus determined from **1.4.6.2 ÷ 1.4.6.4** for maximum value of design bending moment shall be maintained within 0,4L amidships. However, if the maximum design bending moment occurs outside 0,4L amidships, the steady section modulus requirement is applicable over the ship's length up to the section where maximum design bending moment acts.

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

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

$$W_{\min} = c_w B L^2 (C_b + 0{,}7)\, \eta \ , \tag{1.4.6.7-1}$$

where: for c_w – refer to **1.3.1.4**.

For ships of restricted area of navigation, the minimum hull section modulus, in cm3 , within the midship region (for deck and bottom) shall not be less than $W_{\min 1}$ or $W_{\min 2}$, whichever is the greater, determined by the following formulae:

$W_{min1} = \varphi\ W_{min}$; (1.4.6.7-2)

$W_{min2} = 0{,}95\psi\nu\varphi\ W_{min}$, (1.4.6.7-3)

where: φ – refer to Table 1.4.4.3;
ψ - refer to Formula (1.4.4.3-1);
ν - refer to Formula (1.4.4.3-2).

1.4.6.8 Scantlings of all continuous longitudinal members of hull girder based on the section modulus requirement in **1.4.6.7** shall be maintained within 0,4*L* amidships. However, in special cases, based on consideration of type of ship, hull form and loading conditions, the scantlings may be gradually reduced towards the ends of the 0,4*L* part, bearing in mind the desire not to inhibit the ship's loading flexibility.

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

$I_{min} = 3c_w BL^3\ (C_b + 0{,}7)$, (1.4.6.9-1)

where: c_w – as determined from **1.3.1.4.**

For ships of restricted area of navigation, I_{min} shall be multiplied by the reduction factor j0 determined by the formula:

$\varphi_0 = 18\varphi\eta/(L/D)_{max}$, (1.4.6.9-2)

where: for φ – refer to Table 1.4.4.3;
η – refer to **1.1.4.3**;
$(L/D)_{max}$ – maximum permissible value of *L/D* for the area of navigation under consideration, obtained from Table 1.1.1.1.

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

in way of the forward end of the engine room;
in way of the forward end of the foremost cargo hold;
where there are significant changes in the hull cross-section;
where there are changes in the framing system.

The following shall be made outside amidships: buckling strength of members contributing to the longitudinal strength and subjected to compressive and shear stresses shall be checked, in particular in regions where changes in the framing system or significant changes in the hull cross-section occur in compliance with **1.6.5**;

continuity of structure shall be maintained throughout the length of the ship. Where significant changes in structural arrangement occur adequate transitional structure shall be provided;

for ships with large deck openings such as a containerships, sections at 0.25*L* or near to the aft and forward quarter length positions shall be checked. For such ships with cargo holds aft of the superstructure, deckhouse or engine room, strength checks of sections in way of the aft end of the aft-most holds, and the aft end of the deckhouse or engine room shall be performed.

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

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

$s = S\,(N_{sw} + N_w) \cdot 10^2 / (\,2\,\tau\, I\,)$, (1.4.7.1)

where: N_{sw} – as defined in **1.4.3.2**, kN;
for N_w – refer **to1.4.4.2** and **1.4.4.3**;
τ = 110/η, MPa.

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

$s_s = S\,\alpha_s\,(\,N_{sw} + N_w) \cdot 10^2 / (\tau\, I\,)$; (1.4.7.2-1)

$s_l = S\,\alpha_l\,(\,N_{sw} + N_w) \cdot 10^2 / (\tau\, I\,)$; (1.4.7.2-2)

where: for N_{sw} , N_w , τ – refer to **1.4.7.1**;

$\alpha_s = 0{,}27$;

$\alpha_l = 0{,}23$.

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

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

1.4.8 Calculation of actual hull section modulus.

1.4.8. The hull section modulus is determined:

for strength deck W_d^{ϕ} – at moulded deck line at side (lower edge of deck stringer);

for bottom W_b^{ϕ} – at moulded base line (top of plate keel).

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

$$z_T = z(0{,}9+0{,}2\,y/B), \tag{1.4.8.1}$$

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

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

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

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

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

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

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

$$\zeta = m + \frac{0{,}65 + C_b}{3} \frac{L}{\Sigma l_{\text{н}} + \Delta l_1 + \Delta l_2}, \tag{1.4.8.2}$$

where:

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

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

Σl_H – total length of longitudinal deck strips, in m;

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

If the end of the longitudinal deck strip is effectively attached to continuous deck and/or longitudinal bulkhead (refer to Fig. 1.4.8.2):

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

where: f – sectional area of one longitudinal deck strip, in cm²;

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

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

Where a longitudinal deck strip terminates at the transverse deck strip, provided $10b''s'_d \geq nf$ i $b'' > b'$:

$\Delta l_{1,2} = 1{,}3nf \cdot [(b'/ b'') + 1]/10\, s'_d$,

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

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

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

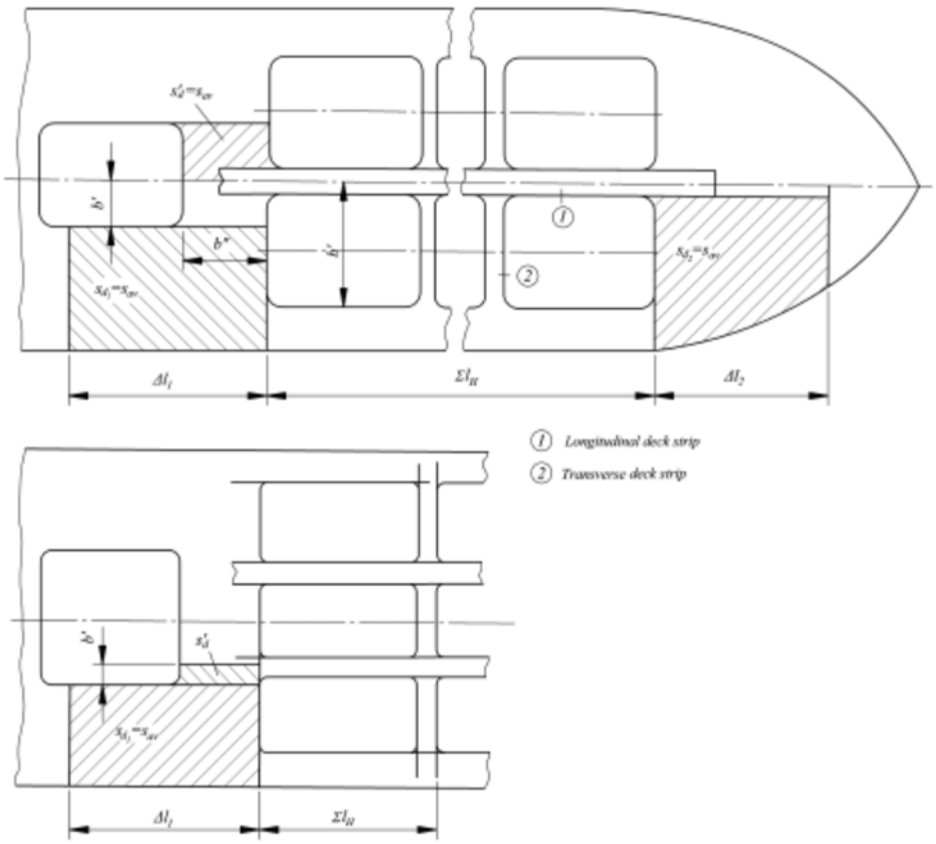


Fig.1.4.8.2. Longitudinal deck strips to be included in the calculation of hull section modulus.

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

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

the sum of their breadths and shadow area breadths (refer to Fig. 1.4.8.3) in one transverse section of the hull does not exceed $0{,}06 \cdot (B - \Sigma b)$, (wjere Σb – is the total breadth of openings) or does not reduce the section modulus at deck or bottom by more than 3%;

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

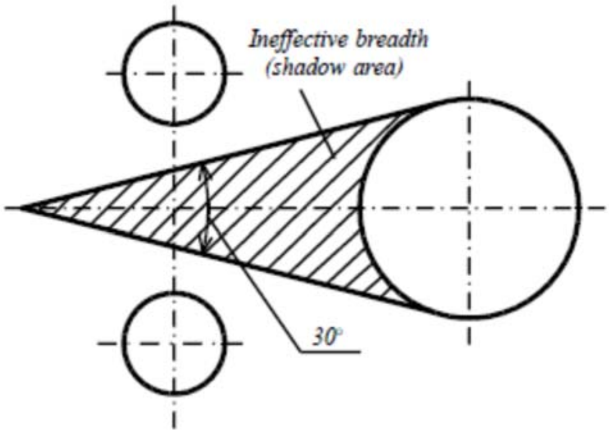


Fig.1.4.8.3. Design section.

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

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

$$\frac{z}{\eta}\frac{W_{à}}{W_{\eta=1}}, \qquad (1.4.8.5)$$

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

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

W_a , $W_{\eta=1}$ – actual section modulus and required section modulus with $\eta = 1$ for the deck (continuous hatch coaming

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

1.4.9 Loading control facilities.

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

1.4.9.2 Ships to be provided with loading control facilities are categorized as follows.

Category I:

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

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

chemical tankers and gas carriers.

Category II:

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

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

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

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

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

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

the results of the calculations of still water bending moments, shear forces for loading conditions stated in **1.4.3.1**;

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

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

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

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

Single point loading instruments are not acceptable.

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

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

1.4.9.5 All ships other than category **II** ships of less 90 m in length, which deadweight is not greater than 30 % of summer load line displacement, shall be provided with the Loading Manual approved by the Register.

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

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

1.4.9.7 The stability and strength Booklet at carriage of non-grain bulk cargoes.

To prevent excessive hull stresses, provision shall be made for the Booklet as per SOLAS regulation VI/7.2 to be carried on board, including the following as a minimum:

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

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

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

.4 maximum permissible cargo hold load;

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

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

.7 where necessary - strength calculations: maximum permissible forces and moments affecting the hull during loading, unloading and the voyage.

The Booklet shall be prepared in a language understood by the ship officers, and in English.

1.5 VIBRATION OF HULL STRUCTURES

1.5.1 General.

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

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

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

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

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

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

1.5.2 Technical documentation.

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

1.5.3 Measured vibration parameters.

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

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

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

1.5.3.2 Vibration parameters shall be measured in absolute units or in logarithmic units (decibels) with regard to standard threshold values of vibration velocity or acceleration equal to $5\cdot10^{-5}$ mm/s i $3\cdot10^{-4}$ m/s^2 accordingly.

1.5.3.3 Measurements shall be carried out in the following directions:

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

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

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

Table 1.5.3.4

Mean geometric values of octave ranges, in Hz	Hull and superstructure, rigid members [1]				Hull structures							
					frames[2]				plates			
	Permissible root mean square values											
	vibration velocity		vibration acceleration		vibration velocity		vibration acceleration		vibration velocity		vibration acceleration	
	mm/s	dB	m/s^2	dB	mm/s	dB	m/s^2	dB	mm/s	dB	m/s^2	dB
1,6	5,6	101	0,054	45	5,6	101	0,054	45	5,6	101	0,054	45
2	5,6	101	0,067	47	5,6	101	0,067	47	5,6	101	0,067	47
2,5	5,6	101	0,084	49	5,6	101	0,084	49	5,6	101	0,084	49
3,15	5,6	101	0,106	51	7,1	103	0,135	53	7,1	103	0,135	53
4	5,6	101	0,135	53	8,9	105	0,21	57	8,9	105	0,21	57
5	5,6	101	0,17	55	11	107	0,34	61	11	107	0,34	61
6,3	5,6	101	0,21	57	11	107	0,43	63	14	109	0,54	65
8	5,6	101	0,27	59	11	107	0,54	65	16	110	0,75	68
10	5,6	101	0,34	61	11	107	0,65	67	16	110	0,94	70
12,5	5,6	101	0,43	63	11	107	0,84	69	16	110	1,2	72
16	5,6	101	0,54	65	11	107	1,06	71	16	110	1,5	74
20	5,6	101	0,67	67	11	107	1,35	73	16	110	1,9	76
25	5,6	101	0,84	69	11	107	1,7	75	16	110	2,4	78
40	5,6	101	1,35	73	11	107	2,7	79	16	110	3,8	82
50	5,6	101	1,7	75	8,9	105	2,7	79	12,5	108	3,8	82
63	5,6	101	2,1	77	7,1	103	2,7	79	10	106	3,8	82
80	5,6	101	2,7	79	5,6	101	2,7	79	8	104	3,8	82

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

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

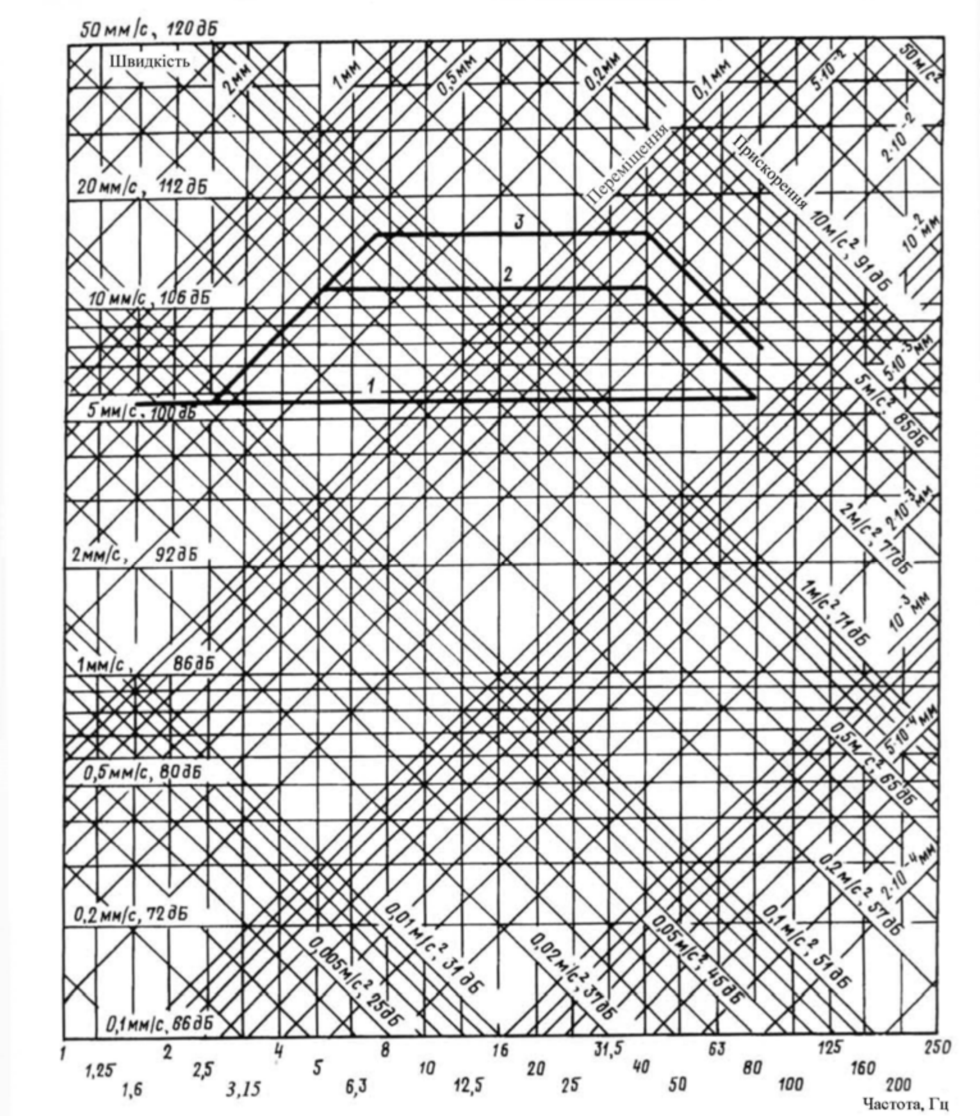


Fig.1.5.3.4. Permissible mean root values of vibration velocity and vibrational acceleration:
1 — hull, superstructures and rigid members; 2 — framing members including the girders by which the foundations of ship machinery and equipment are supported; 3 — plates.

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

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

1.6 REQUIREMENTS FOR SCANTLINGS OF HULL STRUCTURAL MEMBERS

1.6.1 General.

1.6.1.1 This Chapter contains general requirements for plating and framing.

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

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

1.6.1.4 The scantlings of primary and deep members are based on the required section modulus, moment of inertia, web sectional area, thicknesses of web and face plate, as well as width of the face plate. Geometric properties of the member section, unless stated otherwise, are determined taking into account the effective flange. If the member is so arranged that it is not normal to the effective flange, the section modulus shall be increased in proportion to $1/\cos\alpha$ (where α – is the angle, in deg., between the member web and the perpendicular to the effective flange at the section considered). If $\alpha \le 15°$ no increase of section modulus is required.

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

The values of negative rolling tolerances for plates shall comply with the requirements of **3.2.8**, Part XIII "Materials".

1.6.2 Symbols.

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

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

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

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

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

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

h – depth of the member web, in cm;

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

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

a_{f} – primary member effective flange width, in m;

c_{f} – deep member effective flange breadth, in m;

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

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

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

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

1.6.3 Span and effective flange of member.

1.6.3.1 The span of primary and deep member l is measured along the member face plate as the distance between its span points.

Unless provided otherwise, where the end brackets are fitted, the span points shall be taken at the mid-length of the bracket. In this case, the span point position shall be such that the height of the end bracket in it does not exceed the web depth of the member considered (refer to Fig. **1.6.3.1**).

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

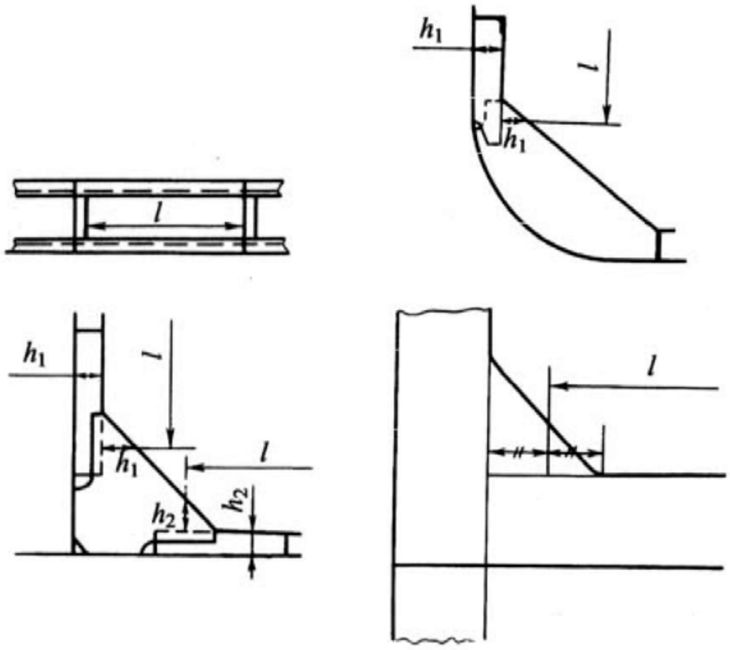


Fig. 1.6.3.1

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

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

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

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

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

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

$$c_f = k\,c, \quad (1.6.3.4)$$

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

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

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

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

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

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

Table 1.6.3.4

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

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

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

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

1.6.4 Scantlings of structural members.

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

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

for built-up welded members

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

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

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

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

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

1.6.4.2 The section modulus of member considered, in cm^3, without taking into account corrosion allowance is determined by the formula:

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

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

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

σ_n – estimated normative yield stress at normal stresses, in MPa, determined from **1.1.4.3**.

1.6.4.3 The net sectional area (excluding openings) f_w, cm^2, of primary and deep member webs shall not be less than:

.1 for members of rolled section

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

.2 for built-up welded members

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

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

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

ω_k - refer to **1.1.5.3**;

τ_n – refer to **1.1.4.3**;

Δs – refer to **1.1.5.1**.

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

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

where: m, k_{σ} – bending moment and permissible stress factors as defined in the relevant chapters of this Part;
$k = 1{,}2 - 0{,}5 \cdot a/a_1$, but not greater than 1;
a, a_1– smaller and greater sizes, in m, of supporting contour sides of plate structure;
Δs – corrosion allowance, in mm, determined from **1.1.5.1.**

1.6.4.5 The scantlings of the corrugated structures shall comply with the following requirements:
.1 the thickness of the trapezoidal corrugations shall be determined by Formula (1.6.4.4), taken a equal to b or c, whichever is the greater (refer to Fig. 1.6.4.5.1).
The following relationship shall be satisfied

$$b/s \le 0{,}06\sqrt{\eta} \qquad (1.6.4.5.1)$$

where β_0 – half-angle of spread of corrugation (refer to Fig. 1.6.4.5.1);
s – товщина, мм, (див. рис. 1.6.4.5.1).
Angle φ (refer to Fig. 1.6.4.5.1, ***a***) shall be assumed not less than 40°.

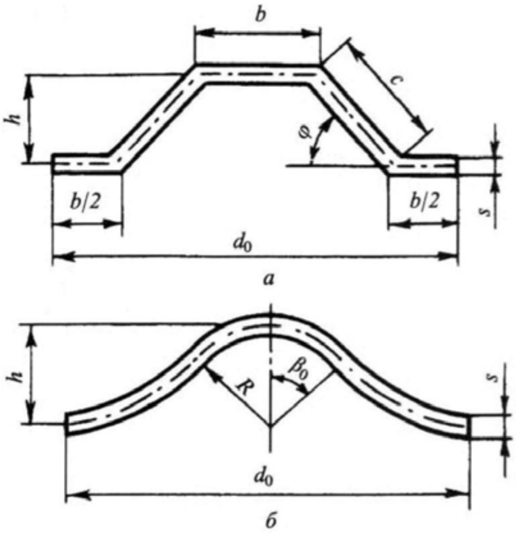


Fig. 1.6.4.5.1

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

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

where: β_0 – half-angle of spread of corrugation (refer to Fig. 1.6.4.5.1, ***b***), in rad;
R – radius of corrugation, in m;
k_{σ} – radius of corrugation, in m determined in the relevant Chapters of this Part;
σ_n – estimated normative yield stress at normal stresses, in MPa, determined from **1.1.4.3**;
Δs – corrosion allowance, in mm, determined from **1.1.5.1**.

In this case, the following relationship shall be satisfied:

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

where : R_{eH} – upper yield stress, in MPa;
s – thickness, mm, (refer to Fig. 1.6.4.5.1).
.3 the section modulus of the corrugation is determined according to **1.6.4.1**:

$Q = pd_0 l$, (d_0 – refer to Fig.1.6.4.5.1).

The spacing and section modulus of corrugations can be determined by the formulae given in Table 1.6.4.5.3. (Linear dimensions are expressed in cm, φ, β_0 – in deg.).

Factor γ is determined by the formula:

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

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

Table 1.6.4.5.3

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

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

R2, **A-R2**, **R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS, B-R3-S** and **B-R3-RS** with restriction of navigation at a wave height of 3% probability of 4,5m or more, by 5 %;

R3-S, **R3-RS**, **B-R3-S** and **B-R3-RS** with restriction of navigation at a wave height of 3% probability of 4,5m or less, **C-R3-S**, **C-R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** by 10%,

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

1.6.5 Buckling strength of hull structural members.

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

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

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

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

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

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

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

M_F – refer to**1.4.5**, in kN·m.

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

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

for side shell plating in ships without effective longitudinal bulkheads

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

for side shell plating in ships with two effective longitudinal bulkheads

$$\tau_c = \frac{N_{sw} + N_w}{s_s}\frac{S}{I}\alpha_s\cdot 10^2, \qquad (1.6.5.1\text{-}3)$$

for longitudinal bulkhead plating in ships with two effective longitudinal bulkheads

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

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

N_w – wave vertical shear force determined from **1.4.4.2**;

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

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

S, I – as defined in **1.4.2**;

for α_s , α_l – refer to **1.4.7.2**.

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

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

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

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

k = 1,1 – for stiffeners;

for σ_c i τ_c – refer to**1.6.5.1**;

for σ_{cr} *i* τ_{cr} – refer to**1.6.5.3**.

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

R1, **A-R1** – by 10%;

R2, **A-R2**, **R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS** (refer to **1.6.4.6**) – by 15%;

B-R3-S, **B-R3-RS** (refer to **1.6.4.6**), **C-R3-S**, **C-R3-RS**, **R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** and for berth-connected ships – by 20%.

In this case, when determining the actual section modulus of hull in accordance with **1.4.8** the strength reduction of compressed plate shall be considered, i.e. where $\sigma_{cr} < \sigma_c$ the plates shall be included in the hull girder section, except for the areas adjoining the longitudinals and having a breadth equal to 0,25 of the shorter side of supporting contour, with the reduced factor ψ_n, to be determined by the formula:

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

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

$$\sigma_{cr} = \sigma_e \quad \text{when} \quad \sigma_e \le 0{,}5\,R_{eH}\,;$$
$$\sigma_{cr} = R_{eH}\,(1{,}00 - R_{eH}/4\sigma_e) \text{ when } \sigma_e > 0{,}5\,R_{eH}\,;$$
$$\tau_{cr} = \tau_e \quad \text{when} \quad \tau_e \le 0{,}29\,R_{eH}\,;$$
$$\tau_{cr} = R_{eH}\,(0{,}58 - 0{,}08\,R_{eH}/\tau_e) \text{ when } \tau_e > 0{,}29\,R_{eH}\,,$$

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

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

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

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

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

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

.2 for torsional buckling of primary longitudinal members

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

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

m – number of half waves, given by Table 1.6.5.4.2;

Table 1.6.5.4.2

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

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

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

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

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

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

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

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

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

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

$$i_w = \frac{b_п^3 h_c^2}{12(b_п + h_c)^2}\left[s_п\left(b_п^2 + 2b_п h_c + 4h_c^2\right) + 3 s_c b_п h_c\right]\cdot 10^{-6}$$ – for angles and bulb profiles;

h_c – web height, in mm;

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

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

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

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

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

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

σ_c – compressive stress according to **1.6.5.1**;

σ_e – Euler stress of supporting plate according to **1.6.5.5**;

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

a – distance between longitudinals.

.3 for web and flange buckling:

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

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

$b_п / s_п \geq 15$,

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

s_f – flange thickness, in mm.

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

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

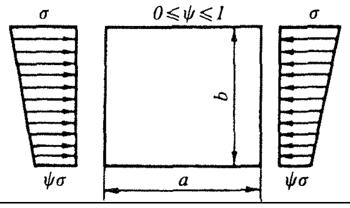
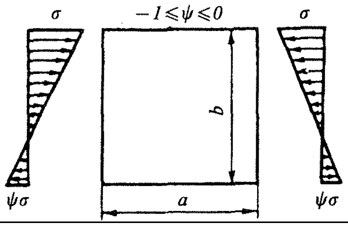
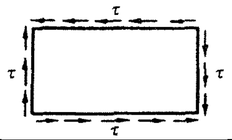
$$\tau_e = 0{,}1854\, n\, (s'/b)^2, \qquad (1.6.5.5\text{-}2)$$

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

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

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

Table 1.6.5.5-1

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

N o t e s :

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

Table 1.6.5.5-2

Structure	Δs, in mm
Compartments carrying dry bulk cargoes. Vertical surfaces and surfaces sloped at an angle greater than 258 to the horizontal line. One side exposure to ballast and/or liquid cargo	$0{,}05\,s$ $(0{,}5 \le \Delta s \le 1)$
Horizontal surfaces and surfaces sloped at an angle less than 258 to the horizontal line. One side exposure to ballast and/or liquid cargo Vertical surfaces and surfaces sloped at an angle greater than 258 to the horizontal line. Two side exposure to ballast and/or liquid cargo	$0{,}10\,s$ $(2 \le \Delta s \le 3)$
Horizontal surfaces and surfaces sloped at an angle less than 258 to the horizontal line. Two side exposure to ballast and/or liquid cargo	$0{,}15\,s$ $(2 \le \Delta s \le 4)$
otherwise	$\Delta s = 0$

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

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

for the stiffeners fitted normal to the girder face plate

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

for the stiffeners parallel to the girder face plate

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

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

a – spacing of stiffeners, in cm;

s – actual thickness of the web, in mm;

f – actual cross-sectional area of the stiffener, in cm^2 ;
l – span of the stiffener, in m;
η – as determined according to **1.1.4.3**.

Table 1.6.5.6

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

Note: The intermediate values of γ are determined by linear interpolation.

1.6.6 Aluminium alloy structures.

1.6.6.1 The scantlings of aluminium alloy structures shall be determined by conversion of the scantlings relating to the corresponding steel structures.

The conversion shall be made using the formulae of Table 1.6.6.1 without considering the limits by minimum scantlings of steel structures.

Table 1.6.6.1

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

Note. $R_{p_{0,2}}$ – proof stress of aluminium alloy, in MPa.

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

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

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

1.6.6.4 The bimetallic (steel — aluminium) pressed elements for connection of steel and aluminium alloy structures may be used based on appropriate technical background.

1.7 WELDED STRUCTURES AND JOINTS

1.7.1 General.

1.7.1.1 Any change in the shape or section of the members of welded hull structure shall take place gradually. All openings shall have rounded corners and smooth edges.

1.7.1.2 The scantlings of sections and the thicknesses of plates used for longitudinal members shall change gradually throughout the ship's length.

Any change of framing system and plating thicknesses used for the strength deck, bottom, side shell and longitudinal bulkheads shall not be permitted in areas where mechanical properties of steel change.

1.7.1.3 Continuity shall be ensured for as many of main longitudinal members as possible, and a gradual change of their sections is required in way of the ends together with other arrangements, contributing to the reduction of stress concentration.

1.7.1.4 In tight structures, as well as in non-tight structures subject to intense vibration, stiffeners and similar details shall be fitted to prevent hard spots in the plating at the toes of brackets and in way of face plates of the members passing through, or terminating at the above-mentioned structures.

1.7.1.5 The length of unsupported plating between the end of a longitudinal and the nearest web normal to direction member shall be as short as possible, however, not more than 4s or 60 mm, whichever is less (s = plate thickness, in mm).

1.7.1.6 For the purpose of this Part, the hull structures subject to intense vibration are those situated in way of machinery and equipment which constitute a source of vibration.

Considered as regions with high level of vibration in all ships are the regions situated below the lower platform continuous within the engine room and bounded:

at aft end, by a section forward of the edge of propeller boss at twice the propeller diameter, but not less than to the after peak bulkhead;

in the engine room, by the bulkheads of this space.

The bulkheads forming boundaries of engine room, the after peak bulkhead and the lower continuous platform in the above regions throughout the length of the ship are considered to be structures subject to intense vibration.

1.7.1.7 7 In way of the ends of bulwark, bilge keels, and other details welded to the hull, as well as generally of gutterway bars, their height shall decrease on a length of at least 1,5 times the height of these members. The ends of bulwarks shall be tapered. This is also recommended for the portions of the ends of the gutter bars.

1.7.1.8 Welded joints, welding consumables and procedures, testing and inspection methods of welded joints shall comply with requirements of Part XIV "Welding".

1.7.2 Connections of framing members.

1.7.2.1 The framing members shall have butt-welded joints, brackets shall be fitted in line with the members connected. Overlapping joints may be permitted, except for in regions with high level of vibration, deep member connections and in way of heavy concentrated loads.

Overlapping brackets may be fitted in line with the members connected in regions where the bending moment in the span point is less than the bending moment in span of the member, for example, in upper section of frames and vertical stiffeners of bullheads.

Brackets shall be made of material having generally the same yield strength as the connections of framing members.

1.7.2.2 Connections of primary members.

1.7.2.2.1 Unless provided otherwise, the size of brackets *c,* in cm, measured in accordance with Fig. 1.7.2.2.1 shall be determined by the formula:

$$c = 5 \cdot \sqrt{W/s}, \qquad (1.7.2.2.1)$$

where: W – required section modulus of the member attached, in cm^3;
s – thickness of bracket, in mm.

The thickness of bracket is taken equal to that of the member web.

Where the web thickness is more than 7 mm the bracket thickness may be reduced by 1 mm;

where the web thickness is more than 12 mm, the bracket thickness may be reduced by 2 mm.

Where a bracket connects two members of different profile, the characteristics of the smaller profile shall be used for determining the bracket size.

The bracket height *h* h (refer to Fig. 1.7.2.2.1) shall be not less than 0,7 times the required size *c.*

The size of brackets determined as indicated above, refers to the case when the members to be interconnected are not welded to each other or the member butts are not welded to the plating. The allowable gap shall not exceed 40 mm or 25 % of size *c*, whichever is less. Otherwise, *c* may be required to be increased.

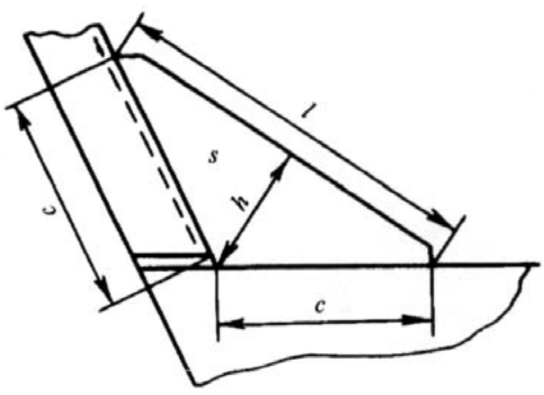


Fig. 1.7.2.2.1

1.7.2.2.2 If the free edge *l* in mm, of a bracket (refer to Fig. 1.7.2.2.1) is longer than 45*s* (*s* – thickness of the bracket, in mm) the bracket shall have a flange (face plate).

The width of the flange shall be not less than 50 mm, the width of the face plate, not less than 75 mm. The thickness of the face plate shall not be less than that of the bracket. The width of the flange (face plate) shall be in accordance with the requirements of **1.7.3.1**.

1.7.2.2.3 The size of brackets may be reduced:

by 10 per cent, where the framing members are welded to each other or to the plating;

by 15 per cent, where a face plate or flange is provided;

by 25 per cent, where the framing members are welded to each other and the brackets are provided with a face plate or flange.

1.7.2.2.4 In regions with high level of vibration the butt ends of framing members shall generally be connected, with the minimum dimensions of the plating portions unsupported by the framing (refer to Fig. 1.7.2.2.4).

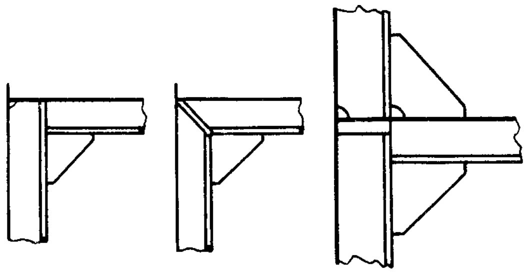


Fig. 1.7.2.2.4

1.7.2.2.5 Where there is a gap between the butt of beam and the frame in way of side strengthening of ships mooring at sea, in region **I** of ships of ice classes **Ice6, Ice5, Ice4,** in areas between *USWL* and *LSWL* ships of polar classes **PC1** ÷ **PC6**, ships of Baltic ice classes **IA Super – IB**, and in region AI of ships of ice class **Ice3** ice strengthening and in areas **B** and **BI** polar class ships **PC7**, and in bow area of Baltic ice class ships **IC**, the beam bracket shall have a face plate or flange.

1.7.2.3 Deep members are recommended to be connected by rounded brackets with smooth change of web depth and face plate size.

1.7.2.3.1 The height and width of brackets interconnecting the members, or attaching them to bulkheads are, unless provided otherwise, to be not less than the members web depth (or the lesser web depth of the members connected). The bracket thickness is assumed equal to the lesser of the member web thicknesses. In member connections no gaps are permissible.

1.7.2.3.2 The brackets connecting the members shall have a face plate or flange along the free edge. In places of transition from the face plates of brackets to those of members, the width and thickness of the face plate along the free edge at different sizes of the member face plates shall change smoothly. The area of face plate (or flange) of tripping bracket shall be taken not less than 0,8 times the area of lesser face plate of the members connected.

If the distance, in mm, between bracket ends exceeds $l \geq 160s\sqrt{\eta}$, in mm, (s = thickness of bracket, in mm), a stiffener shall be fitted parallel to the line connecting bracket ends at the distance a equal to 1/4 of the bracket height or 35 times its thickness (whichever is less). The inertia moment of the stiffener shall be determined by Formula (**1.6.5.6-2**). Brackets shall be additionally stiffened depending on their size and configuration (refer to **1.7.3.2.2**).

1.7.2.3.3 The radius of rounding shall not be less than the depth of the smaller members connected.

The webs and face plates shall be supported by stiffeners and tripping brackets in way of rounding (refer to Fig. 1.7.2.3.3).

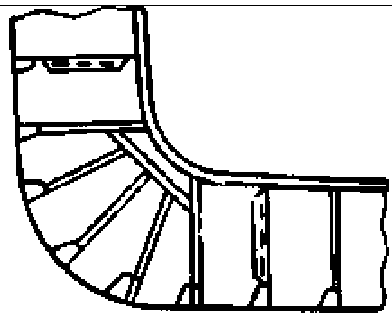


Fig. 1.7.2.3.3

1.7.2.4 The constructions used for the attachment of primary members to supporting members shall comply with existing standards.

1.7.3 Construction of deep members.

1.7.3.1 The depth *h* and thickness s_w of member webs (as well as of built-up primary members) and their sectional area are regulated by the relevant Chapters of this Part. The width of member face plate *b*, in mm, as measured from its web, shall not be more than

$$b = 200 s_{п} / \sqrt{R_{eH}}, \tag{1.7.3.1}$$

where $s_{f.p}$ – thickness of member face plate, in mm.

The thickness of face plate shall not normally exceed a triple thickness of the web plate.

1.7.3.2 Where $h/s_c \geq 160\sqrt{\eta}$, (for *h* and s_w, in mm, refer to **1.7.3.1**), the webs of members (except for those whose buckling strength shall be checked in accordance with 1.6.5) shall be stiffened by tripping brackets and stiffeners (refer to Fig. 1.7.3.2).

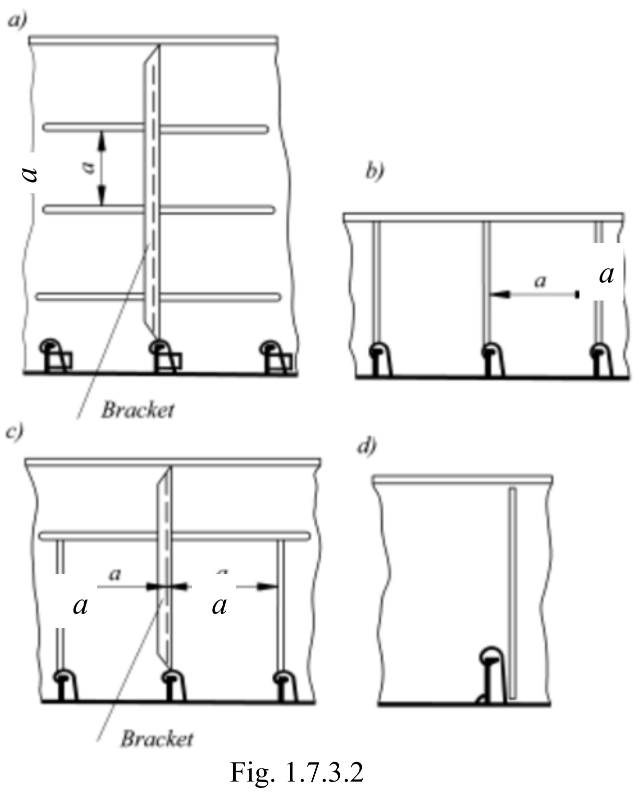


Fig. 1.7.3.2

1.7.3.2.1 Where $h/s_c \geq 160\sqrt{\eta}$, the webs of members shall be stiffened with the stiffeners fitted parallel to the member face plate (refer to Fig. 1.7.3.2, ***a***). Where $h/s_c < 160\sqrt{\eta}$, stiffening may be carried out as shown in Figs. 1.7.3.2, *b, c*.

The spacing of stiffeners (width of non-stiffened web area), in mm, shall not be greater than$a = 90 \cdot s_c \cdot \sqrt{\eta}$.

In some cases, the structure shown in Fig. 1.7.3.2, ***d*** . may be permitted

In way of portions equal to 0,2*l*, but not less than 1,5*h* from supports (*l* and *h* are the span and depth of member web respectively), the spacing a shall be reduced 1,5 times.

Stiffeners fitted normal to the face plate of the member supporting primary members (e.g. longitudinals, bulkhead stiffeners, frames, etc.) shall be fitted not further than in line with every second member in question.

Variation from the above spacing of stiffeners may be permitted on the basis of the results of direct strength calculation.

1.7.3.2.2 The thickness of stiffener shall not be less than$0,8s_w$. Moment of inertia of the stiffeners is determined according to 1 **1.6.5.6**.

1.7.3.2.3 The tripping brackets stiffening deep members shall be fitted at the toes of brackets securing the members in way of roundings and struts as well as in way of span of the member (refer to Figs. 1.7.3.2, *a*, *b*). In any case, the spacing of brackets shall not exceed 3,0m or $15b_{f.p}$ ($b_{f.p}$ – full width of face plate, in mm), whichever is less.

The thickness of the tripping brackets shall be not less than required for the member web. The brackets shall be extended to the member face plate and be welded to it if the width of the face plate exceeds 150 mm, as measured from the member web to the free edge of face plate. The width of the bracket section being welded shall be at least 10 mm smaller than the face plate width. Where the width of face plates symmetric to the member web exceeds 200 mm, small brackets shall be fitted at the opposite side of the web in line with the tripping bracket.

The width of the tripping brackets, measured at the base shall not be less than half their depth.

The bracket shall have a face plate or flange if the length of free edge $l > 60s$ (s – thickness of bracket, in mm). The width of the face plate or flange shall not be less than l / s.

Face plates or flanges ends of the tripping brackets shall be sniped.

1.7.3.3 Lightening holes, cut-outs for the passage of framing members, etc. are permitted in the member webs.

The total depth of openings in the same section shall not exceed 0,5 of the member depth. For deck transverses, deck girders, webs and girders of watertight bulkheads in dry cargo ships, this value may be increased to 0,6 of the member depth.

The distance from the edges of all openings in deep members to the edges of cut-outs for the passage of primary members shall not be less than the depth of these members. The openings in deep member webs, except for cut-outs for the passage of primary members, shall be located at a distance not less than half the deep member depth from the toes of brackets attaching this member. Where it is impossible to satisfy this requirement, compensation shall be provided by local thickening of the web, fitting of collars, etc.

In all cases, the sectional area of a deep member (excluding openings) shall not be less than required in the relevant chapters of this Part.

For requirements regarding openings in floors, side girders and centre girder, refer to **2.4.2.7**.

1.7.4 Details of welded structures.

1.7.4.1 The face plates and/or webs shall be sniped at the member ends depending on the construction used for attachment of members.

1.7.4.2 The width of flange (face plate) of brackets shall not be less than 8 bracket thicknesses unless expressly provided otherwise in the relevant chapters of this Part.

1.7.4.3 The edges of brackets, face plates and webs of the members shall be welded all round and shall have no craters. This requirement also applies to air and drain holes and cut-outs for the passage of framing members and welded joints.

Where these openings are carried to the deck or bottom shell plating, their length as measured at the plating, shall comply with the requirements of **1.7.5.8**.

1.7.4.4 Welded joints shall be arranged in least stressed structural sections, as far as practicable from abrupt changes of sections, openings and details which were subject to cold forming.

1.7.4.5 The butt joints of face plates of the intersection girders under variable dynamic loads (e.g. in regions with high level of vibration) shall be made with smooth transition by means of diamond plates.

1.7.4.6 It is recommended that local concentration of welds, crossings of welds at an acute angle, as well as close locations of parallel butts or fillet welds and butt welds, be avoided. The distance between parallel welded joints, whatever their direction, shall not be less than:

200 mm between parallel butt welds;

75 mm between parallel fillet and butt welds;

50 mm between parallel fillet and butt welds on a length not exceeding 2 m.

The distance between welded joints may be reduced on the basis of appropriate technical background, which includes tests and strength calculations taking into account welding stresses and deformations.

The angle between two butt welds shall not be less than 60° (refer to Fig.1.7.4.6).

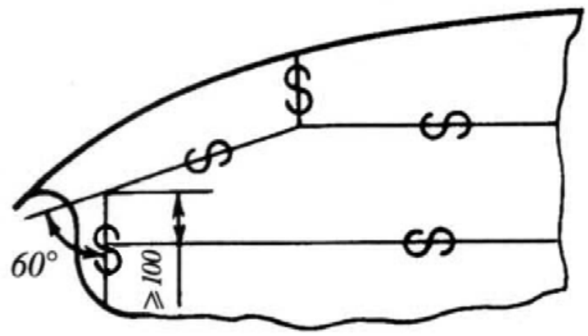


Fig. 1.7.4.6

1.7.4.7 The butts (seams) in assembling joints of the plating shall be located at a distance not less than 200 mm from the bulkheads, decks, inner bottom plating, deep members fitted parallel to the above-mentioned joints.

In assembling joints, the welded butts of built-up members shall be arranged so that the butts of a member web are not less than 150 mm clear of the butts of this member face plate.

The butts of webs and face plates may be arranged in the same plane provided that:

full penetration welding is ensured at the connection of the web to face plate on a length of at least 100 mm each side of the butt by non-destructive testing (NDT) (ultrasonic or radiographic testing) of the welded butt in every third member;

overlapping of the butt by the framing elements (knees, brackets, etc., fitted in line with the web) is ensured on a length not less than the face plate width each side of the butt.

1.7.5 Types and dimensions of fillet welds.

1.7.5.1 The design throat thickness *a*, in mm, of fillet welds for tee-connections for manual and semiautomatic welding shall not be less than:

$$a = \alpha\beta s, \qquad (1.7.5.1)$$

where α – weld factor given in Table 1.7.5.1-1. For structures inside cargo tanks of tankers oc shall be increased by 0,05;

β – factor given in Table 1.7.5.1-2 depending on the ratio of weld pitch *t*, in mm, to weld length /, in mm (refer to Fig. 1.7.5.1-1);

s – thickness of the lesser of the parts joined.

The relationship between the leg length of the fillet weld and the height of the isosceles triangle inscribed into the cross section of the weld (refer to Fig. 1.7.5.1-2) shall be assumed as $k = 1,4a$ or $a = 0,7k$. When automatic welding is employed instead of the proposed manual welding, the weld throat or leg length, whichever is adopted in calculation, may be reduced in height for single-run welds by not more than 30 per cent.

The throat thickness a of a fillet weld shall not be less than:

2,5 mm for $s \le 4$ mm;

3,0 mm for $4 < s \le 10$ mm;

3,5 mm for $10 < s \le 15$ mm;

$0,25s$ mm for $s > 15$ mm.

The dimensions of fillet welds taken from calculations shall not exceed $a \le 0,7s$ ($k \le s$).

Table 1.7.5.1-1

Nos.	Connection of structural members	Weld factor α
1	**2**	3
1	**Double bottom**	
1.1	Centre girder and duct keel to plate keel	0,35
1.2	Ditto to inner bottom plating	0,25
1.3	Ditto to inner bottom plating in the engine room and in way of thrust bearings	0,35
1.4	Floors to centre girder and duct keel under engines, boilers, thrust bearings and within 0,25L from F.P.	0,35
1.5	Floors to centre girder and duct keel elsewhere	0,25
1.6	Floors to margin plate and inner bottom plating under the corrugated bulkhead plates	0,35
1.7	Watertight floors, portions of side girders or centre girder round the boundaries of tanks, plating of bilge wells to their bottom plates and to inner bottom, floors and side girders	0,35
1.8	Floors and side girders to shell plating within 0,25L from F.P.	0,25
1.9	Ditto, elsewhere	0,20
1.10	Floors and side girders to inner bottom plating under engines, boilers and thrust bearings	0,25
1.11	Ditto, elsewhere	0,15
1.12	Floors to side girders within 0,25L from F.P.	0,25
1.13	Ditto, elsewhere	0,20
1.14	Margin plate to shell plating	0,35
1.15	Inclined margin plate to inner bottom plating	0,35
1.16	Bracket floors: bottom frames and brackets to shell plating	0,15
1.17	Reverse frames and brackets to inner bottom plating	0,10
1.18	Brackets, frames (refer to 2.4.4.5) to duct keel, plate keel, shell and inner bottom plating	0,35
1.19	With longitudinal framing, bottom transverses to shell, inner bottom plating, centre girder and duct keel, margin plate where the floor spacing is less than 2,5 m outside the regions defined in 1.4 and 1.7	0,25
1.20	Ditto, with floor spacing 2,5 m and more, in all regions	0,35
1.21	Longitudinals to shell plating within 0,25L from F.P.	0,17
1.22	Ditto, with floor spacing 2,5 m and more, in all regions	0,35
1.23	Longitudinals to inner bottom plating	0,10
1.24	Brackets (refer to 2.4.2.5.2) to shell plating, margin plate, inner bottom plating and longitudinals	0,25
2	**Single bottom**	
2.1	Centre girder to plate keel	0,35
2.2	Centre girder to face plate	0,25
2.3	Floors to centre girder and longitudinal bulkheads	0,45
2.4	Floors and side girder webs to their face plates and to shell plating under engines, boilers and thrust bearings, as well as in the after peak	0,25
2.5	Floors and side girder webs to shell plating elsewhere	refer to 1.8, 1.9, 1.19 i 1.20
2.6	Floors and side girder webs to their face plates elsewhere	0,15
2.7	Side girder webs to floors	0,20
2.8	Bottom longitudinals to shell plating	refer to 1.21 i 1.22
3	**Side framing**	
3.1	Frames (including web frames) and side stringers to shell plating within 0,25L from F.P. in tanks, in the engine room, in way of ice strengthening and strengthening of sides of ships mooring at sea alongside other ships or offshore units	0,17

Nos.	Connection of structural members	Weld factor α
3.2	Ditto, elsewhere	0,13
3.3	Frames (including web frames) and side stringers to their face plates in regions defined in 3.1	0,13
3.4	Ditto, elsewhere	0,10
3.5	Frames (including web frames) and side stringers to shell plating in the after peak	0,25
3.6	Ditto to their face plates	0,17
3.7	Side stringers to web frames	0,25
3.8	Side longitudinals to shell plating	0,17
3.9	Ditto to face plates	0,13
3.10	Bilge brackets to margin plate and face plates of floors outside double bottom	0,35[1]
3.11	Ditto to shell plating	0,25
4	**Deck framing and decks**	
4.1	Deck transverses and girders to deck plating	0,17
4.2	Ditto to their face plates	0,13
4.3	Cantilever beams to deck plating and to their face plates	0,25
4.4	Webs of deck transverses to girder webs and bulkheads	0,25
4.5	Beams in way of tanks, fore and after peaks, as well as hatch end beams, to deck plating	0,15
4.6	Ditto, elsewhere	0,10
4.7	Deck longitudinals to deck plating and their face plates	0,10
4.8	Stringer plate of strength deck to shell plating	0,45[2]
4.9	Ditto for other decks and platforms	0,35[1]
4.10	Hatch coamings to deck plating at hatch corners	0,45[2]
4.11	Ditto, elsewhere	0,35[3]
4.12	Face plates of hatch coamings to vertical plates of same	0,25
4.13	Stays, horizontal and vertical stiffeners to vertical plates of hatch coamings	0,20
4.14	Side and end bulkheads of superstructures and deckhouses to deck plating	0,35
4.15	Other bulkheads of superstructures and deckhouses to deck plating	0,25
4.16	Bulwark stays to bulwark plating	0,20
4.17	Bulwark stays to deck and guard rails	0,35
4.18	Pillars to deck and inner bottom, pillar brackets to pillars, decks, inner bottom and other structures	0,35
5	**Bulkheads and partitions**	
5.1	Fore and after peak bulkheads, tank (cargo oil tank) boundaries, bulkheads (including wash bulkheads) inside after peak around the perimeter	0,35
5.2	Other watertight bulkheads (including wash bulkheads) to bottom shell or inner bottom plating, shell plating in way of the bilge	0,35
5.3	Ditto to sides and deck	0,25
5.4	Vertical box corrugations of corrugated bulkheads to inner bottom plating or upper strake of lower stool	0,35
5.5	Shaft tunnel plating all round	0,35
5.6	Vertical and horizontal stiffeners to bulkhead plates under 5.1, and to wash bulkheads	0,15
5.7	Ditto of other bulkheads	0,10
5.8	Vertical webs and horizontal girders to bulkhead plates according to 5.1, and to wash bulkheads	0,17
5.9	Ditto to their face plates	0,13
5.10	Vertical webs and horizontal girders to plating of other bulkheads	0,13
5.11	Ditto to their face plates	0,10
5.12	Transverse bulkheads to wash bulkheads	0,35[1]
6	**Brackets and stiffeners**	
6.1	Brackets for interconnection of structural members	0,35[3]

Nos.	Connection of structural members	Weld factor α
6.2	Stiffeners and tripping brackets (refer to 1.7.3.2) of deep members, floors, etc	0,10
7	**Foundations for main engines, boilers and other machinery**	
7.1	Vertical plates to shell, inner bottom and deck plating	0,35[4]
7.2	Top plates (face plates) to longitudinal girders, brackets, knees	0,45[2]
7.3	Brackets and knees of foundations to vertical plates, shell plating, inner bottom (floor face 0,353 plates) and to deck plating	0,35[4]
7.4	Brackets and knees to their face plates	0,25

[1] Double continuous weld shall be applied.

[2] Welding through the entire thickness is to be provided.

[3] Fillet welds attaching face plates to member webs shall be welded in way of brackets with weld factor 0,35. The face plates shall be welded to the brackets by the same weld as that of the face plate of the member in the span between the bracket.

[4] The structures under the girder webs, brackets and knees of foundations shall be welded to the inner bottom and decks by double continuous fillet welds with factor 0,35.

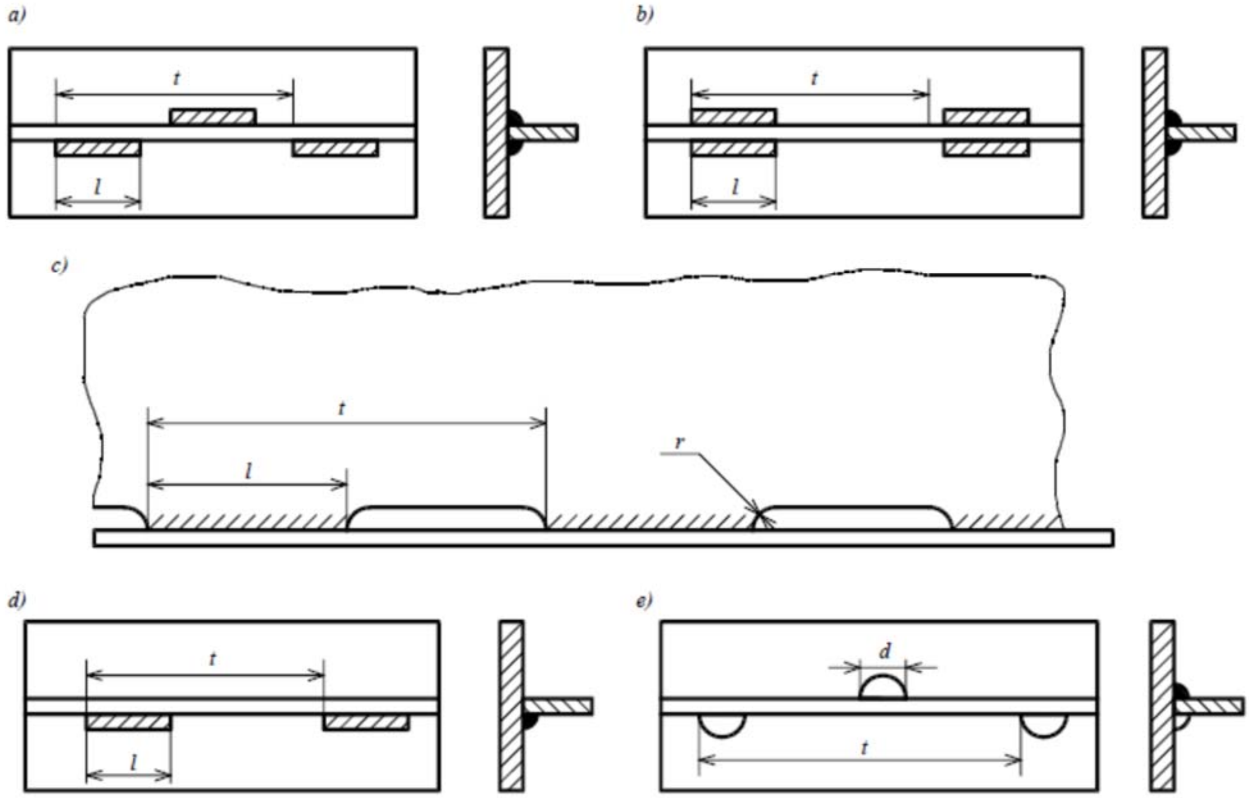


Fig. 1.7.5.1-1

Weld types: ***a*** - staggered intermittent; ***b*** - chain intermittent; ***c*** - scalloped; ***d*** - single intermittent; ***e*** - staggered spot

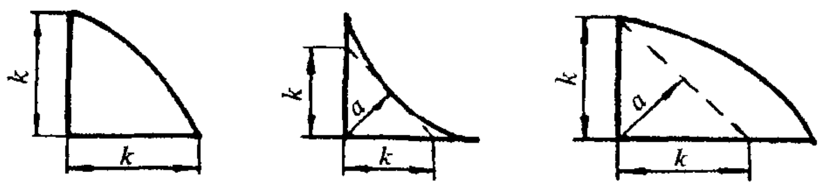


Fig.1.7.5.1-2.

Table 1.7.5.1-2

Type of fillet weld	β
1	**2**
Double continuous	1,0
Staggered, chain and scalloped	t / l
Single continuous	2,0
Single intermittent	$2t / l$

1.7.5.2 Overlapping connections, if allowed (refer to **1.7.2.1**), shall be welded all round by continuous weld with factor 0,4. The length of overlap, in mm, shall be not less than $b = 2s + 25$, but not more than 50 mm (s=thickness of the thinner of the plates joined).

1.7.5.3 The primary members (beams, deck longitudinals, frames, bulkhead stiffeners, etc.) shall be connected to supporting members (deck girders, deck transverses, side stringers, horizontal girders, etc.) by welds with factor 0,35.

The sectional area f, in cm^2, of the welds connecting the primary members to supporting members shall not be less than determined by the formula:

$$f = 25pal / \sigma_n, \quad (1.7.5.3)$$

where p – pressure, in kPa, specified in appropriate Chapters of this Part;

a – spacing of members, in m;

l – span of member, in m;

for σ_n – refer to **1.1.4.3**.

The weld sectional area f, in cm^2, is determined by summing up the results obtained by multiplying the throat thickness by the weld length of each portion of the connection of member web to supporting member.

1.7.5.4 The framing members cut at intersection with other structures shall be in good alignment. A non-alignment shall not exceed half the thickness of the member. Where continuity is obtained by directing welding of the members to the structure involved, the throat thickness of the weld shall be determined considering the thickness of the member concerned. Otherwise, through penetration welding shall be performed. If the thickness of the thinner of the parts joined is less than 0,7 of the thickness of the other part, the throat thickness shall be calculated with regard to the particular loads in way of the intersection.

Where longitudinals are cut at transverse bulkheads, the construction used for their attachment shall comply with the following requirements:

.1 when the brackets are fitted in line on both sides of the bulkhead, the area f_1, in cm^2, of the weld connecting the brackets (and the longitudinal butt ends, if they are welded) to transverse bulkheads (refer to Fig. 1.7.5.4.1 ***a***) shall not be less than determined by the formula:

$$f_1 = 1{,}75S_0, \quad (1.7.5.4.1)$$

where S_0 – cross-sectional area of the longitudinal (effective flange excluded), in cm^2.

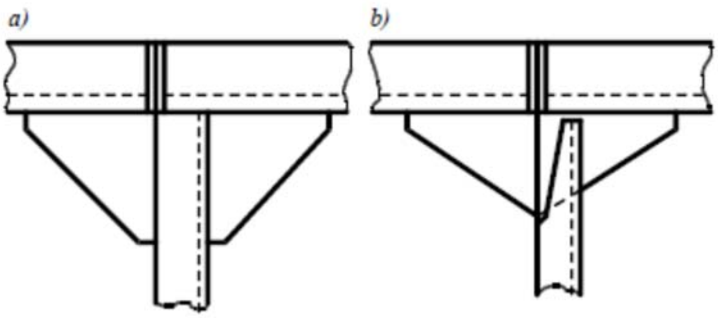


Fig. 1.7.5.4.1

.2 if one continuous bracket plate welded in the appropriate slot cut in the bulkhead plating is fitted (refer to Fig. 1.7.5.4.1 ***b***), the sectional area of the bracket at the bulkhead shall not be less than $1{,}25S_0$.

.3 the arm length l_{br}, in mm, of the bracket, in mm, over the longitudinals shall not be less than determined by the formula:

$$l_{br} = \frac{1{,}75S_0 - S_1}{2a} \cdot 10^2 \qquad (1.7.5.4.3)$$

where S_1 – area of weld connecting longitudinal butt ends to transverse bulkheads, in cm^2;
a – accepted design thickness of fillet weld connecting bracket to longitudinal, in mm.

1.7.5.5 Where plate thickness exceeds 18 mm, for connections made by fillet welds in which excessive stress in Z-direction may be caused by welding process or by external loads, Z-steel (refer to **1.2.2.2**) shall be used or structural measures shall be taken to prevent lamellar tearing. In all cases, reducing of residual stress level shall be provided.

1.7.5.6 Double continuous welds shall be used in the following regions (refer also to Footnote [1] to Table 1.7.5.1-1):

.1 within $0{,}25L$ from the forward perpendicular in ships with length $L \geq 30$ m, for connection of framing members to bottom shell, and in case of only a single bottom in this region, also for welding of the webs of centre girder, side girders and floors to face plates of these members;

.2 in region **I** of ships of ice classes **Ice6, Ice5, Ice4,** in areas between *USWL* and *LSWL* ships of polar classes **PC1** ÷ **PC6**, ships of Baltic ice classes **IA Super – IB**, and in region AI of ships of ice class **Ice3** ice strengthening and in areas **B** and **BI** polar class ships **PC7**, and in bow area of Baltic ice class ships **IC**, for connection of side framing to shell plating

.3 in way of foundations for machinery and equipment which may constitute a source of vibration (refer to **1.7.1.6**), for connection of framing members to bottom and inner bottom platings, deck framing to deck plating;

.4 for the structures in the after peak;

.5 in way of supports and member ends, for connection of framing members to the plating (refer to **1.7.5.8**);

.6 in tanks (including double bottom tanks), exclusive the tanks for fuel oil or lubricating oil;

.7 for structures providing tightness.

1.7.5.7 Single continuous welds shall not be used:

.1 within $0{,}2L$ from F.P. for connection of side framing to shell plating, and within $0{,}25L$ from F.P. for connection of bottom framing to shell plating;

.2 for structures subject to intense vibration (refer to 1.7.1.6);

.3 in region I of ice strengthening of ships;

.4 for welding of side framing in ships mooring alongside other ships at sea or offshore units;

.5 for connections where the angle between a member web and the plating differs by more than 10° from a right angle.

1.7.5.8 For all types of intermittent joints the weld length l (refer to Fig. 1.7.5.1-1) shall not be less than $15a$ (for a, refer to 1.7.5.1) or 50 mm, whichever is the greater. The spacing of welds ($(t - l)$ – for chain welds and scalloped framing, and $(t - 2l)/2$ for staggered welds) shall not exceed $15s$ (s – plate thickness or web thickness, whichever is less). In any case, the spacing of welds or scallop length, where scalloped frames are used, shall not exceed 150 mm.

Intermittent or single continuous welds connecting the framing members to the plating shall be substituted in way of supports and member ends by double continuous welds having the same throat thickness as the intermittent or single continuous welds of the remaining part of the members. The length of joints welded from both sides shall be not less than the sum of bracket arm and the web depth, if a bracket is fitted, and shall be twice the web depth if no bracket is fitted. Where the framing members pass through supporting structures (deck transverses, deck girders, floors, etc.), the aforesaid reinforcement shall be provided on both sides of supporting member. Where single continuous welds are used, back runs at least 50 mm long and spaced not more than 500 mm apart shall be welded on the reverse side of the detail joined.

The throat thickness of back weld shall be the same as that of the single continuous weld.

1.7.5.9 Staggered spot welds and single intermittent welds (refer to Fig. 1.7.5.1-1,***d*** and ***e***) may be used in the structures of deckhouses and superstructures of the second tier and above, on decks inside first tier superstructures, casings, enclosures inside the hull, not subject to intense vibration and impact loads and not affected by active corrosion, provided that the maximum plate or member web thickness is not more than 7 mm. The spot diameter *d*, in mm, shall not be less than:

$$d = 1{,}12\sqrt{\alpha t s}, \quad (1.7.5.9)$$

where t – pitch of spot weld (refer to Fig. 1.7.5.1-1);
t_{max} = 80 mm;
for α, s – refer to **1.7.5.1**.

If $d > 12$ mm, as determined by the Formula (1.7.5.9), the weld pitch shall be increased or another type of weld shall be chosen.

1.7.5.10 Scalloped construction shall not be used:

.1 for side framing within 0,2*L* from F.P. and for connection of framing members to bottom shell plating within 0,25*L* from F.P.;

.2 in regions with high level of vibration (refer to**1.7.1.6**);

.3 for side and bottom framing in region **I** of ice belt and for side framing in ships mooring at sea alongside other ships or offshore units;

.4 for connection of bottom centre girder to plate keel;

.5 for deck and inner bottom framing in locations where containers, trailers and vehicles may be stowed and for upper deck framing under deckhouses in way of their ends at a distance less than 0,25 of the deckhouse height from the intersection of deckhouse side and end bulkhead.

1.7.5.11 In scalloped construction (refer to Fig. 1.7.5.1-1) the welding shall be carried round the ends of all lugs. The depth of scallop in member web shall not exceed 0,25 of the member depth or 75 mm, whichever is less. The scallops shall be rounded with radius not less than 25 mm. The spacing of lugs *l* shall be not less than the length of the scallop. Scallops in frames, beams, stiffeners and similar structures shall be kept clear of the ends of structures, as well as intersections with supporting structures (decks, side stringers, deck girders, etc.) by at least twice the member depth, and from the toes of the brackets by at least half the member depth.

1.7.5.12 In the framing of tanks (including double-bottom tanks and the tanks of tankers), provision shall be made for openings to ensure free air flow to air pipes, as well as an overflow of liquid.

It is recommended that openings in longitudinals shall be elliptical with a distance from the edge of opening to deck plating or bottom shell plating not less than 20 mm.

In way of air and drain holes, cut-outs for the passage of framing members and welded joints the joints shall be welded as double welds on a length of 50 m on both sides of the opening.

1.7.5.13 Where welding of tee-joints by fillet welds is impracticable, plug welds (refer to Fig. 1.7.5.13 ***a***) or tenon welds (refer to Fig. 1.7.5.13 ***b***) may be used.

The length *l* and pitch *t* shall be determined as for scalloped frames under **1.7.5.11.**

For plug welding, the slots shall be of circular or linear form, with throat thickness of weld equal to 0,5 of plate thickness. In general, the ends of slots in plug welding shall be made semicircular. The linear slots shall be arranged with longer side in the direction of the parts to be joined (refer to Fig. 1.7.5.13, ***a***).

Complete filling of slot is not permitted.

In regions of high level of vibration (refer to **1.7.1.6**) welded joints with complete root penetration and permanent backing ring (refer to Fig. 1.7.5.13 ***c***) are recommended instead of tenon welds or plug welds.

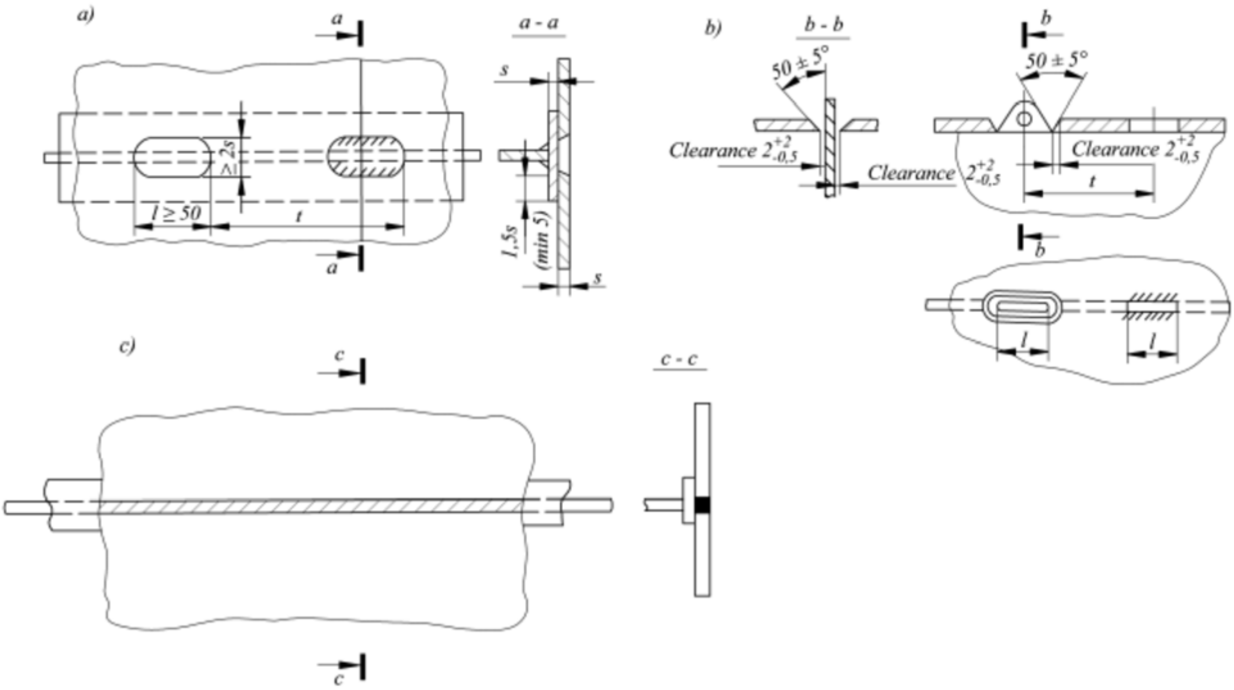


Fig. 1.7.5.13

1.7.5.14 Where aluminium alloy structures are welded according to Table 1.7.5.1-1, it is not permitted:
.1 to use intermittent welds (except in scalloped construction);
.2 to use scalloped construction in regions of high level of vibration (refer to**1.7.1.6**).
The throat thickness of welds shall be not less than 3 mm, but not more than 0,5s (for *s*, refer to**1.7.5.1**).

2. GENERAL REQUIREMENTS FOR HULL STRUCTURES

2.1 GENERAL

2.1.1 Application.

The requirements given in this Section apply to sea-going ships of all types and purposes, having regard to additional provisions of Section 3. This Section contains the requirements for hull structures: shell plating, platings, primary and deep members, pillars, stems, sternframes, seatings, etc.

2.1.2 Symbols.

L_1 – length of the compartment, in m, measured as follows:

with plane bulkheads, as the distance between bulkhead platings;

with corrugated bulkheads, as the distance between corrugation axes or the axes of trapezoidal stools at the inner bottom level;

with cofferdam bulkheads, as the distance between middle cofferdam axes;

B_1 – breadth of the compartment, in m, measured at its mid-length as follows:

for single skin construction, as the distance between the sides or between the side and the longitudinal bulkhead at the upper edge of the floor;

for double skin construction, as the distance between inner skins or between the inner skin and the longitudinal bulkhead;

where hopper side tanks are fitted, as the distance between hopper tanks at the inner bottom level or between the longitudinal bulkhead and the hopper side tank;

where several longitudinal bulkheads are fitted, as the spacing of longitudinal bulkheads or as the distance between the longitudinal bulkhead nearest to the side and the appropriate side;

l – span of the member, in m, defined in **1.6.3.1**, unless provided otherwise;

h – depth of the member web, in cm;

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

s – plate thickness, in mm;

W – section modulus of members, in cm^3;

I – moment of inertia of members, in cm^4;

Δs – corrosion allowance to the plate thickness, in mm (refer to **1.1.5.1**);

ω_k – corrosion allowance to the plate thickness, in mm (refer to **1.1.5.3**);

j_k – factor taking account of corrosion allowance to the section modulus of members (refer to **1.1.5.3**).

2.2 SHELL PLATING

2.2.1 General and symbols.

2.2.1.1 Requirements are given in this Chapter for the thickness of bottom and side shell plating, thickness and width of sheerstrake, plate keel, garboard strakes, as well as the requirements for the minimum structural thicknesses of these members and construction of openings therein. The requirements are applicable to all regions over the ship's length and depth unless additional requirements for shell plating thickness are put forward.

Special requirements to reinforcement of the bottom and side plating in the end parts are specified in **2.8**, and special requirements to to shell plating of ice class ships – in **3.10**.

2.2.1.2 For the purpose of this Chapter the following symbols have been adopted.

p_{st} – design static pressure according to 1.3.2.1;

p_w – design pressure due to the motion of ship hull about wave contour according to 1.3.2.2;

p_c – design pressure from carried liquid cargo, ballast or oil fuel according to 1.3.4.2.1;

r – opening radius, in m.

2.2.2 Construction.

2.2.2.1 No openings shall be cut in the upper edge of sheerstrake or in the side shell plating if the distance between the upper edge of opening and the strength deck is less than half the opening depth.

Rectangular openings cut in the side shell plating shall have their corners rounded with the radius equal to 0,1 of the opening depth or width, whichever is less, but not less than 50 mm.

In all cases when the openings may result in considerable reduction of longitudinal or local strength of the ship, provision shall be made for reinforcement of such areas.

Reinforcement by means of thickened insert plates is required for openings located within 0,35L from the midship region, the distance from their upper edge to the strength deck being less than the depth of opening. The minimum width of thickened insert plates, as measured from the upper or lower edge of opening, shall be equal to 0,25 of the depth or length of the opening, whichever is less; the total width measured outside the opening shall be greater than the minimum thickness by at least 0,25 of the depth or length of the opening, whichever is less. The minimum distance from the end of the thickened insert plate to the nearest edge of opening, as measured along the length, of the ship shall be equal to at least 0,35 of the depth or length of opening, whichever is less. The corners of the thickened insert plate shall be rounded. The thickness of the thickened insert plate shall not be less than:

1,5 s when $s < 20$ mm;

30 mm when $20 \le s \le 24$ mm;

1,25 s when $s > 24$ mm,

where s — thickness of shell plating in way of the opening.

A thicknened insert plate may be fitted around the perimeter of the opening.

In ships of restricted areas of navigation **R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, **R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS**, with shelter upper decks or deck stringers of a longitudinal cargo hatch coamings or the like, all the top free edges of the above structures, as well as free edges of large cutouts in shell plating shall be smooth in the ship's hull longitudinal direction and rounded in the transverse one.

2.2.2.2 The area of transition from sheerstrake to deck stringer may be rounded. In this case, the radius of curvature of sheerstrake shall not be less than 15 times the sheerstrake thickness.

No openings are permitted in the rounded area.

2.2.3 Loads on shell plating.

The external pressure p, in kPa, on the bottom and side shell plating is determined by the formula:

$$p = p_{st} + p_w. \qquad (2.2.3\text{-}1)$$

For ships with double bottom and double skin side construction intended for liquid ballast and for tankers with neither double bottom nor double skin side construction, the internal pressure $p = p_c$ shall be determined additionally by Formulae **1.3.4.2.1**.

Where $p_{st} > p_w$, counterpressure shall be considered:

$$p = p_c - (p_{st} - p_w). \qquad (2.2.3\text{-}2)$$

For ships with double bottom and double skin side construction p_{st} and p_w shall be determined in accordance with **1.3.2** as in the case of the ballasted ships.

As the design pressure, both external and internal pressure may be adopted, whichever is the greater.

The pressure p_w above the summer load waterline shall not be less than p_{min}, , in kPa, determined by the formula:

$$p_{min} = 0{,}03L + 5 \qquad (2.2.3\text{-}3)$$

Where $L > 250$m L shall be taken equal to 250m.

For ships of restricted area of navigation, the value of p_{min} may be reduced by multiplying by the factor φ_r, obtained from Table 1.3.1.5.

2.2.4 Scantlings of plate structures of shell plating.

2.2.4.1 The thickness of bottom and side shell plating shall not be less than determined by Formula (1.6.4.4) taking:

$m = 15{,}8$;

for bottom shell plating:

$k_\sigma = 0{,}3 \cdot k_b \le 0{,}6$ in the midship region for $L \ge 65$ m and transverse framing system;

$k_\sigma = 0{,}6$ in the midship region for $L = 12$ m and transverse framing system.

Where $12\text{m} < L < 65\text{m}$ k_σ shall be determined by linear interpolation taking $k_\sigma = 0{,}45$ for $L = 65$m;

k_σ = 0,6 in the midship region for longitudinal framing system;

k_σ = 0,7 at the ends of the ship within 0,1L from the fore or after perpendicular.

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

for side shell plating in way of (0,4 – 0,5) · D from the base line:

k_σ = 0,6 in the midship region;

k_σ = 0,7 at the ends of the ship within 0,1L from the fore or after perpendicular.

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

For region below 0,4D from the base line, k_σ is determined by linear interpolation between the values of k_σ for bottom shell plating and those for side shell plating in way of (0,4 – 0,5) · D from the base line.

For region above 0,5D from the base line, k_σ is determined by linear interpolation between ks for upper deck level and ks for side shell plating in way of (0,4 – 0,5) · D from the base line;

k_σ for upper deck level is determined in the same way as ks for bottom shell plating, parameter k_b being substituted for parameter k_d.

$$k_b = W_b^{\Phi} /(\eta \cdot W); \quad k_d = W_d^{\Phi} /(\eta \cdot W), \tag{2.2.4.1}$$

where: W – = required hull section modulus amidships in accordance with **1.4.6** and assuming η = 1;

W_b^{Φ} i W_d^{Φ} – actual section moduli for bottom and deck amidships according to **1.4.8**;

η - factor indicating application of the steel mechanical properties for the member for which k_σ is determined, to be established on the basis of **1.1.4.3**.

2.2.4.2 The buckling strength of bottom plating, strake above bilge, sheerstrake and strake below in the midship region of ships over 65 m in length shall be verified in accordance with **1.6.5**.

2.2.4.3 The thickness of bilge strake shall be adopted equal to that of bottom or side shell plating, whichever is the greater.

2.2.4.4 The width of plate keel $b_к$, in mm, shall not be less than:

$$b_к = 800 + 5L, \tag{2.2.4.4}$$

in this case, $b_к$ need not exceed 2000 mm.

The thickness of plate keel shall be 2 mm greater than that of bottom shell plating.

2.2.4.5 The sheerstrake width b_s, in mm, shall not be less than determined by Formula (2.2.4.4) taking bs not greater than 2000 mm.

The sheerstrake thickness amidships shall not be less than that of adjoining strakes of side shell or deck plating (stringer plate), whichever is the greater.

At ends, the sheerstrake thickness may be equal to that of side shell plating in this region.

2.2.4.6 The shell plates adjoining the sternframe, as well as the plates to which the arms of propeller shaft brackets are attached, shall have a thickness s, in mm, of not less than:

$$s = 0{,}1L + 4{,}4, \quad \text{for } L < 80\text{m}; \tag{2.2.4.6-1}$$

$$s = 0{,}055L + 8, \quad \text{for } L \geq 80\text{m}. \tag{2.2.4.6-2}$$

Where L > 200 m, L shall be taken equal to 200 m.

The aforesaid thickness shall be ensured after hot bending, if applied.

2.2.4.7 The thickness of garboard strakes directly adjoining the bar keel shall not be less than that required for the plate keel, and their width shall not be less than half the width required for the plate keel in accordance with **2.2.4.4**.

2.2.4.8 In any case, the thickness of shell plating s, in mm, shall not be less than:

$$s_{min} = 0{,}12L + 3{,}1 \text{ mm}, \quad \text{for } L < 30\text{m}; \tag{2.2.4.8-1}$$

$$s_{min} = (0{,}04L + 5{,}5)\sqrt{\eta} \text{ mm}, \quad \text{for } L \geq 30\text{m}, \tag{2.2.4.8-2}$$

where: where for η – refer to **1.1.4.3**.

Where L > 300 m, L shall be taken equal to 300 m.

Where the adopted spacing is less than the standard one (refer to **1.1.3**) for ships of unrestricted service **A** and restricted area of navigation **R1** and **A-R1**, a reduction of minimum thickness of shell plating is permitted in proportion to the ratio of adopted spacing to standard spacing but not more than 10 per cent10%.

For other ships restricted service –refer to **1.1.4.6**.

2.2.5 Special requirements.

2.2.5.1 The grade of steel used for the sheerstrake shall be the same as that used for the strength deck. The upper edge of sheerstrake shall be smooth, and their corners shall be well rounded in the transverse direction.

Requirement to the edge design covers also free edges of continuous longitudinal structures located above the sheerstrake and ensuring longitudinal strength of the ship's hull.

2.2.5.2 For ships of 65 m and above, within 0. 6L, amidships no parts shall be welded to the upper edge of sheerstrake or to the sheerstrake rounding.

2.2.5.3 Bilge keels shall be attached to the shell plating by means of an intermediate member, 1. e. a flat bar welded to the shell plating with an allround continuous fillet weld. Connection of the bilge keel to this member shall be weaker than that of the member to the shell plating. However, the connection shall be strong enough to keep the bilge keels under the ordinary operating conditions of the ship. The intermediate member shall be made continuous over the length of bilge keel.

Bilge keels shall terminate in the stiffened area of shell plating and shall be gradually tapered at ends. The bilge keel and the intermediate member shall be of the same steel grade as the shell plating in this region.

2.3 SINGLE BOTTOM

2.3.1 General and symbols.

2.3.1.1 Requirements are given in this Chapter for the bottom framing of ships having no double bottom and in way where it is omitted, as well as for the floors, centre girder, bottom longitudinals and the brackets by which they are connected.

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

L_1 – = length of the compartment concerned (hold, tank, engine room, etc.), in m;

B_1– breadth of the compartment concerned, in m, refer to **2.1.2**;

B_x– = breadth of ship, in m, in way of considered section at the level of summer load waterline.

2.3.2 Construction.

2.3.2.1 In tankers of 80 m and above, longitudinal framing shall be provided for single bottom.

2.3.2.2 The structure of centre girder shall satisfy the following requirements:

.1 the centre girder shall extend throughout the ship's length as far as practicable. In ships greater than 65 m in length, a continuous centre girder is recommended between transverse bulkheads;

.2 when the bottom is framed longitudinally, the centre girder shall be stiffened on both sides with flanged brackets fitted between the bottom transverses and between bottom transverse and transverse bulkhead. The distance between brackets, between bracket and bottom transverse or between bracket and transverse bulkhead shall not exceed 1,2 m.

The brackets shall be carried to the face plate of the centre girder if the web of the latter is stiffened vertically or to the second horizontal stiffener from below if the centre girder web is stiffened horizontally.

In way of bottom plating, the brackets shall extend to the nearest bottom longitudinal and shall be welded thereto.

2.3.2.3 When the bottom is framed transversely, floors shall generally be fitted at every frame.

Where the floors are cut at the centre girder, their face plates shall be butt-welded to the face plate of the centre girder. If the actual section modulus of floors exceeds the value required by **2.3.4.1.2** less than 1,5 times, the width of their face plates shall be doubled, where attached to the centre girder face plate, or horizontal brackets of adequate size shall be fitted.

The floor face plates may be replaced by flanges.

Flanged floors are not permitted in way of engine room, in the after peak, and in ships of 30 m and above; they are not permitted within 0,25L from the fore perpendicular, either.

2.3.2.4 When the bottom is framed longitudinally, brackets shall be fitted in line with the bottom transverse web on both sides of the centre girder where the girder is higher than the bottom transverse at the place of their connection. A bracket shall be welded to bottom transverse face plate and to centre girder web and face plate. The free edge of the bracket shall be stiffened with a face plate, and the angle of its inclination to bottom transverse face plate shall not exceed 45° .

Similar requirements apply to the connections of the stringer to bottom transverse where the stringer is higher than the bottom transverse at the place of connection.

2.3.2.5 In dry cargo ships, when the bottom is framed longitudinally, the spacing of side girders and the distance from the centre girder or ship's side to the side girder shall not exceed 2,2 m.

The side girder plates shall be cut at floors and welded thereto.

The face plates of side girders shall be welded to those of floors.

2.3.2.6 In tankers, the side girders, if fitted, shall form a ring system together with vertical stiffeners of transverse bulkheads and deck girders.

Deep side girders having the same depth as the centre girder, as well as conventional side girders having the same depth as bottom transverses, shall run continuous from one transverse bulkhead to another with $L_1/B_1 < 1$.

2.3.2.7 In the engine room, the centre girder may be omitted if the longitudinal girders under engine seating extend from the fore to the after bulkhead of the engine room and terminate with brackets beyond the bulkhead according to **2.3.5.1**.

2.3.2.8 In ships having a length of 65 m and more, the buckling strength of centre girder and side girders in the midship region shall be ensured in accordance with **1.6.5**.

The webs of centre girder, side girders and floors shall be stiffened in accordance with **1.7.3**.

2.3.2.9. Connections of bottom longitudinals to transverse bulkheads shall be such that the effective sectional area of the longitudinals is maintained.

2.3.2.10 When the bottom is framed longitudinally floors shall be fitted within the plane of side web frames, the spacing between floors or the distance between floors and travsverse bulkhead shall be multiple to spacing and shall not exceed five spacings or 2,4m, whichever is less.

2.3.2.11 For hulls of a pontoon shape an alternative design and arrangement of the deck girders and transverses may be permitted, provided the additional longitudinal bulkheads are installed and strength of double bottom structures is verified by direct calculation according to the Register-agreed procedures.

2.3.3 Single bottom loads.

2.3.3.1 The design pressure on single bottom structures of dry cargo ships is the external pressure determined by Formula (2.2.3-1) for a ship in the ballast condition. When determining p_{st} in Formula (2.2.3-1), the ballast draught may be taken as 0,6 of the summer draught.

If a dry cargo ship is designed to operate in a fully loaded condition with some holds empty the static pressure p_{st} in Formula (2.2.3-1) for these holds shall be determined at summer draught.

2.3.3.2 As the design pressure on single bottom structures of tankers, external pressure determined by Formula (2.2.3-1) at summer draught is adopted, or the total pressure determined by Formula (2.2.3-2), whichever is the greater.

2.3.4 Scantlings of single bottom members.

2.3.4.1 The bottom with transverse framing shall satisfy the following requirements:

.1 the depth of floors at the centreline shall not be less than $0{,}055B_1$. In any case, B_1 shall not be taken less than $0{,}6B_x$.

Allowable reduction of floor depth shall not be more than 10 per cent, the required floor section modulus being maintained.

In the engine room, the height of floor web between longitudinal girders under the seating shall not be less than 0,65 of the required depth at the centreline. A reduction of floor section modulus by more than 10 % as compared to that required by **2.3.4.1.2** is not permitted.

At a distance of 3/8 B_x from the centreline, the depth of floors shall not be less than 50 per cent of the required depth of the centreline floors;

.2 at the centreline, the section modulus of floors shall not be less than determined according to **1.6.4.1** and **1.6.4.2** taking:

for p, refer to **2.3.3.1**, but it shall not be less than 35 kPa for dry cargo ships and not less than 85 kPa for tankers;

$l = B_1$, but at least $0{,}6B_x$;

$m = 13$;

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

On portions equal to $0{,}05B_x$ from ship's side, the floor web sectional area shall not be less than determined according to 1.6.4.3 taking:

$N_{max} = 0{,}4pal$;

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

When determining p and l, the above limitations shall be used;

.3 in accordance with **2.3.4.1.2**, the section modulus of centre girder shall be at least 1,6 times greater than the section modulus of a floor at the centreline. The depth of centre girder shall be equal to that of a floor at the place of their connection;

.4 the section modulus of a side girder shall not be less than the section modulus of a floor at the centreline in accordance with **2.3.4.1.2**.

The depth of side girder shall be equal to that of the floor at the place of their connection.

2.3.4.2 If longitudinal system of framing is adopted, the bottom members in way of the cargo tanks in tankers shall satisfy the following requirements:

.1 the section modulus of bottom longitudinals shall not be less than determined in accordance with **1.6.4.1** and **1.6.4.2** taking:

p – as defined in **2.3.3.2**;

$m = 12$;

$k_\sigma = 0{,}45k_b \le 0{,}65$ in the midship region;

$k_\sigma = 0{,}65$ at the ends of the ship within $0{,}1L$ from the fore or after perpendicular.;

k_b – shall be determined by Formula (2.2.4.1).

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

.2 the section modulus of a bottom transverse shall not be less than determined from **1.6.4.1** and **1.6.4.2**. Bottom transverse web sectional area, excluding openings, shall not be less than stipulated under **1.6.4.3** taking:

p – as defined in **2.3.3.2**;

$l = B_1$;

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

for a wing tank

$m = 18$;

$N_{max} = 0{,}35pal$;

for a centre tank

$m = m_{b.t}$;

$N_{max} = 0{,}7n_\Phi pal$;

$m_{b.t}$ and $n_{b.t}$ shall be obtained from Table 2.3.4.2.2 depending upon the parameter m and the number of bottom transverses within a tank:

$\mu = \alpha^{4/3}(L_1/B_1)^3$;

$\alpha = W_{b.t}/W_{c.g}$;

Table 2.3.4.2.2

μ	Number of transverses within a tank															
	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5
	$m_{b.t}$				$m_{c.g}$				$n_{b.t}$				$n_{c.g}$			
0,01	96,0	95,9	95,9	95,8	27,3	21,7	25,5	23,3	0,253	0,255	0,256	0,257	0,329	0,370	0,393	0,409
0,02	95,8	95,6	95,4	95,1	27,6	22,1	26,0	23,9	0,256	0,260	0,261	0,264	0,326	0,367	0,387	0,401
0,04	95,4	95,4	93,9	92,7	28,3	22,8	27,1	25,0	0,261	0,269	0,271	0,277	0,318	0,355	0,375	0,387
0,06	94,7	92,7	91,8	89,3	28,9	23,5	28,1	26,2	0,267	0,277	0,281	0,289	0,311	0,346	0,364	0,374
0,08	93,9	90,5	89,2	85,5	29,6	24,3	29,1	27,4	0,272	0,286	0,290	0,301	0,304	0,337	0,354	0,363

0,1	92,9	88,1	86,3	81,5	30,2	25,0	30,2	28,6	0,276	0,293	0,298	0,311	0,298	0,329	0,344	0,352
0,2	86,5	75,1	72,1	64,0	33,4	28,9	35,5	34,7	0,298	0,326	0,333	0,352	0,269	0,294	0,304	0,307
0,3	79,6	64,0	61,1	52,3	36,6	32,8	40,9	41,0	0,316	0,352	0,359	0,382	0,246	0,266	0,273	0,274
0,4	73,3	55,7	53,1	44,7	39,8	36,9	46,5	47,6	0,330	0,373	0,380	0,404	0,226	0,243	0,249	0,249
0,6	63,2	44,9	43,3	36,1	46,2	45,4	58,0	61,6	0,354	0,404	0,409	0,436	0,195	0,206	0,213	0,214
0,8	56,1	38,5	37,6	31,5	52,6	54,4	70,1	76,6	0,371	0,426	0,429	0,457	0,171	0,184	0,188	0,189
1,0	51,0	34,4	34,0	28,6	59,0	64,0	82,8	93,1	0,386	0,443	0,445	0,471	0,153	0,165	0,170	0,171
1,2	47,2	31,6	31,6	26,9	65,4	74,2	96,6	110,8	0,397	0,456	0,456	0,482	0,138	0,150	0,155	0,158
1,5	43,1	28,8	29,1	25,0	75,0	90,7	117,0	141,1	0,410	0,471	0,469	0,492	0,120	0,132	0,139	0,142

$W_{b.t}$ – bottom transverse section modulus satisfying the present requirements;

$W_{c.g}$ – centre girder section modulus satisfying the requirements of **2.3.4.2.3**.

The value of the parameter α is optional, but shall not exceed 0,6; the value of the parameter m shall not exceed 1,5.

Bottom transverse section modulus shall not be less than $\alpha W_{c.g}$;

.3 centre girder section modulus shall not be less than determined from **1.6.4.1** and **1.6.4.2**. The sectional area of centre girder web shall not be less than stipulated under **1.6.4.3** taking:

p – as defined in **2.3.3.2**;

$l = L_1$;

$m = m_{c.g}$;

$N_{max} = 0{,}7 n_{c.g} pal$;

$m_{c.g}$ and $n_{c.g}$ shall be obtained from Table 2.3.4.2.2 depending upon the parameter μ and the number of floors within a tank;

μ shall be determined in accordance with **2.3.4.2.2**;

$k_\sigma = 0{,}35 k_b \le 0{,}6$ in the midship region;

$k_\sigma = 0{,}6$ at the ends of the ship within 0,1L from the fore or after perpendicular;

k_b – shall be determined by Formula (2.2.4.1).

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

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

The section modulus of centre girder shall not be less than $W_{b.t}/\alpha$, where $W_{b.t}$ – is bottom transverse section modulus satisfying the requirements of **2.3.4.2.2**; α – shall be as stipulated under **2.3.4.2.2**;

.4 in ships of 200 m and above, provision shall be made for side girders midway between longitudinal bulkhead and centre girder, as well as between longitudinal bulkhead and ship's side, in centre and wing tanks.

The section modulus of deep side girders, when fitted in accordance with **2.3.2.6**, shall not be less than 0,5 of centre girder section modulus. The centre girder section moduli may be reduced in conformity with **2.3.4.2.3** and those of bottom transverse, in conformity with **2.3.4.2.2** by 15%.

The section modulus of conventional side girders, when fitted in accordance with **2.3.2.6**, shall not be less than bottom transverse section modulus;

.5 alternatively to the requirements of **2.3.4.2.2 - 2.3.4.2.4**, the scantlings of bottom transverses, centre girder and side girders may be selected proceeding from the calculation of bottom grillage, using beam models. In this case, design loads shall be chosen in accordance with **2.3.3.2**, permissible stress factors, in accordance with **2.3.4.2.2** and **2.3.4.2.3**, boundary conditions, proceeding from cargo distribution over the length and breadth of the ship and the type of structures adjoining the calculated one. The effect of brackets shall be considered.

2.3.4.3 in the engine room, the bottom transverse and side girder web thickness shall not be less than the centre girder web thickness.

If a girder acts as the vertical plate of engine seating, the girder thickness shall not be less than the vertical plate thickness as required by **2.11.3**.

The depth of bottom transverse shall be increased in proportion to the height at which engine seatings are fitted.

2.3.4.4 The thickness, in mm, of single bottom members shall not be less than:

s_{min}=5,3 + 0,04L for L < 80m; (2.3.4.4-1)

s_{min}=6,5 + 0,025L for $L \geq$ 80m. (2.3.4.4-2)

Where L> 250 m, L shall be taken equal to 250 m.

For the centre girder, s_{min} shall be increased by 1,5 mm, but shall not exceed the plate keel thickness; floor web thickness need not exceed the bottom shell plating thickness.

In tankers, the minimum thickness of single bottom members shall also satisfy the requirements of **3.5.4**, whichever is the greater.

2.3.5 Special requirements.

2.3.5.1 End attachments of bottom members and deep member web stiffening shall satisfy the following requirements:

.1 centre girder and side girders shall be attached to transverse bulkheads by brackets. For size of brackets, refer to **1.7.2.3**.

.2 in dry cargo ships, the height of brackets may be reduced to half the centre girder depth if the face plate of centre girder is welded to the transverse bulkhead. In case the centre girder face plate is widened to at least twice the normal value in way of abutting upon the transverse bulkhead, the brackets need not be fitted. If the centre girder is not fitted in the engine room, then at discontinuities beyond bulkheads it shall be terminated in gradually tapered brackets of a length equal to twice the centre girder depth, but not less than three spacings.

.3 in tankers, the bottom transverses shall be attached to side transverses and/or vertical webs of longitudinal bulkheads by brackets. For size of brackets, refer to **1.7.2.3**.

The bottom transverses shall be attached to centre girder by brackets.

2.3.5.2 If transverse system of framing is adopted, the holes cut in floors shall have a diameter not exceeding half the floor depth in this location. The distance between the hole edge and floor face plate shall not be less than 0,25 times the floor depth in this location. The distance between the edges of adjacent holes shall not be less than the floor depth. Floor plates provided with holes shall be strengthened with vertical stiffeners.

2.3.5.3 The webs of side girders and floors shall be provided with drain holes.

2.4 DOUBLE BOTTOM

2.4.1 Загальні положення.

Requirements are given in this Chapter for double bottom structures including bottom framing up to the top of bilge rounding, inner bottom plating and framing, centre girder and duct keel, side girders and half-height girders, margin plate with stiffeners, brackets, knees and intermediate vertical stiffeners in the double bottom space, sea chests and drain wells.

Additional requirements for double bottoms are given in:

1.1.6.4 and **1.1.6.6** (passenger ships);

1.1.6.5 and **1.1.6.6** (cargo ships, other than tankers),;

3.1 (container ships);

3.3 (bulk carriers and oil/bulk dry cargo carriers);

3.4 (ore carriers and ore/oil carriers);

3.10 (icebreakers).

2.4.2 Construction.

2.4.2.1 In tankers of 80 m in length, bulk carriers and ore carriers, as well as in oil/bulk dry cargo carriers and ore/oil carriers, the double bottom shall be framed longitudinally.

2.4.2.2 The centre girder shall extend fore and aft as far as practicable to the stem and sternframe and shall be attached to them whenever possible. The centre girder shall generally be continuous within at least 0,6L amidships. Where longitudinal framing is adopted in the double bottom, brackets shall be fitted on both sides of centre girder, which shall be spaced not more than 1,2 m apart, extended to the nearest longitudinal or ligthened side girder and welded thereto. The distance between brackets shall not exceed 1,2 m.

2.4.2.3 In lieu of centre girder, a duct keel may be fitted consisting of two plates arranged on both sides of the centreline. The duct keel shall be wide enough for the access to all its structures to be ensured.

Transverse members with brackets shall be fitted at every frame in way of the bottom and inner bottom plating between the side plates of the duct keel.

If longitudinal system of framing is adopted, brackets shall be fitted at every frame on both sides of the duct keel, similar to those used for the centre girder.

Where the duct keel fitted only over a part of the ship's length terminates and is transformed into the centre girder, the duct keel and centre girder plates shall overlap over a length of at least one frame spacing and shall terminate in brackets with face plates.

In this case, the length of the brackets shall not be less than three spacings if the transition areas lie within 0,6*L* amidships, and not less than two spacings elsewhere.

2.4.2.4 The design of side girders and margin plate shall satisfy the following requirements:

.1 the spacing of side girders and the distance between a side girder and centre girder or margin plate, as measured at the level of the double bottom plating, shall not exceed 4,2 m for transversely framed double bottom and 5,0 for longitudinally framed double bottom;

.2 if longitudinal framing is adopted in the double bottom, lightened side girders may be fitted on bottom and double bottom instead of longitudinals (for panels with large openings, refer to **2.4.2.7.2** and 2.4.2.7.4);

.3 in the engine room, the arrangement of side girders shall be consistent with that of the engine, boiler and thrust block seatings, so that at least one of the longitudinal girders under the seating is fitted in line with the side girder. In this case, an additional side girder shall be provided under the seating in line with the second longitudinal.

Where side girders cannot be arranged under the seatings in line with longitudinal girders, additional side girders shall be fitted under each longitudinal girder.

Additional side girders may be replaced by half height side girders welded to the inner bottom plating and floors only;

.4 inclined margin plate, if fitted, shall extend throughout the double bottom length.

2.4.2.5 The arrangement and design of floors shall satisfy the following requirements:

.1 if transverse framing is adopted in the double bottom, plate floors shall be fitted at every frame:

in engine and boiler rooms;

at the fore end within 0,25L from the fore perpendicular;

in the holds intended for the carriage of heavy cargo and ore, as well as in holds from which cargo is regularly discharged by grabs;

in ships which may happen to be aground due to the ebb-tide in ports.

In other regions, plate floors may be fitted five spacings or 3,6 m apart, whichever is less.

In this case, provision shall be made for open floors (bracket or lightened).

Bracket floors consist of bottom and reverse frames connected with brackets at centre girder, side girders and margin plate (refer to Fig. 2.4.2.5.1-1).

Lightened floors consist of plate panels having large openings of a smooth shape between side girders (refer to Fig. 2.4.2.5.1-2);

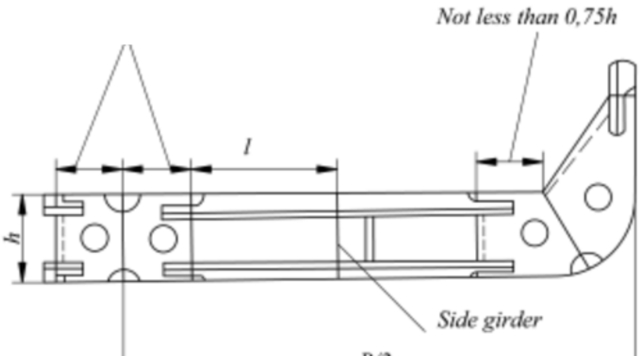


Fig. 2.4.2.5.1-1

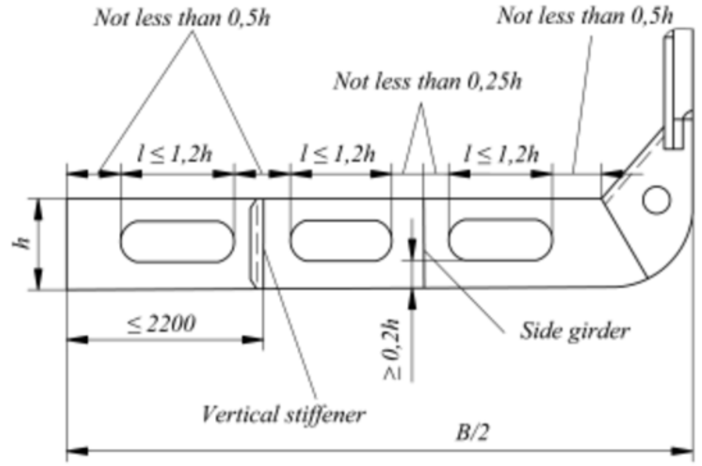


Fig. 2.4.2.5.1-2

.2 if longitudinal framing is adopted in the double bottom, plate floors shall generally be fitted at a distance not exceeding two spacings from each other:

in engine and boiler rooms; at the fore end within 0,25L from the fore perpendicular;

in the holds intended for the carriage of heavy cargo and ore, as well as in holds from which cargo is regularly discharged by grabs;

in ships which may happen to be aground due to the ebb-tide in ports.

In other regions, plate floors may be fitted five spacings or 3,6 m apart, whichever is less. Where lightened side girders are fitted in lieu of bottom and double bottom longitudinals (refer to **2.4.2.4.2**), the above spacing may be increased, but not more than twice.

When the ship's side is framed transversely and double bottom is framed longitudinally, brackets shall be fitted at every frame between plate floors to stiffen the margin plate, which shall be carried to the nearest bottom and inner bottom longitudinals or to the nearest additional side girder, and welded thereto (refer to Fig. 2.4.2.5.2).

Under the seating of main engine, plate floors shall be fitted at every frame and carried to the nearest side girder outside the main engine seating;

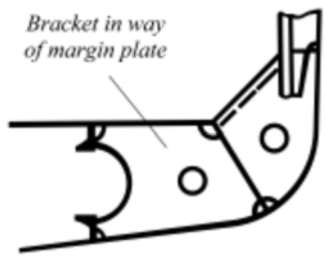


Fig. 2.4.2.5.2

.3 irrespective of the requirements **of 2.4.2.5.1** and **2.4.2.5.2**, plate floors shall be fitted:

under pillars and ends of longitudinal partial bulkheads; under bearers and boiler bearer ends;

under transverse bulkheads and sloping plates of low trapezoidal stools of corrugated bulkheads;

under bracket toes of deep tank bulkhead stiffeners in transversely framed double bottom;

under block bearing seatings. In the above cases, the floors need not be fitted throughout the ship's breadth.

Partial floors may be fitted and carried to the side girder nearest to the structure being stiffened.

2.4.2.6 Arrangement of stiffeners on centre girder and duct keel, side girders and floors shall satisfy the following requirements:

.1 stiffeners shall be provided where transverse system of framing is adopted and plate floors are more than 900 mm in depth. The spacing of stiffeners shall not exceed 1,5 m. The spacing of stiffeners of lightened floors shall not exceed 2,2 m.

If longitudinal system of framing is adopted, the stiffeners on plate floors shall be fitted in line with bottom and inner bottom longitudinals. The stiffeners shall be carried to the longitudinals, and either welded thereto or attached by the brackets.

The stiffeners shall be fitted under the pillars, at bracket toes of end stiffeners of longitudinal partial bulkheads, etc;

.2 watertight floors shall be fitted with vertical stiffeners spaced not more than 0,9 m apart.

2.4.2.7 Holes (manholes) shall satisfy the following requirements:

.1 an adequate number of holes (manholes) shall be provided in the inner bottom plating, side girders and floors for access to all portions of double bottom.

The size of the holes, including lightening holes, shall satisfy the requirements of standards or other normative documents recognized by the Register. Air and drain holes, cut-outs for the passage of welded joints, refer to **1.7.5.12**);

.2 the holes in centre girder, side girders and floors shall have a smooth rounded shape. The minimum allowable height of the plate adjoining bottom shell plating or inner bottom plating is indicated in Table 2.4.2.7.2.

Besides, the minimum height of the plate in way of the hole shall not be less than 1 /8 of the length of the hole.

The plate height indicated in Table 2.4.2.7.2 may be reduced if suitable stiffening is provided.

Besides, lightened side girder and floor plates shall satisfy the requirements of 2.4.4.5.5, and if the plate height h_0, in mm, exceeds $25s\sqrt{\eta}$, the free edge of the plate shall be stiffened.

Where: s – lightened side girder or floor height, in mm;

for η – refer to **1.1.4.3;**

Table 2.4.2.7.2

Member	Minimum allowable plate height (in parts of member height)
Centre girder	0,3
Side girders	0,25
Lightened side girders	0,15
Floors:	
plate	0,25
lightened	0,2

.3 the distance between the edges of adjacent openings in centre girder, side girders and plate floors shall not be less than half the length of the largest opening.

The distance of the edges of openings in the floors from longitudinal bulkheads, centre girder, side girders, inclined margin plate and inner edges of hopper side tanks shall not be less than half the centre girder depth in this region.

The distance of the edge of opening in a lightened floor from the side girder shall not be less than one-quarter of centre girder depth.

In exceptional cases, deviation from the above requirements is permitted;

.4 one or more consecutive openings may be permitted in a lightened side girder web between adjacent floors or in a lightened floor web between adjacent side girders. In the latter case, vertical stiffeners shall be fitted between openings. The length of one opening shall not exceed 1,2 times the accepted depth of centre girder or 0,7 times the distance between floors (side girders) or between a floor (side girder) and vertical stiffener, whichever is less (refer to Fig. 2.4.2.5.1-2). The distance of the edges of openings in lightened side girders and floors from each other shall not be less than half the centre girder depth in this regio;

.5 normally, openings are not permitted:

in centre girder over a length of 0,75L from the fore perpendicular;

in centre girder and side girders (lightened side girders) under pillars and in sections adjoining transverse bulkheads (between the bulkhead and extreme floor for double bottom with transverse framing and on a length equal to the depth of double bottom with longitudinal framing);

in floors under pillars and in way of partial longitudinal bulkheads;

in floors at the toes of brackets transversely supporting main machinery seatings;

in floors between the side (inner side) and the nearest lightened side girder, provided the spacing of floors is increased in accordance with **2.4.2.5.2**.

In exceptional cases, openings are permitted in the above members provided the webs in way of the openings are suitably stiffened;

.6 circular lightening openings are permitted for brackets, having a diameter not greater than 1/3 of the width or height of the bracket, whichever is less.

2.4.2.8 Where double skin side construction is provided, the inner bottom plating shall extend through the inner skin as far as the shell plating.

A side girder shall be fitted in line with the inner skin. Festoon plates may be fitted in lieu of the inner bottom plating inside the double skin side or additional side girder in line with the inner skin.

2.4.2.9 Connections of bottom and inner bottom longitudinals to watertight floors shall be such that the effective sectional area of these members is maintained.

2.4.3 Double bottom loads.

2.4.3.1 The external pressure on double bottom structures is determined by Formula 2.2.3-1.

For design ballast condition, the value of z_i according to 1.3.2.1-2 shall be counted from the design ballast waterline.

2.4.3.2 Double bottom loads from inside:

.1 design pressure on the double bottom from general cargo is determined according to **1.3.4.1**;

.2 design pressure on the double bottom from liquid cargo or ballast is determined according to **1.3.4.2**;

.3 design pressure on the double bottom from bulk cargo is determined according to **1.3.4.3**;

.4 test loads

$$p = 7{,}5h_p, \qquad (2.4.3.2.4)$$

where h_p – vertical distance, in m, from inner bottom plating to the top of air pipe;

.5 loads due to the emergency flooding of double bottom compartments:

$$p = 10{,}5\,(d - h), \qquad (2.4.3.2.5)$$

where h - actual depth of double bottom, in m.

2.4.3.3 The total design pressure on the double bottom is defined as a difference between the external pressure p and the cargo (ballast) pressure from inside p_c.

In this case, the value of p_c is defined as the smallest value of counterpressures determined from **2.4.3.2.**1–**2.4.3.2.3** with $p > p_c$, and as the greatest of the above values with $p < p_c$.

If a hold may be empty during service, the external pressure p shall be taken as the design pressure.

2.4.4 Scantlings of double bottom members.

2.4.4.1 At centre girder, the depth of double bottom h, м, in m, shall not be less than:

$$h = (L - 40) / 570 + 0{,}04 \cdot B + 3{,}5 \cdot d / L, \qquad (2.4.4.1)$$

but not less than 0,65 m, unless a greater value is indicated in other sections of these Rules and the Rules for the Prevention of Pollution from Ships.

2.4.4.2 The centre girder and side girders shall satisfy the following requirements:

.1 the thickness, in mm, of centre girder (duct keel) shall not be less than

$$s = (\alpha_k \cdot h^2 \cdot \sqrt{\eta} / h_ф) + \Delta s, \qquad (2.4.4.2.1)$$

where: h – height of centre girder, in m, required by **2.4.4.1**;
$h_ф$ – = actual height of centre girder, in m;
for η – refer to **1.1.4.3**;
for Δs – refer to **1.1.5.1**;
$\alpha_k = 0{,}03L + 8{,}3$, but not greater than 11,2.

In any case, the thickness of centre girder shall be 1 mm greater than that of a plate floor.

The thickness of side girders shall not be less than that of plate floors;

.2 the buckling strength of centre girder web and of side girders, as well as of longitudinal stiffeners fitted along them shall be ensured in accordance with **1.6.5**;

.3 at ends within 0,1L from the fore and after perpendiculars, the centre girder web thickness may be 10 % less than that in the midship region, as determined for steel used at ends, but not less than the minimum thickness stipulated under **2.4.4.9**.

The thickness of side plates of the duct keel shall not be less than 0,9 of that required for the centre girder in this region;

.4 the thickness of watertight sections of centre girder and side girders shall not be less than determined by Formula (1.6.4.4) taking:

p – as determined by Formulae (1.3.4.2.1-4) and (1.3.4.2.1-5) for the mid-depth of centre girder (side girder), whichever is the greater (where no safety valve is fitted

$p_v = 0$);

$m = 15{,}8$;

if the centre girder (side girder) is stiffened with vertical brackets or stiffeners:

$k_\sigma = 0{,}6k_b \le 0{,}75$ for $L \ge 65$m;

$k_\sigma = 0{,}75$ for $L = 12$m.

For $12 < L < 65$м k_σ shall be determined by linear interpolation taking $k_\sigma = 0{,}68$ при $L = 65$m;

if the centre girder (side girder) is stiffened with horizontal stiffeners, in the midship region:

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

at the ends of the ship within 0,1L from the fore or after perpendicular:

$k_\sigma = 0{,}85$.

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

k_b shall be determined by Formula (2.2.4.1).

The thickness of the watertight sections of centre girder and side girders need not be greater than that of adjacent shell plating.

2.4.4.3 Floors shall satisfy the following requirements:

.1 the thickness, in mm, of floors shall not be less than

$$s = \alpha \cdot k \cdot a \cdot \sqrt{\eta} + \Delta s, \qquad (2.4.4.3.1)$$

where: $\alpha = 0{,}12L - 1{,}1$, but not greater than 6,5 for transversely framed double bottom;

$\alpha = 0{,}023L + 5{,}8$ for longitudinally framed double bottom;

$k = k_1 \cdot k_2$;

k_1, k_2 – coefficients given in Tables 2.4.4.3-1 and 2.4.4.3-2 respectively;

a – spacing, in m, of stiffeners, but not greater than the actual depth of double bottom;

for η – refer to **1.1.4.3**;

for Δs – refer to **1.1.5.1**;

Table 2.4.4.3-1 **Coefficient k_1**

Framing system	a_ϕ/a				
	1	2	3	4	5
Transverse	1	1,15	1,20	1,25	1,30
Longitudinal	-	1,25	1,45	1,65	1,85
Symbols: a_f – distance, in m, between plate floors; a – spacing, in m.					

Table 2.4.4.3-2 **Coefficient k_2**

Framing system	Кількість стрингерів на один борт			
	0	1	2	3 і більше
Transverse	1	0,97	0,63	0,88
Longitudinal	1	0,93	0,86	0,80

.2 the floors shall be stiffened in accordance with **1.7.3.2**.

Between the fore peak bulkhead and 0,25L from the forward perpendicular, in the engine room and peaks, and in the holds of ships which may happen to be aground due to ebb-tide or from which cargo is regularly discharged by grabs, the thickness of plate floors smin, in mm, shall not be less than:

for transverse framing system

$$s_{min} = 0{,}035L + 5\text{mm}; \qquad (2.4.4.3.2\text{-}1)$$

for longitudinal framing system

$$s_{min} = 0{,}035L + 6\text{mm}; \qquad (2.4.4.3.2\text{-}2)$$

.3 the thickness of watertight floors shall not be less than determined by Formula (1.6.4.4) taking:

p – as determined by Formulae (1.3.4.2.1-4) and (1.3.4.2.1-5) for the middepth of the floor, whichever is the greater in the absence of a safety valve:

$p_v = 0$);

$m = 15{,}8$;

$k_\sigma = 0{,}85$.

In any case, the thickness of watertight floors shall not be less than that required for plate floors in this region.

2.4.4.4 Inner bottom plating and margin plate shall satisfy the following requirements:

.1 the thickness of inner bottom plating, including margin plate, shall not be less than determined by Formula (1.6.4.4) taking:

$m = 22{,}4$;

p – maximum design pressure as stipulated under **2.4.3.2**;

$k_\sigma = 0{,}6k_b \le 0{,}8$ in the midship region for $L \ge 65$ m and transverse framing system;

$k_\sigma = 0{,}8$ in the midship region for $L = 12$ m and transverse framing system.

For $12 < L < 65$m k_σ, is determined by linear interpolation taking $k_\sigma = 0{,}7$ for $L = 65$m,

$k_\sigma = 0{,}8$ in the midship region for longitudinal framing system;

$k_\sigma = 0{,}9$ at the ends of the ship within 0,1L from the fore or after perpendicular.

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

k_b shall be determined by Formula (2.2.4.1);

.2 in any case, the thickness of inner bottom plating s_{min}, in mm, shall not be less than:

$$s_{min} = (0{,}05L + 3{,}8)\sqrt{\eta}, \quad \text{for } L < 80\text{m}, \qquad (2.4.4.4.2\text{-}1)$$

$$s_{min} = (0{,}035L + 5)\sqrt{\eta}, \quad \text{for } L \ge 80\text{m}, \qquad (2.4.4.4.2\text{-}2)$$

where: η – as stated in Table 1.1.4.3.

For $L > 260$m, L shall be taken equal to 260 m.

Where the adopted spacing is less than the standard one (refer to **1.1.3**) for ships of unrestricted service and restricted area of navigation **R1** and **A-R1**, the minimum thickness of inner-bottom plating may be reduced in proportion to the ratio of adopted spacing to the standard spacing, but not more than by 10 %. In any case, the minimum thickness shall not be less than 5,5 mm.

The thickness of inner bottom plating in holds into which water ballast may be taken, as well as in the cargo (ballast) tanks of tankers shall not be less than stipulated under **3.5.4**.

In the engine room and holds under cargo hatches where no wood sheathing is provided, s_{min} shall be increased by 2 mm.

In holds where no wood sheathing is provided and cargo is discharged by grabs, s_{min} shall be increased by 4 mm.

.3 in the midship region of ships of 65 m and greater in length, the buckling strength of inner bottom plating and margin plate shall be ensured in accordance with **1.6.5**.

2.4.4.5 Primary members of bottom and inner bottom shall satisfy the following requirements:

.1 the section modulus of bottom and inner bottom longitudinals, as well as of the bottom and reverse frames of bracket floors and duct keel shall not be less than stipulated under **1.6.4.1** taking:

p – design pressure, in kPa, determined for bottom longitudinals and the bottom frames of bracket floors and duct keel in accordance with **2.4.3.1**, and for inner bottom longitudinals and the reverse frames of bracket floors and duct keel, in accordance with **2.4.3.2**;

$m = 12$;

l – = = design span, in m, of longitudinal, defined as the spacing of floors for bottom and inner bottom longitudinals, as the distance betwen bracket toes or between a bracket toe and side girder for the bottom and reverse frames of bracket floors, as the spacing of webs for duct keel;

for bottom longitudinal:

$k_\sigma = 0{,}45k_b \le 0{,}65$ in the midship region;

$k_\sigma = 0{,}65$ at the ends of the ship within 0,1L from the fore or after perpendicular.

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

for inner bottom longitudinals:

$k_\sigma = 0{,}6k_b \le 0{,}75$ in the midship region;

$k_\sigma = 0{,}75$ at the ends of the ship within 0,1L from the fore or after perpendicular.

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

for bottom frames of bracket floors and duct keel:

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

for reverse frames of bracket floors and duct keel:

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

k_b shall be determined by Formula (2.2.4.1);

.2 if intermediate struts are fitted at midspan between bottom and inner bottom longitudinals, the section modulus of such longitudinals may be reduced by 35%;

.3 if the ratio of the span of a bottom or inner bottom longitudinal to its depth is less than 10, the sectional area of the longitudinal web shall not be less than determined by Formula (1.6.4.3-1) taking $N_{max} = 0{,}5pal$ (*p*, *l* – design pressure and design span of longitudinal as stipulated under **2.4.4.5.1**), $k_\tau = k_\sigma$, where k_σ is as determined from **2.4.4.5.1** with $k_b = 1{,}25$;

.4 in the midship region of ships of 65 m in length and above, the buckling strength of bottom and inner bottom longitudinals shall be ensured in accordance with **1.6.5**;

.5 at the centre of openings in lightened side girders and floors, the section modulus of the plate adjoining the shell plating or inner bottom plating shall comply with the requirements of **2.4.4.5.1** for bottom and inner bottom longitudinals and transverses respectively. In this case, the design span l shall be taken equal to the greatest opening length minus its rounding-off radius. The plate section shall include the effective flange of shell plating (inner bottom plating), as described under **1.6.3.2** and **1.6.3.3**, as well as the flange or horizontal stiffener of the free edge of the plate, if these are fitted.

2.4.4.6 The stiffeners on the watertight sections of centre girder (duct keel), side girders and floors shall satisfy the following requirements:

.1 the section modulus of vertical stiffeners on the watertight sections of centre girder (duct keel), side girders and floors shall not be less than stipulated under **1.6.4.1** taking:

p – =as determined by Formula (1.3.4.2.1-5) for mid-height of vertical stiffener;
l – span, in m, of stiffener, defined as the spacing of longitudinals to which the stiffener is welded or as double bottom depth if the stiffener is not in line with bottom or inner bottom longitudinals;
m = 8 and 10 – for stiffeners sniped at ends and welded to the bottom and inner bottom longitudinals respectively;
$k_\sigma = 0{,}75$;
.2 the section modulus of horizontal stiffeners on the centre girder (duct keel) and side girders shall not be less than stipulated under **1.6.4.1** taking:

p – = as determined by Formula (1.3.4.2.1-5) for the level of the horizontal stiffener considered;
l – = distance, in m, between floors or between floors and brackets (refer to **2.4.2.2**);
m = 12;
$k_\sigma = 0{,}5k_b \le 0{,}75$ in the midship region;
$k_\sigma = 0{,}75$ at the ends of the ship within 0,1*L* from the fore or after perpendicular.
For regions between the midship region and the above portions of ship's ends, k_σ shall be determined by linear interpolation;
k_b shall be determined by Formula (2.2.4.1);
.3 in the midship region of ships of unrestricted service **A**, and of restricted areas of navigation **R1**, **A-R1** and **R2**, **A-R2** 65 m and greater in length, as well as of ships of restricted areas of navigation **R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, **R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** 60 m and greater in length, the buckling strength of horizontal stiffeners on the centre girder (duct keel) and side girders shall be ensured in accordance with **1.6.5**.
2.4.4.7 The intermediate struts between bottom and inner bottom longitudinals, as well as between bottom and reverse frames of bracket floors shall satisfy the following requirements:

.1 the sectional are *f*, cm^2, of intermediate struts shall not be less than

$$f = [5pal/(k_\sigma \sigma_n)] + 0{,}1h\Delta s, \qquad (2.4.4.7.1)$$

where *p* – design pressure, in kPa, defined as the greater of the values of *p* or p_c according to **2.4.3.1** or **2.4.3.2**, whichever is the greater;
l – design span, in m, of stiffened longitudinals;
$k_\sigma = 0{,}5$;
h – height, in cm, of the strut cross section;
for Δs – refer to **1.1.5.1**;
.2 the inertia moment *i*, in cm^4, of intermediate struts shall not be less than:

$$i = 0{,}01 f l^2 \sigma_n, \qquad (2.4.4.7.2)$$

where *f* – sectional area of intermediate struts as given in **2.4.4.7.1**;
l – length, in m, of intermediate strut.

2.4.4.8 The thickness of brackets of centre girder (duct keel) and margin plate, as well as of the brackets of bracket floors and the brackets connecting bottom and inner bottom longitudinals to watertight floors, if the longitudinals are cut at the floors, shall not be less than the thickness of plate floors adopted in this region.
In way of centre girder and margin plate, the thickness of brackets fitted in line with the bracket floor shall not be less than 0,75 of the centre girder depth. The free edges of brackets shall be provided with flanges or face plates. The side girder fitted in line with the bracket floor shall be provided with a vertical stiffener whose profile shall be selected in the same way as that of the reverse frame of the floor.
The arm length of brackets connecting longitudinals on the bottom and inner bottom plating to watertight floors shall not be less than 2,5 times the bottom longitudinal depth (refer to Fig. 2.4.4.8).
The scantlings of knees by which bottom and reverse frames of the duct keel are secured shall be determined in accordance with **1.7.2.2**.

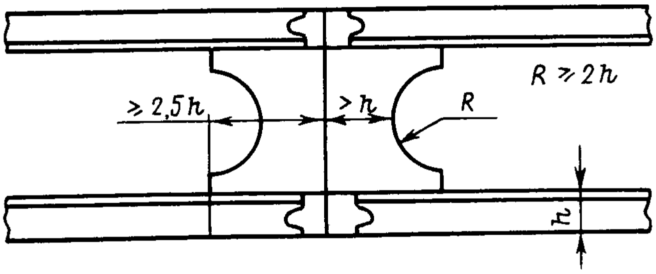


Fig.2.4.4.8

2.4.4.9 Structural members inside the double bottom shall have a thickness s_{min}, in mm, not less than:

s_{min} = 0,045L + 3,9 mm for L<80 m, (2.4.4.9-1)

s_{min} =0,025L + 5,5 mm for $L \geq 80$ m. (2.4.4.9-2)

Where L > 250 m, L shall be taken equal to 250 m.

For centre girder, s_{min} shall be increased by 1,5 mm.

2.4.4.10 In way of holds designed for the carriage of heavy cargoes, the strength of double bottom structure shall be verified by the calculation of the bottom grillage strength using design loads stated in **2.4.3**, as required by **3.3.4.1.1**.

2.4.5 5 Special requirements.

2.4.5.1 Partial double bottom and stiffening in way of variable double bottom depth shall satisfy the following requirements:

.1 where the double bottom terminates, gradual transition from longitudinal members of double bottom to those beyond it shall be ensured.

The inner bottom plating shall be gradually tapered (on a length of at least three frame spaces) into the face plates of centre girder and side girders of single bottom. In way of the double bottom boundary, the width of these face plates shall be not less than half the distance between adjacent side girders.

The margin plate shall extend beyond the double bottom as a bracket with the height equal to the margin plate width and the length equal to at least three frame spaces, with a face plate or flange along its free edge;

.2 where the double bottom depth changes in the form of a knuckle, one end of the knuckle shall be in way of a transverse bulkhead and the other, on the fplate floor. However, both the knuckles may be arranged on plate floors; in this case the strength of the structure shall be verified by calculation;

.3 where the double bottom depth changes in the form of a step, the latter shall normally be arranged on a transverse bulkhead.

At the step, the inner bottom plating of the lower section should extend for a length of three frame spaces when $L \geq$ 80 m and for two frame spaces when L < 80 m. Forward (or aft) of the end of the extension the general requirements for partial double bottom shall be complied with.

If the step is arranged beyond 0,5L amidships or, if the height of the step is less than 660 mm, the extension may be reduced;

.4 continuity and reduction of stress concentrations shall be ensured in way of the step where a variation of the depth of centre girder, side girders, margin plate and inner bottom longitudinals takes place (if longitudinal system of framing is adopted).

2.4.5.2 Bilge wells, sea chests and ice boxes shall satisfy the following requirements:

.1 in cargo ships, the bilge wells shall, as far as practicable, satisfy the requirements of **1.1.6.5.3** or **1.1.6.6.3**.

The capacity of bilge wells is specified in Part VIII "Systems and Piping".

The thickness of the walls and bottom plates of a bilge well shall exceed that of watertight floors by not less than 2 mm;

.2 the thickness of the floors, side girders and inner bottom plating forming the walls of sea chests shall be 2 mm greater than that required by **2.4.4.2** ÷ **2.4.4.4**.

In any case, the thickness of sea chest and ice box walls shall be not less than that required by **2.2.4.1** for the shell plating in the region under consideration.

2.4.5.3 When oil fuel tanks are arranged in the double bottom, the manholes in the tank tops arranged within the engine and boiler rooms for access to the tanks shall be provided with coamings not less than 0,1 m in height, besides the general provisions for the arrangement of fuel oil tanks.

2.4.5.4 Where the bed plate of main engine and the thrust block are seated directly on the inner bottom plating, insert plates having a thickness not less than stipulated under **2.11.3.1** shall be welded to the plating under the supporting parts of bed plate and thrust block. The size of welded inserts shall be such as to ensure an adequate arrangement of supports and the attachment of machinery, and shall in any case be not less than that of the supporting parts of bed plate. Where the engine bed plate and thrust block are fitted on the inner bottom plating, two girders, or one girder and a half-height girder shall be provided in way of their arrangement along each welded insert plate. The upper part of the girder webs shall have the same thickness as the welded insert for at least 0,2 of the girder depth, or alternatively, the thickness of the webs throughout their depth shall be as required by **2.11.3** for the vertical plates of seatings.

Between the girders, a horizontal stiffener of the size required in the foregoing for the upper part of girder webs shall be fitted, account being taken of the holes for the holddown bolts of the bed plate.

Only one side girder may be fitted under the welded insert plate for small power engines.

2.4.5.5 5 The plating of the recess under the engine crankcase, as well as the side girders and floors by which it is confined, shall have a thickness 2 mm greater than that of the inner bottom plating in this region.

The minimum distance from the recess plating to the bottom shell plating shall not be less than 460 mm.

2.5 SIDE FRAMING

2.5.1 General and definitions.

2.5.1.1 Requirements are given in this Chapter for side frames, web frames (side transverses), side longitudinals, side stringers, cross ties connecting side transverses to vertical webs on longitudinal bulkheads in tankers, as well as for specific structures of double skin side.

2.5.1.2 By the double skin side construction, a side structure is meant which consists of watertight side shell plating and inner skin, both either strengthened with frames and longitudinals or not, and connected with plate structures perpendicular thereto: vertical (diaphragms) and/or horizontal (platforms). If no diaphragms or platforms are fitted, the inner skin together with framing shall be considered as longitudinal bulkhead and shall comply with the requirements of **2.7**.

2.5.2 Construction.

2.5.2.1 When the ship's side is framed transversely, side stringers may be provided. In tankers with two or more longitudinal bulkheads, fitting of cross ties is recommended between the side stringers and horizontal girders of longitudinal bulkheads.

Web frames may be fitted if the ship's side is framed transversely, and they shall be fitted, if the ship's side is framed longitudinally.

They shall be fitted in line with plate floors, as well as with deep beams, if any.

In tankers with two or more longitudinal bulkheads, fitting of cross ties is recommended between side transverses and vertical webs of longitudinal bulkhead.

2.5.2.2 Structures of double skin side shall satisfy the following requirements:

.1 if the same framing system is adopted for side shell and inner skin, fitting of frames or longitudinals of both side shell and inner skin in line with each other is recommended. In this case, cross ties may be fitted between the frames or longitudinals of the side shell and inner skin, which shall be arranged at midspan of relevant members ;

.2 diaphragms or platforms shall be stiffened in accordance with 1**.7.3.2**. In this case, the shorter side, in mm, of panel of the diaphragm or platform being stiffened shall not exceed $100s\sqrt{\eta}$, where s is the thickness, in mm, of the diaphragm or platform;

For η – refer to **1.1.4.3**;

.3 an appropriate number of openings (manholes) shall be provided in the diaphragms and platforms for access to all the structures of double skin side.

The total breadth of openings in a diaphragm or platform section shall not exceed 0,6 of the double skin side breadth. The edges of openings in diaphragms and platforms, arranged within 1/4 of the span from their supports, shall be reinforced with collars or stiffeners.

The distance between the edges of adjacent openings shall not be less than the length of the openings.

Normally, openings are not permitted, with the exception of air and drain holes:

in platforms on a length not less than three frame spaces or 1,5 times the double skin side breadth, whichever is less, from transverse bulkheads or partial bulkheads, which serve as platform supports;

in diaphragms on a length not less than 1,5 times the double skin side breadth from deck plating and/or double bottom, which serve as diaphragm supports.

2.5.2.3 In the engine room, the side framing shall be strengthened by fitting of web frames and side stringers.

The web frames shall be fitted not more than 5 standard spacings or 3 m apart, whichever is the greater.

The web frames shall be arranged taking into account the location of main engine, i.e. they shall be fitted at the extremities of the engine at least. In the engine room, the web frames shall be carried to the nearest continuous platform.

Deep beams shall be fitted in line with web frames.

In the engine room, the side stringers shall be fitted so that the vertical distance between them, as well as between a side stringer and deck or tank top (upper edge of floor) at side does not exceed 2,5 m.

2.5.3 Side loads.

2.5.3.1 The design pressure on the side shell shall be determined in accordance with **2.2.3**.

In way of tanks, the pressure determined in accordance with **1.3.4.2** shall additionally be taken into consideration**.**

2.5.3.2 The design pressure on double skin side structures shall be determined as follows:

.1 the design pressure on the inner skin and framing shall be determined in accordance with **1.3.4.2** or **1.3.4.3** depending on the kind of cargo carried and on whether the double side space is used as tank space, but shall not be less than the design pressure on watertight bulkhead structures, as stipulated under **2.7.3.1**;

.2 the scantlings of cross sections of diaphragms and platforms are determined using the design pressure specified in**2.2.3**;

.3 the design pressure on the watertight sections of diaphragms and platforms bounding the tanks in the double side space shall be determined in accordance with **1.3.4.2.**

2.5.4 Member scantlings of side structures.

2.5.4.1 If transverse system of framing is adopted, the section modulus of hold frames in dry cargo ships and of side frames in tankers shall not be less than determined from **1.6.4.1** and **1.6.4.2**. taking:

p – = as defined in **2.5.3**; the value of p for the side shell shall not be less than

$$p_{\min} = 10z + 0{,}3L + 1, \quad \text{for } L < 60 \text{ m}; \qquad (2.5.4.1\text{-}1)$$

$$p_{\min} = 10z + 0{,}15L + 10, \quad \text{for } L \geq 60 \text{ m}; \qquad (2.5.4.1\text{-}1)$$

where: z – = distance, in m, from the mid-span of the frame to the summer load waterline;

l – in m, between adjacent supports, as measured in accordance with **1.6.3.1**; unless expressly provided otherwise, the supports of a frame are bottom, deck or platform, side stringers;

m = 12 for single skin side construction when determining the section modulus of the supporting section of the frame taking into consideration the bracket, if any, included in the section, as well as for frames of the side shell and inner skin forming double skin side construction;

m = 18 for single skin side construction when determining the section modulus in the frame span;

k_σ = 0,65 for frames of the side shell;

k_σ = 0,75 for frames of the inner skin.

For ships of restricted service $p_{\min}$ may be reduced by multiplying by a factor φ_r, determined in accordance with Table 1.3.1.5.

2.5.4.2 The section modulus of tween deck frames shall not be less than determined according to **1.6.4.1** taking:

p – as defined in **2.5.3;**

l – average spacing of web frames or diaphragms, in m determined in accordance with **1.6.3.1**; supporting section of the frame are decks and platforms;

m = 10 for single skin side construction;

m = 12 for frames of the side shell and inner skin within the double-side construction;

k_σ = 0,65 for frames of the side shell;

k_σ = 0,75 for frames of the inner skin.

The above applies in case the lower end of 'tween deck frame is not stiffened by a bracket. If the lower end of the frame is stiffened by a bracket of a height not less than 0,1l and the section modulus of the frame in way of deck is not less than 1,75 of the section modulus determined above, taking the bracket into consideration, the section modulus of 'tween deck frame may be reduced by 30 %.

2.5.4.3 The section modulus of side longitudinals of all ships shall not be less than determined according to **1.6.4.1** taking:

p – as defined in **2.5.3;**

a – spacing of longitudinals, in m;

l – = average spacing of web frames or diaphragms, in m;

m = 12;

for side shell:

k_σ = 0,65 within (0,4 ÷ 0,5)D from the base line.

For regions below 0,4D from the base line, k_σ shall be determined by linear interpolation between k_σ for bottom longitudinals in accordance with **2.4.4.5.1** and k_σ within (0,4 ÷ 0,5)D from the base line.

For regions above 0,5D from the base line k_σ shall be determined by linear interpolation between k_σ s for strength deck longitudinals in accordance with **2.6.4.2** and k_σ within (0,4 ÷ 0,5)D from the base line.

For the inner skin, k_σ shall be determined as in the case of horizontal stiffeners of longitudinal bulkheads in tankers in accordance with **2.7.4.2**.

The buckling strength of three upper and three lower longitudinals in the midship region of ships 65 m and greater in length shall be ensured in accordance with **1.6.5**.

2.5.4.4 In a transversely framed side, the section modulus of side stringers shall not be less than stipulated under **1.6.4.1** taking:

k_σ = 0,65 is determined in the same way as for side shell longitudinals mentioned under **2.5.4.3**;

p – as defined in **2.5.3.1**;

l – spacing, in m, of web frames and where these are not fitted, between transverse bulkheads, including end brackets;

a – = spacing, in m, of side stringers;

m = 18 without cross ties;

m = 27,5 with cross ties.

The cross-sectional area, in cm^2 , of a side stringer web shall not be less than determined according to **1.6.4.3** taking:

$N_{max} = npal$;

n = 0,5 without cross ties;

n = 0,4 with one cross tie;

n = 0,375 with two cross ties;

n = 0,35 with three cross ties;

k_τ = 0,65.

If web frames are fitted, the scantlings of side stringer section may be determined on the basis of the calculation of the side grillage using beam models.

The design loads shall be determined in accordance with **2.5.3.1**, permissible stress factors shall be selected in accordance with this paragraph.

Where cross ties are fitted, the calculation shall consider the interaction between side grillage and grillage of the longitudinal bulkhead being connected with the cross ties.

2.5.4.5 The section modulus of web frames (side transverses) fitted in the holds and 'tween decks of dry cargo ships, as well as in the tanks of tankers, shall not be less than stipulated under **1.6.4.1** and **1.6.4.2** taking:

p – as defined in **2.5.3.1**;

l – = distance, in m, from the upper edge of a single bottom floor or from inner bottom plating to the lower edge of a deep beam;

a – spacing of web frames, in m;

m = 10 for 'tween deck frames;

m = 11 for holds and tanks without cross ties;

m = 18 with one or two cross ties;

m = 27,5 with three cross ties;

k_σ = 0,65.

The cross-sectional area, in cm^2 , of a side transverse (web frame) web, excluding openings, shall not be less than stipulated under **1.6.4.3** taking:

$N_{max} = npal$;

n = 0,5 without cross ties;

n = 0,375 with one cross tie;

n = 0,35 with two or more cross ties;

k_τ = 0,65.

When the side is transversely framed, the scantlings of web frames may be determined on the basis of the side grillage calculation in accordance with the requirements of **2.5.4.4**.

In this case, the permissible stress factors shall be selected in accordance with the requirements of this paragraph.

In single-deck ships, the depth of web frame (side transverse) webs may be taken variable over the ship's depth with reducing at the top end and increasing at the bottom end. Variation of web depth shall not exceed 10 % of its mean value.

For stiffening of web frames (side transverses), refer to **1.7.3**.

2.5.4.6 The sectional area f, in cm^2, of a cross tie fitted between deep members of side framing and of longitudinal bulkhead shall not be less than

$$f = (10kpaa_i/\sigma_{cr}) + 0{,}05\sum h_i\Delta s, \qquad (2.5.4.6)$$

where: p – design pressure, in kPa, at mid-length of a cross tie, as determined from **2.2.3** or **2.7.3.2**, whichever is the greater;

a – spacing of web frames connected with cross ties, in m;

a_i – mean depth, in m, of side area supported by a cross tie;

$\sum h_i$ – perimeter of cross section, in cm, of a cross tie;

k = 2,5 – buckling strength margin;

σ_{cr} – critical stresses in accordance with **1.6.5.3** corresponding to the Euler stresses, in MPa, as determined by the formula:

$\sigma_e = 206i/(fl^2)$,

where: i – minimum moment of inertia, in cm^4 , of a cross tie;

l – cross tie length, in m, as measured between the inner edges of deep members of side framing and of longitudinal bulkhead;

f – as determined by Formula (2.5.4.6).

2.5.4.7 The side framing of the engine room and tanks shall satisfy the following requirements:

.1 scantlings of main frames in the engine room shall be determined in accordance with **2.5.4.1** taking

l – = span measured between side stringers or between the lower side stringer and inner bottom plating (upper edge of floor), or between the upper side stringer and the lower edge of beam.

The scantlings of longitudinals shall be determined in accordance with **2.5.4.3**.

The scantlings of web frames (side transverses) shall be determined in accordance with **2.5.4.5** taking:

l – = span measured between inner bottom plating (upper edge of floor) and the lower edge of deep beam;

.2 in the engine room of ships less than 30 m in length, the web frames and side stringers required by **2.5.2.3** may be omitted on condition that the main frame has a section modulus W, in cm^3 , not less than:

$$W = 1{,}8\ W_1, \qquad (2.5.4.7.2)$$

where: W_1 – section modulus of main frame, as stipulated under **2.5.4.7.1**;

.3 in way of the ballast and fuel oil tanks of dry cargo ships 30 m and greater in length, the scantlings of side framing shall satisfy the requirements of **2.5.4.1**, **2.5.4.3**, **2.5.4.5** for side framing in way of tanks in tankers.

If transverse system of framing is adopted, the section modulus of side stringers shall not be less than determined according **to 1.6.4.1** and **1.6.4.**2 taking:

m = 10;

k_σ = 0,65.

In all other respects, the requirements of **2.5.4.4** shall be complied with;

.4 in the engine room, the web frames shall have a depth not less than 0,1 of the span, and a web thickness not less than 0,01 of the web depth plus 3,5 mm;

.5 in the engine room, the web depth of a side stringer shall be equal to that of a web frame.

The web thickness of a side stringer may be 1 mm less than that of a web frame.

The side stringer face plate thickness shall be equal to the face plate thickness of a web frame.

2.5.4.8 The diaphragms and platforms of the double skin side shall satisfy the following requirements:

.1 the section moduli and cross-sectional areas of diaphragms and platforms shall satisfy the requirements for the section moduli and cross-sectional areas of side stringer webs, as specified in **2.5.4.4**, and of web frames, as specified in **2.5.4.5**, using the design pressure determined in accordance with **2.5.3.2.2**.

In any case, the thickness, in mm, of diaphragm and platform shall not be less than

$$s_{min} = 0{,}018L + 6{,}2; \qquad (2.5.4.8.1)$$

.2 the stiffeners of diaphragms and platforms shall satisfy the requirements of **1.7.3.2.2**;

.3 the platforms in the midship region and their continuous longitudinal stiffeners, if any, shall comply with the requirements for the buckling strength of longitudinal framing members, as specified in **1.6.5.2**, within 0,25*D* above the base line and 0,25*D* below the strength deck;

.4 the thickness of watertight sections of diaphragms and platforms shall not be less than that determined by Formula (**1.6.4.4**) taking:

p – as defined in **2.5.3.2.3**;
m = 15,8;
k_σ = 0,65;

.5 the section modulus of stiffeners of the watertight sections of diaphragms and platforms shall not be less than determined from **1.6.4.1** taking:

p – as defined in **2.5.3.2.3**;
l – = span of stiffener, in m, equal to: the diaphragm spacing, for stiffeners parallel to the shell plating; the distance between the inner edges of primary members of side shell and inner skin if the stiffener is welded thereto, for stiffeners perpendicular to the shell plating; the double skin side breadth if the stiffener ends are sniped;
m = 12 for continuous stiffeners parallel to the side plating;
m = 10 for stiffeners perpendicular to the side plating and welded to primary framing members;
m = 8 elsewhere;
k_σ = 0,75.

2.5.4.9 If there are large openings (exceeding 0,7 times the ship's breadth in width) in the deck, stiffening of the diaphragms and frames of the side shell and inner skin may be required in connection with the upper deck pliability, which shall be determined by calculation (refer also to **3.1.4**).

2.5.4.10 The thickness of inner skin shall comply with the requirements for the thickness of longitudinal bulkhead plating in tankers, as specified in **2.7.4.1**, using the design pressure determined in accordance with **2.5.3.2.1**. In any case, this thickness shall not be less than determined by Formula (2.7.4.1-1).

2.5.4.11 The cross ties between frames and longitudinals of side shell and inner skin, as mentioned under **2.5.2.2.1**, shall comply with the requirements for the intermediate struts of double bottom, as mentioned in **2.4.4.7** using the design pressure determined from **2.5.3.1** or **2.5.3.2.1**, whichever is the greater.

If cross ties are fitted, the section modulus of frames complying with **2.5.4.1** and **2.5.4.2**, as well as of longitudinals complying with **2.5.4.3**, may be reduced by 35 %.

2.5.4.12 In the cargo and ballast tanks of tankers, in holds into which water ballast can be taken and in tanks, the thickness of structural members of side framing shall not be less than that required by **3.5.4**.

2.5.5 Special requirements.

2.5.5.1 If transverse system of framing is adopted, efficient connection of lower ends of frames to bottom structures shall be ensured by means of bilge brackets or other structures of equivalent strength.

The bilge brackets shall comply with the following requirements:

.1 the depth of bilge brackets shall not be less than that of the bilge as a whole. The free edge of a bilge bracket shall be flanged or stiffened with a face plate the dimensions of which shall be in compliance with **1.7.2.2.2**.

The thickness of a bilge bracket is taken equal to that of plate floors in the hull region under consideration, but it need not exceed the frame web thickness more than 1,5 times.

Holes cut in bilge brackets shall be such that the width of plating outside the hole is nowhere less than 1/3 of the bracket width.

In any case, the size of bilge brackets shall not be less than that required by **1.7.2.2**;

.2 the end attachments of a frame to bilge bracket shall be designed so that at no section the section modulus is less than required for a frame;

.3 where an inclined margin plate is fitted in the double bottom, the bilge bracket shall be carried to the inner bottom plating, and its face plate (flange) shall be welded to the plating;

.4 where a horizontal margin plate is fitted in the double bottom or transverse system of framing is adopted in the single bottom, the width of bilge brackets shall be determined proceeding from the condition that their section moduli at the point of connection to the inner bottom plating or upper edge of floor shall be at least twice those of the frame.

The face plate (flange) of a bilge bracket may be welded to either the inner bottom plating or the face plate (flange) of a floor, or it may be sniped at ends. If the face plate (flange) is welded, the floor web shall be stiffened with a vertical stiffener or a bracket at the point of welding, also welded to the inner bottom plating or to the floor face plate (flange).

The depth of a bilge bracket shall not be less than its width;

.5 if longitudinal system of framing is adopted in the single bottom, the bilge bracket shall be carried at least to the bottom longitudinal nearest to the side and shall be welded thereto. The section modulus of the bracket at the section perpendicular to the shell plating where the bracket width is the greatest shall be at least twice the section modulus of the frame.

2.5.5.2 In all the spaces, the upper ends of frames shall be carried to the decks (platforms) with minimum gaps if they are cut at the decks (platforms). The beams of transversely framed decks (platforms) shall be carried to the inner edges of frames with minimum gaps.

The uppermost decks of ships (except for those secured alongside other ships at sea) may be designed with beams carried to the shell plating with minimum gaps, and frames carried to the beams.

The brackets by which the upper ends of frames are attached shall be sized in accordance with the requirements of гам **1.7.2.2**.

If the deck is framed longitudinally, the bracket shall be carried at least to the deck longitudinal nearest to the deck and welded to that longitudinal.

2.5.5.3 If the frame is cut at deck, its lower end shall be attached by a bracket complying with the requirements of **1.7.2.2**.

The bracket may be omitted if the ends of this frame are welded to the deck plating from above and below, and full penetration is ensured.

2.5.5.4 Side stringers shall be attached to web frames by brackets carried to the web frame face plate and welded thereto.

2.5.5.5 If cross ties are fitted in the wing tanks of tankers, the side transverse and side stringer webs in way of the cross tie attachments shall be provided with stiffeners which shall be an extension of the cross tie face plates. Cross tie attachments to side transverse (side stringer) shall comply with the requirements of **1.7.2.3**.

2.5.5.6 Double-side attachment to double-bottom shall comply with **2.4.2.8**.

2.6 DECKS AND PLATFORMS

2.6.1 General.

Requirements are given in this Chapter for the deck and platform structures of ships where the width of opening for a single cargo hatch does not exceed 0,7 times the ship's breadth abreast of the opening. Additional requirements for the decks and platforms of ships having greater width of openings and their length exceeding 0,7 times the spacing of centres of transverse deck strips between the openings, as well as for the decks and platforms of ships with twin or triple hatch openings, are specified in **3.1**.

Requirements for cantilever beams shall also be found there.

For decks and platforms of ro-ro ships, refer to **3.2**.

Requirements for the cargo hatch coamings of bulk carriers are given in **3.3**.

Requirements of this Chapter cover plating and framing members of decks and platforms: deck longitudinals, beams, deck transverses, deck girders, hatch end beams, hatch side coamings and hatch end coamings, wash plate in the tanks of tankers.

Additional requirements for the areas of upper deck situated below the superstructures are given in **2.12.5.1** ÷ **2.12.5.3**.

2.6.2 Construction..

2.6.2.1 In tankers of 80 m and above, bulk carriers and ore carriers, as well as in oil/dry bulk cargo carriers, and ore/oil carriers, longitudinal system of framing shall be adopted for the strength deck in way of cargo holds (tanks).

Where longitudinal system of framing is adopted, the spacing of deck transverses shall not exceed that of bottom transverses.

2.6.2.2 Provision shall be made for the structural continuity of deck girders of the strength deck in the midship region. If the deck girders are cut at transverse bulkheads, their web plates shall be welded to the transverse bulkheads and attached thereto by brackets.

The web plates of hatch end coamings, deck transverses, hatch end beams and wash plates shall be strengthened by stiffeners and brackets (refer to **1.7.3**).

The face plates of deck girders shall be connected to the face plates of hatch end beams by means of diamond plates (refer to **1.7.4.5**) whose thickness shall be equal to the greater face plate thickness.

2.6.2.3 On the strength deck, the ends of side coamings at the corners of hatchways shall be either bent along the line of hatch corner rounding and buttwelded to the hatch end coaming or extended, in the form of a bracket, beyond the corner of the hatchway. Provision shall be made for a gradual termination of the bracket above the deck girder web.

The upper edges of coamings acting as deck girders shall be stiffened with face plates and the lower edges of the coamings shall be rounded.

The upper edge of hatch side coaming shall be smooth and their corners shall be well rounded in the transverse direction.

2.6.2.4 The deck girders and deck transverses in way of pillars shall be strengthened by stiffeners or tripping brackets.

Where deck girders are connected to deck transverses and their web height is different, the deck girder web shall be strengthened by brackets fitted in line with the deck transverse. The brackets shall be welded to the face plate of deck transverse, to the web and face plate of deck girder.

Where deck girders are attached to conventional beams, the web of deck girder shall be strengthened by vertical stiffeners.

2.6.2.5 In the case of connection of deck longitudinals to transverse bulkheads, the effective sectional area of the longitudinals shall be maintained.

2.6.2.6 In tankers with two effective longitudinal bulkheads, provision shall be made for a wash plate at the centreline.

2.6.3 Deck loads.

2.6.3.1 The design pressure on the weather deck shall not be less than

$$p = 0{,}7p_W \geq p_{min}, \qquad (2.6.3.1)$$

where: p_W – wave load at the deck level, as defined in **1.3.2.2**;

p_{min} = 0,1L + 7 at the fore end within 0,2L from the forward perpendicular;

p_{min} = 0,015L + 7 in the midship region and aft of the midship region;
for regions between the fore end and the midship region, p_{min} shall be determined by linear interpolation.

For ships of restricted area of navigation the value of p_{min} For ships of restricted area of navigation the value of φ_r, obtained from Table 1.3.1.5.

2.6.3.2 For weather decks intended to carry deck cargo (except timber and coke), the design pressure shall be taken equal to the cargo pressure p_c, determined by Formula (1.3.4.1).

For weather decks intended to carry timber and coke, the value of h in Formula (1.3.4.1) shall be taken equal to 0,7 times the stowage height of timber and coke on deck.

For lower decks and platforms, the design pressure shall be taken according to 1.3.4.1. For decks where cargo is suspended from beams or deck longitudinals, the design pressure value shall be suitably increased.

For decks and platforms intended for the crew, passengers and equipment, the design pressure shall be determined by Formula (1.3.4.1) while the product hp_cg shall not be less than 3,5 kPa.

For platforms in the engine room, the minimum design pressure shall be 18 kPa.

Watertight lower decks and platforms shall be additionally calculated using the test loads, in kPa, as follows:

$p = 7{,}5h_p$, (2.6.3.2)

where: h_p — vertical distance, in m, from deck (platform) plating to air pipe top.

2.6.3.3 The design pressure on the structures of decks and platforms forming boundaries of compartments intended for the carriage of liquids shall be determined in accordance with **1.3.4.2**.

2.6.4 Scantlings of deck members.

2.6.4.1 Thickness of deck plating.

2.6.4.1.1 The thickness of strength deck plating outside the line of hatch openings, taking deck longitudinals into account, shall be that necessary to give the hull section modulus for strength deck, as required by **1.4.6**.

The adopted thickness of strength deck plating within midship region shall be in accordance with the requirements for buckling strength (refer to **1.6.5**).

2.6.4.1.2 The plating thickness for decks and platforms shall not be less than determined by Formula (1.6.4.4) taking:

$m = 15{,}8$;
p – as defined in **2.6.3**;
for strength deck
$k_\sigma = 0{,}3k_d \le 0{,}6$ in the midship region for $L \ge 65$ m and transverse framing system;
k_d – as determined by Formula (2.2.4.1);
$k_\sigma = 0{,}6$ in the midship region for $L = 12$ m and the deck is transverse framing system.
Where $12 < L < 65$ m, k_σ shall be determined by linear interpolation taking $k_\sigma = 0{,}45$ for $L = 65$ m.
$k_\sigma = 0{,}6$ in the midship region for longitudinal framing system;
$k_\sigma = 0{,}7$ at the ends of the ship within $0{,}1L$ from the fore or after perpendicular.

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

for the second continuous deck situated above $0{,}75D$ from the base line:
$k_\sigma = 0{,}65k_d \le 0{,}8$ in the midship region for $L \ge 65$ m and transverse framing system;
k_d – as determined by Formula (2.2.4.1);
$k_\sigma = 0{,}8$ in the midship region for $L = 12$ m and the deck is transverse framing system.
Where $12 < L < 65$ m, k_σ shall be determined by linear interpolation taking $k_\sigma = 0{,}73$ for $L = 65$ m.
$k_\sigma = 0{,}8$ in the midship region for longitudinal framing system;
$k_\sigma = 0{,}9$ at the ends of the ship within $0{,}1L$ from the fore or after perpendicular.

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

for other lower decks and platforms, $k_\sigma = 0{,}9$.

2.6.4.1.3 If the engine room is located aft, the plating thickness and the scantlings of deck longitudinals, at the poop (aft deckhouse) front shall be maintained abaft the poop (deckhouse) front for a length of at least the width of machinery casing opening.

If the distance from the fore edge of casing opening to the poop (deckhouse) front is less than the width of the opening, additional strengthening of deck may be required in this region.

2.6.4.1.4 If the thickness of strength deck plating is taken less than the side plating thickness, a deck stringer plate shall be provided. The width b, in mm, of the strength deck stringer plate shall not be less than

$$b = 5L + 800 \le 1800, \qquad (2.6.4.1.4)$$

and the thickness of stringer plate shall not be less than that of side shell plating (sheerstrake).

2.6.4.1.5 The thickness s_{min} in mm, of deck plating and platforms shall not be less than:

for upper deck between the ship's side and line of large openings (tank decks of tankers) in the midship region

$$s_{min} = (0{,}05L + 4)\sqrt{\eta} \quad \text{for } L < 100 \text{ m}; \qquad (2.6.4.1.5\text{-}1)$$

$s_{min} = (0{,}02L + 7)\sqrt{\eta}$ for $L \geq 100$ m; (2.6.4.1.5-2)

for upper deck at the ends of the ship and inside the line of large openings, as well as for the second deck

$s_{min} = (0{,}04L + 4)\sqrt{\eta}$ for $L < 100$ m; (2.6.4.1.5-3)

$s_{min} = (0{,}01L + 7)\sqrt{\eta}$ for $L \geq 100$ m; (2.6.4.1.5-4)

for the third deck and other lower decks and platforms

$s_{min} = (0{,}01L + 5)\sqrt{\eta}$; (2.6.4.1.5-5)

where: η – as defined in **1.1.4.3**.

Where $L > 300$ m L shall be taken equal to 300 m.

Where the adopted spacing is less than the standard one (refer to 1.1.3) for ships of unrestricted service **A**, and restricted area of navigation **R1**, **A-R1**, the minimum deck plating and platform thickness may be reduced in proportion to the ratio of adopted spacing to the standard spacing, but not more than by 10 %.

In any case, the minimum thickness shall not be less than 5,5 mm.

In way of compartments intended for the carriage of liquids, the thickness of plating and deck structural members (including perforated members) shall not be less than required by **3.5.4** for tankers and not less than determined by Formula (2.7.4.1-2) for other ship types.

2.6.4.2 The section modulus of deck longitudinals shall not be less than determined according to **1.6.4.1** and **1.6.4.2** taking:

p = as defined in **2.6.3**;

$m = 12$;

for weather deck

$k_\sigma = 0{,}45k_d \leq 0{,}65$ in the midship region;

k_d – shall be determined by Formula (2.2.4.1);

$k_\sigma = 0{,}65$ at the ends of the ship within $0{,}1L$ from the fore or after perpendicular.

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

for other decks $k_\sigma = 0{,}75$.

2.6.4.3 When the decks are framed transversely, the scantlings of beams shall satisfy the following requirements:

.1 the section modulus of beams shall not be less than that determined from **1.6.4.1** taking:

p – as defined in **2.6.3**;

$m = 12$;

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

.2 the inertia moment i_b, in cm^4, of weather deck beams in the midship region of ships 65 m and greater in length shall be determined on the basis of a buckling strength calculation of deck grillage using beam models in accordance with **1.6.5**.

For beams having two or more intermediate rigid supports, the required inertia moment may be determined, alternatively to the grillage calculation, by the following formula:

$$i_б = 6{,}33 \cdot (s/a)^3 \cdot l^4 \cdot \varphi \cdot \chi \cdot 10^{-3}, \quad (2.6.4.3.2)$$

where: l – beam span, in m, between supports;

$\varphi = 1$ where $\sigma_c \leq 0{,}5R_{eH}$;

$\varphi = 4 \cdot \sigma_c \cdot (1 - \sigma_c/R_{eH})/R_{eH}$ where $\sigma_c > 0{,}5R_{eH}$;

$\chi = \lambda^2/(4 - 1{,}5\lambda^4)$;

$\lambda = 4 \cdot \sigma_c \cdot (a/s)^2/\varphi$, but not more than 1;

σ_c – = compressive stresses as determined according to **1.6.5.1**;

s – actual deck plating thickness, in mm.

2.6.4.4 The scantlings of deck framing members, such as deck transverses, deck girders, hatch coamings and hatch end beams, shall be determined on the basis of deck grillage calculation using beam models, except for cases mentioned under **2.6.4.5** ÷ **2.6.4.8**.

Design loads shall be chosen in accordance with **2.6.3**. Where pillars are fitted, the interaction between deck grillage and upper and/or lower structures shall be considered with regard for the arrangement of pillars.

Permissible stress factors shall be taken as follows

strength deck

for deck girders and hatch side coamings which are arranged in line with the deck girders,

$k_\sigma = 0{,}35k_d \le 0{,}65$ in the midship region for $L \ge 65$ m;

k_d – shall be determined by Formula (2.2.4.1);

$k_\sigma = 0{,}65$ in the midship region for $L = 12$ m.

Where $12 < L < 65$ m, k_σ shall be determined by linear interpolation taking $k_\sigma = 0{,}5$ for $L = 65$ m;

$k_\sigma = 0{,}65$ at the ends of the ship within $0{,}1L$ from the fore or after perpendicular.

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

for deck transverses and half beams, hatch coamings, which are not arranged in line with the deck girders and hatch end beams

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

for deep members, which are calculated using the shear stresses

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

for deep members of other decks and platforms

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

The deep members of weather deck in the midship region shall also comply with the requirements of **2.6.4.9**.

2.6.4.5 In tankers with two effective longitudinal bulkheads and with no deck girders, and where longitudinal system of framing is adopted, the scantlings of deck deep members in the centre tank shall comply with the following requirements:

.1 the section modulus of deck transverse shall not be less than determined according to **1.6.4.1** and **1.6.4.2**, the sectional area of deck transverse web, excluding openings, shall not be less than determined from **1.6.4.3** taking:

p – as defined in **2.6.3**;

k_σ and k_τ – as defined in **2.6.4.4**;

$l = B_1$, B_1 – breadth, in m, of centre tank;

$m = m_{b.t}$;

$N_{max} = 0{,}7n_{b.t}pal$;

$m_{b.t}$ and $n_{b.t}$ shall be determined from Table 2.3.4.2.2 depending upon the parameter m and the number of deck transverses within the tank:

$\mu = \alpha^{4/3}(L_1/B_1)^3$;

$\alpha = W_{b.t}/W_{w.p}$;

where: L_1 – tank length, in m;

$W_{b.t}$ – section modulus of deck transverse complying with the present requirements;

$W_{w.p}$ – = section modulus of wash plate complying with the present requirements.

The value of the parameter α is optional, but shall not be greater than 0,6; the value of the parameter m shall not exceed 1,5.

The deck transverse section modulus shall not be less than $\alpha W_{w.p}$;

.2 the section modulus of wash plate shall not be less than stipulated under **1.6.4.1** and **1.6.4.2**, the sectional area of wash plate web, excluding openings, shall not be less than stipulated under **1.6.4.3** taking:

p – as defined in **2.6.3**;

k_σ and k_τ – as determined for deck girders in accordance with **2.6.4.4**;

$l = L_1$, where L_1 – = tank length, in m;

a – = distance, in m, between the wash plate and longitudinal bulkhead;

$m = m_{c.g}$;

$N_{max} = 0{,}7 n_{c.g} pal$;

$m_{c.g}$ and $n_{c.g}$ shall be obtained from Table 2.3.4.2.2 depending upon the parameter μ and the number of deck transverses within the tank; μ shall be determined in accordance with **2.6.4.5.1**.

Besides, the section modulus of wash plate shall not be less than $W_{b.t} /\alpha$, where $W_{b.t}$ – is the deck transverse section modulus complying with the requirements of **2.6.4.5.1**; α – shall be determined in accordance with **2.6.4.5.1**.

Along the free edge, the wash plate shall be strengthened with a face plate the sectional area of which shall not be less than that of the deck transverse face plate.

2.6.4.6 The deck transverses of tankers having a single longitudinal bulkhead, tankers with two longitudinal bulkheads and no deck girders or strengthened longitudinals (in wing tanks only), as well as deep half beams, deep beams and hatch end coamings of dry cargo ships, which may be considered as members with rigid supports shall have a section modulus not less than stipulated under **1.6.4.1** and **1.6.4.2** and a web sectional area, excluding openings, not less than stipulated under **1.6.4.3** taking:

p – as defined in **2.6.3**;

k_σ and k_τ – as defined in **2.6.4.4**;

$m = 10$;

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

2.6.4.7 Deck girders and hatch side coamings shall satisfy the following requirements:

.1 deck girders and hatch side coamings which may be considered as members with rigid supports shall have a section modulus not less than determined in accordance with **1.6.4.1** and **1.6.4.2**, and a web sectional area, excluding openings, not less than stipulated under **1.6.4.3** taking:

p – as defined in **2.6.3**;

k_σ and k_τ – as defined in **2.6.4.4**;

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

$m = 10$ for intercostal deck girders, hatch side coamings when determining the section modulus at supporting section taking into account the bracket, if any, included in this section;

$m = 18$ for continuous deck girders and hatch side coamings when determining the section modulus in the span of a deck girder, hatch side coaming;

.2 for ships less than 30 m in length, the deck girder web thickness need not be taken greater than the deck plating thickness, and the hatch coaming web thickness shall be 1 mm greater than the thickness of deck plating;

.3 if the side coamings of strength deck hatches terminate in brackets, the length l_b, in m, of these brackets on the deck shall be:

$$l_b \geq 0{,}75 h_b \quad \text{at } R_{eH} \leq 315 \text{ MPa};$$
$$l_b \geq 1{,}50\, h_b \quad \text{at } R_{eH} = 390 \text{ MPa}, \qquad (2.6.4.7.3)$$

where: h_b – = height of coaming above deck, in m.

For the intermediate values of R_{eH} the bracket length shall be determined by linear interpolation;

.4 if containers or other cargo are stowed on cargo hatch covers, the scantlings of stiffeners for vertical coaming plates shall be so chosen as to consider both the horizontal and vertical components of inertia forces acting upon the stiffeners in the event of rolling.

2.6.4.8 If deck deep member can be considered separately from others, its section modulus shall not be less than stipulated under 1.6.4.1 and 1.6.4.2 using the design loads and factor k_σ determined from **2.6.4.4** and with $m = 10$.

The sectional area of such member shall not be less than determined by **1.6.4.3** taking:

k_τ as stipulated under **2.6.4.4**;

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

p – as defined in **2.6.3**.

2.6.4.9 In the midship region of a ship 65 m and greater in length, the deep member scantlings of the weather deck shall comply with the buckling strength requirements of **1.6.5**, the buckling strength values to be determined by calculation of the deck grillage using beam models.

Where deck is framed longitudinally and no deck girders are fitted, or deck girders serve as rigid supports for deck transverses, the required moment of inertia $I_{d.t}$, in cm^4, of deck transverses may be determined by the following formula, as an alternative to grillage calculation:

$$I_{d.t} = 0{,}76 \cdot (l/c)^3 \cdot (l/a_1) \cdot i \cdot \varphi \cdot \chi, \qquad (2.6.4.9)$$

where: l – span of deck transverse between supports, in m;
c – distance, in m, between deck transverses;
a_1 – spacing of deck longitudinals, in m;
i – actual inertia moment, in cm^4 , of deck longitudinal provided with a face plate;
$\varphi = 1$ where $1{,}15\sigma_c \le 0{,}5R_{eH}$;
$\varphi = 4{,}6 \cdot \sigma_c \cdot (1 - 1{,}15\sigma_c/ R_{eH})/ R_{eH}$ where $1{,}15\sigma_c > 0{,}5R_{eH}$;
$\chi = \lambda^2/(4 - 1{,}5\lambda^4)$;
$\lambda = 1{,}15 \cdot \sigma_c /(\varphi \cdot \sigma_e)$;
σ_c – compressive stress as defined in **1.6.5.1**;
σ_e – actual Euler stresses in deck longitudinals, determined in accordance with **1.6.5.4.**

2.6.5 Special requirements.

2.6.5.1 The requirements for hatch openings as given below apply to single hatches whose scantlings do not exceed those stipulated under **2.6.1**.

The openings are supposed to be arranged in the fore-and-aft direction with their greater side.

2.6.5.1.1 For the strength deck within 0,6L amidships if $L \ge 65$ m and 0,5L if 40м $\le L < 65$ m, the corner radii of openings in cargo hatches and engine and boiler casings shall comply with the following requirements:

when the corners are rounded along the circumferential arc with a radius r, in m:

$$r \ge 0{,}1ab_1; \qquad (2.6.5.1.1\text{-}1)$$

the corner radii of openings in cargo hatches and engine and boiler casings shall comply with the following requirements: when the corners are rounded along the circumferential arc with a radius r, in m d_1, in m, to the length of transverse half-axis c_1 in m, being equal to 2 2,

$$c_1 \ge 0{,}07ab_1; \qquad (2.6.5.1.1\text{-}2)$$

where: $a = 1$, if the corners of openings are not reinforced by thickened insert plates;
$a = 0{,}7$, if the corners of openings are reinforced by thickened insert plates;
$b_1 = c$, when $c \le c_o$ for adjacent edges of successive openings;
$b_1 = b$, when $c > c_o$ for adjacent edges of successive openings and in all other cases;
c – distance, in m, between adjacent edges of successive openings (length of landing between openings);
b – breadth, in m, of opening;
$c_o = B \cdot (b/l) \cdot \{[2/(\sqrt{(b/B)}] - 1\}$;
l – = length of opening, in m.

The size of thickened insert plates by which the corners of openings are reinforced shall be in compliance with Fig. **2.6.5.1.1** or with the requirements of **2.6.5.1.5** where r shall be determined by Formula (2.6.5.1.1-1) if the rounding is made along the circumferential arc;

$r = c_1$ for the transverse dimensions of the insert plate, and $r = d_1$ for its longitudinal dimensions if the rounding is made along the elliptical arc, and c_1 shall be determined by Formula (2.6.5.1.1-2).

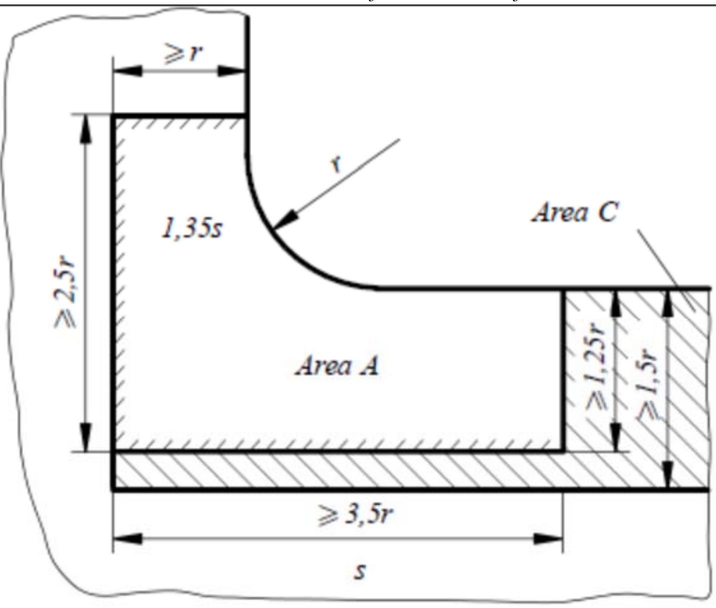


Fig. 2.6.5.1.1

2.6.5.1.2 For the strength deck outside the area indicated in **2.6.5.1.1** and for the second continuous deck situated above 0,75D from the base line, the corner radii of openings, as required by **2.6.5.1.1**, may, in accordance with **1.1.3**, be reduced by half in the midship region.

The minimum radius shall not be taken less than 0,2 m. For other regions, other decks and platforms, as well as for ships less than 40 m in length, the minimum corner radius of openings in cargo hatches and engine and At corners of openings in the cargo hatches of decks (irrespective of their location over the length and depth of the hull) exposed to low temperatures, the radii of curvature shall comply with the requirements for similar structures of the strength deck, situated in the midship region (refer to **2.6.5.1.1**).

2.6.5.1.4 4 In the area A (refer to Fig. 2.6.5.1.1), butts of deck plating and coaming plates, butt welds of primary and deep longitudinal members, openings welding of shackles, frames, etc., as well as mounting parts, to deck plating are not permitted.

In the area C (refer to Fig. 2.6.5.1.1), only small openings generally of a round or elliptical shape with a minimum size not exceeding 20*s* (*s* – deck plating thickness, in mm) are permitted. Penetration of welds to longitudinal edges of openings shall be avoided as far as practicable.

If the deck plating is terminated at a hatch coaming (or engine casing) and welded thereto, full penetration welds shall be used. Where the deck plating extends inside a hatch coaming, the free edges of plating shall be smooth within the hatch and free of weld attachments.

If the hatch side coaming terminates in a bracket, the bracket the shall not coincide with the butt joint of the deck plating.

2.6.5.1.5 If the lost cross-sectional area of deck shall be compensated in way of an isolated opening, reinforcement shall be applied as shown in Fig. 2.6.5.1.5. The value of factor *k* shall be selected proceeding from the relationship between the deck plating thickness *s*, insert plate thickness s_1 and opening width *b*, but shall not be taken less than $k = 0{,}35s/s_1$.

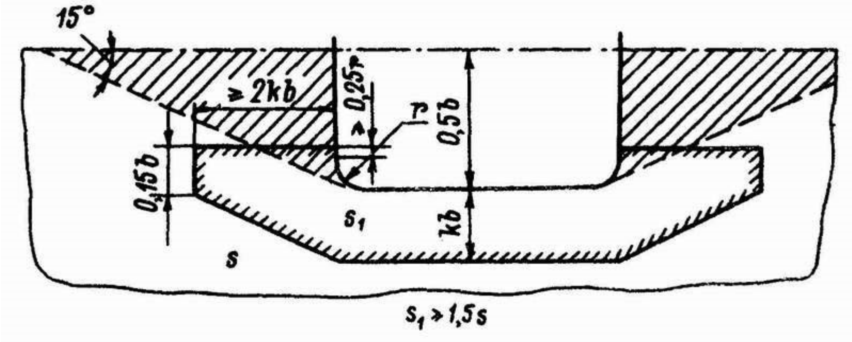


Fig. 2.6.5.1.5

2.6.5.1.6 The deck plating thickness between transverse edges of adjacent successive openings in cargo hatches and engine casings (refer to **2.6.5.1.1**) within their width except for the transverse dimensions of rounding shall not be less than stipulated under **2.6.4.1.5**. The thickness s_{min} is permitted in way of transverse edges of isolated openings in the area shown in Fig. 2.6.5.1.6.

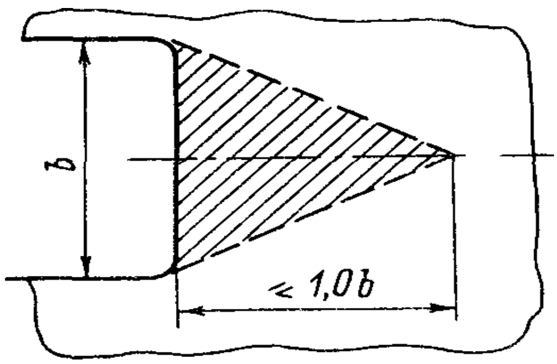


Fig. 2.6.5.1.6

If longitudinal system of framing is adopted, the deck plating between hatch end coamings shall be additionally strengthened by fitting of transverse intercostal stiffeners at every frame.

2.6.5.1.7 Single openings in the strength deck and in the second continuous deck situated above 0,75*D* from the base line, in areas within the midship region, as mentioned in **2.6.5.1.1** and **2.6.5.1.**2, and between the ship's side and the line of hatch openings in ships of 40 m and greater in length shall be as small as practicable and be arranged well clear of the corners of openings in cargo hatches and engine and boiler casings, as well as of the ends of superstructures.

Rectangular and circular openings in the above areas need not be reinforced, if their width (diameter) is less than 20 times the deck plating thickness in way of the opening, or 300 mm, whichever is less.

No openings are permitted in the thickened insert plates by which the corners of cargo hatches and engine and boiler casings are reinforced, as well as in the thickened deck stringer plates at the ends of superstructures and at the toes of brackets in which side coamings terminate.

Openings (including rectangular ones) shall not be reinforced when located inside the line of large hatchway openings not more than 0,25b from the centreline and 0,5b from the transverse edges of a cargo hatchway opening (where b is the width of cargo hatch, in m).

For isolated openings in the area indicated in Fig. 2.6.5.1.6, reinforcement is not required. If the distance between the edge of an opening in the strength deck and ship's side (or a hatch side coaming) is less than twice the opening width, appropriate reinforcement shall be provided irrespective of the width and shape of opening. The aforesaid distance shall not be less than 75 mm.

The corners of rectangular openings shall be rounded with a radius.

In general, r_{min} = 0,1*b* (where *b* is the width of opening, in m). In any case, the minimum radius of curvature shall not be taken less than twice the plating thickness in way of the opening or 50 mm, whichever is the greater.

2.6.5.2 The thickness *s*, in mm, of the coamings of ventilators (ventilating tubing, ducts, trunks, etc.) on the freeboard deck and quarter deck, as well as on the open decks of superstructures within 0,25*L* from the forward perpendicular shall not be less than:

$$s = 0{,}01d_к + 5, \qquad (2.6.5.2)$$

where: $d_к$ – internal diameter or length of the greater side of a coaming section, in mm.

The thickness *s* shall not be less than 7 mm, but it need not be greater than 10 mm.

In ships of restricted areas of navigation **R2, A-R2, R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS, C-R3-S**, **C-R3-RS, R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** less than 24 m in length, the thickness *s*, in mm, of ventilator coamings shall not be less than:

$s = 0{,}01d + 4,$ (2.6.5.2-1)

or

$s = s_d + 1,$ (2.6.5.2-2)

where: d – internal diameter or length of the greater side of a coaming section, in mm;
s_d – thickness of deck plating, in mm.

whichever is the greater

The thickness of coamings on decks of the first tier superstructures situated outside 0,25*L* from the forward perpendicular may be reduced by 10 % as compared to that required for coamings on freeboard deck and raised quarter deck.

Where the thickness of deck plating is less than 10 mm, a welded insert or doubling plate shall be fitted in way of the coaming, having a thickness equal to at least 10 mm, length and breadth not less than twice the diameter or twice the length of the greater side of the coaming section. In case of an efficient connection of the coaming to the deck framing, fitting of welded insert or doubling plate is not required.

Where the height of a ventilator coaming is greater than 0,9 m and the coaming is not supported by adjacent hull structures, brackets shall be fitted to attach the coaming to the deck.

The height of ventilator coamings shall be determined in accordance with **7.8**, Part III "Equipment, Arrangements and Outfit".

The structure of companionway and skylight coamings shall have strength equivalent to that of cargo hatches, whereas the thickness of the coamings shall not be taken less than 7 mm, but need not exceed the thickness of deck plating in way of the coaming.

2.7 BULKHEADS, PROPELLER SHAFT TUNNEL

2.7.1 General and definitions.

2.7.1.1 Requirements are given in this Chapter for various types of bulkheads, propeller shaft tunnel and cofferdams. Requirements for cofferdam bulkheads are given under **3.3**.

2.7.1.2 Definitions.

For the purpose of this Chapter, the following definitions have been adopted.

Wash bulkhead is a bulkhead with openings, fitted inside a compartment in order to reduce impact pressure due to the movement of liquid therein.

Watertight (emerg ency) bulkhead is a bulkhead restricting the flow of water through ship spaces in the case of emergency.

Cofferdam bulkhead is a bulkhead having two parallel tight platings, either strengthened with vertical or horizontal stiffeners or not, which are connected to each other by plate structures perpendicular to the platings: vertical structures (diaphragms) and/or horizontal structures (platforms). If no diaphragms and platforms are fitted, the structure shall be considered as two bulkheads bounding the cofferdam.

Partial bulkhead is a bulkhead fitted in a compartment or part thereof, which shall ensure additional support for deck structures.

Tight bulkhead is a bulkhead proof against water and other liquids.

Tank/cargo tank bulkhead is a bulkhead bounding a ballast, fuel or other tank, as well as a cargo tank of tanker.

2.7.1.3 The total number of transverse watertight bulkheads, including fore and after peak bulkheads, shall be not less than specified in Table 2.7.1.3. These requirements apply to cargo ships only and are minimum.

Where compliance with subdivision requirements shall be ensured, the number and disposition of watertight bulkheads (and of partial watertight bulkheads) shall be determined proceeding from the requirements of Part V "Subdivision".

All the transverse watertight bulkheads located between fore and after peak bulkheads shall be carried to the freeboard deck.

Table 2.7.1.3

	Total number of bulkheads

Length of the ship, in m	Machinery amidships	Machinery aft[1]
Up to 65	4	3
65 to 85	4	4
85 to 105	5	5
105 to 125	6	6
125 to 145	7	6
145 to 165	8	7
165 to 185	9	8
Above 185	In accordance with Part V "Subdivision".	
[1] With after peak bulkhead forming after boundary of the engine room.		

2.7.1.4 Peak and engine room bulkheads, shaft tunnels shall also comply with the requirements of **1.1.6.3**.

2.7.2 Construction.

2.7.2.1 Tight bulkheads may be either plane or corrugated. Wash bulkheads with openings shall be plane bulkheads.

For the construction of longitudinal tight bulkheads, as well as for the tight bulkheads of log and depth sounder wells, escape trunks, propeller shaft tunnel, etc., the same requirements apply as for transverse tight bulkheads.

In bulkheads, watertight steps and recesses are permitted.

In tankers, the longitudinal bulkheads shall be tight throughout the cargo tank region (including pump rooms and cofferdams) with the exception of the third bulkhead at the centreline which may be constructed as a wash bulkhead.

At intersections of longitudinal and transverse bulkheads, structural continuity of longitudinal bulkheads shall be ensured.

The termination of longitudinal bulkheads shall be smooth.

Partial bulkheads shall be plane bulkheads.

2.7.2.2 In corrugated longitudinal bulkheads, the corrugations shall generally be arranged horizontally, while in transverse bulkheads the arrangtement of corrugations may be both horizontal and vertical. Plane bulkheads shall be strengthened by vertical or horizontal stiffeners.

The vertical and horizontal stiffeners of plane bulkheads as well as the vertical and horizontal corrugations of corrugated bulkheads may be supported by horizontal girders or vertical webs respectively.

The horizontal girders and vertical webs shall be stiffened in accordance with the requirements of **1.7.3**.

Partial bulkheads shall be strengthened by vertical webs.

2.7.2.3 The end attachments of bulkhead framing members shall comply with the following requirements:

.1 the ends of vertical webs and horizontal stiffeners of bulkheads shall generally be attached by brackets complying with the requirements of **1.7.2.2**. Bracket attachments are required for the ends of main framing of forepeak bulkhead below the freeboard deck;

.2 if transverse system of framing is adopted, the brackets by which the vertical webs of transverse bulkheads are attached to deck plating and inner bottom plating (bottom plating) shall be carried to the beam or floor nearest to the bulkhead and welded thereto.

Where transverse framing system is adopted, the brackets by which the horizontal stiffeners of bulkheads are attached to the side or other bulkhead shall be carried to the frame or vertical stiffener nearest to the bulkhead and welded thereto;

.3 when the vertical stiffeners of bulkheads are cut at decks, platforms or horizontal girders and no brackets are fitted, the stiffener ends shall be welded to deck or platform plating, to horizontal girder web, or sniped at ends;

.4 the end attachments of vertical webs and horizontal girders shall comply with the requirements of **1.7.2.3**.

Where there are no horizontal girders on longitudinal bulkheads and/or side stringers at the level of the horizontal girder brackets of transverse bulkheads, the brackets shall be carried to the nearest vertical web on longitudinal bulkhead and/or the nearest frame and welded thereto.

If the vertical web on a transverse bulkhead is not in line with the centre girder or side girder, a bracket shall be fitted in the double bottom under the bracket by which the lower end of the vertical web is attached.

2.7.2.4 The attachments of corrugated bulkheads shall comply with the following requirements:

.1 where a horizontally corrugated bulkhead is attached to deck and bottom (inner bottom) or a vertically corrugated bulkhead is attached to ship's sides and longitudinal bulkheads, provision shall be made for flat transition areas whose structure, thickness and stiffening shall be in compliance with the requirements for plane bulkheads;

.2 attachment of corrugation ends shall be effected by welding them directly to the inner bottom plating (bottom plating), side plating, deck plating, etc. In so doing, attention shall be given to eliminating hard spots (refer to **1.7.1.4**) in the above structures;

.3 requirements for the attachments of corrugated bulkheads in bulk carriers are given in **3.3.2**.

2.7.2.5 The ends of the shaft tunnel stiffenerss shall be attached with brackets similar to the stiffeners of waterproof and tanks bulkheads.

2.7.3 Bulkhead loads.

2.7.3.1 The design pressure *p*, in kPa, on watertight bulkhead structures and propeller shaft tunnel shall be taken equal to:

$$P = \alpha \cdot z_b, \qquad (2.7.3.1)$$

where: α = 10 for forepeak bulkhead structures;

α = 7,5 elsewhere;.

z_b – distance, in m, as measured at the centreline, from the point of design load application to its upper level; the upper load level is: the bulkhead deck for watertight bulkheads and propeller shaft tunnel, the upper edge of forepeak bulkhead for the forepeak bulkhead.

If partial watertight bulkheads are fitted on the bulkhead deck in line with the watertight bulkheads or in close vicinity to them, z_b shall be measured to the upper edge of the watertight partial bulkheads.

In any case, the design pressure shall be not less than 12 kPa for watertight bulkhead structures and not less than 16 kPa for forepeak bulkhead structures.

2.7.3.2 The design pressure on the bulkheads of tanks, cargo tanks and water ballast holds shall be determined in accordance with **1.3.4.2**.

The design pressure on the wash bulkheads and plates shall be determined by Formulae (1.3.4.2.2-1) and (1.3.4.2.2-2), but shall not be less than pmin = 25 kPa.

The design pressure on bulkheads bounding heavy bulk cargo holds shall be determined in accordance with **1.3.4.3.**

2.7.4 Scantlings of bulkhead members.

2.7.4.1 The thickness of bulkhead plating shall be not less than determined by Formula (1.6.4.4) taking:

p – as defined in **2.7.3**;

m =15,8;

for the longitudinal bulkheads of tankers 65 m or greater in length, with transverse framing in the midship region:

$k_\sigma = 0,55k_b \le 0,8$ at the level of base line;

k_b – shall be determined by Formula (2.2.4.1);

$k_\sigma = 0,55k_d \le 0,8$ at the upper deck level;

k_d – shall be determined by Formula (2.2.4.1);

k_σ = 0,8 in way of (0,4÷0,5)*D* from the base line.

For intermediate regions over the ship's depth, k_σ shall be determined by linear interpolation.

k_σ = 0,8 for *L* = 12 m.

Where 12 < *L* < 65 m k_σ shall be determined by linear interpolation taking k_σ =0,68 for *L* = 65 m at the level of base line and upper deck.

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

k_σ = 0,9 for other bulkheads.

In ships of 50 m in length, the thickness of watertight bulkhead plating may be reduced by 0,5 mm, and in ships of 40 m in length or below, by 1 mm. For intermediate ship lengths, the reduction in thickness shall be determined by linear interpolation.

In tankers, the thickness of top and bottom strakes of longitudinal bulkheads shall comply with the requirements for side plating, as given in **2.2.4**, with regard for the liquid cargo pressure.

The plating thickness s_{min}, in mm, of watertight bulkheads and bulkheads of lubricating oil tanks shall not be less than:

$s_{min} = 4 + 0,02L$, (2.7.4.1-1)

Where $L > 150$ m, L shall be taken equal to 150 m.

The thickness of bottom plates of bulkheads shall exceed the above value by 1 mm, determined by the Formula (2.7.4.1-1), but shall not be less than 6 mm.

For tank bulkheads (except lubricating oil tanks), the thickness s_{min}, in mm, of plating, face plates and webs of framing members shall not be less than:

$s_{min} = 5 + 0,015L$, (2.7.4.1-2)

6,0 mm $\le s_{min} \le$ 7,5 mm.

In tankers, the minimum bulkhead plating thickness in way of cargo and ballast tanks shall not be less than that required by **3.5.4**.

Bulkhead plating may have a thickness not exceeding that of relevant shell plating strakes and deck plating, where the spans and yield stress values are identical. The same applies to the thickness relationship of bulkhead bottom plating and inner bottom plating (bottom plating).

The breadth of top and bottom strakes of bulkheads shall be determined in accordance with **2.7.5.1**. Where sterntubes penetrate through bulkhead plating, the thickness of the latter shall be doubled.

The thickness of corrugated bulkheads shall be determined in accordance with **1.6.4.5** with regard for the requirements for the section moduli of vertical and horizontal stiffeners, as specified in **2.7.4.2**.

2.7.4.2 The section modulus of vertical and horizontal stiffeners of bulkheads shall not be less than stipulated under **1.6.4.1** and 1.6.4.2 **taking**:

p – as defined in **2.7.3**;
m – as obtained from Table 2.7.4.2;

Table 2.7.4.2

Framing members	m
Single span vertical stiffeners:	
both ends sniped	8
upper end sniped, lower end welded to supporting structure	9
both ends welded to supporting structure	10
upper end welded to supporting structure, lower end bracketed [1]	14
both ends bracketed [1]	18
Multispan vertical stiffeners:	
within span	18
within intermediate supporting section, where stiffener is continuous through supporting structure [2]	12
Horizontal stiffeners	12

[1] Additionally, strength in the supporting section shall be verified, considering the bracket as part of the section, with m=12.
[2] With regard for a bracket, if fitted, in the supporting section

for horizontal stiffeners of longitudinal bulkheads fitted in the midship region of tankers 65 m and greater in length:
$k_\sigma = 0,55k_b \le 0,75$ at the level of base line;
k_b – shall be determined by Formula (2.2.4.1);
$k_\sigma = 0,55k_d \le 0,75$ at the upper deck level;
k_d – shall be determined by Formula (2.2.4.1);
$k_\sigma = 0,75$ within $(0,4\div0,5)D$ from the base line.
For intermediate regions over the ship's depth, k_σ shall be determined by linear interpolation.
$k_\sigma = 0,75$ for $L = 12$ m.

Where 12 < 65 m, k_σ shall be determined by linear interpolation, taking k_σ = 0,65 for L = 65 m at the base line and upper deck level;

k_σ = 0,75 at the ends of the ship within 0,1*L* from the fore or after perpendicular.

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

k_σ = 0,75 for other girders of bulkhead framing.

m=10 for corrugations;

m = 13 for vertical corrugations of bulkheads whose top and bottom ends are attached to deck and bottom or to inner bottom by transverse members of rectangular or trapezoidal section and by supports of trapezoidal section complying with **3.3**, respectively.

Horizontal stiffeners of longitudinal bulkheads fitted at a distance of 0,15*D* from deck and bottom shall comply with the buckling strength requirements of **1.6.5**.

For tank bulkheads (except lubricating oil tanks), the thickness of member webs and face plates as well as of their stiffening brackets shall not be less than required by Formula (2.7.4.1-2), and for the bulkheads of tankers in way of cargo and ballast tanks it shall not be less than stipulated under **3.5.4**.

2.7.4.3 Bulkhead vertical webs and horizontal girders shall satisfy the following requirements:

.1 the section modulus and web sectional area, excluding openings, of the vertical webs of bulkheads whose structure does not include horizontal girders, and of the horizontal girders of bulkheads whose structure does not include vertical webs, shall not be less than stipulated under **1.6.4.1 - 1.6.4.3** taking:

$N_{max} = npal$;

p – as defined in **2.7.3**;

m, *n* for the longitudinal bulkheads of tankers shall be determined from Table 2.7.4.3-1 depending upon the number of cross ties fitted in wing tanks between deep members of bulkhead and of ship's side;

for other bulkheads for which vertical webs are provided, but horizontal girders are omitted, or vice versa, the values of *m* and *n* shall be obtained from Table 2.7.4.3-2;

l – span, including the brackets, in m;

k_σ – is determined for horizontal girders of longitudinal bulkheads in tankers in the same way as for the horizontal stiffeners of those bulkheads in accordance with **2.7.4.2**;

for other webs and girders, k_σ = 0,75;

k_τ = 0,75;

Table 2.7.4.3.1-1

Member	Parameter	Number of cross ties			
		0	1	2	3
Vertical web	*m*	11	24	24	24
	n	0,5	0,325	0,3	0,275
Horizontal girder	*m*	18	36	36	36
	n	0,5	0,35	0,3	0,3

Таблиця 2.7.4.3.1-2

Member	*m*	*n*
Vertical web:		
in holds or tanks	11	0,5
in 'tween decks	10	0,5
Horizontal girder:		
in tanks	10	0,5
in wing tanks	18	0,5

.2 where the bulkhead structure incorporates both vertical webs and horizontal girders, the scant-lings of those members shall be determined on the basis of grillage calculation using beam models, with design loads as stipulated under **2.7.3** and permissible stress factors as stipulated under **2.7.4.3.1**;

.3 for the girders and webs of corrugated bulkheads, the lowest cross section shall be adopted as the design cross section; the face plate width shall be determined in accordance with **1.6.3.6**;

.4 for tank bulkheads (except lubricating oil tanks), the web and face plate thickness of girders and of their brackets and stiffeners shall not be less than required by Formula (2.7.4.1-2); for tanker bulkheads in way of cargo and ballast tanks, this thickness shall not be less than that required by **3.5.4**.

2.7.4.4 In compartments intended for the carriage of liquid cargoes and ballast, the scantlings of members of wash bulkheads and wash plates shall comply with the following additional requirements:

.1 in the wash bulkheads, the total area of openings shall not be greater than 10 % of the bulkhead area as a whole. The number and size of openings in the top and bottom strakes shall be as small as possible.

The thickness and breadth of the top and bottom plates of wash bulkheads shall comply with the requirements for the bulkhead plating of tanks or cargo (ballast) tanks proceeding from the purpose;

.2 a wash plate shall be stiffened by framing complying with the requirements for wash bulkhead framing.

The free edge of the wash plate shall be stiffened by a horizontal stiffener or a face plate. Their section modulus shall comply with the requirements for the primary members of wash bulkheads.

Where a wash plate serves as the undeck girder, it shall comply with the requirements of ам **2.6**.

2.7.4. The scantlings of partial bulkhead members shall comply with the following requirements:

.1 the thickness of partial bulkhead plating shall not be less than that required by Formula **(2.7.4.1-1);**

.2 partial bulkhead stiffeners supporting deck transverses and hatch end beams shall be in accordance with the requirements for relevant pillars (refer to **2.9**).

In any case, the Euler stresses, in MPa, in a stiffener, to be determined in accordance with 2.9.4.1, shall not be less than:

$$\sigma_e = 200\eta. \qquad (2.7.4.5.2)$$

The moment of inertia and sectional area of the stiffener on the basis of which the Euler stresses therein are determined shall be calculated with regard for the face plate of partial bulkhead plating equal in width to half the distance between the stiffeners;

.3 if the partial bulkhead takes up the load directly from cargo, the scantlings of its members shall comply with the requirements for hold bulkheads with regard for the particular cargo.

2.7.4.6 The scantlings of shaft tunnel members, its recess included, and those of the tight bulkheads of log and depth sounder wells, escape trunks, etc. shall comply with the requirements for the scantlings of watertight bulkhead members.

If the shaft tunnel passes through a compartment intended for the carriage of liquid cargo or ballast, the scantlings of its members shall comply with the requirements for the scantlings of the members of tight bulkheads bounding the compartment.

If the top plating is well curved, the thickness may be reduced by 10 %.

Under hatchways the top plating thickness shall be increased by 2 mm.

2.7.5 Special requirements.

2.7.5.1 The breadth of the bottom strake of bulkhead, as measured from inner bottom plating, or, where double bottom is omitted, from the bottom shell, shall be not less than 0,9 m for ships of 40 m and greater in length, and not less than 0,4 m for ships of 12 m in length. For intermediate ship lengths, the breadth of this strake shall be determined by linear interpolation. If the double bottom extends to the bulkhead on one side only, the bottom strake of bulkhead plating shall extend for at least 0,3 m above the inner bottom plating.

In the boiler room, the bottom strake of the bulkhead shall extend for at least 0,6 m above the flooring.

The upper edge of bottom strake of transverse bulkheads in the cargo tanks of tankers shall be at least 100 mm above the upper toes of brackets of bottom longitudinals. The top and bottom strake breadth of longitudinal bulkhead plating shall not be less than $0{,}1D$, but need not exceed 1,8 m.

2.7.5.2 Cofferdams and the bulkheads forming their boundaries shall comply with the following requirements:

.1 unless expressly provided otherwise in the other Parts of the Rules, the breadth of vertical cofferdams stipulated under **2.4.7**, Part VI "Fire Protection", **4.3.4** Part VII "Machinery Installations" and **13.7.5**, **14.5.2**, **17.3** Part VIII "Systems and Piping" shall be equal to one spacing, but not less than 0,6 m, and the height of horizontal cofferdams shall not be less than 0,7 m.

In any case, cofferdam dimensions shall be so selected as to make the cofferdams accessible for inspection and repair.

Instead of cofferdams, cofferdam bulkheads may be fitted in accordance with **3.3** unless expressly provided otherwise by the Rules;

.2 cofferdams adjoining cargo tanks and fuel tanks shall be watertight.

Bulkheads separating cofferdams from tanks shall comply with the requirements for the bulkheads of those tanks.

The bulkheads of cofferdams filled with water shall comply with the requirements for tank bulkheads.

The bulkheads of cofferdams which shall ensure tightness, but which are not filled with water, shall comply with the requirements for watertight bulkheads.

The bulkheads of cofferdams which are non-tight shall comply with the requirements for partial bulkheads as stipulated under 2.7.4.5, except the requirement for vertical webs supporting deck transverses and hatch end beams. They may have openings provided the corners of the openings are rounded and the edges are suitably reinforced. Such openings shall not generally be arranged in the top and bottom strakes of longitudinal bulkheads.

2.8 FORE AND AFTER ENDS

2.8.1 General and symbols.

2.8.1.1 Requirements are given in this Chapter for the following structures:

fore peak and bulb (if any),

bottom within 0,25*L* aft of the fore perpendicular,

side within 0,15*L* aft of the fore perpendicular, structures located aft of the after peak bulkhead, as well as strengthening of bottom and side forward in the region of impact pressure.

It is assumed in this Chapter that the upper boundary of the fore and after peak is formed by a tight deck or platform arranged directly above the summer load waterline.

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

d_f – minimum design draught, in m, in way of forward perpendicular;

α_x – кут між вертикальною лінією і прямою лінією, яка з'єднує точки перетинання літньої вантажної ватерлінії та верхньої відкритої палуби з бортом судна у поперечному перерізі, який знаходиться на відстані 0,05*L* від носового перпендикуляра (див. рис. 2.8.1.2-1), град;

β_x – angle, in deg., between a tangent to the waterline at vertical mid-distance between the summer load waterline and weather deck on forward perpendicular, and a line parallel to the centreline at a cross section within 0,05L from the forward perpendicular (refer to Fig. 2.8.1.2-2).

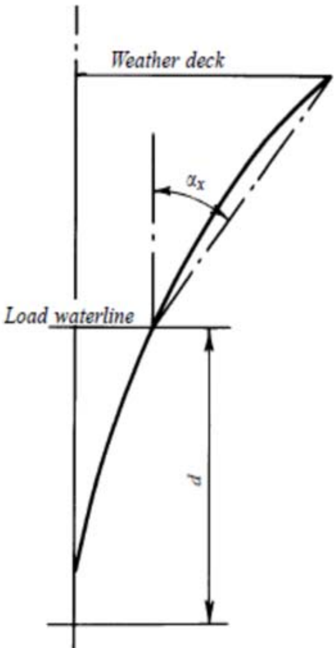


Fig. 2.8.1.2-1
Determination of angle α_x

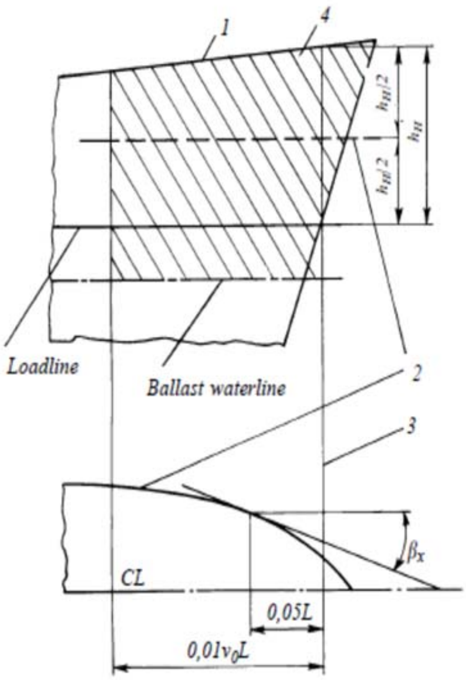


Fig. 2.8.1.2-2
Diagram for determining the angle β_x and the area (lined) to which the move impact pressure is applied:

1 – open upper deck;
2 – water line for determining the angle;
3 – forward perpendicular;

4 – impact pressure area;
h_H – vertical distance between the loadline and the open upper deck at forward perpendicular.

2.8.2 Construction.

2.8.2.1 The following framing systems are adopted at ends:

transverse system of framing for bottom in peaks;

transverse or longitudinal system of framing for other structures.

Transverse or longitudinal framing for all structures shall be adopted for hulls of a pontoon shape.

2.8.2.2 Fore peak floors shall be fitted at every frame. Their height shall not be less than stipulated under **2.4.4.1**, but need not exceed 2,25 m, and the thickness shall not be less than required by Formula (2.4.4.3.1) at k =1 and a =0,6 m; however, they need not be thicker than the bottom shell plating in this region.

Floor webs shall be strengthened with vertical stiffeners to be spaced not more than 0,6 m apart. Floor face plates shall have a thickness not less than the floor thickness and a breadth required by **1.7.3.1**.

At the centreline an intercostal side girder with a face plate shall be fitted as an extension of centre girder in way of the holds. The height and thickness of girder plates as well as the thickness and width of girder face plate shall be equal to those of the floors.

Where the webs of the girder cannot be arranged, the floor face plates shall be interconnected at the centreline by an angle, tee section, etc. the flanges of which have the same width and thickness as the floor face plates. If transverse system of framing is adopted in the fore peak side, the side stringers shall be fitted at least up to the deck directly above the summer load waterline. Side stringers shall be so fitted that the distance measured vertically between them does not, in general, exceed 2 m.

Side stringers shall be supported by panting beams fitted at alternate frames and shall, where possible, be supported at the centreline by a longitudinal bulkhead.

The free edge of the side stringers shall be stiffened by a face plate having a thickness not less than that of a stringer web and a breadth in accordance with **1.7.3.1**.

At every frame, the stringer web shall be stiffened by brackets having the side dimensions not less than half the stringer web height, and where panting beams are fitted, these shall be not less than required by **1.7.2.2**. The thickness of brackets shall not be less than that of the stringer web.

Instead of panting beams, the side stringers may be supported by web frames spaced not more than 3 m apart.

It is recommended that non-tight platforms be fitted instead of side stringers with panting beams or web frames. In this case, the distance between the platforms may be increased to 2,5 m. The beams of non-tight platforms shall be fitted at every frame.

If in the structure with panting beams or web frames the distance from the base line to the nearest deck or platform exceeds 9 m, a non-tight platform shall be fitted at the middle of this length, in which the total area of openings shall not exceed 10 % of its area.

With longitudinally framed fore peak side, the spacing of web frames shall not exceed 2,4 m. Deck transverses shall be fitted in way of the web frames passage through or attachment to decks and platforms.

Floors without web frames fitted in line with them shall be attached to the nearest side longitudinals by brackets.

2.8.2.4 The bulb shall be strengthened by platforms spaced not more than 2 m apart. Beams of the platform shall be fitted at every frame.

If the length of the bulb forward of the forward perpendicular exceeds 0,03L, a non-tight bulkhead shall be fitted at the centreline, with stiffeners arranged at every frame.

If the length of the bulb is less than 0,03L, the bulb may be strengthened by a girder fitted at the centreline in continuation of the centre girder.

The construction of the fore end shall provide for the anchor to be lowered freely past the bulb with the ship listed 5°either side.

In way of eventual touching of the bulb, the shell plating thickness shall be increased and intermediate frames fitted.

2.8.2.5 In ships with single bottom, the bottom structure in way of the fore end outside the fore peak shall comply with the requirements of **2.3.2**, **2.3.4** and, besides, with those given below:

.1 if transverse system of framing is adopted, the spacing of side girders, as well as the distance from the centre girder or the ship's side to a side girder, shall not exceed 1,1 m within 0,25*L* from the forward perpendicular.

If longitudinal system of framing is adopted and minimum draught is less than 0,035*L* in way of the forward perpendicular, in cargo tanks of tankers an additional transverse with a face plate along its free edge shall be fitted midway between the bottom transverses. The depth of this transverse shall not be less than that of bottom longitudinals;

.2 forward of cargo tanks:

if transverse system of framing is adopted, intercostal side girders with face plates along their free edges shall be fitted in continuation of every second bottom longitudinal, extending forward as far as practicable. The depth and thickness of the side girder webs, as well as the scantlings of the face plates, shall be taken the same as for the floors;

if longitudinal system of framing is adopted, the spacing of floors shall not exceed 2,8 m. An intercostal side girder having the same scantlings as the floors shall be fitted on either side of the ship between the centre girder and longitudinal bulkhead.

2.8.2.6 In way of the fore end, the double bottom structure outside the fore peak shall comply with the requirements of **2.4.2** and those given below.

Within 0,25*L* from the forward perpendicular the distance between side girders shall not exceed 2,2 m. If transverse system of framing is adopted, in this region half-height side girders shall be fitted additionally and welded to the bottom and floors. The distance between side girders and half-height girders shall not exceed 1,1 m. These half-height girders shall be extended as far forward as practicable, whereas their free edges shall be reinforced with flanges or face plates.

If longitudinal system of framing is adopted, the floors shall be strengthened with stiffeners in line with each half-height side girder and each bottom longitudinal.

In ships greater than 80 m in length with a minimum draught less than 0,025L in way of the forward perpendicular, the edges of openings in floor, side girder and centre girder webs shall be stiffened within 0,25*L* from the forward perpendicular.

2.8.2.7 If transverse framing system is adopted, intercostal side stringers shall be fitted within 0,15L from the forward perpendicular, outside the fore peak, at the level of the fore peak side stringers.

The depth and thickness of a stringer plate shall be equal to those of the frame. The intercostal brackets fitted as stringer plates shall be welded to the webs of frames at both ends and to the shell plating. On the free edge of a stringer, a face plate shall be fitted with the thickness not less than that of the web and the breadth in accordance with 1.7.3.1.

The intercostal side stringer may be of the same profile as the frames.

The stringer face plate (flange) shall not be welded to the face plate of frame.

Intercostal stringers shall be attached to the bulkheads by brackets.

The face plates (flanges) of intercostal stringers may be omitted where the spacing of frames does not exceed their double depth. In this case, their thickness$s$, in mm, shall not be less than:

$s = l/4s_c + \Delta s$ або $s = 0,05h$,

whichever is the greater,

where: l — length of the free edge of stringer between frames, in mm;

h — stringer depth, in mm;

s_c— stringer thickness, in mm, in accordance with **1.6.5.4**;

Δs— value, in mm, in accordance with **1.6.5.5**.

In ships having the characteristic $(v_0/\sqrt{L}) > 1,5$ or a large bow flare, provision shall be made for web frames and side stringers supported thereby. The spacing of web frames shall not exceed 5 frame spaces.

Where longitudinal framing is adopted in the ship's side forward outside the fore peak, the spacing of side transverses shall not exceed 3 m. In the holds of any ship, as well as in 'tween decks and superstructures of ships with the characteristic $(v_0/\sqrt{L}) > 1,5$ or with a large bow flare, provision shall be made for a vertical intercostal member having the same scantlings as side longitudinals, to be fitted between side transverses. The structure of the member shall be similar to that of the intercostal side stringers required by transverse framing system. The intercostal member can terminate at the upper and lower side longitudinals of the hold, 'tween decks and superstructure. Every second side longitudinal shall be attached to the side transverses by brackets extended to the frame face plate.

2.8.2.8 Within 0,1L from the forward perpendicular, the span of weather deck transverses shall not exceed 3 m, and the deck girder span shall not exceed 3,6 m.

Within 0,2L from the forward perpendicular, the section modulus of weather deck transverses shall not be less than required for deck girders with equal spans and spacing of members.

2.8.2.9 The structure located aft of the after peak bulkhead shall be sufficiently rigid in the vertical and horizontal plane. For this purpose, fitting of additional longitudinal bulkheads or platforms, thickening of deck plating and shell plating, as well as connection of bottom and upper deck longitudinals with pillars or struts may be required. If the stern overhang is large or the after peak widthexceeds 20 m at any section, fitting of additional longitudinal non-tight bulkheads is recommended port or starboard.

Where there is a flat of the bottom, additional strengthening may be required to take up the loads due to impact pressure.

2.8.2.10 Floors in the after peak shall comply with the requirements of **2.8.2.2**.

In single screw ships, the floors shall be extended above the sterntube, but in any case to a height of not less than 0,8 m. If this is impracticable, tie plates with face plates on both edges shall be fitted transversely at every frame above the sterntube. The thickness of the tie plates shall not be less than that of the floor. Tie plate exceeding 1,5 m in length shall be provided with a stiffener fitted in the middle of its length.

Floors with flanged edges are not permitted.

In ships greater than 200 m in length, floors shall be extended to the platform located above the sterntube. Longitudinally, the floors shall be stiffened with brackets fitted at the centreline and, if practicable, supporting the floor for a full depth. Brackets above the sterntube are necessary. The brackets shall be carried to the propeller post. They need not be fitted where a wash plate is located above the floors, with its lower edge extending at least 0,8 m below the face plates of the floors. The opening in floors for the sterntube shall be reinforced with face plate along the edges.

Below the sterntube, the openings shall be reinforced with face plates or stiffeners.

2.8.2.11 If transverse framing is adopted in the after peak side, panting beams and side stringers, beam knees, frame to side stringer attachments, arrangement and structure of web frames and non-tight platforms shall comply with the requirements of **2.8.2.3**. The vertical distance between side stringers shall not exceed 2,5 m, and the frame span, as measured on the side plating, shall not exceed 3,5 m.

In 'twin- and multi-screw ships having a cruiser or transom stern, the distance between stringers, as measured on the side plating, shall not exceed 2 m, with one of the stringers being fitted in way of the top edge of propeller shaft bossing or in line with the shaft bracket. Where web frames are fitted, their spacing shall not exceed 2,4 m.

If longitudinal framing is adopted in the after peak side, relevant requirements of **2.8.2.3** shall be complied with.

2.8.2.12 The ends of after peak members (including deck, platform and bulkhead framing), as well as the ends of horizontal and, where practicable, vertical stiffeners of floors shall be secured (refer to **1.7.1.4**).

The face plates of the after peak floors and deck transverses shall be sniped in way of their attachments to longitudinal bulkheads.

Bulkhead stiffeners shall be attached to the floor face plates by brackets fitted on either side of the bulkhead.

This also applies to deck girder and side girder attachments to transverse bulkheads.

2.8.2.13 The spacing of ordinary and bevel frames may be the same as in the midship region, but shall not exceed 750 mm.

A side girder of the same depth as that of floors shall be fitted at the centreline. In case of transom stern and/or flat of the bottom, the side girders shall be spaced not more than 2 m apart.

In full cruiser sterns and where the frame span from the upper edge of floors to the nearest deck exceeds 2,5 m, additional strengthening shall be provided by means of web frames and a side stringerepa.

2.8.2.14 If peaks are used as tanks, fitting of a wash bulkhead is recommended at the centreline.

2.8.3 Loads on structures at ends.

2.8.3.1 The design pressure on the structures at ends is determined using the design loads specified in **2.2 - 2.7** and the extreme loads specified in **2.8.3.2** and **2.8.3.3**.

The scantlings of fore end members subject to impact pressure shall be verified by applying extreme loads:

- in accordance with **2.8.3.2** for ships greater than 65 m in length with a minimum draught of 0,045L in way of the forward perpendicular;
- in accordance with **2.8.3.3** for ships having the characteristic $(v_0/\sqrt{L}) > 1,5$ or a considerable bow flare.

2.8.3.2 Under the wave impact upon the bottom of the fore end, the extreme values of the design hydrodynamic pressureку p_{SL}, in kPa, shall be determined by the formula:

$$P = 5{,}5 c_1 c_2\ \varphi_r\ (b_x/B)(1-5d_f/L)\times(1-x_1/l_b)\cdot 10^3, \qquad (2.8.3.2\text{-}1)$$

where: $c_1 = \sqrt{L}$ for $L \le 200$ m;

$c_1 = 5\sqrt{(10 - L/100)}$ for $L > 200$ m;

$c_2 = 0{,}07\, v_0\, (1\text{-}17{,}1\ d_f/L)/\sqrt{L}$;

$l_b = (0{,}22 + 1{,}5c_2)L$,

v_0 – refer to **1.1.3**;

φ_r – as obtained from **1.3.1.5** (for ships of unrestricted service $\varphi_r = 1$);

b_x – ship breadth, in m, in the considered cross section at the level of 0,04B above the base line, but not greater than 0,8B;

x_1 – distance, in m, from the considered cross section to the forward perpendicular, but not greater than l_f;

d_f – smallest estimated draft at the forward perpendicular.

Formula (2.8.3.2-1) is used for derivation of p values in a number of sections within the portion l_b, from which the maximum value of p (hereinafter - symbol p_{max}) and the value of x_1 (hereinafter - symbol x_{max}) corresponding to pmax are chosen.

The design pressure p_{SL} (refer to Fig. 2.8.3.2) is determined by the formula:

$$p_{SL} = p_н + (p_{max} - p_н)\, x_1/(x_{max} - 0{,}05L), \text{ when } 0 \le x_1 < x_{max} - 0{,}05L;$$

$$p_{SL} = p_{max}, \quad \text{when } x_{max} - 0{,}05L \le x_1 \le x_{max} + 0{,}05L;$$

$$p_{SL} = p_{max}\,(0{,}5L - x_1)/(0{,}45L - x_{max}), \quad \text{when } x_{max} + 0{,}05L \le x_1 \le 0{,}5L. \qquad (2.8.3.2\text{-}2)$$

where: $p_н = 0{,}5p_{max}$ – with bulb;

$p_н = 0$ – without bulb.

The hydrodynamic pressure as determined by Formula (2.8.3.2-2) is distributed over a height of 0,04B above the base line.

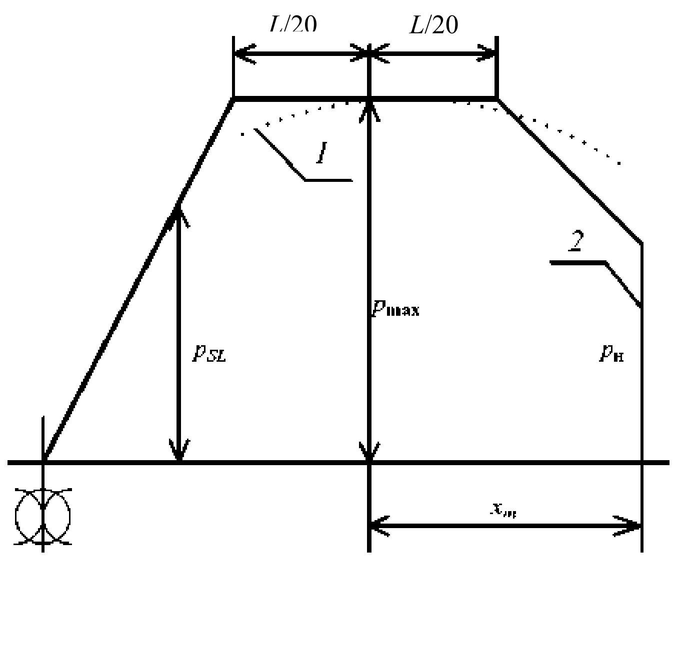


Fig.2.8.3.2 Determination of design pressure p_{SL}.
1- value of p determined by Formula (2.8.3.2-1);
2- forward perpendicular.

2.8.3.3 Under the wave impact upon the side at the fore end, the extreme values of the design hydrodynamic pressure p_{SL}, in kPa, shall be determined by the formula:

$$p_{SL} = 0,9\, c_3\, c_4^2, \tag{2.8.3.3}$$

where: $c_3 = 2,2 + 1,5\ \mathrm{tg}\,\alpha_x$;
$c_4 = [v_o \cdot (0,6 - 20/L) \cdot (1,2 - 0,2\beta_x/60) \cdot \sin\beta_x] + 0,6\sqrt{L}$;
for v_o – refer to **1.1.3**;
α_x, β_x – as defined in **2.8.1.2**.

Depthwise the impact pressure is distributed over the part of the side above the ballast waterline, and lengthwise - over the part of the side extending as far aft as the cross section at $0,01 v_0 L$ from the forward perpendicular and as far forward as the intersection of the upper deck with the stem (refer to Fig. 2.8.1.2-2).

2.8.4 Scantlings of structural members at ends.

2.8.4.1 The shell plating thickness, scantlings of single bottom and double bottom members and of side framing shall comply with the requirements of **2.2.4**, **2.3.4**, **2.4.4**, **2.5.4** using the service loads given in **2.2**, **2.3**, **2.4**, **2.5**. Besides, when determining the scantlings of fore and after peak members, the following requirements shall be satisfied:

.1 the section modulus of frames shall be determined by Formulae (1.6.4.1) and (1.6.4.2) taking:
$m = 12$;
l – spacing of side stringers, as measured along the shell plating;

.2 scantlings of panting beams shall comply with the requirements of **2.9.4.1**;

.3 in calculating the section modulus and cross-sectional area of web frames:
$m = 10$;

$$N_{\max} = 0,5pal, \text{ in kN,} \tag{2.8.4.1.3}$$

where: p – design pressure, in kPa, according to **2.5.3**;
a – spacing of web frames, in m;
l – span of web frame, in m, as measured between the upper edge of floor and the deck (platform) bounding the fore peak (after peak) or the non-tight platform, if any, nearest to the bottom, or between non-tight platforms, the deck and non-tight platform less the height of deck transverse of the relevant deck (platform);

.4 plating thickness and framing of non-tight platform shall satisfy the requirements of 2.6.4 for platforms at ends. When determining the design load by Formula (1.3.4.1), the product $h\rho_c g$ shall not be less than 3,5 kPa.

The thickness of non-tight platform plating, in mm, shall not be less than:

$$s_{\min} = (0,02L + 5)\sqrt{\eta}, \tag{2.8.4.1.4}$$

but not less than 5 mm.
Where $L > 300$ m, L shall be taken equal to 300 m;

.5 if the fore peak (after peak) is used as tanks, the scantlings of their members shall also comply with the requirements for the structural members of tanks.

2.8.4.2 Where exposed to extreme loads to be determined in accordance with **2.8.3.2**, the scantlings of bottom framing members at the fore end shall comply with the requirements of **2.2.4**, **2.3.4** and **2.4.4**, as well as with the following additional requirements:

.1 the thickness of shell plating shall be determined by Formula (1.6.4.4) taking

$$p = 0,4p_{SL}, \tag{2.8.4.2.1}$$

where: p_{SL} – as determined by Formula (2.8.3.2-2);

m = 15,8;

k_σ = 0,7;

.2 the section modulus, in cm^3, of a primary member shall not be less than:

$$W = 0{,}75pal^2\omega_c \cdot 10^3/(mk_\sigma\sigma_n), \qquad (2.8.4.2.2)$$

where: p – as determined by Formula (2.8.4.2.1);

k_σ = 0,65;

m = 16, if the members are continuous through the webs of supporting structures;

m = 8, if the members are cut at supports;

m = 28, if the supporting sections of the member are reinforced with brackets on both sides of the supporting structure; the depth and length of brackets are not less than 1,5 of the member depth;

for ω_c – refer to **1.1.5.3**;

.3 the cross-sectional area f, in cm^2, of a primary member or of welds by which intercostal members are connected to supporting structures shall not be less than:

$$f = [5pal \cdot (l - 0{,}5a)/(k_\tau\tau_n)] + 0{,}05\sum h_i\Delta s, \qquad (2.8.4.2.3)$$

where: p – as determined by Formula (2.8.4.2.1);

k_τ = 0,65;

$\sum h_i$ – length of member section perimeter, in cm;

Δs – as obtained from **1.1.5.1**.

The cross-sectional area of a member includes the web area, as well as the portion of the sectional area of shell plating, having a breadth $b_1 = 3s$ s (where s is the thickness, in mm, of shell plating).

If the member is of bulb profile, the whole of its face plate is included in the cross-sectional area. In the case of member of T-section, a portion of its breadth $b_2 = 3s_{f.p}$ (where $s_{f.p}$ – is the face plate thickness of the member, in mm);

.4 the web thickness s, in mm, of floor, side girder and centre girder shall not be less than:

$$s = [0{,}75pab/(k_\tau\tau_n h)] + \Delta s, \qquad (2.8.4.2.4)$$

where: p – as determined by Formula (2.8.4.2.1);

k_τ = 0,65;

h – depth, in m, of floor, side girder or centre girder accordingly;

a and b – average spacing of floors and girders accordingly (centre girder and side girder); when determining b, half-height side girders shall be disregarded;

Δs – as obtained from **1.1.5.1**.

2.8.4.3 Where exposed to extreme loads to be determined in accordance with **2.8.3.3**, the scantlings of side framing members at the fore end shall comply with the requirements of **2.2.4** and **2.5.4**, as well as with the following additional requirements:

.1 the thickness of shell plating shall be determined by Formula (1.6.4.4) taking:

$$p = 0{,}4p_{SL}, \qquad (2.8.4.3.1)$$

where: p_{SL} – as determined by Formula (2.8.3.3);

m = 15,8;

k_σ = 0,7;

.2 the section modulus of a primary member shall comply with the requirements of **2.8.4.2.2** using the design load determined by Formula (2.8.4.3.1);

.3 the section modulus of a primary member shall comply with the requirements of **2.8.4.2.3** using the design load determined by Formula (2.8.4.3.1).

2.8.4.4 Within the area of the stern counter, the scantlings of frames shall be not less than those of the after peak frames, unless their span exceeds 2,5 m. With a greater span, the frame scantlings shall be increased accordingly. The thickness of floors and side girders shall not be less than required by **2.8.4.5**.

2.8.4.5 The side stringers of fore and after peaks shall have a web sectional area f_c, in cm^2, not less than

$$f_c = 0{,}45L + 12. \qquad (2.8.4.5\text{-}1)$$

The side stringer width b, in m, shall not be less than:

$$b = 0{,}005L + 0{,}24, \quad \text{for } L \le 80 \text{ m};$$
$$b = 0{,}003L + 0{,}4, \quad \text{for } L > 80 \text{ m}. \qquad (2.8.4.5\text{-}2)$$

The web thickness, in mm, of a side stringer shall not be less than

$$s = (0{,}02L + 5) \cdot \sqrt{\eta}, \qquad (2.8.4.5\text{-}3)$$

but not less than 5 mm.

Where L> 300 m, L shall be taken equal to 300 m.

2.8.4.6 The thickness of shell plating in way of the bulb shall not be less than 0,08L+6, but it need not be taken greater than 25 mm. In this case, the shell plating thickness at the lower part of the bulb shall not be less than stipulated under **2.8.4.2.1** for the hull section in way of the forward perpendicular.

2.8.5 Special requirements.

2.8.5.1 Visor-type bow doors.

2.8.5.1.1 The present requirements apply to the construction of visor-type bow doors which form a component part of the fore end of the ship, being mechanically connected with the side and deck structures and capable of moving in the vertical direction to provide access for motor vehicles and/or other transport means.

2.8.5.1.2 The thickness of visor-type bow door plating shall not be less than that required by **2.8.4** for the appropriate sections of shell plating.

2.8.5.1.3 The section modulus of primary members shall not be less than that required by 2.8.4 for the appropriate fore end regions.

In this case, the design load, in kPa, shall not be less than:

$$p_{\min} = 0{,}8(1{,}5v_0 + 0{,}6\sqrt{L})^2. \qquad (2.8.5.1.3\text{-}1)$$

The sectional area of member web shall not be less than determined by Formula (1.6.4.3-1) taking:

$$N_{\max} = 0{,}5pal, \text{ in kN}, \qquad (2.8.5.1.3\text{-}2)$$

where: p – design load in accordance with 1.3.2.2 or 2.8.3.3, whichever is the greater, but not less than p_{min}, in kPa, as determined by Formula (2.8.5.1.3-1);

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

2.8.5.1.4 Structural measures shall be taken to ensure rigid attachment of primary members and support members of bow doors.

2.8.5.1.5 The scantlings of support members shall be obtained by strength calculation using the design loads given in 1.3.2.2 or 2.8.3.3, whichever is the greater, but not less than p_{min} determined by Formula (2.8.5.1.3-1), as well as the permissible stress factors $k_\sigma = k_\tau = 0{,}6$.

2.8.5.1.6 The construction of support members shall comply with the requirements of **1.7.3**.

2.8.5.2 In ships provided with fixed propeller nozzles, transverse bulkheads or support members shall be fitted in way of the nozzle attachment to the hull.

2.8.5.3 In hull curvilinear sections (deadrise, flare), it is recommended that the framing be fitted at an angle of approximately 908 to the shell plating.

2.9 PILLARS AND PANTING BEAMS

2.9.1 General and symbols.

2.9.1.1 Requirements are given in this Chapter for the scantlings of pillars fitted in the hull, superstructures and deckhouses and for the panting beams in peaks.

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

l – length of pillar (panting beam), in m, measured:

for the pillar – between the face plate of the deck girder (or the deck transverse, if the latter is supported by the pillar) and the deck plating (or the inner bottom plating);

for the panting beam – between the inner edges of the starboard and port frames or from the inner edge of the frame to a strong support at the centerline;

f – = sectional area of the pillar (panting beam), in cm^2;

i – the least moment of inertia of the pillar (panting beam), in cm^4;

d_0 – = outer diameter of the pillar, in mm.

2.9.2 Construction.

2.9.2.1 The pillar axes in 'tween deck spaces and holds shall generally be fitted in the same vertical line, the heads and heels of the pillars shall be bracketed.

Where the heel of a tubular pillar with the load $P < 250$ kN has no brackets, the deck (inner bottom) plating under the heel shall be strengthened with doubling or insert plates (P = as determined from **2.9.3.1**).

The web of a framing member to which the head of a pillar is attached shall be strengthened with brackets to transmit the load to the pillar.

The pillars shall be fitted on plate floors and side girders which shall be strengthened with vertical brackets. Openings in floors and side girders under the pillars are not permitted.

With the load $P > 250$ kN (P = as defined in 2.9.3.1), the pillars shall be fitted at the intersection of plate floors and side girders, otherwise the plate floor (side girder) shall be strengthened with vertical brackets attached to the adjacent floors (side girders).

2.9.2.2 The pillars shall be attached at their heads and heels by brackets or other arrangements, in order to effectively transmit the loads to the hull structures below:

in the holds of ships of ice classes**Ice6** and **Ice5;**

in the tanks under watertight platforms, deckhouses, ends of superstructures, windlasses, winches, capstans, etc.;

at the fore end of ships with the specified speed $v_0 > 1,5\sqrt{L}$ (for v_0 – refer to **1.1.3**) or large bow flare.

2.9.3 Design loads.

2.9.3.1 Loads on the pillar P, in kN, is determined by the formula

$$P = pl_m b_m + \sum_i \left(pl_m b_m\right)_i , \qquad (2.9.3.1)$$

where: p – design pressure on the above deck specified in **2.6.3**, in kPa;

l_m – distance measured along the deck girders between mid-points of their spans, in m;

b_m – mean breadth of deck area (including the hatchways in the region concerned) supported by the pillar, in m;

$\sum_i \left(pl_m b_m\right)_i$ – sum of loads from the pillars fitted above, determined having regard to **2.6.3**, which may be transmitted to the pillar considered, in kN.

2.9.3.2 Loads on the panting beam P, in kN, is determined by the formula

$$P = pac, \qquad (2.9.3.2)$$

where: $p = p_{st} + p_w$ – design pressure on the ship's side in way of installation of the panting beam, determined from **1.3.2.1** and **1.3.2.2**, in kPa;

a – spacing of frames on which panting beams are fitted, in m;

c – half-sum of frame spans measured vertically above and under the beam considered, in m.

2.9.4 Scantlings of pillars and panting beams.

2.9.4.1 The sectional area of pillalrs and panting beams f, in cm^2, shall not be less than determined by the iterative method according to the formula

$$f = 10Pk/\sigma_{cr} + \Delta f, \qquad (2.9.4.1)$$

where: P – as determined in accordance with **2.9.3**;
k = 2 – buckling strength margin;
σ_{cr} – critical stress according to **1.6.5.3** at Euler stress determined by the formula:

$\sigma_e = 206\, i / f\, l^2$;
Δf – wear allowances, in cm^2 , determined by the following formulae:

for tubular pillars
$\Delta f = 0{,}03 d_o \Delta s$;

for box-shaped pillars
$\Delta f = 0{,}1 \sum h_i \Delta s$,
where: $\sum h_i$ – perimeter length of cross section, in cm;
Δs – refer to **1.1.5.1**;
i, f, l, d_o – refer to **2.9.1.2**.

2.9.4.2 The wall thickness s, in mm, of tubular pillars shall not be taken less than

$$s = (d_0/50) + 3{,}5. \qquad (2.9.4.2\text{-}1)$$

The wall thickness of built-up pillars (box-shaped, made of channels or I-beams, etc.) s, in mm, shall not be less than

$$s = h_p/50, \qquad (2.9.4.2\text{-}2)$$

where: h_p – width of the pillar wall, in mm.
The wall thickness of a pillar, in general, shall not be taken less than 6 mm.
In small ships the thickness of the pillar walls may be reduced to 5 mm, provided the required sectional area of the pillar is maintained.
2.9.4.3 The thickness of insert plate under the lower end of pillar (refer to **2.9.2.1**) s, in mm, shall not be taken less than

$$s = 3{,}3P \cdot 10^{-3} + 10, \qquad (2.9.4.3)$$

where: P – as defined in **2.9.3.1**.

The diameter of the insert plate shall exceed the diameter of the pillar by ≈ 6s.

2.10 STEMS, KEELS, RUDDER HORN, PROPELLER SHAFT BRACKETS, FIXED NOZZLES OF PROPELLER

2.10.1 General.
Requirements are given in this Chapter for the construction and scantlings of the stem, sternframe (rudder post, propeller post), solepiece of the sternframe, rudder horn of semi-spade rudders, propeller shaft brackets, bar keel, fixed nozzles of propellers.
2.10.2 Construction.
2.10.2.1 It is recommended to use a bar or plate type welded stem. The lower part of the stem shall be efficiently connected to the bar or plate keel and, whenever possible, to the centre girder.
The welded stem plates shall be stiffened with transverse brackets. Arrangement of transverse brackets of the stem shall, as far as possible, be consistent with the hull framing. Transverse brackets stiffening the stem plate are fitted not more than 1 m apart below and not more than 1,5 m above the summer load waterline. The brackets shall overlap the joints of the stem with the shell plating and shall be extended and welded to the nearest frames.
The brackets which cannot be extended to the framing, except for the brackets in way of ice belt in ships with ice categories, shall have their rear edge made along a smooth curve.
In case where the radius of curvature of the stem is sufficiently large, it is recommended to fit a centerline girder with a face plate.
2.10.2.2 The construction of sternframe of a single screw ship shall comply with the following requirements:

.1 the solepiece shall be made with a smooth rise in the aft direction;

.2 the propeller post shall be provided with transverse brackets in the case of welded sternframe and webs in the case of cast sternframe. The brackets and webs shall be spaced at least 1 m apart; their arrangement shall be consistent with the hull framing;

.3 the sternframe shall be efficiently attached to the hull.

The lower part of the sternframe shall be extended forward from the propeller post and shall be attached by its brackets (webs) to at least three floors in ships with a length $L > 120$ m and at least two floors in ships with a length $L \leq 120$ m.

In small ships the sternframe may be attached to one floor only.

The rudder post shall extend over the counter to a height sufficient for its attachment to the transom floor. In ships of 80 m and above and in ships with cruiser stern, the propeller post shall also be extended upwards to a distance sufficient for its attachment to the additional transom floor.

The thickness of transom floor and additional transom floor shall be increased as compared to that of the floors in the after peak. In general, the above floors shall be extended to the nearest deck or platform.

2.10.2.3 The sternframe in twin screw ships shall comply with the requirements for the sternframe in single screw ships, as specified in **2.10.2.2**.

The lower part of the sternframe to be extended forward, may be attached to at least two main floors.

2.10.2.4 The sternframe of triple screw ships shall comply with the requirements for the sternframe of single screw ships, as specified in **2.10.2.2** and **2.10.4.2**.

2.10.2.5 The rudder horn of semi-spade rudder shall be efficiently connected to the respective floors of the after peak and its centreline wash bulkhead.

The welded rudder horn shall be provided inside with transverse brackets; its main supporting structures shall be extended to the nearest deck or platform; the thickness of the floors to which the rudder horn is connected shall be increased as compared to that of the floors in the after peak.

2.10.2.6 The struts of two-strut shaft brackets shall form an angle not less than 50º to each other.

2.10.2.7 The outer and inner plating of propeller nozzle shall be strengthened by stiffeners whose arrangement and size as well as connection with outer and inner plating of the propeller nozzle shall be determined according to **2.4.2.**2, Part III "Equipment, Arrangements and Outfit".

In general, the transverse web plates shall be arranged in line with the floors of the after peak.

In way of attachment of the nozzle to the hull smooth transition from the nozzle to the ship's hull shall be provided. The bottom part of the nozzle shall be connected to the hull. If the propeller nozzle is attached to the hull by shaft brackets, provision shall be made for an efficient connection of the brackets with the framing in the aft region of the hull and the framing inside the nozzle.

The construction of shaft brackets shall satisfy the requirements of **2.10.2.6**.

Drain plugs of non-corrosive material shall be fitted in the top and bottom parts of outer plating.

2.10.3 Design loads.

Design loads for the structures of the solepiece and rudder horn of semi-spade rudders is taken equal to the reaction force of lower support of the rudder R_4 according to **2.2.4.12**, Part III "Equipment, Arrangements and Outfit". In the Formulae (2.2.4.7-2) - (2.2.4.7-4) the coefficient α_4 shall be taken equal to zero.

2.10.4 Scantlings of stem, sternframe, rudder horn and propeller shaft brackets, bar keel and fixed nozzle of propeller.

2.10.4.1 The stem shall satisfy the following requirements:

.1 the sectional area f, in cm^2, of a bar stem from the keel to the summer load waterline shall not be less than

$$f = 1{,}3L - 4. \qquad (2.10.4.1.1)$$

The sectional area may be reduced for ships of restricted areas of navigation:

R2, **A-R2, R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S** and **B-R3-RS** (refer to **1.6.4.6**) – by 10%;

B-R3-S i **B-R3-RS** (refer to **1.6.4.6), C-R3-S**, **C-R3-RS, R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** – by 20%.

Above the summer load waterline the sectional area may be gradually reduced to 70 % of the area stated above;

.2 the plate thickness s, in mm, of welded stem shall not be less than

$$s = (0{,}085L + 5{,}5)\sqrt{\eta}, \qquad (2.10.4.1.2)$$

where: η – as determined from **1.1.4.3**,

but not less than 7 mm.

Where L> 220 m, L shall be taken equal to 200 m;

The plate thickness of the stem may be reduced for ships of restricted areas of navigation:

R2, **A-R2, R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S** and **B-R3-RS** (refer to **1.6.4.6**) – by 5%;

B-R3-S i **B-R3-RS** (refer to **1.6.4.6**), **C-R3-S**, **C-R3-RS, R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** – by 10%.

The plate thickness of the stem above the summer load waterline may be gradually reduced to that of shell plates adjoining the stem.

The thickness and width of the stem plates in way of attachment to the plate keel shall not be less than the thickness and width of the latter.

When the distance between the brackets strengthening the stem is reduced by 0,5 m, as compared to that required by **2.10.2.1**, the reduction of plate thickness of stem by 20 % may be permitted.

If the reduction of the distance between the brackets is less than 0,5 m, the permissible reduction of plate thickness shall be determined by linearinterpolatio;

.3 the thickness of brackets strengthening the stem shall not be less than that of shell plating adjoining the stem. The thickness of web and face plate of the girder stiffening the stem at the centreline shall not be less than that of the brackets.

2.10.4.2 The sternframe of a single screw ship shall satisfy the following requirements:

.1 the length l_s and width b_s , in mm, of rectangular solid propeller post section, from the keel to the counter, shall not be less than

$$l_s = 1{,}30\,L + 95;\quad b_s = 1{,}60L + 20, \qquad \text{for } L < 120 \text{ m}; \qquad (2.10.4.2.1)$$

$$l_s = 1{,}15L + 110;\quad b_s = 0{,}675L + 130, \qquad \text{for } L \geq 120 \text{ m}.$$

The thickness of webs shall be at least 50 % greater than that of the shell plating adjoining the sternframe:

R2, A-R2, R2-S, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S** and **B-R3-RS** (refer to **1.6.4.6**) – by 5%;

B-R3-S and **B-R3-RS** (refer to **1.6.4.6**), **C-R3-S**, **C-R3-RS, R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS** – by 10%.

Above the counter the sectional area of sternframe may be gradually reduced. And nowhere its sectional area shall be less than 40 % of the required area of the propeller post, corresponding to the scantlings stated above (2.10.4.2.1);

.2 the scantlings of the propeller post cross section of a cast sternframe with the rudder having top and bottom supports shall be established in accordance with Fig. 2.10.4.2.2 depending on the value s_0, in mm, determined by the following formulae:

$$s_0 = 0{,}1L + 4{,}4, \qquad \text{for } L < 200 \text{ m}; \qquad (2.10.4.2.2)$$

$$s_0 = 0{,}06L + 12{,}4, \qquad \text{for } L \geq 200 \text{ m}.$$

The thickness of webs shall be at least 50 % greater than that of the shell plating adjoining the sternframe;

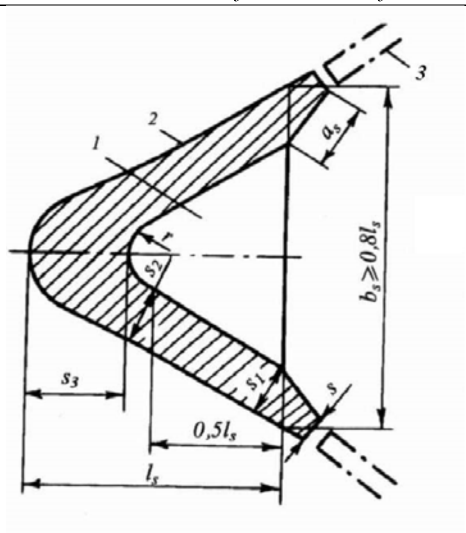


Fig. 2.10.4.2.2
1– web; 2 – along the hull shape; 3 – adjoining plate of shell;
s_1 = 1,5s_o; s_2 = 2,5s_o; s_3 = 3,5s_o;
$l_s \geq$ 1,9L + 135 mm for L < 200 m;
$l_s \geq$ 1,4L + 235 mm for $L \geq$ 200 m;
r – cast radius.

.3 the scantlings of the propeller post cross section of a welded sternframe with the rudder having top and bottom supports shall be established according to Fig. 2.10.4.2.3 where s_o shall be determined in accordance with **2.10.4.2.2**.

The thickness of transverse brackets shall be at least 20 % greater than that of the shell plating adjoining the sternframe.

Welded propeller post of other construction may be used, provided that its strength is equivalent to that of the abovementioned construction;

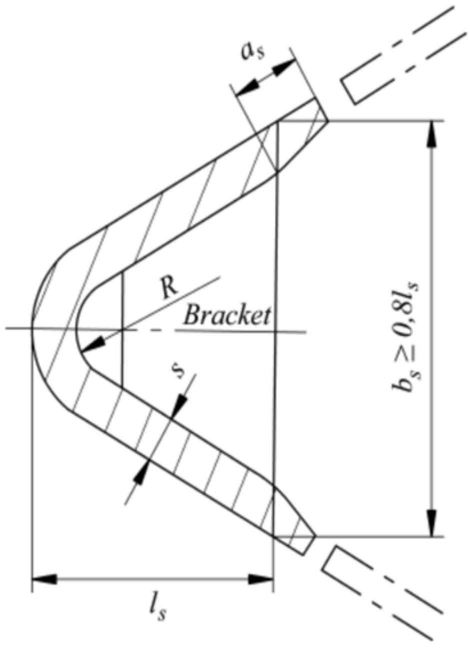


Fig.2.10.4.2.3:
s = 1,65s_o for L < 150 m;
s = 1,5s_o for $L \geq$ 150 m;
l_s =2,5L + 180 mm for L < 200 m;
l_s =1,4L + 400 mm for $L \geq$ 200 m;

R – bending radius.

.4 the finished thickness of propeller boss shall be not less than 30 % of the shaft diameter;
.5 the section modulus W_s, in cm^3 , of the solepiece about the vertical axis shall not be less than

$$W_s = 8\alpha R_4 x_s \eta. \quad (2.10.4.2.5\text{-}1)$$

The section modulus $W_{r.p}$, in cm^3 , of the rudder post about the horizontal longitudinal axis shall not be less than

$$W_{r.p} = 8(1\text{-}\alpha) R_4 l_p \eta. \quad (2.10.4.2.5\text{-}2)$$

where: α= 0,85 if there is a rudder post;
α= 1,0 if there is no rudder post or a bolted rudder post is fitted;
x_s – distance from the solepiece section concerned to the centre of the rudder stock (x_s shall not be taken less than 0,5l_s and more than l_s);
R_4 – as determined according to **2.10.3**;
l_s – span of the solepiece, measured from the centre of the rudder stock to the beginning of rounding of the propeller post, in m;
$l_{r.p}$ – =span of the rudder post, measured vertically from the mid-thickness of solepiece at the centre of the rudder stock to the beginning of rounding in the upper part of the rudder post, in m;
η – as determined according to **1.1.4.3**.

The section modulus of the solepiece about the horizontal transverse axis shall not be less than 0,5 W_s where W_s shall be determined by Formula (2.10.4.2.5-1).
The section modulus of the rudder post about the horizontal transverse axis shall not be less than 0,5 $W_{r.p}$ where $W_{r.p}$ p shall be determined by Formula (2.10.4.2.5-2);
.6 the scantlings of the sternframe structural members may be determined on the basis of direct strength calculation taking the permissible stress factor k_σ = 0,55 and external loads according to **2.2**, Part III "Equipment, Arrangements and Outfit".
2.10.4.3 The scantlings of the sternframe of twin screw ships shall satisfy requirements for the scantlings of propeller post in single screw ships as given in **2.10.4.2** with the following amendments:
.1 the section width of the sternframe of a solid rectangular cross section may be reduced by 50 % as compared with that required by **2.10.4.2.1**;
.2 the scantlings of the cast or welded sternframe may be reduced as compared with those required by **2.10.4.2.2** and **2.10.4.2.3** respectively, so that their section moduli about the horizontal longitudinal and transverse axes, are reduced by not more than 50 %. The thickness of the sternframe wall shall be at least 7 mm.
2.10.4.4 For semi-spade rudders with one gudgeon upon the horn, the section modulus, in cm^3 , of the rudder horn about the horizontal longitudinal axis shall not be less than

$$W = 12 R_4 z_s \eta. \quad (2.10.4.4)$$

where: R_4 – = as defined in to **2.10.3**;
z_s – vertical distance for the mid-thickness of the horn gudgeon to the section concerned, in m (z_s shall not be taken less than 0,5l_h and more than l_h);
l_h – horn span measured vertically from the mid-thickness of the horn gudgeon to the point of intersection of the horn axis with shell plating, in m;
η – as determined according to **1.1.4.3**.

Where the rudder horn is welded of plates, the thickness of the plates, in all cases, shall be at least 7 mm.
The scantlings of the rudder horn may be determined on the basis of direct strength calculation taking the permissible stress factor k_σ = 0,35 and external loads according to **2.2**, Part III "Equipment, Arrangements and Outfit"..

2.10.4.5 The sectional area of either strut of two-strut shaft brackets shall be equal to not less than 60 % of the propeller shaft section in the bracket plane, the strut thickness _ to not less than 45 %, and the boss thickness – to not less than 35 % of the propeller shaft diameter.

The length of the boss shall be in accordance with 5.6.1, Part VII "Machinery Installations".

The strength of the welded shaft brackets shall not be less than that specified above. The plate thickness shall not be less than 7 mm.

The weld area of rivets attaching each strut to the hull shall not be less than 25 % of the propeller shaft sectional area. Where the struts are attachhed by means of flanges, the thickness of the latter shall be not less than 25 % of the propeller shaft diameter.

2.10.4.6 The height h_s and width b_s in mm, of the bar keel cross section shall not be less than:

$$h_s = 1{,}3L + 100;$$
$$b_s = 0{,}7L + 8, \quad \text{for } L < 60 \text{ m}; \qquad (2.10.4.6)$$
$$b_s = 0{,}4L + 26, \quad \text{for } L \ge 60 \text{ m}.$$

The height and width of the bar keel cross section may be reduced for ships of restricted areas of navigation:

R2, **A-R2, R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S** and **B-R3-RS** (refer to **1.6.4.6**) **-** by 5%;

B-R3-S and **B-R3-RS** (refer to **1.6.4.6**), **C-R3-S**, **C-R3-RS, R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS -** by 10%.

2.10.4.7 The thickness of outer and inner plating of fixed propeller nozzle shall comply with the requirements of **2.4.2**, Part III "Equipment, Arrangements and Outfit" taking the following into consideration:

width of middle belt of inner plating shall be not less than the distance from 0,03 D_o forward of the propeller blade tips and 0,07D_o aft of the propeller blade tips where D_o is the internal diameter of propeller nozzle;

thickness of forward part of the inner and outer plating shall be not less than required for side shell plating (refer to **2.2.4.1** for transverse framing system).

The width of attachment shall be at least 0,15D_o.

The cross-sectional area of the joint shall be not less than required by **2.10.4.2.**5 for the solepiece.

For twin screw ships when the propeller nozzle is not attached to the hull at its bottom part, the width of attachment at the top part shall be not less than 0,3D_o.

If the propeller nozzle is attached to the hull by shaft brackets, their strength shall comply with the requirements of **2.10.4.5**.

In way of attachment of the nozzle to the hull the thickness of framing members shall not be less than required by Formula (2.4.2.2-2), Part III "Equipment, Arrangements and Outfit".

2.11 SEATINGS OF MACHINERY AND BOILERS

2.11.1 General.

2.11.1.1 Requirements are given in this Chapter for the construction and dimensions of the seatings intended for main machinery and boilers, deck machinery, fishing installations, cargo handling gear, auxiliary machinery, etc.

2.11.1.2 Requirements of this Chapter are minimal. Requirements concerning construction and dimensions of structural components of a seating, which are contained in the technical documentation of the machinery, unit or device to be installed on the seating concerned, shall also be complied with.

2.11.1.3 For dimensions of the structural components of the seatings intended for mooring and towing appliances — refer to **4.3** and **5.3**, Part III "Equipment, Arrangements and Outfit".

2.11.2 Construction of seatings.

2.11.2.1 The construction of seatings shall satisfy the following requirements:

.1 the seating shall be of substantial construction to ensure efficient attachment of machinery, gear or device and transmission of forces to the hull framing, which shall be sufficiently strong. If necessary, the framing may be strengthened;

.2 the seating shall be so constructed that the resonance vibration of the seating as a whole and of its structural components can be avoided under all specified running conditions;

.3 where the seating in ships with a length $L > 65$ m is installed on the continuous longitudinals of strength deck and double bottom (bottom) within $0{,}5L$ amidships, the height of the vertical plates of the seating at the ends shall be gradually reduced.

If the length of the vertical plate is more than six times its height, the vertical plate and its top plate shall be made of the same steel grade as the deck or double bottom (bottom) structural member on which it is installed.

The structural components of the seating shall not terminate at the unsupported portions of plating;

.4 the seating shall be so designed that the plating beneath is accessible for inspection. Measures shall be taken to prevent water from accumulating under the seating.

2.11.2.2 In general, a seating of main machinery and boilers shall comprise two vertical plates (girder webs) (for medium-speed and high power engines — four vertical plates (two — either side of the engine)) and horizontal face plates (top plates) to which the machinery (boiler) shall be attached directly.

The vertical plates shall be strengthened with brackets (knees) having face plates (flanges) along the free edges.

Where the seating comprises four vertical plates, the top plate is attached to two vertical plates fitted on one side of the machinery; the outer plates shall have openings to provide access into the seating.

In the case of medium-speed engines, such openings shall not extend to the top plate.

The outer plates may be made sloped.

All the vertical plates shall be fitted in line with the main or additional side girders.

2.11.2.3 Machinery and equipment may be installed on shell plating of the hull, tight bulkheads, decks and platforms (including tank bulkheads and crown), inner bottom and shaft-tunnel platings on condition they are attached to the framing members and stiffeners (refer to **1.7.1.4**), or on cantilevers connected to framing members or stiffeners.

Attachment of small-sized machinery and equipment directly to the above-mentioned structure with the help of welded pads is not permitted.

2.11.3 Dimensions of structures of seatings.

2.11.3.1 The thickness s, in mm, of structural components of a seating of main machinery or boiler shall not be less than

$$s = k_0\sqrt[3]{Q} + k_1, \qquad (2.11.3.1)$$

where: Q – mass of machinery (boiler) in working condition, in t;
k_0 – factor given in Table 2.11.3.1-1;
k_1 – factor given in Table 2.11.3.1-2.

Table 2.11.3.1-1

Seating of machinery (boiler)	k_0		
	Top plates	Vertical plates[1]	Brackets, knees
Main internal combustion engine	4,65	3,0	2,5
Main geared turbine set, main diesel generator and propulsion motor	4,15	2,7	2,7
Boiler	3,65	2,4	2,4
[1]In a seating with four vertical plates the thickness of the plates may be taken equal to the thickness of brackets and knees.			

Table 2.11.3.1-2

Mass of machinery (boiler), in t	≤ 20	> 20 ≤ 50	> 50 ≤ 100	> 100 ≤ 200	> 200
k_1	4	3	2	1	0

2.11.3.2 The thickness s, in mm, of structural components of a seating of main internal combustion engine shall not be less than:

$$s = k_2\sqrt[3]{N} + k_3, \qquad (2.11.3.2)$$

where: N – specified power of the engine, in kW;

k_2, k_3 – factors given in Table 2.11.3.2,

Таблиця 2.11.3.2

N, in kW	Number of vertical plates	Factor	Top plates	Vertical plates	Brackets, knees
≤ 1000	2	k_2	1,7	1,1	0,9
		k_3	6	4	3
	4	k_2	1,4	0,9	0,9
		k_3	5	3	3
> 1000	2	k_2	1,0	1,0	0,7
		k_3	13	5	5
	4	k_2	0,8	0,7	0,7
		k_3	11	5	5

but not less than required by **2.11.3.1**.

2.12 SUPERSTRUCTURES, DECKHOUSES AND QUARTER DECKS

2.12.1 General provisions, definitions and symbols.

2.12.1.1 Requirements are given in this Chapter for short and long bridges extending from side to side of the ship as well as to short bridges which do not extend to the sides of the ship, forecastle, poop, long forecastle and poop extending to ship's sides, short deckhouses and quarter decks.

2.12.1.2 L o n g d e c k h o u s e is a deckhouse of a length not less than that determined by Formula (2.12.1.2-1), but not less than 0,20 L, having no expansion or sliding joints .

L o n g b r i d g e is a superstructure having a length not less than:

$l_1 = 2\,l_e$, (2.12.1.2-1)

but not less than 0,15 L .

Q u a r t e r d e c k is the after part of upper deck stepped up to a portion of 'tween deck height.

E n d s o f s u p e r s t r u c t u r s a n d d e c k - h o u s e s are the ends of the length measured from the end bulkheads, in m,

$L_e = 1{,}5\,(B_2/2 + h)$. (2.12.1.2-1)

S h o r t d e c k h o u s e is any deckhouse which is not a long deckhouse.

Deckhouses of ships less than 65 m in length are considered as short deckhouses.

S h o r t b r i d g e is any bridge which is not a long bridge.

Superstructures of ships less than 65 m in length are considered as short superstructures.

T r a n s i t i o n a r e a o f q u a r t e r d e c k – is an area measured from the forward edge of break to the after edge of upper deck plating and extending below the quarter deck.

L o n g f o r e c a s t l e (p o o p) is a forecastle (poop) having a length not less than

$l_1 = 0{,}1L + l_e$, (2.12.1.2-3)

in ships of 65 m and greater in length

D e c k s t e p u p is a stepped up or lowered part of the deck upon side depth, (may be vertical or inclined).

2.12.1.3 Symbols:

B_2 – breadth of superstructure deck measured at its mid-length, excluding the breadth of openings of cargo hatches, machinery casings, if any, in m; helicopter deck (platform), which is part of the upper deck or the superstructure or deckhouse top;

B_x – ship's breadth at the level of the upper deck at the section considered, in m;

b – breadth of the deckhouse, in m;

h – height of the first tier of superstructure or deckhouse, in m;

l_1 – = length of superstructure (deckhouse) measured between the end bulkheads; the length of forecastle (poop) measured from the fore or after perpendicular to the end bulkhead of the forecastle (poop), in m;

2.12.2 Construction.

2.12.2.1 For the first tier of long bridge outside the end portions, long forecastle (poop) outside the end portion, the requirements of **2.6** for the upper deck and the requirements of **2.2** and **2.5** for the ship's side in way of the upper 'tween deck space shall be complied with.

2.12.2.2 For the buttom strake of side plating and longitudinal bulkhead plating of short bridge, the ends of 1st tier long bridges and long forecastle (poop), the bottom strake of side plating of steel short deckhouses and the ends of steel long deckhouses fitted on the strength deck, grade of steel and yield stress shall be the same as required for the strength deck in this region. The width of the bottom strake shall not be less than 0,5h.

2.12.2.3 Whenever practicable, the end bulkheads of superstructures and deckhouses shall be situated in line with the hull transverse bulkheads or as close to the latter as possible.

Web frames or vertical webs, bulkheads or partial bulkheads shall be fitted in superstructures and deckhouses in such a way as to be in line with girder webs or bulkheads of hull structures located below. The vertical webs of end bulkheads shall be fitted in line with the vertical webs of hull bulkheads.

2.12.2.4 The lower ends of vertical stiffeners of the end bulkheads of the 1st tier superstructures and deckhouses shall be welded to the deck. The lower ends of side vertical stiffeners of 1st tier houses shall be attached to the deck by brackets.

2.12.2.5 Adequate strengthening shall be provided for the structures of deckhouses and superstructures where launching and recovery appliances for survival craft and rescue boats are fitted.

2.12.3 Design loads.

2.12.3.1

.1design pressure on the superstructure sides is determined according to **2.2.3**;

.2 design pressure on weather areas of the superstructure and deckhouse decks shall be determined by the formula

$$p = \alpha \cdot p_w, \tag{2.12.3.1.2}$$

where: p_w – wave load at the deck level according to **1.3.2.2**;

α = 0,9 for forecastle deck, long forecastle deck or part of long bridge deck within 0,2L from the fore perpendicula;

α = 0,8 for poop deck, long poop deck or part of long bridge deck within 0,2L from the after perpendicular;

α = 0,7 for short bridge and deckhouse decks, long superstructure and deckhouse decks, long forecastle and poop decks within the midship region.

For areas of long bridge and deckhouse decks, long forecastle and poop decks outside the midship region and outside areas situated at 0,2L from the fore or after perpendicular, α shall be determined by linear interpolation.

but not less than p_{min}.

For the 1st tier superstructure and deckhouse decks, p_{min} in kPa, shall be determined by the following formulae:

for forecastle, long forecastle decks or part of long bridge deck within 0,2L from the fore perpendicular

$$p_{min} = 0,1L + 7;$$

for poop, long poop deck or part of long bridge deck within 0,2L from the after perpendicular

$$p_{min} = 0,015L + 4 \quad \text{for } L \le 80 \text{ m};$$
$$p_{min} = 0,03L + 2,8 \quad \text{for } L > 80 \text{ m};$$

for bridge and deckhouse decks, long forecastle and poop decks within the midship region

$$p_{min} = 0,015L + 4;$$

for areas of bridge and deckhouse decks, long forecastle and poop decks outside the midship region and outside areas situated at 0,2L from the fore or after perpendicular, p_{min} shall be determined by linear interpolation.

For decks of the superstructures and deckhouses of the 2nd and upper tiers

p_{min} = 2 kPa.

For ships greater than 250 m in length, p_{min} is determined taking L = 250 m.

For ships of restricted area of navigation, p_{min} may be reduced by multiplying by the factor φ_r, obtained from Table **1.3.1.5**.

2.12.3.2 Pressure on the end bulkheads of superstructures and deckhouses as well as on sides of deckhouses p, in kPa, is determined by the formula

$$p = 5{,}1nc_2(kz_0 - z_1), \qquad (2.12.3.2)$$

where: n – factor determined from Table 2.12.3.2-1;

$c_2 = 0{,}3 + 0{,}7b/B_x$, in this case $c_2 \geq 0{,}5$;

$k = 1{,}0 + \left(\frac{x_1/L - 0{,}45}{C_b + 0{,}2}\right)^2$ when $x_1/L \leq 0{,}45$;

$k = 1{,}0 + 1{,}5\left(\frac{x_1/L - 0{,}45}{C_b + 0{,}2}\right)^2$ when $x_1/L > 0{,}45$;

for the sides of deckhouses the factor k is assumed to vary for the length of bulkhead. For this purpose the deckhouse is subdivided into parts of approximately equal length not exceeding 0,15L each, and x_1 is taken as the distance between the after perpendicular and the middle of the part considered;

C_b – shall be taken as not less than 0,6, nor greater than 0,8; for the aft end bulkheads forward of amidships C_b = 0,8;

z_0 – as given in Table 2.12.3.2-2;

z_1 – = vertical distance, in m, from the summer load waterline to the mid-point of the plate panel considered or the mid-point of span of the bulkhead stiffener.

The above-stated valus of factor n apply to a ship having the freeboard equal to minimum tabular freeboard of Type "B" ships, and a standard height of superstructures according to Section **4** of the Load Line Rules for Sea-Going Ships.

If the deck of the tier considered is situated higher than the standard position due to an increase of freeboard, as against the tabular value, then the appropriate factor n may be determined by linear interpolation between the values of that factor for superstructures with standard and actual positions of decks under the superstructures.

In any case, the design pressure shall not be taken less than indicated in Table 2.12.3.2-3.

Table 2.12.3.2-1

Bulkhead	Structure		n
Front	Unprotected	1st tier	$2 + L_0/120$
		2nd tier	$1 + L_0/120$
		3rd tier	$0{,}5 + L_0/150$[1]
	Protected		
Aft end	Aft of amidships		$0{,}7 + (L_0/1000) - 0{,}8x_1/L_0$
	Forward of amidships		$0{,}5 + (L_0/1000) - 0{,}4x_1/L_0$

L_0 – length of ship, in m (to be taken not greater than 300 m for the purpose of calculation);
x_1 – distance, in m, between the after perpendicular and the bulkhead under consideration.
[1] Formula is also used for the deckhhouses sides.

Table 2.12.3.2-2

L, m	z_0, m	L, m	z_0, m
20	0,87	180	9,85
40	2,59	200	10,25
60	4,07	220	10,55
80	5,42	240	10,77
100	6,60	260	10,92
120	7,69	280	11,00

140	8,63	300	11,03
160	9,35	350	11,05

Table 2.12.3.2-3

L, m	Design pressure p, in kPa	
	for 1st tier unprotected fronts	elsewhere
≤ 50	15,6	7,8
50 < L< 250	13 + 0,052L	6,5 + 0,026L
≥ 250	26	13

For ships of restricted area of navigation the design pressure may be reduced by multiplying by the factor φ_r, obtained from Table 1.3.1.5.

2.12.4 Розміри конструкцій надбудов, рубок і квартердеку.

2.12.4.1 The thickness of side plating of short and long bridges, forecastle and poop, long forecastle and poop shall be determined according to **2.2.4.1** using the design loads given in **2.12.3.1.1**.

For short bridges, forecastle and poop, k_σ = 0,7.

For long bridge, long forecastle and poop outside the end portions, ks is determined according to **2.2.4.1**;

at sections in way of end bulkheads k_σ = 0,7;

within the end portions k_σ shall be determined by linear interpolation.

The thickness of side plating of long bridges, long forecastle and poop shall satisfy the requirements of **2.2.4.8**.

In any case, the thickness s_{min}, in mm, of side plating of short bridges, forecastle and poop shall not be less than:

for superstructures of the lowest tier

$$s_{\min} = (4,5 + 0,025L) \cdot \sqrt{\eta}; \qquad (2.12.4.1\text{-}1)$$

for superstructures of other tiers

$$s_{\min} = (4 + 0,02L) \cdot \sqrt{\eta}, \qquad (2.12.4.1\text{-}2)$$

where η is obtained from Table 1.1.4.3.

Where L> 300 mm, L shall be taken equal to 300 m.

For ships of unrestricted service **A** and ships of restricted area of navigation **R1**, **A-R1** the reduction of minimal thickness, but not more than 10 %, is permitted in proportion to the ratio of adopted spacing to standard spacing, where the adopted spacing is less than the standard one (refer to **1.1.3**). In any case, for ships of 30 m and greater in length the minimum thickness shall be not less than 5 mm.

2.12.4.2 The thickness of deck plating of short and long bridges, forecastle and poop, long forecastle and poop, short and long deckhouses shall be determined according to **2.6.4.1.1** and **2.6.4.1.2** using the design loads stated in **2.12.3.1.2**.

For short bridges, forecastle, poop and short deckhouses, k_σ = 0,7.

For long bridge, long forecastle and poop outside the end portions, k_σ is determined as for the strength deck according to 2.6.4.1.2;

at sections in way of end bulkheads k_σ shall be determined by linear interpolation.

The thickness of deck plating of long bridges, long forecastle and poop, long deckhouses shall satisfy the requirements of 2.6.4.1.5 for the upper deck between the side and the line of large openings.

In any case, the thickness $s_{\min}$, in mm, of deck plating of short bridges, forecastle and poop, short deckhouses shall not be less than:

for open forecastle deck

$$s_{\min} = (4 + 0,04L) \cdot \sqrt{\eta} \quad \text{for } L < 100 \text{ m}; \qquad (2.12.4.2\text{-}1)$$

$$s_{\min} = (7 + 0,01L) \cdot \sqrt{\eta} \quad \text{for } L \geq 100 \text{ m};$$

for other decks of superstructures and deckhouses of the lowest tier

$s_{min} = (5 + 0{,}01L) \cdot \sqrt{\eta}$; (2.12.4.2-2)

for superstructure and deckhouse decks of other tiers

$s_{min} = (4 + 0{,}01L) \cdot \sqrt{\eta}$, (2.12.4.2-3)

where: η is obtained from **1.1.4.3**.

Where L> 300 mm, L shall be taken equal to 300 m.

For ships of unrestricted service **A** and ships of restricted area of navigation **R1**, **A-R1**, the reduction of minimal thickness, but not more than 10 %, is permitted in proportion to the ratio of adopted spacing to standard spacing, where the adopted spacing is less than the standard one (refer to **1.1.3**).

In any case, the minimum thickness shall not be less than 5 mm for ships of length $L \geq 50$ m.

The minimum thickness may be reduced to 4 mm for ships of length $L \leq 50$ m, and to 3 mm for ships of length $L < 20$ m.

2.12.4.3 The plate thickness of the end bulkheads of superstructures, sides and end bulkheads of deckhouses shall not be less than that determined by Formula (1.6.4.4) taking:

$m = 15{,}8$;
$k_\sigma = 0{,}6$;
$\Delta s = 0$;
p – as defined in **2.12.3.2**.

The thickness of side plating of deckhouses may be not less than that of superstructures as stated in **2.12.4.1**, provided they are arranged similarly over the ship's length and depth.

The thickness of bottom plates of end bulkheads in superstructures (deckhouses) of 1st tier shall be increased by 1 mm as compared with the design thickness.

The width of bottom plate shall be not less than 0,5 mm. If the deckhouse front extends in a fair convex form beyond the intersection with the deckhouse sides, the thickness of plating may be taken 0,5 mm less as compared with the design value.

2.12.4.4 In any case, the plate thickness s_{min}, in mm, of superstructure end bulkheads, sides and end bulkheads of deckhouses shall not be less than:

for the lowest tier

$s_{min} = (5 + 0{,}01L) \cdot \sqrt{\eta}$, (2.12.4.4-1)

for other tiers

$s_{min} = (4 + 0{,}01L) \cdot \sqrt{\eta}$, (2.12.4.4-2)

where: η is obtained from **1.1.4.3.**

Where L> 300 mm, L shall be taken equal to 300 m.

In any case, the minimum thickness shall not be less than 5 mm for ships of length $L \geq 50$ m.

The minimum thickness may be reduced to 4 mm for ships of length $L \leq 50$ m, and to 3 mm for ships of length $L < 20$ m.

Reduction of the minimum thickness is not permitted for fronts of bridge and unprotected front of poop in ships of length$L \geq 20$м.

2.12.4.5 Framing of the sides, decks and end bulkheads of the forecastle, poop and bridge, quarter deck and deckhouse shall satisfy the following requirements:

.1 side framing of the superstructure shall comply with the requirements for side framing in 'tween deck space as specified in **2.5.4.2 - 2.5.4.5** using the design loads given in **2.12.3.1.1**. For longitudinals and side stringers of short bridge, forecastle and poop, $k_\sigma = 0{,}65$.

For longitudinals and side stringers of long bridge, long forecastle and poop outside the end portions, k_σ is determined according to **2.5.4.3** and **2.5.4.4**;

at sections in way of the end bulkheads k_σ = 0,65; within the end portions k_σ shall be determined by linear interpolation;

.2 underdeck framing of the superstructure and deckhouse shall satisfy the requirements of **2.6.4.2 - 2.6.4.9** using the design loads stated in **2.12.3.1.2**.

For longitudinals and deck girders of long bridge, long forecastle and poop outside the end portions, k_σ is determined in accordance with **2.6.4.2** and **2.6.4.4**; at sections in way of the end bulkheads ks=0,65; within the end portions k_σ shall be determined by linear interpolation;

.3 section modulus of vertical stiffeners of the end bulkheads of superstructures, deckhouse sides and end bulkheads shall not be less than that determined according to **1.6.4.1** taking:

$k_\sigma = 0,6$;
$\Delta W = 0$;
$\omega_k = 1$;
p – as defined in **2.12.3.2**;
m = 12, if the lower end of the stiffener is attached to the deck by a bracket;
m = 10, if the lower end of the stiffener is welded to the deck;
m = 8, if the lower end of the stiffener is sniped.

The section modulus of stiffeners of deckhouse sides need not be greater than that of frames of superstructures as stated in **2.12.4.5.1**, where arranged similarly over ship's length and depth.

2.12.4.6 The scantlings of members of bulkheads and partial bulkheads inside the superstructures and deckhouses shall satisfy the requirements of **2.7.4.5**, unless stated otherwise.

2.12.5 Special requirements.

2.12.5.1 The upper deck areas situated under the long bridge, long forecastle and poop outside the end portions shall satisfy the requirements of **2.6** for the second deck.

Requirements for the upper deck areas situated under the ends of long bridge, long forecastle and poop are determined by linear interpolation between the requirements for the upper deck and those for the second deck.

2.12.5.2 In way of the end bulkheads the following requirements shall be complied with:

.1 where the superstructure end bulkhead is not in line with the transverse bulkhead of the hull, partial bulkheads or pillars shall be fitted in spaces below the end bulkhead, or frames and beam knees shall be strengthened;

.2 where the end bulkhead of long deckhouse is not in line with the transverse bulkhead below, short deck girders shall be fitted in line with deckhouse sides under the house deck so as to extend further for three frame spaces forward and aft of the deckhouse end bulkhead;

.3 at the section, where the end bulkheads of superstructures and deckhouses abut on the undeck longitudinal structures and the sides of deckhouses _ on the transverse underdeck structures fitted below (bulkheads, partial bulkheads, undeck girders, deck transverses, etc.), the webs of these underdeck structures shall be stiffened with brackets.

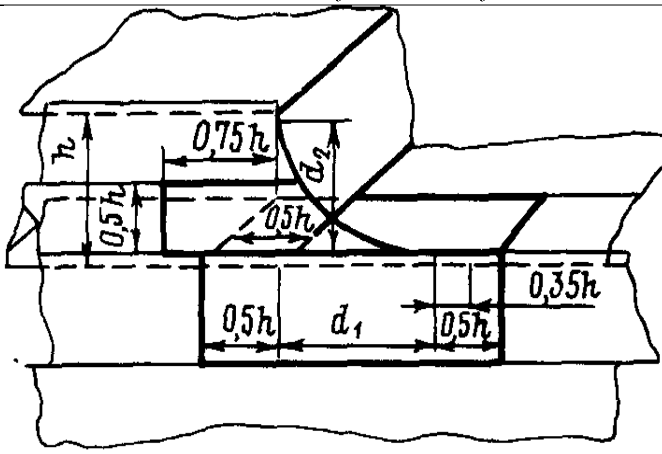
2.12.5.3 The structure at the ends of superstructures shall satisfy the following requirements:

.1 at the ends of bridge, long forecastle and poop located within 0,6L midship region of a ship with a length $L \geq 60$ m the side plating shall be extended beyond the end bulkhead with smooth tapering to the ship's side on a length d_1, in m, (refer to Fig. 2.12.5.3.1), determined by the formula:

$$d_1 \geq 0,2 \cdot (0,5 \cdot B_2 + h), \qquad (2.12.5.3.1)$$

where: for B_2, h – refer to **2.12.1.3**.

The value of d_1 may be reduced provided that the thickness of bottom strake of the superstructure side plating, sheerstrake and deck stringer plate within the region shown in Fig. 2.12.5.3.1 is increased;



$0{,}5h \le d_2 = 0{,}65d_1 \le 0{,}75h$

Fig. 2.12.5.3.1

.2 if the end of superstructure (forecastle, poop) is located within 0,1L from the fore or after perpendicular, as well as in ships of length L≥65 m the value of d_1 may be reduced by half.

If the end of a superstructure is located outside the above-mentioned regions and outside 0,6L amidships, the value of d1 shall be determined by linear interpolation;

.3 the blunted ends of projecting side plates shall be machined flush with the deck. The curved edge of side plating shall be stiffened by flat bar carried down for 50 mm from the edge. The ends of that bar shall be sniped.

Openings in side plating projecting beyond the ends of a superstructure are normally not permitted.

The projecting plates shall be attached to the bulwark by means of flexible joints;

.4 at the ends of short bridge not extending from side to side of ship the attachment of the side to the deck shall be made similarly to the attachment required by **2.12.5.4** for deckhouses, otherwise gussets shall be used to provide smooth transition from the side to a short deck girder strengthening the deck under that side with simultaneous strengthening of the deck stringer plate within the region shown in Fig. 2.12.5.3.1.

2.12.5.4 Attachment of sides of the deckhouse to the end bulkhead arranged within 0,6*L* amidships of a ship with a length *L*≥65 m shall be performed by rounding with a radius *r*, in m, determined by the formula:

$$r = l_1 \cdot (1{,}5 + 0{,}1 \cdot l_1/b)/100 \le 1{,}4, \qquad (2.12.5.4)$$

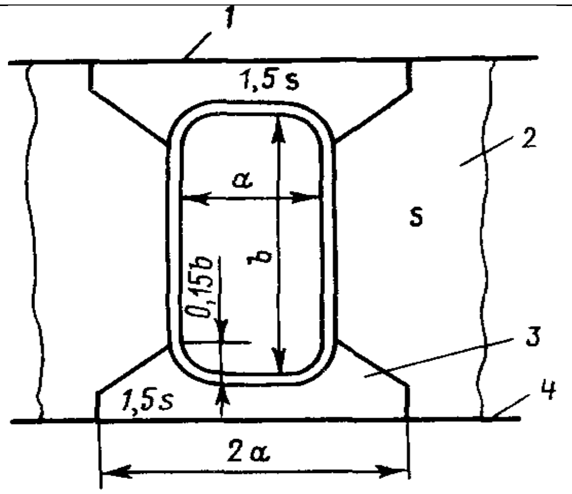
where: b – breadth of the deckhouse in way of the end bulkhead, in m;
l_1 – refer to **2.12.1.3**.

2.12.5.5 Rectangular openings in outer sides and top plating of long deckhouses shall have their corners well rounded and shall be substantially framed.

Door openings in the sides of a deckhouse, arranged within 0,6L amidships, shall be additionally reinforced with thickened plates as shown in Fig. 2.12.5.5. Rectangular openings are not permitted for a length not less than the height of the deckhouse counted from the end bulkhead, if the deckhouse is situated on the strength deck.

If door openings in sides are arranged outside the midship region or if the deckhouse is short, the thickened plates may be fitted only below the opening as shown in Fig. 2.12.5.5.

Where the distance between the expansion or sliding joints is less than a triple height of the deckhouse, it is sufficient to provide the rounding of the corners of openings. Openings for side scuttles shall have the upper and lower edges reinforced with horizontal stiffeners.



1 – deckhouse top; 2 – deckhouse side; 3 – thickened plate; 4 – _ strength dec
Fig. 2.12.5.5

2.12.5.6 The structures in way of the break at connection of the upper deck to quarter deck in ships of 90 m and under shall satisfy the following requirements:

.1 the upper deck plating in way of the break shall extend abaft the break for three frame spaces in ships of 60 m in length and above, and for two frame spaces in ships less than 60 m in length.

The upper deck plating of ships less than 40 m in length need not extend abaft the break.

.2 the upper deck stringer plate shall extend abaft the steel plating for three frame spaces, where $L \geq 60$ m, and for two frame spaces, where $L < 60$ m. The stringer plate so arranged shall be tapered from its full width to a width equal to the depth of frame to which it is welded;

.3 the stringer plate of quarter deck shall extend forward in the form of a bracket gradually tapered to ship's side on a length of three frame spaces. The quarter deck stringer plate projecting beyond the break shall be adequately stiffened and its free edge shall have a face plate or flange;

.4 the sheerstrake of quarter deck shall extend forward of the deck stringer plate projecting beyond the break bulkhead for at least 1,5 times the height of break and shall be smoothly tapered into the upper edge of ship's side sheerstrake. For other structural requirements, refer to **2.12.5.3**;

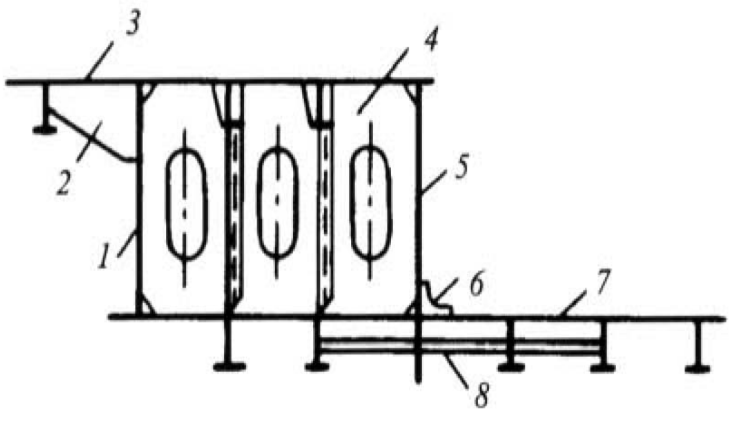
.5 diaphragm plates spaced not more than 1,5 m apart shall be fitted over the ship's breadth between the overlapping decks in way of the break. The thickness of diaphragms shall not be less than the thickness of the break bulkhead plating.

The diaphragm plates shall be strengthened by vertical stiffeners.

Vertical stiffeners with effective flange shall have a moment of inertia not less than that determined by Formula (1.6.5.6-1).

Continuous welds shall be used to attach the horizontal edges of diaphragm plates to the decks, and the vertical edges to break bulkhead on one side, and on the other side to an extra supporting bulkhead made of continuous plate welded to the decks over the ship breadth. The plate thickness of that bulkhead shall be not less than the thickness of break bulkhead plating and may have openings between diaphragms;

.6 where a supporting bulkhead is fitted, the diaphragm plates shall be stiffened with brackets fitted to their ends (refer to Fig. 2.12.5.6.6);



1 - supporting bulkhead; 2, 6 - brackets; 3 - quarter deck; 4 - diaphragm; 5 - break bulkhead; 7 - upper deck; 8 - stiffener in line with bracket

Fig. 2.12.5.6.6

.7 where a raised quarter deck is adjoining the bridge, it shall extend into that superstructure for two frame spaces beyond the break, the extension being, in any case, not less than the elevation of superstructure above the quarter deck.

The quarter deck stringer plate shall extend forward for two frame spaces with the width gradually reduced as required by **2.12.5.6.2**.

Strengthening of the overlapping decks in way of break shall comply with requirements of **2.12.5.6.5** and **2.12.5.6.6** depending on the location of the break along the length of the ship.

The superstructure side plates extending aft of the superstructure shall be smoothly tapered into the sheerstrake on a length of at least 1,5 times the height of break (refer also to **2.12.5.3.1**).

.8 strengthening in case where the break bulkhead is located within 0,25L from the after perpendicular shall comply with the following requirements:

in ships greater than 60 m in length, the supporting bulkhead fitted over the breadth the ship may be omitted. The free edges of diaphragm plates shall, in this case, be stiffened with face plates or flanges of a width equal to at least ten thicknesses of the diaphragm plate;

in ships of 60 m in length and below, the upper deck plating need not extend aft of the break over the ship breadth, however, the upper deck stringer and the raised quarter deck stringer and sheerstrake shall be extended forward and aft as provided in **2.12.5.6.3** and **2.12.5.6.4**.

2.12.5.7 The use of aluminium alloys for the construction of deckhouses is permitted. Decks of accommodation and service spaces situated above the machinery and cargo spaces shall be made of steel.

The scantlings of aluminium deckhouses shall be determined according to **1.6.6**. The minimum scantlings shall be the same as those required for steel deckhouses.

The degree to which the deckhouse of aluminium alloys contributes to longitudinal bending of the hull and stresses in ship's hull and deckhouse shall be determined according to the procedure approved by the Register.

2.12.6 Helicopter deck.

2.12.6.1 The design of the Helicopter Deck, which is the upper deck or the superstructure or deckhouse top:

.1 The main members of the deck framing should be installed parallel to the axis of the helicopter during its take-off and landing;

.2 Plating thickness, section modulus cross-section area of the deck main and web members webs is determined in accordance with **3.2.4.1** ÷ **3.2.4.3** with Q, determined by the Formula (3.2.3.4), and l_a and l_b taken 0,3 m. In formula (3.2.3.4) Q_0 is taken equal to the take-off weight of the helicopter, in kN; $k_d = 3$, $n_0 = 2$, $n = 1$;

.3 Scantling of members, pillars, as well as cross stays and panting beams for the helicopter, which is fitted with skids instead of wheels, shall be determined by direct calculation.

2.12.6.2 The design of the Helicopter Deck (platform), which is not the upper deck or the superstructure or deckhouse top:

.1 Plating thickness, section modulus cross-section area of the deck main and web members webs is determined in accordance with **2.12.4.2**, **2.12.4.5**, **2.12.6.1**, as for the short deck house or deck house of corresponding tier;

.2 Scantling of stiffeners and panting beams is determined in accordance with **2.9** as for pillars;

.3 Scantling of members, pillars, as well as cross stays and panting beams, are to be determined taking into account forces of inertia of the mass of deck structures. Acceleration to determine the inertial forces are determined according to **1.3.3.1** and **1.3.4.4**;

.4 Use of aluminum alloys is allowed. Strength and stability of the Helicopter decks made of aluminum alloys are allowed to be determined by the method of model tests, which is to be carried out in the presence of a representative of the Register under an agreed program;

.5 Helicopter Deck (platform) construction is to take into account the provisions of **11.2.6** of Part III "Equipment, Arrangements and Outfit".

2.13 MACHINERY CASINGS

2.13.1 General.

Openings in decks and platforms over engine rooms shall be protected by strong casings.

The casings may be omitted only in cases where the space on the deck or platform is a part of the engine room.

2.13.2 Construction.

2.13.2.1 Where there are large openings in the deck in way of engine room, additional pillars and deck transverses shall be fitted for strengthening of the deck in way of machinery casing.

2.13.2.2 For the lower strake of the casing longitudinal wall plating, adjoining the strength deck within the 0,6*L*, midship region of ships with a length $L \geq 65$ m of steel grade and yield stress shall be the same as for the strength deck plating in this region.

2.13.2.3 Where the opening for machinery casing is arranged in the strength deck, the requirements of **2.6.5.1** regarding the design of corners and compensation for openings shall be complied with.

2.13.3 Scantlings of machinery casing structures.

2.13.3.1 The part of machinery casing located inside the enclosed spaces ('tween deck spaces, forecastle, poop, bridge, deckhouse) shall comply with the requirements of **2.7.4.5** for partial bulkheads.

The spacing of stiffeners shall not exceed 0,9 m.

The thickness of plating of the part of machinery casing located inside the poop, bridge or deckhouse may be 0,5 mm less than specified.

2.13.3.2 The part of machinery casing located below the bulkhead deck shall comply with the requirements of **2.7.2.3**, **2.7.4.1 - 2.7.4.3** for waterlight bulkheads where it is included in subdivision calculation as watertight construction.

2.13.3.3 The part of machinery casing located above weather deck shall comply with the requirements of **2.12** for deckhouses situated in the same region of the ship. In calculating the design loads by Formula (2.12.3.2) $c_2 = 1$.

2.14 BULWARKS

2.14.1 General.

Bulwarks of strong construction shall be provided in places specified in **8.6**, Part III "Equipment, Arrangements and Outfit".

The construction of bulwarks in the midship region of ships of 65 m and above shall be such that the bulwark does not contribute to longitudinal bending of the hull.

2.14.2 Construction.

2.14.2.1 The height of the bulwark as measured from the upper edge of the deck plating or from that of planking, if any, to the upper edge of the rail section shall comply with the requirements of 8.6.2, Part III "Equipment, Arrangements and Outfit".

2.14.2.2 The bulwark plating within the 0,6L midship region of ships of 65 m and above shall not be welded to the upper edge of sheerstrake. Outside the above-mentioned region as well as in ships less than 65 m in length, the openings cut in bulwarks shall be so designed as to ensure a smooth transition (with a radius not less than 100 mm) from the bulwark plate to the sheerstrake.

Within 0,07L from the fore perpendicular the welding of bulwark plating to the sheerstrake is necessary.

2.14.2.3 The bulwark shall be supported by stays spaced not more than 1,8 m apart. In the region of uprights for timber deck cargo, fastening to bulwarks, as well as at the fore end within 0,07L from the fore perpendicular, the spacing of stays shall be not more than 1,2 m.

In the ships with large flare of sides and in ships with minimum assigned freeboard, stays may be required to be fitted at every frame within the region considered.

2.14.2.4 The stays shall be fitted in line with deck beams, brackets and other structures and shall be welded to the rail section, bulwark plate and deck. The attachment of stays to bulwark shall be ensured on a length not less than half the height of the bulwark.

In welding the stays to the deck, holes sufficient in size to allow free passage of water to the scuppers shall be provided in the stays.

The welded connection of the beam (bracket) to deck plating under the stay shall not be weaker than the attachment of stay to deck.

Directly under the lower ends of stays no cut-outs in the deck beams and no gaps between frame ends and deck are permitted.

The dimensions of lightening holes in stays shall not exceed half the stay width in any section of the stay. The free edges of stays shall be stiffened with face plates or flanges. In general, the flanges (face plates) of stays shall not be welded to deck plating and rail section.

The flanges (face plates) on the outer edge of the stay shall not be welded to horizontal stiffener (flange) of lower edge of the bulwark in way of continuous cut-out.

2.14.2.5 The rail section shall have a flange (face plate) or shall be of bulb profile.

The lower edge of bulwark shall be stiffened with horizontal stiffener or flange in way of continuous cut-out.

Bulwarks shall be adequately strengthened in way of mooring pipes, fairleads and eyeplates for cargo gear.

2.14.2.6 Requirements for the design of freeing ports in bulwarks are given in**1.1.6.7**.

2.14.3 Loads on bulwarks.

The external pressure determined by the Formula (1.3.2.2-2) is the design pressure p, in kPa, acting on the bulwark. The design pressure shall be taken not less than

$$p_{\min} = 0{,}02L + 14 \,, \qquad (2.14.3)$$

but not less than 15 kPa.

Where $L > 300$ m L shall be taken equal to 300 m.

For ships of restricted area of navigation the value of $p_{\min}$ may be reduced by multiplying by the factor φ_r, obtained from Table1.3.1.5.

2.14.4 Scantlings of bulwark structures.

2.14.4.1 The thickness of the bulwark plating shall not be less than:

$$s = 0{,}065L + 1{,}75, \text{ for } L \le 60 \text{ m and}$$

$$s = 0{,}025L + 4{,}0, \text{ for } L > 60 \text{ m}, \qquad (2.14.4.1)$$

but not less than 3,0, nor greater than 8,5 mm.

The thickness of bulwark plating of a superstructure located beyond 1 /4 of the ship's length from the fore perpendicular, as well as that of bulwark plating of 2nd tier deckhouses or superstructures may be reduced by 1 mm.

For 3rd and above tiers of the deckhouses the thickness of the bulwark plating need not exceed the thickness required for the plating of sides of 3rd tier deckhouse.

2.14.4.2 The section modulus of bulwark stay adjoining the deck plating shall not be less than determined according to **1.6.4.1** takin:

p – as defined in **2.14.3**;

$m = 2$;

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

Where the bulwarks are cut to form a gangway or provision is made for expansion joints, the section modulus of stay at the ends of the openings or expansion joints shall be increased by 25 %.

The width of stay at the upper end shall be equal to that of the rail sectiony.

2.14.4.3 Where the deck cargo effect on the bulwark is contemplated, the scantlings of the bulwark stays shall be determined by strength calculation involving effect of the said cargo, with regard for heel of the ship determined by Formula (1.3.3.1-5) and acceleration in the horizontal-transverse direction, determined by Formulae (1.3.3.1-2); the permissible stress factor is determined according to **2.14.4.2**.

3. REQUIREMENTS FOR STRUCTURES OF SHIPS OF SPECIAL DESIGN

3.1 SHIPS WITH LARGE DECK OPENINGS

3.1.1 General and symbols.

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

The functional requirements on load cases to be considered on finite element analysis for the structural strength assessment of container ships and ships, dedicated primarily to carry their cargo in containers, both of length 150 m or above are specified in IACS UR S34 (May 2015).

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

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

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

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

3.1.1.4 The cantilever beam is a short deep half beam for which the supporting effect of the side hatch coaming is disregarded in the strength and buckling strength calculation to be made for deck grillage in accordance with **2.6.4.4** and **2.6.4.9** respectively.

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

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

l – length of hatchway opening, in m;

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

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

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

3.1.2 Construction.

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

3.1.2.2 Upper deck and side longitudinals shall be continuous within the region stated in**3.1.1.2**.

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

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

3.1.2.5 It is recommended that transverse and longitudinal deck strips have a box-shaped cross-section.

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

3.1.2.7 Large deck openings:

.1 adjacent corners of hatch openings in the upper deck arranged in one line shall be rounded with a radius r, in m, (refer to Fig. 3.1.2.7.1) not less than

$$r = kb, \qquad (3.1.2.7.1)$$

where: $k = 0{,}025$ when $c/b \leq 0{,}04$;
$k = 0{,}050$ when $c/b \geq 0{,}2$; the intermediate values of k shall be obtained by linear interpolation;
for c and b – refer to **3.1.1.5**.

In way of longitudinal deck strips the value of r may be reduced by 40 %.

Given below are minimum radii of rounding of opening corners:

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

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

Thickened insert plates are required at hatch corners (refer to Fig. 3.1.2.7.1);

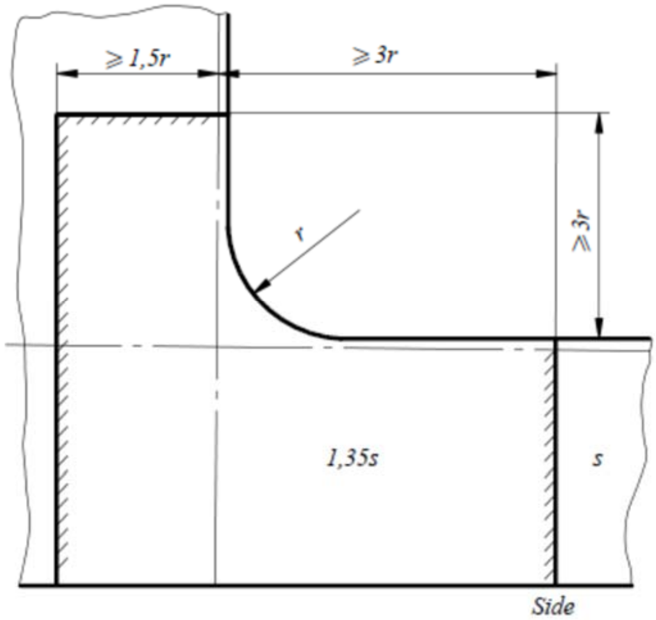


Fig. 3.1.2.7.1

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

$r = 0{,}07b$; (3.1.2.7.2)

.3 for general requirements regarding deck openings, refer to **2.6.5.1**.

3.1.2.8 The cantilever beams shall be fitted in line with web frames. Their connection shall satisfy the requirements of**1.7.2.3**.

The cantilever beams shall be fitted with minimum stiffeners as shown in Fig.**3.1.2.8**.

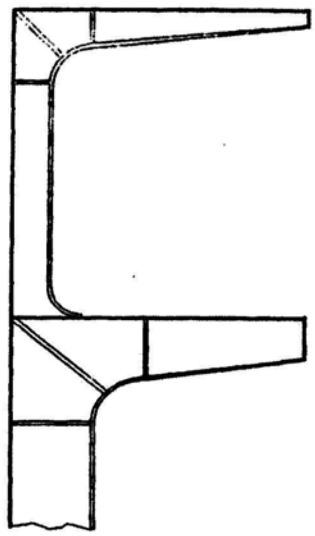


Fig. 3.1.2.8 Stiffening of cantilever beams

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

The above also applies to lashing pots.

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

3.1.3 Design loads.

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

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

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

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

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

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

for c_w – refer to **1.3.1.4**;

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

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

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

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

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

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

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

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

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

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

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

For α – refer to **3.1.3.3**;

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

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

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

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

for x – refer to **3.1.3.3**.

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

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

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

3.1.3.6 For ships of restricted area of navigation, the horizontal wave bending moment (refer to **3.1.3.3**) and the components of a wave torque (refer to **3.1.3.4**) shall be multiplied by the reduction factor φ_r, determined in accordance with **1.4.4.3**.

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

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

24,0 t for 20-ft containers;

30,5 t for 40-ft container.

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

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

3.1.4 Scantlings of structural members.

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

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

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

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

where: for M_{sw} – , in kN/m, refer to **1.4.3**;

$W_d^{ф}$ – actual hull section modulus in way of deck, as defined in 1.4.8 **1.4.8**;

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

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

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

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

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

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

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

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

where: for M_w – refer to **1.4.4**;

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

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

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

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

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

where: for M_h – refer to **3.1.3.3**;

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

$W_{dz}^{ф} = I_z \cdot 10^2 / y$;

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

y – half the ship's breadth in the considered section, in мм;

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

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

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

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

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

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

3.1.4.2 Kinematic parameters of warping shall be determined.

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

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

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

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

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

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

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

a – distance between adjacent cantilever beams, in m;

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

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

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

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

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

$k_\sigma = 0,6$;

ω_k – as defined in **1.1.5.3**.

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

$k_\tau = 0,6$;

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

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

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

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

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

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

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

3.2 ROLL-ON/ROLL-OFF SHIPS

3.2.1 General and symbols.

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

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

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

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

n_0 – number of wheels on an axle;

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

u – size of a tyre print normal to the axis of rotation, in m;

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

e – spacing between adjacent tyre prints, in m;

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

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

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

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

3.2.2 Construction.

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

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

The Rules provide for movable deck structure consisting of a top decking with a web structure and longitudinals welded thereto.

3.2.3 Loads from wheeled vehicles.

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

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

3.2.3.2 The design load spot dimensions l_a and l_b shall be chosen as the overall dimensions of the print of a wheel group consisting of a maximum number of wheels and complying with the following conditions:

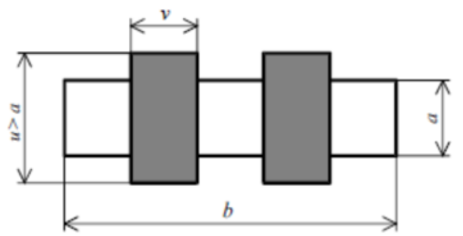
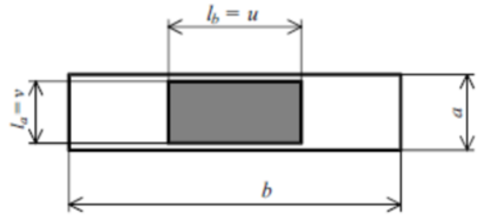
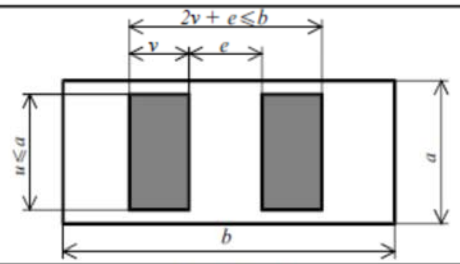
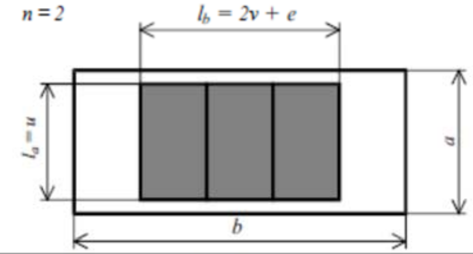
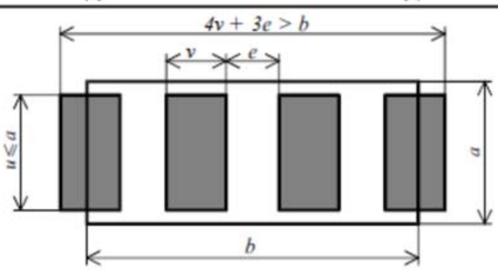
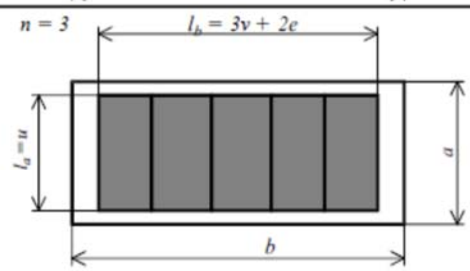
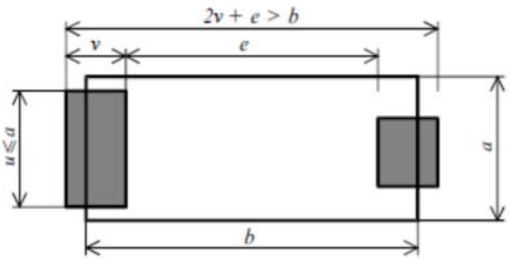
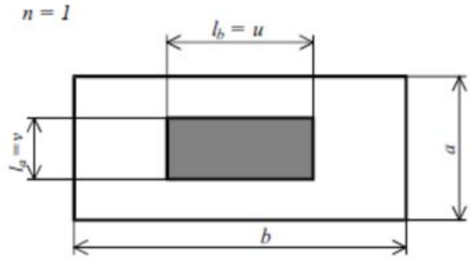
when determining the required plating thickness, the prints of all the wheels in a group shall be arranged within the panel surface (i.e. $l_a \le a$ i $l_b \le b$ – refer to Table 3.2.3.2);

when determining the section modulus and cross section of a main framing girder, the prints of all the wheels of a group shall be fully arranged within the surfaces of two panels adjacent to the girder under consideration (i.e. $l_a \le 2a$ i $l_b \le l$ – refer to Table 3.2.3.2).

The wheels may be united in a group irrespective of the distance between prints provided the overall dimensions of the group are in accordance with the above limitations.

Where two positions of the design load spot are possible (along and across main framing), $l_b \ge l_a$ shall be adopted as the design case (i.e. the spot positioned with its larger side along main framing).

Table 3.2.3.2 **Procedures for choosing design load spot dimensions when establishing deck plating thickness**

Wheel prints	Design load spot
	n = 1 
	n = 2 
	n = 3 
	n = 1 

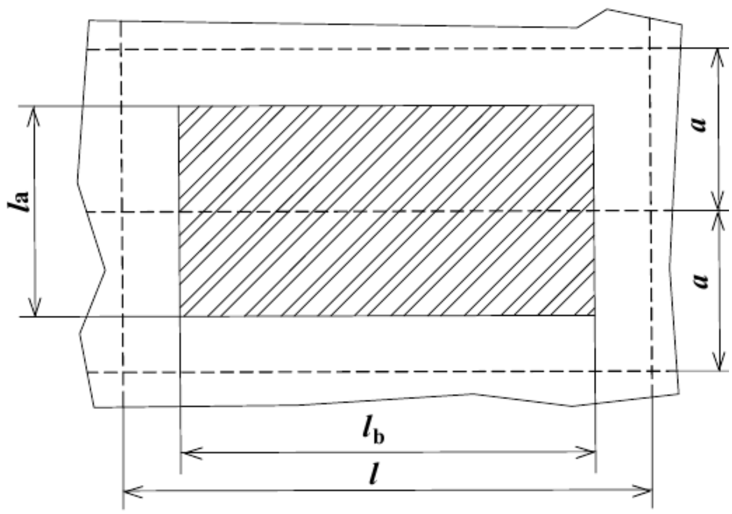


Fig.3.2.3.2 Design load spot dimension for main framing

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

3.2.3.4 The design load Q, in kN, shall be determined by the formula

$$Q = k_d Q_0 \cdot (n/n_o), \qquad (3.2.3.4)$$

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

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

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

$k_d = 1 + a_z/g$ – dynamic factor characterizing the ship motions;

a_z – acceleration in the ship section under consideration in accordance with **1.3.3.1**.

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

3.2.3.5 Where specifications on tyre print dimensions are not available, the tyre print dimension normal to the wheel axle u, in m, shall be determined by the formulae:

for wheels with cast tyres

$$u = 0{,}01 Q_0/n_o, \quad \text{where } Q_0/n_o \le 15 \text{ kN};$$

$$(3.2.3.5\text{-}1)$$

$$u = 0{,}15 + 0{,}001 \cdot [(Q_0/n_o) - 15], \quad \text{where } Q_0/n_o > 15 \text{ kN};$$

for wheels with pneumatic tyres

$$u = 0{,}15 + 0{,}0025 Q_0/n_o, \quad \text{where } Q_0/n_o \le 100 \text{ kN};$$

$$(3.2.3.5\text{-}2)$$

$$u = 0{,}4 + 0{,}002[(Q_0/n_o) - 100], \quad \text{where } Q_0/n_o > 100 \text{ kN}.$$

The tyre print dimension of a wheel parallel to the wheel axle v, in m, shall be determined by the formula:

$$v = Q_0/(n_o u p_k), \qquad (3.2.3.5\text{-}3)$$

where: p_k – static specific pressure, in kPa, to be adopted from Table 3 3.2.3.5.

Table 3.2.3.5

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

3.2.3.6 If the size of wheel prints is adopted in accordance with **3.2.3.5**, the design load Q shall be increased by 15 %

3.2.3.7 The design load for train rails Q, in kN, shall be determined by the formula:

$$Q = 0{,}5 k_d Q_0 n_1, \qquad (3.2.3.7)$$

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

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

a_z – acceleration in considered ship section in accordance with **1.3.3.1**;

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

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

3.2.3.9 The design load Q, in kN, for the transverses and girders of movable decks shall be determined by the formula

$$Q = k_d (p_c + p_d) a_2 l, \qquad (3.2.3.9)$$

where: k_d – as defined in **3.2.3.4**;
p_c – static deck loads from the cargo carried , in kPa;
p_d – static deck loads from deck own mass, in kPa;
a_2 – mean spacing of transverses and girders, in m.
for l – refer to **3.2.1.2**.
The value of ($p_c + p_d$) shall not be taken less than 2,5 kPa.

3.2.4 Scantlings of deck and side shell structures.

3.2.4.1 The thickness of plating s, in mm, shall not be less than

$$s = [17Qk_o/(l_a l_b R_{eH} k_1 k_2 k_3)]^{0,6} + 2, \qquad (3.2.4.1)$$

where: Q – as defined under **3.2.3**;
k_o – factor accounting for the effects of total hull bend:
$k_o = 1/(1,4 - 0,8W/W_d^{\Phi}) \geq 1$ – for the upper (strength) deck amidships with loads acting at sea;
$k_o = 1$ – elsewhere;
$k_1 = 0,83/\sqrt{a}$;
$k_2 = (0,84/\sqrt{l_a}) - 0,185$;
$k_3 = (0,18/l_b) + 0,38$;
W_d^{Φ} – actual hull section modulus for deck in accordance with **1.4.8.**

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

Q – as defined under **3.2.3**;
$m = 5,84/\{[1 - 0,57l_b/l]k_a\}$;
$k_a = 1 - 0,204(l_a/a)^2 + 0,045(l_a/a)^3$;
$k_\sigma = 0,8/k_o$ – for cargo handling operations in port;
$k_\sigma = 0,7/k_o$ – with loads applied at sea;
k_o – factor defined in **3.2.4.1**.

3.2.4.3 The web cross-sectional area f_c, in cm^2, of beams and longitudinals shall not be less than obtained from **1.6.4.3** with:

$$N_{max} = Qk_a(1 - 0,47l_b/l); \qquad (3.2.4.3)$$

$k_\tau = k_\sigma$,
wherer: Q – as defined under **3.2.3**;
k_a and k_σ – factors defined in **3.2.4.2**.

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

$$m = 8/[k_a(2 - l_b/l)], \qquad (3.2.4.4)$$

where: k_a – factor defined in **3.2.4.2**.
Otherwise, the factor m shall be determined as for beams and longitudinals of permanent cargo decks according to **3.2.4.2**.

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

Q – as defined under **3.2.3.7**;
m to be determined by the formula

$$m = 5{,}85/[(1 - k_5 e_2)/l], \quad (3.2.4.5)$$

where: $k_5 = 0$ with $n_1 = 1$;
$k_5 = 0{,}5n_1$ with $n_1 \geq 2$;
for n_1 – refer to **3.2.3.7**;
e_2 – = mean spacing of centres of wheels arranged within the design member span, in m;
$k_\sigma = 0{,}7/k_o$;
k_o – factor determined by **3.2.4.1.**

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

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

Q – as defined in **3.2.3.9**;
m = 12 – for fixed members;
m = 8 – for freely supported members;
$k_\sigma = 0{,}7$.

3.2.5 Special requirements.

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

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

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

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

3.3 BULK CARRIERS AND OIL OR BULK DRY CARGO CARRIERS

3.3.1 General.

3.3.1.1 The requirements of this Chapter apply to bulk carriers and combination carriers intended for the carriage of bulk cargoes and crude oil, and not covered by the requirements of **1.1.1.1** of this Chapter and and which hall coply with the requirements of Part XVII «Common Structural Rules non-CSR bulk carriers and combination carriers».

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

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

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

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

3.3.1.5 In combination carrier the length of the holds shall not exceed $0{,}1L$.

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

"Classification".

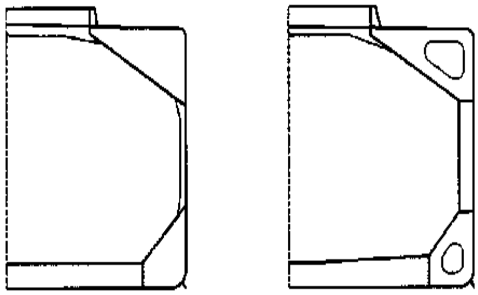
3.3.1.6 Descriptive notation and distinguishing mark (ESP).

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

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

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

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



a) b)

Fig. 3.3.1.6.1

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

A typical midship section is given in Fig. 3.3.1.6.1.

3.3.1.6.3 The ship type descriptive notation Self-unloading bulk carrier and the distinguishing mark (ESP) shall be assigned to sea-going self-propelled ships which are constructed generally with single deck, double bottom, hopper side tanks and topside tanks and with single or double side skin construction in cargo length area and intended to carry and self-unload dry cargoes in bulk.

Typical midship sections are given in Fig. 3.3.1.6.3.

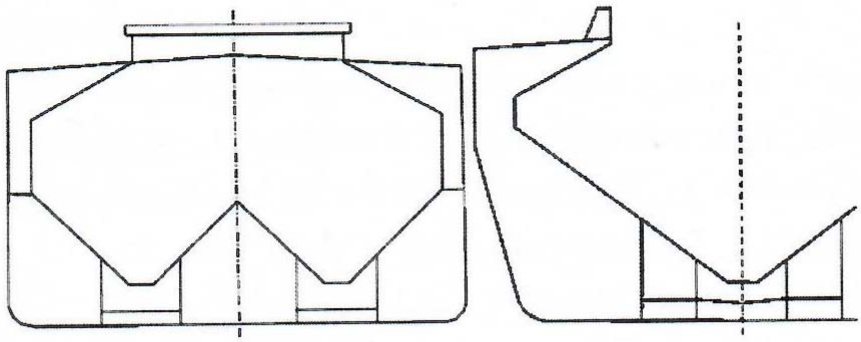


Fig. 3.3.1.6.3

3.3.2 Construction.

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

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

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

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

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

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

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

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

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

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

At every frame, in the lower corner of the tank, brackets shall be fitted in line with the brackets attaching the hold frame to the sloped bulkhead of the tank. These brackets shall be carried to the ship's side and tank sloped bulkhead longitudinals nearest to the lower corner of the tanks and welded to them so as to extend beyond the brackets of frames.

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

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

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

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

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

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

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

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

$$r=4b^2_{br} / s_{br} \quad (3.3.2.5.3)$$

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

.4 normal steel frames may be asymmetric. The face plates or flanges of brackets shall be sniped at both ends. The brackets shall be arranged with soft toes;

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

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

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

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

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

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

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

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

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

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

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

3.3.2.7 The cofferdam bulkheads shall satisfy the following requirements:

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

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

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

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

.4 for access to all parts of the cofferdam bulkhead an adequate number of openings (manholes) shall be provided in the diaphragms and platforms. The total width of openings in one section of the diaphragm or platform shall not exceed 0,6 of the cofferdam bulkhead thickness.

Openings other than the air and drain scuppers are generally not permitted:

in the platforms, at a distance not less than 1,5 times the cofferdam bulkhead thickness from the longitudinal bulkheads or side, which act as the platform supports;

in the diaphragms, at the same distance from the inner bottom plating or the upper point of the bulkhead bottom trapezoidal stool, if any, and the upper deck plating or the lower point of the horizontal underdeck stiffener of rectangular or trapezoidal section, being the bulkhead top stool, if any, which act as the diaphragm supports.

Edges of the openings cut in the diaphragms and platforms located within 1/4 of the span from their supports shall be reinforced with face plates or stiffeners. The distance between the edges of adjacent openings shall be not less than the length of these openings.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.3.3 Design loads.

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

3.3.3.2 The design pressure on the plating and framing of the hopper side tank sloped sides and of the plates of the transverse bulkhead bottom stools shall be determined as required by **1.3.4.3** for the heaviest of the anticipated bulk cargoes and as required by **1.3.4.2** for liquid cargo, whichever is appropriate. In any case, the design pressure need not be taken less than that determined by Formula (1.3.4.2.1-4), and for the trapezoidal stools also in accordance with **2.7.3.1**.

3.3.3.3 The design pressure on the plating and framing of the topside tank longitudinal bulkheads and of the plates of the transverse bulkhead top stools of rectangular or trapezoidal section shall be determined as required by **1.3.4.2** for the holds filled with liquid cargo (water ballast). In any case, the design pressure need not be taken less than that determined by Formula (1.3.4.2.1-4), and for the top stools also in accordance with **2.7.3.1**.

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

3.3.4 Scantlings of structural members.

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

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

for centre girder and side girders:

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

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

$k_\sigma = 0{,}6$ - at the ship's ends within 0,1*L* from the fore or after perpendicular.

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

for floors:

$k_\sigma = 0,6$;

when the strength is verified using the shear stresses$k_\tau = 0,6$.

k_b shall be determined by Formula (2.2.4.1).

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

For ships of 150 m in length and upwards, intended to carry solid bulk cargoes having a density of 1,78 t/m^3 or above, and with:

single side skin construction; or

double side skin construction in which any part of longitudinal bulkhead is located within *B*/5 or 11,5 m, whichever is less, inboard from the ship's side at right angle to the centreline at the assigned summer load line;

contracted for construction on or after 1 July 2006, the strength of double bottom structural members in the case when each cargo hold considered individually flooded shall be additionally checked according to the procedure specified in Appendix **4**;

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

for longitudinals

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

$k_\sigma = 0,65$ - at the ship's ends within 0,1*L* from the fore or after perpendicular.

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

for transverse members

$k_\sigma = 0,65$.

k_b shall be determined by Formula (2.2.4.1);

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

for longitudinals

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

$k_\sigma = 0,75$ - at the ship's ends within 0,1*L* from the fore or after perpendicular.

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

for transverse members

$k_\sigma = 0,75$.

k_b shall be determined by Formula (2.2.4.1).

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

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

$m = 15,8$;

p – design pressure as defined in **3.3.3**;

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

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

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

where: η – shall be obtained from Table 1.1.4.3,

but not greater than the bottom strake thickness.

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

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

p – design pressure as defined in**3.3.3**;

m = 10 – for transverse stiffeners;

m = 12 – for longitudinal stiffeners;

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

The longitudinal stiffeners shall comply with buckling strength requirements, as specified in **1.6.5.2**;

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

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

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

$$W_{sup} = W_o/\cos^2\alpha, \qquad (3.3.4.3)$$

where: W_{sup} – = section modulus at the frame support section as required by **2.5.5.1**, in cm^3;

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

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

.1 the thickness of frame webs $s_{w\min}$, in mm, shall not be less than:

$$s_{w\min} = k(0{,}03L + 7), \qquad (3.3.4.4.1)$$

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

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

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

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

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

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

m = 15,8;

p – design pressure as defined in **3.3.3**;

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

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

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

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

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

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

m = 12;

k_σ shall be taken as for horizontal stiffeners of longitudinal bulkheads of tankers as specified in **2.7.4.2**.

The longitudinal stiffeners of the vertical and sloped bulkheads shall comply with buckling strength requirements of **1.6.5.2**;

.3 the section modulus of the transverse web of the sloped bulkhead shall be not less than that determinated in **1.6.4.1** and **1.6.4.2**, and the sectional area of the web plate shall not be less than that determined in accordance with **1.6.4.3** taking:

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

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

$m = 10$;

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

.4 the section modulus and sectional area of the deck transverse web inside the tank shall comply with the requirements of **2.6.4.6**.

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

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

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

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

3.3.4.6 6 In any case, the hold bulkhead plating and corrugations shall have a thickness not less than 10 mm.

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

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

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

$m = 15{,}8$;

p – design pressure as defined in **3.3.3**;

$k_\sigma = 0{,}9$.

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

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

p – design pressure as defined in **3.3.3**;

$m = 10$;

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

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

.3 the thickness of diaphragm shall not be less than that of side girders. Size of the openings cut in diaphragms and their reinforcement shall comply with the requirements for openings and reinforcement of the hopper side tank diaphragms as specified in **3.3.4.2.3**.

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

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

$m = 15{,}8$;

p – design pressure as defined in **3.3.3**;

$k_\sigma = 0{,}9$.

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

.2 the section modulus of the stiffeners of vertical or sloped plate shall not be less than that determined according to **1.6.4.1** and **1.6.4.2** taking:

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

m = 12 – for horizontal stiffeners;

m = 10 – for other stiffeners;

$k_σ$ = 0,75.

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

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

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

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

m = 10;

$k_σ = k_τ$ = 0,75.

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

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

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

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

m = 15,8;

p – design pressure as defined in **3.3.3**;

$k_σ$ = 0,9.

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

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

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

m = 12;

$k_σ$ = 0,75;

.3 якщо у складі конструкції кофердамної перегородки є лише діафрагми або лише платформи, їх момент опору повинний бути не менше визначеного у **1.6.4.1** та **1.6.4.2**, а площа перерізу – не менше визначеної в **1.6.4.3**. При цьому:

$N_{max} = 0{,}50pal$ – for platforms,

$N_{max} = 0{,}65pal$ – for diaphragms;

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

l – span, in m, equal to:

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

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

m = 10;

$k_σ = k_τ$ = 0,75;

.4 where the construction of the cofferdam bulkhead consists both the diaphragms and platforms, their thickness shall be determined on the basis of the calculation of the grillage as a system using beam models, with the loads specified in **3.3.3** but not less than 25 kPa and the permissible stress factors $k_σ = k_τ$ = 0,75;

.5 in any case, the thickness of the cofferdam bulkhead diaphragms and platforms shall not be less than that determined by Formula (2.5.4.8.1).

Where the interior of the cofferdam bulkhead is used as a fuel oil or ballast tank, the thickness of the diaphragms and platforms shall not be less than that required by **3.5.4**;

.6 stiffening of the diaphragms and platforms shall comply with the requirements of **1.7.3.2.2**;

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

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

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

3.3.4.10 For ships of 150 m in length and upwards, intended to carry solid bulk cargoes having a density of 1,78 t/m^3 or above, and with:

single side skin construction; or

double side skin, in which any part of longitudinal bulkhead is located within B/5 or 11,5 m, whichever is less, inboard from the ship's side at right angle to the centerline at the assigned summer load line;

contracted for construction on or after 1 July 2006, the strength of vertically corrugated transverse watertight bulkheads in the case when each cargo hold considered individually flooded shall be additionally checked according to the procedure specified in Appendix **3.**

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

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

$$s = 17a, \qquad (3.3.4.11)$$

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

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

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

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

$$s_{min} = \sqrt{L}. \qquad (3.3.4.12)$$

3.3.5 Special requirements.

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

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

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

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

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

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

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

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

- at least one cargo loaded condition with specified holds empty, with cargo density 3,0 t/m3 , and the same filling ratio (cargo mass/hold cubic capacity) in all loaded cargo holds at maximum draught with all ballast tanks empty;

- normal ballast (no cargo) condition, where the ballast tanks may be full, partially full or empty, any cargo hold or holds adapted for the carriage of water ballast at sea shall be empty, the trim shall be by the stern and shall not exceed 0,015L, where L is the length between perpendiculars of the ship, the propeller shall be fully immersed;

- normal ballast (no cargo) condition, where all ballast tanks are 100 % full, other conditions - refer to the previous case;

- heavy ballast (no cargo) condition, where the ballast tanks may be full, partially full or empty, at least one cargo hold adapted for carriage of water ballast at sea shall be full, the trim shall be by the stern and shall not exceed 0,015L, where L is the length between perpendiculars of the ship, the moulded forward draught in the heavy ballast condition shall not be less than the smaller of 0,03L or 8 m, whichever is the less, the propeller immersion I/D shall be at least 60 % where I = the distance from propeller centerline to the waterline, D = propeller diameter;

− heavy ballast (no cargo) condition where all ballast tanks are 100 % full, other conditions _ refer to the previous case.

At departure condition: with bunker tanks not less than 95 % full and other consumables 100 %; and at arrival condition: with 10 % of consumables;

.2 the structures of bottom forward shall meet the requirements of **2.8**;

.3 for calculation of local strength of double bottom (vertical keel, bottom stringers and floors) the following definitions and symbols shall apply:

M_H - the actual cargo mass in a cargo hold corresponding to a homogeneously loaded condition at maximum draught;

M_{Full} - the cargo mass in a cargo hold corresponding to cargo with virtual density (homogeneous mass/hold cubic capacity, minimum 1,0 t/m^3) filled to the top of the hatch coaming, and M_{Full} shall in no case be less than M_H ;

M_{HD} - maximum cargo mass allowed to be carried in a cargo hold with specified holds empty at maximum draught;

.4 local strength of double bottom in each cargo hold shall be checked, inter alia, for the following cases of load on the double bottom due to cargo mass in the holds, as well as mass of fuel oil and water ballast contained in double bottom tanks, as well as sea water pressure along the hold.

General conditions applicable for all ships:

- cargo mass M_{Full}, fuel oil tanks being 100 % full, ballast water tanks being empty, at maximum draught;

- cargo mass minimum 50 % of M_H, fuel oil tanks and ballast water tanks being empty, at maximum draught;

- any cargo hold being empty, fuel oil tanks and ballast water tanks being empty, at the deepest ballast draught;

except the ships when the entry ***(no MP)*** *is added to the class notation after the distinguishing marks*:

- cargo massM_{Full}, fuel oil tanks being 100 % full, ballast water tanks being empty, at 67 % of the maximum draught;

- any cargo hold, fuel oil tank and ballast water tank being empty, at 83 % of the maximum draught;

- cargo mass M_{Full} in each of two adjacent holds, fuel oil tanks being 100 % full, ballast water tanks being empty, at 67 % of the maximum draught. Applicable also in case when the adjacent hold is filled with ballast;

- two adjacent cargo holds being empty, fuel oil tanks and ballast water tanks being empty, at 75 % of the maximum draught;

applicable only for ships with ***BC-A*** *distinguishing mark in the class notation*:

- cargo holds intended to be empty at maximum draught and fuel oil tanks and ballast water tanks are being empty;

- cargo mass $M_{HD}+0,1M_H$ in cargo holds intended to be loaded with high density cargo, fuel oil tanks being 100 % full, ballast water tanks being empty, at maximum draught. In operation maximum allowable cargo mass shall be limited to M_{HD};

- cargo mass 10 % of M_H in each of two adjacent cargo holds which may be loaded with the next holds being empty, fuel oil tanks being 100 % full, ballast water tanks being empty, at maximum draught;

for ballast hold(s) only:

- cargo holds being 100 % full of ballast water including hatchways, fuel oil tanks and ballast tanks being 100 % full, at any heavy ballast draught;

during loading and unloading in harbour only:

- maximum allowable cargo (sea-going) mass in any single cargo hold, at 67 % of the maximum draught;

- cargo mass M_{Full} in any two adjacent holds, fuel oil tanks being 100 % full, ballast water tanks being empty, at 67 % of the maximum draught;

- at reduced draught during loading and unloading in harbour, the maximum allowable mass in a cargo hold may be increased by 15 % of the maximum mass allowed at the maximum draught in sea-going condition, but shall not exceed the mass allowed at maximum draught in the sea-going condition.

3.3.5.3 Hull girder longitudinal strength for bulk carriers with:

single side skin construction,

double side skin construction in which any part of longitudinal bulkhead is located within B/5 or 11,5 m, whichever is less, inboard from the ship's side at right angle to the centreline at the assigned summer load line**;**

applicable for ships with ***BC-A*** or ***BC-B*** distinguishing marks in the class notation;

which were contracted for construction on or after 1 July 2006,

which were contracted for construction on or after 1 July 2006, shall be checked for specified flooded conditions, in each of the cargo and ballast loading conditions defined in **1.4.3.1** and **3.3.5.2**, except that harbour conditions, docking condition afloat, loading and unloading transitory conditions in port and loading conditions encountered during ballast water exchange need not be considered.

The actual hull girder bending stress σ_{fld}, in MPa, shall be determined by the formula

$$\sigma_{fld} = \frac{M_{sw}^{fld} + 0{,}8M_w}{W} \cdot 10^3, \qquad (3.3.5.3\text{-}1)$$

where: M_{sw}^{fld} – still water bending moment, in kN/m, in the flooded conditions for the section under consideration;

M_w – wave bending moment, in kN/m, as given in **1.4.4.1** for the section under consideration;

W – section modulus, in cm^3, for the corresponding location in the hull girder.

The actual hull girder shear stress τ_{fld}, in MPa, shall be determined by the formula

$$\tau_{fld} = \frac{N_{sw}^{fld} + 0{,}8N_w}{2s} \frac{S}{I} \cdot 10^3, \qquad (3.3.5.3\text{-}2)$$

where: N_{sw}^{fld} – still water shear force, in kN, in flooded conditions for the section under consideration;

N_w – wave shear force, in kN, as given in **1.4.4.2** for the section under consideration;

I, S – as defined in **1.4.2**;

s – thickness of side shell plating, in mm.

Strength calculation in flooded condition shall demonstrate that the actual hull girder bending stress shall not exceed 175/η, in MPa, and the actual shear stress shall not exceed 110/η, in MPa.

To calculate the strength in flooded condition, the following assumptions shall be made:

the damaged structure is assumed to remain fully effective in resisting the applied loading;

each cargo hold shall be considered individually flooded up to the equilibrium waterline. Position of the waterline and the volume of ingressed water are determined on the basis of damage trim and stability calculations which shall be made in accordance with a program approved by the Register;

"permeability" for solid bulk cargo means the ratio of the floodable volume between the particles, granules or any larger pieces of the cargo, to the gross volume of the bulk cargo;

the permeability of empty cargo spaces and volume left in loaded cargo spaces above any cargo shall be taken as 0,95;

appropriate permeabilities and bulk densities shall be used for any cargo carried. For iron ore, a minimum permeability of 0,3 with a corresponding bulk density of 3,0 t/m^3 shall be used. For cement, a minimum permeability of 0,3 with a corresponding bulk density of 1,3 t/m^3 shall be used;

for packed cargo conditions (such as steel mill products), the actual density of the cargo shall be used with a permeability of zero.

3.3.5.4 All the bulk carriers and combination carriers contracted for construction on or after 1 July 2003 shall comply with the following requirements:

.1 the ships shall have the forecastle located above the freeboard deck. In case the above requirement hinders hatch cover operation, the aft bulkhead of the forecastle may be fitted forward of the forward bulkhead of the foremost cargo hold provided the forecastle length is not less than 7 % of ship length abaft the forward perpendicular where the ship length - refer to **1.2.1**, Part I "General" of the Load Line Rules for Sea-Going Ships.

The forecastle shall have at least a standard height according to the International Convention on Load

Lines, 1966 as amended by the Protocol of 1988 or shall be by 0,5 m above the forward hatch-end coaming of the fore hold No. 1, whichever is greater. In this case, the distance between the aft edge of the forecastle deck and the forward hatch-end coaming of the fore hold No. 1 over the entire breadth of the ship's hull shall not exceed the value, in m, determined by the formula

$$l_F = \sqrt{H_F - H_C}, \quad (3.3.5.4.1)$$

where: H_F - forecastle height, in m;
H_C - height of the forward hatch-end coaming of the fore hold No. 1, in m.

No breakwater is allowed on the forecastle deck for protection of the forward hatch-end coaming and hatch covers of the fore hold No. 1.

However, if fitted for other purposes, the breakwater shall be placed at a distance of at least 2,75 its height along the centerline from the aft edge of the forecastle deck;

.2 a net thickness (no wear allowance) of hatch coamings shall not be less than that determined by the formula

$$s_{net} = 14{,}9a\sqrt{1{,}15p_{coam}/0{,}95R_{eH}}, \quad (3.3.5.4.2)$$

where: a − distance between stiffeners, in m;
p_{coam} - pressure equal to 220 kPa; if the requirements of **3.3.5.2.1** are not met, the pressure for the forward hatch-end coaming of the fore hold No. 1 shall be assumed equal to 290 kPa.

The net thickness increased by 1,5 mm shall be taken as the minimum construction thickness.

In any event, the coaming thickness shall not be less than 11 mm;

.3 the section modulus of longitudinal and transverse stiffeners of hatch coamings at the net thickness of all section elements, in cm^3, shall not be less than determined by the formula

$$W_{net} = \frac{1{,}15al^2p_{coam}}{0{,}95mc_pR_{eH}}\cdot 10^3, \quad (3.3.5.4.3)$$

where: for a and p_{coam} − refer to **3.3.5.4.2**;
l − stiffener span, in m;
m − coefficient equal to:
16 – for snipped stiffener ends;
12 – in way of hatch corners;
c_p – plastic-to-elastic section modulus ratio for a stiffener with an effective flange 40*snewidet*, where s_{net} – net thickness of a coaming.

If precise data are lacking, c_p may be assumed equal to 1,16.

The net thickness of all cross-section elements increased by 1,5 mm shall be taken as the minimum construction thickness.

.4 stays (brackets) of hatch coamings shall comply with the following requirements:

the section modulus of stays (brackets) in the plane of beams with a net thickness of all section elements shall not be less than that determined by the formula

$$W_{net} = 500a\,H^2_C\,p_{coam}/0{,}95R_{eH}, \quad (3.3.5.4.4\text{-}1)$$

where: a − distance between stays in the plane of beams, in m;
for p_{coam}− refer to **3.3.5.2.2**;
H_C - висота комінгса люка, м.

In determination of the actual section modulus, the face plate of the coaming stay may be considered only when it is welded to the deck plating with full penetration and appropriately dimensioned stiffeners, knees or brackets are fitted in its plane under the plating.

The net thickness of a web of stays in the plane of beams shall not be less than that determined by the formula

$$s_{net} = \frac{1000aH_c p_{coam}}{0,5hR_{eH}}, \quad (3.3.5.4.4\text{-}2)$$

where: h − depth of a stay web at its attachment to deck plating, in mm;

a and H_C − refer to Formula (3.3.5.4.4-1);

for p_{coam}− refer to **3.3.5.4.2**.

The net thickness of all cross-section elements increased by 1,5 mm shall be taken as the minimum construction thickness.

In strength calculations for stays off the plane of beams, the permissible stresses shall be assumed equal to 0,8 and 0,46 of the steel yield stress for normal and shear stresses accordingly.

The stay web shall be joined to deck plating by a double continuous weld having an effective throat thickness not less than 0,44s where s is the minimum construction thickness of the stay web, in mm. At least 15 % of the weld length therewith beginning at the "free" end of the stay shall be made with deep penetration (double-bevel preparation).

The strength of underdeck structures taking forces from coaming stays shall be checked against permissible normal and shear stresses equal to 0,95 and 0,5 the steel yield stress accordingl;

.5 longitudinal and transverse stiffeners, stays and plate elements of cargo hatch coamings shall be replaced if the actual residual thickness of the coaming element is less than t_{net} + 0,5 mm.

Where the actual residual thickness is greater than t_{net} + 0,5 mm, but less than t_{net} + 1,0 mm, a protective coating instead of replacement may be applied in accordance with the manufacturer's procedure or annual measurements of the actual residual thickness may be conducted.

3.3.6 Strength control during ship loading.

3.3.6.1 Bulk carriers, ore carriers and combination carriers of 150 m length and above shall be provided with the Loading Manual and loading instrument approved by the Register.

3.3.6.2 Loading Manual is a document approved by the Register, which describes:

.1 the loading conditions on which the design of the ship has been based, including permissible limits of still water bending moments and shear forces;

.2 the results of the calculations of still water bending moments, shear forces and where applicable, limitations due to torsional loads;

.3 envelope results and permissible limits of still water bending moments and shear forces in the hold flooded condition according to **3.3.5.4**;

.4 the cargo holds or combination of cargo holds that might be empty at full draught. If no cargo hold is allowed to be empty at full draught, this shall be clearly stated in the Loading Manual;

.5 maximum allowable and minimum required mass of cargo and double bottom contents of each hold as a function of the draught at mid-hold position;

.6 maximum allowable and minimum required mass of cargo and double bottom contents of any two adjacent holds as a function of the mean draught in way of these holds. This mean draught may be calculated by averaging the draught of the two mid-hold positions;

.7 maximum allowable tank top loading together with specification of the nature of the cargo (density or stowage factor) for cargoes other than bulk cargoes;

.8 maximum allowable load on deck and hatch covers. If the ship is not approved to carry load on deck or hatch covers, this shall be clearly stated in the Loading Manual;

.9 the maximum rate of ballast change together with the advice that a load plan shall be agreed with the terminal on the basis of the achievable rates of change of ballast.

3.3.6.3 In addition to the requirements given in 1.4.3.1.1, the following conditions, subdivided into departure and arrival conditions as appropriate, shall be included in the Loading Manual:

.1 alternate light and heavy cargo loading conditions at maximum draught, where applicable;

.2 homogeneous light and heavy cargo loading conditions at maximum draught;

.3 ballast conditions. For ships having ballast holds adjacent to double bottom tanks, it shall be strengthwise acceptable that the ballast holds are filled when double bottom tanks are empty;

.4 short voyage conditions where the vessel shall be loaded to maximum draught but with limited amount of bunkers;

.5 multiple port loading/unloading conditions;

.6 deck cargo conditions, where applicable;

.7 typical loading sequences where the vessel is loaded from commencement of cargo loading to reaching full deadweight capacity, for homogeneous conditions, relevant part load conditions and alternate conditions where applicable. Typical unloading sequences for these conditions shall also be included. The typical loading/unloading sequences shall also be developed to not exceed applicable strength limitations. The typical loading sequences shall also be developed paying due attention to loading rate and the deballasting capability;

.8 typical sequences for change of ballast at sea, where applicable.

3.3.6.4 A loading instrument is an approved digital system as defined in **1.4.9.4**. In addition to the requirements in **1.4.9.4**, it shall ascertain as applicable that:

.1 the mass of cargo and double bottom contents in way of each hold as a function of the draught at mid-hold position;

.2 the mass of cargo and double bottom contents of any two adjacent holds as a function of the mean draught in way of these holds;

.3 the still water bending moment and shear forces in the hold flooded conditions according to **3.3.5.3**; are within permissible values.

3.3.6.5 Conditions of approval of loading instruments, as stated in 1.4.9.4, shall include the following:

.1 acceptance of hull girder bending moment limits for all read-out points;

.2 acceptance of hull girder shear force limits for all read-out points;

.3 acceptance of limits for mass of cargo and double bottom contents of each hold as a function of draught;

.4 acceptance of limits for mass of cargo and double bottom contents in any two adjacent holds as a function of draught**.**

3.4 ORE CARRIERS AND ORE OR OIL CARRIERS

3.4.1 General.

3.4.1.1 The requirements of this Chapter apply to ships for the carriage of ore and other bulk cargoes, as well as to combination carriers for transportation of ore and oil (petroleum products).

3.4.1.2 The requirements for structures not mentioned in this Chapter shall be as stated in Sections **1** and **2**, having regard to those contained in **3.3** as regards structures exposed to the loads from heavy dry bulk and liquid cargoes.

In any case, the requirements for the hull and its structures shall not be less stringent as those of Sections **1** and **2**.

3.4.1.3 The basic structural type of a ship is considered to be a single deck ship, with machinery aft, having longitudinal bulkheads separating the centre ore compartment from the wing tanks and a double bottom throughout the entire breadth of the ship or the centre part between the longitudinal bulkheads.

3.4.1.4 Descriptive notation and distinguishing mark (ESP).

3.4.1.4.1 The descriptive notation **Ore carrier** and the distinguishing mark (**ESP**) shall be assigned to sea-going self-propelled single deck ships having two longitudinal bulkheads and a double bottom throughout the cargo region and intended for the carriage of ore cargoes in the center holds only. A typical midship section is given in Fig. 3.4.1.4.1.

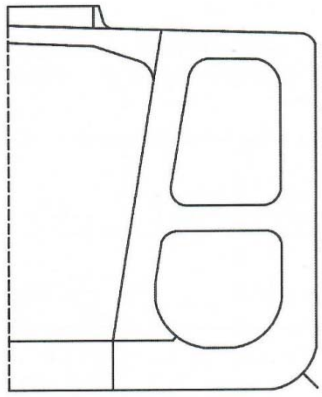


Fig. 3.4.1.4.1

3.4.1.4.2 Combination carrier is a general term applied to ships intended for the carriage of both oil and dry cargoes in bulk; these cargoes are not carried simultaneously, with the exception of oil retained in slop tanks.

3.4.1.4.3 The descriptive notation **Ore/Oil** carrier and the distinguishing mark (**ESP**) shall be assigned to sea-going self-propelled single deck ships having two longitudinal bulkheads and a double bottom throughout the cargo region and intended for the carriage of ore cargoes in the centre holds or of oil cargoes in centre holds and wing tanks. Typical midship sections are given in Fig. 3.4.1.4.3.

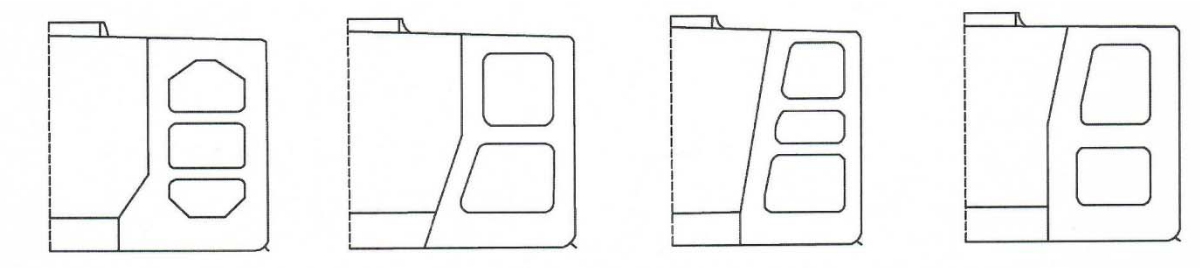


Fig. 3.4.1.4.3

3.4.2 Construction.

3.4.2.1 The deck and bottom (double bottom) shall be longitudinally framed. The side shell and longitudinal bulkheads may, in general, be framed either longitudinally or transversely.

Deck plating between end coamings of adjacent cargo hatches shall be strengthened by transverse stiffeners as required by **3.3.2.1**.

Transverse bulkheads may be plane with stiffeners arranged vertically, corrugated with vertical corrugations or of a cofferdam type.

3.4.2.2 Floors in the centre hold and in the wing tanks shall be aligned and to form, in conjunction with side transverses, vertical webs of longitudinal bulkheads and deck transverses, a single transverse ring structure.

3.4.2.3 Where transverse bulkheads in the wing tanks are not aligned with centre hold bulkheads, transverse ring structures shall be fitted in line with the latter bulkheads.

In this case, provision shall be made in the wing tanks for a smooth tapering of the sloped bulkheads of trapezoidal stools fitted under centre hold bulkheads.

3.4.2.4 Longitudinal bulkheads shall, in general, be plane with horizontal or vertical stiffening. Longitudinal bulkheads may be slightly sloped or to have a knuckle.

3.4.2.5 Where a double bottom in wing tanks is omitted, floors shall be backed by substantial knees or brackets fitted in line with the inner bottom plating of the centre hold.

3.4.2.6 Diaphragms shall be fitted in line with the longitudinal bulkheads inside the bottom trapezoidal stools and top stools of rectangular or trapezoidal sections.

The diaphragms of the bottom stools shall comply with the requirements of **3.3.2.10.3**, the diaphragms of the top stools - with the requirements for the topside tank bulkheads as specified in **3.3.2.3**.

3.4.3 Design loads.

3.4.3.1 The design pressure on the centre hold boundary structures shall be determined according to

1.3.4.3 assuming that the centre hold is loaded with ore or other heavy bulk cargo.

3.4.3.2 Structures which are likely to be subjected to one-sided pressure of a liquid cargo (ballast water) shall be examined for the design pressure of the liquid cargo as required by **1.3.4.2**.

3.4.4 Scantlings of structural members.

3.4.4.1 The scantlings of structural members of the cargo spaces intended only for the carriage of bulk cargoes or bulk cargoes and oil, oil products or water ballast shall comply with the requirements of Section **2** and **3.3.4**.

The scantlings of structural members of the cargo spaces intended only for the carriage of oil, oil products or water ballast shall comply with the requirements of Section **2** and **3.5.4**.

3.4.4.2 The scantlings of longitudinal bulkhead members shall comply with the requirements of **2.7.4** at the design pressure defined in **3.4.3**.

In any case, the thickness of longitudinal bulkhead plating shall not be less than that required by Formula (3.3.4.5.1) or, where oil, oil products or water ballast is carried in any compartment bounded by that bulkhead, it shall be not less than that required by **3.5.4**, whichever is the greater.

3.4.4.3 The scantlings of structural items of diaphragnis of transverse bulkhead bottom trapezoidal stool, fitted in line with the longitudinal bulkheads, shall comply with the requirements of **3.3.4.7.3**.

3.4.4.4 The scantlings of structural items of diaphragms of transverse bulkhead top stool, fitted in line with longitudinal bulkheads, shall comply with the requirements of **3.3.4.5.5** for the transverse bulkheads inside the topside tanks.

3.4.5 Special requirements.

3.4.5.1 All ore carriers shall have the forecastle located above the freeboard deck. The forecastle arrangement and dimensions, as well as the thickness and scantlings of stiffeners and plate elements of cargo hatch coamings shall meet the requirements of **3.3.5.4**.

3.5 TANKERS

3.5.1 General.

3.5.1.1 The requirements of this Chapter apply to tankers, chemical tankers, as well as to oil recovery ships and gas carriers, as applicable, with machinery aft, having a single or a double bottom arrangement and one, two or three longitudinal bulkheads. Hull structural members of tankers not covered by this Chapter shall comply with the requirements of Sections **1** and **2**.

Double hull oil tankers of 150 m in length and above, contracted for construction on and after 1 July 2015, shall comply with the requirements of **1.1.1.1**.

3.5.1.2 Descriptive notation and distinguishing mark (ESP).

3.5.1.2.1 The descriptive notation **Oil tanker** and the distinguishing mark (**ESP**) shall be assigned to sea-going self-propelled ships having integral tanks and intended for the carriage of oil in bulk. The above mentioned descriptive notation and distinguishing mark shall be assigned to tankers of both single and double skin side construction, as well as tankers with alternative structural arrangements, e.g. mid-deck designs. Typical midship sections are given in Fig. 3.5.1.2.1.

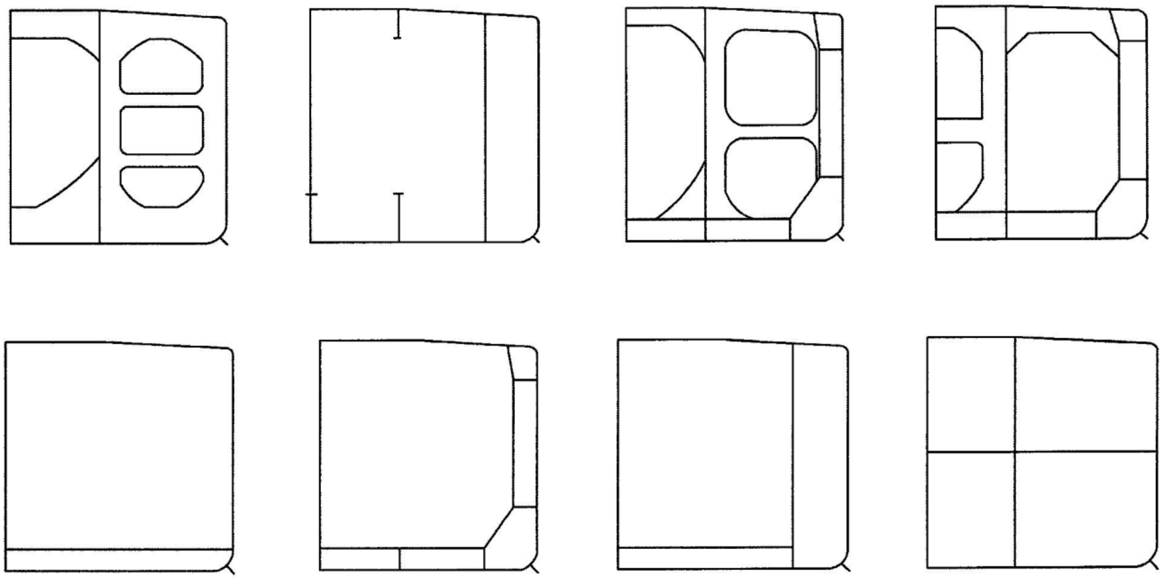


Fig.3.5.1.2.1

3.5.1.2.2 The descriptive notation **Chemical tanker** and the distinguishing mark (**ESP**) shall be assigned to sea-going self-propelled ships having integral tanks intended for the carriage of chemicals in bulk. This descriptive notation shall be assigned to tankers of both single or double skin side construction, as well as tankers with alternative structural arrangements. Typical midship sections are given in Fig. 3.5.1.2.2.

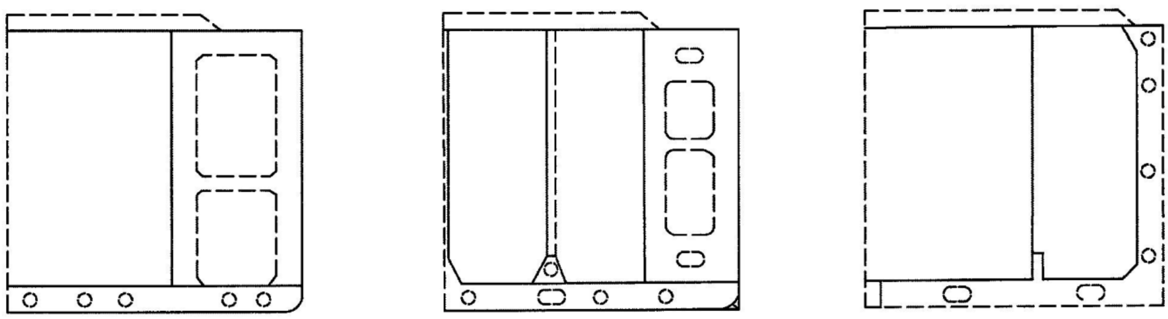


Fig. 3.5.1.2.2

3.5.2 Structural configuration.

3.5.2.1 The scantlings of the cofferdams shall be determined according to **2.7.5.2**.

5.2.2 Longitudinal corrugated bulkheads are permitted in ships under 180 m in length.

Longitudinal corrugated bulkheads shall have horizontally arranged corrugations, and their upper and lower strakes for 0,1*D* from the deck and bottom, respectively, shall be plane.

In way of connections between longitudinal and transverse bulkheads, continuity of strength shall be maintained at the top and bottom strakes of the longitudinal bulkheads.

3.5.2.3 The deck and bottom in the cargo tank region shall be framed longitudinally, for the side shell and longitudinal bulkheads, longitudinal or transverse framing may be adopted.

The deck and bottom of ships under 80 m in length may be transversely framed.

It is recommended that longitudinal framing be used for side shell and longitudinal bulkheads of ships over 180 m in length.

Where the longitudinal framing is adopted, spacing of transverse members shall correspond to that of bottom transverses (refer to **2.3.2.4** and **2.4.2.5**).

3.5.2.4 The longitudinal scantlings of deck, bottom, side shell and longitudinal bulkheads within the midship portion of the ship shall not vary. Structural continuity of the above longitudinals shall be ensured within 0,1*D* from deck and bottom.

In ships of 150 m in length and more, the above longitudinals shall pass through the transverse bulkheads without cutting.

3.5.2.5 The primary supporting members (bottom centreline girder, side girders, vertical webs on bulkheads, deck centreline girder, continuous deck girders, side and bottom transverses, side stringers and bulkhead horizontal girders) in way of cargo tanks shall form a transverse ring structure, whenever possible.

3.5.2.6 Hull structural members shall be interconnected as required by **1.7.2**. The webs of primary supporting members shall be supported by horizontal or vertical stiffeners in accordance with **1.7.3.2**. The inertia moment of stiffeners shall comply with **1.6.5.6**.

3.5.3 Design loads.

Unless provided otherwise in this Chapter, the design loads on hull structures of tankers shall be taken according to **1.3** and relevant chapters of Section **2**.

3.5.4 Scantlings of structural members.

The scantlings of structural members of tankers shall be determined in compliance with Section **2**, having regard to the provisions of this Chapter.

The thickness s_{min}, in mm, of structural members, forming the boundaries of cargo and ballast tanks as well as members fitted inside these tanks shall not be less than:

$$s_{\min} = 0{,}035L + 5{,}5, \quad \text{for } L < 80 \text{ m};$$
$$s_{\min} = 0{,}02L + 6{,}7, \quad \text{for } L \geq 80 \text{ m}. \qquad (3.5.4)$$

Where $L > 290$ m, L shall be taken equal to 290 m.

In this case, the minimum thickness of the primary members need not exceed 11,5 mm.

3.5.5 Special requirement.

3.5.5.1 The number of openings for access to cofferdams, pump rooms, cargo and ballast tanks shall be kept to the minimum required. They shall be as far distant as practicable from end bulkheads of superstructures. Hatches to wing tanks in line with a centre tank hatch in the athwart direction are not permitted.

Hatch openings shall be either circular or elliptical in shape, the elliptical openings having the major axis fore and aft. Structural continuity of deck girders and longitudinals shall be maintained. The thickness of cargo hatch coamings less than 750 mm high shall be 10 mm, while coamings 750 mm and more in height shall have a thickness equal to 12 mm. Coamings more than 750 mm in height, provided they are more than 1,25 m long, shall be stiffened.

3.5.5.2 Guard rails, bulwark, gangway or an equivalent arrangement shall be fitted in compliance with **8.6**, Part III "Equipment, Arrangements and Outfit".

The gangway, if fitted, shall not contribute to hull longitudinal bending.

3.6 DREDGERS, HOPPER BARGES, FLOATING CRANES, CRANE SHIPS

3.6.1 General.

3.6.1.1 The requirements of this Chapter apply to the hulls of the vessels of dredging fleet and floating cranes. Areas where such ships operate and/or transport spoil are called work areas. The transfer of the ship from one work area to another is called a voyage.

3.6.1.2 Industrial fleet includes dredgers, opening hopper dredgers, hopper barges, floating cranes and crane ships (refer to definitions in **1.2.1** Part, I «Classification»).

3.6.1.3 The basic structural configuration of a vessel of dredging fleet, considered in this Chapter, is a single-deck vessel with ordinary ship lines or of a pontoon shape, having a ladder well or other hull cut-outs.

The pontoon hull shape may be used only in vessels of restricted service **R2**, **R2-RS**, **R2-S, R3-RS**, **R3-S, R3-IN** and **R3.**

3.6.1.4 The requirements of this Chapter apply to dredgers, single-hulled and opening double-hulled hopper dredgers and hopper barges, floating cranes and crane ships.

3.6.1.4 In opening hopper dredgers and hopper barges, subject to the Register supervision are deck and deckhouse hinges, hydraulic presses and their hull connections as well as longitudinal and transverse structures between the hulls and deckhouses.

3.6.1.6 For the purpose of this Chapter the following symbols have been adopted:

d_1 – maximum dredging draught, in m, at which the vessel is designed to operate;

d_2 – draught during sea voyage, in m;

Δ – displacement at the draught d_1 or d_2, in t;;

Δ_l – light-ship displacement without spoil mixture, in m;

l_h – full length of the hopper, in m;

$h_{l.cr}$ – depth of a hopper lower cross-member, in m;

$l_{l.cr}$ – hopper lower cross-member span measured at mid-depth between longitudinal bulkheads of the hopper, in m;

H_1 – distance from the mid-depth of the hopper lower cross-member to the deck at side, in m;

H_2 – distance from the base line to the upper edge of the coaming, in m;

h_c – coaming height above the deck line at side, in m;

B_2 – distance between the side shell and the longitudinal bulkhead at mid-depth of a hopper lower cross-member, in m;

B_3 – distance between the side shell and the longitudinal bulkhead at the deck level, in m;

Q_s – maximum mass of the spoil mixture in the hopper, in t;

ρ_s – density of spoil mixture, defined as a ratio of the spoil mass in the hopper at the maximum draught d_1 to the hopper volume up to the level of overflow or to the upper edge of the hopper coaming where there is no overflow, in t/m^3; it shall not be taken more than 1,8;

$A_{b.k}$, $A_{l.cr}$ - = areas enveloped in the contour of the centre line box keel, hopper lower cross-member, respectively, in m2 ; where the centre line keel and/or a hopper lower cross-member are an ordinary girder (web with a face plate), it is assumed that $A_{b.k} = A_{l.cr} = 0$;

$b_{b.k}$ – centre line box keel width at lower portion, in m;

b_b – = bottom breadth from the side shell to the point of intersection of the hopper longitudinal bulkhead with the bottom, in m;

$b_{f.p}$ – width of the coaming upper face plate, in m;

a – spacing of frames, hopper side stiffeners, longitudinals, in m;

b – spacing of transverse ring structures, in m;

l_1, l_2 – length of the upper and lower face plate of the hopper lower cross-member, measured from the hopper longitudinal bulkhead to the centre line box keel, in m;

$R_{up.cr}$, $R_{l.cr}$ – axial force acting on the hopper upper and lower cross-member, respectively, in kN;

N – design axial force, in kN.

Δs - corrosion allowance, in mm, for plate thickness (refer to **1.1.5.1**);

ω_c – = factor taking corrosion allowance into account with regard to the section modulus of members (refer to **1.1.5.3**).

Some of the symbols are shown in Fig. 3.6.1.6.

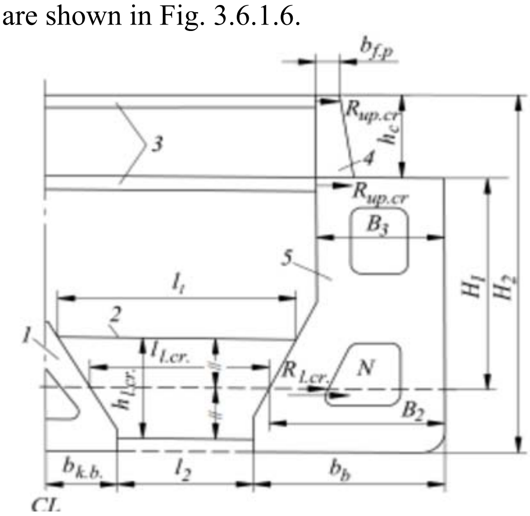


Fig. 3.6.1.6:
1 - centre line box keel; 2 - hopper lower cross member; 3 - hopper upper cross member; 4 - stay of coaming; 5 - diaphragm

3.6.2 Construction.

3.6.2.1 Main hull structures shall comply with the requirements of Section **2**, having regard to the provisions and additions given in this Chapter.

Referred to the particular structures of vessels of dredging fleet are:

hopper longitudinal and transverse bulkheads;

hopper lower and upper cross-members;

centre line box keels, hopper coamings;

diaphragms and transverse ring structures in buoyancy spaces (refer to **3.6.2.11**).

For floating cranes strengthening shall be provided of the pontoon hull beneath the fixed crane tower supporting the upper crane structure, this strengthening including the crane tub, the bulkhead cross and the bearing contour (refer to Fig. 3.6.2.1).

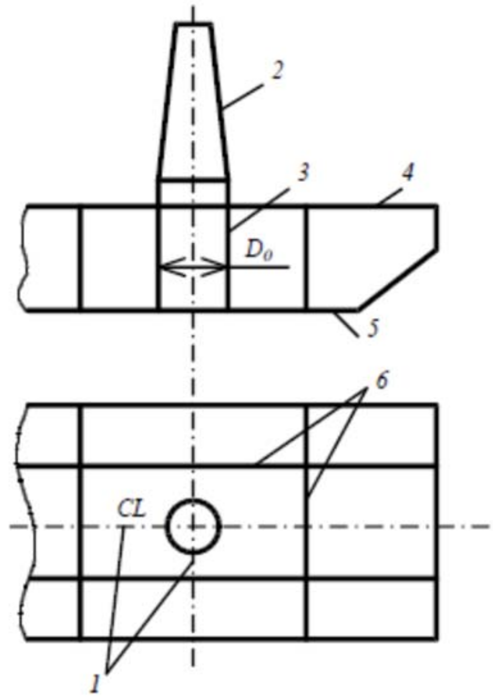


Fig. 3.6.2.1:
1 - bulkhead of the cross; 2 - fixed crane tower; 3 - tub; 4 - upper deck;
5 - bottom; 6 - bulkheads of the bearing contour

3.6.2.2 Shell plating.

3.6.2.2.1 Corners of hopper and well openings in the bottom plating shall be rounded. Insert plates shall be fitted at the corners.

3.6.2.2.2 The cutting of overflow discharge trunk openings in the sheerstrake shall be avoided wherever practicable. Where such openings cannot be dispensed with, their upper edge shall not be within 800 mm of the deck line at side. They shall have corner radii of not less than 150 mm.

3.6.2.2.3 Angular connection of the side shell plating or longitudinal bulkhead of the well with the bottom plating shall be made by means of section steel (rod, bar).

3.6.2.3 Single bottom.

3.6.2.3.1 The bottom centre girder in way of the hopper and well of hopper dredgers shall not be fitted.

3.6.2.3.2 The depth of floors abreast of hoppers in hopper dredgers and barges with transverse framing and abreast of dredging wells in hopper dredgers shall not be less than 1/18 B_1.

The breadth B_1 is taken: in way of the hopper, equal to the breadth of the vessel after deducting the breadth of the hopper at bottom, but not less than 0,6B; in way of the well, equal to the breadth of the vessel after deducting the breadth of the well.

3.6.2.3.3 Side girders shall be fitted in side buoyancy tanks of hopper dredgers and hopper barges where the tank width between the vessel's side and the longitudinal bulkhead exceeds 3,5 m in transversely framed vessels, and 4 m in longitudinally framed vessels.

Side girders in opening hopper barges may be omitted.

3.6.2.3.4 In the pump rooms of hopper dredgers, the bottom framing shall be identical to that of the engine room.

3.6.2.3.5 In floating cranes plate floors shall be fitted at every frame within 0,2*L* from the forward perpendicular over the entire breadth of the hull and additional bottom transverses or longitudinals spaced not more than 0,35 m apart shall be fitted.

3.6.2.4 Double bottom.

2.6.2.4.1 In lieu of the bottom centre girder, two side girders may be fitted on each side of ship's centre line at a distance not exceeding 1 m from each other and passing into the webs of the centre line box keel or into the well sides (refer to Fig. 3.6.2.4.1).

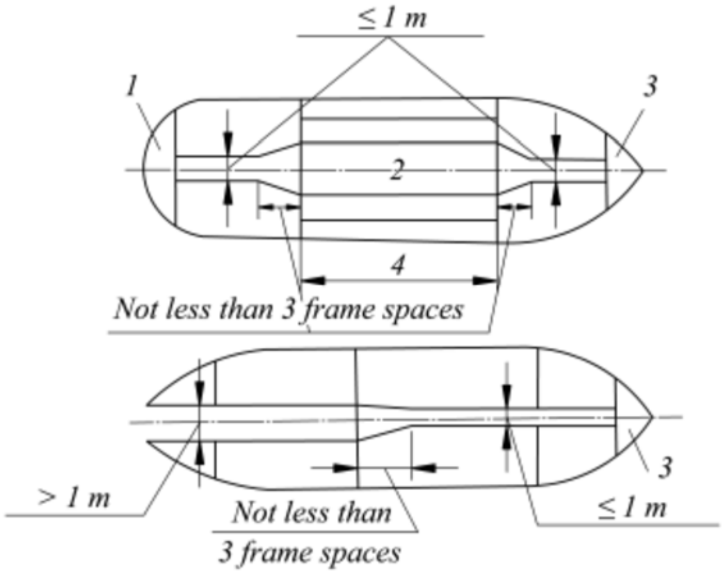


Fig. 3.6.2.4.1

1 - after peak; 2 - centre line box keel; 3 - fore peak; 4 - hopper space.

3.6.2.4.2 Additional side girders extending over a distance of not less than three spacings from the end of the bracket shall be fitted in the double bottom under the lower brackets of longitudinal bulkheads of the hopper space or the well and under the brackets of the centre line box keel.

3.6.2.5 Side framing.

3.6.2.5.1 In floating cranes, hopper dredgers designed to work in conjunction with hopper barges, and in hopper barges, the side framing shall be reinforced as follows:

two rows of efficient fenders, one fitted at the deck level or 200 mm below it, the other 200 to 300 mm above the lowest operating waterline amidships;

the upper and lower fenders in hopper dredgers shall be connected by vertical fenders fitted in line with frames;

it is recommended that a side stringer required by **2.5.4.4** which shall be taken into account in determining the scantlings of the frames or an intercostal side stringer be fitted at a level of the lower fenders.

3.6.2.5.2 In floating cranes the strengthening of the side framing within 0,2*L* from the forward perpendicular shall comply with the requirements of **3.6.2.8**. Web frames shall be spaced not more than four spacings apart.

3.6.2.5.3 In floating cranes, intermediate frames of the same scantlings as the main frames shall be fitted in the fore peak and in areas extending forward for 0,1L from the stern transom and inboard for 0,1*B* over the entire depth. The extension and end attachments of intermediate frames shall comply with the requirements of **3.10**.

3.6.2.6 Decks and platforms.

3.6.2.6.1 Corners of openings in the deck plating in way of the hopper and the well shall be rounded. Insert plates shall be fitted at the corners.

3.6.2.6.2 In hopper side buoyancy spaces, the hopper lower cross members shall be fitted in line with the web frames unless partial bulkheads are fitted.

3.6.2.7 Watertight bulkheads.

3.6.2.7.1 Bulkheads forming the ends of the hopper shall extend from side to side.

3.6.2.7.2 In bucket dredgers, protective bulkheads shall be provided parallel to the well sides at a distance of not less than 600 mm from them.

The extension of protective bulkheads shall be such as to prevent the ship from flooding in case of damage to the shell plating by objects brought up in the dredge buckets.

A protective bulkhead shall be also provided at the end of the well. The scantlings of framing members and the plating thickness of the protective bulkheads shall be determined as for permanent watertight bulkheads of dry cargo ships. The framing inside the cofferdam formed by the well side and the protective bulkhead may consist of brackets with openings cut therein. Cofferdams shall have access openings for maintenance.

3.6.2.7.3 Bulkheads forming the ladder well in hopper dredgers shall be protected against possible damage by the ladder when moved.

3.6.2.7.4 Longitudinal bulkheads of the hopper and well sides shall terminate at deck and bottom in brackets. The length of the arms of the brackets shall not be less than 0,25D and their thickness shall not be less than the plating thickness of the longitudinal bulkhead. The brackets shall be strengthened with stiffeners and to have a face plate over the free edge. The top bracket shall be extended by a deck girder, the bottom bracket by a side girder for at least three spacings beyond the bracket end.

3.6.2.7.5 In floating cranes the bulkheads forming the cross shall be rigidly connected with the bulkheads forming the bearing contour. These bulkheads shall be carried to the nearest transverse and longitudinal bulkheads (sides, transoms).

3.6.2.8 In ships with a pontoon shape of the forward and after ends, the following structural requirements shall be fulfilled:

.1 the fore and after peak bulkheads shall be fitted within the distance of 0,05L — 0,11L from the forward and after transoms accordingly, but not less than one spacing from the line connecting the sloped and flat bottom;

.2 frame spacing in peaks shall be not more than 550 mm;

.3 the bottom framing within 0,15L from the forward and after perpendiculars shall consist of plate floors fitted at every frame, with side girder spaced not more than 1 m apart.

The scantlings of floors and side girders shall be determined as for the midship region;

.4 the side framing within 0,2L from the forward and after perpendiculars shall be strengthened with web frames and side stringers.

The web frames shall be fitted not more than three or four spacings.

The side stringers shall be fitted so that the distance between the side stringers measured over the vessel's side in way of the floor nearest to the fore peak bulkhead, the distance from the side stringer to the upper edge of the floor, as well as from the side stringer to the deck is not more than 2 m.

The scantlings of main frames fitted between the web frames shall comply with the requirements of **3.6.4.7** as for the midship region where side stringers are not provided.

The side stringers shall have the same scantlings as the web frames and terminate at the bulkhead or at the web frame (refer to **2.5.4.7.2**).

Construction and end attachments of the web frames shall comply with the requirements of **2.5.5**;

.5 the transom bulkheads shall be strengthened with vertical stiffeners spaced not more than 0,5 m apart, and with horizontal girders arranged at the side stringer level.

Vertical webs shall be fitted in line with side girders. The scantlings of the vertical webs and horizontal girders shall be the same as those of web frames and side stringers in the fore peak. The scantlings of vertical stiffeners shall be the same as those of the frames. The attachments of stiffener ends with brackets shall comply with the requirements of **2.7.2** for watertight bulkheads.

3.6.2.9 Structural requirements for hull members of opening vessels.

3.6.2.9.1 Opening vessels consist of two separate semihulls with asymmetrical lines, connected by hinges positioned above the deck at the ends of the hopper. When discharging the spoil, the semi-hulls are opened about a common longitudinal axis on the centreline of the ship by means of hydraulic devices.

The structure of each semi-hull shall comply with the requirements of Section **2** with due regard for **3.6.2**; transverse or longitudinal or both framing systems may be adopted. In hopper side buoyancy tanks transverse ring structures spaced as required by **3.6.2.11.1** shall be fitted.

3.6.2.9.2 Where hinges are installed in opening hopper dredgers and hopper barges, deck plating and framing shall be strengthened. Hinge eyes shall pierce the decks.

3.6.2.9.3 Stops shall be fitted in the opening vessels between semi-hulls forward and aft from the hopper space. The stops shall be arranged at the levels of the bottom and the deck and shall prevent the hulls from displacement relative to one another.

3.6.2.9.4 Scantlings of brackets connecting framing members of each semi-hull shall comply with the requirements of **3.6.2.11.3**.

3.6.2.9.5 Longitudinal bulkheads and coamings of the hopper shall be extended with brackets as required by **3.6.2.7.4** and **3.6.2.11.7**.

3.6.2.10 Fixing of dredging gear.

3.6.2.10.1 Hull framing shall be strengthened in way of the main and ladder gallows.

The stanchions of the ladder gallows may terminate at the deck. In such case, pillars, vertical webs or other equivalent structures shall be provided under the stanchions or longitudinal and transverse bulkheads shall be fitted.

The stanchions of the main gallows shall extend to the bottom and be efficiently connected with longitudinal and transverse framing, otherwise transverse bulkheads shall be fitted under the stanchions.

3.6.2.10.2 In way of grab crane, spuds and other dredging gear adequate strengthening shall be provided.

3.6.2.11 Specific structures.

3.6.2.11.1 Whatever the hull framing of single-hull hopper dredgers and barges in way of the hopper is adopted, transverse ring structures consisting of the following items shall be fitted:

solid platforms or ring structures in the side buoyancy spaces and centre line box keel;

a lower cross member in the bottom part of the hopper, connecting the centre line box keel with longitudinal bulkheads of the hopper;

an upper cross member inside the hopper at a level of the main deck and upper edge of the coaming where its height more than 0,2 m (where the requirements of 3.6.4.11.10 are complied with, upper cross members need not be fitted);

vertical webs on the hopper coaming.

The maximum distance between transverse ring structures shall not be less than $b = (0{,}012L + 2{,}9)$ м.

3.6.2.11.2 The construction of diaphragms shall comply with the requirements of 2.5.2.2. Diaphragms which are more than 1 m in width shall be strengthened by vertical and horizontal stiffeners. Where longitudinal framing is adopted, horizontal stiffeners shall be fitted in line with side and bulkhead longitudinals. In lieu of the diaphragms watertight (non-tight) bulkheads complying with the requirements of **2.7.2** may be used.

3.6.2.11.3 The transverse ring structure in the side buoyancy space, fitted in lieu of the diaphragm, shall consist of side shell, bulkhead, bottom and deck transverses. The longitudinal bulkhead and side shell transverses shall be connected by means of cross ties which shall be so positioned that the distance between them, between a cross tie and a bottom or deck transverse is not more than 3 m. In lieu of the cross ties, use may be made of braces connecting a bulkhead transverse with a bilge or deck transverse bracket. Where platforms are fitted in side buoyancy spaces at the same distance as cross ties, cross ties and braces may be omitted.

The brackets connecting transverse ring structure items in the side buoyancy space shall have the length of the arms not less than one-twelfth of the greater span of the connected members. The free edge of the bracket shall have a face plate of the same width as that of the face plate of the greater member connected. The bracket thickness shall be equal to the web thickness of the greater member connected.

3.6.2.11.4 Hopper lower cross members may consist of a web with openings and face plates provided on the upper and lower edges or may take the form of a hollow box, generally of triangular cross-section.

The web thickness of the hopper lower cross member shall be taken equal to the plating thickness of the hopper longitudinal bulkheads at the corresponding level.

A cross member web shall be strengthened with stiffeners spaced 900 mm apart.

The upper face plate of the hopper lower cross member shall be made of a tube, section, round or flat bar, the lower face plate shall be fabricated of a flat bar having a thickness not less than that of the bottom plating.

The hopper lower cross members shall be connected with the hopper longitudinal bulkhead and centre line box keel by brackets having length of the arms equal to one-tenth of the length of the cross member upper face plate. The thickness of brackets shall be taken equal to the thickness of the cross member web. Where the depth of the cross member and centre line box keel is the same, brackets on the centre keel need not be fitted. The structure of box-type cross members is similar to that of the centre box keel. Where cross members are of a box shape, their lower and upper face plates shall be welded to the plating of the buoyancy spaces and centre line box keel.

3.6.2.11.5 The centre line box keel fitted in the hopper is generally fabricated as a closed box structure. The plating thickness of the sides shall be equal to that of hopper longitudinal bulkheads at the corresponding level, but not less than 8 mm for vessels of 60 m in length and less than 10 mm for vessels of more than 60 m in length. The thickness of the centre line keel bottom strake shall be not less than that of the plate keel. Where the transverse framing is adopted, the stiffeners in the upper part of the centre line box keel shall be connected with brackets, the thickness of which shall be not less than that of the floor and height not less than 2,5 times the depth of the stiffener web.

Where the breadth of the centre line box keel at bottom exceeds 1 m, but not more than 2 m, a bottom longitudinal shall be fitted on centre line box keel bottom, the depth of which shall be equal to half the floor depth. Where the breadth of the centre line keel is more than 2 m, an intercostal side girder having the same scantlings as the floor shall be fitted in lieu of the above longitudinal. The scantlings of floors are assumed the same as those of floors fitted in correspondingly framed buoyancy spaces.

On the top, the centre line box keel shall terminate in a bar, or an angle, or a cover plate, the thickness of which shall be equal to that of the centre line box keel.

The centre line box keel sides shall extend beyond the hopper transverse bulkheads by brackets, the arm lengths of which shall be equal to the depth of the centre line box keel, and the thickness equal to that of the centre line box keel side.

3.6.2.11.6 The upper cross members of the hopper space may consist of a web with openings and face plates on the upper and lower edges or be fabricated in the form of a hollow box generally of a triangular or another cross-section.

It is recommended that the upper cross members be attached to the hopper longitudinal bulkhead by brackets the arm lengths of which shall be equal to the depth of the upper cross member, and the thickness to its web thickness.

The upper cross members shall be connected to the centre line box keel by pillars, where such a keel is fitted.

3.6.2.11.7 The hopper coaming may be transversely or longitudinally framed. The upper edge of the coaming shall be stiffened with a face plate having a width not less than one-tenth of the coaming height and a thickness not less than a coaming thickness.

In case of longitudinal framing, the coaming shall be strengthened by longitudinals spaced not more than 900 mm apart.

In case of transverse framing, vertical stiffeners shall be fitted between stays at every frame.

The hopper side coamings shall be extended beyond the hopper ends by the brackets for a distance equal to 1,5 times the coaming height. Deck girders extending not less than three frame spaces from a bracket end shall be fitted under the brackets.

3.6.2.11.8 In floating cranes, the tub plating shall not be cut at the upper deck. No horizontal welds are permitted in the tub plating within the area extending for $0,2h$ up and down from the upper deck (where h is the distance between the bottom and the upper deck in way of the tub position).

3.6.2.11.9 Diaphragms shall be fitted inside the crane tub in line with the upper deck and platform.

3.6.2.11.10 For outer plating of specific structures 20 mm and more in thickness in way of the hopper steel of not lower than grade *D* shall be utilized.

3.6.3 Design load.

3.6.3.1 Design loads on the main hull structures shall be determined in compliance with Sections *1* and **2** at draughts d_1 and d_2 and the wave coefficient c_w under dredging conditions and during voyage. For dredging conditions, the wave coefficient cw shall not be taken greater than:

$$c_w = (D + h_c - d_1). \qquad (3.6.3.1)$$

3.6.3.2 The maximum value of the design load for vessel's extremities during voyages shall be obtained as required by **2.8.3** using the draught at the section 0,1L from the forward perpendicular. For the transom bulkhead angles $\alpha_x = 0$ and $\beta_x = 90°$ are assumed.

3.6.3.3 The design bending moments and shear forces in vessels of dredging fleet having $L \geq 60$ m shall be determined for voyage and for dredging conditions.

For voyage the hopper space is considered to be filled with water up to the effective waterline (or empty if such case is possible), stores and outfit are taken as 100 %, all gear being stowed for sea.

For the case of dredging operations, the hopper space is considered to be filled with homogeneous spoil up to the upper overflow level (coaming), there are no stores on board, the draught is equal to d_1, gear being stowed for sea.

Wave bending moments and shear forces shall be determined as required by **1.4.4**.

3.6.3.4 Opening vessels.

3.6.3.4.1 In opening vessels, still water and wave bending moment is created both by vertical and horizontal forces. Bending moments are calculated first in *vGu*, coordinate system and then recalculated for the basic inertia axes *x* and *y* of each semi-hull (refer to Fig. 3.6.3.4.1). A fully loaded hopper space at the maximum draught of the vessel is taken as a design case. Bending of each semi-hull hopper is considered separately. Deck hinges and hydraulic cylinders are assumed to be supports located at the hopper ends.

Besides, the following cases are considered:

sailing in the work area with spoil in the hopper, dredging gear stowed for sea;

voyage with water in the hopper space or in the ballast condition (the hopper is empty, wherever practicable). Stores and outfit are taken in full, all gear stowed for sea.

3.6.3.4.2 The type of supporting structures and the clearance between two semi-hulls in the fore and aft ends of the hopper space determine the conditions of horizontal moments calculation.

Where supporting structures fitted at the deck or bottom level forward or aft of the hopper space provide the absence of any clearance between the semi-hulls, and the length of the supporting structures creates adequate fixing against the horizontal forces acting athwart the hopper space, the horizontal force calculation is made assuming that a semi-hull is rigidly restrained at each hopper end.

Otherwise a semi-hull is considered to be freely supporte.

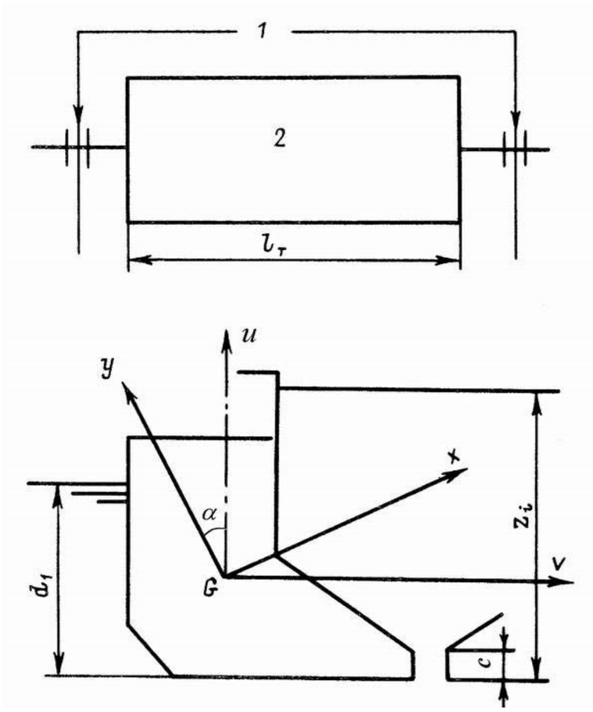


Fig. 3.6.3.4.1
1 – hinges; 2 – hopper space

3.6.3.4.3 Vertical loads.

The vertical bending moment at any section M_v, in kN. m, acting on each semi-hull shall be determined by the formula

$$M_v = 0,5(M_{sw} + M_w), \quad (3.6.3.4.3)$$

where: M_{sw} – still water bending moment to be obtained by load integration of the vessel with connected hulls for loading conditions referred to in 3.6.3.4.1, in kN · m;

M_w – wave bending moment for the vessel with connected hulls, to be determined as required by **1.4.4**, in kN · m.

Vertical moments are considered positive in case of hogging and negative in case of sagging.

3.6.3.4.4 Horizontal loads.

The horizontal bending moment M_{hi}, кН·м, in kN/m, acting on each semi-hull at the sections taken in the middle and at ends of the hopper space shall be determined by the formula

$$M_{hi} = M_{swhi} + M_{whi}, \qquad (3.6.3.4.4\text{-}1)$$

where: M_{swhi}, M_{whi} – horizontal still water and wave bending moments at the section under consideration, respectively, in kNm.

Horizontal moments are considered positive where the outer side of one semi-hull is subjected to tensile stresses.

The horizontal moment acting on a semi-hull depends on the fixing used at the ends of the hopper space.

Where a semi-hull is considered rigidly fixed at the ends of the hopper space, the horizontal moment shall be determined using the following formulae:

in still water:

at the section taken in the middle of the hopper space

$$M_{swh} = 0{,}10\,pl_h^2\,; \qquad (3.6.3.4.4\text{-}2)$$

at the hopper end sections

$$M'_{swh} = -0{,}10\,pl_h^2\,, \qquad (3.6.3.4.4\text{-}3)$$

where: $p = 0{,}5g\left(\rho_{\text{г}}\ H_2^2 - \rho d_1^2\right)$ (p – in kN/m);

in waves:

at the section taken in the middle of the hopper space

$$M_{wh} = M_w \frac{d_1}{B}\left(\psi_1 + \psi_2 \frac{E}{d_1}\right); \qquad (3.6.3.4.4\text{-}4)$$

at the hopper end sections

$$M'_{wh} = -M_w \frac{d_1}{B}\left(\psi_3 + \psi_4 \frac{E}{d_1}\right); \qquad (3.6.3.4.4\text{-}5)$$

$\psi_1 = 0{,}61 l_T / L - 0{,}103$;

$\psi_2 = 0{,}50 l_T / L - 0{,}100$;

$\psi_3 = 0{,}85 l_T / L - 0{,}112$;

$\psi_4 = 0{,}37 l_T / L - 0{,}050$;

$$E = \chi(C_b + 0{,}7)\left[1{,}38 - 0{,}128\left(\frac{300 - L}{100}\right)^{3/2}\right];$$

$\chi = 1{,}35L / 100 - 0{,}215.$

Where the semi-hull is not fixed at the hopper ends, the horizontal moment at the section at the middle of the hopper space shall be determined by the following formulae:

in still water

$$M_{swh} = 0{,}15p\, l_h^2; \qquad (3.6.3.4.4\text{-}6)$$

in waves

$$M_{wh} = M_w \frac{d_1}{B}\left(1 + \psi_5 \frac{E}{d_1}\right), \qquad (3.6.3.4.4\text{-}7)$$

wherer: $\psi_5 = 1{,}23(l_h / L - 0{,}5)$.

The still water and wave horizontal bending moments at the hopper end sections are equal to zero.

The sign of M_w shall be taken into account in determination of M_{wh} and M'_{wh}.

It is assumed that M_{swh} and M'_{swh} are equal to zero during voyage whatever the fixing conditions are.

3.6.3.5 Bending moments acting on the hull of the floating crane shall be determined for operating conditions in the work area and a voyage.

For the operation in the work area the design vertical bending moment M_{op}, in kN m, shall be determined by the formula:

$$M_{op} = M_{sw} + M_g + M_w, \qquad (3.6.3.5)$$

where: M_{sw} – still water bending moment according to **1.4.3**, in kN·m;

M_g – bending moment due to the weight of the load suspended on the crane hook, in kN·m. for a voyage M_g is assumed to be equal to zero;

M_w – wave bending moment for work areas and a voyage to be determined using a procedure agreed with the Register for a specified length and height of the wave.

3.6.3.6 The design pressure p_s, in kPa, on the bulkheads bounding the hopper space, on the structures of the enclosed watertight centre line box keel shall be determined by the formula

$$p_s = \rho_s g z_i, \qquad (3.6.3.6)$$

where: z_i – distance of the load application point from the upper weir level (upper edge of the coaming), in m.

3.6.3.7 The design load p_1, in kPa, on a partial bulkhead (diaphragm) or a transverse ring structure of the side buoyancy space at a level of the mid-height of the hopper lower cross member due to spoil pressure, having regard to the outer counterpressure, shall be determined by the formula

$$p_1 = g\,(0{,}8\rho_{гр} H_1 - 1{,}5\rho_{гр} h_к - 0{,}1\rho H_1 \varepsilon), \qquad (3.6.3.7)$$

where: $\varepsilon = 0$ when $D \le 4$ m;

for $D > 4$ m:

$\varepsilon = 0{,}2\,D - 0{,}8$ when $d_1/D \le 0{,}75$;

$\varepsilon = 0{,}4\,D - 1{,}6$ when $d_1/D > 0{,}75$.

3.6.3.8 The vertical design load p_2, in kPa, due to spoil pressure, having regard to the counterpressure of the water on the lower cross member of the hopper space shall be determined by the formula

$$p_2 = g\,[\rho_s H_2 - (\rho d_1 + 0{,}5\rho c_w) - \rho_s(l_{l.cr} - b_{b.k})\,A_{l.cr}/(b l_{l.cr}) - 1{,}5\rho_s A_{b.k}/l_{l.cr}] \qquad (3.6.3.8)$$

3.6.3.9 The horizontal design load p3, in kPa, due to the dredged spoil pressure on face plates of the hopper lower cross member shall be determined by the formulae:

for the upper face plate

$$p'_3 = g\rho_s h_{l.cr}/6$$

(3.6.3.9)

for the lower face plate

$$p''_3 = g\rho_s h_{l.cr}/3$$

3.6.3.10 The design load p_4, in kPa, on the framing members and on the plating of the hopper coaming shall be determined by the formula

$$p_4 = g\rho_s h_c. \qquad (3.6.3.10)$$

The value p_4 shall be taken not less than 15 kPa.

3.6.3.11 The design axial force N, in kN, acting at the mid-height level of the hopper lower cross member on a diaphragm or a transverse ring structure of the side buoyancy space shall be determined by the formula

$$N = gbH_1\,[0{,}4\rho_s H_1 + 0{,}63\rho_s h_c - 0{,}03\rho H_1 m], \qquad (3.6.3.11)$$

where: $m = 0$ for $D \le 3{,}5$ m;
$m = 1$ for $D > 3{,}5$ m, $d_1/D \le 0{,}75$;
$m = (9D - 31{,}5)(d_1/D - 0{,}75)$ for $D > 3{,}5$ m, $d_1/D > 0{,}75$.

3.6.3.12 The design axial force $R_{l.cr}$, in kN, acting on the lower cross member of the hopper space shall be determined by the formula

$$R_{l.cr} = 0{,}163g\frac{b}{H_1}[\rho_s H_2^2(3D - H_2) - \rho(d_1 - 0{,}5c_w)^2(3D - d_1 + 0{,}5c_w)]. \quad (3.6.3.12)$$

3.6.3.13 The design axial force $R_{up.cr}$, in kN, acting on the upper cross members of the hopper space shall be determined by the following formulae:

.1 for the upper cross member fitted at the deck level

$$R_{up.cr} = R_1 - R_2 - R_3 - R_4, \quad (3.6.3.13.1)$$

where: R_1 – pressure of dredged spoil on the upper cross member determined as:

$$R_1 = g\rho_s\frac{0{,}082bH_2^2}{H_1}(2H_2 - 3h_{l.cr});$$

R_2 – external hydrostatic pressure on the upper cross member determined as:

$$R_2 = g\rho\frac{0{,}082b(d_1 - 0{,}5c_w)^2}{H_1}(2d_1 - c_w - 3h_{l.cr});$$

R_3 – reaction due to supporting bending moment at the junction of the diaphragm with the lower cross member determined as

$$R_3 = p_2\frac{bl_{l.cr}^2}{12H_1};$$

R_4 – force resulting from supporting reactions of the hopper lower cross member determined by the formula

$$R_4 = \frac{b\,l_{l.cr}}{4}\frac{b_2}{H_1}\left(p_2 + \frac{0{,}5g\rho_s\ A_{k.b}}{l_{l.cr}}\right);$$

.2 for the upper cross member fitted at the upper face plate of the hopper coaming

$$R_{up.cr} = g\rho_s bh_c^2. \quad (3.6.3.13.2)$$

3.6.3.14 The design load on deck shall be not less than 20 kPa.

3.6.3.15 The design loads on the structures of each semi-hull of opening vessels shall be determined in compliance with **3.6.3.1 ÷ 3.6.3.14**.

3.6.3.16 In opening hopper dredgers and hopper barges, for each hydraulic press, the horizontal statical force F_H, in kN, necessary to keep the hull closed is determined by the formula (refer also to Fig. 3.6.3.16):

$$F_H = (1/n_1a_3)[-F_h a_1 + F_d a_2 + 0{,}5(g\Delta b_1 - g\Delta_n b_2 - gQ_s b_3)], \quad (3.6.3.16\text{-}1)$$

where: n_1 – number of hydraulic presses;
F_h – horizontal force of water pressure on the hull, determined by the formula

$$F_h = 0{,}5\rho gl_h(d_1 - 0{,}5c)^2;$$

F_d – horizontal force of dredged spoil pressure on the hull, determined by the formula

$$F_d = 0{,}5\rho_s gl_h(H_2 - 0{,}5c)^2;$$

where: for c – refer to Fig.3.6.3.4.1;

a_1, a_2, a_3, b_1, b_2, b_3 – force arms, in m (refer to Fig. 3.6.3.16).

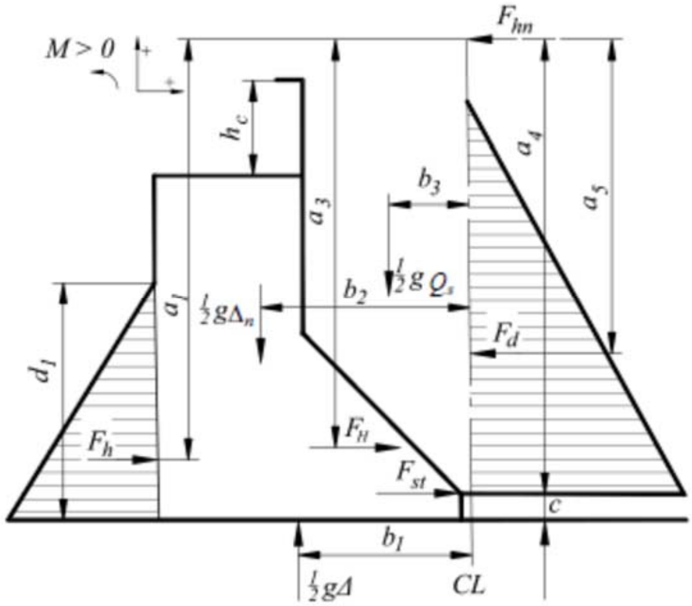


Fig. 3.6.3.16

For design force F_{des}, the maximum pressure value achieved by the hydraulic press is adopted, with $F_{des} \geq F_H$.

The horizontal static force in each hinge F_{hn}, in kN, is determined by the formula

$$F_{hn} = 0,5[F_h + n_1F_H - F_d - n_1a_3(F_{des} - F_h) / a_4], \qquad (3.6.3.16\text{-}2)$$

where: a_4 – =arm of the force acting upon the stop, in m.

The horizontal static force acting upon each stop is determined by the formula

$$F_{st} = n_1a_3(F_{des} - F_h) / (n_2a_4), \qquad (3.6.3.16\text{-}3)$$

where: n_2 – number of stops.

The vertical components of static forces in hinges are assumed equal to zero.

3.6.3.17 The dynamic forces acting on hydraulic cylinders and deck hinges shall be determined by calculations of vessel's motions in a seaway, with various course angles, in light-ship and full-load conditions. Based on these calculations, maximum vertical and horizontal forces acting on the hydraulic presses are determined. The calculation shall be made using a procedure approved by the Register.

3.6.4 Scantlings of structural members.

3.6.4.1 Scantlings of structural members shall be determined in compliance with Sections 1 and 2, having regard to the provisions of this Chapter.

3.6.4.2 The required hull section modulus of a singlehull vessel of 60 m in length and over shall be determined as required by **1.4.6** for deck, bottom, upper edge of the hopper coaming, having regard to specified work areas and voyages. The greater value obtained for the work area or voyage (refer to **3.6.3.3** and **3.6.3.4**) shall be taken.

For opening hopper dredgers and hopper barges the required section modulus shall be determined for the case when both semi-hulls are connected (refer to **3.6.3.4**).

3.6.4.3 When calculating the actual section modulus of the hull in way of the hopper space as required by 1.4.8, account shall be taken of all continuous longitudinals, longitudinal bulkheads and the hopper space coamings with longitudinals, 85 % of the total area of centre line box keel longitudinal members, provided they are properly interconnected with the longitudinal framing members beyond the hopper and fitting of transverse members regulated by the Rules, inside the hopper.

The continuous deck plating longitudinally framed above the hopper space and a wash bulkhead in the hopper may be included in the actual section modulus calculation using a procedure approved by the Register.

3.6.4.4 Longitudinal strength of each semi-hull of opening hopper dredgers and hopper barges shall be checked for vertical and longitudinal bending moments in asymmetrical bending (refer to Fig. 3.6.3.4.1).

3.6.4.4.1 Normal stresses arising in cross-section points under conditions of asymmetrical bending shall be determined amidships and at the end bulkhead sections of the hopper space (from inside the hopper), provided the hulls at this position are rigidly restrained.

Stresses σ, in MPa, shall be determined by the formula:

$$\sigma = \left(M_x \frac{y}{I_x} - M_y \frac{x}{I_y} \right) \cdot 10^{-3}, \qquad (3.6.4.4.1\text{-}1)$$

where: $M_x = M_v \cos\alpha - M_h \sin\alpha$;

$M_y = M_v \sin\alpha + M_h \cos\alpha$;

For M_v, M_h – refer to **3.6.3.4.3** and **3.6.3.4.4**;

α – rotation angle of main inertia axis (positive value of α – rotation *Gu* axis counter-clockwise), it shall be determined by the formula

$$\mathrm{tg}\, 2\alpha = 2I_{uv}/(I_u - I_v); \qquad (3.6.4.4.1\text{-}2)$$

$I_{uv} = \sum_i u_i v_i \, dS_i$ – centrifugal inertia moment about axes *Gu*, *Gv* with no regard for wear allowance, in m^4;

u_i, v_i – distance of the centre of gravity of *i*-th member area from the axes *Gu*, *Gv*, in m;

dS_i – *i*-th member area, in m^2;

I_u, I_v – inertia moments of the semi-hull cross-section about axes *Gu, Gv* with no regard for wear allowance, in m^4;

x, *y* – coordinates of the section point under consideration about main axes *Gx, Gy* (refer to Fig. 3.6.3.4.1), in m;

I_x, I_y – inertia moments of the semi-hull cross-section about the main axes with no regard for wear allowance, in m^4.

3.6.4.4.2 Normal stresses acting in the semi-hull cross-section (for normal strength structural steel) shall not exceed:

150 MPa for the lower edge of the deck stringer;

145 MPa for the upper edge of the plate keel;

165 MPa in the face plate of the hopper coaming.

3.6.4.4.3 Permissible shear stresses for members made of normal strength structural steel and participating in the longitudinal bending are assumed equal to 115 MPa. Equivalent stresses $\sigma_{eq} = \sqrt{\sigma^2 + 3\tau^2}$ at the sections where substantial normal stresses σ and shear stresses τ (at the hopper ends) act shall be not more than 170 MPa.

3.6.4.4.4 Buckling strength of compressed members according to **1.6.5** shall be ensured.

3.6.4.5 Bottom framing.

3.6.4.5.1 When the bottom is transversely framed, the moment of inertia and scantlings of floors in side buoyancy spaces shall be determined as required by **2.3.4.1.1**; in this case, to be taken as B_1 is doubled breadth of the buoyancy space over the bottom.

3.6.4.5.2 Where a single bottom is longitudinally framed, the section modulus of bottom longitudinals in buoyancy spaces shall be not less than that determined in compliance with **2.3.4.2.1**. The floors shall be fitted in line with transverse ring structures, their section modulus and cross sectional area shall be not less than determined from **2.3.4.2.3** and **2.3.4.2.4**. The section modulus and depth of a side girder shall be not less than those required for the floor. The floor web depth shall not be less than $0{,}13B_1$ (refer to **3.6.4.5.1**).

3.6.4.5.3 The scantlings of the bottom framing members in each semi-hull of opening vessels shall be determined as required by **2.3.4.2**; to be taken as breadth B_1 is the breadth of one semi-hull at the section under consideration. There is no bottom centre girder in opening vessels.

3.6.4.5.4 The scantlings of double bottom members in way of the hopper space are determined as for dry cargo ships having double skin construction according to **2.4** with regard to **3.6.2.4**; beyond the hopper as for dry cargo ships with single skin construction in compliance with the requirements of the same paragraphs.

The plate floor spacing shall not exceed the maximum spacing of transverse ring structures, specified in **3.6.2.11.1**.

3.6.4.5.5 For floating cranes the section modulus of bottom transverses shall be as required by **2.3**, and additional bottom longitudinals shall have the same section modulus as for main longitudinals.

3.6.4.5.6 In calculating the section modulus and the depth of floors in accordance with **2.3**, B_1 is assumed to be the floor span between the side shell and the longitudinal bulkhead or between the longitudinal bulkheads, but not less than 0,4 of the full breadth of the ship.

3.6.4.5.7 In case of longitudinally framed bottom, the scantlings of floors and bottom longitudinals of floating cranes beyond the double bottom area shall be determined in accordance with **2.3.4.2**.

3.6.4.6 Shell plating.

3.6.4.6.1 Shell plate scantlings are determined in accordance with **2.2.4**. The thickness of the bottom strakes to which hopper longitudinal bulkheads or well sides are connected shall be increased by 15 per cent as against that of the bottom plating. Where there is no centre line box keel, the thickness of the bottom strakes abutting on the hopper longitudinal bulkhead shall be increased by 50%.

3.6.4.6.2 The side shell plating thickness at the hopper ends shall not be less than required by **1.4.7**.

3.6.4.6.3 In vessels with pontoon hulls, the thickness of the bottom and side shell plating within 0,15L from the forward and after perpendiculars shall not be less than the plating thickness within the midship region.

3.6.4.6.4 The thickness of the well side plating shall be equal to the thickness of the side shell plating in area concerned, but not less than 8 mm.

3.6.4.6.5 In opening vessels the shell plating thickness shall be determined with regard for **3.6.4.4**.

The thickness of the bottom strakes at the hopper longitudinal bulkhead need not be increased.

3.6.4.6.6 In floating cranes the thickness of the bottom plating within 0,2L from the forward perpendicular shall be increased over the entire breadth of the hull by 30 % as against the minimum thickness required by **2.2.4.8**.

In the fore peak and the areas extending forward for 0,1L from the stern transom corners and inboard for 0,1B, the thickness of the side shell plating shall be increased over the entire depth by 30 % as compared to the minimum thickness required by **2.2.4.8** (refer also to **3.6.2.5.2**).

In other regions along the hull length, the minimum thickness of the shell plating shall be increased by 10 % as against that prescribed by **2.2.4.8**.

3.6.4.6.7 The plating thickness of the bow and stern transoms in floating cranes shall not be less than required by **3.6.4.6.3**.

3.6.4.7 Side framing.

The scantlings of the side framing members shall be determined in compliance with 2.5, having regard to **3.6.2.5**, **3.6.2.11** and the requirements given below:

.1 the section modulus of frames in transversely framed side buoyancy spaces shall be determined from **2.5.4.1** as for dry cargo ships.

Where a side stringer is fitted at a level of fenders, main frame span may be determined in compliance with **2.5.1.2** as for side transverses of tankers, provided the structure of the side stringer meets the requirements of **3.6.4.7.2**. Where no transverse ring structures are fitted, braces may be provided in line with horizontal girders of longitudinal bulkheads;

.2 the scantlings of side stringers shall be determined as required by **2.5.4.4** as for the case of fitting web frames. The width of the side stringer shall not be less than 0,08l (l =stringer span as measured between web frames or between those and tight transverse bulkheads) or 2,5 times the frame depth, whichever is the greater. Side stringers shall be aligned with cross ties of the transverse ring structures;

.3 the section modulus of side longitudinals shall be determined as required by **2.5.4.3** with k_σ values taken as for dry cargo ships;

.4 the section modulus and cross-sectional area of web frames which are a part of a transverse ring structure shall be not less than those required in **2.5.4.5** for side transverses of tankers.

A web frame span shall be measured between the inner edges of the floor and an inner edge of the beam.

The depth of the web frame shall not be less than 0,1l or 2,5 times the width of longitudinals (whichever is the greater) and may be assumed varying with reduction at the upper end and increase at the lower end by 10 % as against the average value;

.5 the section modulus of well longitudinal bulkhead stiffeners shall not be less than required for side frames;

.6 in floating cranes, the section modulus of main and intermediate frames in the fore peak shall be increased by 20 % as compared to that required by **2.8.4.2.2**;

.7 the section modulus of web frames in floating cranes W, in cm^3, within the region specified in **3.6.2.5.3** shall not be less than

$$W = 0{,}95\left(300 + \frac{120}{\sigma_n} bp\,l^2\right)\omega_c , \qquad (3.6.4.7.7)$$

where: l – web frame span measured between the deck and the upper edge of the floor, in m;
p – as defined in **3.6.3**, but not less than $0{,}5\rho g l$, in kPa;

.**8** the scantlings of the framing members of the bow and stern transoms shall not be less than required by**3.6.4.7.2 – 3.6.4.7.4** and **3.6.4.7.6**.

3.6.4.8 Decks.

3.6.4.8.1 The plating thickness of the strength deck within the midship region shall be taken not less than the sheerstrake thickness. The minimum thickness of the deck plating in vessels of dredging fleet shall be determined according to **2.6.4.2** as for the strength deck. For floating cranes the minimum thickness of the upper deck shall be increased by 10 % as against that prescribed by **2.6.4.2** as for the strength deck.

2.6.4.8.2 Compressive stresses in deck shall be determined under the action of bending moment components according to **3.6.3**. The buckling strength requirements of **1.6.5** shall be met.

2.6.4.8.3 The depth of deck transverses in buoyancy spaces which form a part of the transverse ring structure shall be equal to two-thirds of the floor depth, while the thickness of the web plate and sizes of the face plate shall be equal to those of the vertical webs. The depth of the deck transverse shall be not less than 2,5 times the height of the deck longitudinal.

2.6.4.8.4 For floating cranes the section modulus of deck girders shall be determined as required by **1.6.4.1** with $k_\sigma = 0{,}6$ and
$m = 12$.

2.6.4.8.5 The deck plating thickness under the seats of special arrangements fitted on the deck (cat cranes of suction tubes, transfer appliances, grab cranes, etc.) and where special metal structures pass through the deck (main and ladder gallows) shall be increased by 25%.

3.6.4.9 The scantlings of side and deck framing members, the thicknesses of deck plating, bulkhead framing and plating, and coamings of opening vessels shall be determined with regard for **3.6.4.4**.

Where vertical webs and web frames are connected by cross ties or braces, the scantlings of vertical webs, web frames and braces shall be determined by calculation.

3.6.4.10 In vessels with pontoon hulls, the scantlings of side stringers at the forward end of the vessel shall be prescribed as required by **2.8.4.5**, the height and thickness of vertical webs and web frames shall be the same as the width and thickness of the stringer.

3.6.4.11 Specific structures of vessels of dredging fleet.

3.6.4.11.1 The section modulus W, in cm^3, of the diaphragm of the buoyancy space after deduction of openings, or the total section modulus of a vertical web and a web frame of the transverse ring structure at the section of a mid-point of the hopper lower cross member depth shall not be less than

$$W = \frac{p_1 b H_1^2 \cdot 10^3}{m k_\sigma \sigma_n}\omega_k , \qquad (3.6.4.11.1)$$

where: for H_1 – refer to Fig. 3.6.1.6;
$m = 12$;
$k_\sigma = 0{,}6$;
p_1 – as defined in **3.6.3.7**.

3.6.4.11.2 The cross-sectional area f, in cm^2, of the diaphragm, or the total sectional area of a vertical web and a web frame of the transverse ring structure at a level of a mid-point of the hopper lower cross member depth shall be not less than

$$f = \frac{10N}{k_\tau \tau_n} + 0{,}1\Delta f_i , \qquad (3.6.4.11.2)$$

where: N – as defined in **3.6.3.11**;
$k_\tau = 0{,}65$;
$\Delta f_i = \Delta s b_i$;

b_i – typical member scantlings (half-breadth of deck, web height of longitudinal, etc.), in cm.

The scantlings of the transverse ring structure members (bottom transverse, vertical web, side and deck transverses) shall be not less than required by the relevant paragraphs of this Chapter for such members.

3.6.4.11.3 The section modulus W, in cm^3, sectional area of the hopper lower cross member web f_w, in cm^2, after deducting openings, sectional area of the floor with face plates f_0, in cm^2, shall not be less than::

$$W = \frac{10^3 b l_{l.cr}^2}{m k_\sigma \sigma_n} p_2 \omega_c; \quad (3.6.4.11.3\text{-}1)$$

$$f_w = 5\frac{b l_{l.cr}}{k_\tau \tau_n}\left(p_2 + \frac{0{,}5\rho_s g}{l_{l.cr}} A_{b.k}\right) + 0{,}1\Delta f_i; \quad (3.6.4.11.3\text{-}2)$$

$$f_0 = \frac{10 R_{l.cr}}{k_{\sigma_p}\sigma_n} + 0{,}1\Delta f_i, \quad (3.6.4.11.3\text{-}3)$$

where: m = 12;

k_σ = 0,45;

k_{σ_p} = 0,2 ;

k_τ = 0,45;

p_2 – as defined in **3.6.3.8**;

$R_{l.cr}$– as defined in **3.6.3.12**;

for Δf_i – refer to **3.6.4.11.2.**

3.6.4.11.4 The section modulus of the face plates of the hopper lower cross members W, in cm^3, about the horizontal axis and sectional area $f_{f.p}$, in cm^2, shall not be less than:

for the upper face plate

$$W = \frac{10^3 h_{l.cr} l_1^2}{m k_\sigma \sigma_n}\left[3 - \frac{(l_1 - l_2)^2}{l_1^2}\right] p_3' \omega_c; \quad (3.6.4.11.4\text{-}1)$$

$$f_п = \frac{2{,}5 p_3' h_{l.cr}(l_1 + l_2)}{k_\tau \tau_n} + 0{,}1\Delta f_i; \quad (3.6.4.11.4\text{-}2)$$

for the lower face plate

$$W = \frac{2 p_3'' h_{l.cr} l_2^2 \cdot 10^3}{m_1 k_\sigma \sigma_n}\omega_c; \quad (3.6.4.11.4\text{-}3)$$

$$f_{f.p} = \frac{5 p_3'' h_{l.cr} l_2}{k_\tau \tau_n} + 0{,}1\Delta f_i, \quad (3.6.4.11.4\text{-}4)$$

where: for l_1, l_2 – refer to **3.6.1.6**;

m = 24;

m_1 = 12;

k_σ = 0,6;

k_τ = 0,45;

p_3', p_3'' – as defined in **3.6.3.9**;

Δf_i – as defined in **3.6.4.11.2**.

3.6.4.11.5 The section modulus of bulkhead vertical webs, horizontal girders, vertical stiffeners and longitudinals of the hopper longitudinal bulkheads shall be determined as for side framing according to 3.6.4.7 with substitution of p according to **2.5.3** by p_s according to **3.6.3.6**. For the longitudinal bulkhead stiffeners m=11 and k_σ = 0,75.

The depth of the vertical web shall be not less than 0,12l and may be assumed varying with reduction at the upper end and increase at the lower end by 10 % as compared to the average value.

Two upper longitudinals shall be taken the same as the third longitudinal from the deck.

Besides, three upper and three lower longitudinals shall be checked according to **1.6.5.4**.

The width of the horizontal girder shall be equal to that of the bulkhead vertical web.

3.6.4.11.6 The plating thickness of the hopper longitudinal and end bulkheads shall be determined as required by 1.6.4.4 assuming p $=p_s$ (where p_s shall be obtained from **3.6.3.6**), $k_\sigma = 0{,}7$, $m = 15{,}8$.

The upper strake thickness of the hopper longitudinal bulkhead at 0,1D below the deck shall not be less than the sheerstrake thickness. The lower strake thickness of the longitudinal bulkhead at 0,1D from the base line shall not be less than the bottom plating thickness.

3.6.4.11.7 The minimum thickness of hopper bulkhead plating shall be equal to 8 mm for vessels having the length $L < 60$ m and 10 mm for vessels having the length $L \geq 80$ m. For intermediate values of L, the minimum thickness shall be determined by linear interpolation.

3.6.4.11.8 The section modulus W, in cm^3, of vertical stiffeners and stanchions of the hopper coaming shall not be less than determined by the formula[1]:

$$W = \frac{p_4 a h_c^2 \cdot 10^3}{m k_\sigma \sigma_n} \omega_c, \qquad (3.6.4.11.8\text{-}1)$$

where: p_4 – as defined in **3.6.3.10**;

$m = 15$ – for stanchions where upper cross members are fitted in line with transverse ring structures at the coaming top;

$m = 6$ – for stanchions where no upper cross members are fitted at the coaming top;

$m = 15{,}6$ – or vertical stiffeners where transverse framing is adopted;

$k_\sigma = 0{,}6$.

The section modulus W, in cm^3, of horizontal stiffeners and face plate of the coaming shall not be less than

$$W = \frac{p_4 a b^2 z_i \cdot 10^3}{m k_\sigma \sigma_n h_c} \omega_c, \qquad (3.6.4.11.8\text{-}2)$$

where: z_i – distance between the coaming top and horizontal stiffeners, but not less than half the coaming height, in m;

$m = 12$;

$k_\sigma = 0{,}2$.

The sectional area f_{st} of the coaming stanchion, in cm^2, at deck shall not be less than

$$f_{\text{ст}} = \frac{4 p_4 a h_c}{k_\tau \tau_n} + 0{,}1\Delta f_i, \qquad (3.6.4.11.8\text{-}3)$$

where: $k_\tau = 0{,}45$;

Δf_i – as defined in **3.6.4.11.2.**

The plate thickness of the side (end) coaming shall be determined as for the longitudinal (end) bulkhead of the hopper p_s according to **3.6.3.6** as measured at the deck level, but it shall be taken not less than the upper strake thickness of the longitudinal bulkhead.

The depth of the stanchion at deck shall be not less than 0,12h_c and the thickness not less than the coaming thickness.

The plate thickness of the coaming and moment of inertia of the horizontal stiffeners and face plate of the coaming shall meet the buckling strength requirements according to **1.6.5**.

3.6.4.11.9 The sectional area of the upper cross members spanning hopper space at deck level and/or coaming level $f_{up.cr}$, in cm^2, shall not be less than

$$f_{up.cr} = 0{,}085 R_{up.cr} + 0{,}1\Delta f_i, \qquad (3.6.4.11.9\text{-}1)$$

where: Δf_i – as defined in **3.6.4.11.2.**

Where a load from bottom closing appliances is applied to the upper cross members, their strength shall be checked using the equivalent stress given below

$$\sigma_{eq} = \sqrt{\sigma_{max}^2 + 3\tau_{sh}^2} \le 0{,}75\sigma_n, \qquad (3.6.4.11.9\text{-}2)$$

where:

$$\sigma_{max} = \frac{10R_{up.cr}}{f_{up.cr}} + \frac{M_b}{W} \cdot 10^3;$$

$\tau_{sh} = 10N_{sh}/f_w$;

M_b, N_{sh} – maximum bending moment, in kNm, and shear force, in kN, due to transverse load;

W – actual section modulus of the upper cross member, in cm^3;

$f_{up.cr}$, f_w – full sectional area of the upper cross member and sectional area of the cross member web, in cm^2.

3.6.4.11.10 Where no upper cross members are fitted at a deck level in line with transverse ring structures, a part of the coaming structure with the upper portion of the side buoyancy space located at 0,1D below the deck line (refer to Fig. 3.6.4.11.10) shall have a section modulus W, in cm^3, about a horizontal axis not less than

$$W = \frac{550R_{up.cr}(l_h - b)^2}{b\sigma_n}\omega_c. \qquad (3.6.4.11.10\text{-}1)$$

The thickness of the deck plating s, in mm, shall not be less than

$$s = \frac{1{,}11R_{up.cr}(l_h - b)}{bB_3\tau_n} + \Delta s, \qquad (3.6.4.11.10\text{-}2)$$

where: for B_3 – refer to Fig. 3.6.4.11.10.

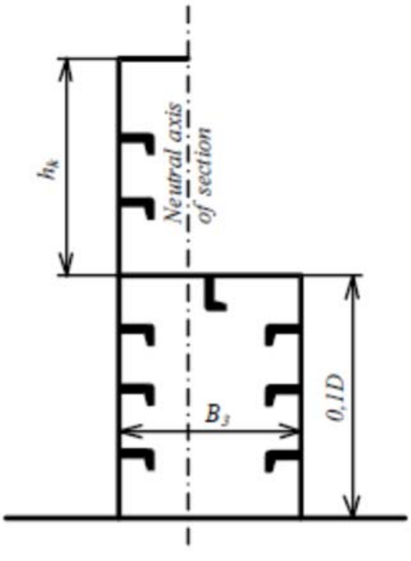


Fig. 3.6.4.11.10

3.6.4.11.11 The scantlings of hull structural items in places where hinges and hydraulic presses of opening vessels are installed shall be determined by direct calculation of the effect of static and dynamic forces in accordance with **3.6.3.16**.

3.6.4.11.12 The strength calculation of foundations and attachments of hydraulic presses shall be made as regards the effect of forces determined according to **3.6.4.11.11**.

3.6.4.12 Specific structures of floating cranes.

3.6.4.12.1 The thickness of the tub plating at the upper deck shall be determined by calculation based on the total bending moment due to load and weight of the moveable upper structure of the crane applied to the supporting tower, and the horizontal component of the load for the case when a design safe working load of the crane with the lifting height from the water level at the maximum outreach is used.

Permissible stresses for normal strength steel shall not be more than:

σ = 140 MPa and τ = 80 MPa.

The buckling strength of the tub plating over its entire height shall be ensured to the value

$\sigma_{cr} = 2{,}5R_{eH}$.

3.6.4.12.2 The inertia moment I_{min}, in cm^4, of the tub vertical stiffeners (if any) shall not be less than

$$I_{min} = (1{,}03l - 1{,}80y)\, s^3, \qquad (3.6.4.12.2)$$

where l= stiffener span measured between the bottom and the platform or between the platform and the deck, whichever is the greater, in m. Where the platform is omitted, the distance between the bottom and the deck is measured;

y= spacing of stiffeners, measured along the chord line, in m;

s= tub plating thickness at the stiffener mid-span, in mm.

3.6.4.12.3 The plating thickness of the bulkheads forming a cross and the bearing contour shall not be less than determined according to **2.7.4.1**, assuming

$k_\sigma = 0{,}70$;

$\Delta s \geq 4$ mm for bulkheads forming the cross and

$\Delta s \geq 2$ mm for those forming the bearing contour.

For cranes having a safe working load more than 100 t, the stressed condition of framing members and plating of bulkheads forming the cross under the loads transferred from the fixed supporting tower in case of using the design safe working load at the maximum outreach shall be checked according to the procedure approved by the Register.

3.6.4.12.4 The plating thickness of the upper deck and the bottom s', in mm, in way of the crane tub shall not be less than

$$s' = \alpha s\,, \qquad (3.6.4.12.4)$$

where: s – as defined in **3.6.4.12.1**;

α = 0,6 and 0,4 for the upper deck plating and bottom plating, respectively.

The dimensions of the plates of increased thickness shall be taken in accordance with Fig. 3.6.4.12.4.

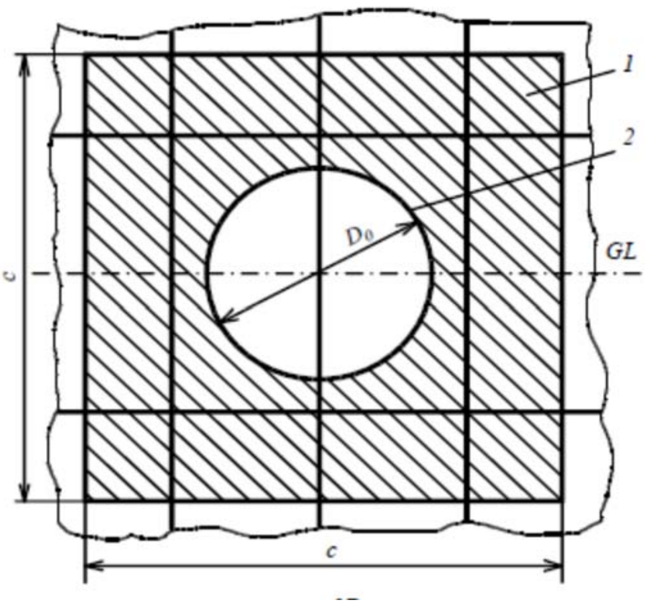


Fig. 3.6.4.12.4
1 - thickened plate; 2 - tub

3.6.5 Special requirements.

3.6.5.1 Where vessels are intended to ground during the course of normal service, the bottom of such vessels shall be suitably strengthened, as follows:

.1 the thickness of the bottom shell plating shall be increased by 20 % over the minimum requirement;

.2 where the double bottom is omitted and transverse framing system is adopted, the bottom shell plating between the bottom side girders shall be strengthened by horizontal stiffeners.

In line with horizontal stiffeners vertical stiffeners shall be fitted. The horizontal stiffeners shall pass through openings in the floors and be welded to them;

.3 where double bottom is omitted and longitudinal framing system is adopted, the bottom shell plating shall be strengthened by additional floors, the depth of which shall be not less than 2,5 times the depth of the bottom longitudinal and a thickness equal to that of the main floors. The main floors shall be strengthened by vertical stiffeners fitted in line with bottom longitudinals. Side girders shall not be spaced more than 2,2 m apart. The scantlings of bilge longitudinals shall not be less than those required for the bottom;

.4 in transversely framed double bottom plate floors shall be fitted at every frame, side girders shall be spaced not more than 2,5 m apart, they shall be also fitted inboard or from longitudinal bulkheads at a distance not exceeding 2,5 m. The bottom shell plating shall be strengthened by horizontal stiffeners fitted between the side girders. Vertical stiffeners shall be fitted in line with horizontal stiffeners at every floor and be welded to them.

In longitudinally framed double bottom floors shall be fitted at every second frame, and side girders shall be spaced 2,5 m apart;

.5 n way of a recess for vertical girders of suction tubes, the following hull strengthening shall be provided:

side framing shall be reinforced by at least three web frames, the scantlings of which shall be the same as those required for the engine room, and by not less than three intercostal side stringers extending for three spacings from the extreme web frames which shall be fitted not less than 50 mm from the edge of the recess;

side shell plating in way of the recess shall be made of a curved welded-in plate, the vertical butt joint of this plate shall be not less than 100 mm from the edge of the recess;

the thickness of the deck stringer in way of the recess shall be increased by 60 % over the length equal to one spacing forward and abaft of web frames.

3.6.5.2 The requirements of **3.6.5.1** shall not apply to floating cranes for which deep sea service is specified and which are not likely to ground under any conditions of heel and trim.

3.6.5.3 The thickness of structural members which are subjected to abrasive wear due to the effect of spoil/water mixture (in particular, in case of special dredging methods used) shall be increased.

3.6.5.4 Dredging pumps shall be located in special spaces bounded by watertight bulkheads.

3.6.5.5 The scantlings of deck framing members on deck portions where heavy dredging (cargo handling) gear is installed, as well as where large heavy cargoes may be carried on decks of floating cranes or hopper dredgers shall be determined by calculation for the following conditions:

beams are considered to be rigidly fixed to the supporting structure;

a load (concentrated, partially distributed, etc.) shall be taken into account;

equivalent stresses for items made of normal strength steel σ_{eq}, in MPa, shall comply with the

$$\sigma_{eq} = \sqrt{\sigma^2 + 3\tau^2} \le 170\,, \qquad (3.6.5.5)$$

where: σ, τ – normal and shear design stresses at the section under consideration.

3.7 FISHING VESSELS AND SPECIAL PURPOSE SHIPS USED FOR PROCESSING OF SEA LIVING RESOURCES

3.7.1 General and symbols.

3.7.1.1 The requirements of this Chapter apply to fishing vessels having a stern trawling arrangement or a side trawling arrangement and to special purpose ship intended for processing, storage and/or transportation of catch.

3.7.1.2 The requirements for hull structures not referred to in this Chapter are given in Sections **1** and **2**.

In no case shall the requirements for hull structures be less stringent than those contained in Sections **1** and **2**.

3.7.1.3 For the purpose of this Chapter, the following symbols have been adopted:

b – = breadth of stern ramp, in m;

G_1 – greatest specified mass of catch which can be handled by a special wheeled device or another transport means, in t;

G_2 – mass of moving part of special wheeled device or another transport means, in t;

G – mass of processing equipment, in t;

S_d – factory deck area, in m^2,

h – spacing of boundaries of region of side strengthening from summer load line and ballast waterline;

A1–A7, E1–E6 – regions of strengthenings;

a – = spacing of framing members under consideration, in m (refer t0 **2.1.2**);

l – = span of member under consideration (refer to **1.6.3.1**);

Δ*s* – corrosion and wear allowance added to plate thickness, in mm (refer to **1.1.5.1**);

ω_k – = factor taking account of corrosion allowance to the section modulus of the to framing member (refer to **1.1.5.3**).

3.7.1.4 The regions of side strengthening of vessels mooring at sea are to be as required by 3.7.1.4-1 (for fishing vessels) and 3.7.1.4-2 (for special purpose ships) taking account notices from Tables 3.7.1.4-1 - 3.7.1.5-2. Spacing of boundaries of region of side strengthening up from summer loadline and down from ballast waterline depending on sea state at which ship would be moored is not to be less than determined in Table3.7.1.4-3.

For special purpose ships, one or more fender areas shall be additionally established the boundaries of which are formed by sections lying within 0,05*L*, forward and aft of the forward and aft edges accordingly of a group of floating fenders providing one mooring place for all specified variants of mooring. The boundaries of fender areas shall be determined at extreme positions of fenders and for all specified variants of mooring.

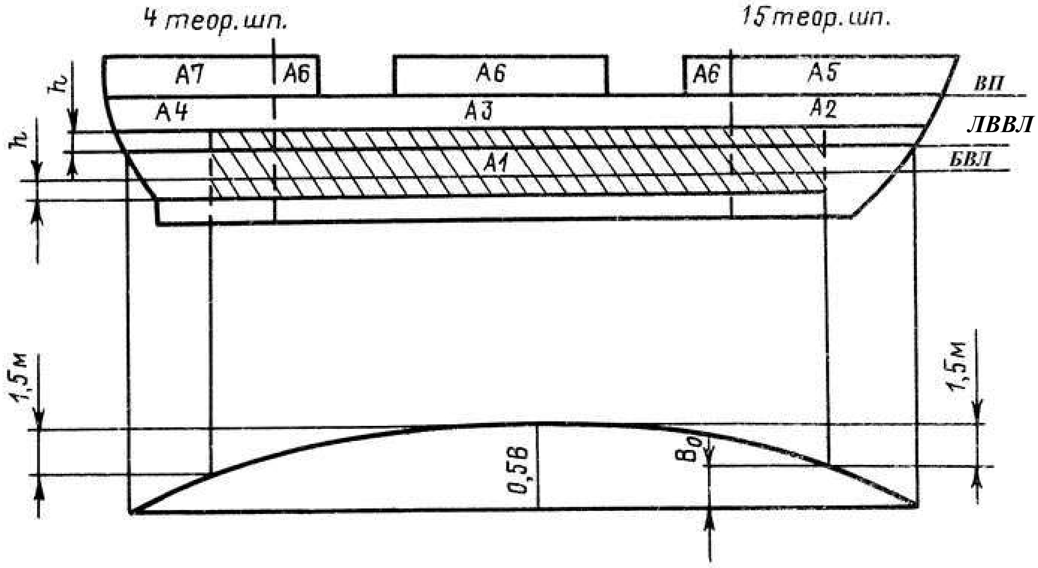


Fig. 3.7.1.4-1. Regions of strengthening of fishing vessels

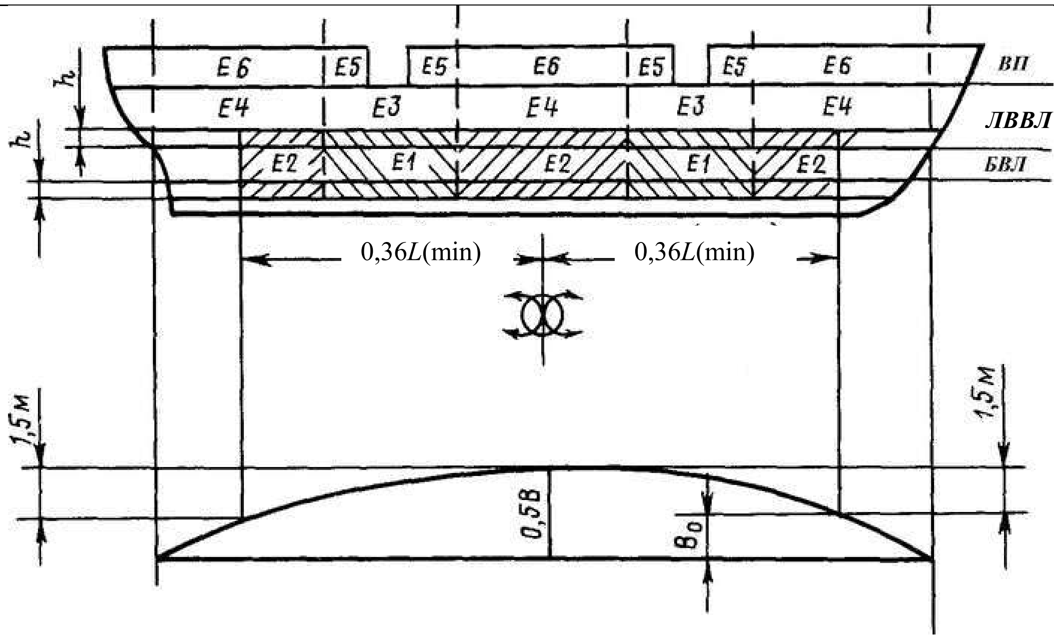


Fig. 3.7.1.5-2. Regions of strengthening of special purpose vessels

Table 3.7.1.4-1

Region of strengthening	Zone of regions of strengthening	
	lengthwise	depthwise
A1	between sections in which ship half-breadth at summer loadline level $B_0 = 0{,}5B - 1{,}5$	Between the level higher than the summer loadline by the value of h andlevel lower than the ballast waterline by the value of h
A2	between forward part and section 0,25L from fore perpendicular	between the upper edge of A1 region and upper deck
A3	(0,25-0,80)L from fore penperdicular	the same as for A2 region
A4	between after region and section 02L from after perpendicular	the same as for A2 region
A5	the same as for A2 region	between the upper edge of A2 region and the first tier superstructure deck
A6	the same as for A3 region	between the upper edge of A3 region and the first tier superstructure deck
A7	the,same as for A4 region	between the upper edge of A4 region and the first tier superstructure deck

Table 3.7.1.4-2

Region of strengthening	Zone of regions of strengthening	
	lengthwise	depthwise
E1	From section which extended within 0.05L from forward point to forward part of the berthing region, to section which extended within 0,05L to aft point of the aft berthing region[1]	Between the level higher than the summer loadline by the value of h and level lower than the ballast waterline by the value of h
E2	between external boundaries of El regions and sections in which ship half-breadth at summer loadline level B_0 (refer to Table 3.7.1.5 - 1), but not less than 0,35L forward and aft midship region as well as between El regions in ships with two fender areas	The same as for El region
E3	the same as for El region	between the upper edge of El region and upper deck
E4	between external edge of E3 regions and forward and alf region as well as between E3 regions in ships with two fender areas	The same as for A2 region

E5	the same as for E3 region	between the upper edge of E3 region and the first tier superstructure deck
E6	the same as for E4 region	between the upper edge of E4 region and the first tier superstructure deck
[1] The boundaries of each berthing region are the forward edge of the bow and the aft edge of the aft floating fenders. The boundaries of the regions must be determined at the extreme positions of the fenders for any given mooring options.		

Table 3.7.1.4-3

Sea force No	*h*, in m
4	0,8
5	1,2
6	2,0

3.7.1.5 Fishing vessels designed for systematic fishing in ice conditions.

3.7.1.5.1 Fishing vessels intended for systematic operation in ice conditions shall have an ice class not lower than **Ice3** in accordance with the requirements of **3.10**.

3.7.1.5.2 Fishing vessels intended for systematic operation in ice conditions, which have the ice class **Ice3**, shall comply with the requirements of **3.10**, as well as with additional requirements contained in **3.7.1.6.4**, **3.7.2.10**, **3.7.3.4** and **3.7.4.5.**

3.7.1.5.3 No additional requirements are put forward with regard to the fishing vessels of ice class **Ice4** and above.

3.7.1.5.4 If the loadline entrance of a fishing vessel of ice class **Ice3** exceeds 0,25L, an intermediate region of ice strengthening may be established, the boundaries of which shall be determined as in the case of **Ice4** ice class.

3.7.2 Construction.

3.7.2.1 Stern ramp construction.

3.7.2.1.1 The after end structure of vessels having a stern ramp and/or stern trawling arrangements shall be strengthened by fitting additional longitudinal and transverse members (girders, transverses, cross ties, bulkheads and partial bulkheads).

The stern ramp shall be so constructed as to avoid flat of bottom in way of stern counter.

The connection of stern ramp sides to transom plating and of the ramp deck to bottom plating shall have a radius of rounding not less than 200 mm.

This connection may be made by using a bar not less than 70 mm in diameter.

3.7.2.1.2 Stern ramp sides shall, in general, be carried downwards to the shell plating and forward to the after peak bulkhead and shall be smoothly tapered into deck girders and transverses.

3.7.2.1.3 Where the catch is dragged onto the deck, it is recommended that the stern ramp be longitudinally framed with transverses fitted at intervals not exceeding four frame spacings. The stern ramp longitudinals shall be spaced not more than 600 mm apart.

In vessels where special transport means are used to carry the catch onto the deck, the stern ramp shall be framed transversely.

3.7.2.2 The construction of ships having a side trawling arrangement.

3.7.2.2.1 1 It is recommended that vessels more than 30 m in length be fitted up with a forecastle.

3.7.2.2.2 Within the location of each gallow, determined as the distance between sections at three spacings forward and aft of the gallow ends, the strengthening shall be as follows:

intermediate frames shall be fitted extending from the upper deck down to a level not less than 0,5 m below the ballast waterline and having a section modulus not less than 75 % of that required by **2.5.4.2** for the frames in the 'tween deck space concerned;

the upper and lower ends of intermediate frames shall be secured to the decks, platforms and longitudinal intercostal members fitted between the main frames;

longitudinal intercostal members shall have the same section as intermediate frames and be aligned with them;

the upper longitudinal intercostal member shall be fitted not more than 350 mm below the upper deck;

bulwark stays shall be fitted at every frame.

3.7.2.3 Structures in processing shops.

3.7.2.3.1 Where the number of bulkheads in the processing shops located above the bulkhead deck is less than specified in **2.7.1.3** and where the distance between the bulkheads forming the boundaries of that space exceeds 30 m, partial bulkheads extending inboard for not less than 0,5 m of the 'tween deck height shall be fitted on the bulkhead deck at each side of the vessel in line with watertight bulkheads. The thickness of the partial bulkhead plating shall be not less than that of the top strake of the corresponding watertight bulkhead below the deck where the considered processing shop is located.

Partial bulkheads shall be strengthened with horizontal stiffeners in accordance with **1.7.3.2**. Strengthening with vertical stiffeners is permitted with fitting the horizontal stiffeners between the side shell and the nearest vertical stiffener in compliance with **3.7.2.5.4**.

Partial bulkheads shall be interconnected with deck transverses supported by pillars in a required number.

3.7.2.3.2 Where multi-tier deckhouses are arranged above the processing shops, the requirements of **2.12.5.2** for rigid members (bulkheads, partial bulkheads) to be fitted in such spaces shall be complied with.

3.7.2.4 In fishing vessels, bulwark stays shall be fitted at intervals equal to not more than two frame spacings.

3.7.2.5 Structural strengthening of ships mooring at sea.

3.7.2.5.1 In regions strengthened for mooring at sea, transverse framing shall be adopted for the vessel's sides. In single-deck ships, the deck and bottom in the above regions shall also be framed transversely. In multi-deck ships, transverse framing shall be adopted for the deck located on the fender level. Longitudinal framing of sides is permissible in the upper 'tween deck space only. In this case, the spacing of web frames shall not exceed three frame spacings or 2,4 m, whichever is less.

3.7.2.5.2 In the regions **A1**, **E1** and **E2** intermediate frames are recommended through the region length in fishing vessels and within fender areas in special purpose ships.

3.7.2.5.3 In any case, it is recommended that symmetrical sections be used and the minimum possible web depth be ensured for the particular section modulus.

3.7.2.5.4 Between the ship's side and vertical stiffener nearest to it, transverse bulkheads shall have horizontal stiffeners with a section height not less than 75 % of the vertical stiffener height. In ships with $L \leq 80$ m, horizontal stiffeners shall be spaced not more than 600 mm apart, and with $L \geq 150$ m, not more than 800 mm apart. For ships of intermediate lengths, linear interpolation may be used to determine this distance. The ends of horizontal stiffeners shall be welded to vertical stiffeners and sniped at the ship's sides.

3.7.2.5.5 The bulwark shall be inclined towards the centreline of the ship at not less than one-tenth or be fitted inboard of the ship's side at not less than one-tenth of its height.

3.7.2.5.6 Bilge keels of ships with the length $L \leq 80$ m shall be, as far as practicable, so arranged that a tangent drawn to the frame and passing through the outer free edge of the bilge keel would form an angle of not less than 15° with the vertical axis. For ships with the length $L \geq 150$ m, this angle may be zero. For ships of intermediate lengths, the above angle shall be obtained by linear interpolation.

3.7.2.5.7 The lower end attachments of hold frames shall be as required by **2.5.5.1**.

In 'tween decks, the attachments of frame lower ends shall comply with the requirements of **2.5.5.3**.

The frame ends shall be welded to the deck plating.

Upper ends of frames shall be carried to the deck plating and welded thereto. Beams shall be carried to the inner edges of frames with a minimal gap. Beam knees shall have a face plate or flange.

The ends of intermediate frames shall be attached to longitudinal intercostals, decks or platforms.

3.7.2.5.8 Side longitudinals shall be attached to transverse bulkheads with knees. The height and width of the knees shall comply with **1.7.2.2**.

3.7.2.5.9 Bulwark stays welded to sheerstrake shall be so constructed as to prevent deck plating damage in case of bumping.

3.7.2.6 Besides the requirements of *3.10*, the ice-strengthening structure of fishing vessels of ice class **Ice3** intended for systematic operation in ice conditions shall comply with the following requirements:

.1 for the case of transverse main framing, at least one load distributing side stringer shall be fitted in each grillage in way of region of ice strengthening **AI**, **A_1I**, **BI** and **CI** (refer to **3.10.1.3.2**);

.2 bulbous forebody is not recommended;

.3 in the forepeak, the spacing of stringers and their dimensions, as well as stem dimensions, shall be in accordance with the requirements of **3.10** for fishing vessels of ice class **Ice4**;

.4 in the afterbody, provision shall be made for an appendage (ice knife) aft of the rudder to protect the latter on the sternway.

3.7.3 Design loads.

3.7.3.1 Design loads on ramp structures shall be determined as follows:

.1 the design pressure p, in kPa, on the ramp sides and deck in vessels where the catch is dragged in shall be determined by the formula

$$p = 6{,}5b, \qquad (3.7.3.1.1)$$

Where the breadth of the ramp varies along its length, the minimum breadth shall be taken as the design value;

.2 in vessels equipped with a special wheeled catch-transport arrangement, the design load, in kN, for ramp deck plating shall be determined by the formula

$$p = 27(G_1 + G_2) / n_w, \qquad (3.7.3.1.2)$$

where n_w – number of the wheel axes of the arrangement.

3.7.3.2 For factory decks, the design pressure p, in kPa, shall be determined by the formula

$$p = 15G / S_d . \qquad (3.7.3.2)$$

3.7.3.3 The design pressure p, in kPa, on the sides and superstructure sides of ships moored at sea shall be determined by the following formulae

$$p = \alpha_1 \alpha_2 \alpha_3 (\beta_1 + \beta_2 \sqrt{\Delta z \cdot 10^{-3} - 0{,}464}), \qquad (3.7.3.3)$$

where α_1 – shall be adopted from Table 3.7.3.3-1 depending on the ship displacement and the sea conditions specified for mooring at sea;

α_2, α_3, β_1, β_2 – shall be adopted from Table 3.7.3.3-2 and 3.7.3.3-3depending on the ship purpose and the region of strengthening;

Δ – design ship displacement, in t. For a fishing vessel Δ displacement to the summer load waterline;

For a special purpose ship Δ shall not be taken greater than 7500 t;

z – distance in m, from the mid-span of member calculated to the summer load waterline. Where a special purpose ship has the freeboard depth $h_1 = D - d$ greater than the freeboard depth $h_2 = D - d$ of the biggest fishing vessel, the value of z shall be reduced by the difference of $h_1 - h_2$. In any case, z shall not be less than 1,0 m. in regions A1, E1, E2 z = 1,0 m.

Table 3.7.3.3-1 **Factor α_1**

Ship displacement, in t	Sea state No		
	4	5	6
≤ 2000	1,00	1,15	1,60
> 2000	0,82	1,00	1,16

Table 3.7.3.3-2 **Factor α_2**

Factor α_2	Region of ice strengthening			
	A1 – A7	E1	E2	E3 – E6
	1,0	1,1	0,8	$1 + 0{,}05n^{1/3}$

n – number of moorings, during a voyage, alongside the ship whose displacement has been adopted as the design value in Formulae (3.7.3.3). For regions E3 – E6 α_2 is taken not less 1,1 and not greater than 1,4.

Table 3.7.3.3-3

Factors	Region of ice strengthening		
	A1, E1, E2	A2 – A4, E3, E4	A5 – A7,E5, E6
α_3	1,0	$1/ (0{,}22z + 0{,}6)$	$1 / (0{,}12z +1{,}28)$
β_1	190	129	
β_2	51	59	

3.7.3.4 For fishing vessels of ice class **Ice3** intended for systematic operation in ice conditions, the ice load parameters shall be determined on the basis of the following provisions:

.1 in the forward region of ice strengthening A , the load parameters shall be determined in accordance with the requirements of **3.10** for the ice class **Ice3.** In the case of a bulbous forebody, the rake angle of frame β shall be determined as stipulated in **3.10.3.2.1** for fishing vessels of ice class **Ice4**;

.2 in the intermediate region of ice strengthening $\mathbf{A_1}$, the ice load parameters shall be taken equal to:

$$p_{A_1I} = 0{,}75p_{AI};$$

$$p_{A_1II} = 0{,}75p_{AII};$$

$$b_{A_1} = b_A;$$

$$l^H_{A_1} = l^H_A; \qquad (3.7.3.4.2)$$

where: p_{A1I}, p_{A1II}, b_{A1}, l_{A1}^H - ice load parameters for the forward region A, as determined in accordance with the requirements of **3.10**, with due regard for **3.7.3.4.1**;

.3 in the midship region of ice strengthening B, the ice pressure, in kPa, is determined by the formula

$$p_{B1} = p^o_{B1}k_B, \qquad (3.7.3.4.3)$$

where: p^o_{B1} - ice pressure in midship region (B) according to **3.10.3.2.3**;

$k_B = 2k_1$, but not less than 1;

;

$$k_1 = \frac{r^2}{\sqrt{\Delta/1000}}(l_k/L - 0{,}18);$$

$$r = \frac{17{,}4P_b^{1/2}\,a^{1/2} - B^2}{57{,}3P_b^{1/3}};$$

Δ — displacement, in t, to summer load waterline;

P_B — shaft power, in kW, determined with due regard for power take-off in the trawling condition;

l_k — distance, in m, from forward perpendicular to a section aft where the reduction of summer load waterline breadth begins.

The height and length (b_B and l_B^H) to which the midship region is covered by the ice load shall be determined in accordance with **3.10.3.3.3** and **3.10.3.4.3**.

.4 the ice pressure, in kPa, in the aft region of ice strengthening **C** is determined by the formula

$$p_{C1} = p^o_{C1}k_C, \qquad (3.7.3.4.4)$$

where: p^o_{C1} - =ice pressure in the aft region according to **3.10.3.2.4**;

$k_C = 2{,}5k_1$, but not less than1;

for k_1 – refer to **3.7.3.4.3**.

The height and length (b_C i l_C^H) to which the aft region is covered by the ice load shall be determined in accordance with **3.10.3.3.4** and **3.10.3.4.4**.

3.7.4 Scantlings of structural members.

3.7.4.1 Requirements for the scantlings of stern ramp framing.

3.7.4.1.1 The section modulus of longitudinals, beams and deck transverses of the stern ramp is to be determined according to **1.6.4.1**, taking:

p – as obtained from (3.7.3.1-1) for vessels where the catch is dragged in or (3.7.3.1-2) – for vessels where the catch is carried onto the deck by a special wheeled arrangement;

m – as obtained from Table 3.7.4.1.1 for vessels where the catch is dragged in;

$m = 9{,}3l^2\sqrt[4]{a/l}$ – for vessels where the catch is carried onto deck by a special wheeled arrangement;

$k_σ = 0,6$.

Таблиця 3.7.4.1.1* Коефіцієнт *m

Stern ramp framing	Fishing vessels	Special purpose ships
Deck longitudinals	11,3	7,9
Beas and deck transverses	12,6	8,8

3.7.4.1.2 The section modulus, in cm^3, of stern ramp side stiffeners shall not be less than determined by Formula 1.6.4.1 with the design load p as determined by Formula (3.7.3.1-1), $k_σ = 0,9$, m = 17,0 and 22,6 for fishing vessels and special purpose ships respectively. The stiffener span l shall be adopted equal to the maximum distance between the ramp deck and the nearest deck above or to the distance between two decks adjoining the ramp side, but shall not be less than 2,6 m.

In vessels engaged in pelagic fishing, the section modulus of ramp side stiffener, in cm^3, shall not be less than

$$W = 45,5(1 – 0,5 / l)[(820 / σ_n) –(l / a)]ω_c, \qquad (3.7.4.1.2)$$

In no case shall the section modulus of stern ramp side stiffeners be less than required in **2.5.4.2** for the frames of upper 'tween deck and superstructure.

3.7.4.1.3 The length of thickened ramp deck plating sections along the ramp length shall be equal to:

the ramp width at least, if measured forward of the ramp edge, in way of bottom rounding;

double ramp width at least in way of top rounding.

3.7.4.1.4 Where the connection of the ramp side with transom plating is rounded, the thickness of the plating strake not less than 700 mm broad, if measured from the ramp deck plating, shall not be less than 20 mm.

Ramp thickness thinning may be permitted while installing doubling plates.

If a welded half-round bar not less than 70 mm in diameter is fitted to the junction of the rounding and the flat part of the side, but not farther than 200 mm from the transom, the plating thickness may be adopted in accordance with the requirements of **3.7.4.1.6**.

3.7.4.1.5 For vessels not engaged in pelagic fishing, the plating strakes of ramp sides shall be thickened, in way of connection with the transom and along the ramp deck, to a value not less than required under **3.7.4.1.6**.

The thickened side plating strakes fitted along the ramp length shall have a breadth not less than 0,4 of the ramp breadth, or 1,0 m, whichever is greater. The lower edge of those strakes shall coincide with the ramp deck in vessels where the catch is dragged in and be level with the catch stowage surface in vessels where the catch is carried onto the deck by a wheeled arrangement.

If measured forward of the rounding-to-flat-side-junction line, the length of thickened section of the side plating in way of transom shall not be less than 0,5 of the ramp breadth.

3.7.4.1.6 For vessels where the catch is dragged in, the plating thickness of ramp deck and sides, in mm, shall not be less than determined by Formula (1.6.4.4), taking:

m, $Δs$ - to be adopted from Table 3.7.4.1.6;

p – = as determined by Formula (3.7.3.1.1);

$k_σ = 0,8$;

$k = 1$.

Table 3.7.4.1.6

Ramp structure	Location along ramp length	Fishing vessel		Special purpose ship	
		m	$Δs$, in mm	m	$Δs$, in mm
Deck	Bottom rounding and sterncounter plating	26,8	10,0	26,8	10,0
	Mid-region	26,8	5,5	26,8	5,5
	Top rounding	26,8	9,5	26,8	5,5
Sides	In way of friction	25,9	5,5	21,9	5,5
	Elsewhere on deck	25,9	4,5	21,9	4,5

3.7.4.1.7 Where doubling plates are fitted on the ramp deck in way of bottom rounding or top rounding or where devices to prevent excessive wear of stern ramp plating with wire ropes are installed, the plating thickness may be adopted as for the mid-region.

3.7.4.1.8 In vessels engaged in pelagic fishing, the lower strake of the side having a width from the stern ramp plating to a point at least 100 mm above the upper half-round bar shall have a thickness s, in mm, not less than

$$s = 2 \cdot 10^4 a_s / \sigma_n + 1, \qquad (3.7.4.1.8)$$

where: a_s – distance, in m, between adjacent edges of half-round bars.

3.7.4.1.9 Whatever the mode of carrying the catch along the stern ramp, the thickness of ramp plating in vessels of all types shall be 2 mm greater than required by **2.2.4.8** for the shell plating. This thickness shall be maintained on the length from the stern ramp end to a line at least 600 mm above the bulkhead deck within the particular section of the vessel length. Forward of this region the thickness of stern ramp plating shall be 2 mm greater than required under **2.6.4.1.5** for the upper deck plating at ends.

3.7.4.1.10 On a length at least 1,0 m forward of the stern ramp edge and at least over the whole ramp breadth, the stern-counter plating shall be 1 mm thicker than stipulated under **2.2.4.1**.

3.7.4.2 Requirements for the member scantlings of vessels having a side trawling arrangement.

3.7.4.2.1 In vessels over 30 m in length, the side plating and sheerstrake thickness between the gallows, determined as the distance between the section three spacings forward of the fore end of forward gallow and the section three spacings abaft the after end of after gallow, shall be 1 mm greater than stipulated under **2.2.4.1**.

3.7.4.2.2 Within the location of each gallow, to be determined in accordance with **3.7.2.2.2**, provision shall be made for strengthening as follows:

sheerstrake thickness to be increased by 2 mm;

thickness of strake adjacent to sheerstrake to be increased to equal that of the sheerstrake between gallows;

deck stringer thickness to be increased by 3 mm as compared to that required by **2.6.4.1**;

bulwark plate thickness to be increased by 2 mm as compared to that required by **2.14.4.1**.

3.7.4.3 Requirements for member scantlings of holds and fish handling spaces.

3.7.4.3.1 The section modulus of factory deck beams and longitudinals shall be determined as required by **2.6.4** with the design pressure according to **3.7.3.2** where it exceeds that required by **2.6.3**.

3.7.4.3.2 In holds and fish handling spaces in which non-packed salted catch or salt is stored or which are exposed to the detrimental effect of catch wastes and sea water, the plating thickness shall be increased by 1 mm as compared to that required by the relevant sections of these Rules. Where the structure is so influenced from both sides, relevant thickness shall be increased by 2 mm.

3.7.4.3.3 The vertical web plate thickness of coamings not acting as deck girders shall not be less than the deck plating thickness, or 7 mm, whichever is greater.

3.7.4.4 Requirements for member scantlings of ships mooring at sea.

3.7.4.4.1 The side plating and sheerstrake thickness of ships below 80 m in length shall be by 1 mm greater than required under **2.2.4.8**.

3.7.4.4.2 In strengthened regions, the side plating and sheerstrake thickness, in mm, shall not be less than

$$s = 21{,}7\, a \sqrt{p/(k_n R_{eH}) - 0{,}242} + \Delta s \qquad (3.7.4.4.2)$$

where: a – frame spacing, in mm. If panting frames are provided, a is the distance between main and panting frames;

p – as defined under **3.7.3.3**;

$k_n = 1{,}1$;

$\Delta s = 4{,}0$ mm for region **A1** in case trawling is effected from the vessel side;

$\Delta s = 1{,}2$ mm for regions **A2** ÷ **A7**, **E3** ÷ **E6**;

$\Delta s = 3{,}0$ mm mm elsewher.

3.7.4.4.3 In regions **A1**, **E1** i **E2** the section modulus of frames, in cm^3, shall not be less than

$$W = pab(2l - b)\ \omega_c \cdot 10^3/(mk_nR_{eH}),\qquad (3.7.4.4.3)$$

where: p – as determined by Formula **3.7.3.3**;
a – spacing, in m, of main frames;
b = 1,5 m;
$m = 20{,}4k_1k_2(1 + k_3k_4)$;
k_1, k_2, k_3 – shall be adopted from Table 3.7.4.4.3 proceeding from the number of load distributing side stringers fitted;
k_4 = 0 – where no panting frames are fitted;
k_4 = 0,69 – if panting frame ends terminate at longitudinal intercostal members;
k_4 = 1 – if the end attachments of main and panting frames are similar;
k_n = 1,1;
l – frame span, in m, as measured along the chord between the upper edge of inner bottom plating or floor face plate and the lower edge of deck at side (side stringer where web frames are fitted);
for ω_c – refer to **1.1.5.3**.

Table 3.7.4.4.3

Factor	No load distributing side stringers	One load distributing side stringer	Two load distributing side stringers or more
k_1	1,0	$1{,}12 + 0{,}038l\overline{\omega}/a$	$1{,}27 + 0{,}039l\overline{\omega}/a$
k_2	$1 + 6{,}8\sqrt{[f(f/l + 0{,}28)/l] - 12{,}5f_1/l}$	$1 + 7f/l - 8f_1/l$	
k_3	1,0	0,75	0,65
$\overline{\omega} = W_c/W$ – section modulus ratio of load distributing side stringer and frame; f – distance, in m, between a section at the lower support of frame and a tangent to the frame contour in way of the section at the upper support, as measured normal to the tangent (refer to Fig. 3.7.4.4.3); f_1 – maximum deflection of frame according to Fig. 3.7.4.4.3, in m.			

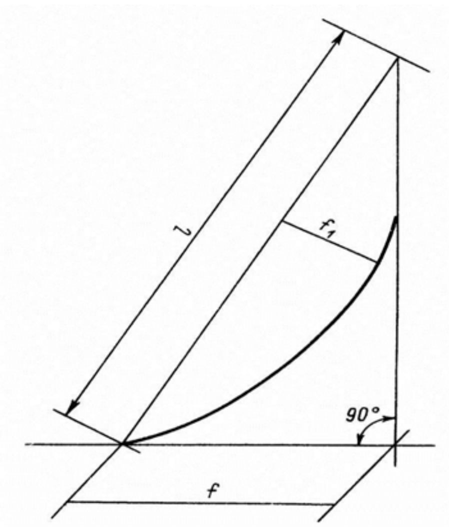


Fig. 3.7.4.4.3

3.7.4.4.4 In regions **A2** ÷ **A7**, **E3** ÷ **E6** the section modulus of frames, in cm^3, shall not be less than determined by Formula3.7.4.4.3. The value of p shall be determined by Formula**3.7.3.3**.

Where the actual shell plating thickness is greater than 8 mm, p may be reduced by the value

$$\Delta p = (2{,}9 + l)s^2R_{eH(o)} \cdot 10^{-3}/(al),\qquad (3.7.4.4.4)$$

where: s – actual shell plating thickness, in mm, but not greater than 20 mm;
l – frame span, in m;
$R_{eH(o)}$ – yield stress, in MPa, of shell plating material;
a – main frame spacing, in m;
b = 2,2 m;

$m = 25\ k_1k_2k_4/k_3$;

k_1 = 1,3 – for regions **E3** ÷ **E4** of special purpose ships;

k_1 = 1 – elsewhere;

k_2 = 1 – where no load distributing stringers are fitted;

$k_2 = 1{,}12 + 2{,}46\bar{\omega}/a(8{,}6 - l)$ – with one load distributing stringer;

$k_2 = 1{,}15 + 5{,}06\bar{\omega}/a(8{,}6 - l)$ – with two load distributing stringers or more;

$\bar{\omega} = W_c/W$ – section moduli ratio of load distributing stringer and frame;

$k_3 = 2a$ – for the fender areas of special purpose ships and within (0 ÷ 0,25)L of forward perpendicular in fishing vessels;

$k_3 =(2a - 0{,}1)$ - within (0 ÷ 0,2)L of aft perpendicular in fishing vessels;

$k_3 =(2a - 0{,}2)$ – elsewhere;

k_4 = 1 – where no pantig frames are fitted;

$k_4 = k'_3(1 + 0{,}5\ k_1\ k'_3)/k_3$ – where panting frames are fitted;

the factor k'_3 is determined in the same way as k_3, with a equal to the spacing of main and panting frames;

k_n =1,1.

3.7.4.4.5 If longitudinal framing system is applied for 'tween deck spaces, the section modulus, in cm^3, of side longitudinals shall not be less than

$$W = 24paa_p^2\ \omega_c / R_{eH}, \qquad (3.7.4.4.5)$$

where: p – = as determined by Formula **3.7.3.3**;

a – spacing, in m, of longitudinals;

a_p – web frame spacing, in m.

3.7.4.4.6 Where superstructure sides of ships mooring at sea are inclined to the centre line at not less than 1 /10 or fitted inboard at not less than 1 /10 of their height, no additional strengthening as per **3.7.4.4** is required.

Where the inclination of superstructure sides to the vessel side or the distance between those and the vessel side is less than specified above, the strengthening of their frames and shell plating shall be determined by linear interpolation proceeding from the requirements of **3.7.4.4** and **2.2.4.1**, **2.5.4.2**.

3.7.4.5 The member scantlings in the ice strengthened regions of fishing vessels of ice class **Ice3,** which are intended for systematic operation in ice conditions shall be determined in accordance with **3.10.4** where the ice load parameters are as stipulated in **3.7.3.4** bearing the following specification in mind. When determining shell plating thickness in the intermediate region of ice strengthening in accordance with **3.10.4.1** the annual average thickness reduction of shell plating as a result of corrosion wear and abrasion shall be adopted as u = 0,25 mm/year.

3.7.5 Special requirements.

3.7.5.1 Stern ramp structure.

3.7.5.1.1 Transom plating shall be protected from excessive wear with half-round steel bars of at least 70 mm in diameter, which shall be fitted inclined and secured by welding.

3.7.5.1.2 Half-round steel bars of at least 70 mm in diameter shall be welded along the junction line of rounding and flat side, but not farther than 200 mm from the transom.

3.7.5.1.3 In vessels engaged in pelagic fishing, stern ramp sides shall be stiffened with longitudinal half-round steel bars of at least 70 mm in diameter, welded to the sides and spaced not more than 200 mm apart. The edge of the upper bar shall be not less than 650 mm above the ramp deck plating.

3.7.5.1.4 Suitable devices are recommended to prevent excessive wear of ramp plating with wire ropes when dragging the catch. Where the rated winch pull exceeds 30 kN on each wire rope, such devices are compulsory.

Devices preventing excessive wear of plating may be substituted by doubling plates in the thickened areas of top and bottom rounding over the full breadth of the ramp, and doubling strips at least 400 mm wide may be fitted at the sides over the rest of the ramp length.

3.7.5.2 Within the location of each gallow complying with **3.7.2.2.2**, bulwark, sheerstrake and shell plating above ballast waterline shall be protected with half-round steel bars fitted inclined and secured by welding.

3.7.5.3 The 'tween deck height in way of heavy items of machinery and equipment installed in fish handling spaces shall not exceed 3,5 m.

3.7.5.4 When determining the requirements for sternframe scantlings of ships having the length $L < 60$ m the design length and width of a solid rectangular propeller post shall be those stipulated under **2.10.4.3**, as increased by 10 %.

3.8 SUPPLY VESSELS

3.8.1 The requirements of this Chapter apply to supply vessels, including supply of MODU/MFP, standby vessels and anchor handling vessels.

Structural members not covered by this Chapter shall comply with the requirements of Sections **1** and **2**.

3.8.2 Construction.

3.8.2.1 Provision shall be made for longitudinal fenders at the weather deck and the deck below level.

3.8.2.2 The fenders shall extend not less than 0,02L forward of the section where the weather deck has its full breadth.

3.8.2.3 The weather deck shall be efficiently stiffened in way of deck equipment or cargo which load exceeds the design deck load value.

3.8.2.4 Shell plating in way of stern rollers and fenders areas shall be efficiently stiffened.

3.8.2.5 In the forward region 0,2L from the forward perpendicular (FP) the ends of framing members of hull, forecastle and the first tier of deckhouse shall be connected by brackets.

3.8.3 Design loads.

3.8.3.1 Design loads on hull structures shall be taken in compliance with Sections **1** and **2**.

3.8.3.2 For determining the scantlings of deck stiffeners according to **3.8.2.4** as well as scantlings of the supporting pillars, the load shall be calculated with due regard to the inertia force components in horizontal and vertical direction due to the vessel's rolling and pitching.

3.8.4 Scantlings of structural members.

3.8.4.1 The thickness of the side shell plating shall be 1 mm greater than required by **2.2.4**. In any case the thickness of the side shell plating shall not be taken less than 9,0 mm.

3.8.4.2 In fenders area the thickness of the side shell plating shall not be taken less than

$$s_{\min} = (6 + 0{,}05L) \cdot a/a_0,$$

where: a – main framing spacing;
a_0 – normal spacing according to **1.1.3**;
a/a_0 shall not be taken less than 1,0.

3.8.4.3 If fenders are suspended in the length, the thickness of unprotected side areas shall be 50 % greater than required by **3.8.4.2**. The reinforced region shall be extended 600 mm transversely below deck or 'tween deck, as far as applicable.

3.8.4.4 Scallop and one-sided welds shall not be used in connections between side frames and shell plating.

3.8.4.5 Section modulus of hold, 'tween deck or forecastle frames shall not be less than specified in **3.7.4.4**, with p, determined by Formula 3.7.3.3, $\alpha_1 = 1{,}16$ and $\alpha_2 = 1{,}0$. Factors α_3, β_1 and β_2 are taken from Table 3.7.3.3-3 as for region A1.

However, no needs to take the section modulus of side longitudinals, hold or 'tween deck frames more than 1,25 times as required in **2.5.4**.

3.8.4.6 The thickness of weather deck plating shall be determined from **2.6.4**, but it shall not be less than 8,0 mm.

If the weather deck is intended to carry deck cargoes, the thickness shall be increased by 1,0 mm as required by **2.6.4**.

If the weather deck is intended to carry anchors and anchor chain cables, the thickness shall be increased by 2,5 mm as required by **2.6.4**.

3.8.4.7 The thickness of the weather deck stringer in the region of rescue zone shall be not less than

$$s_{\min} = (7 + 0{,}02L) \cdot a/a_0,$$

where: a – shall not be less than;
a_0 – normal spacing according to **1.1.3**;

a/a_0 shall not be taken less than 1,0.

3.8.4.8 The scantlings of weather deck framing members shall be determined as required by **2.6.4** with a design load corresponding to the specified value but not less than 35 kPa.

3.8.4.9 While determining reinforcements for stern rollers and mooring winches, the requirements of **4.3.5**, Part III "Equipment, Arrangements and Outfit" shall apply.

Thickness of plate structures in way of stern rollers and shark jaws shall be at least 25 mm.

3.8.4.10 The section modulus of vertical frames of fronts, sides and after ends of deckhouses located on the forecastle deck shall be not less than required by **2.12.4.5.2**.

The assumed head *p*, in kPa, shall not be taken less than given in Table 3.8.4.10.

Table 3.8.4.10

Deckhouse tier	*p*, in kPa			s_{min}, in mmм
	Front bulkhead	Side bulkhead	After bulkhead	
First	90	60	25	10,8*a*
Second and above	75	50	25	10*a*
Note. *a* – spacing between bulkhead vertical frames.				

3.8.4.11 The plate thickness of the side and end bulkheads of deckhouses shall be not less than indicated in Table 3.8.4.10.

3.8.4.12 Thickness of bulwark plating shall be at least 7 mm, and the width of the stanchion lower edge measured along the weld shall be not less than 360 mm. The distance between stanchions shall not exceed two spacings or 1,3 m, whichever is the lesser.

3.9 TUGS

3.9.1 General and symbols.

3.9.1.1 The requirements of this Chapter apply to all tugs irrespective of purpose or service area.

3.9.1.2 Structural items not covered by this Chapter shall comply with the requirements of Sections **1** and **2**.

3.9.1.3 For the purpose of this Chapter the following symbols have been adopted:

b_s – width of stem cross section, in mm;

l_s – length of stem cross section, in mm.

3.9.2 Construction.

3.9.2.1 Plate floors shall be fitted at each frame. Where the double bottom is omitted, the floors shall have a symmetrical face plate.

3.9.2.2 Where a main frame span exceeds 3,0 m, load distributing side stringers shall be fitted along the length of the ship except for the engine room.

3.9.2.3 In the engine room, web frames shall be fitted between the inner bottom (floor face plates) and the upper deck at a distance not exceeding four spacings. Web frames shall be fitted at main engine ends. The distance specified may be increased provided side grillage structure strength and stiffening are verified by direct calculation in accordance with the RS-agreed procedures.

3.9.2.4 A fender shall be fitted at upper deck and long forecastle deck level.

3.9.2.5 Areas to which concentrated loads are applied (e.g. due to towing winches) shall be additionally strengthened.

3.9.2.6 The stems of harbour tugs shall have rounded shape above the summer load waterline.

3.9.3 Design loads.

Design loads on hull structures of tugs shall be assumed in compliance with the requirements of Sections **1** and **2**.

3.9.4 Scantlings of structural members.

3.9.4.1 The minimum plating thickness of shell and upper deck as well as of watertight bulkheads shall not be less than 5 mm.

3.9.4.2 The thickness of shell plating adjacent to the stem shall not be less than stipulated under **2.2.4.**6.

The shell plating thickness in way of the engine room, when located aft, shall not be less than required for the midship region.

3.9.4.3 When determining the section modulus of the web frames in accordance with **2.5.4.5**, the distance measured from the inner bottom plating (floor upper edge) and the upper deck at side shall be taken as the design span.

3.9.4.4 The scantlings of load distributing side stringers shall be determined in accordance with **2.8.2.7**.

3.9.4.5 Within the region from the keel to the summer load waterline, the cross-section of a rectangular solid bar stem shall not be less than:

$$l_s = 1{,}6L + 100; \qquad (3.9.4.5\text{-}1)$$

$$b_s = 0{,}5L + 25. \qquad (3.9.4.5\text{-}2)$$

The scantlings and location of brackets for strengthening the stem shall be determined proceeding from **2.10.4.1.3**.

The stem shall be extended abaft the fore peak bulkhead for not less than three spacings.

Ship-handling tugs are not permitted to have reduced cross-section and scantlings of the stem (if constructed of steel plates) above the summer load waterline.

The steel plates of the stem shall be strengthened over their length with horizontal brackets spaced not more than 0,6 m apart, the plate thickness of the stem determined in accordance with **2.10.4.1.2 being not reduced**.

3.9.4.6 Rectangular solid propeller posts shall have scantlings from the keel to the counter not less than:

$$l_s = 1{,}5L + 100; \qquad (3.9.4.6\text{-}1)$$

$$b_s = 1{,}8L + 25. \qquad (3.9.4.6\text{-}2)$$

The sternframe shall be attached according to **2.10.2.2.3** to two floors, whatever the length of the tug may be.

3.9.4.7 The thickness of the bulwark plating shall be taken according to **2.14.4.1**, but not less than 4 mm.

The section modulus of bulwark stays shall be determined in accordance with **2.14.4.2** where m = 1,5. Bulwark stays shall be fitted not farther than at alternate frames.

Bulwark stays welded to the sheerstrake plate may have a flexible element in their structure. The bulwark shall be inclined to the centre line of the vessel at not less than 7°.

3.9.5 Special requirements.

3.9.5.1 For unrestricted service tugs above 40 m in length, the number of watertight bulkheads shall be not less than four.

3.9.5.2 For requirements to ice strengthening of tugs refer to **3.12**.

3.10 STRENGTHENING OF ICE CLASS SHIPS AND ICEBREAKERS

3.10.1 General and requirements.

3.10.1.1 Application.

3.10.1.1.1 The requirements of this Chapter apply to self-propelled ice class ships and icebreakers, as well as to ships which may be given the same status proceeding from the conditions of their ice navigation. Requirements for polar class ships (refer to **2.2.3.1**, Part I "Classification") are specified in **3.11**.

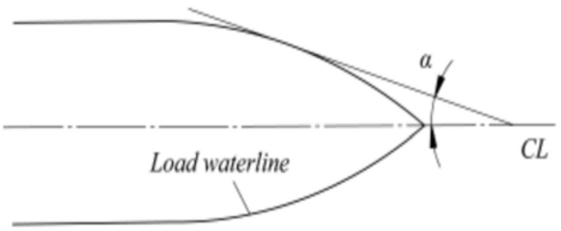
The requirements for the Baltic ice class ships (refer to **2.2.3.1**, Part I "Classification") are given in **3.12**.

3.10.1.1.2 Self-propelled ice-strengthened ships which comply with the requirements of this Chapter are assigned an ice class mark in their class notation in accordance with **2.2.3**, Part I "Classification".

3.10.1.1.3 Requirements of this Chapter are supplementary with regard to those of other chapters of these Rules which apply to a particular ship, and they establish the minimum strength level necessary to withstand ice loads, as well as hull structure, proceeding from the ice class mark in the class notation.

3.10.1.2 Requirements to hull configuration.

3.10.1.2.1 The hull configuration parameters α, α_0, β, φ, in deg., shall be measured in conformity with Figs. 3.10.1.2-1 ÷ 3.10.1.2-4.



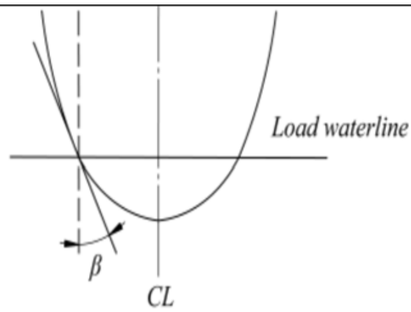
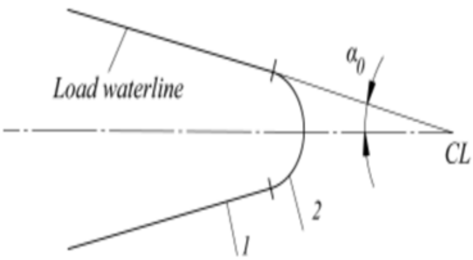


Fig.3.10.1.2-1:
α – slope of design ice waterline at the section considered, in deg.

Fig.3.10.1.2-2:
β – slope of frame on the level of design ice waterline at the section considered, in deg.



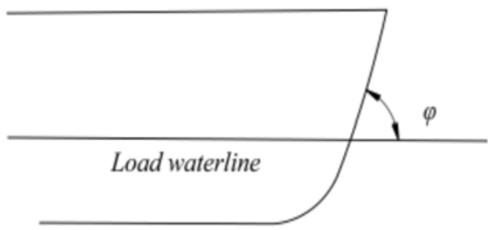


Fig.3.10.1.2-3:
α_o – slope of design ice waterline at the fore perpendicular, in deg.; 1 - shell plating; 2 - stem

Fig.3.10.1.2-4
φ – slope of stem on the level of design ice waterline, in deg.

3.10.1.2.2 The hull configuration parameters of ice class ships are recommended to be within the limits stated in Table 3.10.1.2.2.

In the forward and intermediate region of ice strengthening of **Ice6**, **Ice5**, **Ice4** ice class ships and icebreakers, there shall be no areas of shell plating within which the configuration parameters β and α would simultaneously take the values β = 0 and α > 0.

Table 3.10.1.2.2

Hull configuration parameter	Ice class			
	Ice6	**Ice5**	**Ice4**	**Ice2, Ice3**
φ, not greater than	30°	45°	60°	-
α_o, not greater than	30°	40°	40°	50°
β_o within 0,05L from fore perpendicular, minimum	40°	25°	20°	-

3.10.1.2.3 Hull configuration parameters of icebreakers.

For icebreakers, at 0 - 0,25L from the area of fore perpendicular within service draughts, straight and convex waterlines shall be used. The recommended entrance angles for above waterlines α_0, are within the limits of α_0 = 22° ÷ 30°.

At service draughts, the angle shall not exceed:

30° - for icebreakers of ice classes **Icebreaker1**, **Icebreaker2**;

25° - for icebreakers of ice classes **Icebreaker3**, **Icebreaker4**.

The cross section of stem shall be executed in the form of a trapezoid with a bulging forward face.

For icebreakers with standard bow lines, slope angles of frames shall be adopted from Table 3.10.1.2.3.

In way of construction water line, frames shall have a straight-lined or moderately convex shape.

The design water line shall cover the blade tips of side propellers.

Table 3.10.1.2.3

Distance from section to fore perpendicular	$0{,}1L$	$0{,}2L \div 0{,}25L$	$0{,}4L \div 0{,}6L$	$0{,}8L \div 1{,}0L$
Permissible range of the angle variation β, in deg.	$40^{o} \div 55^{o}$	$23^{o} \div 32^{o}$	$15^{o} \div 20^{o}$	Approximately coinciding with the angles β of within $0 \div 0{,}2L$

3.10.1.2.4 In the afterbody of icebreakers and **Ice6**, **Ice5** and **Ice4** ice class ships, there shall be an appendage (ice knife) aft of the rudder to protect the latter on the sternway.

3.10.1.2.5 No transom stern (with the transom coming in the region of ice strengthening) is permitted for icebreakers and **Ice6** ice class ships.

For **Ice4** and **Ice5** ice class ships the transom aft end is not recommended in the regions of ice strengthening.

When the flat transom of **Ice4** and **Ice5** ice class ships is in way of ice strengthening region, the minimum possible transom area in the ice strengthening region shall be provided.

Transom structural members in the ice strengthening region shall comply with the requirements for structural members in region **B1**.

3.10.1.2.6 For icebreakers and **Ice6** ice class ships ice class ships, there shall be a step in the lower part of the stem.

The height of the step shall be $0{,}1d$ at least. The transition from the step to the lower part of the stem shall be smooth.

3.10.1.3 Region of ice strengthening.

3.10.1.3.1 There are ice strengthening regions lengthwise as follows:

forward region - **A**;

intermediate region - **A1**;

midship region - **B**;

aft region - **C**.

There are ice strengthening regions transversely as follows:

region of alternating draughts and similar regions - **I**;

region from the lower edge of region **I** to the upper edge of bilge strake - **II**;

bilge strake - **III**;

region from the lower edge of bilge strake to the centre line - **IV**.

3.10.1.3.2 The length of regions of ice strengthening in ice class ships shall be determined on the basis of Fig. 3.10.1.3.2 and Table 3.10.1.3.2.

An ice loadline shall be determined as a loadline enveloping all the ship loadlines (heel and mass of ice in case of icing disregarded) possible during ice navigation.

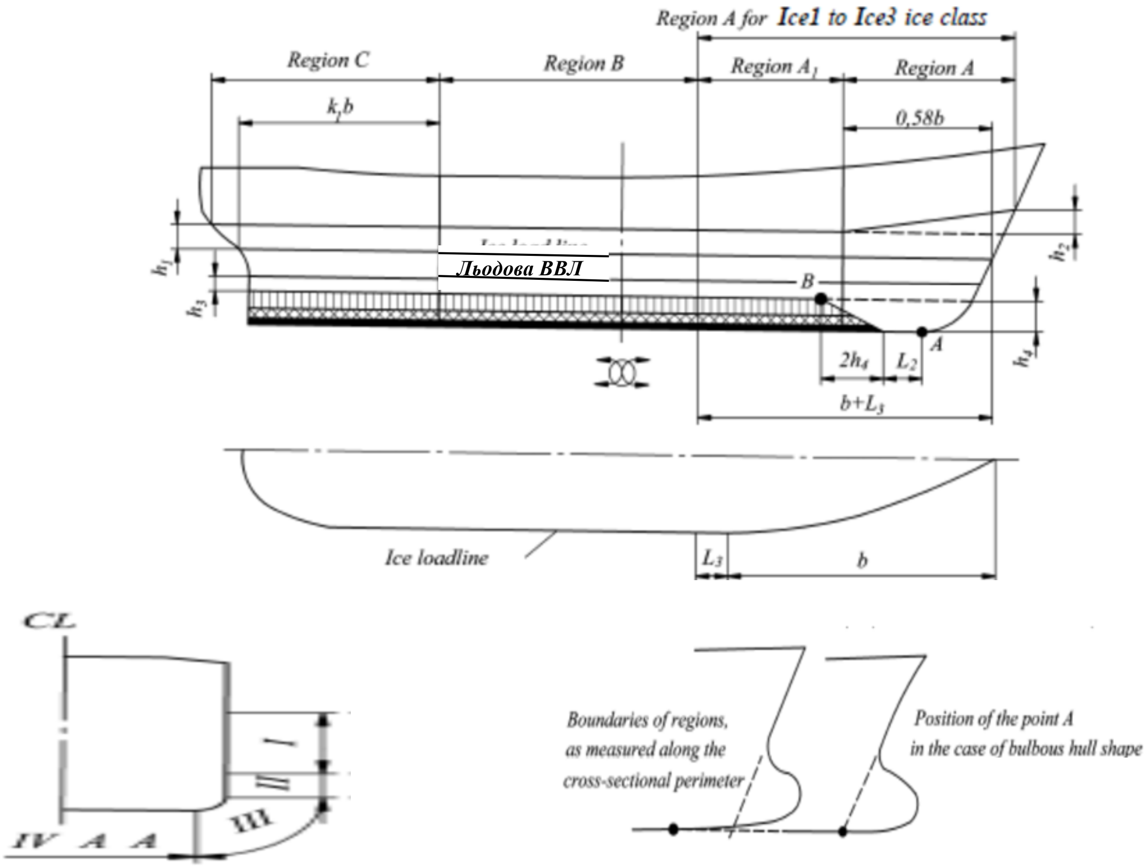
Ballast waterline shall be determined as a waterline enveloping from below all the possible waterlines of the ship in service (heel and mass of ice in case of icing is disregarded).

For **Ice1** - **Ice3** ice class ships no intermediate region of ice strengthening will be established.

In this case, it shall be considered that the aft boundary of the forward region of ice strengthening coincides with the forward boundary of the midship region of ice strengthening.

TAble 3.10.1.3.2

Parameter		Ice class				
		Ice6, Ice5	**Ice4**	**Ice3**	**Ice2**	**Ice1**
h_1, in m	where $B \leq 20$ m	0,75	0,6	0,5		
	where $B > 20$ m	$(0{,}5B+8)/24$	$(0{,}5B+8)/30$	$(0{,}5B+8)/36$		0,5
h_2, in m		0,8	0,6	0,2		
h_3, in m		$1{,}35\ h_1$	$1{,}2\ h_1$	$1{,}1\ h_1$	h_1	
L_2, in m		$0{,}1L$	$0{,}05L$	$0{,}02L$		-
L_3, in m		$0{,}05L$	$0{,}045L$	$0{,}04L$	$0{,}02L$	
k_1		0,69	0,55	0,53	0,50	–



	I – ice strake in the region of alternating draughts
	II – from the lower biundary of region **I** to the upper biundary of region **III**
	III – bilge strake
	IV – from the lower edge of bilge strake to the centre line .

Fig.3.10.1.3.2. Regions of ice strengthening of ice class ships:

b – distance from the point of the ice loadline and stem intersection to the section where the ice loadline is the widest, but not greater than 0,4*L*.

Notes: 1. For **Ice1** ice class ships, the lower boundary of the region **A** is by h_3 distant from the ballast waterline.

2**.** Point **B** shall not be further than the aft boundary of the region **A1**.

For calculation procedures of this Chapter ice loadline shall be taken as the design ice waterline, unless stated otherwise.

3.10.1.3.3 The length of regions of ice strengthening in icebreakers shall be determined on the basis of Fig. 3.10.1.3.3 and Table 3.10.1.3.3.

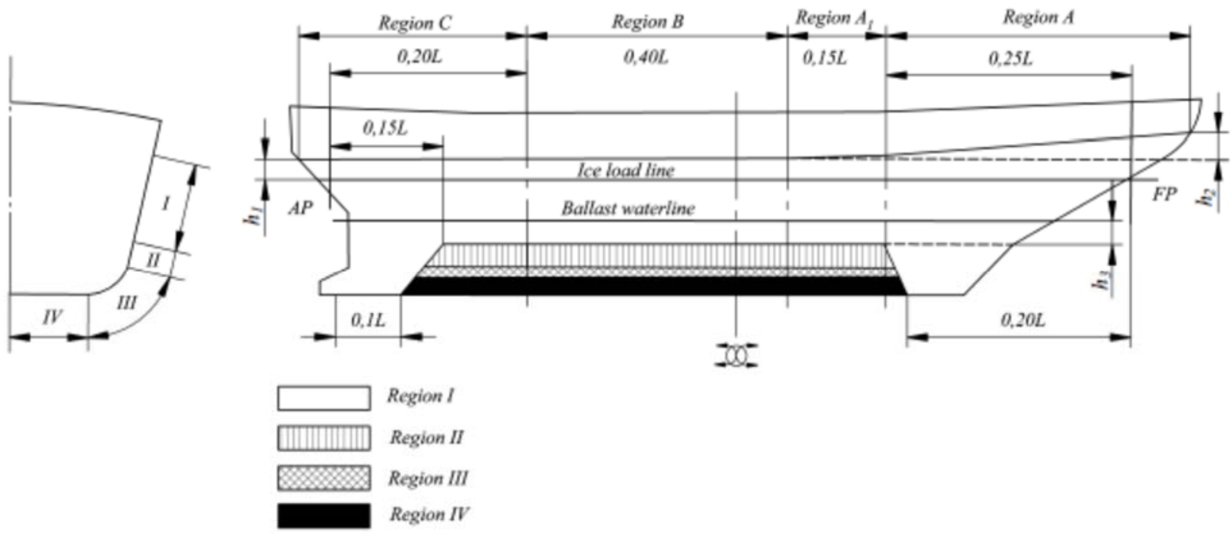


Fig. 3.10.1.3.3 Regions of ice strengthening of icebreakers

Table 3.10.1.3.3

Parameter		Ice class of icebreaker			
		Icebreaker4	**Icebreaker3**	**Icebreaker2**	**Icebreaker1**
h_1, in m	where $B \le 20$ m	1,0	0,8	0,75	
	where $B > 20$ m	$(0,5B + 12)/22$	$(0,5B + 7,6)/22$	$(0,5B + 8)/24$	
h_2, in m		2	1,7	1,4	1,1
h_3, in m		$1,9 + 1,6h_1 \ge 3,5$	$1,72 + 1,6h_1 \ge 3,0$	$1,6 + 1,6h_1 \ge 2,8$	$0,4 + 1,6h_1 \ge 1,6$

3.10.1.3.4 Proceeding from the ice class, the requirements of this Chapter apply to the regions of ice strengthening marked with «+» in Table 3.10.1.3.4. For the purpose of Table 3.10.1.3.4, the absence of this mark means that the particular region of ice strengthening is not covered by the requirements of this Chapter.

Table 3.10.1.3.4

Ice class	Vertical regioning															
	I				II				III				IV			
	Horizontal regioning															
	A	**A_1**	**B**	**C**	**A**	**A_1**	**B**	**C**	**A**	**A_1**	**B**	**C**	**A**	**A_1**	**B**	**C**
Icebreaker4, Icebreaker3	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Icebreaker2, Icebreaker1, Ice6	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+
Ice5	+	+	+	+	+	+	+	+	+	+	+		+	+		
Ice4	+	+	+	+	+	+	+		+	+			+	+		
Ice3	+		+	+	+											
Ice2	+		+	+												
Ice1	+															

3.10.2 Structure.

3.10.2.1 Side grillage structure transversely framed.

3.10.2.1.1 A grillage may include vertical girders of main framing which are denoted as conventional frames, vertical web members which are denoted as deep frames, and longitudinals which are denoted as stringers.

Conventional frames are subdivided into:

main frames in plane of floors or bilge brackets;

intermediate frames not in plane as floors or bilge brackets.

The intermediate frames are not mandatory within a side grillage. Not more than one intermediate frame may be fitted between main frames.

Stringers are subdivided into:

intercostal stringers by which joint taking-up of local ice loads by the frames is ensured.

It is recommended that the stringers shall be inter-costal;

side stringers by which a transition of forces is ensured from conventional frames which directly take up the ice load to deep frames or to transverse bulkheads.

Side grillage structures are permitted as follows:

grillage with transverse main frames which is formed by conventional frames of the same section and by intercostal stringers;

grillage with transverse web frames which is formed by conventional frames, side stringers and deep frames. Intercostal stringers may be fitted together with side stringers.

With a double-bottom structure available, the functions of deep frames are taken over by vertical diaphragms, and those of the side stringers, by horizontal diaphragms.

3.10.2.1.2 In icebreakers and **Ice5** ÷ **Ice6** ice class ships, frames shall be attached to decks and platforms with brackets; if a frame is intercostal in way of deck, platform or side stringer, brackets shall be fitted on both sides of it.

3.10.2.1.3 The end attachments of main frames shall comply with the requirements of **2.5.5**.

In icebreakers solid floors shall be fitted on each main frame.

The end attachments of intermediate frames shall comply with the following requirements.

In **Ice4** ÷ **Ice6** ice class ships and icebreakers, the bottom ends of intermediate frames shall be secured at margin plate stiffened with a lightened margin bracket (or a system of stiffeners) reaching up to longitudinal stiffeners or intercostal members and welded thereto (refer to Fig. 3.10.2.1.3-1).

Where there is no double bottom, the intermediate frames shall extend as far as longitudinal stiffeners or intercostal structure and welded thereto. The particular longitudinal stiffener or intercostal structure shall be fitted not higher than the floor face-plate level.

In **Ice1** ÷ **Ice3** ice class ships having monotonic main framing, the bottom ends of intermediate frames may be secured at intercostal longitudinal fitted 1000 mm beneath the lower boundary of region **I**.

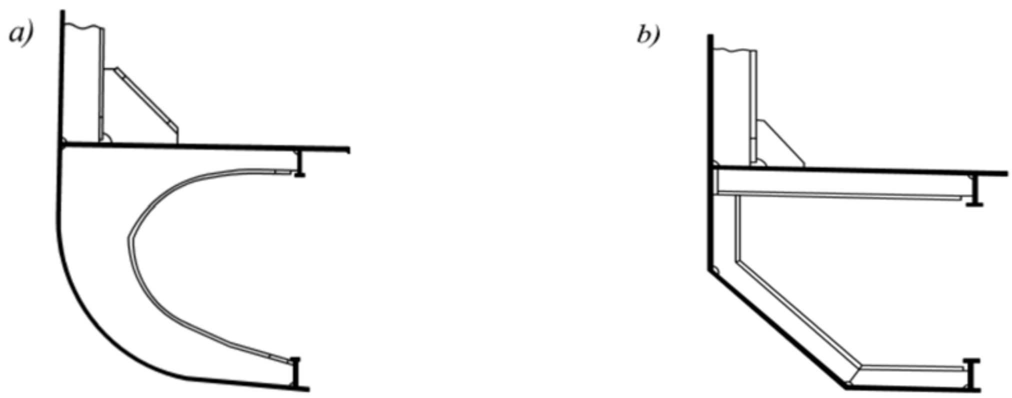


Fig. 3.10.2.1.3-1:
a - lightened margin bracket; *b* - system of stiffeners

In **Ice1** ÷ **Ice3** ice class ships with deep framing, it is permitted to secure the bottom ends of intermediate frames, except for the region **A** of ice class **Ice3**, at a longitudinal (which may be intercostal) fitted 1000 mm below the side stringer lying beneath the lower boundary of region **I** (refer to Fig. 3.10.2.1.3-2).

In this case, the web area and plastic modulus of the above side stringer shall not be less than required for a stringer fitted in region **I**.

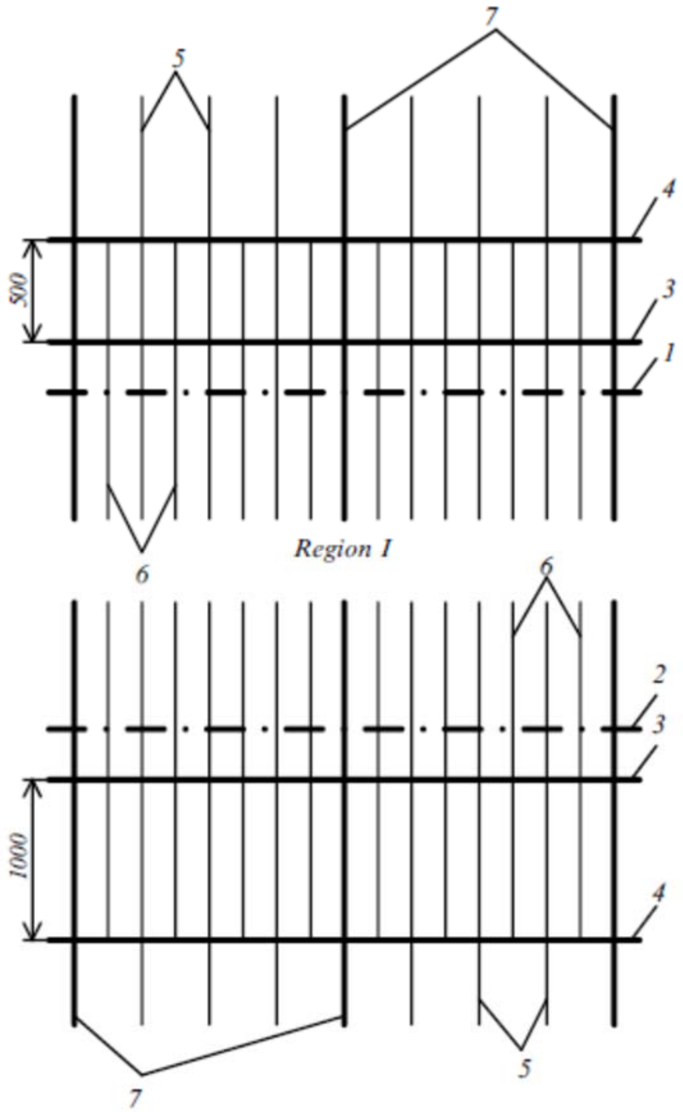


Fig. 3.10.2.1.3-2
Permissible method for securing the ends of intermediate frames in Ice1 - Ice3 ice class ships with deep framing:
1 - upper boundary of region **I**;
2 - lower boundary of region **I**;
3 - side stringer; 4 – intercostal longitudinal; 5 - main frames;
6 - intermediate frames; 7 - deep frames.

In icebreakers and **Ice4** ÷ **Ice6** ice class ships, the upper ends of intermediate frames shall be secured on a deck or platform lying above the upper boundary of region **I**.

In **Ice1** ÷ **Ice3** ice class ships having monotonic main framing, the upper ends of intermediate frames may be secured in way of an intercostal longitudinal fitted 500 mm above the upper boundary of region **I**.

In **Ice1** ÷ **Ice3** ice class ships with deep framing, the upper ends of intermediate frames may be secured in way of a longitudinal (which may be intercostal) fitted 500 mm higher than the side stringer lying above the upper boundary of region I (refer to Fig. 3.10.2.1.3-2). In this case, the web area (and the ultimate section modulus of the above side stringer shall not be less than those required for a stringer fitted in region **I**.

3.10.2.1.4 In regions I and II of icebreakers and **Ice4** ÷ **Ice6** ice class ships, intercostal and/or side stringers shall be fitted the distance between which or the stringer-to-deck or platform distance shall not exceed 2 m, as measured on a chord at side.

For region I of Ice1 ÷ Ice3 ice class ships, this distance shall not exceed 3 m.

Side stringers shall be fitted in the loadline and ballast water line regions. If there is a deck or platform lying on the same level, the side stringer may be omitted.

Stringers shall be attached to bulkheads by means of brackets.

3.10.2.2 Determining the supporting sections of frames in grillages with transverse framing.

3.10.2.2.1 The supporting sections of conventional and deep frames shall be found in supporting structures only. For frames, horizontal grillages (decks, platforms, bottom) are considered to be supporting structures. A supporting structure consists of plating (decks, platforms, double bottom) and framing connected thereto (beams, half-beams, floors, tank-side brackets).

Where there is no double bottom, the formulae to be found below shall be used on the assumption that the plating lies level with floor face plates.

3.10.2.2.2 The supporting section of a conventional frame is considered to be fixed, if one of the following conditions is met at least:

the frame is connected to the framing of a supporting structure;

the frame crosses the plating of a supporting structure.

A supporting section is considered to be simply supported, if a conventional frame is not connected to supporting structure framing and is terminated on the structure plating.

Where a conventional frame terminates on an intercostal longitudinal (intercostal stringer), its end is considered to be free, i.e. with no supporting section.

3.10.2.2.3 The position of a supporting section of a frame (conventional or deep frame) is determined in the following way.

Where the frame is connected to the supporting structure plating only, the supporting section coincides with the plating surface.

Where the frame is connected to the supporting structure framing, the supporting section:

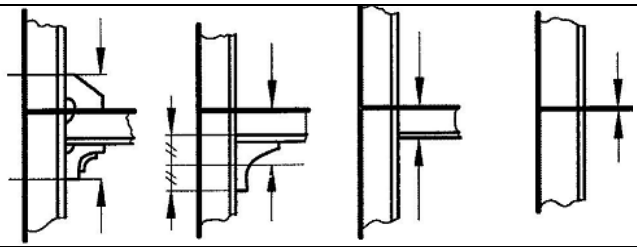
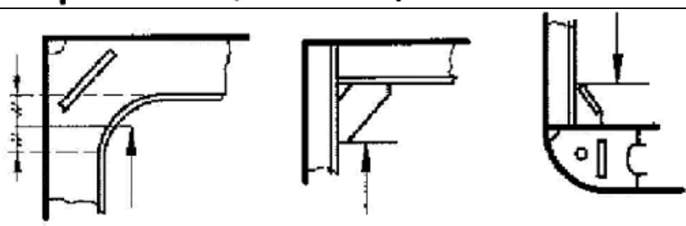
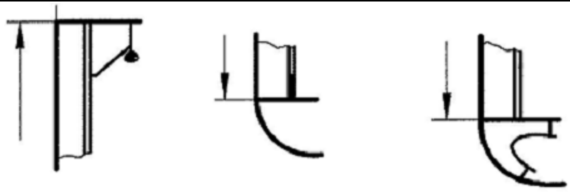
coincides with the face plate surface of the supporting structure frame in case of bracketless joint;

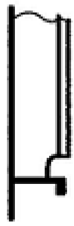
lies at bracket end where brackets with a straight or rounded and stiffened edge are concerned;

lies in the middle of the bracket side where brackets with a rounded free edge are concerned.

3.10.2.2.4 When determining the conditions of fixation and the position of supporting sections in typical structures, one shall be guided by Table 3.10.2.2.4 (the position of a supporting section is indicated with an arrow in the sketches of the Table), as well as by the requirements of 3.10.2.2.2 and 3.10.2.2.3.

Table 3.10.2.2.4

Type of joint in way of the supporting section of the frame	Type of supporting section	Sketch showing structure and the position of supporting section therein
Intersection of supporting structure	Fixed	
Securing on supporting structure with connection to its framing	Fixed	
Securing on supporting structure without connection to its framing	Simply supported	

Securing on intercostal longitudinal	Free end	 No supporting section

3.10.2.3 Side grillage structure where longitudinal framing is used.

3.10.2.3.1 A longitudinally framed side grillage structure is permitted which consists of longitudinals and web frames. Intercostal additional frames may be fitted between deep frames (refer to **3.10.2.3.3**).

In a double-side structure, the functions of deep frames are taken over by vertical diaphragms. Where a double-side structure includes horizontal diaphragms, they are considered to be platforms, and the requirements of **3.10.2.4** and **3.10.4.9** for platforms apply to them. Longitudinal framing system is not recommended for icebreakers and **Ice5** ÷ **Ice6** ice class ships.

3.10.2.3.2 Longitudinals which are intercostal in way of plate structures (refer to **3.10.2.4**) shall be secured with brackets on both sides of the plate structure, and the webs of the longitudinals shall be welded to the plate structure.

3.10.2.3.3 In icebreakers and **Ice4** – **Ice6** ice class ships where the spacing of frames is greater than 2 m, additional frames shall be fitted.

The end fixation method shall be the same as in the case of intermediate frames of **Ice1** ÷ **Ice3** ice class ships with transverse main framing in accordance with **3.10.2.1.3**, irrespective of the ice class**.**

3.10.2.4 Plate structures.

3.10.2.4.1 By plate structures, the sections of deck, platform and double bottom plating, of transverse bulkhead plating, deep frame plates, stringers of side and bottom, centre-plane girder, solid and lightened plate floors and bilge brackets which adjoin the shell plating are meant.

3.10.2.4.2 For hull members mentioned under 3.10.2.4.1, the areas to be covered by the requirements for plate structures shall be established as follows:

fore peak and after peak bulkheads of icebreakers and **Ice5** and **Ice6** - ice class ships throughout their breadth;

for ships of other ice class, on a breadth of 1,2 m from the shell plating;

other bulkheads in regions **I** and **II** of ice-breakers and **Ice4** ÷ **Ice6**, ice class ships, decks and platforms of icebreakers and **Ice4** ÷ **Ice6** ice class ships, on a breadth of 1,2 m from the shell plating;

other hull members - on a breadth of 0,6 m from the shell plating.

3.10.2.4.3 In the areas of plate structures mentioned under **3.10.2.4.2**, corrugated structures with corrugations arranged along the shell plating (i.e. vertical corrugations on transverse bulkheads and longitudinal corrugations on decks or platforms) are not permitted.

3.10.2.4.4 The plate structures of icebreakers and ships of ice classes **Ice5** and **Ice6**, including those located inside the bulb, as well as plate structures of region **I** of **Ice4** ice class ships shall be strengthened with stiffeners fitted approximately normal to the shell plating. The stiffeners shall be spaced not farther apart than stipulated in Table 3.10.2.4.4.

The plate structures of **Ice1**, **Ice2**, **Ice3**, **Ice4** (except region **I**) ice class ships may be strengthened with stiffeners fitted approximately parallel to the shell plating.

Table 3.10.2.4.4

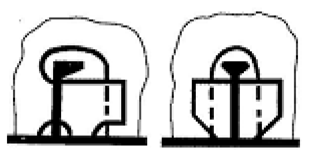
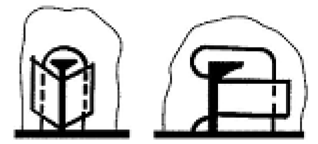
Orientation of main framing fitted at shell plating	Maximum spacing of stiffeners	
	Icebreakers **Ice5** (region **I**), **Ice6 ice class ships**	**Ice5** (except region **I**), **Ice4** (region **I**) ice class ships
Main framing lies across a plate structure	*a*, but not greater than 0,5 m	2*a*, but not greater than 1,0 m
Main framing lies parallel to a plate structure	0,6	0,8 m
Note. *a* – is the spacing of main framing girder, as measured on the shell plating		

3.10.2.4.5 The intersections of plate structures with main framing shall be executed in accordance with Table **3.10.2.4.5**.

The stiffeners by which the plate structure is strengthened and which lie on the same plane as the main framing girders shall be secured to the above girders.

Other methods of attaching the webs of main framing girders to the plate structure may be applied, if found equivalent by the Register.

Table 3.10.2.4.5

Ice class	Sketch of structure		
			
Icebreaker4, Icebreaker3	Fore peak, after peak, region **I**, region **II** with longitudinal framing	Regions **II**, **AIII**, **A_1III**, **CIII**, **AIV**, **A_1IV**	Other regions as per Table 3.10.1.3.4
Icebreaker2, Icebreaker1	Fore peak, after peak, regions **I**, **II** with longitudinal framing	Regions **I** and **II** (except fore peak and after peak), **AIII**, **A_1III**, **CIII**	Ditto
Ice6, Ice5	Fore peak, region **AI**, **A_1I**, **BI** with longitudinal framing	Regions **I** (except fore peak), **II**, **AIII**, **A_1III**	Ditto
Ice4	-	Райони **I, AII**, **A_1II**, **AIII**, **A_1III**	Ditto
Ice3, Ice2, Ice1	-	-	All regions
Note. Stiffeners of plate structure and brackets stipulated in 3.10.2.4 are not shown schematically in the sketches.			

3.10.2.4.6 Where main framing girders are intercostal in way of the plate structure, brackets shall be fitted on both sides of the structure on the same plane as each of the girders, and the girder webs shall be welded to the plate structure.

3.10.2.4.7 7 The following requirements are put forward additionally for the intersections (connections) of the plate structures of decks and platforms with main framing.

Where transverse framing is used for sides, the frames shall be attached to the beams with brackets. In **Ice5** (region **I** only), **Ice6** ice class ships, the girders shall be fitted on the same plane as each of the frames (refer also to Table 3.10.2.4.4).

In **Ice5** (region **I** only) and **Ice4** (region **I**) ice class ships, the frame on whose plane no beam is fitted shall be secured to the plate structure with brackets which shall terminate on the intercostal stiffener.

Where longitudinal framing is used for sides, the beams shall be attached to the shell plating with brackets reaching as far as the nearest side longitudinal.

3.10.2.4.8 The distance from the edge of opening or manhole to the shell plating shall not be less than 0,5 m in a plate structure. For openings during installation of ship systems, the distance specified may be reduced provided the structures are efficiently stiffened. The distance from the edge of opening or manhole in a plate structure to the edge of opening for the passage of a girder through the plate structure shall not be less than the height of that girder.

3.10.2.5 Fore peak and after peak structure.

3.10.2.5.1 A longitudinal bulkhead welded to the stem or sternframe shall be fitted on the centreline of the ship in the fore peak and after peak of icebreakers and the lower ends of all frames shall be connected by floors or brackets.

In the fore peak of **Ice4** ÷ **Ice6** ice class ships with bulbous bows, a longitudinal bulkhead shall be fitted inside the bulb.

3.10.2.5.2 In the fore peak of icebreakers and **Ice5** and **Ice6** ice class ships, platforms with lightening holes shall be fitted instead of stringers and panting beams (refer to **2.8.2.3**), the distance between platforms measured along a chord at side, shall not exceed 2,0 m. This structure is recommended for **Ice4** ice class ships as well.

In **Ice5** ÷ **Ice6** ice class ships with bulbous bows, the specified distance shall not exceed 1,5 m. In this case, the stringer span inside the bulb shall not be more than 3 m.

3.10.2.5.3 In the after peak of icebreakers and **Ice5**, **Ice6** ice class ships (refer to 2.8.2.10), side stringers and panting beams shall be fitted so that the distance between the stringers as measured along a chord at side, would not be greater than 2,0 m.

The dimensions of stringer webs shall not be less than determined by the formulae:

height $h = 5L + 400$ mm;

thickness $s = 0{,}05L + 7$ mm.

Platforms with lightening holes are recommended instead of panting beams and stringers.

3.10.2.5.4 4 In icebreakers and **Ice6** ice class ships, the side stringers in the fore peak and after peak shall generally be a continuation of those fitted in the regions **A** and **C** (refer to **3.10.2.1.4**).

3.10.2.5.5 In the case of **Ice4** ice class ships, the area and inertia moment of panting beams shall be increased by 25 % as compared to those required by **2.9.4**.

The dimensions of stringer webs shall not be less than given by the formulae:

height $h = 3L + 400$ mm;

thickness $s = 0{,}04L + 6{,}5$ mm.

3.10.2.5.6 In the fore peak and after peak, the free edges of side stringers shall be stiffened with face plates having a thickness not less than the web thickness and a width not less than ten thicknesses. The interconnections of frames with side stringers shall be in accordance with Table 3.10.2.4.5, and brackets shall be carried to the face plates of the stringers.

3.10.2.6 Stem and sternframe construction.

3.10.2.6.1 Icebreakers and ice class ships shall have a solid section stem made of steel.

3.10.2.6.2 A combined stem with bar welded thereto (Fig. 3.10.2.6.2-1, *a*), or a plate stem (Fig. 3.10.2.6.2-1, *b*) may be used.

Combined or plate stem structures shall be welded with full penetration in compliance with the requirements of Part XIV "Welding".

For ships of less than 150 m in length with a sharp-lined bow, the stem shown in Fig. 3.10.2.6.2-2 may be used (the value of s shall be determined by Formula (3.10.4.10.1-3)).

Для суден льодових класів **Ice1** ÷ **Ice4** допускається застосування ахтерштевнів комбінованої або листової конструкції.

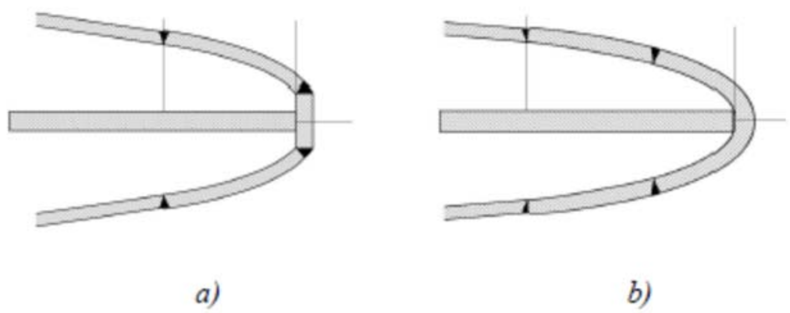


Fig. 3.10.2.6.2-1 Examples of combined (a) and plate (b) stems

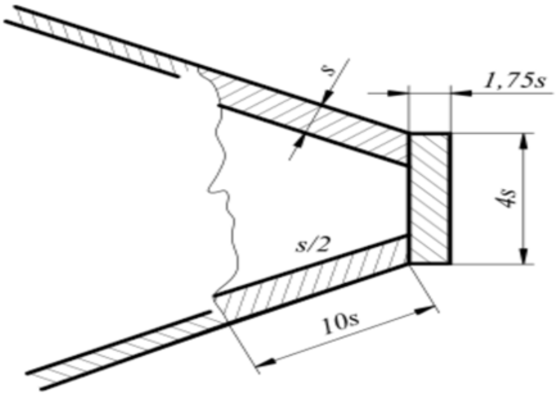


Fig. 3.10.2.6.2-2

3.10.2.6.3 For **Ice1 ÷ Ice6** ice class ships, the stem shall, where practicable, be strengthened by a centre line web having its section depth equal to h_v at least (refer to Table 3.10.4.10.1) with a face plate along its free edge or a longitudinal bulkhead fitted on the ship centreline, on the entire stem length from the keel plate to the nearest deck or platform situated above the level H_1 referred to in **3.10.4.10** and in Table 3.10.4.10.1. The thickness of this plate shall not be less than that of the brackets with which the stem is strengthened (refer to **3.10.2.6.4**).

In icebreakers a longitudinal bulkhead may be substituted for the centre line web.

3.10.2.6.4 Within the vertical extent defined in 3.10.2.6.3, the stem shall be strengthened by horizontal webs at least 0,6 m in depth and spaced not more than 0,6 m apart. The webs shall be carried to the nearest frames and connected thereto. Where in line with side stringers, the webs shall be attached to them. In stems of combined or plate type, the webs shall be extended beyond the welded butts of the stem and shell plating. Above the deck or platform located, by the value of H_1 at least (refer to **3.10.4.10.1** and Table 3.10.4.10.1), higher than the upper boundary of region I, the spacing of horizontal webs may gradually increase to 1,2 m in icebreakers and **Ice6**, **Ice5** and **Ice4** ice class ships, and to 1,5 m in ships of other ice classes. The web thickness shall be adopted not less than half the stem plate thickness

The side stringers of the fore peak shall be connected to the webs fitted in line with them.

In case of a full bow, vertical stiffeners may be required additionally to be fitted to the stem plates.

3.10.2.6.5 Where the stern frame has an appendage (ice knife), the clearance between the latter and the rudder plate shall not exceed 100 mm. The appendage shall be reliably connected to the stern frame. Securing the appendage to plate structures is not permitted.

3.10.2.6.6. In icebreakers, the lower edge of solepiece shall be constructed with a slope of 1:8 beginning from the propeller post.

3.10.2.7 Bottom structure.

3.10.2.7.1 In icebreakers and **Ice5** and **Ice6** ice class ships, double bottom shall be provided between the fore peak bulkhead and the after peak bulkhead.

3.10.2.7.2 In icebreakers, provision shall be made for solid floors at each main frame.

3.10.2.7.3 In regions of ice strengthening in way of bottom, as established in accordance with Table 3.10.1.3.4, bracket floors are not permitted.

3.10.2.7.4 In icebreakers the centreline girder height shall not be less than determined by the formula

$$h = \varphi(9L + 800), \qquad (3.10.2.7.4)$$

where: $\varphi = 1$ – for icebreakers.

3.10.2.7.5 In icebreakers the spacing of bottom stringers shall not exceed 3,0 m.

3.10.2.8 Special requirements.

3.10.2.8.1 In icebreakers, double side structure shall generally be provided between the fore peak bulkhead and the after peak bulkhead.

3.10.2.8.2 Where the web plate of a girder or a plate structure is considerably inclined to the shell plating (the angle between them being less than 50°), the framing normal to the shell plating or an inclined plate structure is recommended (Fig. 3.10.2.8.3). Otherwise, special measures shall be taken to prevent the collapsing of the girder or the bulging of the plate structure.

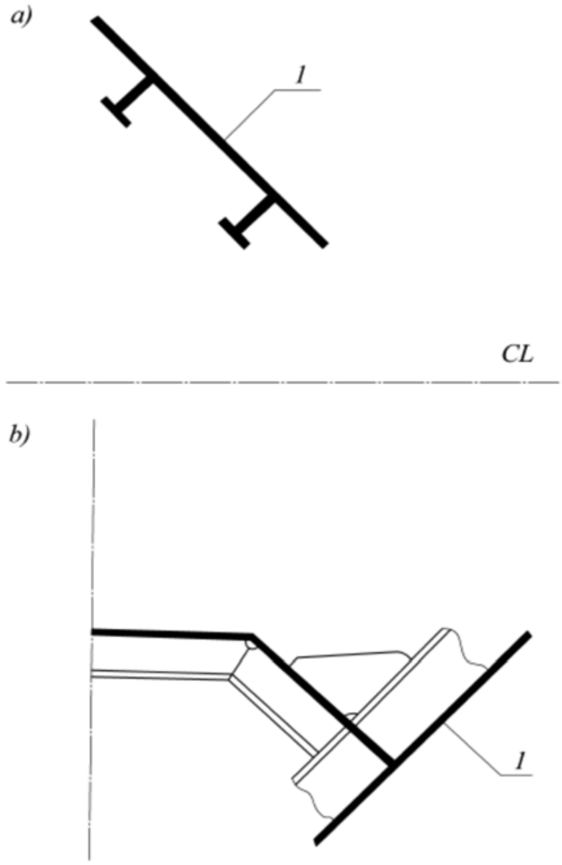


Fig. 3.10.2.8.2
a – framing normal to shell plating; *b* – nclined plate structure; *1* – shell plating

3.10.3 Ice load.

3.10.3.1 *Ice load* is the approximate design load acting on the hull due to ice forces, by which the level of requirements for scantlings is determined based on the ice class mark, hull shape and ship displacement.

The ice load depends on three parameters:

p - ice pressure being a characteristic of the maximum pressure in the area of dynamic contact between the hull and ice, in kPa;

b - vertical distribution of ice pressure characterizing the maximum transverse dimension of the dynamic contact area between the hull and ice, in m;

l^p - horizontal distribution of ice pressure characterizing the maximum longitudinal dimension of the dynamic contact area between the hull and ice, in m.

The ice load is solely intended to determine the scantlings of structural components of ice strengthening on the basis of the formulae included in this Chapter.

Using the ice load parameters for strength estimation on the basis of other procedures and programs is not permitted without prior consent of the Register.

The ice load parameters, determined in compliance with **3.10.3.2** ÷ **3.10.3.7**, are applicable only to ice class ships and icebreakers with a hull shape that meets the requirements of **3.10.1.2.2** i **3.10.1.2.3**.

At the fore part with slope of design ice waterline $\alpha > 3°$, for ice class ships with bulbous bows, and when $\beta \leq 5°$, the ice load parameters shall be determined in compliance with **3.10.3.8**.

3.10.3.2 For ice class ships, the ice pressure, in kPa, shall be determined by the following formulae:

.1 in region **AI**

$$p_{AI} = 2500 a_1 v_m (\Delta/1000)^{1/6}, \qquad (3.10.3.2.1)$$

where: a_1 – factor to be taken from Table 3.10.3.2.1 based on the ice class;

Δ - displacement to summer load waterline, in t;

v_m – value of the shape factor v, which is the maximum one for the region, as determined at sections within x = 0; 0,025*L*; 0,05*L*; 0,075*L*; 0,1*L*, etc. from the forward perpendicular (as far as Ice1, Ice2 and Ice3 ice class ships are concerned, design sections where $x \le 0{,}58b$, shall only be considered; for *b*, refer to Fig. 3.10.1.3.2) at the design ice waterline.

The value shall be determined by the following formulae:

for ships and icebreakers with the hull shape compliant with the provisions of **3.10.1.2.2** and **3.10.1.2.3**

$v = [0{,}278 + (0{,}18x/L)] \cdot (\alpha^2/\beta)^{1/4}$ at $x/L \le 0{,}25$;

$v = [0{,}343 - (0{,}08x/L)] \cdot (\alpha^2/\beta)^{1/4}$ at $x/L > 0{,}25$;

for other ships and icebreakers

$v = f_\upsilon(0{,}9 + 0{,}3x/L + 0{,}005\alpha - 0{,}0015\beta')$,

where: *L* – length at design ice waterline;

x – distance between the considered section and the forward perpendicular, in m;

α – angle of design waterline inclination which shall be measured in accordance with Figs. 3.10.1.2-1 and 3.10.1.2-3 (where *x* = 0), in deg.;

β – angle of frame inclination at design ice waterline on the considered section which shall be measured in accordance with Fig. 3.10.1.2.1-2, in deg.; where the frame is concave, in case of **Ice4** ÷ **Ice6** ice class ships, β shall be chosen as a minimum angle, which is measured at service waterlines;

$\beta' = \mathrm{arctg}(\mathrm{tg}\beta \cdot \cos\alpha)$ – = side inclination angle with regard to normal, deg;

$f_\upsilon = [(\sin\alpha \cdot \cos\beta')^{0{,}54}]/[(\cos\beta')^{0{,}17} \cdot (\sin\beta')^{0{,}25}]$.

If $\alpha > 0$ and $\beta = 0$ in a section under consideration of **Ice1** ÷ **Ice3** ice class ships, it shall be considered that $v = 0{,}72$ in this section.

If the angle of *α* is less than 3° in a section of **Ice1** ÷ **Ice5** ice class ships, such a section may be omitted when calculating v_m;

Table 3.10.3.2.1

Factor	Ice class					
	Ice1	**Ice2**	**Ice3**	**Ice4**	**Ice5**	**Ice6**
a_1	0,36	0,49	0,61	0,79	1,15	1,89
a_2	-	-	-	0,8	1,17	1,92
a_3	-	0,22	0,33	0,5	0,78	1,2
a_4	-	0,5	0,63	0,75	0,87	1

.2 in region **A₁I**

$$p_{A1I} = 2500a_2v_m(\Delta/1000)^{1/6}, \quad (3.10.3.2.2)$$

where: a_2 – =factor to be taken from Table 3.10.3.2.1 based on the ice class;

v_m – shall be determined by the method described in **3.10.3.2.1**;

for Δ - refer to **3.10.3.2.1**;

.3 in region **BI**

$$p_{BI} = 1200a_3(\Delta/1000)^{1/6}, \quad (3.10.3.2.3)$$

where: a_3 – factor to be taken from Table 3.10.3.2.1 based on the ice class;

for Δ - refer to **3.10.3.2.1**;

.4 in region **CI** of **Ice2 – Ice6** ice class ships

$$p_{CI} = a_4 p_{BI}, \quad (3.10.3.2.4\text{-}1)$$

where: a_4 – factor to be taken from Table 3.10.3.2.1 based on the ice class;
for p_{BI} – refer to **3.10.3.2.3**.

.5 in regions **II**, **III** and **IV**, the ice pressure is determined as a part of the ice pressure in region **I** at the appropriate section of the ship length:

$$p_{kl} = a_{kl} \cdot p_{kI}, \quad (3.10.3.2.5)$$

wherer: k = **A**, **A1**, **B**, **C**;
l = **II**, **III**, **IV**;
a_{kl} – factor to be taken from Table 3.10.3.2.5.

Table 3.10.3.2.5

Ice class	Region lengthwise								
	forward and interme diate regions (**A** and **AI**)			midship region (**B**)			aft region (**C**)		
	Region vertically								
	II	**III**	**IV**	**II**	**III**	**IV**	**II**	**III**	**IV**
Ice3	0,4	-	-	-	-	-	-	-	-
Ice4	0,5	0,4	0,35	0,4	-	-	-	-	-
Ice5	0,65	0,65	0,45	0,5	0,4	-	0,5	-	-
Ice6	0,65	0,65	0,5	0,5	0,45	-	0,5	0,35	0,15

3.10.3.3 The vertical distribution of ice pressure, in m, shall be determined by the following formulae:
.1 in regions **AI**, **AII**, **AIII**, **AIV**

$$b_A = C_1 k_\Delta u_m, \quad (3.10.3.3.1)$$

where: C_1 – =factor to be taken from Table 3.10.3.3.1 based on the ice class;

$k_\Delta = (\Delta/1000)^{1/3}$, but not greater than 3,5;

Table 3.10.3.3.1

Factor	Ice class					
	Ice1	**Ice2**	**Ice3**	**Ice4**	**Ice5**	**Ice6**
C_1	0,38	0,42	0,44	0,49	0,6	0,62
C_2	-	-	-	0,55	0,7	0,73
C_3	-	0,27	0,3	0,34	0,4	0,47

For Δ - refer to **3.10.3.2.1**;
u_m - maximum value of the shape factor u for the region, as determined at sections within x = 0; 0,025L; 0,05L; 0,075L; 0,1L, etc. from forward perpendicular (as far as Ice1, Ice2 and Ice3 ice class ships are concerned, sections where $x \le 0,58b$, shall only be considered; for b, refer to Fig. 3.10.1.3.2) at the design ice waterline.
The value shall be determined by the following formulae:
for ships and icebreakers with the hull shape compliant with the provisions of **3.10.1.2.2** i **3.10.1.2.3**

$$u = k_B \cdot [0,635 + (0,61x/L)] \cdot \sqrt{\alpha/\beta} \text{ at } x/L \le 0,25;$$

$$u = k_B \cdot [0,862 - (0,3x/L)] \cdot \sqrt{\alpha/\beta} \text{ at } x/L > 0,25;$$

for other ships and icebreakers

$$u = f_u(0,72 + x/L + 0,001\alpha - 0,013x\beta'/L),$$

where for L, x, α, β, β′ - refer to **3.10.3.2.1**;

$k_B = 1$ at $\beta \ge 7°$;

$k_B = 1,15 - 0,15\,\beta/7$ at $\beta < 7°$;

$f_u = [(\sin\alpha \cdot \cos\beta')^{0,58}]/[(\cos\beta')^{0,33} \cdot (\sin\beta')^{0,5}]$.

If α > 0 and β = 0, in a section of **Ice1** ÷ **Ice3** ice class ships, it shall be considered that u=0,92 for this section.

If the angle α is less than 3° in a section of **Ice1** ÷ **Ice5** ice class ships, such a section may be omitted when calculating u_m;

.2 in regions **A₁I**, **A₁II**, **A₁III**, **A₁IV**

$b_{A1} = C_2 k_\Delta u_m$, but not greater than $1{,}25 b_A p_{AI}/p_{A1I}$, (3.10.3.3.2-1)

where: C_2 – factor to be taken from Table 3.10.3.3.1 based on the ice class;
for k_Δ - refer to **3.10.3.3.1**;
u_m - shall be determined by the procedure described in **3.10.3.3.1**;
for b_A – refer to **3.10.3.3.1**;
for p_{AI} - refer to **3.10.3.2.1**;
for p_{A1I} – refer to **3.10.3.2.2**.

In any case, the vertical distribution b_{A1} shall be not less than that determined by the formula:

$b_{A1} = p_{BI} b_B / p_{A1I}$, (3.10.3.3.2-2)

where for p_{A1I} – refer to **3.10.3.2.2**;
for p_{BI} - refer to **3.10.3.2.3**;
for b_B – refer to **3.10.3.3.3**;

.3 in regions **BI**, **BII**, **BIII**, **BIV**

$b_B = C_3 C_4 k_\Delta$, (3.10.3.3.3)

де: C_3 - factor to be taken from Table 3.10.3.3.1 based on the ice class;
C_4 - = factor to be taken from Table 3.10.3.3.3 based on the minimal side inclination angle with regard to normal;
for k_Δ - refer to **3.10.3.3.1**;

Table 3.10.3.3.3

Factor	Angle of side slope amidships, in deg.						
	≤ 6	8	10	12	14	16	18
C_4	1,0	0,81	0,68	0,54	0,52	0,47	0,44

.4 in regions **CI**, **CII**, **CIII**, **CIV**

$b_C = 0{,}8 b_B$ - for **Ice2** ÷ **Ice6** ice class ships;

where for b_B – refer to **3.10.3.3.3**.

3.10.3.4 Horizontal distribution of ice pressure, in m, shall be determined by the following formulae:

.1 in regions **AI**, **AII**, **AIII**, **AIV**

$l^H_A = 11{,}3\sqrt{b_A \sin\beta^A_m}$, but not less than $3{,}5\sqrt{k_\Delta}$, (3.10.3.4.1)

where for b_A, k_Δ - refer to **3.10.3.3.1**;
β^A_m - =angle β′ in the design section of region A for which the value of the *u* parameter is maximum (refer to **3.10.3.3.1**);
for β′ - refer to **3.10.3.2.1**;

.2 in regions **A₁I**, **A₁II**, **A₁III**, **A₁IV**

$l^H_{A1} = 11{,}3\sqrt{b_{A1} \sin\beta^{A1}_m}$, but not less than $3\sqrt{k_\Delta}$, (3.10.3.4.2)

where for b_{A1} – refer to **3.10.3.3.2**;

$\beta^{A1}{}_{m}$ - angle β′ in the design section of region **A1** for which the value of the u parameter is maximum (refer to **3.10.3.3.1**);

for β′ - refer to **3.10.3.2.1**;

for k_Δ - refer to **3.10.3.3.1**;

.3 in regions **BI**,**BII**,**BIII**,**BIV**

$l^{H}{}_{B} = 6b_B$, but not less than $3\sqrt{k_\Delta}$, (3.10.3.4.3)

where for b_B – refer to **3.10.3.3.3**;

for k_Δ - refer to **3.10.3.3.1**;

.4 in regions **CI**, **CII**, **CIII**, **CIV**

$l^{H}{}_{C} = 6b_C$, but not less than $3\sqrt{k_\Delta}$, (3.10.3.4.4)

where for b_C – refer to **3.10.3.3.4**;

for k_Δ - refer to **3.10.3.3.1.**

3.10.3.5 For icebreakers, the ice pressure shall be determined by the following formulae:

.1 in region **AI**

$p_{AI} = k_p \cdot p^{o}{}_{AI}$, (3.10.3.5.1)

where: $p^{o}{}_{AI}$ – =ice pressure in region **AI**, to be determined in accordance with **3.10.3.2.1** as in the case of a ship whose ice class number coincides with the ice class number of the icebreaker;

k_p =1 where $N_\Sigma \le N_0$;

$k_p = (N_\Sigma / N_0)$ where $N_\Sigma > N_0$;

N_Σ - propeller shaft output, in MW;

N_0 – shall be taken from Table 3.10.3.5.1;

Table 3.10.3.5.1

Ice class of icebreaker	N_0, in MW
Icebreaker1	10
Icebreaker2	20
Icebreaker3	40
Icebreaker4	60

.2 in regions **A1I**, **BI** i **CI**

$p_{kI} = a_k\, p_{AI}$, (3.10.3.5.2)

where for p_{AI} – refer to **3.10.3.5.1**;

a_k – factor to be taken from Table 3.10.3.5.2 based on the region of the ship length and the ice class of icebreaker;

k = **A1**, **B**, **C**;

Table 3.10.3.5.1

Region	Ice class of icebreaker			
	Icebreaker1	**Icebreaker2**	**Icebreaker3**	**Icebreaker4**
A1I	0,65	0,75	0,85	0,85
BI	0,6	0,65	0,7	0,75
CI	0,75	0,75	0,75	0,75

.3 in regions **II**, **III** and **IV**, the ice pressure shall be determined as a part of the ice pressure in region **I** for the appropriate region of ship length:

$p_{mn} = a_{mn} \cdot p_{mI}$, (3.10.3.5.3)

where: m = **A**, **A1**, **B**, **C**;

n = **II**, **III**, **IV**;

a_{mn} – factor to be taken from Table 3.10.3.5.3.

Table 3.10.3.5.3

Factor	Region vertically and region lengthwise											
	AII	**AIII**	**AIV**	**A_1II**	**A_1III**	**A_1IV**	**BII**	**BIII**	**BIV**	**CII**	**CIII**	**CIV**
a_{mn}	0,7	0,65	0,5	0,6	0,55	0,45	0,55	0,45	0,35	0,55	0,4	0,3

3.10.3.6 As far as icebreakers are concerned, the vertical distribution of ice pressure shall be adopted equal for all regions and shall be determined in accordance with **3.10.3.3.1**, i.e. as for the forward region of the ship whose ice class number coincides with the ice class number of the icebreaker. When determining u_m the values of u shall be calculated for those sections only which are included in the forward region of ice strengthening of the icebreaker.

3.10.3.7 As far as icebreakers are concerned, the horizontal distribution of ice pressure shall be adopted equal for all regions and shall be determined in accordance with **3.10.3.4.1**, i.e. as for the forward region of the ship whose ice class number coincides with the ice class number of the icebreaker.

When determining β_m only those sections shall be considered which are included in the forward region of ice strengthening of the icebreake.

3.10.3.8 Ice load parameters for the bow areas with the vertical side ($\beta < 5$) in the region of alternating draughts, or bulbous bows.

3.10.3.8.1 For ships of ice classes, the ice pressure, in kPa, shall be determined by the following formulae:

for ships of ice classes **Ice1**, **Ice2** i **Ice3**

$p_{AI} = 0{,}985 \cdot p^i_{ref} \cdot \upsilon_m \cdot (\Delta/1000)^{0{,}0132}$, $1 \le \Delta \le 5$ thousand t;

$p_{AI} = 0{,}976 \cdot p^i_{ref} \cdot \upsilon_m \cdot (\Delta/1000)^{0{,}0052}$, $5 < \Delta \le 200$ thousand t;

for ice classes **Ice4**, **Ice5** i **Ice6**

$p_{AI} = 0{,}790 \cdot p^i_{ref} \cdot \upsilon_m \cdot (\Delta/1000)^{0{,}0614}$,

where: p^i_{ref} – factor to be taken from Table 3.10.3.8.1-1 based on the ice class;

υ_m – maximum value of the shape factor υ to be determined in bow area sections with the vertical side at design waterline by the formula:

$\upsilon[(x/L), \alpha] = b^\upsilon_0 + b^\upsilon_1 \cdot (x/L) + b^\upsilon_2 \cdot \alpha + b^\upsilon_{11} \cdot (x/L)^2 + b^\upsilon_{22} \cdot \alpha^2 + b^\upsilon_{12} \cdot (x/L) \cdot \alpha$;

b^υ_i – factors to be taken from Table3.10.3.8.1-2;

Δ - displacement at design ice waterline, t.

For ships with bulbous bows, when determining the design loads on the bulb structure, υ_m is determined at the ballast waterline, if it passes through the bulb, otherwise - at the waterline, where inclination angle of the bulb plating $\beta = 0 \div 5°$.

Table 3.10.3.8.1-1

	$1 \le \Delta \le 5$ thousand t			$5 < \Delta \le 200$ thousand t			**Ice4**	**Ice5**	**Ice6**
	Ice1	**Ice2**	**Ice3**	**Ice1**	**Ice2**	**Ice3**			
p^i_{ref}	1100	1430	1760	1120	1460	1810	3620	5910	10360
b^H	-	-	-	-	-	-	1,5	2,0	3,7
b^i_{ref}	0,65	0,80	1,00	0,65	0,80	1,00	-	-	-
l^i_{ref}	3,66	4,33	4,27	12,05	14,22	13,94	4,55	4,52	4,39

Table 3.10.3.8.1-2

b^υ_i	$1 \le \Delta \le 5$ thousand t			$5 < \Delta \le 200$ thousand t			**Ice4**	**Ice5**	**Ice6**
	Ice1	**Ice2**	**Ice3**	**Ice1**	**Ice2**	**Ice3**			
b^υ_0	0,769	0,747	0,714	1,015	1,020	1,008	0,728	0,754	0,790
b^υ_1	-4,004	-3,924	-3,373	-5,829	-5,975	-5,679	-3,758	-4,790	-6,170
b^υ_2	0,039	0,040	0,040	0,035	0,036	0,037	0,021	0,021	0,020

b^{u}_{11}	11,17	11,26	9,75	14,57	15,06	13,46	20,50	24,90	32,21
b^{u}_{22}	-0,0003	-0,0003	-0,0003	-0,0003	-0,0003	-0,0003	-0,0003	-0,0002	-0,0002
b^{u}_{12}	-0,0490	-0,0517	-0,0642	-0,0393	-0,0404	-0,0481	0,0688	0,0917	0,1188

3.10.3.8.2 Vertical distribution of ice pressure, in m, for ice class ships **Ice1**, **Ice2**, **Ice3** shall be determined by the formula:

$b_A = b^{i}_{ref} \cdot u_{b\text{-}m}$, but not exceeding the distance between the side stringers (for structures inside the bulb - platforms or webs installed according to **3.10.2.6.4**),

where: b^{i}_{ref} – the factor taken as per Table 3.10.3.8.1-1 depending on the ice class;
$u_{b\text{-}m}$ – = maximum value of the shape factor u_b, to be determined in sections of bow area with the vertical side at design ice waterline by the formula

$u_b(x/L) = b^{u}_{0} + b^{u}_{1} \cdot (x/L) + b^{u}_{11} \cdot (x/L)^2$;

b^{u}_{i} – = factors to be taken from Table 3.10.3.8.3.

Vertical distribution of ice pressure, in m, for ships of ice classes **Ice4**, **Ice5** and **Ice6** shall be determined by the formula

$b_A = b^{11}$, but not exceeding the distance between the side stringers (for structures inside the bulb - platforms or webs installed according to **3.10.2.6.4**),

where: b^{11} – н is taken from Table 3.10.3.8.1-1 based on the ice class.

Table 3.10.3.8.2

b^{u}_{i}	**Ice1**	**Ice2**	**Ice3**
b^{u}_{0}	2,283	2,283	2,146
b^{u}_{1}	-11,88	-11,85	-10,28
b^{u}_{11}	22,14	22,02	17,60

3.10.3.8.3 Horizontal distribution of ice pressure, in m, shall be determined by the following formulae:
for ships of ice classes **Ice1**, **Ice2** and **Ice3**:

$l_A = 0{,}748 \cdot l^{i}_{ref} \cdot u_{l\text{-}m} \cdot (\Delta/1000)^{0{,}3065}$, $1 \le \Delta \le 5$ thousand t;

$l_A = 0{,}218 \cdot l^{i}_{ref} \cdot u_{l\text{-}m} \cdot (\Delta/1000)^{0{,}3311}$, $5 \le \Delta \le 200$ thousand t;

for ships of ice classes **Ice4**, **Ice5** i **Ice6**:

$l_A = 0{,}337 \cdot l^{i}_{ref} \cdot u_{l\text{-}m} \cdot (\Delta/1000)^{0{,}2906}$,

where: l^{i}_{ref} – = factor to be taken from Table 3.10.3.8.1-1 based on the ice class;
$u_{l\text{-}m}$ – maximum value of the shape factor u_l, 1 to be determined in sections of bow area with the vertical side at design waterline by the formula

$u_l\,[(x/L), \alpha] = b^{u}_{0} + b^{u}_{1} \cdot (x/L) + b^{u}_{2} \cdot \alpha + b^{u}_{11} \cdot (x/L)^2 + b^{u}_{22} \cdot \alpha^2 + b^{u}_{12} \cdot (x/L) \cdot \alpha$;

b^{u}_{i} – factors to be taken from Table 3.10.3.8.3.

Table 3.10.3.8.3

b^{u}_{i}	$1 \le \Delta \le 5$ thousand t			$5 < \Delta \le 200$ thousand t			**Ice4**	**Ice5**	**Ice6**
	Ice1	**Ice2**	**Ice3**	**Ice1**	**Ice2**	**Ice3**			
b^{u}_{0}	0,186	0,171	0,166	0,167	0,155	0,139	0,307	0,302	0,324
b^{u}_{1}	-3,339	-3,319	-2,377	-3,297	-3,318	-2,607	0,205	0,325	0,294
b^{u}_{2}	0,0241	0,0227	0,0184	0,0231	0,0216	0,0222	0,0370	0,0375	0,0363
b^{u}_{11}	17,2	17,6	18,4	17,4	17,9	15,02	2,37	1,78	1,17
b^{u}_{22}	-0,0003	-0,0003	-0,0002	-0,0003	-0,0003	-0,0003	-0,0002	-0,0003	-0,0002

b^{u}_{12}	0,148	0,159	0,110	0,153	0,165	0,152	0,031	0,030	0,030

3.10.3.8.4 For ships of ice classes **Ice1**, **Ice2** i **Ice3**, with stretched area of vertical side (from the forward perpendicular to parallel midship body), intermediate regions of ice strengthening may be added at the length of bow. In this case, the values of hull shape factors υ_m, u_{b-m}, u_{l-m} shall be taken equal to the maximum value of the relevant factors determined for each intermediate regions at designed ice waterline.

3.10.3.8.5 For ships of ice classes **Ice4**, **Ice5** i **Ice6** with bulbous bows and extended bow area at design waterline, an intermediate region of ice strengthening inside the region A may be added, in addition to the requirements of **3.10.1.3.1**. In this case, the values of hull shape factors υ_m, u_{b-m}, u_{l-m} shall be taken equal to the maximum value of the relevant factors determined for each intermediate region inside the A region at design waterline.

3.10.4 Scantlings of ice-strengthening structures.

3.10.4.1 Shell plating.

In regions of ice strengthening, the shell plating thickness s_{sp}, in mm, shall not be less than determined by the formula

$$s_{sp} = s_{sp0} + \Delta s_{sp0}, \qquad (3.10.4.1)$$

where: $s_{sp0} = 15{,}8a_0\sqrt{p/R_{eH}}$;

$\Delta s_{sp0} = 0{,}75Tu$;

$a_0 = a/(1 + 0{,}5a/c)$;

p - ice pressure in the region under consideration according to **3.10.3.2** or **3.10.3.5**, in kPa;

$c = b$ - where the grillage is transversely framed in the region under consideration. In this case, c shall not be greater than the spacing of intercostal stringers or the distance between plate structures;

$c = l$ - where the grillage is longitudinally framed in the region under consideration;

b - vertical distribution of ice pressure in the region under consideration according **to 3.10.3.3** or **3.10.3.6**, in m;

l - distance between adjacent transverse members, in m;

a - spacing of shell plating stiffeners, in m;

T - planned ship life, in years;

u - annual reduction of shell plating as a result of corrosion wear and abrasion, in mm per year, to be taken from Table 3.10.4.1 of this Part.

When taking measures to protect the shell plating from corrosion wear and abrasion complying with **6.5.3** Part XIII "Materials" of this Rules and 3.5.1, Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships the value u may be reduced by 25 % when applying Class II protective coatings and by 50 % when applying protective coatings of Class I. In this case the value Δs_{sp0} shall not be taken less than determined in **1.1.5.2** of this Part. In the drawings of hull structures the scantlings determined at u according to Table **3.10.4.1** of this Part shall be additionally indicated. A special entry shall be made in the Classification Certificate of such ships (refer to **2.3.1**, Part I "Classification" of these Rules).

Table 3.10.4.1.1

Ice class	u, in mm per year	
	Region lengthwise	
	forward and intermediate (**A** and **A₁**)	midship and after (B an C)
Ice1	0,17	In accordance with **1.1.5.2**
Ice2	0,22	
Ice3	0,25	
Ice4	0,3	0,2
Ice5, Ice6	0,35	0,24
Icebreaker1	0,4	0,3
Icebreaker2	0,5	0,35
Icebreaker3	0,6	0,4
Icebreaker4	0,7	0,4

3.10.4.2 Procedure for determining the required and actual geometrical characteristics of girder structures.

3.10.4.2.1 The formulae, as given in **3.10.4.3 ÷ 3.10.4.8**, for determining the required geometrical characteristics of girder structure cross sections, such as the ultimate section modulus W and the web area A, are based on the ultimate strength criterion.

The recommendations of **3.10.4.2.2 ÷ 3.10.4.2.6** shall preferably be considered when determining the values of W and A.

3.10.4.2.2 The required value of the ultimate section modulus W is proportionate to the factor k which varies on the basis of the dependence between the required web area A and the actual web area A_a (adopted when choosing the section):

$$W = W_0 k; \quad k = k(\gamma); \quad \gamma = A/A_a, \qquad (3.10.4.2.2\text{-}1)$$

where: W_0 - required value of W, web area margin disregarded, to be determined in accordance with**3.10.4.3.1**, **3.10.4.4.1**, **3.10.4.5.1**, **3.10.4.6.1**, **3.10.4.7.1**.

In the absence of a web area margin ($A = A_a$, $\gamma = 1$) the value of W is maximum ($k = 1$).

The increase of the actual web area as compared with the required one ($\gamma < 1$) makes it possible to reduce the value of W (assuming $\gamma = 0{,}9 \div 0{,}8$; k = 0,7 ÷ 0,63).

Thus, the application of a flexible procedure for choosing a profile is ensured to avoid redundant margins of material with several approximations during the calculation.

By way of the first approximation, the following assumptions shall be made in Formulae (3.10.4.3-1), (3.10.4.4-1), (3.10.4.5-1), (3.10.4.6-1), (3.10.4.7-1):

$\gamma_i = 0{,}9$, i.e. the actual girder web area shall be at least by 10 % greater than the required one;

$$k_f = 1/(F + 0{,}15j) \text{ - for conventional frames;} \qquad (3.10.4.2.2\text{-}2)$$

$k_i = 0{,}63$ - for other girder types,

where: i - girder type index (f for frame, s for stringer, wf for web frame, l for longitudinal);
for F, j – refer to **3.10.4.3.1**.

3.10.4.2.3 For grillages comprising deep frames, a procedure is implemented to take account of the redundant margins of material which emerge when choosing girder sections as a result of the actual section modulus W_a and the actual web area A_a exceeding the required values of W and A. Redundant margins are accounted for by applying the factors:

$$\gamma_i \le 1; \ \psi_i = (W_{\phi i}/W_{0i}) \le k_i, \qquad (3.10.4.2.3)$$

where for k_i, γ_i, W_{0i} – refer to Formula (3.10.4.2.2-1);
for i – refer to Formula (3.10.4.2.2-2).

If the actual geometrical characteristics of a conventional frame exceed the required ones ($\gamma_f < 1$, $\psi_f > k_f$), in a transversely framed grillage, the required geometrical characteristics of the supporting stringer and deep frame (in the case of the latter, redundant margins, if any, of the bearing stringer ($\gamma_s < 1$, $\psi_s > k_s$) are also considered) are lowered due to this.

Similarly, case of a longitudinally framed grillage for lowering the requirements for the deep frame where longitudinals have redundant margins ($\gamma_l < 1$, $\psi_l > k_l$).

3.10.4.2.4 Where the profile selection procedures in accordance with **3.10.4.2.2** and the procedures for considering the redundant margins of materials in accordance with **3.10.4.2.3** appear too complicated, a simplified calculation can be carried out, assuming

$\gamma_i = 0{,}9$;

$$k_f = 1/(F + 0{,}15j) \text{ - for conventional frames;} \qquad (3.10.4.2.2\text{-}2)$$

k_i = 0,63 - for other types of girders;

$\psi_i = k_i$.

Precise instructions concerning the simplified calculation procedure shall be found directly in **3.10.4.3** ÷ **3.10.4.**7.

No simplified calculation is allowed if flat bar profile is used for conventional frames. The simplified calculation results in increase of girder scantinds.

Therefore, the simplified calculation is not recommended for icebreakers and **Ice4** ÷ **Ice6** ice class ships.

3.10.4.2.5 When selecting profiles, the face plate and effective flange sections whose breadth is equal to the web thickness (refer to Fig. 3.10.4.2.5) shall be included in the actual web area A_a, in cm^2.

If there are cutouts in girder webs, they may be ignored in the case of side stringers only provided the openings are not made in the vicinity of supporting sections. The requirements for the area of frame webs (both conventional and deep frames) shall be verified on the basis of net sections.

3.10.4.2.6 To determine the actual value of the ultimate section modulus of the girders of ice strengthening structures it is recommended to use the formula

$$W_a=h(f_{sec}-0,5f_w-C), \text{ in cm}^3, \quad (3.10.4.2.6\text{-}1)$$

where: $C = 0$, with $f_{ef} \geq f_{sec}$;

$C = ((f_{sec} - f_{ef})^2/(4 f_w)$, with $f_{ef} < f_{sec}$;

f_{sec} – girder sectional area minus effective flange of shell plating, in cm^2;

f_w– 0,1[h-0,05(t_{fp}+t_{ef})]s, in cm^2;

h – section height measured from the mid-thickness of effective flange to the mid-thickness of face plate (refer to Fig. 3.10.4.2.5), in cm;

s – section web thickness, in mm;

f_{ef} = 0,1$b_{ef}t_{ef}$ – effective flange area of shell plating, in cm^2;

t_{fp} – effective flange thickness, in mm, of shell plating, to be adopted equal to the average shell plating thickness in way of effective flange breadth;

f_p = face plate thickness, in mm, (t_{fp}= *1,5s* to be adopted for bulb steel sections);

b_{ef} - effective flange breadth, in cm, to be adopted equal to:

conventional frame spacing, for conventional and deep frames where transverse framing is used; longitudinals spacing, for longitudinals where longitudinal framing is used;

1/6 of deep frame span between decks or platforms, or of frame spacing, whichever is less, for deep frames where longitudinal framing is used;

1/6 of frame spacing, for stringers where web framing is used;

half the sum of spacings of two adjacent girders of the same direction or 1/6 of girder span, whichever is less, in all other cases.

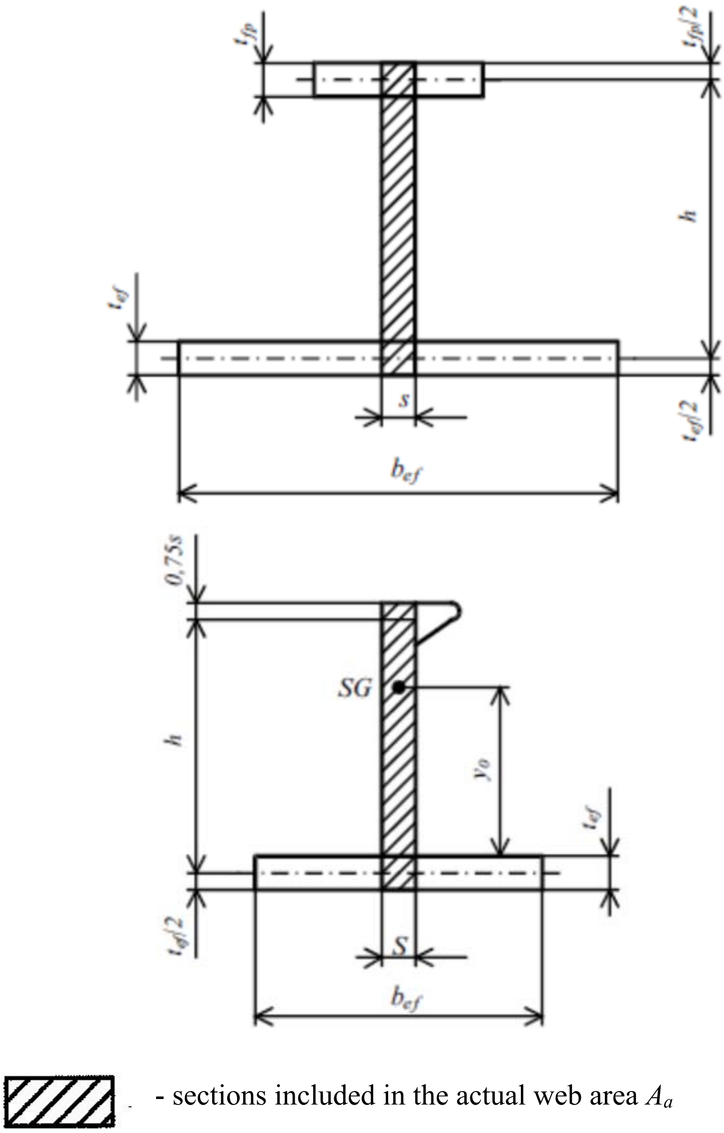


Fig. 3.10.4.2.5.

For rolled profiles where $f_{ef} \geq f_{sec}$ it may be assumed that:

$W_a = f_{sec}(y_0 + 0{,}05t_{ef})$, in cm^3, (3.10.4.2.6-2)

where: y_0 – distance between the gravity centre of the profile cross section, minus effective flange, and the shell plating, in cm (refer to Fig. 3.10.4.2.5).

3.10.4.3 Conventional frames where transverse framing is used.

The requirements of this paragraph apply to conventional frames in grillages with transverse main framing and in grillages with deep frames where transverse framing is used.

In the case of grillages with transverse main framing, the requirements shall be applied to a single span of a conventional frame which lies between the supporting sections of the frame on the upper and lower supporting structures.

In the case of grillages with deep frames, the requirements shall be applied to all the spans of a conventional frame, i.e. between the supporting sections of the upper supporting structure and the upper side stringer, between side stringers (*m* - 1 section where *m* is the number of side stringers), between the lower side stringer and the supporting section of the lower supporting structure.

3.10.4.3.1 The ultimate section modulus W_f, in cm^3, of a conventional frame shall not be less than determined by the formula:

$W_f = k_f W_{f0}$, (3.10.4.3.1)

where: $k_f = 1/[F + 0{,}25j \cdot \sqrt{(1 - k_s \gamma^2_f)}]$, $k_f = 1/(F + 0{,}15j)$ – for the case of the simplified calculation in accordance with **3.10.4.2.4**;

$F = 1$ with $k = 4$;

$F = 0{,}5$ with $k < 4$;

k – factor equal to:

as far as grillages with transverse main framing are concerned, refer to Table 3.10.4.3.1-1;

4 for grillages with deep frames;

Table 3.10.4.3.1-1

Parameter	Type of intermediate frame end fixation		
	both ends supported	one end supported, the other free (attached to an intercostal member)	both ends free (attached to an intercostal member)
k	4	3	2
l	Half the sum of distances between the supporting sections of two adjacent frames	Distance between the supporting sections of main frame	

j – = factor equal to:

the number of fixed supporting sections of two adjacent frames, $j \leq 4$ as far as grillages with transverse main framing are concerned;

in the case of grillages with web framing, refer to Table 3.10.4.3.1-2;

Table 3.10.4.3.1-2

Position of conventional frame zone under consideration	l	j
Between side stringers	Distance between side stringers	4
Between upper (lower) supporting structure and the nearest side stringer	Half the sum of distances between supporting sections on supporting structure and the nearest side stringer for two adjacent frames	j_0 +2, where $j_0 \leq 2$ – is the number of fixed supporting sections on the supporting structure for two adjacent frames

$k_s = 1$ for plate sections;

$k_s = 0{,}8$ in other cases;

$\gamma_f = A_f/A_a$;

for A_f – refer to **3.10.4.3.2**;

for A_a – refer to **3.10.4.3.3**;

$W_{f0} = 250pbalYk_kE\omega_f/R_{eH}$;

p - ice pressure in the region under consideration in accordance with **3.10.3.2** or **3.10.3.5**, in kPa;

where the lower boundary of region **I** is included in the grillage and the requirements of this Chapter cover region of ice strengthening **I** and **II** (refer to **3.10.1.3.4**), the following values of p shall be adopted:

$p = p_{kI}$ - , if the distance from the plating of the upper supporting structure of the grillage to the lower boundary of region **I** is greater than 1,2b, otherwise $p = p_{kII}$;

p_{kI}, p_{kII} - ice pressure in regions **I** and **II** (refer to **3.10.3.2**);

b - vertical distribution of ice pressure, in m, in the region under consideration in accordance with **3.10.3.3** or **3.10.3.6**.

If $b > l$, $b = l$ shall be adopted for the purpose of determining W_{f0} and A_f;

a - conventional frame spacing, in m, as measured at side;

l - design frame span, in m, to be determined in accordance with Table 3.10.4.3.1-1 in the case of transverse main framing and with Table 3.10.4.3.1-2 in the case of web framing;

$Y = 1 - 0{,}5\beta$;

$\beta = b/l$, but not greater than 1;

k_k - factor equal to 0,9 for conventional frames joined with knees to bearing stringers in a side grillage with deep frames, and equal to 1,0 in other cases;

E - factor equal to:

$E = 4l_i(l - l_i)/l^2$ якщо $l_i < 0,5l$;

$E = 1$ якщо $l_i \geq 0,5l$,

where: l_i - section of the span length l, in m, overlapped by the region of ice strengthening;

$\omega_f = 1 + k_c\ \Delta s/s_{as}$, for the purpose of simplified calculation in accordance with **3.10.4.2.4** $\omega_f = 1,15$ may be adopted;

s_{as} - actual frame web thickness, in mm;

for Δs – refer to **1.1.5.1**;

$k_c = 0,9$ - for rolled profile;

$k_c = 0,85$ - for welded profile.

3.10.4.3.2 The web area A_f, in cm^2, of a conventional frame shall not be less than determined by the formula

$$A_f = (8,7pabk_2k_3k_4/R_{eH}) + 0,1h_f\Delta s, \qquad (3.10.4.3.2)$$

where: $k_2 = 4/k$;

$k_3 = 1/[1 + z + (\sqrt{2z}) \cdot \beta^{2,5}]$, or $k_3 = 0,7$ whichever is greater;

$z = (a/l)^2/2\beta$;

for p,a,b,l,k,β – refer to **3.10.4.3.1**, the values of b and l adopted shall not exceed the distance between bracket ends;

$k_4 = 1$ – where no side stringer is provided;

$k_4 = 0,9$ – where there is a side stringer in the span;

$k_4 = 0,8$ – where there is a side stringer in the frame span for which effective flange continuity is ensured;

h_f – frame web height, in cm; $h_f = 0,89$hs for symmetric bulb and h_f=0,84h_s for asymmetric bulb;

h_s – rolled profile height, in cm;

for Δs – refer to **1.1.5.1**.

3.10.4.3.3 3 The actual web area A_a, in cm^2, shall be determined in accordance with *3.10.4.2.5*. When a simplified calculation is performed in accordance with **3.10.4.2.4**, the value of A_a shall be at least by 10 % greater than the required web area.

3.10.4.3.4 The web thickness s_f, in mm, of a conventional frame shall be adopted not less than the greater of the following values:

$$s_f = (k_s pa/R_{eH}) + \Delta s; \qquad (3.10.4.3.4\text{-}1)$$

$$s_f = 0,0114h_f\sqrt{R_{eH}} + \Delta s, \qquad (3.10.4.3.4\text{-}2)$$

where: $k_s = 1,4W_f/W_{af}$, but not less than $k_s = 1,0$;

for W_f – refer to **3.10.4.3.1**;

W_{af} – actual ultimate section modulus, in cm^3, of a conventional frame, to be determined in accordance with **3.10.4.2.6**, (as a first approximation or for the purpose of the simplified calculation in accordance with **3.10.4.2.4**, $W_f = W_{af}$ shall be adopted);

for p, a – refer to **3.10.4.3.1**;

for hf – refer to **3.10.4.3.2**;

for Δs – refer to **1.1.5.1**.

3.10.4.3.5 The face plate breadth c_f, in mm, of a conventional frame made of bulb or T-sections shall not be less than the greater one of the following values

$$c_f = (0,0145\ R_{eH}\ W_f/W_{af}) \cdot (h_f/s_{af} - 0,98) \cdot \sqrt{t_f s_{af}}; \qquad (3.10.4.3.5\text{-}1)$$

$$c_f = 2,5t_f; \qquad (3.10.4.3.5\text{-}2)$$

$$c_f = 69,6\ s_{af}\sqrt{h_f(\beta^2 - 0,0029)/t_f}, \qquad (3.10.4.3.5\text{-}3)$$

where: $\beta = (2 - \alpha)l_s/\alpha h_s$, but not less than $\beta = 0,055$;

$\alpha = (s_{af}/s_{as})^2 + 0,01h_f s_{as}/as_{af}$, but not less than $\alpha = 1$;

for W_f – refer to **3.10.4.3.1**;

for W_{af} – refer to **3.10.4.3.4**;

s_{af} – actual web thickness of a conventional frame, in mm;
t_f – face plate breadth of a conventional frame, in mm (for beams made of bulbs $t_f = 1,5s_{af}$ shall be adopted);
for h_f – refer to **3.10.4.3.2**;
s_{as} – actual shell plating thickness, in mm;
for a – refer to **3.10.4.3.1**;
l_s – the greatest spacing, in m, of adjacent stringers crossing the frame span or the greatest distance, in m, between the stringer and the supporting section.

In the case of frames made of standard profiles, compliance with the requirements for the face plate breadth may not be verified where a simplified calculation in accordance with 3.10.4.2.4 is carried out.

3.10.4.3.6 Where the face plate is lacking, the height of a conventional frame shall not be less than determined by the formula

$$h_f = 23,4(s_{af} - \Delta s) / \sqrt{R_{eH}}, \qquad (3.10.4.3.6)$$

where for s_{af} – refer to **3.10.4.3.5**;
for Δs – refer to **1.1.5.1**.

A distance between side stringers or a side stringer and a supporting structure for conventional frames without face plates shall not exceed 1,3 m.

3.10.4.4 Side and intercostal stringers as part of transverse framing with deep frames.

3.10.4.4.1 The ultimate section modulus W_s, in cm^3, of a bearing side stringer shall not be less than determined by the formula:

$$W_s = W_{s0}k_s, \qquad (3.10.4.4.1)$$

where: $W_{s0} = 125k_s^p p a^2_1 bQ\omega_s$;

$k_s = 1/(1 + \sqrt{1 - 0,8\gamma^2_s})$, for the purpose of simplified calculation in accordance with **3.10.4.2.4** $k_s = 0,63$ shall be adopted;

$\omega_s = 1 + 0,95\Delta s/s_{as}$, for the purpose of simplified calculation in accordance with **3.10.4.2.4** $\omega_s = 1,15$ shall be adopted;

$k_s^p = 0,82 - 0,55a_1/ l^p \geq 0,6$ with $l^p \geq a_1$;
$k_s^p = 0,82\, l^п/ a_1 - 0,55 \geq 0,6\, l^p/ a_1$ with $l^p < a_1$;
for l^p – refer to **3.10.3.4**;
for p, b – refer to **3.10.4.3.1**;
a_1 – deep frame spacing, in m, as measured along the side;
$Q = C_{1i} + C_{2i}b/l + C_{3i}\psi_f + C_{4i}/\gamma_f + C_{5i}\psi_f/\gamma_f$;
for the purpose of simplified calculation in accordance with **3.10.4.2.4** $Q = C_{6i} + C_{2i}b/l$;
i – factor taking up the following values:
i = 1 with $m = 1$;
i = 2 with $m \geq 2$;
m – number of side stringers in a grllage;
for C_{1i} , C_{2i} ……,C_{6i} – refer to Table 3.10.4.4.1.

Table 3.10.4.4.1

i	C_{1i}	C_{2i}	C_{3i}	C_{4i}	C_{5i}	C_{6i}
1	0,003	0,132	0,398	0,584	-0,785	0,320
2	0,363	0,11	-0,078	0,186	-0,202	0,358

for l, γ_f – refer to **3.10.4.3.1**;
ψ_f – factor to be adopted equal to the lesser of the following:
$\psi_f = W_{af}/W_{f0}$;
$\psi_f = 1,4k_f$;
for W_{f0}, k_f – refer to **3.10.4.3.1**;
for W_{af} – refer to **3.10.4.3.4**;
$\gamma_c = A_s/A_a$;

for A_s – refer to **3.10.4.4.2**;
for A_a - refer to **3.10.4.4.3**;
S_a – actual web thickness of a side stringer, in mm;
for Δs – refer to **1.1.5.1**.

3.10.4.4.2 The web area A_s, in cm^2, of a side stringer shall not be less than determined by the formula

$$A_c = 8{,}7k^p{}_s pabQn/R_{eH} + 0{,}1h_s\Delta s, \qquad (3.10.4.4.2)$$

where for p, a, b – refer to **3.10.4.3.1**;
n – number of frames fitted between two adjacent deep frames;
$k^p{}_s$,Q – refer to **3.10.4.4.1**;
h_c – web height of a bearing side stringer, in cm;
for Δs – refer to **1.1.5.1**.

3.10.4.4.3 The actual web area A_a, in cm^2, of a side stringer shall be determined in accordance with **3.10.4.3.3**.

3.10.4.4.4 The web thickness s_s, in mm, of a side stringer shall not be less than determined by the formula

$$S_s = 2{,}63c_1\sqrt{\gamma_s\, R_{eH}/[5{,}34 + 4(c_1/c_2)^2]} + \Delta s, \qquad (3.10.4.4.4)$$

where: c_1, c_2 – коротка і довга сторони панелей, на які стінка стрингера розбивається ребрами жорсткості, що її підкріплюють, м;
для непідкріпленої стінки $c_1 = 0{,}01(h_s – 0{,}8h_f)$, $c_2 = a_1$;
for h_s – refer to **3.10.4.4.2**;
for h_f – refer to **3.10.4.3.2**;
for a_1 і γ_s – refer to **3.10.4.4.1**;
for Δs – refer to **1.1.5.1**.

3.10.4.4.5 The web height h_s, in cm, of a side stringer shall not be less than determined by the formula

$$h_s = 2\,h_f, \qquad (3.10.4.4.5)$$

where for h_f – refer to **3.10.4.3.2**.

3.10.4.4.6 The face plate thickness of a side stringer shall not be less than its actual web thickness.

3.10.4.4.7 The face plate breadth c_s, in mm, of a side stringer shall not be less than the greater of the following values:

$$c_s = 0{,}0165\, R_{eH}W_s\sqrt{t_s\, s_{as}} \cdot (h_s/s_{as} – 2{,}6)/W_{as}; \qquad (3.10.4.4.7\text{-}1)$$

$$c_s = 7{,}5t_s, \qquad (3.10.4.4.7\text{-}2)$$

where for W_s – refer to **3.10.4.4.1**;
W_{as} – actual ultimate section modulus, in cm^3, of a side stringer, to be determined in accordance with **3.10.4.2.6**, ((in first approximation or for the purpose of simplified calculation in accordance with **3.10.4.2.4** $W_{as} = W_s$ shall be adopted);
T_s – face plate thickness, in mm, of a bearing stringer;
for s_{as} – refer to **3.10.4.4.1**;
for h_s – refer to **3.10.4.4.2**.

Bearing stringer without face plate (flat bar) is not permitted.

3.10.4.4.8 The web height h_{is}, in cm, of an intercostal stringer in way of a conventional frame shall not be less than determined by the formula

$$h_{is} = 0{,}8\,h_f, \qquad (3.10.4.4.8)$$

for h_f – refer to **3.10.4.3.2**.

3.10.4.4.9 The web thickness of an intercostal stringer shall not be less than that of a conventional frame, as required in accordance with **3.10.4.3.4**.

3.10.4.5 Deep frames as part of transverse framing.

3.10.4.5.1 The ultimate section modulus W_{wf}, in cm^3, of a deep frame shall not be less than determined by the formula

$$W_{wf} = W_{wf0}k_{wf}, \quad (3.10.4.5.1)$$

where: $W_{wf0} = 250k^{p}_{wf}pabl_{wf}(1 - 0{,}5b/l_{wf} + k_m G)\omega_{wf}/R_{eH}$;

$k_{wf} = 1/(1 + \sqrt{1\text{-}0{,}8\gamma^2_{wf}})$;

$G = 2nQ_m(1 - R)$, при цьому при виконанні спрощеного розрахунку згідно **3.10.4.2** приймається $k_{wf} = 0{,}63$;
$G = nQ_m$;
for n – refer to **3.10.4.4.2**;
for k_m – refer to Table 3.10.4.5.1-1;

Table 3.10.4.5.1-1

m	1	2	3	4	5	6
k_m	1,0	1,33	2,0	2,4	3,0	3,43

$R = 0{,}5\sqrt{2\psi_s - (\psi_s\gamma_{s1})^2}$ with $\psi_s < 1/\gamma^2_{s1}$;

$R = 0{,}5/\gamma_{s1}$ with $\psi_s \geq 1/\gamma^2_{s1}$;

$\gamma_{wf} = A_{wf}/A_a$;

$\psi_s = W_{as}k_d/W_{s0}$;

γ_{c1} – factor to be adopted as the greater of the following:

$\gamma_{c1} = \gamma_c/k_d$, або $\gamma_{c1} = 0{,}7$;

$k_d = 1$ with $m \leq 2$;

$k_d = Q/Q_m$ with $m > 2$, for the purpose of a simplified calculation in accordance with **3.10.4.2.4** $k_d = 1{,}2$ with $m > 2$ shall be adopted;

$Q_m = Q$ with $m = 1; 2$;

$Q_m = C_{m1} + C_{m2}[0{,}5b(\psi_f - 0{,}5)/l - \psi_f]$ with $m = 3; 4; 5; 6$;

C_{m1}, C_{m2} – factors to be taken from Table 3.10.4.5.1-2;

Table 3.10.4.5.1-2

m	3	4	5	6
C_{m1}	0,5	0,417	0,333	0,292
C_{m2}	0,25	0,167	0,111	0,083

$\omega_{wf} = 1 + 0{,}95\Delta s/s_{af}$, for the purpose of a simplified calculation in accordance with **3.10.4.2.4** $\omega_{wf} = 1{,}15$;
for p, a, b – refer to **3.10.4.3.1**;
$m, l, Q, \psi_f, W_{s0}, \gamma_c$ – refer to **3.10.4.4.1**;
l_{wf} – span length, in m, of a deep frame, equal to the distance between supporting sections;
for W_{as} – refer to **3.10.4.4.7**;
$k^p_{wf} = 0{,}82(1 - a_1/l^p) \geq 0{,}6$ with $l^p \geq 2a_1$;
$k^p_{wf} = 0{,}41(l^p/a_1 - 1) \geq 0{,}3\ l^p/a_1$ with $l^p < 2a_1$;
for $l^н$ – refer to **3.10.3.4**;
for a_1 – refer to **3.10.4.4.1**;
for A_{wf} – refer to **3.10.4.5.2**;
for A_a – refer to **3.10.4.5.3**;

s_{awf} – actual thickness, in mm, of a deep frame web;
for Δs – refer to **1.1.5.1**.

3.10.4.5.2 The web area A_{wf}, in cm2 , of a deep frame shall not be less than determined by the formula

$$A_{wf} = 8{,}7pabk^{p}_{wf}(1 + mG)/R_{eH} + 0{,}1h_{wf}\Delta s, \qquad (3.10.4.5.2)$$

where for p, a, b – refer to **3.10.4.3.1**;
for m – refer to **3.10.4.4.1**;
for k^{p}_{wf}, G – refer to **3.10.4.5.1**;
h_{wf} – deep frame web depth, in cm;
for Δs – refer to **1.1.5.1**.

3.10.4.5.3 The actual web area A_a, in cm^2, of a deep frame shall be determined in accordance with **3.10.4.3.3**.

3.10.4.5.4 The web thickness s_{wf}, in mm, shall be adopted not less than the greater of the following values:

$$s_{wf} = k_s pa/R_{eH} + \Delta s; \qquad (3.10.4.5.4\text{-}1)$$

$$s_{wf} = 2{,}63c_1\sqrt{\gamma_p R_{eH}/[5{,}34 + 4(c_1/c_2)^2]} + \Delta s, \qquad (3.10.4.5.4\text{-}2)$$

where: $k_s = 1/(1{,}25\ W_{wf}/W_{awf} - 0{,}75)$, but not less than $k_s = 1{,}0$;
for W_{wf} and g_{wf}, refer to **3.10.4.5.1**;
W_{awf} – actual ultimate section modulus, in cm3 , of a deep frame, to be determined in accordance with **3.10.4.2.6** (in the first approximation or for the purpose of the simplified calculation in accordance with **3.10.4.2.4**, $W_{awf} = W_{wf}$ shall be adopted);
for p, a – refer to **3.10.4.3.1**;
c_1, c_2 – the shorter and the longer side, in m, of panels into which the web of a deep frame is divided by its stiffeners;
for Δs – refer to **1.1.5.1**.

3.10.4.5.5 The face plate thickness of a deep frame shall not be less than the actual thickness of its web.

3.10.4.5.6 The face plate breadth c_{wf}, in mm, of a deep frame shall not be less than the greater of the following values:

$$c_{wf} = A_1R_{eH}W_{wf}\sqrt{t_p s_{awf}} \cdot (h_{wf}/s_{awf} - A_2)/W_{awf}; \qquad (3.10.4.5.6\text{-}1)$$

$$c_{wf} = A_3t_{wf}, \qquad (3.10.4.5.6\text{-}2)$$

where for W_{wf} – refer to **3.10.4.5.1**;
$_{awf}$ – refer to **3.10.4.5.4**;
t_{wf} – face plate thickness, in mm, of a deep frame;
s_{awf} – refer to **3.10.4.5.1**;
h_{awf} – refer to **3.10.4.5.2**;
$A_1 = 0{,}0039$; $A_2 = 1{,}4$; $A_3 = 5$, if the deep frame web is provided with stiffeners fitted approximately normal to the shell plating;
$A_1 = 0{,}0182$; $A_2 = 2{,}6$; $A_3 = 10$, if the deep frame web is provided with stiffeners fitted approximately parallel to the shell plating or if it is unstiffened.

Deep frame without face plate (flat bar) is not permitted.

3.10.4.6 Side and bottom longitudinals as part of longitudinal framing.

3.10.4.6.1 The ultimate section modulus W_l, in cm^3, of a longitudinal shall not be less than determined by the formula:

$$W_l = W_{l0}k_l, \qquad (3.10.4.6.1)$$

where: $W_{l0} = 125pb_1l(l - 0{,}5a)c^2\omega_l/R_{eH}$;

$k_l = 1/(1 + \sqrt{1 - k_s\gamma^2{}_l})$, for the purpose of simplified calculation in accordance with **3.10.4.2.4** for k_l = 0,63; k_s = refer to **3.10.4.3.1**;

c = 1 – for bottom longitudinals and for side longitudinals where no panting frames are fitted;

c = 1/(1 + 0,25/e) – for side longitudinals where panting frames are fitted;

$b_1 = k_0b_2$;

$b_2 = b(1 - 0{,}25\overline{b})$ with $\overline{b} < 2$;

$b_2 = a$ with $\overline{b} \geq 2$;

$e = \overline{b} + 1$;

$\overline{b} = b/a$;

$k = 1 - 0{,}3/\overline{b}$;

$\omega_l = 1 + k_c\Delta s/s_{al}$, may be adopted for the purpose of the simplified calculation in accordance with **3.10.4.2.4** ω_l = 1,15;

for p, b – refer to **3.10.4.3.1**;

a – spacing, in m, of longitudinals;

l – = spacing, in m, of deep frames or floors;

$\gamma_l = A_l/A_a$;

for A_l – refer to **3.10.4.6.2**;

for A_a – refer to **3.10.4.6.3**;

s_{al} – actual web thickness, in mm, of a longitudinal;

for Δs – refer to **1.1.5.1**;

for k_c = refer to **3.10.4.3.1**.

3.10.4.6.2 The web area A_l, in cm^2, of a longitudinal shall not be less than determined by the formula

$$A_l = 8{,}7pb_1lck_1/R_{eH} + 0{,}1h_l\Delta s, \quad (3.10.4.6.2)$$

where for p – refer to **3.10.4.3.1**;

for b_1, l, c – refer to **3.10.4.6.1**;

k_1 – factor to be adopted as the greater of the following:

$k_1 = 1/(1 + 0{,}76a_0/l)$, або k_1 = 0,8;

for a_0 – refer to **3.10.4.1**;

$h_б$ – web height, in cm, of a longitudinal;

for Δs – refer to **1.1.5.1.**

3.10.4.6.3 The actual web area A_a, in cm^2, of a longitudinal shall be determined in accordance with **3.10.4.3.3**.

3.10.4.6.4 The web area s_l, in mm, of a longitudinal shall be adopted not less than the greater one of the following values:

$$s_l = k_s pb_1/R_{eH} + \Delta s, \text{ or} \quad (3.1.4.6.4\text{-}1)$$

$$s_l = 0{,}013h_l\sqrt{R_{eH}} + \Delta s, \quad (3.1.4.6.4\text{-}2)$$

where: $k_s = 1{,}4W_l/W_{al}$, but not less than k_s = 1,0;

for W_l – refer to **3.10.4.6.1**;

W_{al} – actual ultimate section modulus, in cm^3, of a longitudinal, to be determined in accordance with **3.10.4.2.6** (in the first approximation or for the purpose of the simplified calculation in accordance with **3.10.4.2.4** приймається $W_{al} = W_l$);

for p – refer to **3.10.4.3.1**;

for b_1 – refer to **3.10.4.6.1**;

for h_l – refer to **3.10.4.6.2**;

for Δs – refer to **1.1.5.1.**

3.10.4.6.5 The face plate breadth c_l, in mm, of a longitudinal of bulb or T-bar shall not be less than the greater of the following values:

$$c_l = 0{,}0145\, R_{eH}W_l\sqrt{t_ls_{al}} \cdot (h_l/s_{al} - 0{,}98); \quad (3.10.4.6.5\text{-}1)$$

$$c_l = 2{,}5t_l; \quad (3.10.4.6.5\text{-}2)$$

$$c_l = 69{,}6s_{al}\sqrt{h_б(\beta^2 - 0{,}0029)}, \qquad (3.10.4.6.5\text{-}3)$$

where: $\beta = (2 - \alpha)l_s/(\alpha h_б)$, but not less than $\beta = 0{,}055$;
$\alpha = (s_{al}/s_{as})^2 + 0{,}01h_l\, s_{as}/(as_{al})$, but not less than $\alpha = 1$;
for W_l – refer to **3.10.4.6.1**;
for W_{al} – refer to **3.10.4.6.4**;
s_{al} – actual web thickness, in mm, of a longitudinal;
$t_б$ – face plate thickness, in mm, of a longitudinal (for longitudinals of bulb, $t_l = 1{,}5s_{al}$ shall be adopted);
for h_l – refer to **3.10.4.6.2**;
s_{as} – actual shell plating thickness, in mm;
for a – refer to **3.10.4.6.1**;
l_s – maximum spacing, in m, of adjacent transverse members crossing the span of a longitudinal.

As far as longitudinals made of standard profiles are concerned, conformance with the requirements for the face plate breadth may not be verified in case of carrying out a simplified calculation in accordance with **3.10.4.2.4**.

3.10.4.6.6 Where the face plate is lacking, the height of a longitudinal shall not be less than the value determined by Formula (3.10.4.3.6) where s_{af} shall be assumed equal to s_{al} - refer to **3.10.4.6.5**. A distance between deep frames or a deep frame and a supporting structure for longitudinals without face plates shall not exceed 1,3 m.

3.10.4.7 Deep frames as part of longitudinal framing.

3.10.4.7.1 The ultimate section modulus W_{wf}, in cm3 , of a deep frame shall not be less than determined by the formula:

$$W_{wf} = W_{wf0}k_p, \qquad (3.10.4.7.1)$$

where: $W_{wf0} = pabk^p_{wf}(1 + k_g)\cdot(Q - k_gR/e)\omega_{wf}/R_{eH}$;

$k_{wf} = 1/(1 + \sqrt{1 - 0{,}8\gamma_{wf}^2})$;
$Q = 2 - N$;

$N = \sqrt{2\psi_l\beta - (\psi_l/\gamma_l)^2}$ with $\psi_l < \beta/\gamma_l^2$;

$N = \beta/\gamma_б$ with $\psi_l \geq \beta/\gamma_l^2$;

$R = \beta\psi_l/\sqrt{(\psi_l/\gamma_l)^2 + 4}$.

For the purpose of a simplified calculation in accordance with **3.10.4.2.4**, $k_{wf} = 0{,}63$, $N = 1{,}1\beta$, $R = 0{,}33\beta$;
$\beta = b_1e/b$;
for p, b – refer to **3.10.4.3.1**;
for a, l, b_1, e, γ_l – refer to **3.10.4.6.1**;
for k^p_{wf}, ω_{wf} – refer to **3.10.4.5.1**;
k_g – factor to be adopted as the lesser of the following:
$k_g = 0{,}5(eQ/R - 1)$;
$k_g = 0{,}5[k - 0{,}25(e + 1)]$;
k – number of longitudinals in a deep frame span;
$\psi_l = W_{al} / W_{l0}$;
for W_{al} – refer to **3.10.4.6.4**;
for W_{l0} – refer to **3.10.4.6.1**;
$\gamma_{wf} = A_{wf}/A_a$;
for A_{wf} – refer to **3.10.4.7.2**;
for A_a – refer to **3.10.4.7.3**.

3.10.4.7.2 The web area A_{wf}, in cm^2, of a deep frame shall not be less than determined by the formula

$$A_{wf} = 8{,}7pbk^p_{wf}lQ/R_{eH} + 0{,}1h_{wf}\Delta s, \qquad (3.10.4.7.2)$$

where for p, b – refer to **3.10.4.3.1**;
for l – див. **3.10.4.6.1**;

for Q – refer to **3.10.4.7.1**;
h_p – deep frame web height, in cm;
for Δs – refer to **1.1.5.1**.

3.10.4.7.3 The actual web area A_a, in cm^2, of a deep frame shall be determined in accordance with **3.10.4.3.3**.

3.10.4.7.4 The web thickness of a deep frame shall not be less than the greater of the values determined by Formulae (3.10.4.5.4-1), (3.10.4.5.4-2) while W_{wf} shall be in accordance with **3.10.4.7.1** and a shall be in accordance with **3.10.4.6.1**.

3.10.4.7.5 The web height of a deep frame shall not be less than determined by the formula:

$$h_{wf} = 2h_l \qquad (3.10.4.7.5)$$

where for hl, refer to **3.10.4.6.2**.

3.10.4.7.6 The face plate thickness of a deep frame shall not be less than its actual web thickness.

3.10.4.7.7 The face plate breadth of a deep frame shall be determined in accordance with **3.10.4.5.6** while W_{wf} shall be in accordance with **3.10.4.7.1**. The deep frame without face plate (flat bar) is not permitted.

3.10.4.8 Additional frames and horizontal diaphragms as part of longitudinal framing.

3.10.4.8.1 The web height of an additional frame $h_{ad.f}$, in cm, (refer to 3.10.2.3) in way of a longitudinal shall not be less than determined by the formula

$$h_{ad.f} = 0{,}8h_l, \qquad (3.10.4.8.1)$$

where: h_l – web height, in cm, of a longitudinal.

3.10.4.8.2 The web thickness of an additional frame shall not be less than that of a longitudinal, as required in accordance with **3.10.4.6.4**.

3.10.4.8.3 The cross-sectional area of a horizontal diaphragm forming part of double-side structure where the outboard side is longitudinally framed shall not be less than the web area of a deep frame (vertical diaphragm) in accordance with **3.10.4.7.2**.

3.10.4.9 Plate structures.

3.10.4.9.1 The thickness of plate structures forming part of web framing of side grillages (deep frames, side stringers) shall be determined in accordance with **3.10.4.4.4**, **3.10.4.5.4**, **4.10.4.7.4**.

3.10.4.9.2 The plate structure thickness of decks and platforms, as well as of double bottom, bottom stringers and centre girder shall not be less than s_{ps1}, in mm, to be determined by the formula:

$$s_{ps1} = s_{ps0} + \Delta s, \qquad (3.10.4.9.2)$$

where: $s_{ps0} = s_{ps01}$ - if the plate structure is stiffened approximately normal to the shell plating;
$s_{ps0} = s_{ps02}$ - if the plate structure is unstiffened approximately normal to the shell plating (permitted for **Ice1**, **Ice2**, **Ice3** ice class ships);
$s_{ps01} = b\{0{,}8p_1/R_{eH} - 0045k_2[1+4\,(c_{sp}/\,k_2b)^2]\cdot(s_{sp0}/10c_{sp})^{3,5}\}$;

$s_{ps02} = 0{,}95p_1b/R_{eH}$;
$p_1 = k_1p$;
for k_1 - refer to Table 3.10.4.9.2;
$k_2 = k_T\cdot(k_p)^{1/2}$;
$k_T = 0{,}17\Delta^{1/6}$, but not less than 1,0;
k_p - shall be in accordance with 3.10.3.5.1 as far as icebreakers are concerned;
$k_p = 1$ - for ice class ships;
for Δ - refer to **3.10.3.2.1**;
for p, b – refer to **3.10.4.3.1**;
c_{sp} - spacing, in m, of stiffeners in a plate structure or distance, in m, between other framing members fitted approximately normal to the shell plating;
for s_{sp0} - refer to **3.10.4.1**;
for Δs - refer to **1.1.5.1**.

Table 3.10.4.9.2

Ice class	k_1
Ice1, Ice2, Ice3, Ice4, Ice5	1,3
Ice6, **Icebreaker1**	1,2
Icebreaker2	1,1
Icebreaker3, Icebreaker4	1,0

3.10.4.9.3 In addition to the requirements of 3.10.4.9.2, the thickness of plate structures in decks and platforms, where the side is transversely framed, shall not be less than s_{ps2}, in mm, to be determined by the formula

$$v = s_{ps0} + \Delta s, \qquad (3.10.4.9.3)$$

where: $s_{ps0} = 0{,}866 \cdot [1{,}1\, p_1 b \cdot (1 - b/4l)/R_{eH} - 0{,}5\, W_{af}\, l \cdot (h_f/10l)^{1,5} \cdot 10^{-3}/(\omega_f a l_1 l_2) - 0{,}1 f_{st}/a_1]/\alpha$;

p_1 – refer to **3.10.4.9.2**;

$l = 0{,}5(l_1 + l_2)$;

$\alpha = 1 - a_2/a$;

l_1, l_2 - distance, in m, from the plate structure under consideration to the nearest plate structures (decks, platforms, side stringers, inner bottom plating) on both sides;

a_1 - spacing, in m, of plate structure stiffeners fitted approximately normal to shell plating and welded thereto;

f_{st} - cross-sectional area of stiffener, in cm^2, without effective flange; where stiffeners are fitted parallel to the shell plating or snipped, $f_{st} = 0$ shall be adopted;

for b, a, ω_f – refer to **3.10.4.3.1**;

for W_{af} – refer to **3.10.4.3.4**;

for h_f – refer to **3.10.4.3.2**;

a_2 - length, in m, of unstiffened section of opening in plate structure for the passage of a conventional frame, as measured on the shell plating;

for Δs - refer to **1.1.5.1**.

3.10.4.9.4 Transverse bulkhead plating thickness where the side is longitudinally framed and the floor and bilge bracket thickness where the bottom is longitudinally framed shall not be less than s_{ps3}, in mm, to be determined by the formula:

$$s_{ps3} = s_{ps\,0} + \Delta s, \qquad (3.10.4.9.4)$$

where: $s_{ps\,0} = a\{1{,}8 p_2/R_{eH} - 0{,}009 \cdot [1+(a/k_g)^2] \cdot (s_{sp0}/10a)^{3,5}\}$;

$p_2 = p_1/k_2$;

for p_1, k_2 – refer to **3.10.4.9.2**;

$k_g = 0{,}4 k_2 b$, but not greater than $k_g = a$;

a - spacing, in m, of side (bottom) longitudinals;

for b – refer to **3.10.4.3.1**;

for s_{sp0}– refer to **3.10.4.1**;

for Δs – refer to **1.1.5.1**.

3.10.4.9.5 The plate structure thickness of transverse bulkheads in a transversely framed side, and of floors in a transversely framed bottom shall not be less than s_{ps4}, in mm, to be determined by the formula

$$s_{ps4} = s_{ps0} + \Delta s, \qquad (3.10.4.9.4)$$

where: $s_{ps0} = a\{1{,}8 p_2/R_{eH} - 0{,}009 \cdot [1+(a/k_g)^2] \cdot (s_{sp0}/10a)^{3,5}\}$;

$k_g = 0{,}4 k_2 b$, but not greater than $k_g = c_{sp}$;

for b – refer to **3.10.4.3.1**;

for k_2, c_{sp} – refer to **3.10.4.9.2**;

for p_2 – refer to **3.10.4.9.4**;

a - spacing, in m, of conventional frames (for plate structures of bulkheads) or floors (for plate structures of floors);

for s_{ps0} – refer to **3.10.4.1**;

for Δs – refer to **1.1.5.1**.

3.10.4.9.6 In any case, the plate thickness of decks and platforms, transverse bulkheads, inner bottom, floors and bilge brackets, bottom stringers and centre girder shall not be less than s_{ps}, in mm, to be determined by the formula

$$s_{ps} = s_{ps0} + \Delta s, \qquad (3.10.4.9.6)$$

where: $s_{ps0} = (q/n)^{1/3}$ with $q \le q_1$;

$s_{ps0} = 0{,}455 \cdot [q/R_{eH} + \sqrt{(q/R_{eH})^2 + 1{,}32R_{eH}/n}\ ]$ with $q_1 < q < q_2$;

$s_{ps0} = 1{,}73\sqrt{R_{eH}/n}$ with $q \ge q_2$;

$q = 0{,}6p_1b \cdot (1 - 0{,}1bk_2/a)$ - for plate structures of decks and platforms, inner bottom, bottom stringers and centre girder in a longitudinally framed side or bottom;

$q = 0{,}89p_2a$ - for the rest of plate structures where the bottom is transversely framed and for all plate structures where the bottom and side are framed transversely;

for p_1, k_2 – refer to **3.10.4.9.2**;

for p_2 – refer to **3.10.4.9.4**;

$q_1 = 0{,}353\sqrt{R^3_{eH}/n}$;

$q_2 = 4{,}9q_1$;

$n = 0{,}294n_1/c_1^2$;

$n_1 = [1+(c_1/c_2)^2]^2$ - where the longer side of plate structure panel adjoins the shell plating;

$n_1 = 4$ - where the shorter side of plate structure panel adjoins the shell plating;

c_1, c_2 - the shorter and longer sides, in m, of panels into which a plate structure is divided by its stiffeners;

for b – refer to **3.10.4.3.1**;

a - spacing, of shell plating stiffeners, in m;

for Δs – refer to **1.1.5.1**.

3.10.4.9.7 The intertia moment i, in cm^4, of stiffeners by which the plate structures are strengthened and which are fitted approximately normal to the shell plating shall not be less than determined by the formula

$$i = 0{,}01R_{eH}l^2\,(10s_{ps}a + f_p), \qquad (3.10.4.9.7)$$

where: l - span length, in m, of stiffener, not greater than $l = 6a$;

s_{ps}- thickness, in mm, of plate structure being strengthened;

a - spacing, in m, of stiffeners;

f_p - sectional area of stiffener, in cm^2, without effective flange.

3.10.4.9.8 A horizontal grillage adjoining the shell plating in region of ice strengthening, but not reaching from side to side (deck or platform in way of large openings, horizontal diaphragm of double side, etc.) may be considered a platform if the sectional area of its plating (on one side) is not less than F, in cm^2, to be determined by the formula

$$F = 6pbl^* \cdot (1 - b/4l)/R_{eH}, \qquad (3.10.4.9.8)$$

where for p – refer to **3.10.3.2**;

for b – refer to **3.10.3.3**;

l^* - =design distribution length, in m, for the load taken up by the transverse main framing of side, to be adopted equal to l^p, or to l^p or $2a_1$, whichever is less, in the case of framing (transverse or longitudinal) including deep frames;

for l^p – refer to **3.10.3.4**;
for a_1 – refer to **3.10.4.4.1**;
for l – refer to **3.10.4.9.3**.

Otherwise, such a structure shall be considered a bearing side stringer.

A structure considered to be a platform shall comply with the requirements of **3.10.4.9** for the plate structures of platforms, and one considered to be a stringer, with the requirements of **3.10.4.4**.

3.10.4.10 Stems and sternframes.

3.10.4.10.1 The requirements of this paragraph for the area, section modulus and plate thickness of stem shall be complied with on the stem span from the keel to a level extending above the upper boundary of the ice strake by a value of H_I (refer to Table 3.10.4.10.1). In the case of icebreakers, this stem shall extend up to the nearest deck or platform lying higher than this level. Outside the borders of the area considered, the stem scantlings may gradually reduce and the cross-sectional area of the bar shall not be less than required in **2.10.4** while the plate thickness of a combined or plate stem shall not be less than ks (where s is the shell plating thickness in way of ice strake in region **AI**, for k, refer to Table 3.10.4.10.1).

Table 3.10.4.10.1

Parameter	Ice class ships						Icebreakers			
	Ice1	**Ice2**	**Ice3**	**Ice4**	**Ice5**	**Ice6**	**Ice-brea-ker1**	**Ice-brea-ker2**	**Ice-brea-ker3**	**Ice-brea-ker4**
Section H_I, in m, from top of ice belt to upper boundary of ice strengthening of the stem	0,5	0,5	0,6	0,7	0,8	0,9	1,0	1,5	1,75	2,0
Factor k of stem plate thickening above the upper boundary of strengthening	1,25	1,2	1,15	1,1	1,1	1,05	1,0	1,0	1,0	1,0
Factor k_k from Formula (3.10.4.10.1-1)	0,3	0,34	0,4	0,54	0,66	1,02	1,43	1,75	1,96	2,17
Depth of centreline vertical web h_v, in m, by which the stem is strengthened	0,5	0,5	0,5	0,6	1,0	1,3	Longitudinal bulkhead in fore peak centreline			

The cross-sectional area S, in cm^2, of stem irrespective of configuration shall not be less than determined by the formula

$$S = k_k \eta f(\Delta), \qquad (3.10.4.10.1\text{-}1)$$

where: k_k – factor whose values shall be obtained from Table 3.10.4.10.1;

$f(\Delta) = 0{,}031\Delta + 137$ при $\Delta < 5000$т;
$f(\Delta) = \Delta^{2/3}$ при $\Delta \geq 5000$т;
Δ - displacement, in t;
η – application factor of mechanical properties of material determined according to **1.1.4.3**.

The section modulus W, in cm^3, of the stem cross-sectional area about an axis perpendicular to the centreline shall not be less than determined by the formula

$$W = 1{,}16\eta pb, \qquad (3.10.4.10.1\text{-}2)$$

where for p, b – refer to **3.10.4.3.1** as far as region of ice strengthening **AI** is concerned**;**
η – application factor of mechanical properties of material determined according to **1.1.4.3**.

To be included in the design cross-sectional area of a combined or plate stem are areas of shell plates and centreline girder or of longitudinal bulkhead on the centreline on a breadth not exceeding ten times the thickness of relevant plates.

The plate thickness s, in mm, of combined and plate stems, as well as of the structure shown in Fig. 3.10.2.6.2-2, shall not be less than determined by the formula

$s = 1{,}2 \cdot [(s_{sp}a_b\sqrt{R^{н}_{eH}/R_{eH}})/a_{sp} + \Delta s_s]$, (3.10.4.10.1-3)

where for s_{sp0}, Δs_{sp0} – refer to **3.10.4.1** as far as the region of ice strengthening **AI** is concerned;
a_b – spacing, in m, of transverse brackets of stem;
a_{sp} – main framing spacing, in m, in way of shell plating in the region of ice strengthening AI, which was adopted when determining s_{sp0};
R^{sp}_{eH} – yield stress, in MPa, of shell plating material, which was adopted when determinings_{sp0};
R_{eH} – yield stress, in MPa, of stem plate material.

In this case, the plate thickness *s*, in mm, of combined and plate stems shall not be less than determined by the formula

$s = s_{sterm} + \Delta s_{sp0}$, (3.10.4.10.1-4)

where: $s_{sterm} = 18{,}7a_b\sqrt{p_{AI}/R_{eH}}$;

for Δs_{sp0}, a_b, R_{eH} – refer to Formula (3.10.4.10.1-3);
p_{AI} – = ice pressure for icebreakers according to *3.10.3.5.1*, for ice class ships according to **3.10.3.2.1**.

3.10.4.10.2 Sternframe.
The cross-sectional area S, in cm^2, of sternframe shall not be less than determined by the formula:

$S = kS_0$, (3.10.4.10.2)

where: *k* - factor whose values shall be obtained from Table 3.10.4.10.2;
S_0 - cross-sectional area of starnpost or rudderpost, cm^2, in required for ships without ice claas in accordance with **2.10.4**.

For sternframe of single screw vessels of ice classes **Ice1**, **Ice2**, **Ice3**, without rudderpost, or having a steering wheel spindle «Symplex», cross-sectional area of sternframe sole are accepted the largest, based on those required by **2.10.4.2.5** (taking into account **2.2.2.2,** Part III «Equipment, Arrangements and outfit») or by the Formula (3.10.4.10.2), whichever is greater.
If the sternframe has a bracket for semi-suspended rudder, then the dimensions of the bracket shall be determined according to **2.10.4.4** taking into account **2.2.2.2,** Part III «Equipment, Arrangements and outfit».
The sternframe cross-sectional area of twin-screw ice class ships or icebreakers shall not be less than rudderpost area accordinc to **3.10.4.10.2**.

Table 3.10.4.10.2

Ice strengthening factor *k*	Ice class								
	Ice1	**Ice2**	**Ice3**	**Ice4**	**Ice5**	**Ice6, Icebreaker1**	**Icebreaker2**	**Icebreaker3**	**Icebreaker4**
Propeller post	1,1	1,1	1,15	1,25	1,5	1,75	2	2,5	3
Rudder post and sternframe sole	1,15	1,15	1,25	1,5	1,8	2	2,5	3,5	4

3.10.4.11 Bulbous bow.
3.10.4.11.1 Thickness of centreline longitudinal bulkhead within the area in accordance with Thickness of centreline longitudinal bulkhead within the area in accordance with 3.10.2.4.2 shall not be less than half the thickness of the bulb shell plating shall not be less than half the thickness of the bulb shell plating.
3.10.4.11.2 Within its vertical extent the bulb shall be strengthened by transverse brackets spaced not more than 0,6 m apart (refer to **3.10.2.6.4**) and carried to the nearest transverse bulkhead. The thickness of the brackets shall not be taken less than half the thickness of the bulb shell plating.
3.10.4.11.3 The thickness of shell plating, in mm, of **Ice4**, **Ice5**, **Ice6** class ships, shall not be less than determined by the Formula (3.10.4.1), where *p* is determined by Formulae
$p_1 = p_0/(\cos\alpha \cdot \cos\beta)$; (3.10.4.11.3-1)

$p_2 = 2700/(\,tg^2\beta \cdot \cos\alpha)$; (3.10.4.11.3-2)

whichever is greater

where: p_0 - shall be obtained from Table 3.10.4.11.3;

α and β (refrer to Fig. 3.10.4.11.3) are detrmined in cross-sections within $0{,}25L_b$, $0{,}5\ L_b$, $0{,}75\ L_b$ form the bulb edge, remote from the main plane at a distance $d = d_б - d_1$.

For α and β > 60°, α and β = 60°.

For β < 20°, β = 20°;

L_b – length of the bullb according to Fig. 3.10.4.11.3;

d_1 – as defined in Table 3.10.4.11.3.

In any case the bulb shell plating shall not be taken less than shell plating in region **AI**.

Table 3.10.4.11.3

Ice class ships	**Ice4**	**Ice5**	**Ice6**
d_1, in m	0,24	0,32	0,44
p_0, in kPa	6800	7500	9000
b_0, in m	0,39	0,52	0,72

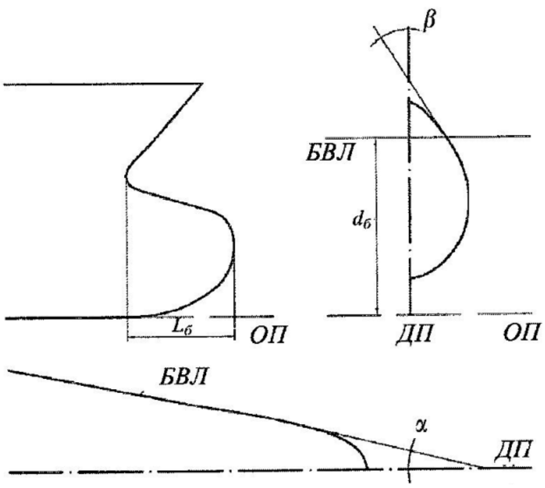


Fig. 3.10.4.11.3 Bulb design parameters L_b, α, β.

3.10.4.11.4 Bulb frame web area (refer to **3.10.4.2.5**), in cm^2, shall not be less than determined by Formula

$A_f = 8{,}7pba/R_{eH} + 0{,}1h_f\Delta s$, (3.10.4.11.4)

where: b – ice load distribution height in bulb shell plating glacing impact area, in m, determined by Formula

$b = b_0/\cos\beta \le l$;

b_0 as defined in Table 3.10.4.11.3;

α and β as defined in **3.10.4.11.3**;

a – transverse framing spacing, in m;

p – pressure, in kPa, determined in accordance with **3.10.4.11.3**;

h_f – frame web depth, in cm; for a flat bulb $h_f = 0{,}84h$, where h – profile depth;

l – estimated span of the frame, in m;

for Δs – refer to **1.1.5.1**.

3.10.4.11.5 Frame section modulus W_f, in cm^3, shall not be taken less than

$W_f = k_f W_{f0}$, (3.10.4.11.5)

where: $k_f = 1/(1 + \sqrt{1 - K_{пр}\gamma^2{}_f}$;

$\gamma_f = A_f/A_a$;

A_a - actual web area, in cm ^{2}, determined in accordance with **3.10.4.2.5**;
A_f - площа стінки, см^2, determined in accordance with до **3.10.4.11.4**;
K_p =1,0 – for flat bulb;
K_p = 0,8 – elsewhere;

$W_{f0} = 250pbalY\omega_f / R_{eH}$;
p - as defined in **3.10.4.11.3**;
a - transverse framing spacing, in m;
l - estimated span of the frame, in m, assumed equal to the distance between the support cross sections (refer to **3.10.4.2.5**);
b - ice load distribution height in bulb shell plating, in m, as defined in **3.10.4.11.3**;

$Y = 1 - 0{,}5\, b/l$;

$\omega_f = 1{,}15$.

3.10.4.11.6 The thickness of frame web shall not be taken less than:

$$s_f = 0{,}011\, h_f \sqrt{R_{eH}} + \Delta s \geq 0{,}35 s\sqrt{R_{eH}}/235, \qquad (3.10.4.11.6\text{-}1)$$

where for h_f i Δs – refer to **3.10.4.11.4**;
s – bulb plating thickness, as defined in **3.10.4.11.3**.

The following ratios of the frame cross-section shall be provided:

$$h_f/s_f \leq 282/\sqrt{R_{eH}} \text{ – for flat bulb;} \qquad (3.10.4.11.6\text{-}2)$$

$$h_f/s_f \leq 805/\sqrt{R_{eH}} \text{ - elsewhere;} \qquad (3.10.4.11.6\text{-}3)$$

$$b_{f.p}/s_{f.p} \leq 5; \qquad (3.10.4.11.6\text{-}4)$$
$$b'_{f.p}/s_{f.p} \leq 155/\sqrt{R_{eH}}; \qquad (3.10.4.11.6\text{-}5)$$

where: s_f, h_f – frame web thickness and depth, in mm;
$b_{f.p}$, $s_{f.p}$ - face plate breadth and thickness, in mm;
$b'_{f.p}$ – distance of face plate edge from frame web, in mm.

3.10.4.11.7 The scantling of side stringers and web frames inside the bulb shall be taken based on the requirements of **3.10.4.4** and **3.10.4.5** with p as defined in **3.10.4.11.4**.

3.10.4.11.8 The thickness of side stringer web, as well as thickness of longitudinal plating, shall not be taken less than determined by Formula (3.10.4.4.4) with $\gamma_s = 1{,}0$.

3.10.4.11.9 The thickness of deep frame web, as well as thickness of longitudinal plating, shall not be taken less than determined by Formula (3.10.4.5.4-2) при $\gamma_p = 1{,}0$.

3.11 POLAR CLASS SHIPS

3.11.1 DESCRIPTION OF POLAR CLASSES AND THEIR AAPPLICATION

3.11.1.1 Application.

3.11.1.1.1 The Requirements for Polar Class ships apply to ships constructed of steel and intended for independent navigation in ice-infested polar waters.

The requirements of this chapter apply to ships, contracted for construction on or after 1 July 2017.

Note. The "contracted for construction" date means the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder. For further details regarding the date of "contract for construction", refer to **1.2.2** Part I «Classification».

3.11.1.1.2 Polar class signs specified in Table 2.2.3.1-1, Part I «Classification», may be assigned to ships complying with the requirements of **3.11.2** and **2.8** «Machinery Requirements for Polar Class Ships» Part VII «Machinery Installations» are in addition to the open water requirements of the Register. If the hull and machinery are constructed such as to comply with the requirements of different Polar Classes, then both the hull and machinery are to be assigned the lower of these classes in the Certificate of Classification. Compliance of the hull or machinery with the requirements of a higher Polar Class is also to be indicated in the Certificate of Classification or equivalent.

3.11.1.1.3 Ships which are assigned a Polar Class notation and complying with the relevant requirements of **3.11.2** and **2.8** «Machinery Requirements for Polar Class Ships» Part VII «Machinery Installations», may be given the additional notation "**Icebreaker**" refer to **2.2.3.2** Part I «Classification».

3.11.1.1.4 For ships which are assigned a Polar Class notation, the hull form and propulsion power are to be such that the ship can operate independently and at continuous speed in a representative ice condition, as defined in Table 2.2.3.1-1, Part I «Classification» for the corresponding Polar Class. For ships and ship-shaped units which are intentionally not designed to operate independently in ice, such operational intent or limitations are to be explicitly stated in the Certificate of Classification or equivalent.

3.11.1.1.5 For ships which are assigned a Polar Class notation **PC 1** through **PC** 5, bows with vertical sides, and bulbous bows are generally to be avoided. Bow angles should in general be within the range specified in **3.11.2.3.1.5.**

3.11.1.1.6 For ships which are assigned a Polar Class notation **PC 6** and **PC 7**, and are designed with a bow with vertical sides or bulbous bows, operational limitations (restricted from intentional ramming) in design conditions are to be stated in the Certificate of Classification or equivalent.

3.11.1.2 Polar Classes.

3.11.1.2.1 The Polar Class (PC) notations and descriptions are given in Table 2.2.3.1-1, Part I «Classification». It is the responsibility of the Owner to select an appropriate Polar Class.

3.11.1.2.2 The Polar Class notation is used throughout this Chapter Requirements for Polar Class ships to convey the differences between classes with respect to operational capability and strength.

3.11.1.3 Upper and Lower Ice Waterlines.

3.11.1.3.1 *The upper ice waterline* – a line enveloping the highest points of the waterline at which the ship will navigate in the ice. Such a line enveloping the indicated points may be a broken line.

The lower ice waterline - a line enveloping the lowest points of the waterline at which the ship will navigate in the ice. Such a line enveloping the indicated points may be a broken line.

3.11.1.3.2 The upper and lower ice waterlines upon which the design of the ship has been based is to be indicated in the Certificate of Classification. The upper ice waterline (UIWL) is to be defined by the maximum draughts fore, amidships and aft. The lower ice waterline (LIWL) is to be defined by the minimum draughts fore, amidships and aft.

3.11.1.3.3 The lower ice waterline is to be determined with due regard to the ship's ice-going capability in the ballast loading conditions. The propeller is to be fully submerged at the lower ice waterline.

3.11.2 STRUCTURAL REQUIREMENTS FOR POLAR CLASS SHIPS

3.11.2.1 Application.

3.11.2.1.1 The requirements of **3.11.2** apply to Polar Class ships according to **3.11.1**.

3.11.2.2 Hull areas.

3.11.2.2.1 The hull of Polar Class ships is divided into areas reflecting the magnitude of the loads that are expected to act upon them. In the longitudinal direction, there are four regions: Bow, Bow Intermediate, Midbody and Stern. The Bow Intermediate, Midbody and Stern regions are further divided in the vertical direction into the Bottom, Lower and Icebelt regions. The extent of each hull area is illustrated in Figure 3.11.2.2.1.

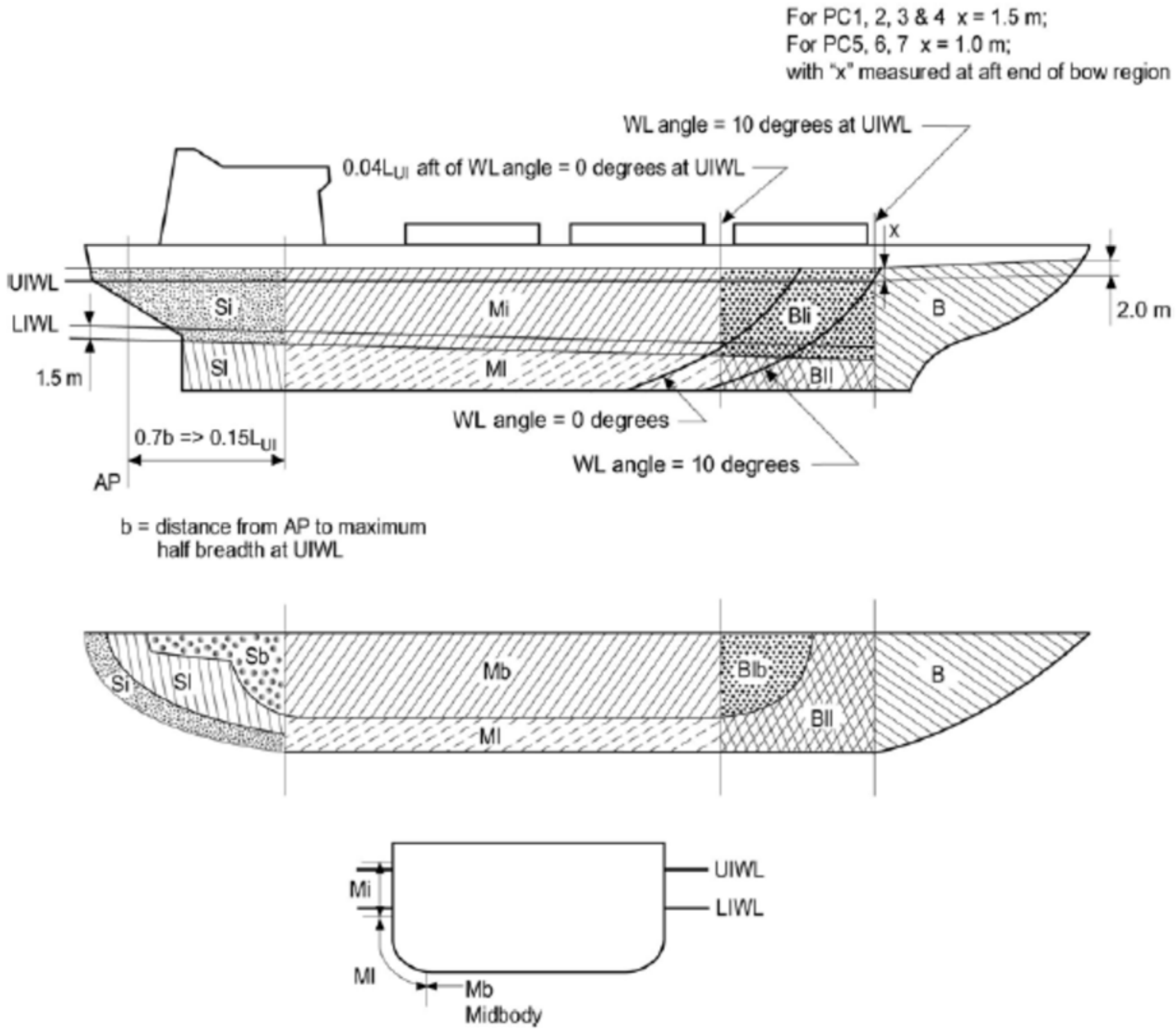


Fig.3.11.2.2.1 Hull area extents

3.11.2.2.2 The upper ice waterline (UIWL) and lower ice waterline (LIWL) are as defined in **3.11.1.3**.

3.11.2.2.3 3.11.2.2.1, notwithstanding, at no time is the boundary between the Bow and Bow Intermediate regions to be forward of the intersection point of the line of the stem and the ship baseline.

3.11.2.2.4 Figure 3.11.2.2.1, notwithstanding, the aft boundary of the Bow region need not be more than 0.45 L_{UI} aft of the fore side of the stem at the intersection with the upper ice waterline (UIWL).

3.11.2.2.5 The boundary between the bottom and lower regions is to be taken at the point where the shell is inclined 7° from horizontal.

3.11.2.2.6 If a ship is intended to operate astern in ice regions, the aft section of the ship is to be designed using the Bow and Bow Intermediate hull area requirements.

3.11.2.2.7 If the ship is assigned the additional notation "Icebreaker", the forward boundary of the stern region is to be at least 0.04 L_{UI} forward of the section where the parallel ship side at the upper ice waterline (UIWL) ends.

3.11.2.3 Design ice loads.

3.11.2.3.1 General.

3.11.2.3.1.1 A glancing impact on the bow is the design scenario for determining the scantlings required to resist ice loads.

3.11.2.3.1.2 The design ice load is characterized by an average pressure (P_{avg}) uniformly distributed over a rectangular load patch of height (b) and width (w).

3.11.2.3.1.3 Within the Bow area of all Polar Class ships, and within the Bow Intermediate Icebelt area of Polar Class **PC6** and **PC7**, the ice load parameters are functions of the actual bow shape. To determine the ice load parameters (P_{avg}, b and w), it is required to calculate the following ice load characteristics for sub-regions of the bow area; shape coefficient (f_{ai}), total glancing impact force (F_i), line load (Q_i) and pressure (P_i).

3.11.2.3.1.4 In other ice-strengthened areas, the ice load parameters (P_{avg}, b_{NonBow} and w_{NonBow}) are determined independently of the hull shape and based on a fixed load patch aspect ratio, AR = 3.6.

3.11.2.3.1.5 Design ice forces calculated according to **3.11.2.3.2.1.1**, are applicable for bow forms where the buttock angle γ at the stem is positive and less than 80 deg, and the normal frame angle β' at the centre of the foremost sub-region, as defined in **3.11.2.3.2.1**, is greater than 10 deg.

3.11.2.3.1.6 Design ice forces calculated according to **3.11.2.3.2.1.2**, are applicable for ships which are assigned the Polar Class **PC6** or **PC7** and have a bow form with vertical sides. This includes bows where the normal frame angles β' at the considered sub-regions, as defined in **3.11.2.3.2.1**, are between 0 and 10 deg.

3.11.2.3.1.7 For ships which are assigned the Polar Class **PC6** or **PC7**, and equipped with bulbous bows, the design ice forces on the bow are to be determined according to **3.11.2.3.2.1.2**. In addition, the design forces are not to be taken less than those given in **3.11.2.3.2.1.1** assuming

$f_a = 0{,}6$ and $AR = 1{,}3$.

3.11.2.3.1.8 For ships with bow forms other than those defined in **3.11.2.3.1.5** – **3.11.2.3.1.7**, design forces are to be specially considered by the Register.

3.11.2.3.1.9 Ship structures that are not directly subjected to ice loads may still experience inertial loads of stowed cargo and equipment resulting from ship/ice interaction. These inertial loads, based on accelerations determined by the Register, are to be considered in the design of these structures.

3.11.2.3.2 Glancing impact load characteristics.

The parameters defining the glancing impact load characteristics are reflected in the Class Factors listed in Table 3.11.2.3.2-1 and Table 3.11.2.3.2-2.

Table 3.11.2.3.2-1 **Class factors to be used in 3.11.2.3.2.1**

Polar Class	Crushing failure Class Factor CF_C	Flexural failure Class Factor CF_F	Load patch dimensions Class Factor CF_D	Displacement Class Factor CF_{DIS}	Longitudinal strength Class Factor CF_L
1	2	3	4	5	6
PC1	17,69	68,6	2,01	250	7,46
PC2	9,89	46,8	1,75	210	5,46
PC3	6,06	21,17	1,53	180	4,17
PC4	4,50	13,48	1,42	130	3,15
PC5	3,10	9,00	1,31	70	2,50
PC6	2,40	5,49	1,17	40	2,37
PC7	1,80	4,06	1,11	22	1,81

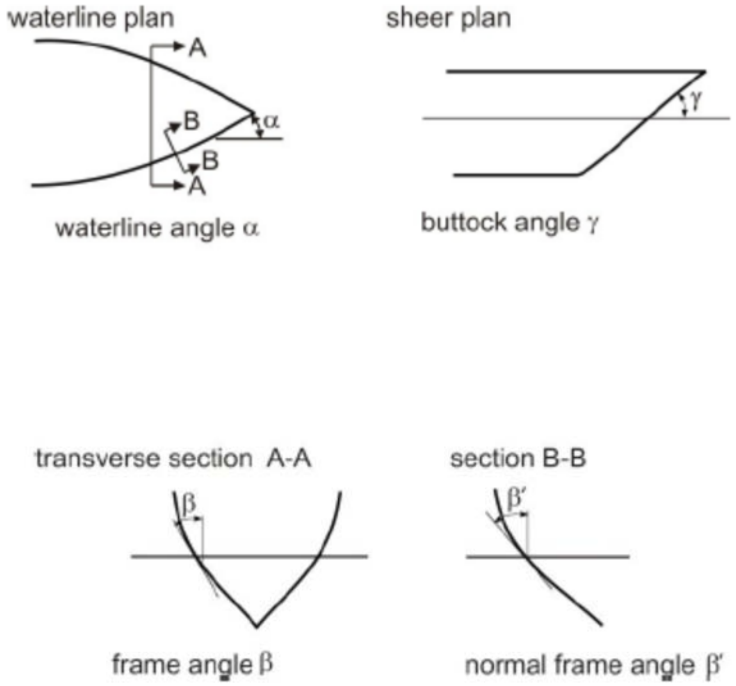
Table3.11.2.3.2-2 **Class factors to be used in 3.11.2.3.2.2**

Polar Class	Crushing failure Class Factor CF_C	Line load Class Factor CF_{QV}	Pressure Class Factor CF_{PV}
PC6	3,43	2,82	0,65
PC7	2,60	2,33	0,65

3.11.2.3.2.1 Bow area.

In the Bow area, the force (F), line load (Q), pressure (P) and load patch aspect ratio (AR) associated with the glancing impact load scenario are functions of the hull angles measured at the upper ice waterline (UIWL). The influence of the hull angles is captured through calculation of a bow shape coefficient (f_a). The hull angles are defined in Figure3.11.2.3.2.1.

The waterline length of the bow region is generally to be divided into 4 sub-regions of equal length. The force (F), line load (Q), pressure (P) and load patch aspect ratio (AR) are to be calculated with respect to the mid-length position of each sub-region (each maximum of F, Q and P is to be used in the calculation of the ice load parameters P_{avg}, b and w).



Definition of hull angles
Fig. 3.11.2.3.2.1

Note: β′ = normal frame angle at upper ice waterline [deg]
α = upper ice waterline angle [deg]
γ = buttock angle at upper ice waterline (angle of buttock line measured from horizontal) [deg] $\tan(\beta) = \tan(\alpha)/\tan(\gamma)$
$\tan(\beta') = \tan(\beta)\cos(\alpha)$

3.11.2.3.2.1.1 The Bow area load characteristics for bow forms defined in **3.11.2.3.1.5**, are determined as follows::

Shape coefficient f_{ai}:

$f_{ai} = \min(f_{ai,1}; f_{ai,2}; f_{ai,3})$, (3.11.2.3.2.1.1-1)

$f_{ai,1} = [0{,}097 - 0{,}68 \cdot (x/L - 0{,}15)^2] \cdot \alpha_i/(\beta'_i)^{0,5}$;

$f_{ai,2} = 1{,}2CF_F/[(\sin(\beta'_i) \cdot CF_C \cdot \Delta^{0,64})]$;

$f_{ai,3} = 0{,}60$;

Force F, in MN:

$F_i = f_{ai} \cdot CF_C \cdot \Delta^{0,64}$, (3.11.2.3.2.1.1-2)

Load patch aspect ratio AR:

$AR = 7{,}46 \cdot \sin(\beta'_i) \geq 1{,}3$, (3.11.2.3.2.1.1-3)

Line load Q, in MN/m:

$Q_i = F_i^{0,61} CF_D / AR_i^{0,35}$, (3.11.2.3.2.1.1-4)

Pressure P, in MPa:

$P_i = F_i^{0,22}\, CF_{D2}\, AR_i^{0,3}$, (3.11.2.3.2.1.1-5)

where: i - sub-region considered;
L – length, in m, as defined in **1.1.3**, measured along *UIWL*;
x - distance from the fore side of the stem at the intersection with the upper ice waterline (UIWL) to station under consideration;
α - waterline angle in deg., (refer to Fig. 3.11.2.3.2.1);
β' - normal frame angle in deg., (refer to Fig. 3.11.2.3.2.1);
Δ - displacement, not to be taken less than 5 kt;
CF_C – Crushing failure Class Factor from Table 3.11.2.3.2-1;
CF_F - Flexural failure Class Factor from Table 3.11.2.3.2-1;
CF_D - Load patch dimensions Class Factor from Table 3.11.2.3.2-1.

3.11.2.3.2.1.2 The Bow area load characteristics for bow forms defined in **3.11.2.3.1.6** are determined as follows:

Shape coefficient f_{ai}:

$f_{ai} = \alpha_i / 30$; (3.11.2.3.2.1.2-1)

Force F, in MN:

$F_i = f_{ai} \cdot CF_{CV} \cdot \Delta^{0,47}$, (3.11.2.3.2.1.2-2)

Line load Q, in MN/m:

$Q_i = F_i^{0,22} CF_{QV}$, (3.11.2.3.2.1.2-3)

Pressure P, in MPa:

$P_i = F_i^{0,56}\, CF_{PV}$, (3.11.2.3.2.1.2-4)

where: i - ділянка носового району, яка розглядається;
α - waterline angle in deg., (refer to Fig. 3.11.2.3.2.1);
Δ - displacement, not to be taken less than 5 kt;
CF_{CV} – Crushing failure Class Factor from Table 3.11.2.3.2-2;
CF_{QV} - Line load Class Factor from Table 3.11.2.3.2-2;
CF_{PV} - Pressure Class Factor from Table 3.11.2.3.2-2.

3.11.2.3.2.2 Hull areas other than the bow.
In the hull areas other than the bow, the force F_{NonBow}, in MN and line load Q_{NonBow}, in MN/m, used in the determination of the load patch dimensions b_{NonBow} and w_{NonBow}, and design pressure P_{avg}, are determined as follows:

$F_{NonBow} = 0,36 CF_C DF$; (3.11.2.3.2.2-1)

$Q_{NonBow} = 0,639\, F_{NonBow}\, CF_D$, (3.11.2.3.2.2-2)

where: CF_C - Crushing failure Class Factor from Table 3.11.2.3.2-1;
DF - ship displacement factor:

$DF = \Delta^{0,64}$ if $\Delta \le CF_{DIS}$;

$DF = CF_{DIS}^{0,64} + 0,1 \cdot (\Delta - CF_{DIS})$ if $\Delta > CF_{DIS}$;

Δ - displacement, not to be taken less than 10 kt;

CF_{DIS} - Displacement Class Factor from Table 3.11.2.3.2-1.

3.11.2.3.3 Design load patch.

In the Bow area, and the Bow Intermediate Icebelt area for ships with class notation **PC6** and **PC7**, the design load patch has dimensions of width, w_{Bow}, in m, and height b_{Bow}, in m, defined as follows:

$$w_{Bow} = F_{Bow}/Q_{Bow}; \qquad (3.11.2.3.3\text{-}1)$$

$$b_{Bow} = Q_{Bow}/P_{Bow}, \qquad (3.11.2.3.3\text{-}2)$$

where: F_{Bow} - maximum force F_i, in MN, in the Bow area as defined in **3.11.2.3.2.1**;

Q_{Bow} - maximum line load Q_i, in MN/m, in the Bow area as defined in **3.11.2.3.2.1**;

P_{Bow} - maximum pressure P_i, in MPa, in the Bow area as defined in **3.11.2.3.2.1.**

In hull areas of ice strengthening the design load patch has dimensions of width w_{NonBow}, in m, and heightb_{NonBow}, in m, defined as follows:

$$w_{NonBow} = F_{NonBow}/Q_{NonBow}; \qquad (3.11.2.3.3.2\text{-}1)$$

$$b_{NonBow} = w_{NonBow}/3,6, \qquad (3.11.2.3.3.2\text{-}2)$$

where: F_{NonBow} - force as defined in **3.11.2.3.2.2**;

Q_{NonBow} - line load as defined in **3.11.2.3.2.2**.

3.11.2.3.4 Pressure within the design load patch.

3.11.2.3.4.1 The average pressure P_{avg}, in MPa, within a design load patch is determined as follows:

$$P_{avg} = F/(b \cdot w), \qquad (3.11.2.3.4.1)$$

where: F - F_{Bow} or F_{NonBow} as appropriate for the hull area under consideration, in MN;
b - b_{Bow} or b_{NonBow} as appropriate for the hull area under consideration, in m;
w - w_{Bow} or w_{NonBow} as appropriate for the hull area under consideration, in m.

3.11.2.3.4.2 Areas of higher, concentrated pressure exist within the load patch. In general, smaller areas have higher local pressures. Accordingly, the peak pressure factors listed in Table 3.11.2.3.4.2 are used to account for the pressure concentration on localized structural members.

Table 3.11.2.3.4.2 **Peak Pressure Factors**

Structural member		Peak Pressure Factor PPF_i
Plating	Transversely-framed	$PPF_p = (1,8 - s) \geq 1,2$
	Longitudinally-framed	$PPF_p = (2,2 - 1,2s) \geq 1,5$
Frames in transverse framing systems	With load distributing stringers	$PPF_t = (1,6 - s) \geq 1,0$
	With no load distributing stringers	$PPF_t = (1,8 - s) \geq 1,2$
Frames in bottom structures		$PPF_s = (1,6 - s) \geq 1,0$ $PPF_s = 1,0$ if $S_W \geq 0,5w$ $PPF_s = 2 - 2S_W/w$ if $S_W < 0,5w$
Load carrying stringers		
Side longitudinals		
Web frames		
where: s – frame or longitudinal spacing, in m; S_W – web frame spacing, in m; w – ice load patch width, in m.		

3.11.2.3.5 Hull area factors.

Associated with each hull area is an Area Factor that reflects the relative magnitude of the load expected in that area.

The Area Factor (AF) for each hull area is listed in Table. 3.11.2.3.5-1.

In the event that a structural member spans across the boundary of a hull area, the largest hull area factor is to be used in the scantling determination of the member. Ships having propulsion arrangements with azimuth thruster(s) or "podded" propellers are to have specially considered *S*i, *Sl* and *Sb* hull area factors *AF* listed in Table 3.11.2.3.5-2.

Таблиця 3.11.2.3.5-1 **Hull Area Factors (*AF*)**

Hull area		Area	Polar Class						
			PC1	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**
Bow (B)	All	***B***	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Bow Intermediate (BI)	Icebelt	***BIi***	0,90	0,85	0,85	0,80	0,80	1,00[1]	1,00[1]
	Lower	***BIl***	0,70	0,65	0,65	0,60	0,55	0,55	0,50
	Bottom	***BIb***	0,55	0,50	0,45	0,40	0,35	0,30	0,25
Midbody (M)	Icebelt	***Mi***	0,70	0,65	0,55	0,55	0,50	0,45	0,45
	Lower	***Ml***	0,50	0,45	0,40	0,35	0,30	0,25	0,25
	Bottom	***Mb***	0,30	0,30	0,25	[2]	[2]	[2]	[2]
Stern (S)	Icebelt	***Si***	0,75	0,70	0,65	0,60	0,50	0,40	0,35
	Lower	***Sl***	0,45	0,40	0,35	0,30	0,25	0,25	0,25
	Bottom	***Sb***	0,35	0,30	0,30	0,25	0,15	[2]	[2]

[1] refer to **3.11.2.3.1.3.**
[2] Indicates that strengthening for ice loads is not necessary.

Table 3.11.2.3.5-2

Hull area		Area	Polar Class						
			PC1	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**
Stern (S)	Icebelt	***Si***	0,90	0,85	0,80	0,75	0,65	0,55	0,50
	Lower	***Sl***	0,60	0,55	0,50	0,45	0,40	0,40	0,40
	Bottom	***Sb***	0,35	0,30	0,30	0,25	0,15	[1]	[1]

[1] Indicates that strengthening for ice loads is not necessary.

Hull Area Factors (*AF*) for ships with additional notation **Icebreaker** are listed in Table3.11.2.3.5-3.

Table 3.11.2.3.5-3

Hull area		Area	Polar Class						
			PC1	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**
Bow (B)	All	***B***	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Bow Intermediate (BI)	Icebelt	***BIi***	0,90	0,85	0,85	0,85	0,85	1,00	1,00
	Lower	***BIl***	0,70	0,65	0,65	0,65	0,65	0,65	0,65
	Bottom	***BIb***	0,55	0,50	0,45	0,45	0,45	0,45	0,45
Midbody (M)	Icebelt	***Mi***	0,70	0,65	0,55	0,55	0,55	0,55	0,55
	Lower	***Ml***	0,50	0,45	0,40	0,40	0,40	0,40	0,40
	Bottom	***Mb***	0,30	0,30	0,25	0,25	0,25	0,25	0,25
Stern (S)	Icebelt	***Si***	0,95	0,90	0,80	0,80	0,80	0,80	0,80
	Lower	***Sl***	0,55	0,50	0,45	0,45	0,45	0,45	0,45
	Bottom	***Sb***	0,35	0,30	0,30	0,30	0,30	0,30	0,30

3.11.2.4 Shell plate requirements.

3.11.2.4.1 The required minimum shell plate thickness, *t*, is given by:

$$t = t_{net} + t_s, \qquad (3.11.2.4.1)$$

where: t_{net} - plate thickness required to resist ice loads according to **3.11.2.4.2**;
t_s - corrosion and abrasion allowance according to **3.11.2.11**, in mm.

3.11.2.4.2 The thickness of shell plating required to resist the design ice load, t_{net}, in mm, depends on the orientation of the framing.

In the case of transversely-framed plating (Ω ≥ 70º), including all bottom plating, i.e. plating in hull areas ***Blb***, ***Mb*** and ***Sb***, the net thickness is given by:

$t_{net} = 500s \cdot [(AF \cdot PPF_p \cdot P_{avg})/\sigma_y]^{0,5}/(1 + s/2b).$ (3.11.2.4.2-1)

In the case of longitudinally-framed plating ($\Omega \le 20$ deg), when b ≥ s, the net thickness is given by:

$t_{net} = 500s \cdot [(AF \cdot PPF_p \cdot P_{avg})/\sigma_y]^{0,5}/(1 + s/2l).$ (3.11.2.4.2-2)

In the case of longitudinally-framed plating ($\Omega \le 20$ deg), when b < s, the net thickness is given by:

$t_{net} = 500s \cdot [(AF \cdot PPF_p \cdot P_{avg})/\sigma_y]^{0,5} \cdot [2b/s - (b/s)^2]^{0,5}/(1 + s/2l),$ (3.11.2.4.2-3)

where: Ω - smallest angle between the chord of the waterline and the line of the first level framing as illustrated in Figure 3.11.2.4.2, in deg.;

s - transverse frame spacing in transversely-framed ships or longitudinal frame spacing in longitudinally-framed ships, in m;

AF - Hull Area Factor as defined in **3.11.2.3.5**;

PPF_p - Peak Pressure Factor from Table 3.11.2.3.4.2;

P_{avg} - average patch pressure as defined in **3.11.2.3.4.1**, in MPa;

σ_y – minimum upper yield stress of the material, in N/mm^2;

b - height of design load patch [m], where *b* is to be taken not greater than $b \le l - s/4$;

l - distance between frame supports, i.e. equal to the frame span as given in **3.11.2.5.5**, but not reduced for any fitted end brackets, in m. When a load-distributing stringer is fitted, the length l need not be taken larger than the distance from the stringer to the most distant frame support.

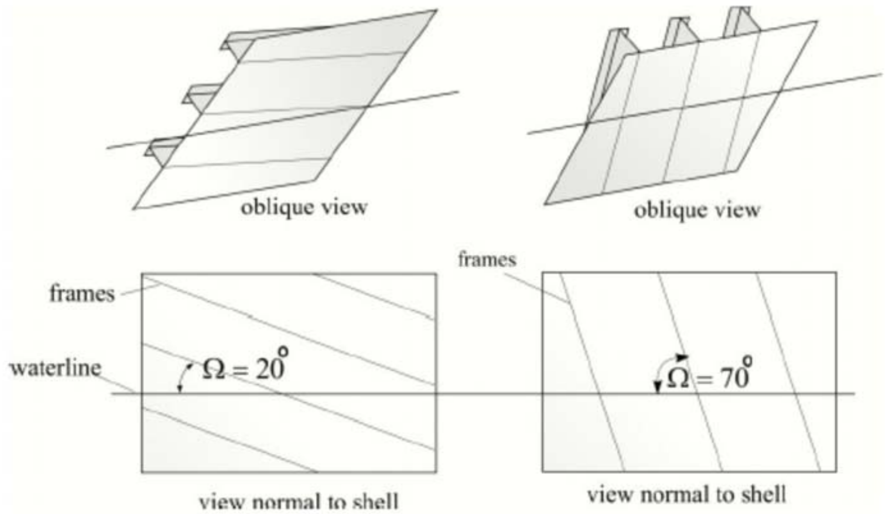


Fig. 3.11.2.4.2
Shell framing angle Ω

In case 20° < Ω < 70°, net thickness of plating is determined by the linear interpolation.

3.11.2.5 Framing - General.

3.11.2.5.1 Framing members of Polar Class ships are to be designed to withstand the ice loads defined in**3.11.2.3**.

3.11.2.5.2 The term "framing member" refers to transverse and longitudinal local frames, loadcarrying stringers and web frames in the areas of the hull exposed to ice pressure, (refer to Fig. 3.11.2.2.1).

3.11.2.5.3 The strength of a framing member is dependent upon the fixity that is provided at its supports. Fixity can be assumed where framing members are either continuous through the support or attached to a supporting section with a connection bracket. In other cases, simple support is to be assumed unless the connection can be demonstrated to provide significant rotational restraint. Fixity is to be ensured at the support of any framing which terminates within an ice-strengthened area.

3.11.2.5.4 The details of framing member intersection with other framing members shall be in accordance with **3.10.2.4.5**.

Details for securing the ends of framing members at supporting sections, are to be in accordance with**1.7.2.2** and **2.5.5**.

3.11.2.5.5 The effective span of a framing member is to be determined on the basis of its moulded length. If brackets are fitted, the effective span may be reduced in accordance with **3.10.2.2.3**.

Brackets are to be configured to ensure stability in the elastic and post-yield response regions.

3.11.2.5.6 When calculating the section modulus and shear area of a framing member, net thicknesses of the web, flange (if fitted) and attached shell plating are to be used.

The shear area of a framing member may include that material contained over the full depth of the member, i.e. web area including portion of flange, if fitted, but excluding attached shell plating.

3.11.2.5.7 The actual net effective shear area A_w, in cm^2, of a transverse or longitudinal local frame is given by:

$$A_w = ht_{wn}\sin\varphi_w/100, \qquad (3.11.2.5.7)$$

where: h - height of stiffener, in mm, see Figure 3.11.2.5.7;

t_{wn} - net web thickness, in mm;

$t_{wn} = t_w - t_c$;

t_w - as built web thickness, in mm, see Figure 3.11.2.5.7;

t_c - corrosion deduction [mm] to be subtracted from the web and flange thickness;

t_c is specified in accordance with **1.1.5.2**, but not less than as required by **3.11.2.11.3**;

φ_w - smallest angle between shell plate and stiffener web, measured at the midspan of the stiffener, (see Figure 3.11.2.5.7). The angle φ_w may be taken as 90 deg provided the smallest angle is not less than 75 deg.

3.11.2.5.8 When the cross-sectional area of the attached plate flange exceeds the crosssectional area of the local frame, the actual net effective plastic section modulus, Z_p, in mm, of a transverse or longitudinal frame is given by:

$$Z_p = A_{pn}t_{pn}/20 + h^2_w t_{wn}\sin\varphi_w/2000 + A_{fn}\,(h_{fc}\sin\varphi_w - b_w\cos\varphi_w)\,/10, \qquad (3.11.2.5.8\text{-}1)$$

where: h, t_{wn}, t_c i φ_w – refer to **3.11.2.5.7**, and s – as defined in **3.11.2.4.2**;

A_{pn} - net cross-sectional area of the local frame, in cm^2;

t_{pn} - fitted net shell plate thickness, in mm, complying with tnet as required by**3.11.2.4.2**;

h_w - height of local frame web, in mm, (see Figure 3.11.2.5.7);

A_{fn} - net cross-sectional area of local frame flange, in cm^2;

h_{fc} - height of local frame measured to centre of the flange area, in mm, (see Figure 3.11.2.5.7);

b_w – distance from mid thickness plane of local frame web to the centre of the flange area, in mm, (see Figure 3.11.2.5.7).

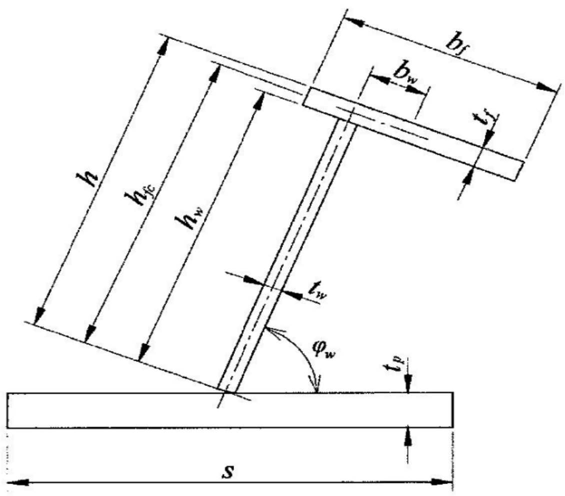


Fig. 3.11.2.5.7
Stiffener geometry

When the cross-sectional area of the local frame exceeds the cross-sectional area of the attached plate flange, the plastic neutral axis is located a distance zna above the attached shell plate, given by:

$$z_{na} = (100A_{fn} + ht_{wn} - 1000t_{pn}s)\ /2t_{wn}, \qquad (3.11.2.5.8\text{-}2)$$

When the cross-sectional area of the attached plate flange exceeds the crosssectional area of the local frame, the actual net effective plastic section modulus, Z_p, of a transverse or longitudinal frame is given by:

$$Z_p = t_{pn}s \cdot (z_{na} + t_{pn}/2) \cdot \sin\varphi_w + \{[(h_w - z_{na})^2 + z^2_{na}] \cdot t_{wn}\sin\varphi_w/2 + A_{fn} \cdot [(h_{fc} - z_{na}) \cdot \sin\varphi_w - b_w\cos\varphi_w]/10\}. \qquad (3.11.2.5.8\text{-}3)$$

3.11.2.5.9 In the case of oblique framing arrangement 20º < Ω < 70º, deg, where Ω is defined as given in **3.11.2.4.2**, linear interpolation is to be used.

3.11.2.6 Framing - Local frames in bottom structures and transverse local frames in side structures.

3.11.2.6.1 The local frames in bottom structures (i.e. hull areas $\mathbf{B_{Ib}}$, $\mathbf{M_b}$ and $\mathbf{S_b}$) and transverse local frames in side structures are to be dimensioned such that the combined effects of shear and bending do not exceed the plastic strength of the member. The plastic strength is defined by the magnitude of midspan load that causes the development of a plastic collapse mechanism.

For bottom structure the patch load shall be applied with the dimension (b) parallel with the frame direction.

3.11.2.6.2 The actual net effective shear area of the frame, A_w, as defined in **3.11.2.5.7**, is to comply with the following condition: $A_w \geq A_t$, where:

$$A_t = 100^2 \cdot 0{,}5LL \cdot s \cdot (AF \cdot PPF \cdot P_{avg})/(0{,}577\sigma_y), \qquad (3.11.2.6.2)$$

where LL – length of loaded portion of span – lesser of a and b, in m;
a - local frame span as defined in **3.11.2.5.5**, in m;
b - height of design ice load patch as defined in **3.11.2.3.3**;
s - spacing of local frame, in m;
AF - Hull Area Factor from **3.11.2.3.5**;
PPF - Peak Pressure Factor, PPF_t or PPF_s as appropriate from Table 3.11.2.3.4.2;
P_{avg} – average pressure within load patch as defined in **3.11.2.3.4**;
σ_y - minimum upper yield stress of the material, in N/mm^2.

3.11.2.6.3 The actual net effective plastic section modulus of the plate/stiffener combination, Z_p as defined in **3.11.2.5.8**, is to comply with the following condition: $Z_p \geq Z_{pt}$, where Z_{pt}, in cm^3, is to be the greater calculated on the basis of two load conditions: a) ice load acting at the midspan of the local frame, and b) the ice load acting near a support. The A_1 parameter defined below reflects these two conditions:

$$Z_{pt} = 100^3 \cdot LL \cdot Y \cdot s \cdot (AF \cdot PPF_t \cdot P_{avg}) \cdot a \cdot A_1/(4\sigma_y), \qquad (3.11.2.6.3)$$

where: AF, PPF_t, P_{avg}, LL, b, s, a and σ_y are as given in **3.11.2.6.2**;
Y =1 - 0,5 (LL/a);
A_1 – maximum of:
$A_{1A} = 1/\{1 + j/2 + (k_w j/2) \cdot [(1 - a^2_1)^{0,5} - 1]\}$;
$A_{1B} = [1 - 1/(2a_1 \cdot Y)]\ /(0{,}275 + 1{,}44k_z^{0,7})$;
j = 1 for a local frame with one simple support outside the ice-strengthened areas;
j = 2 for a local frame without any simple supports;
$a_1 = A_t/A_w$;
A_t - minimum shear area of the local frame as given in **3.11.2.6.2**, in cm^2;
A_w - effective net shear area of the local frame (calculated according to **3.11.2.5.7**), in cm^2;
$k_w = 1/\ (1+2A_{fn}/A_w)$, where A_{fn} as given in **3.11.2.5.8**;
$k_z = z_p/Z_p$, in general;
k_z = 0, when the frame is arranged with end bracket;
z_p = sum of individual plastic section moduli of flange and shell plate as fitted, in cm^3;

$z_p = (b_f \cdot t^2_{fn}/4 + b_{eff} \cdot t^2_{pn}/4)/1000$;
b_f - flange breadth, in mm, (see Figure 3.11.2.5.7);
t_{fn} - net flange thickness, in mm;
$t_{fn} = t_f - t_c$, (t_c as given in **3.11.2.5.7**);
t_f - as-built flange thickness, in mm, (see Figure 3.11.2.5.7);
t_{pn} - the fitted net shell plate thickness, in mm, (not to be less than t_{net} as given in **3.11.2.4**);
b_{eff} - effective width of shell plate flange, in mm;
$b_{eff} = 500s$;
Z_p - net effective plastic section modulus of the local frame (calculated according to **3.11.2.5.8**), in cm^3.

3.11.2.6.4 The scantlings of the local frame are to meet the structural stability requirements of **3.11.2.9**.

3.11.2.7 Framing - Longitudinal local frames in side structures.

3.11.2.7.1 Longitudinal local frames in side structures are to be dimensioned such that the combined effects of shear and bending do not exceed the plastic strength of the member.

The plastic strength is defined by the magnitude of midspan load that causes the development of a plastic collapse mechanism.

3.11.2.7.2 The actual net effective shear area of the frame, A_w, as defined in **3.11.2.5.7**, is to comply with the following condition: $A_w \geq A_L$, where:

$$A_L = 100^2 \cdot (AF \cdot PPF_s \cdot P_{avg}) \cdot 0{,}5b_1a/(0{,}577\sigma_y), \text{ in cm}^2, \qquad (3.11.2.7.2)$$

where: AF - Hull Area Factor from **3.11.2.3.5**;
PPF_s - Peak Pressure Factor from Table **3.11.2.3.4.2**;
P_{avg} - average pressure within load patch as defined in **3.11.2.3.4**;
$b_1 = k_0 b_2$, in m;
$k_0 = 1 - 0{,}3/b'$;
$b' = b/s$;
b - height of design ice load patch as defined in **3.11.2.3.3**;
s – spacing of longitudinal frames, in m;
$b_2 = b(1 - 0{,}25b')$, in m, if $b' < 2$;
$b_2 = s$, in m, if $b' \geq 2$;
a - effective span of longitudinal local frame as given in **3.11.2.5.5**;
σ_y - minimum upper yield stress of the material, in N/mm^2.

3.11.2.7.3 The actual net effective plastic section modulus of the plate/stiffener combination, Z_p as defined in **3.11.2.5.8**, s to comply with the following condition: $Z_p \geq Z_{pL}$, where:

$$Z_{pL} = 100^3 \cdot (AF \cdot PPF_s \cdot P_{avg}) \cdot b_1a^2A_4/8\sigma_y, \text{ in cm}^3, \qquad (3.11.2.7.3)$$

where: AF, PPF_s, P_{avg}, b_1, a and σ_y are as given in **3.11.2.7.2**;
$A_4 = 1/\{2 + k_{wl} \cdot [(1 - a^2_4)^{0,5} - 1]\}$;
$a_4 = A_L/A_w$;
A_L - minimum shear area for longitudinal as given in **3.11.2.7.2**, in cm^2;
A_w - net effective shear area of longitudinal (calculated according to **3.11.2.5.7**), in cm^2;
$k_{wl} = 1/(1+2A_{fn}/A_w)$, where A_{fn} as given in **3.11.2.5.8**.

3.11.2.7.4 The scantlings of the longitudinals are to meet the structural stability requirements of **3.11.2.9.**

3.11.2.8 Framing - Web frames and load carrying stringers.

3.11.2.8.1 Web frames and load-carrying stringers are to be designed to withstand the ice load patch as defined in **3.11.2.3**. The load patch is to be applied at locations where the capacity of these members under the combined effects of bending and shear is minimised.

3.11.2.8.2 Web frames and load-carrying stringers are to be dimensioned such that the combined effects of shear and bending do not exceed the limit state(s).

Where the structural configuration is such that members do not form part of a grillage system, the appropriate peak pressure factor (PPF) from Table 3.11.2.3.4.2 is to be used. Shear capacity in way of lightening holes and cutouts in way of intersecting members shall comply with **3.10.2.4.8**.

3.11.2.8.3 For determination of scantlings of load carrying stringers, web frames supporting local frames, or web frames supporting load carrying stringers forming part of a structural grillage system, appropriate methods as outlined in **3.11.2.17** are normally to be used.

3.11.2.8.4 The scantlings of web frames and load-carrying stringers are to meet the structural stability requirements of **3.11.2.9**.

3.11.2.9 Framing - Structural stability.

3.11.2.9.1 To prevent local buckling in the web, the ratio of web height h_w to net web thickness t_{wn} of any framing member is not to exceed:

For flat bar sections:

$$h_w/t_{wn} \le 282/\sigma^{0,5}_y; \qquad (3.11.2.9.1\text{-}1)$$

For bulb, tee and angle sections:

$$h_w/t_{wn} \le 805/\sigma^{0,5}_y, \qquad (3.11.2.9.1\text{-}2)$$

where: h_w - web height, in mm;

t_{wn} - net web thickness, in mm;

σ_y - minimum upper yield stress of the material, in N/mm^2.

3.11.2.9.2 Framing members for which it is not practicable to meet the requirements of **3.11.2.9.1** (e.g. load carrying stringers or deep web frames) are required to have their webs effectively stiffened. The scantlings of the web stiffeners are to ensure the structural stability of the framing member. The minimum net web thickness for these framing members is given by:

$$t_{wn} = 2,63 \cdot 10^{-3} c_1 \cdot \sqrt{\sigma_y/[5,34 + 4\,(c_1/c_2)^2]}, \qquad (3.11.2.9.2)$$

where: $c_1 = h_w - 0,8h$, in mm;

h_w - web height of stringer / web frame, in mm, (see Figure 3.11.2.9.2);

h - height of framing member penetrating the member under consideration (0 if no such framing member), in mm (see Figure 3.11.2.9.2);

c_2 - spacing between supporting structure oriented perpendicular to the member under consideration, in mm, (see Figure 3.11.2.9.2);

σ_y - minimum upper yield stress of the material, in N/mm^2.

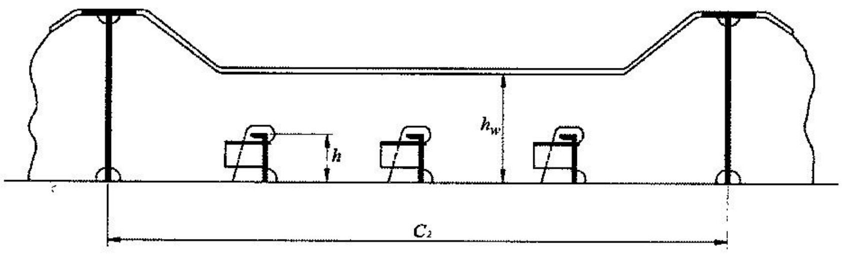


Fig. 3.11.2.9.2
Parameter definition of web stiffening

3.11.2.9.3 In addition, the following is to be satisfied:

$$t_{wn} \ge 0,35 t_{pn} \cdot (\sigma_y/235)^{0,5}, \qquad (3.11.2.9.3)$$

where: σ_y - minimum upper yield stress of the material, in N/mm^2;

t_{wn} - net thickness of the web, in mm;

t_{pn} - net thickness of the shell plate in way of the framing member, in mm.

3.11.2.9.4 To prevent local flange buckling of welded profiles, the following are to be satisfied:

.1 The flange width, b_f, in mm, is not to be less than five times the net thickness of the web, t_{wn};

.2 The flange outstand, b_{out}, in mm, is to meet the following requirement:

$$b_{out}/t_{fn} \le 155/\sigma_y^{0,5}, \qquad (3.11.2.9.4.2)$$

where: t_{fn} - net thickness of flang, in mm;

σ_y - minimum upper yield stress of the material, in N/mm^2.

3.11.2.10 Plated structures.

3.11.2.10.1 Plated structures are those stiffened plate elements in contact with the hull and subject to ice loads. These requirements are applicable to an inboard extent which is the lesser of:

.1 web height of adjacent parallel web frame or stringer; or

.2 2.5 times the depth of framing that intersects the plated structure.

3.11.2.10.2 The thickness of the plating and the scantlings of attached stiffeners are to be such that the degree of end fixity necessary for the shell framing is ensured.

3.11.2.10.3 The stability of the plated structure is to adequately withstand the ice loads defined in **3.11.2.3**.

3.11.2.11 Corrosion/abrasion additions and steel renewal.

3.11.2.11.1 Effective protection against corrosion and ice-induced abrasion is recommended for all external surfaces of the shell plating.

3.11.2.11.2 The values of corrosion/abrasion additions, ts, to be used in determining the shell plate thickness are listed in Table 3.11.2.11.2.

Table 3.11.2.11.2

Hull area	t_s, in mm					
	With effective protection			Without effective protection		
	PC1-PC3	**PC4. PC5**	**PC6, PC7**	**PC1-PC3**	**PC4. PC5**	**PC6, PC7**
Bow; Bow Intermediate Icebelt	3,5	2,5	2,0	7,0	5,0	4,0
Bow Intermediate Lower; Midbody & Stern Icebelt	2,5	2,0	2,0	5,0	4,0	3,0
Midbody & Stern Lower; Bottom	2,0	2,0	2,0	4,0	3,0	2,5

3.11.2.11.3 Запас на знос конструкцій усередині корпусу, , що потрапляють в район льодових підсилень, в т.ч. листових конструкцій, стінок і поясків балок набору, не повинен прийматися менше t_s = 1,0мм.

3.11.2.11.4 When the gauged thickness is less than t_{net} + 0,5 mm, steel renewal for ice strengthened structures is required, where for t_{net} – refer to **3.11.2.4.2**.

3.11.2.12 Materials.

3.11.2.12.1 Steel grades of plating for hull structures are to be not less than those given in Table 3.11.2.12.4 and **3.11.2.12.5** based on the as-built thickness, the Polar Class and the material class of structural members according to **3.11.2.12.2**.

3.11.2.12.2 Material classes specified in Table 1.2.3.7-1 are applicable to Polar Class ships regardless of the ship's length. In addition, material classes for weather and sea exposed structural members and for members attached to the weather and sea exposed plating are given in Table 3.11.2.12.2

Where the material classes in Table 1.2.3.7-1 and those in Table 3.11.2.12.2 differ, the higher material class is to be applied.

Table 3.11.2.12.2 **Material classes for structural members**

Structural members	Material class
1	2
Shell plating within the bow and bow intermediate icebelt hull areas (***B***, ***BIi***).	II
All weather and sea exposed SECONDARY and PRIMARY, as defined in Table 1.2.3.7-1 structural members outside 0.4 L_{UI} amidships	I
Plating materials for stem and stern frames, rudder horn, rudder, propeller nozzle, shaft brackets, ice skeg, ice knife and other appendages subject to ice impact loads	II
All inboard framing members attached to the weather and sea-exposed plating, including any contiguous inboard member within 600 mm of the plating	I
Weather-exposed plating and attached framing in cargo holds of ships which by nature of their trade have their cargo hold hatches open during cold weather operations	I
All weather and sea exposed SPECIAL, as defined in Table 1 of UR S6.1, structural members within 0,2*L* from FP	II

3.11.2.12.3 Steel grades for all plating and attached framing of hull structures and appendages situated below the level of 0.3 m below the lower waterline, as shown in Figure 3.11.2.12.3, are to be obtained from Table 1.2.3.7-2 based on the material class for structural members in Table 3.11.2.12.2 above.

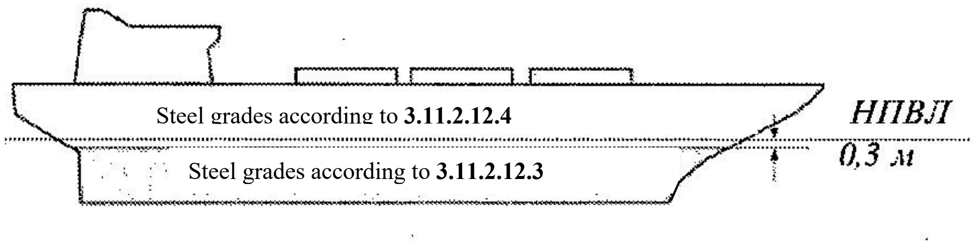


Fig. 3.11.2.12.3
Steel grade requirements for submerged and weather exposed shell plating

3.11.2.12.4 Steel grades for all weather exposed plating of hull structures and appendages situated above the level of 0.3 m below the lower ice waterline, as shown in 3.11.2.12.3, are to be not less than given in Table 3.11.2.12.4.

Table 3.11.2.12.4 **Steel grades for weather exposed plating**

Thickness t, in mm	Material class I				Material class II				Material class III					
	PC1÷PC5		**PC6, PC7**		**PC1÷PC5**		**PC6, PC7**		**PC1÷PC3**		**PC4, PC5**		**PC6, PC7**	
	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT
$t \le 10$	B	AH	B	AH	B	AH	B	AH	E	EH	E	EH	B	AH
$10 < t \le 15$	B	AH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
$15 < t \le 20$	D	DH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
$20 < t \le 25$	D	DH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
$25 < t \le 30$	D	DH	B	AH	E	EH2	D	DH	E	EH	E	EH	E	EH
$30 < t \le 35$	D	DH	B	AH	E	EH	D	DH	E	EH	E	EH	E	EH
$35 < t \le 40$	D	DH	D	DH	E	EH	D	DH	F	FH	E	EH	E	EH
$40 < t \le 45$	E	EH	D	DH	E	EH	D	DH	F	FH	E	EH	E	EH
$45 < t \le 50$	E	EH	D	DH	E	EH	D	DH	F	FH	F	FH	E	EH

Notes: 1. Includes weather-exposed plating of hull structures and appendages, as well as their outboard framing members, situated above a level of 0.3 m below the lowest ice waterline.
2. Grades D, DH are allowed for a single strake of side shell plating not more than 1.8 m wide from 0.3 m below the lowest ice waterline.

3.11.2.12.5 Castings are to have properties, specified in XIII «Materials» consistent with the expected service temperature for the cast component.

3.11.2.13 Longitudinal strength.

3.11.2.13.1 Application.

3.11.2.13.1.1 A ramming impact on the bow is the design scenario for the evaluation of the longitudinal strength of the hull.

3.11.2.13.1.2 Intentional ramming is not considered as a design scenario for ships which are designed with vertical or bulbous bows. Hence the longitudinal strength requirements given in **3.11.2.13** is not to be considered for ships with stem angle γ_{stem} equal to or larger than 80 deg.

3.11.2.13.1.3 Ice loads are only to be combined with still water loads. The combined stresses are to be compared against permissible bending and shear stresses at different locations along the ship's length. In addition, sufficient local buckling strength is also to be verified.

3.11.2.13.2 Design vertical ice force at the bow.

3.11.2.13.2.1 The design vertical ice force at the bow, F_{IB}, is to be taken as:

$$F_{IB} = \min(F_{IB,1}; F_{IB,2}), \qquad (3.11.2.13.2.1\text{-}1)$$

where: $F_{IB,1} = 0{,}534 K_I^{0{,}15} \sin^{0{,}2}(\gamma_{stem}) \cdot (\Delta K_h)^{0{,}5} \cdot CF_L$; (3.11.2.13.2.1-2)

$F_{IB,2} = 1{,}2CF_F$;

(3.11.2.13.2.1-3)

K_I - indentation parameter = K_f/K_h;

.1 for the case of a blunt bow form: $K_f = [2C \cdot B^{1-e_b}/(1+e_b)]^{0,9} \mathrm{tg}(\gamma_{stem})^{-0,9(1+e_b)}$;

.2 for the case of wedge bow form ($\alpha_{stem} < 80^o$), $e_b = 1$ and the above simplifies to:

$K_f = [\mathrm{tg}(\alpha_{stem})/\mathrm{tg}^2(\gamma stem)]^{0,9}$;

$K_h = 0{,}01A_{wp}$, in MN/m;

CF_L - Longitudinal Strength Class Factor from Table 3.11.2.3.2.1;

e_b - bow shape exponent which best describes the waterplane (see Figures 3.11.2.13.2.1-1 and 3.11.2.13.2.1-2):

e_b = 1,0 for a simple wedge bow form;

e_b = 0,4 - 0,6 for a spoon bow form;

e_b = 0 for a landing craft bow form;

An approximate e_b, determined by a simple fit is acceptable;

γ_{stem} - stem angle to be measured between the horizontal axis and the stem tangent at the upper ice waterline [deg] (buttock angle as per Figure 3.11.2.3.2.1.1.1, measured on the centreline);

α_{stem} - waterline angle measured in way of the stem at the upper ice waterline, see Figure 3.11.2.13.2.1-1, in deg.;

C = $1/[2(L_B/B)^{e_b}]$;

B - moulded breadth corresponding to the upper ice waterline, in m;

L_B - bow length used in the equation $y = B/[2(x/L_B)^{e_b}]$, in m, (see Figures 3.11.2.13.2.1-1 and 3.11.2.13.2.1-2);

Δ - displacement as defined in I2.1.2.2, not to be taken less than 10 kt;

A_{wp} - waterplane area corresponding to the upper ice waterline, in m^2;

CF_F - Flexural Failure Class Factor from Table 3.11.2.3.2.1.

Where applicable, values dependent on draft shall be determined at the waterline level corresponding to the observed load case.

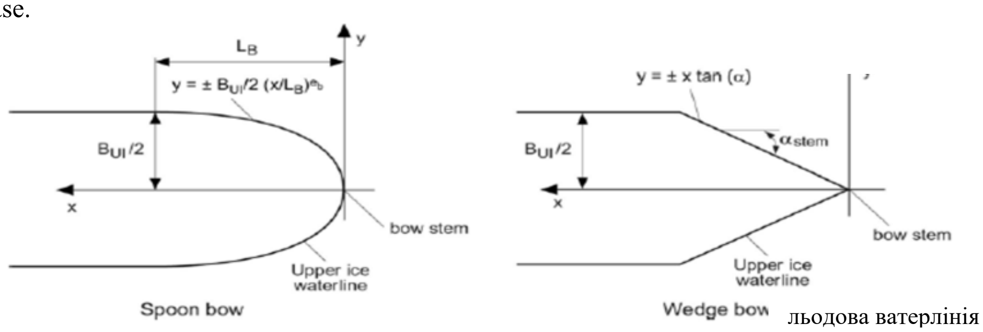


Fig. 3.11.2.13.2.1-1
Bow shape definition

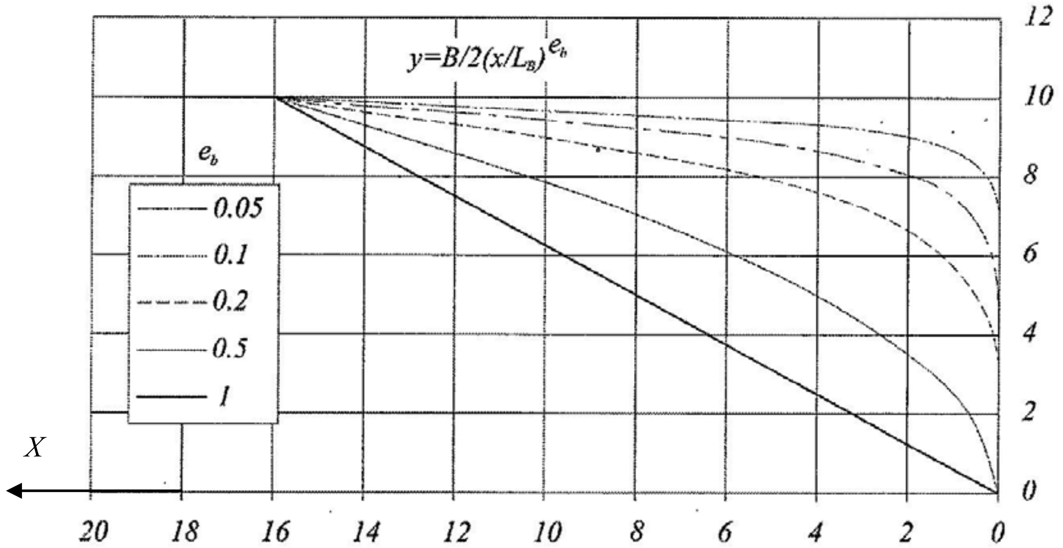


Fig. 3.11.2.13.2.1-1
Illustration of e_b effect on the bow shape for B = 20 m and L_B = 16 m

3.11.2.13.3 Design vertical shear force.
3.11.2.13.3.1 The design vertical ice shear force, F_I, along the hull girder is to be taken as:

$$F_I = C_f F_{IB}, \quad (3.11.2.13.3.1)$$

where: C_f - longitudinal distribution factor to be taken as follows:

Positive shear force

C_f = 0.0 between the aft end of L and 0.6L from aft;

C_f = 1.0 between 0.9 L from aft and the forward end of L;

Negative shear force

C_f = 0.0 at the aft end of L;

C_f = - 0,25 between 0.0 L and 0,2 L from aft;
C_f = - 0,5 between 0.2 L and 0.6 L from aft;

C_f = 2,5 x/L - 2 в перерізах 0,6 < x/L < 0,8;

C_f = 0,0 between 0.8 L from aft and the forward end of L;

x - distance of the calculated section from the aft perpendicular, in m;

L –length as defined in **1.1.3**.

3.11.2.13.3.2 The applied vertical shear stress is to be determined along the hull girder in a similar manner as in **1.6.5.1** by substituting the design vertical ice shear force for the design vertical wave shear force.

3.11.2.13.4 Design vertical ice bending moment.
3.11.2.13.4.1 The design vertical ice bending moment, M_I, along the hull girder is to be taken as:

$$M_I = 0{,}1 C_m L \sin^{-0{,}2}(\gamma_{stem})\, F_{IB}, \quad (3.11.2.13.4.1)$$

where: L - length as defined in **1.1.3**;

γ_{stem} – is as given in **3.11.2.13.2.1**;

F_{IB} - design vertical ice force at the bow, in MN;

C_m - longitudinal distribution factor for design vertical ice bending moment to be taken as follows:

C_m = 0.0 at the aft end of L;

C_m = 2,0x/L between 0,0 L and 0,5 L from aft;

C_m = 1.0 between 0.5L and 0.7L from aft;

C_m = 2.96 – 2.8x/L between 0.7L and 0,95 L from aft;

C_m = 0.3 at 0.95 L from aft;

C_m = 6.0 – 6.0x/L between 0,95 and 1,0 L from aft;

C_m = 0.0 at the forward end of L;

x - distance of the calculated section from the aft perpendicular, in m.

Where applicable, values dependent on draft shall be determined at the waterline level corresponding to the observed load case.

3.11.2.13.4.2 The applied vertical bending stress, σ_a, is to be determined along the hull girder in a similar manner as in **1.6.5.1** by substituting the design vertical ice bending moment for the design vertical wave bending moment. The ship still water bending moment is to be taken as the permissible still water bending moment in sagging condition.

3.11.2.13.5 Longitudinal strength criteria.

3.11.2.13.5.1 The strength criteria provided in Table 3.11.2.13.5.1 are to be satisfied.

The design stress is not to exceed the permissible stress.

Table 3.11.2.13.5.1 **Longitudinal strength criteria.**

Failure mode	Applied stress	Permissible stress when $\sigma_y/\sigma_u \le 0,7$	Permissible stress when $\sigma_y/\sigma_u > 0,7$
Tension	σ_a	$\eta\sigma_y$	$\eta \cdot 0,41 \cdot (\sigma_u + \sigma_y)$
Shear	τ_a	$\eta\sigma_y/3^{0,5}$	$\eta \cdot 0,41 \cdot (\sigma_u + \sigma_y)/3^{0,5}$
Buckling	σ_a	σ_c for plating and for web plating of stiffeners $\sigma_c/1,1$ for stiffeners	
	τ_a	τ_c	

where: σ_a = applied vertical bending stress [N/mm2];
τ_a = applied vertical shear stress [N/mm2]
σ_y = minimum upper yield stress of the material [N/mm2]
σ_u = ultimate tensile strength of material [N/mm2]
σ_c = critical buckling stress in compression, according to **1.6.5.3** [N/mm2]
τ_c = critical buckling stress in shear, according to **1.6.5.3** [N/mm2]
η = 0,6 for ships which are assigned the additional notation **Icebreaker**.

3.11.2.14 Stem and stern frames.

3.11.2.14.1 The stem of polar class ships shall be made of steel with a solid cross-section. The stem of polar class **PC1** and **PC2** ships and icebreakers, as well as stem and stern frame of icebreakers and **PC1**, **PC2**, **PC3**, **PC4** and **PC5** polar class ships shall be made of forged or cast steel. The use of stems and stern frames welded from separate cast or forged parts is allowed.

3.11.2.14.2 For **PC3**, **PC4**, **PC5**, **PC6**, **PC7** polar class ships and icebreakers of the polar classes weaker than **PC4** the use of combined (made of bar or bar with thick plates welded to it) or plate design stem is allowed. Welds of combined or plate design stems must be performed with full penetration in accordance with the requirements of part XIV "Welding". For **PC6** and **PC7** polar class ships the use of combined or plate design stem is allowed.

3.11.2.14.3 For **PC3**, **PC4**, **PC5**, **PC6**, **PC7** ice class ships, the stem shall, where practicable, be strengthened by a centre line web having its section depth equal to h_p at least (refer to Table 3.11.2.14.3) with a face plate along its free edge or a longitudinal bulkhead fitted on the ship centreline, on the entire stem length from the keel plate to the nearest deck or platform situated above the level *B* referred to in 3.11.2.2.1). The thickness of this plate shall not be less than that of the brackets with which the stem is strengthened (refer to **3.11.2.14.4**). In icebreakers and **PC1**, **PC2** ice class ships, a longitudinal bulkhead may be substituted for the centre line web.

Table 3.11.2.14.3

h_p, in m				
PC7	**PC6**	**PC5**	**PC4**	**PC3**
0,6	0,6	1,0	1,3	1,5

3.11.2.14.4 Within the vertical extent defined in **3.11.2.14.3**, the stem shall be strengthened by horizontal webs at least 0,6 m in depth and spaced not more than 0,6 m apart. The webs shall be carried to the nearest frames and connected thereto. In stems of combined or plate type, the webs shall be extended beyond the welded butts of the stem and shell plating.

Above the deck or platform located at a distance higher than the upper boundary of region B, the spacing of horizontal webs may gradually increase to 1,2 m in icebreakers and **PC1**, **PC2**, **PC3** ice class ships, and to 1,5 m in ships of other ice classes.

The web thickness shall be adopted not less than half the stem plate thickness according to **3.11.2.4.7**. The side stringers of the fore peak shall be connected to the webs fitted in line with them.

Side stringers in the fore peak shall be connected to the brackets installed in their plane.

In case of a full bow, vertical stiffeners may be required additionally to be fitted to the stem plates.

3.11.2.14.5 Where the stern frame has an appendage (ice knife), the clearance between the latter and the rudder plate shall not exceed 100 mm. The appendage shall be reliably connected to the stern frame. Securing the appendage to plate structures is not permitted.

3.11.2.14.6 In icebreakers, the lower edge of solepiece shall be constructed with a slope of 1:8 beginning from the propeller post.

3.11.2.14.7 The cross-sectional area A_{st}, in cm^2, of the stem of any design shall not be less than determined by the formula:

$$A\text{st} = c_t \cdot c_k \cdot f(\Delta), \qquad (3.11.2.14.7\text{-}1)$$

where: $f(\Delta) = 31\Delta + 137$ with $\Delta < 5$ kt;

$f(\Delta) = 100 \cdot \Delta^{(2/3)}$ with $\Delta \geq 5$ kt;

Δ - displacement, in t;

c_t - 1,0 for polar class ships and 1,4 for icebreakers;

c_k - factor whose values shall be obtained from Table 3.11.2.14.7.

Table 3.11.2.14.7

c_k						
PC7	**PC6**	**PC5**	**PC4**	**PC3**	**PC2**	**PC1**
0,54	0,54	0,66	1,02	1,25	1,4	1,55

The section modulus Z_{st}, in cm^3, of the stem cross-sectional area about an axis perpendicular to the centreline shall not be less than determined by the formula:

$$Z_{st} = 1{,}2\, Q_{Bow}, \qquad (3.11.2.14.7\text{-}2)$$

where: Q_{Bow} - linear load in accordance with **3.11.2.3.2.1**, kN/m.

To be included in the design cross-sectional area of a combined or plate stem are areas of shell plates and centreline girder or of longitudinal bulkhead on the centreline on a breadth not exceeding ten times the thickness of relevant plates.

The plate thickness t^{stem}_{net} in mm, of combined and plate stems, as well as of the structure shown in Fig. 3.10.2.6.2-2, shall not be less than determined by the formula:

$$t^{stem}_{net} = 1{,}2\ t_{net} \cdot (a_b / a) \cdot \sqrt{\sigma_y/\sigma_{y1}}, \qquad (3.11.2.14.7\text{-}3)$$

where: t_{net} - net thickness of the shell plating in accordance with **3.11.2.4.2**;

a - main framing spacing, in m;

a_b - spacing, in m, of transverse brackets of stem;

σ_y - yield stress, in N/mm^2, of shell plating material;

σ_{y1}- yield stress, in N/mm^2, of stem plate materia.

3.11.2.15 Appendages.

3.11.2.15.1 All appendages are to be designed to withstand forces appropriate for the location of their attachment to the hull structure or their position within a hull area.

3.11.2.15.2 Load definition and response criteria are to be determined by the Register.

3.11.2.16 Local details.

3.11.2.16.1 For the purpose of transferring ice-induced loads to supporting structure (bending moments and shear forces), local design details are to comply with the requirements of the Register.

3.11.2.16.2 The loads carried by a member in way of cut-outs are not to cause instability. Where necessary, the structure is to be stiffened.

3.11.2.17 Direct calculations.

3.11.2.17.1 Application.

Direct calculations are not to be utilised as an alternative to the analytical procedures prescribed for the shell plating and local frame requirements given in **3.11.2.4**, **3.11.2.6** and **3.11.2.7**.

Direct calculations should be performed by the finite element method in a static nonlinear elastic-plastic formulation. When performing calculations, the nonlinear relationship between stresses and deformation s shall be taken into account when the yield strength of the material is reached.

A linear tensile diagram should be used to describe material properties.

3.11.2.17.2 Requirements for a finite element model.

When performing calculations, a three-dimensional finite element model shall be used. The scantling of model shall be chosen to include a section of the side grillage located in the area of ice reinforcements in accordance with **3.11.2.2**, and also the minimum requirements for the dimensions of the finite element model are fulfilled, as are given in table 3.11.2.17.2-1.

Table 3.11.2.17.2-1 **Minimum requirements for a finite element model**

Boundary	Type of side structure	
	Double side structure	Single side structure
Fore	Transverse bulkhead	
Aft	Transverse bulkhead	
Upper	Upper deck	Deck or platform above the upper edge of the ice belt
Lower	Double bottom	Deck or platform below the upper edge of the ice belt

The finite element model shall repeat the hull design.

Ultimate conditions shall be selected in accordance with Table 3.11.2.17.2-2.

Table 3.11.2.17.2-2 **Ultimate conditions**

Location of finite element model boundary	Shear			Turn		
	δ_x	δ_y	δ_z	θ_x	θ_y	θ_z
Upper and lower biundaries	-	x	x	x	x	x
Fore and aft boundaries	x	x	-	x	x	x
Note. x – fixed shear						

The finite-element model shall include shell plating, web frames, stringers, deep members, double-side plating and adjacent framing, stiffeners of deep members webs, knees and brackets.

The degree of structural idealization when creating the finite element model shall be sufficient to solve the nonlinear problem, and the following minimum requirements shall also be met:

shell plating, double-side plating, web frames, stringers and face plates and beam flanges of deep memders shall be modeled by plate elements;

deep members outside the area of ice strengthening shall be modeled by beam elements;

stiffeners of deep members webs shall be modeled by rod elements. Scantling of web shall be selected sufficient to solve a nonlinear problem, the following minimum requirements shall also be fulfilled:

preference shall be given to rectangular finite elements close in shape to a square; aspect ratio should be no more than 1/3;

the use of triangular elements shall be avoided wherever possible;

the web of the deep member shall be devided in height by at least five elements;

structural elements in which stress concentration zones or high strains can occur shall be modeled by a fine mesh; a large mesh can be used to model structural elements outside the ice strengthening region.

The thickness of the finite elements shall be assumed equal to the thickness of the net structure.

3.11.2.17.3 Strength criteria.

The purpose of performing a direct calculation is to demonstrate that, grillage ultimate pressure P_{ult} in MPa, not lower than the design ice pressure within the region considered in accordance with 3.11.2.3.4 and applied to the load patch according to **3.11.2.17.4**.

The carrying capacity of the grillage is determined according to **3.11.2.17.5**.

3.11.2.17.4 Ice load curve.

The parameters of the ice load are determined according to **3.11.2.3.3**. Other loads shall not be taken into account.

The curve of the ice load shall be placed along the normal to the shell plating.

The curve of the ice load shall be placed in places of the lowest carrying capacity of a web frame or stringer. At a minimum, the following locations shall be considered:

the upper edge of the load curve is combined with the upper boundary of the ice belt, the curve is symmetrical with respect to the vertical axis connected to the web of the middle web frame of the grillage;

the lower edge of the load curve is combined with the lower boundary of the ice belt, the curve is symmetrical with respect to the vertical axis connected to the web of the middle web frame of the grillage;

the center of the load patch is combined with the mid-span of the middle web frame of the grillage;

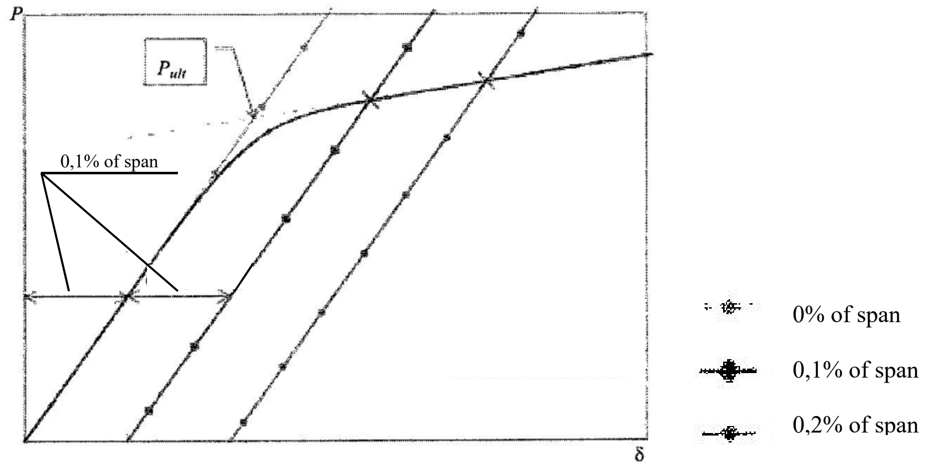
the center of the load patch is combined with the mid-span of the middle supporting stringer of the grillage.

3.11.2.17.5 Grillage ultimate pressure.

Grillage ultimate pressure is determined on the basis of nonlinear static finite element calculation by gradually increasing the estimated load. The step of increasing the load shall be small enough to ensure the accuracy of the curve (P - δ).

The technical capability to control the possible loss of stability of structural members shall be ensured by a method agreed with the Register.

The ultimate pressure P_{ult} is determined from the curve (P - δ) by the method of intersecting tangents in accordance with Fig. 3.11.2.17.5.



Note: P – pressure of grillage;

δ – maximum arrow deflection of the web frame or the supporting stringer.

Fig. 3.11.2.17.5 Determination of the grillage ultimate pressure by the intersection of tangents

3.11.2.17.6 Software Requirements.

The software for performing finite element calculations should allow modeling the structure, taking into account the nonlinearity of the material properties, creating a finite element mesh and performing elastic-plastic calculations in accordance with the requirements **3.11.2.17.1 ÷ 3.11.2.17.5**.

In addition, the software used shall output reports on errors that occur during calculations.

3.11.2.18 Welding.

3.11.2.18.1 All welding within ice-strengthened areas is to be of the double continuous type.

3.11.2.18.2 Continuity of strength is to be ensured at all structural connections.

3.12 BALTIC ICE CLASS SHIPS

3.12.1 GENERAL

3.12.1.1 The requirements for the Baltic ice class ships comply with the requirements of the Finnish-Swedish rules for ice class ships, 2017, and apply to ships intended for operation in the Baltic Sea in winter, as well as in the waters of other seas with similar ice conditions.

3.12.1.2 Ships intended to operate under appropriate ice and climatic conditions are provided with the relevant signs by the Register after fulfilling relevant to the sign requirements of this section and **2.9** “Requirements for machinery installations of the Baltic ice classes” of Part VII “Machinery installations” and **2.11** “Additional requirements for ships of the Baltic ice classes "Part of the III "Equipment arrangements and outfit".

3.12.2 BALTIC ICE CLASSES

3.12.2.1 The symbols and descriptions of the Baltic ice classes are listed in Table 2.2.3.1-2, Part I «Classification».

3.12.3 BALTIC ICE CLASS DRAUGHT

3.12.3.1 Верхня і нижня льодові ватерлінії.

The upper ice waterline – a line enveloping the highest points of the waterline at which the ship will navigate in the ice. Such a line enveloping the indicated points may be a broken line.

The lower ice waterline - a line enveloping the lowest points of the waterline at which the ship will navigate in the ice. Such a line enveloping the indicated points may be a broken line.

3.12.3.2 Maximum and minimum draught fore and aft.

3.12.3.2.1 The maximum and minimum ice class draughts fore and aft shall be determined in accordance with UIWL and LIWL.

Restrictions on draft when operating in ice shall be entered in the ship's documents and stored on board in a place accessible to the master of the ship. The maximum and minimum ice class draughts fore and aft shall be stated in the Supplement to Classification certificate (form 3.1.2-1). Fresh Water Load Line in Summer is above *UIWL*, a warning sign of a triangular shape and a draft mark of an ice class ship on the maximum permissible draft of an ice class ship on the midship shall be applied on the ship's side, appropriate entry shall also be made in the classification certificate.

The draught and trim, limited by the LWL, must not be exceeded when the ship is navigating in ice. The salinity of the sea water along the intended route shall be taken into account when loading the ship.

The ship shall always be loaded down at least to the BWL when navigating in ice. Any ballast tank, situated above the BWL and needed to load down the ship to this water line, shall be equipped with devices to prevent the water from freezing. In determining the BWL, regard shall be paid to the need for ensuring a reasonable degree of ice-going capability in ballast. The propeller shall be fully submerged, if possible entirely below the ice. The forward draught shall be at least $(2 + 0{,}00025\Delta)\ h_0$, but need not exceed $4h_0$,

where: Δ – displacement of the ship, in t, on the maximum ice-class draught according to **3.12.3.1**;
h_0 – level ice thickness, in m, according to **3.12.4.2.1**.

3.12.4 HULL STRUCTURAL DESIGN

3.12.4.1 General.

The method for determining the hull scantlings is based on certain assumptions concerning the nature of the ice load on the structure. These assumptions are from full scale observations made in the northern Baltic.

It has thus been observed that the local ice pressure on small areas can reach rather high values. This pressure may be well in excess of the normal uniaxial crushing strength of sea ice. The explanation is that the stress field in fact is multiaxial.

Further, it has been observed that the ice pressure on a frame can be higher than on the shell plating at midspacing between frames. The explanation for this is the different flexural stiffness of frames and shell plating. The load distribution is assumed to be as shown in figure 3.12.4.1-1.

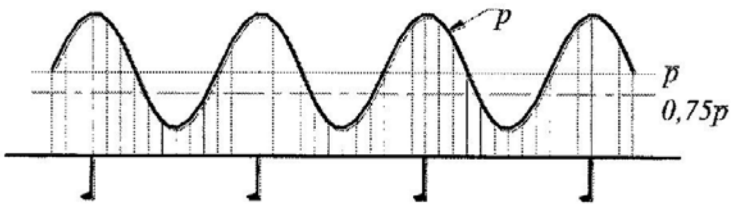


Fig. 3.12.4.1-1
Ice load distribution on a ship's side

For the formulae and values given in this section for the determination of the hull scantlings more sophisticated methods may be substituted subject to approval by the Register. If scantlings derived from these regulations are less than those required by the Register for an unstrengthened ship, the requirements of **3.12.4.3 - 3.12.4.5** shall be met.

When performing strength calculations by numerical methods, the characteristics of the load curve (p, h, l_a) shall be adopted in accordance with **3.12.4.2**.

The pressure shall be taken equal to $1{,}8p$, where p is determined in accordance with **3.12.4.2.2**. The curve shall be located in regions of construction with minimal carrying capacity under the combined action of buckling and shear. In particular, it is necessary to consider cases where the center of the curve is at a level of *UIWL*, at a distance $0{,}5h_0$ below *LIWL*, as well as for several intermediate positions vertically. Several horizontal positions of the curve shall be considered, in particular, in the middle of the span of the framing members or in the half the distance between the members. In addition, if for this design a direct determination of the length of the ice load distribution l_a is not possible, several values of l_a shall be considered using the appropriate values of coefficient c_a.

Permissible stresses for structures shall be taken according to the Mises theory, taking into account the combined effect of buckling and shear, not higher than the yield strength of the material σ_y.

When performing direct calculations using the theory of memebr buckling, the permissible shear stress when using the theory of memebr buckling shall be taken not more than $0{,}9\tau_y$, де $\tau_y = \sigma_y/\sqrt{3}$. If the scantling of structures obtained in accordance with these requirements are smaller than the scantling required for this ship in accordance with other requirements of the regulatory documents of the Register, without taking into account the requirements for ice strengthening, the latter shall be used.

Notes: **1**. The spacing between the deep mebers and the span length of the framing mebers are used in this section are generally measured (in accordance with the applicable requirements of the Register) along the plating; for shell plates - perpendicular to the axis of the deep mebers; for elements with a top plate - along the top plate; for flat profile members - along the free edge. For curved elements, the span (or distance between the memebrs) is determined as the length of the chord between the extreme points of the span (or the distance between the memebrs).

The end points of the span are determined by the intersection of the face plate or the upper edge of the element with the supporting structure (stringer, web frame, deck or bulkhead). The procedure for determining the span and the spacing between the framing memebrs for curved elements is given in Fig. 3.12.4.1-2.

2. When determining the section modulus of the framing members, plating face plate shall be taken into account, the width of which is determined in accordance with the requirements of **1.6**.

In any case, the width of the face plate shall not be greater than prescribed by the requirements of the Regulations of the Register for that type of ship.

3. Requirements for the section modulus and the cross-sectional area of the webs of deep and web framin members according to **3.12.4.4**, **3.12.4.5** and **3.12.4.6**, refer to the effective cross-section of the profile. If the memebr is installed perpendicular to the top plate, the necessary cross-sectional characteristics shall be increased in accordance with the requirements of **1.6.1.4**.

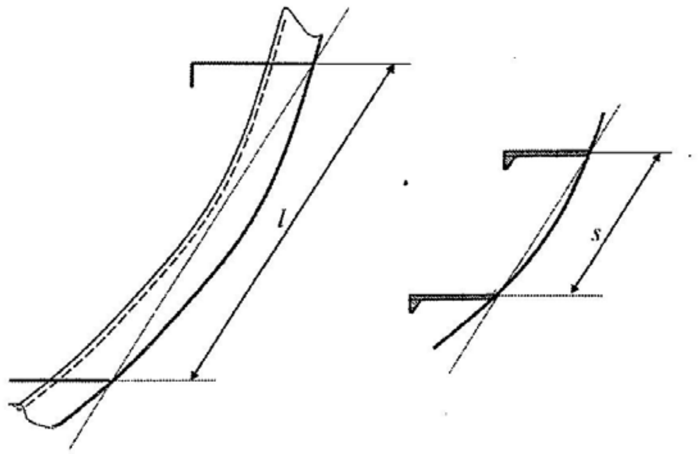


Fig. 3.12.4.1-2
Determination of the span of the frame (left) and the distance between the deep members (right) for curved elements.

3.12.4.1.1 Regions.

For the purpose of this section, the ship's hull is divided into regions as follows (see also figure 3.12.4.1-1):

Forward region: From the stem to a line parallel to and 0.04·L aft of the forward borderline of the part of the hull where the waterlines run parallel to the centreline. For ice classes **IA Super** and **IA** the overlap over the borderline need not exceed 6 meters, for Baltic ice classes **IB** and **IC** this overlap need not exceed 5 meters.

Midship region: From the aft boundary of the Forward region to a line parallel to and 0.04·L aft of the aft borderline of the part of the hull where the waterlines run parallel to the centreline. For ice classes IA Super and IA the overlap over the borderline need not exceed 6 meters, for Baltic ice classes IB and IC this overlap need not exceed 5 meters.

Aft region: From the aft boundary of the Midship region to the stern.

L- as defined in **1.1.3**.

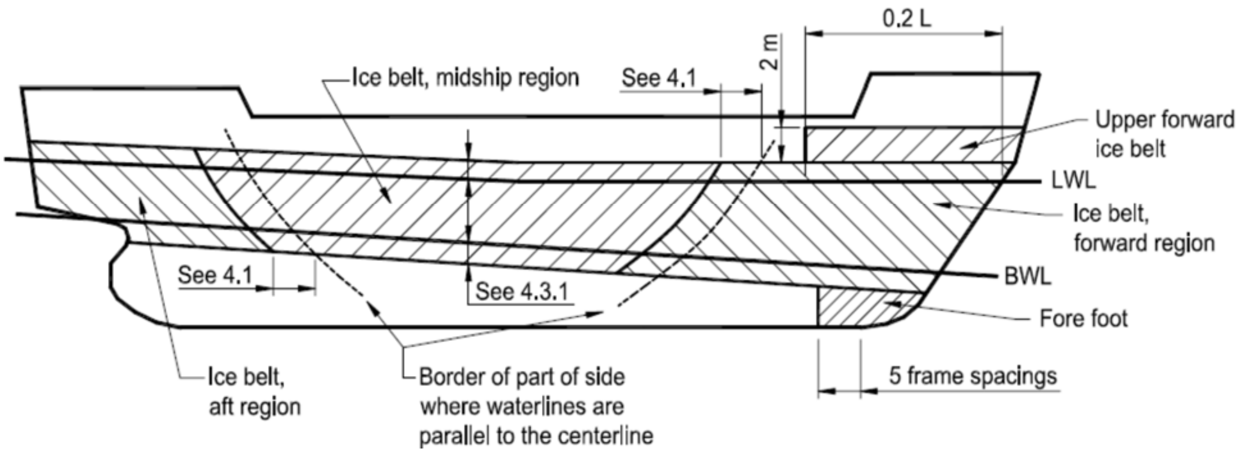


Fig. 3.12.4.1.1
Regions of ice strengthening

3.12.4.2 Ice load.

3.12.4.2.1 Height of load area.

An ice-strengthened ship is assumed to operate in open sea conditions corresponding to a level ice thickness not exceeding h_i. The design height (h) of the area actually under ice pressure at any particular point of time is, however, assumed to be only a fraction of the ice thickness. The values for h_i and h are given in the following table 3.12.4.2.1:

Table 3.12.4.2.1

Baltic Ice Class	h_i, in m	h, in m
IA Super	1,0	0,35
IA	0,8	0,3
IB	0,6	0,25
IC	0,4	0,22

3.12.4.2.2 Ice pressure.

The design ice pressure is determined by the formula:

$$p = c_d \cdot c_p \cdot c_a \cdot p_0, \qquad (3.12.4.2.2)$$

where: c_d - a factor which takes account of the influence of the size and engine output of the ship. c_d shall not be taken greater than 1,0 and is calculated by the formula:

$c_d = (ak + b)/1000$,

where: $k = \sqrt{\Delta P}/1000$;

a and b are given in the following table 3.12.4.2.2-1:

Таблиця 3.12.4.2.2-1

	Region			
	Forward		Midship & Aft	
	$k \le 12$	$k > 12$	$k \le 12$	$k > 12$
a	30	6	8	2
b	230	518	214	286

Δ - the displacement of the ship at maximum ice class draught, in t (refer to **3.12.3.1**);

P - the actual continuous engine output of the ship, in kW.

If, in addition to the main engine (s), there are additional sources of traction power (for example, a shaft generator operating in electric motor mode), their capacity shall also be included in the total power used to determine the dimensions of the hull structures. The power of the main machinery, used to determine the dimensions of the hull structures, shalld be given on the drawing of the shell plating extesion;

c_p - a factor which takes account of the probability that the expected value of ice load in this area of the hull is changed compared with the load in the forward area.

c_p as defied in Table 3.12.4.2.2-2.

Table 3.12.4.2.2-2

Baltic ice classc	Region		
	Forward	Midship	Aft
IA Super	1,0	1,0	0,75
IA	1,0	0,85	0,65
IB	1,0	0,7	0,45
IC	1,0	0,5	0,25

c_a - a factor which takes account of the probability that the full length of the area under consideration will be under pressure at the same time. c_a is calculated by the formula:

$c_a = \sqrt{l_0/l_a}$, $0,35 \le c_a \le 1,0$,

where: $l_0 = 0,6$ m;

l_a – as defined in Table 3.12.4.2.2-3;

p_0 = the nominal ice pressure; the value 5.6 MPa shall be used.

Table 3.12.4.2.2-3

Construction	Framing	l_a
Shell plating	Transverse	Frame spacing
	Longitudinal	1,7 · (frame spacing)
Framing members	Transverse	Frame spacing
	Longitudinal	Span of frame
Stringer		Span of stringer
Web frame		2 · (web frame spacing)

3.12.4.3 Shell plating.

3.12.4.3.1 Vertical extension of ice strengthening (ice belt). The vertical extension of the ice belt shall be as in Table 3.12.4.3.1 (див. рис. 3.12.4.1.1).

Table 3.12.4.3.1

Ice Class	Regions	Above UIWL	Below LIWL
IA Super	Forward	0,6 m	1,2 m
	Midship		
	Aft		1,0 m
IA	Forward	0,5 m	0,9 m
	Midship		0,75 m
	Aft		
IB and IC	Forward	0,6 m	0,7 m
	Midship		0,6 m
	Aft		

In addition, the following areas shall be strengthened.

Fore foot. For Baltic ice class **IA Super**, the shell plating below the ice belt from the stem to a position five main frame spaces abaft the point where the bow profile departs from the keel line shall have at least the thickness required in the ice belt in the midship region.

Upper forward ice belt. For Baltic ice classes **IA Super** and **IA** on ships with an open water service speed equal to or exceeding 18 knots, the shell plate from the upper limit of the ice belt to 2 m above it and from the stem to a position at least 0.2 L abaft the forward perpendicular, shall have at least the thickness required in the ice belt in the midship region. A similar strengthening of the bow region is advisable also for a ship with a lower service speed, when it is, e.g. on the basis of the model tests, evident that the ship will have a high bow wave.

Sidescuttles shall not be situated in the ice belt. If the weather deck in any part of the ship is situated below the upper limit of the ice belt (e.g. in way of the well of a raised quarter decker), the bulwark shall be given at least the same strength as is required for the shell in the ice belt.

The strength of the construction of the freeing ports shall meet the same requirements.

3.12.4.3.2 Plate thickness in the ice belt.

For transverse framing the thickness of the shell plating shall be determined by the formula:

$$t = 667 \cdot s \cdot \sqrt{(f_1 \cdot p_{pl} / \sigma_y)} + t_c. \qquad (3.12.4.3.2\text{-}1)$$

For longitudinal framing the thickness of the shell plating shall be determined by the formula:

$$t = 667 \cdot s \cdot \sqrt{p / (f_2 \cdot \sigma_y)} + t_c. \qquad (3.12.4.3.2\text{-}2)$$

where: s – the frame spacing, in m;

$p_{pl} = 0{,}75p$, in MPa;

p – as given in **3.12.4.2.2**;

$f_1 = 1{,}3 - 4{,}2/(h/s + 1{,}8)^2$, maximum 1,0;

$f_2 = 0{,}6 + 0{,}4/(h/s)$ with $h/s \le 1$;

$f_2 = 1{,}4 - 0{,}4 \cdot (h/s)$ with $1 < h/s \le 1{,}8$,

where: h - as given in **3.12.4.2.1**;

σ_y – yield stress of the material, in MPa, the following values shall be used:

σ_y = 235 MPa for normal-strength hull structural steel;

σ_y = 315 MPa or higher for high-strength hull structural steel;

t_c - = increment for abrasion and corrosion, in mm, normally t_c shall be 2 mm.

if a special surface coating, by experience shown capable to withstand the abrasion of ice, is applied and maintained may be reduced to 1 mm by agreement with the shipowner and subject to the providing the Register with documents listed in 8.6 Guidance on the application of the Finnish-Swedish regulations for ice class ships.

At the same time, the dimensions determined by the increment for corrosion and abrasion shall also be indicated on the drawing of the hull structures. A special mark is entered in the Classification Certificate of such ships (refer to 2.3.1, Part I "Classification").

3.12.4.4 Frames.

3.12.4.4.1 Vertical extension of ice strengthening.

The vertical extension of the ice strengthening of the framing shall be at least as given in Table 3.12.4.4.1.

Table 3.12.4.4.1

Baltic ice class	Region	Above UIWL	Below LIWL
IA Super	Forward	1,2 m	To double bottom or below top of floors
	Midship		2,0 m
	Aft		1,6 m
IA, **IB** and **IC**	Forward	1,0 m	1,6 m
	Midship		1,3 m
	Aft		1,0 m

Where an upper forward ice belt is required (see Fig. 3.12.4.3.1) the ice-strengthened part of the framing shall be extended at least to the top of this ice belt.

Where the ice-strengthening would go beyond a deck or a tanktop by no more than 250 mm, it can be terminated at that deck or tanktop.

3.12.4.4.2 Transverse frames.

3.12.4.4.2.1 Section modulus.

The section modulus of a main or intermediate transverse frame shall be calculated by the formula:

$$Z = p \cdot s \cdot h \cdot l \cdot 10^6/(m_t \cdot \sigma_y). \qquad (3.12.4.4.2.1\text{-}1)$$

Cross section area of a main or intermediate transverse frame shall shall not be less than determined by Formula:

$$A = \sqrt{3} \cdot f_3 \cdot p \cdot h \cdot s \cdot 10^4/(2 \cdot \sigma_y). \qquad (3.12.4.4.2.1\text{-}2)$$

where: p - ice pressure as given in **3.12.4.2.2**, in MPa;

s - frame spacing, in m;

h - height of load area as given in **3.12.4.2.1**, in m;

l - span of the frame, in m;

$m_t = 7m_0/[7 - (5h/l)]$;

$f_3 = 1{,}2$ - factor taking into account the influence on the maximum cutting force of the load curveve position and distribution of shear stresses;

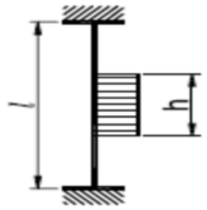
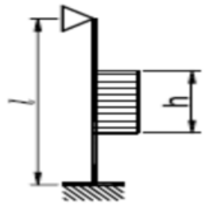
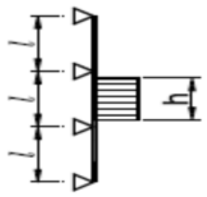
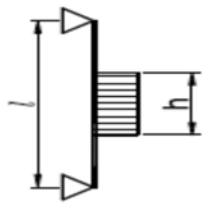
σ_y – yield stress as in **3.12.4.3.2**, in MPa;

m_0 - values are given in Table 3.12.4.4.2.1.

The boundary conditions are those for the main and intermediate frames. Load is applied at mid span.

Where less than 15% of the span, l, of the frame is situated within the ice-strengthening zone for frames as defined in **3.12.4.4.2.1** ordinary frame scantlings may be used.

Table 3.12.4.4.2.1

Boundary Condition	m_o	Example
	7	Frames in a bulk carrier with top wing tanks
	6	Frames extending from the tank top to a single deck
	5.7	Continuous frames between several decks or stringers
	5	Frames extending between two decks only

3.12.4.4.2.2 Upper end of transverse framing.

The upper end of the strengthened part of a main frame and of an intermediate ice frame shall be attached to a deck of an ice stringer in accordance with **3.12.4.5**. Where a frame terminates above a deck or a stringer which is situated at or above the upper limit of the ice belt, the part above the deck or stringer may have the scantlings required by the classification society for an unstrengthened ship and the upper end of an intermediate frame may be connected to the adjacent frames by a horizontal member having the same scantlings as the main frame.

3.12.4.4.2.3 Lower end of transverse framing.

The lower end of the strengthened part of a main frame and of an intermediate ice frame shall be attached to a deck, tanktop or ice stringer in accordance with **3.12.4.5**.

Where an intermediate frame terminates below a deck, tanktop or ice stringer which is situated at or below the lower limit of the ice belt, the lower end may be connected to the adjacent main frames by a horizontal member of the same scantlings as the frames.

The main frame below the lower limit of the ice belt shall be connected, as well as in the middle of ice belt in accordance **3.12.4.4.1**.

3.12.4.4.3 Longitudinal frames.

The requirements of this section apply to the longitudinal frames, regardless of the method of fixing them at the ends.

3.12.4.4.3.1 Longitudinal frames, fixed with or without brackets.

The section modulus of a longitudinal frame shall be calculated by the formula:

$$Z = f_4 \cdot p \cdot h \cdot l^2 \cdot 10^6/(m \cdot \sigma_y). \quad (3.12.4.4.3.1\text{-}1)$$

The shear area of a longitudinal frame shall be:

$$A = \sqrt{3} \cdot f_4 \cdot f_5 \cdot p \cdot h \cdot l \cdot 10^4/(2 \cdot \sigma_y). \quad (3.12.4.4.3.1\text{-}2)$$

where: $f_4 = 1 - 0{,}2h/s$ – factor which takes account of the concentration of load to the point of support;

$f_5 = 2{,}16$ - factor taking into account the influence on the maximum cutting force of the load curveve position and distribution of shear stresses;

p - ice pressure as given in **3.12.4.2.2**, in MPa;

s - frame spacing, in m;

h - height of load area as given in **3.12.4.2.1**, in m;

l - span of the frame, in m;

m - boundary condition factor; m = 13.3 for a continuous beam; where the boundary conditions deviate significantly from those of a continuous beam, e.g. in an end field, a smaller boundary factor may be required subject to providing the Register with appropriate documentation;

σ_y - yield stress as in **3.12.4.3.2**, in MPa.

The actual cross-sectional area of the longitudinal is determined without taking into account the sectional area of the bracket.

3.12.4.4.4. General on framing.

3.12.4.4.4.1 Connection with supporting structures.

Within the ice-strengthened area all frames shall be effectively attached to all the supporting structures. A longitudinal frame shall be attached to all the supporting web frames and bulkheads by brackets. When a transversal frame terminates at a stringer or deck, a bracket or similar construction is to be fitted. When a frame is running through the supporting structure, both sides of the web plate of the frame are to be connected to the structure (by direct welding, collar plate or lug). When a bracket is installed, it has to have at least the same thickness as the web plate of the frame and the edge has to be appropriately stiffened against buckling.

3.12.4.4.4.2 Supporting of frames agains tripping.

The frames shall be attached to the shell by double continuous weld. No scalloping is allowed (except when crossing shell plate butts).

The web thickness of the frames shall not be less than the greater of the following values:

$h_w \cdot \sqrt{\sigma_y}/C$,

where: h_w – web depth, in mm;
C – for a flat bulb;
C – elswhere;
σ_y - yield stress as in **3.12.4.3.2**, in MPa;

$(t - t_c)/2$,

where: t – the thickness of the shell plating, required according to 3.12.4.3.2, in mm, in the determination of which σ_y is taken equal to the yield strength of the framing material;
for t_c – refer to **3.12.4.3.2**;
or 9 mm.

If, instead of one of frames, a plate is adjacent to the shell plating (for example, deck, platform or double bottom top, plating of the transverse bulkhead), then its thickness shall comply with the above requirements at a width equal to the depth of the adjacent side frames. The following values of the variables are accepted: material properties of the plate, h_w - web height of adjacent frames, C = 805.

To avoid tripping, framing webs of asymmetrical profile and framing, not at right angles to the plating, shell be supported by brackets, intercostal stiffeners, stringers або іншими конструктивними елементами, spaced not morde than 1.3 m. If the frame spacing is greater than 4 m, framing webs shall be supported in all regions of ice strengthenings of all Baltic ice classes.

If the frame spacing is 4 m or less, framing webs shall be supported in all regions of ice strengthenings of Baltic ice class **IA Super** ships, in forward and intermediate regions of ice strengthening of Baltic ice class **IA** ships, in forward regions of ice strengthening of Baltic ice classes **IB** and **IC** ships. Alternative strengthening schemes can be grounded by direct calculation methods.

3.12.4.5 Ice stringers.

3.12.4.5.1 Stringers within the ice belt.

The section modulus of a stringer situated within the ice belt (see **3.12.4.3.1**) shall be calculated by the formula:

$$Z = f_6 \cdot f_7 \cdot p \cdot h \cdot l^2 \cdot 10^6/(m \cdot \sigma_y). \qquad (3.12.4.5.1\text{-}1)$$

The shear area shall be:

$$A = \sqrt{3} \cdot f_6 \cdot f_7 \cdot f_8 \cdot p \cdot h \cdot l \cdot 10^4/(2\sigma_y). \qquad (3.12.4.5.1\text{-}2)$$

where: p - ice pressure as given in **3.12.4.2.2**, in MPa;

h - height of load area as given in **3.12.4.2.1**, in m.
The product p · h shall not be taken as less than 0,15;

l - span of the stringer, in m;

m - boundary condition factor as defined in **3.12.4.4.3**;

f_6 = 0,9 - factor which takes account of the distribution of load to the transverse frames;

f_7 = 1,8 - safety factor for stringer;

f_8 = 1,2 - factor taking into account the influence on the maximum cutting force of the load curve position and the distribution of shear stresses;

σ_y – yield stress as in **3.12.4.3.2**, in MPa.

3.12.4.5.2 Stringers outside the ice belt.

The section modulus of a stringer situated outside the ice belt but supporting ice-strengthened frames shall be calculated by the formula:

$$Z = f_9 \cdot f_{10} \cdot p \cdot h \cdot l^2 \cdot (1 - h_s/l_s) \cdot 10^6/(m \cdot \sigma_y). \qquad (3.12.4.5.2\text{-}1)$$

The shear area shall be:

$$A = \sqrt{3} \cdot f_9 \cdot f_{10} \cdot f_{11} \cdot p \cdot h \cdot l \cdot (1 - h_s/l_s) \cdot 10^4/(2\sigma_y). \qquad (3.12.4.5.1\text{-}2)$$

where: p - ice pressure as given in **3.12.4.2.2**, in MPa;

h - height of load area as given in **3.12.4.2.1**, in m.

The product p · h shall not be taken as less than 0,15;

l - span of the stringer, in m;

m - boundary condition factor as defined in **3.12.4.4.3**;
l_s - the distance to the adjacent ice stringer, in m;

h_s - the distance to the ice belt, in m;

f_9 = 0,8 - factor which takes account of the distribution of load to the transverse frames;

f_{10} = 1,8 - safety factor for stringer;

f_{11} = 1,2 - factor taking into account the influence on the maximum cutting force of the load curve position and the distribution of shear stresses;

σ_y – yield stress as in **3.12.4.3.2**, in MPa.

3.12.4.5.3 Deck strips.

Narrow deck strips abreast of hatches and serving as ice stringers shall comply with the section modulus and shear area requirements in **3.12.4.5.1** and **3.12.4.5.2** respectively. In the case of very long hatches the classification society may permit the product p · h to be taken as less than 0.15, but in no case as less than 0.10.

Regard shall be paid to the deflection of the ship's sides due to ice pressure in way of very long hatch openings when designing weatherdeck hatch covers with length *B*/2 and their fittings.

3.12.4.6 Web frames.

3.12.4.6.1 Ice Load.

The load transferred to a web frame from an ice stringer or from longitudinal framing shall be calculated by the formula:

$$F = f_{12} phS, \qquad (3.12.4.6.1)$$

where: p - ice pressure as given in **3.12.4.2.2**, in MPa, in calculating c_a however, l_a shall be taken as $2S$;

h - height of load area as given in **3.12.4.2.1**, in m.

The product p · h shall not be taken as less than 0.15;

S - distance between web frames, in m;

f_{12} = 1,8 – safety factor for web frame.

shall be taken as defined in **3.12.4.5.2**.

3.12.4.6.2 Section modulus and shear area.

Section modulus and shear area shall not be taken less than determined by Formulae:

Shear area

$$A = \sqrt{3} \cdot \alpha \cdot f_{13} \cdot Q \cdot 10^4/2\sigma_y, \qquad (3.12.4.6.2\text{-}1)$$

Section modulus

$$Z = M \cdot \sqrt{1/[1-(\gamma A/A_a)^2]} \cdot 10^6/\sigma_y, \qquad (3.12.4.6.2\text{-}2)$$

where: M - maximum calculated shear force under the load F, as given in, or $M = 0{,}193Fl$;

for F – refer to. **3.12.4.6.1**;

l – web frame span, in m;
γ - as given in the table 3.12.4.6.2;

A - required shear area;

A_a - actual cross sectional area of the web frame, $A_a = A_f + A_w$;

A_f – cross section area of free flange;

A_w – cross section area of web plate.

Table 3.12.4.6.2

A_f/A_w	0	0,2	0,4	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0
α	1,5	1,23	1,16	1,11	1,09	1,07	1,06	1,05	1,05	1,04	1,04
γ	0	0,44	0,62	0,71	0,76	0,80	0,83	0,85	0,87	0,88	0,89

3.12.4.7 Stem.

The stem shall be made of rolled, cast or forged steel or of shaped steel plates. A sharp edged stem (see figure 3.12.4.7.1) is allowed.

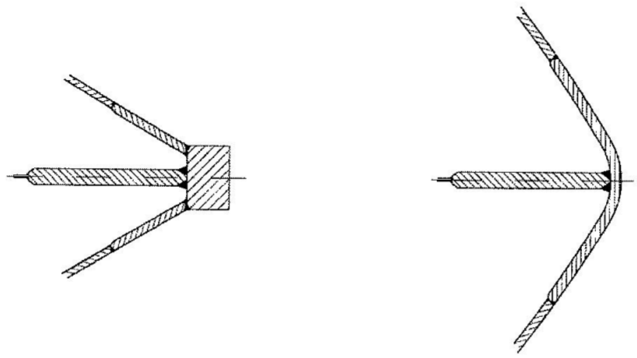


Fig. 3.12.4.7 Examples of a suitable stem

The plate thickness of a shaped plate stem and in the case of a blunt bow, any part of the shell which forms an angle $\alpha \geq 30^{o}C$ and $\psi \geq 75^{o}C$ (refer to Fig 3.12.4.7.2), to the centreline in a horizontal plane, shall be calculated according to the formula in **3.12.4.3.2**, assuming that:

s - spacing of elements supporting the plate, in m;

$p_{PL} = p$, in MPa (refer to **3.12.4.3.2**);

l_a - spacing of vertical supporting elements, in m.

The stem and the part of a blunt bow defined above shall be supported by floors or brackets spaced not more than 0.6 m apart and having a thickness of at least half the plate thickness.

The reinforcement of the stem shall extend from the keel to a point 0.75 m above UIWL or, in case an upper forward ice belt is required (refer to **3.12.4.3.1**), to the upper limit of this.

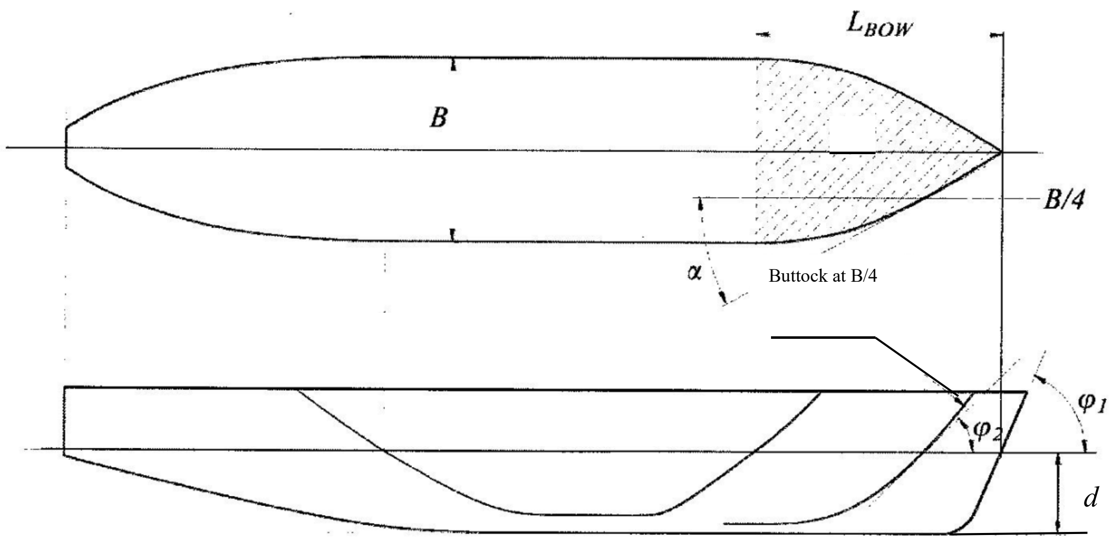


Fig. 3.12.4.7.2

L_{BOW} – length of the bow; B - maximum breadth of the ship; d - draft; α - the angle of the waterline at B/4, in deg.; $φ_1$ – the rake of the stem at the centreline, in deg. With bulb $φ_1$ = 90°; $φ_2$ – the rake of the bow at B/4, in deg.; ψ = arctan (tanφ/sinα), in deg., using α and φ, corresponding to the location.

3.12.4.8 Stern.

The introduction of new propulsion arrangements with azimuthing thrusters or ”podded” propellers, which provide an improved manoeuvrability, will result in increased ice loading of the aft region and the stern area. This fact should be considered in the design of the aft/stern structure.

An extremely narrow clearance between the propeller blade tip and the stern frame shall be avoided as a small clearance would cause very high loads on the blade tip (refer to **3.12.4.2.1**).

On twin and triple screw ships the ice strengthening of the shell and framing shall be extended to the double bottom for 1.5 metres forward and aft of the side propellers.

Shafting and stern tubes of side propellers shall normally be enclosed within plated bossings.

If detached struts are used, their design, strength and attachments to the hull shall comply with requirements of **2.10**.

3.13 ICE STRENGTHENING OF TUGS

3.13.1 General requirements.

3.13.1.1 Tugs provided with ice strengthening in compliance with the requirements stated below are provided with one of the following ice class marks in their class notation: I**ce2**, **Ice3**, **Ice4**, **Ice5**.

3.13.1.2 The hull form of ice-strengthened tugs shall be in accordance with the requirements of **3.10.1.2** for the hull form of the appropriate ice class ships.

3.13.1.3 Regions of ice strengthening.

3.13.1.3.1 For tugs, the boundaries of regions of ice strengthening shall be established in accordance with **3.10.1.3** as in the case of ice class ships, unless specifically provided otherwise below.

3.13.1.3.2 In tugs with a small length of loadline fore run ($b + L_3 < 0,35L$ – refer to **3.10.1.3**) the intermediate region of ice strengthening (or the forward region where no intermediate region is established) shall be extended aft so that the forward boundary of the midship region would be at least 0,35L away from the forward perpendicular.

3.13.1.3.3 The parameters h_1, h_3, L_2 (refer to Fig. 3.10.1.3.2) shall be adopted from Table 3.13.1.3.3.

Table 3.13.1.3.3

Parameter, in m	Ice class	
	Ice2, **Ice3**	**Ice4**, **Ice5**
h_1	0,3	0,5
h_3	0,6	0,8
L_2	0,1L	0,15L

3.13.1.3.4 In tugs of ice classes **Ice2** and **Ice3**, an intermediate region of ice strengthening may also be established, and its boundaries shall be determined on the basis of the same regulations as for tugs of higher ice classes.

3.13.1.3.5 The regions of ice strengthening of tugs to which the requirements of this Chapter apply shall be determined based on Table 3.10.1.3.4 as in the case of a transport ship of the appropriate ice class, with due regard for **3.11.1.3.4**.

3.13.2 Structure.

3.13.2.1 The ice-strengthening structure of tugs shall comply with the requirements of 3.10.2 for construction of the appropriate ice class ships.

3.13.2.2 The hull attachments of ice-protection components of the azimuth thruster shall ensure their reliable connection to main and web framing and, as far as practicable, to the sternframe and to longitudinal and transverse bulkheads so as to rule out the possibility of crack formation as a result of ice impacts on the stern.

3.13.3 Ice load.

3.13.3.1 The ice pressure shall be determined by the following formulae:

.1 in region **AI**

$$p_{AI} = k_p\, p^o_{AI}, \qquad (3.13.3.1.1)$$

where: p^o_{AI} - ice pressure in region **AI**, as determined in accordance with **3.10.3.2.1** as in the case of a transport ship whose ice class coincides with the ice class of the tug;

$k_p = 1$ with $N_\Sigma \le N_0$;

$k_p = (N_\Sigma / N_0)^{0,4}$ with $N_\Sigma > N_0$;

N_Σ - total shaft power of tug, in kW;

$N_0 = C_N \Delta^{2/3}$;

C_N - factor to be taken from Table 3.13.3.1.1;

Δ - displacement to summer load waterline, in t;

Table 3.13.3.1.1

Factor	Ice category of tug			
	Ice2	**Ice3**	**Ice4**	**Ice5**
C_N	14	16	18	20

.2 in regions **A$_1$I**, **BI** and **CI**

$$p_{kI} = a_k\, p_{AI}, \qquad (3.13.3.1.2)$$

for p_{AI}, refer to 3.11.3.1.1;

a_k – factor to be taken from Table 3.11.3.1.2 based on the region of ice strengthening and the ice class of the tug;

k = **A$_1$**, **B**, **C**;

Table 3.13.3.1.2 **Values of factor a_k**

Regions	Ice class of tug			
	Ice2	**Ice3**	**Ice4**	**Ice5**
A_1I	0,55	0,6	0,65	0,65
BI	0,4	0,5	0,55	0,6
CI	0,65	0,7	0,75	0,75

.3 in regions **II**, **III** and **IV**, an ice pressure shall be taken as required by **3.10.3.2.5** as in the case of transport ships of appropriate ice class.

3.13.3.2 For tugs the vertical extension of ice load shall be adopted equal in all regions and shall be determined in accordance with **3.10.3.3.1** as in the case of the forward region of a transport ship whose ice class coincides with that of the tug. When determining u_m, the values of u shall be found for those sections only which are included in the forward region of ice strengthening of the tug.

3.13.3.3 For tugs the horizontal extension of ice load shall be adopted equal in all regions and shall be determined in accordance with **3.10.3.4.1** as in the case of the forward region of a transport ship whose ice class coincides with that of the tug. When determining β_m only those sections shall be considered which are included in the forward region of ice strengthening of the tug.

3.13.4 Scantlings of ice-strengthening structures.

3.13.4.1 The scantlings of ice-strengthening structures in tugs shall be determined in accordance with **3.10.4** as in the case of transport ships of the appropriate ice class, unless expressly provided otherwise below.

3.13.4.2 When establishing the shell plating thickness in regions of ice strengthening in accordance with **3.10.4.1**, the wear allowance, Δs_{sp0} may be reduced if special measures are taken to protect the shell plating from corrosion wear and abrasion, but in any case, Δs_{sp0} shall be adopted not less than 2 mm.

3.13.4.3 In addition to the requirements of **3.10.4.10**, the stem and sternframe shall have a sectional area not less than determined by the formula:

$$S = kS_0, \qquad (3.13.4.3)$$

where: k – factor whose values shall be found in Table 3.11.4.3;

S_0 – area of stem or sternframe of the tug without ice class to be determined in accordance with **3.9.4.5** or **3.9.4.6**.

Table 3.13.4.3 **Values of factor *k***

Structural member	Ice class			
	Ice2	**Ice3**	**Ice4**	**Ice5**
Stem	1,2	1,3	1,4	1,5
Sternframe	1,1	1,2	1,3	1,4

3.14 REQUIREMENTS TO CONSTRUCTION OF ICE STRENGTHENING OF SHIPS INTENDED FOR OPERATION ASTERN

3.14.1 APPLICATION

3.14.1.1 Ships that shall comply with the requirements of this Chapter, at the request of the ship-owner, an additional **DAS** sign ("ice class mark") is provided for the ship's class notation (refer to **2.2.3.3.5**, Part I "Classification").

3.14.2 REQUIREMNTS TO HULL CONSTRUCTION

3.14.2.1 The requirements of this paragraph apply to ships that are operated in the ice stern ahead, and are additional to the requirements of **3.10**, Part II "Hull".

3.14.2.2 Regions.

3.14.2.2.1 For the purpose of this section, the ship's hull is divided into regions as follows:

for ships that can run in ice, both ahead and astern:

forward – **A**;
intermediate – $\mathbf{A_1}$;
midship – **B**;
aft – **C**;

for ships that can run in ice only astern:

forward – **A**;
midship – **B**;
aft – **C**.

3.14.2.2.2 By depth and by the bottom, the regions of ice reinforcement are divided into:

region of variable drafts and equivalent regions – **I**;
region, from the lower edge of region **I** to the upper edge of bilge strake **II**;
bilge strake **III**;
from the lower edge of bilge strak, where the plating has a slope to the horizon of 7 °, to centre plane – **VI**.

For ships that can run in ice only astern positions of forward, midship and aft ice regions are given relative to the plane of the flat side:

forward – form stem to L_3 line astern from forward boundary of flat side;
midship – from forward boundary of forwar region to L_3 line ahead from aft boundary of flat side;
aft - from aft boundary of midship to sternframe.

The length of the ice belt in the forward region of the bottom is regulated by the parameter L2, equal to the distance from point A to the point of intersection of the main plane with the vertical line that defines the boundary of the forward region at the lower boundary of the ice belty.

These requirements must be met at both the upper and lower operational waterlines.

The position of the point K is defined as a point located at a distance of at least five normal spacings (refer to **1.1.3**, Part II "Hull") ahead from the beginning of the skeg.

3.14.2.2.3 The extent of the ice reinforcement regions of ice class ships is determined according to Fig. 3.14.2.2.3 of this paragraph and Table 3.10.1.3.2, Part II "Hull".

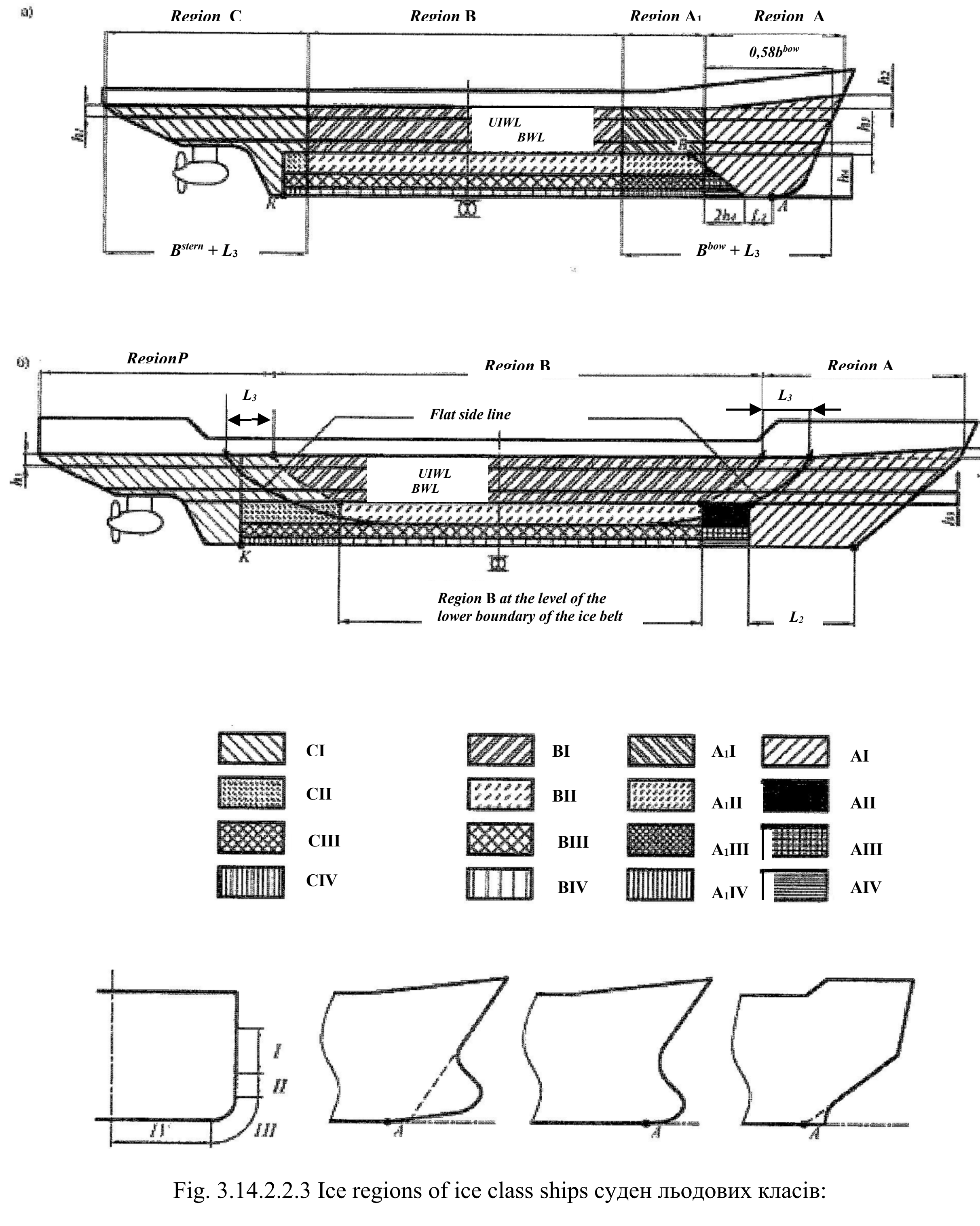


Fig. 3.14.2.2.3 Ice regions of ice class ships суден льодових класів:

а) ships designed to run in the ice, both ahead and astern;

б) ships designed to run in the ice only astern;

b^{bow} – the distance from the point of intersection of the UIWL with the stem to the cross section in which the UIWL has the largest breadth but no more 0,4*L*;

b^{stern} the distance from the point of intersection of the UIWL with the sternframe to the cross section in which the UIWL has the largest breadth but no more 0,2*L*.

3.14.2.2.4 The extent of the ice reinforcement regions of double-acting Arctic ships that can periodically perform icebreaking operations and have the ice class **Icebreaker 1** or **Icebreaker 2** in the class notation when running astern is determined according to Fig. 3.14.2.2.4 and Table 3.14.2.2.4.

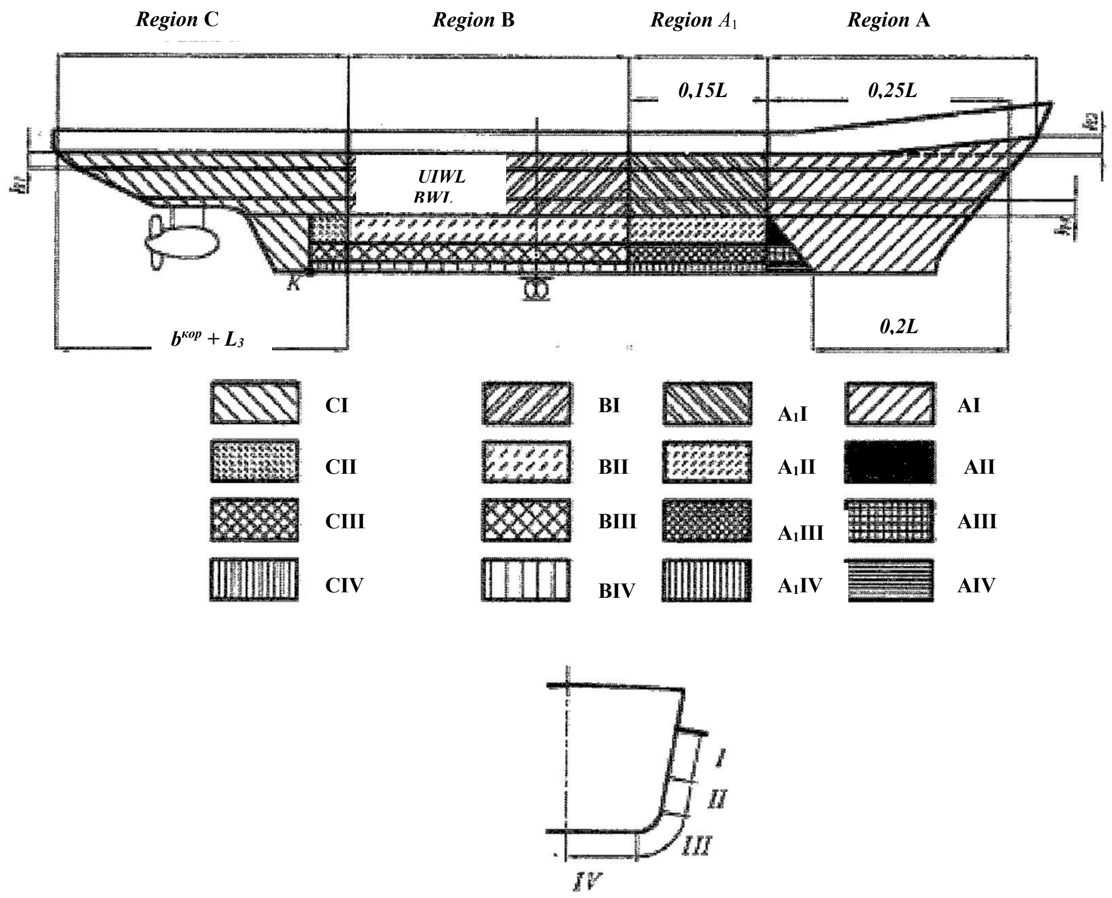


Fig. 3.14.2.2.4 Ice reinforcement regions of double-acting Arctic ships that have the ice class **Icebreaker 1** or **Icebreaker 2** in the class notation when running astern:
$b^{кор}$ – the distance from the point of intersection of the UIWL with the sternframe to the cross section in which the UIWL has the largest breadth but no more 0,2*L*.

Table 3.14.2.2.4

Parameter		Ice class	
		Icebreaker 2	**Icebreaker 1**
h_1, m	if $B \leq 20$ m	0,75	
	if $B > 20$ m	$(0{,}5B + 8)/24$	
h_2, m		1,4	1,1
h_3, m		$1{,}6 + 1{,}6\,h_1 \geq 2{,}8$	$0{,}4 + 1{,}6\,h_1 \geq 1{,}6$
L_3, m		$0{,}06L$	$0{,}05L$

3.14.2.2.5 Depending on the ice class, the requirements of the paragraph apply to the regions of ice reinforcement indicated in Table 3.14.2.2.5-1 (for ships that can run in the ice, both ahead and astern) and Table 3.14.2.2.5-2 (for ships that can run in the ice only astern) with a "+" sign. The absence in the column of the Table. 3.14.2.2.5-1 and Tab. 3.14.2.2.5-2 of the "+" sign means that the requirements of this paragraph do not apply to this reinforcement region.

Table 3.14.2.2.5-1

Ice class	Region depthwise															
	I				**II**				**III**				**IV**			
	Region lengthwise															
	A	**A_1**	**B**	**C**	**A**	**A_1**	**B**	**C**	**A**	**A_1**	**B**	**C**	**A**	**A_1**	**B**	**C**
Icebreaker 2	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Icebreaker 1, Ice6	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+
Ice5	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+
Ice4	+	+	+	+	+	+	+	+	+	+		+	+	+		+
Ice3	+		+	+	+			+								
Ice2	+		+	+												
Ice1	+			+												

Table 3.14.2.2.5-2

Ice class	Region depthwise											
	I			**II**			**III**			**IV**		
	Region lengthwise											
	A	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**
Ice6	+	+	+	+	+	+	+	+	+	+		+
Ice5	+	+	+	+	+	+		+	+			+
Ice4	+	+	+		+	+			+			+
Ice3	+	+	+			+						
Ice2	+	+	+									
Ice1			+									

3.14.2.3 Construction

3.14.2.3.1 Sternframe construction.

3.14.2.3.1.1 To increase the rigidity of the structures of the stern, to reduce the length of the aft overhang and protect the rudder propellers from the influence of ice, which falls into the area of the aft rake, the skeg shall be fitted in the centre plane.

The bottom surface of the skeg shall coincide with the flat bottom. The extent of the skeg lengthwise shall be consistent with the location of the transverse bulkheads of the ships stern.

The choice of skegs framing construction is carried out on the condition of coordination with the structural scheme of the aft rake bottom.

In the case of the longitudinal framing system of the aft rake bottom, vertical diaphragms are installed inside the skegs, located in the plane of the transverse framing of aft rake bottom, as well as in the plane of the transverse bulkheads.

The design of the diaphragms, bulkheads and platforms shall comply with the requirements of 3.10.2.4, Part II "Hull".

3.14.2.3.1.2 Rudder propeller support drum must have a reinforced thickened flange for bolting to the flange of the propeller-steering gear. The design of the drum and reinforcements should provide access to the bolt connection of the steering gear. Reinforcement of the supporting drum shall be joined with reinforced floors and double-bottom stringers. Additionally installed bottom strings shall be aligned with transverse bulkhead stiffeners, which enclose the steering gear compartment and smoothly form longitudinal memebers at a length of 3 to 4 spacings outside the compartment. Reinforce floors shall be supported by frames and longitudinal bulkheads stiffeners, reinforced in height to the nearest deck or platform.

3.14.2.4 Ice load.

3.14.2.4.1 The angles of the waterline in the aft end part are determined according to Fig. 3.14.2.4.1:

when installing one rudder propeller - as for stem according to 3.10.1.2.1, Part II "Hull";

when installing two/three rudder propellers – as for the parts of water lines located to the side of the axial line of the column.

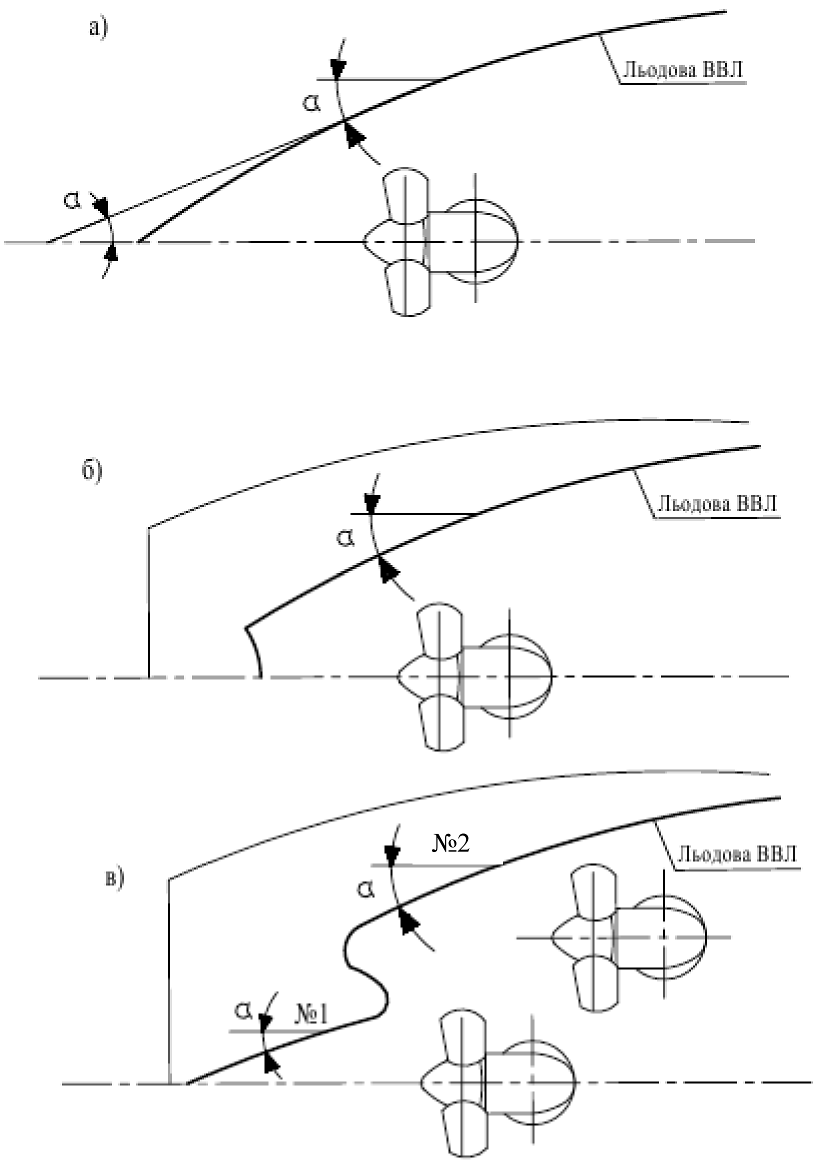


Fig. 3.14.2.4.1 Determination of the ice waterline angles in the aft of the ship:
a) one RP; b) two RPs; c) three RPs.

3.14.2.4.2 Ice pressure.

3.14.2.4.2.1 In region **AI**:

for ships that can run in ice both ahead and astern:

in accordance with **3.10.3.2.1**, Part II «Hull»;

for ships that can run in ice only astern:

for ices classes **Ice2**, **Ice3**, **Ice4**, **Ice5** and **Ice6**:

$$p^{o}_{AI} = a_4 p_{BI}, \qquad (3.14.2.4.2.1\text{-}1)$$

where: a_4 – factor, as given in Table 3.10.3.2.1, Part II «Hull»;

p_{BI} – ice pressure in region **BI** (refer to 3.14.2.4.2.2);

3.14.2.4.2.2 In regions **A₁I** and **BI** – in accordance with **3.10.3.2.2** and **3.10.3.2.3**, Part II «Hull» respectively. If the ice class when the ship runs ahead differs from the ice class when the ship runs astern, the factor a_3 shall correspond to the higher ice class.

3.14.2.4.2.3 In region **CI:**

$p_{CI} = 2100 a_1 v_m (\Delta/1000)^{1/6}$,

where: a_1 – factor given in Table 3.10.3.2.1, Part II «Hull» depending on the ship's ice class;
v_m – maximum within the region value of v, determined in cross sections x = 0; 0,025L; 0,05L; 0,075L respectively, from aft boundary of estimated ice wwaterline by the Formula:

$$v = f_v\left(b_0^v + b_1^v\frac{x}{L} + b_2^v\alpha + b_3^v\beta'\right),$$

where: b_i^v – factors given in Table 3.14.2.4.2.3 depending on the number of RPs.

Table 3.14.2.4.2.3

	b_0^v	b_i^v	b_2^v	b_3^v
One RP	0,8731	0,1537	0,0011	-0,0012
Two RPs	0,8721	0,2090	0,0009	-0,0011
Three RPs, part №1 (Fig. 3.14.2.4.1)	0,8265	0,2474	0,0011	0,0004
Three RPs, part №2 (Fig. 3.14.2.4.1)	0,8660	-0,1016	0,0010	-0,0007

3.14.2.4.2.4 In regions **II**, **III** and **IV** the ice load intensity is determined as the part of the ice load intensity of region **I** in the corresponding area lengthwise:

$p_{kl} = a_{kl} p_k$, (3.14.2.4.2.4)

where: k = **A, A₁, B, C;**
l = **II, III, IV**;
a_{kl} – factor given in Table 3.14.2.4.2.4.

Table 3.14.2.4.2.4

Ice class	Region lengthwise								
	Forward and intermeditae (**A**, **A₁**)			Midship (**B**)			Aft (**C**)		
	Region depthwise								
	II	**III**	**IV**	**II**	**III**	**IV**	**II**	**III**	**IV**
Ice3	0,4	-	-	-	-	-	0,4	-	-
Ice4	0,5	0,4	0,35	0,4	-	-	0,5	0,4	0,35
Ice5	0,65	0,65	0,45	0,5	0,4	-	0,65	0,65	0,45
Ice6	0,65	0,65	0,5	0,5	0,45	-	0,65	0,65	0,5

3.14.2.4.3 Ice load distribution depth.
3.14.2.4.3.1 In regions **AI, AII, AIII, AIV**:

for ships that can run in ice both ahead and astern:
in accordance with **3.10.3.3.1**, Part II «Hull»;

for ships that can run in ice only astern:
for ices classes **Ice2**, **Ice3**, **Ice4**, **Ice5** and **Ice6**:

$b_A = 0{,}8 b_B$, (3.14.2.4.3.1)

where for b_B – refer to **3.10.3.3.3** Part II «Hull»;

3.14.2.4.3.2 In regions **A₁I, A₁II, A₁III, A₁IV –** in accordance with **3.10.3.3.2** Part II «Hull», and in regions **BI, BII, BIII** and **BIV** – in accordance with **3.10.3.3.3** Part II «Hull».

3.14.2.4.3.3 In regions **CI, CII, CIII** and **CIV**:

$b_C = C_1 k_\Delta u_m$, (3.14.2.4.3.3) where: C_1 and k_Δ - factors given in Table **3.10.3.3.1**, Part II «Hull»;

u_m – maximum within the region value of u, determined in cross sections x = 0; 0,025L; 0,05L; 0,075L respectively, from aft boundary of estimated ice wwaterline by the Formula:

$$u = f_u\left(b_0^u + b_1^u\frac{x}{L} + b_2^u\alpha + b_3^u\beta' + b_4^u\frac{x}{L}\beta' + b_5^u\alpha\beta'\right),$$

where: b_i^u – factors given in Table 3.14.2.4.2.3 depending on the number of RPs.

Table 3.14.2.4.3.3

	b_0^u	b_1^u	b_2^u	b_3^u	b_4^u	b_5^u
One RP	0,6445	1,0425	0,0035	0,0010	-0,0201	-0,0001
Two RPs	0,6584	0,8894	0,0036	0,0005	-0,0128	-0,0001
Three RPs, part №1 (Fig. 3.14.2.4.1)	0,6075	1,3355	0,0037	0,0025	-0,0225	-0,0001
Three RPs, part №2 (Fig. 3.14.2.4.1)	0,6021	1,3103	0,0040	0,0024	-0,0368	-0,0001

3.14.2.4.4 Ice load distribution length.

3.14.2.4.4.1 In regions **AI, AII, AIII, AIV**:

for ships that can run in ice both ahead and astern:
in accordance with **3.10.3.3.1**, Part II «Hull»;

for ships that can run in ice only astern:

$$l^{и}_A = 6b_A \geq 3{,}5\sqrt{k_\Delta}, \qquad (3.14.2.4.4.1)$$

where: b_A – ice load distribution depth in accordance with **3.14.2.4.3.1.**

3.14.2.4.4.2 In regions **A₁I, A₁II, A₁III, A₁IV –** in accordance with **3.10.3.3.2**, Part II «Hull», and in regions **BI, BII, BIII** and **BIV** – in accordance with **3.10.3.3.3**, Part II «Hull».

3.14.2.4.4.3 In regions **CI, CII, CIII** i **CIV**:

$$l^{и}_C = 11{,}3\sqrt{b_C\sin\beta^C_m} \geq 3{,}5\sqrt{k_\Delta}, \qquad (3.14.2.4.4.3)$$

where: b_C – ice load distribution depth in accordance with **3.14.2.4.3.3**;
β^C_m –angle β in the estimated cross-section of region **C**, with u maximum.

3.14.2.4.5 Ice load intensity for Arctic ice class Icebreaker 1 and Icebreaker 2 ships.

3.14.2.4.5.1 In regions **AI, A₁I** and **BI** the ice load intensity is determined in accordance with **3.10.3.5.1** and **3.10.3.5.2**, Part II «Hull». p^o_{AI} is determined in accordance with **3.14.2.4.2.1**.

3.14.2.4.5.2 the ice load intensity in region **CI** is determined in accordance with **3.10.3.5.2**, Part II «Hull».

3.14.2.4.5.3 In regions **II, III** i **IV** the ice load intensity is determined in accordance with **3.10.3.5.3**, Part II «Hull»:

$$p_{mn} = a_{mn} \cdot p_{m\mathrm{I}}, \qquad (3.14.2.4.5.3)$$

where for a_{mn}, m, n – refer to **3.10.3.5.3**, Part II «Hull».

3.14.2.4.6 The depth of ice load intensity distribution for Arctic ice class **Icebreaker 1** and **Icebreaker 2** ships in regions **A, A₁** and **B** is assumed to be the same and is determined in accordance with **3.10.3.3.1,** Part II «Hull» as for the new region of ship, the ice class number of which is the same as the icebreaker ice class. In region **C** the depth of ice load intensity distribution is determined in accordance with **3.14.2.4.3.3** as for the aft region of ship, the ice class number of which is the same as the icebreaker ice class.

3.14.2.4.7 The length of ice load intensity distribution for Arctic ice class **Icebreaker 1** and **Icebreaker 2** ships in regions **A, A₁** and **B** is assumed to be the same and is determined in accordance with **3.10.3.4.1**

Part II «Hull» as for the new region of ship, the ice class number of which is the same as the icebreaker ice class. In region **C** the length of ice load intensity distribution is determined in accordance with **3.14.2.4.4.3** as for the aft region of ship, the ice class number of which is the same as the icebreaker ice class.

3.14.2.5 Scantling of ice reinforcement structures.

3.14.2.5.1 Scantling of ice reinforcement structures shall be determined in accordance with the requirements of **3.10.4**, Part II "Hull" for the ice load parameters determined in accordance with the calculation procedure described in **3.14.2.4**.

3.14.2.5.2 Scantling of skeg and aft rake construction shall be determined in accordance with the requirements of **3.10.4**, Part II "Hull" for the hull constructions (shell plating, deep and web frames, longitudinals, plate structures) using the ice load parameters determined in accordance with the calculation procedure described in **3.14.2.4**.

3.15 SHIPS INTENDED FOR OPERATION IN CONDITIONS OF LOW AIR TEMPERATURE

3.15.1 GENERAL

3.15.1.1 Application.

3.15.1.1.1 The requirements for ships to ensure long-term operation at low air temperatures apply to ships designed for operation in cold climatic conditions (refer to **2.2.3.1.4**, Part I “Classification”) and are additional to the requirements of this part of the Rules.

3.15.1.1.2 Ships which shall comply with the requirements of this paragraph for design temperature are provided with an additional distinguishing mark **WINTERIZATION (DAT)** (refer to **2.2.30**, Part I “Classification”).

3.15.1.2 Definitions.

Design Ambient Temperature, DAT - outdoor temperature in degrees Celsius, which is used as a criterion for the selection and testing of materials and equipment that are exposed to low temperatures.

Design Structural Temperature - temperature in degrees Celsius, which is accepted for the choice of structural material. If there are no additional instructions in the Rules or in this section regarding the design temperature of the structure, the design ambient temperature is adopted.

3.15.2 DESIGN TEMPERATURES

3.15.2.1 The design ambient temperature is set by the ship-owner based on the purpose of the ship and her operating conditions.

3.15.2.2 The requirements of the Rules provide for the following standard values of the dewsign ambient temperature: -30°C (distinguishing mark **WINTERIZATION (-30)**); -40°C (distinguishing mark **WINTERIZATION (-40)**) i -50°C (distinguishing mark **WINTERIZATION (-50)**). Application of requirements fordesign ambient temperatures above -30° C, as well as for intermediate values, is determined by the Register in agreement with the ship-owner.

3.15.2.3 The design ambient temperature cannot be accepted above that specified in **1.2.3.3** of this part of the Rules for the corresponding ice class of the ship.

3.15.2.4 The design temperature of the hull structures shall be taken in accordance with 1.2.3.4 of this part of the Rules. In this case design ambient temperature shall be taken as T_A.

3.16 FLOATING DOCKS

3.16.1 General.

3.16.1.1 Application.

The requirements of this Chapter apply to hull structures of wing-walled (caisson, pontoon, sectional) docks.

Caisson dock is a structure fitted with a solid pontoon and two wings continuous along the entire length and structurally inseparable (including caisson docks with end pontoons for docking a centre pontoon).

Pontoon dock is a structure fitted with two wings continuous along the entire length and several pontoons connected to the wings by bolts, rivets, welding.

Sectional dock is a structure consisting of several sections, each section being a caisson or a pontoon dock, connected by bolts, welded plates, hinges.

The requirements apply to the docks having a ratio of the length over the pontoon deck to the breadth more than 3,5.

Other structural configurations of docks and their proportions shall be subject to calculation according to the agreed procedure.

3.16.1.2 Definitions:

Ballast water is sea water pumped into ballast compartments in order to change dock's draught and trim.

Ballast compartment is a compartment in a pontoon or wing wall of the dock, bounded by watertight structures and intended for pumping ballast water.

Dock wing wall is a part of floating dock hull structurally connected to a pontoon or pontoons and intended to provide stability when the dock is lowered and lifted; a wing wall is divided by decks, platforms, bulkheads into spaces and compartments for arranging dock equipment and ballast.

Lifting capacity o f the dock Δ, *in t* is mass of the heaviest ship or ships that the dock shall lift in normal service.

Depth o f the dock D is a vertical distance measured at the midship section from the base line to the moulded surface of the top deck at the outer wall side.

Pontoon depth D_p is a distance measured at the centreline from the base line to the moulded surface of the pontoon deck.

Maximum submersion depth $d_{m.s}$ is a vertical distance measured at the midship section from the base line to the waterline to which the dock may theoretically be lowered.

Length o f dock at the pontoon deck $L_{p.d}$ is the distance measured along the pontoon deck parallel to the base line between moulded surfaces of the pontoon end bulkheads.

Length o f keel blocks track L_k is a distance measured at the centreline parallel to the base line between outer ends of keel blocks.

Ship weight for docking Δ_t, *in t* is weight of the light ship to be docked with necessary stores and ballast to provide the ship's draught and trim as required for docking.

Rest water ballast is ballast water which pumps cannot discharge.

Design waterline is a waterline of a floating dock corresponding to its draught with full stores, a ship of a design weight and a required quantity of ballast.

Crinolines are cantilever structures of the dock, fitted at the end bulkheads of the dock pontoon at the pontoon deck level, aiming to increase an area available for docking operations at the ship's ends projecting beyond the pontoon deck.

Light draught d_l *is a vertical distance measured at the midship section from the base line to the waterline corresponding to the dock displacement with no stores, docked ship and ballast.*

Safety deck is a watertight deck in wing walls of the dock, forming a boundary of the ballast compartments from above.

Air cushion is an area of a higher air pressure between the top of compartment and a level of ballast water therein.

Pontoon is a part of the dock hull intended to maintain buoyancy of the dock which is defined by volumes of its compartments.

Compensating ballast water is ballast water pumped into ballast tanks in order to reduce transverse and/or longitudinal bending moments and deflections of pontoon and/or wing wall structures.

Design draught d is a vertical distance measured from the base line to the design waterline.

Pontoon deck is a deck on which keel blocks or bilge blocks are fitted.

Dry compartment is a compartment below the safety deck (or below the margin line where safety deck is omitted) not intended for pumping ballast water.

Top deck is a uppermost deck of dock wing walls.

Wall breadth at top deck $b_{t.d}$ is a distance measured normal to the centreline between the moulded surfaces of the inner and outer wall sides at the level of the moulded surface of the top deck.

Wall breadth at pontoon deck $b_{p.d}$ is a distance measured normal to the centreline between the moulded surfaces of the inner and outer wall sides at the level of the moulded surface of the pontoon deck.

Breadth o f the dock B is a distance measured normal to the centre line between the moulded surfaces of the outer wall sides.

Pontoon deck breadth $B_{p.d}$ is a distance measured normal to the centre line between the lines of intersection of moulded surfaces of the inner wall sides and the pontoon deck.

3.16.1.3 Materials:

3.16.1.3.1 When selecting steel for hull structures of floating docks, provisions of **1.2** shall be applied, having regard to subdivision of structural members into groups according to Table 3.16.1.3.1.

Table 3.16.1.3.1

Dock members	Group of members	
	within midship region	outside midship region (refer to **1.1.3**)
Thickened top deck plates in way of openings; bottom plating of pontoon deck wing walls and plate strengthenings of pontoon structures in pontoon docks at sections between pontoons and in adjacent regions, plate members of sectional dock structures in way of dock section connections	III	II
Pontoon deck plating and bottom plating of pontoon (pontoons); transverse and longitudinal framing members of pontoon deck and bottom; plate structures of primary transverse members (non-tight and tight bulkheads) of pontoon (pontoons); bottom strakes of wing walls and adjacent strakes of shell plating, longitudinal bulkhead plating of pontoon docks	II	II
Plating strakes, framing members of top deck, safety deck, wing walls and pontoon shell plating; plates and framing members of wing wall interior structures (other than dock structural members referred to in 1 and 2)	II	I

3.16.1.3.2 Plate and beam items of crinolines, walkways and other secondary structures of a floating dock may be fabricated from steel having lower strength characteristics than specified in **1.2.2.1**, provided their welding is guaranteed at the shipyard.

3.16.1.4 Estimation of wear. Minimum thicknesses.

3.16.1.4.1 The effect of wear on the scantlings of structures is estimated on the basis of specification of strength to the end of the dock service life. Corrosion allowances shall permit operation of the dock during the full specified service life with average corrosion rates of structural items.

3.16.1.4.2 Scantlings and strength characteristics of structures with due regard for wear and corrosion shall be determined in compliance with 1.1.5, with a corrosion allowance Δs, in mm, being determined by the formula:

$$\Delta s = kuT, \quad (3.16.1.4.2)$$

where: k – factor taking into account zone conditions of floating dock service and equal to:
1,0 – for Baltic basin;
1,1 – for Northern, Black-and-Azov and Caspian-and-Volga basins;
1,2 – for Pacific basin;
u – average annual reduction in thickness of structural members according to Table 3.16.1.4.2, in mm/year;
T – design service life of dock; where service life is not specified, it shall be taken as T =50 years.

Table 3.16.1.4.2

Nos.	Structure	u, in mm/year
1	Top deck plating and wing wall plating above margin line	0,04
2	Safety deck plating	0,08[1]
3	Wing wall bottom of pontoon docks	0,08
4	Inner and outer wing wall plating from pontoon deck to the margin line	0,08[1]
5	Pontoon deck plating:	
5.1	in the middle portion	0,10
5.2	in the middle portion at ends over a length $0,1L_{p.d}$	0,12
6	Side plating and outer transverse wall plating of pontoon (pontoons):	
6.1	top (≤ 1,0 m) and bottom (≤ 0,5 m) strakes	0,09[1]
6.2	other strakes	0,08[1]
7	Bottom plating of pontoon (pontoons)	0,08[1,2]
8	Interior bulkheads of ballast compartments:	
8.1	bottom strake (≤ 0,5 м)	0,09
8.2	other strakes	0,08[1]

9	Framing members, dock truss items in ballast compartments	0,10[1]
10	Plates and framing members of internal wing structures above safety deck, top deck and wing wall framing	0,04
[1] In way of compartments heated in winter by live steam, u shall be increased by 10 %. [2] For bottom plating in way of ballast system suctions and discharges, u shall be increased by 15 %.		

3.16.1.4.3 Average annual thickness reduction of dock structures plates and beams, given in Table 3.16.1.4.2, shall be used when dock structures have appropriate protective paint coatings.

Specified corrosion rates may be reduced if special protective arrangements are used in agrrement with the Register.

3.16.1.4.4 Thickness of primary members (including corrosion allowance) shall not be less than given in Table 3.16.1.4.4 and determined depending on the assumed spacing *a*.

Table 3.16.1.4.4

Structure	s_{min}, in mm	Remarks
Plating of outer structures other than pontoon deck; structural items in ballast compartments and tanks, including framing members	7,5	$a < 0,6$ m
	$7,5 + 10 \cdot (a - 0,6)$	$a \le 0,75$ m
	$8 + 6,5 \cdot (a - 0,6)$	$a > 0,75$ m
Pontoon deck plating	9,0	$a < 0,6$ m
	$9 + 13 \cdot (a - 0,6)$	$a \le 0,75$ m
	$10 + 6 \cdot (a - 0,6)$	$a > 0,75$ m
Top deck plating; plates and beams of structures above safety deck	$6,5 + 8 \cdot (a - 0,6)$	$a \ge 0,6$ m
	6,5	$a < 0,6$ m

3.16.1.5 Guidelines on design of floating dock structures.

When designing floating dock structures, the following sequence is recommended:

.1 execution of structural layout of pontoon (pontoons) and wing walls (refer to **3.16.2**);

.2 determination of design loads resulting in local and longitudinal deflection of dock hull structures (refer to **3.16.3**);

.3 design of plate items and framing members of dock structures on the basis of local strength and buckling, having regard to minimum thickness restrictions;

.4 design of structures which provide both transverse and longitudinal strength of dock pontoon. Values of structural parameters obtained in implementation of **3.16.1.5.3**, are used here as initial data;

.5 design of dock hull structures which provide dock longitudinal strength under design operating conditions (docking operations). Values of structural parameters obtained in implementation of **3.16.1.5.3** and **3.16.1.5.4**, are used here as initial data;

.6 design of structures, having regard to the requirements for strengthening (e.g. wing wall decks and sides in way of openings, engine room, etc.);

.7 check calculations of both longitudinal and transverse, as well as local strength of hull structures under conditions of real ship docking;

.8 check calculations of both longitudinal and transverse, as well as local strength of dock structures during passage from a place of build to a place of operation. Development of recommendations on dock structure strengthening.

3.16.2 Construction.

3.16.2.1 Framing systems of pontoon (pontoons) and wing walls.

For pontoon (pontoons) of caisson, pontoon and sectional docks transverse framing is preferable.

Wing wall sides and decks of pontoon docks with lifting capacities of 10 000 t and above shall be longitudinally framed; docks having lifting capacities below 10 000 t may be framed transversely.

Wing wall sides and decks of caisson docks above the safety deck shall be longitudinally framed, wing wall sides below the safety deck may be transversely framed.

For pontoon bottom plating portions of caisson docks in way of wing walls a longitudinal framing may be adopted.

For transverse and longitudinal bulkheads of the pontoon and wing walls structures with horizontal and vertical stiffeners are permitted.

Truss arrangements may be used in the pontoon (pontoons) and wing walls.

3.16.2.2 Structural layout of pontoons.

Plate and beam structures of the pontoon shall maintain local strength of the appropriate pontoon strucures (pontoon deck, bottom, longitudinal and transverse bulkheads, etc.), as well as transverse strength of the pontoon.

Spacing of primary longitudinal and transverse framing members of the pontoon shall be determined according to 1.1.3 with $L = L_{p.d}$.

Primary transverse structures of the pontoon (pontoons), i.e. non-tight bulkheads, shall be fitted in 3 to 7 spacings, but they shall not be spaced more than $(B - B_{p.d})/6$ apart.

A centreline bulkhead shall be fitted under the keel blocks. A box structure formed by two longitudinal bulkheads arranged symmetrically on each side of the centre line may be used in lieu of the centre line bulkhead.

Bulkheads or girders shall be aligned with inner wall sides.

Where transverse framing is adopted for a pontoon (pontoons), additional primary longitudinal supporting members may be fitted to limit a span of transverse members of the bottom and pontoon deck. They shall be spaced not more than 3 to 5 spacings apart.

3.16.2.3 Structural layout of wing walls.

Spacing of primary longitudinal and transverse framing members of wing walls shall be determined as required by **1.1.3**.

Where wall sides and decks are longitudinally framed, deck transverses and web frames shall be aligned with primary transverse structures of the pontoon (pontoons) (refer to **3.16.2.2**).

Where wall sides are transversely framed, side stringers shall be fitted. Spacing of stringers and distance between stringers and deck shall, in general, not exceed 3,5 m.

Where transverse framing is adopted for wing walls below the safety deck it is advisable to provide web frames on wall sides in line with primary transverse structures of the pontoon, and deck transverses on the safety deck plating.

Primary supporting members of outer and inner wall sides below the safety deck (web frames with longitudinal framing and side stringers with transverse framing) shall be connected by cross ties which shall be fitted in line with each primary transverse of the pontoon (refer to **3.16.2.2**).

3.16.2.4 Additional provisions.

Use of butt-lap connections for girders and transverses of pontoon (pontoons) and wing walls is permitted.

Where proper quality control of welding joints is provided, assembling joints aligned on plate structures and framing members are permitted.

Hollow square and tubular cross ties and struts shall not be used in ballast compartments and other tanks.

3.16.3 Design loads.

3.16.3.1 Loads for structure design based on local strength.

3.16.3.1.1 Design pressure p, in kPa, for plate and beam bottom structures shall be determined by the formulae:

in way of dry compartments

$$p = 10d_{m.s}; \qquad (3.16.3.1.1\text{-}1)$$

in way of ballast compartments not communicated with wing walls

$$p = 10(d_{m.s} - D_p); \qquad (3.16.3.1.1\text{-}2)$$

and communicated with wing walls

$$p = 10(d_{m.s} - z_{s.d} + \Delta z), \qquad (3.16.3.1.1\text{-}3)$$

where: $z_{s.d}$ – distance of the safety deck from the base line, in m;

Δz – thickness of air cushion, in m;

for D_p, $d_{m.s}$ – refer to **3.16.1.2**.

3.16.3.1.2 Design pressure p, in kPa, for plate and beam structures of the pontoon deck in way of dry and ballast compartments shall be determined by Formula (3.16.3.1.1-2).

3.16.3.1.3 Design pressure p, in kPa, for plate and beam structures of pontoon sides and end bulkheads shall be determined by the following formulae:

in way of dry compartments

$$p = 10(d_{m.s} - z_i), \qquad (3.16.3.1.3\text{-}1)$$

where: z_i – distance of the lower edge of the plate or midspan of the framing member from the base line, in m;

in way of ballast compartments

$$p = 10(d_0 - D_p), \qquad (3.16.3.1.3\text{-}2)$$

where: d_0 – depth of the dock corresponding to filling of a side ballast compartment up to the safety deck, in m; d_0 shall not be taken more than $d_{m.s}$.
As the first approximation, where no special information is available.
it may be assumed that:

$$d_0 = D_p + G/2L_{p.d}b_{p.d}\rho,$$

where: G – mass of dock without rest water and compensating ballast;
ρ – sea water density (refer to **1.1.3**);
For D_p, $d_{m.s}$, $L_{p.d}$, $b_{p.d}$ – refer to **3.16.1.2**.

3.16.3.1.4 Design pressure p, in kPa, for plate and beam structures of wall sides and end bulkheads shall be determined by the following formulae

in way of dry compartments, using Formula (3.16.3.1.3-1);

in way of ballast compartments

$$p = 10(d_0 - z_i), \qquad (3.16.3.1.4)$$

where for z_i, d_0 – refer to **3.16.3.1.3**.

3.16.3.1.5 Design pressure p, in kPa, for plate and beam structures of the safety deck in way of dry compartments shall be taken equal to 5 kPa; in way of ballast compartments p shall be determined by the formula

$$p = 10(d_{m.s} - z_{s.d} + \Delta z), \qquad (3.16.3.1.5)$$

for $z_{s.d}$, Δz, $d_{m.s}$ – refer to **3.16.3.1.1**.

3.16.3.1.6 Design pressure p, in kPa, for plate and beam structures of inner watertight bulkheads of ballast compartments shall be determined by the formula

$$p = 10(d_{m.s} - z_t + \Delta z), \qquad (3.16.3.1.6)$$

where: z_t – distance of ballast compartment top from the base line, in m;
Δz, d_m – as defined in **3.16.3.1.1**.

3.16.3.1.7 Design pressure p, in kPa, for plate and beam structures of main watertight bulkheads shall be determined by Formula (3.16.3.1.3-1).

3.16.3.1.8 Design pressure for plate and beam structures of the top deck shall be equal to 5 kPa.

3.16.3.1.9 Design pressure p, in kPa, for plate and beam structures of fuel oil, lubricating oil, water and other tanks is determined by the following formulae:

when internal pressure is calculated

$$p = 10\rho_1(z_{a.p} - z_i), \qquad (3.16.3.1.9)$$

where: ρ_1 – density of liquid contained in the tank, in t/m^3;
$z_{a.p}$ – distance of the upper edge of the air pipe from the base line, in m;
when external pressure is calculated, Formula (3.16.3.1.3-1) shall be used;
for z_i – refer to **3.16.3.1.3**.

For plate structures arranged parallel to the base line, z_i is a distance of the plate structure from the base line.

3.16.3.1.10 Design pressure on crinoline structures is assumed to be equal to 5 kPa.

3.16.3.1.11 Design pressure on walkway structures is assumed to be equal to 3,5 kPa.

3.16.3.1.12 Design pressure on structures of safety deck, intermediate deck and platforms where equipment of the electric generating plant is arranged are assumed equal to 18 kPa; in way of accommodation and service spaces, 5 kPa.

3.16.3.2 Loads for structure design based on both transverse and longitudinal strength of pontoon (pontoons).

3.16.3.2.1 Design loads to be used in design of pontoon structures of caisson, pontoon and sectional docks shall be calculated for the condition when the ship of length L_s and weight equal to the maximum lifting capacity of the dock Δ is supported on the keel blocks symmetrically about the midship section of the dock. The draught of the dock shall correspond to the design one (refer to **3.16.1.2**), ballast water is considered evenly distributed over the length and breadth of the dock.

3.16.3.2.2 For pontoon and sectional docks an additional condition shall be considered for pontoons loaded by buoyancy forces the value of which corresponds to the condition specified in **3.16.3.2.1**, corrected for rest-water counterpressure and gravitational forces of light-dock weight components, opposite in direction.

Where no initial data are available, buoyancy force p, in kPa, may be determined by the formula

$$p = g\Delta / [B L_s - (n - 1)Ba_0], \qquad (3.16.3.2.2)$$

where: n – number of pontoons of pontoon docks or sections of sectional docks;
a_0 – distance between pontoons or sections, in m;
B, L_s, Δ - as defined in **3.16.1.2**.

3.16.3.2.3 Design length of the ship Ls shall be assumed equal to the length of the shortest ship whose docking weight is equal to the maximum lifting capacity of the dock, but not more than $0{,}9L_{p.d}$. For docks having lifting capacity more than 40 000 t, the design length of the ship L_s shall not be taken less than $0{,}9L_{p.d}$.

3.16.3.2.4 The weight curve of the ship shall be taken as a rectangle with a superimposed parabola of half the area of the rectangle. Linear docking load q_x, in kN/m, at the section distant at x forward and aft from the midship section shall be determined by the formula

$$q_x = \frac{g\Delta}{L_s\varphi}\left[1 - 3(1-\varphi)(2x/L_s)^2\right], \qquad (3.16.3.2.4)$$

where φ – block coefficient of ship weight curve.

For docks of 40 000 t lifting capacity and less block coefficient of the ship weight curve shall be assumed depending on a design ship type according to Table 3.16.3.2.4.

For docks above 40 000 t lifting capacity, φ = 0,8 shall be assumed.

Table 3.16.3.2.4

Type of ship	φ
Icebreakers Ships with engine room aft or semi-aft	0,67
Ships with engine room amidships	0,75 ÷ 0,8
Ships with engine room aft or semi-aft	1,0

3.16.3.2.5 Where it is intended to lift ships simultaneously on keel and side blocks, as well as where different cases of simultaneous docking of several ships are expected, they shall be taken into account in design of structures which provide both longitudinal and transverse strength of the pontoon. Design loads shall be determined using the procedures approved by the Register.

3.16.3.2.6 Design loads on end pontoons of pontoon and sectional docks or on the end portions of caisson docks and when ships with overhung ends are docked shall be specially considered by the Register.

3.16.3.3 Loads for design of structures based on longitudinal strength.

3.16.3.3.1 Design loads shall be determined for the following conditions:

dock's sagging when a ship having the shortest length L_s expected and a weight equal to the maximum lifting capacity of the dock Δ is lifted;

dock's hogging when a ship having the largest length L_s expected and a weight equal to the maximum lifting capacity of the dock Δ is lifted, or two or more ships installed in line and having a total weight equal to Δare docked.

Ballast water is considered to be evenly distributed over the entire length of the dock.

3.16.3.3.2 The form of ship weight curve is determined by Formula (3.16.3.2.4).

3.16.3.3.3 The design length of the shortest ship shall be as required by **3.16.3.2.3**.

The design length of the largest ship or a total length of several ships installed in line over the length of the dock shall not be less than $1{,}3L_{p.d}$.

3.16.3.3.4 The design block coefficient of the ship weight curve shall be assigned according to **3.16.3.2.4**, for hogging, $\varphi = 1{,}0$ shall be taken, unless expressly provided otherwise.

3.16.4 Scantlings of structural members.

3.16.4.1 The thickness requirements for plate structures based on local strength.

The plating thicknesses of pontoon (pontoons), wall sides, interior and outer watertight bulkheads, decks and platforms shall be determined by Formula (1.6.4.4) with $m = 22{,}4$ and $k_\sigma = 1{,}8$. A corrosion allowance shall be obtained according to the recommendations given in **3.16.1.4.** The design transverse pressure p is specified in **3.16 3.1**.

3.16.4.2 Scantling requirements for framing members based on local strength.

3.16.4.2.1 The section modulus of primary members shall be determined as required by **1.6.4.1**.

3.16.4.2.2 The net sectional area of girders and transverses, as well as sectional area of beams and longitudinals having a relationship $l/h \le 10$ (where l– design span, in m; h =web depth of a beam or longitudinal, in cm) shall be obtained from **1.6.4.3.**

3.16.4.2.3 The design pressure p shall be determined at a mid-span of framing members as required by **3.16.3.1**.

3.16.4.2.4 The design span l of framing members shall be selected in accordance with **1.6.3.1**.

3.16.4.2.5 Coefficients of permissible normal and shear stresses specified in 1.6.4.1 and 1.6.4.3 shall be assumed equal to $k_\sigma = 0{,}8$ and $k_\tau = 0{,}8$.

3.16.4.2.6 The factor ω_c, which takes account of framing member wear as given in 1.1.5.3 shall be taken with Δs according to **3.16.1.4**.

3.16.4.2.7 Factors of design bending moments m and shear forces n shall be assumed as follows:

$m = 12$ and $n = 0{,}5$ – for bottom transverse and longitudinal members, beams and longitudinals of the pontoon deck; for stiffeners of watertight transverse bulkheads with longitudinally framed bottom and pontoon deck; for stiffeners of interior watertight longitudinal bulkheads with transversely framed bottom and pontoon deck; for longitudinal framing members of wall sides and decks; for safety deck beams with transversely framed wall sides below the safety deck; for girders and transverses of bottom and pontoon deck and side stringers of outer and inner wall sides;

$m = 8$ і $n = 0{,}5$ – для стояків водонепроникних поперечних перегородок при поперечній системі набору днища і стапель-палуби; для стояків внутрішніх поздовжніх перегородок при поздовжній системі набору днища і стапель-палуби; для горизонтальних балок водонепроникних поперечних перегородок башт при поперечній системі набору стінок башт; для бімсів палуби безпеки при поздовжній системі набору стінок башт;

$m = 13$ and $n = 0{,}5$ – for wall deck and platform beams with transversely framed wall sides below the considered deck or platform; top deck or safety deck transverses;

$m = 11$ and $n = 0{,}6$ – for frames and web frames of the pontoon (pontoons), outer and inner wall sides.

3.16.4.2.8 The scantlings and structures of girders and transverses of the pontoon and wing walls shall satisfy the requirements of **1.7.3.3**. For girders and transverses of the wing walls above the safety deck the requirements for similar structures of dry cargo ships may be applied.

3.16.4.3 Requirements for cross ties, struts and braces.

3.16.4.3.1 The sectional area of cross ties and struts S, in cm^2, shall not be less than determined by a successive approximation method using Formula (2.9.4.1) with a design load $P = 0{,}5 \cdot (P_1 + P_2)$, in kN, and factor $k = 1{,}15$ (where $P_1 = p_1ac$, $P_2 = p_2ac$ – are maximum compressive forces acting at the ends of struts and cross ties; p1 and p2 are design pressures (refer to**3.16.3.1**), in kPa; a – distance between members supported by struts or cross ties, in m; c is half-sum of span lengths on each side of the strut or cross tie under consideration, in m).

As a first approximation, S may be taken as

$S = 0{,}11P$,

and the radius of gyration $i = \sqrt{I/S}$, n cm, may be estimated for a suitable section having this area (where I – minimum central moment of inertia, cm^4).

If the area determined by Formula (2.9.4.1) using this radius of gyration differs by more than 10 % from the first approximation, a second approximation calculation shall be made. The radius of gyration shall correspond to the mean area of the first and second approximation.

3.16.4.3.2 The web plates of cross ties and struts of channel or I sections shall be so selected that the ratio of the breadth to the thickness shall not exceed $42l/i$ or 40, whichever is the greater (where l is length of a cross tie or strut, in m).

For ordinary angle or channel sections, the ratio of the breadth to the thickness of the flanges shall not exceed $14l/i$ or 13, whichever is the greater.

For cross ties of fabricated sections or I sections cross ties, the ratio of the breadth to the thickness of face plates shall not exceed $28l/i$ or 25, whichever is the greater.

The thickness of cross tie or strut items shall not be less than 7,5 mm.

3.16.4.3.3 The scantlings of trusses shall be determined according to a procedure approved by the Register.

3.16.4.4 Additional local strength requirements for plates and beams.

If hull structures of the dock are subjected to the loads not covered by **3.16.3.1**, the scantlings of plates and beams shall be determined using the procedures approved by the Register.

3.16.4.5 Scantling requirements for primary transverse and longitudinal members of pontoon (pontoons).

3.16.4.5.1 The section modulus W, in cm^3, of the primary transverse and longitudinal members of the pontoon (pontoons) shall be determined by the formula

$$W = W' + \Delta W, \qquad (3.16.4.5.1\text{-}1)$$

where: W' – required section modulus of the end of the dock service life to be determined by the formula:

$$W' = M \cdot 10^3/(k_\sigma \sigma_n), \qquad (3.16.4.5.1\text{-}2)$$

M – = design bending moment, in kN.m (refer also to **3.16.4.5.6**);

ΔW – corrosion allowance to the section modulus to be determined by the formula

$$\Delta W = 100h\left[\Delta f_d + \frac{\Delta f_w}{6}(2-\beta)\right], \qquad (3.16.4.5.1\text{-}3)$$

where: h – web depth of members of the section under consideration, in m,

Δf_d, Δf_w – additions to the upper flange and web area of members, respectively, including corrosion allowances as based on the entire service life of the dock, in cm^2, determined by the formulae:

$\Delta f_d = 10\Delta s_d b_{e.f} + \Delta f_{fr}$;

$\Delta f_w = 10\Delta s_w h$;

$\Delta s_{d(w)} = u_{d(w)}\,T$ – reduction, in mm, of the plating thickness of the pontoon deck (member web) due to wear during service life of the dock T (years) with corrosion rate $u_{d(w)}$, in mm/year, according to Table 3.16.1.4.2;

$b_{e.f}$ – width of the effective flange (refer to **3.16.4.5.5**), in m;

Δf_{fr} – addition to the flange area of the member allowing for corrosion wear of framing members, to be taken as:

for framing members of tee sections or flat

$$\Delta f_{fr} = 0{,}1n(b_0+h_0)u_{fr}T; \qquad (3.16.4.5.1\text{-}4)$$

for framing members of bulb flat

$\Delta f_{fr} = 0{,}86 n f_0 u_{fr} T/s_0$; (3.16.4.5.1-5)

when addition Δf_{fr} is determined, results obtained in design of framing members based on local strength (refer to **3.16.4.2**) are used. Where the sectional area of members does not include primary members, $\Delta f_{fr} = 0$;

n – number of primary members over the breadth $b_{e.f}$;

b_0 and h_0 – face plate width and web depth of T-beam, respectively (for members of flat, $b_0 = 0$), in cm;

f_0 – area of isolated section;

s_0 – web thickness of bulb flat;

u_{fr}, specified corrosion rate for framing members of ballast compartments (refer to Table 3.16.1.4.2), in mm/year;

β – = factor dependent on web areas f'_w, of the upper f'_d and lower f'_b face plates, having regard to wear to the end of the service life, to be determined by the formula

$\beta = (2f'_d + f'_w)/(2f'_d + f'_w)$; (3.16.4.5.1-6)

β =1,0 – as a first approximation.

3.16.4.5.2 The sectional area of the web f_w, in cm^2, of primary transverse members of the pontoon (pontoons) shall be determined by the formula

$f_w = f'_w + \Delta f_w$, (3.16.4.5.2-1)

where: f'_w – specified sectional area, in cm2 , of the web to the end of the service life of the dock, to be determined by the formula

$f'_w = 10 N_x/(k_\tau \tau_n)$; (3.16.4.5.2-2)

where: N_x – designed shear force (refer to **3.16.4.5.7**), in kN;

for Δf_w – refer to **3.16.4.5.1**.

3.16.4.5.3 The scantlings of the truss (struts and braces) of the pontoon (pontoons) shall be adequate to take shear forces arising in longitudinal bending of the pontoon.

3.16.4.5.4 To be included in the design section of primary transverse members of the pontoon (pontoons) are all structural items which are continuous between the pontoon sides; design section of primary longitudinal members shall include all structural items which are continuous between the end bulkheads of the pontoon.

3.16.4.5.5 The width of the effective flanges of the primary transverse members $b_{e.f}$, in m, of the bottom and pontoon deck plating shall be taken as

$b_{e.f} = \min\{(B - b_{p.d})/6;\ c\}$, (3.16.4.5.5)

where c – average distance between the member under consideration and members on the right and on the left thereof, in m.

3.16.4.5.6 The design bending moments M_x and M_y, in kN. m, acting in transverse and longitudinal members at the middle of a continuous pontoon of a caisson dock (refer to Fig. 3.16.4.5.6-1) for the cases referred to in **3.16.3.2**, shall be determined by the formulae:

$M_x = q(B - b_{p.d})\, c_x \delta_1$; (3.16.4.5.6-1)

$M_y = q(B - b_{p.d})\, c_y \delta_2$, (3.16.4.5.6-2)

where: $q = g\Delta/L_s$ – average value of the linear load of the dock, in kN/m (L_s, Δ as defined in **3.16.3.2**);

B, $b_{p.d}$ – breadth of the dock and wing wall at the pontoon deck level;

c_x i c_y – distance between primary transverse and longitudinal members of the pontoon, respectively, as shown in Fig. 3.16.4.5.6-1, in m;

δ_1, δ_2 – factors to be obtained from the diagrams given in Fig. 3.16.4.5.6-2 and 3.16.4.5.6-3 as dependent on parameters

$L_s/L_{p.d}$, $n = L_{p.d}/(B - b_{p.d})$ and φ.

For pontoon and sectional docks, the design bending moment in design of primary transverse members M_x, in kN. m, shall be equal to the greater of the two values

$$M_x = 0{,}25q\,\frac{c_x}{\varphi}\,(B - b_{p.d})\left(1 - 0{,}5\varphi\,\frac{L_s}{L_{p.d}}\,\frac{B - b_{p.d}}{B}\right); \qquad (3.16.4.5.6\text{-}3)$$

$$M_x = 0{,}125pc_x(B - b_{p.d})^2 \qquad (3.16.4.5.6\text{-}4)$$

where for p – refer to **3.16.3.2.2**.

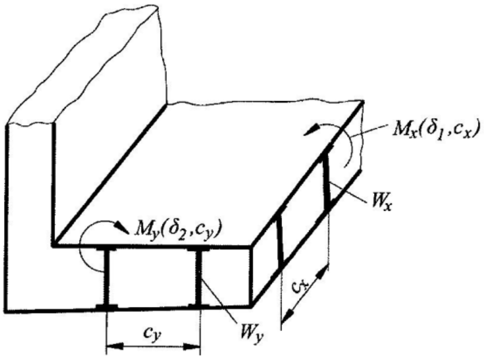


Fig.3.16.4.5.6-1

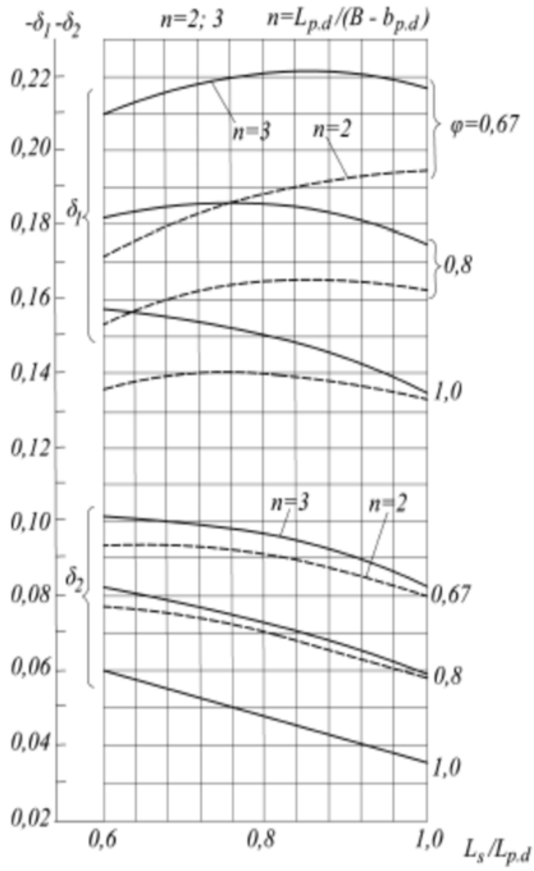


Fig.3.16.4.5.6-2

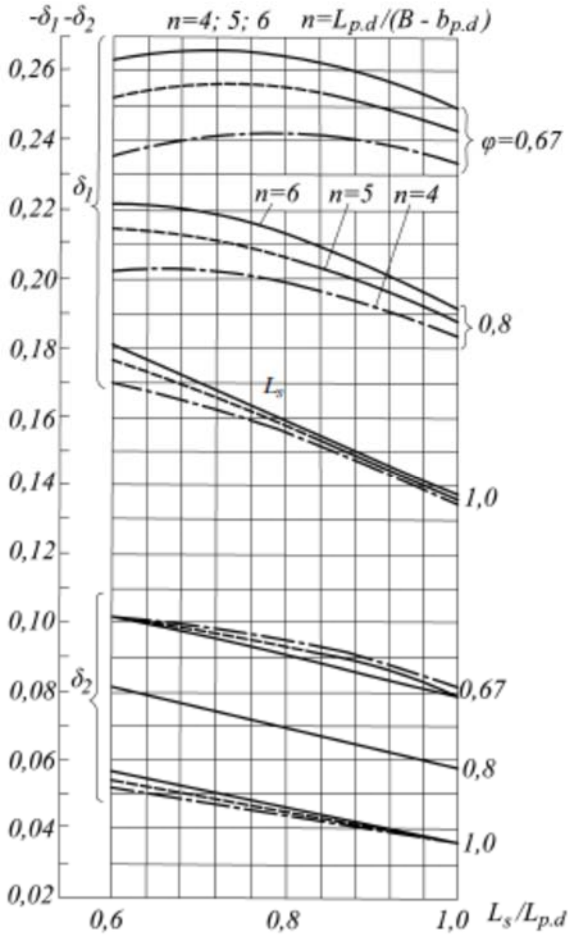


Fig.3.16.4.5.6-3

3.16.4.5.7 The design shear force N_x, in kN, taken by a transverse member of the dock (primary transverse member, or struts and braces of the pontoon truss) shall be determined by the formula

$$N_x = 0{,}75\,\frac{g\Delta}{L_s}\left(1 - 1{,}33\,\frac{L_s}{L_{p.d}}\,\frac{y}{B}\right)c,$$

(3.16.4.5.7-1)

where: y – distance of the section under consideration from the centreline of the dock, in m;

c – distance between the members under consideration, in m.

In design of the primary transverse members or struts and braces of the pontoon trusses of pontoon and sectional docks, the design shear force N_x, in kN, shall not be taken less than

$$N_x = pcy, \quad (3.16.4.5.7\text{-}2)$$

where p – as defined in **3.16.3.2.2.**

3.16.4.5.8 The coefficients of permissible stresses in Formulae (3.16.4.5.1-2) and (3.16.4.5.2-2) in design of primary transverse members of the pontoon (pontoons) shall be taken as follows: $k_\sigma = 0{,}85$; $k_\tau = 0{,}8$.

Guidelines on the selection of permissible normal stresses in primary longitudinal members of the pontoon of caisson-type docks are given in **3.16.4.6.4**.

3.16.4.5.9 The web thickness of primary transverse members shall meet the buckling strength requirements under the action of shear and normal stresses arising in transverse bending of the pontoon (pontoons).

The plating thickness of the pontoon deck and bottom shall meet the requirements for buckling strength under the action of compressive stresses arising in transverse bending of the pontoon (pontoons).

3.16.4.5.10 Buckling strength conditions shall comply with **1.6.5.2** and **1.6.5.3**. Factor k in Formula (**1.6.5.2**) is taken equal to 0,75.

When Euler's stresses are determined according to the formulae given in **1.6.5.5** it shall be taken that $s' = s - \Delta s$, where Δs is obtained in compliance with **3.16.1.4**.

3.16.4.6 The scantling requirements for structures based on strength and buckling conditions in longitudinal bending.

3.16.4.6.1 The assumed scantlings of dock longitudinal structures (with regard to the provisions of **3.16.4.6.2**) shall provide the required hull section modulus of the floating dock.

The hull section modulus W, in cm^3, of a floating dock shall not be less than

$$W = W'\,\omega_k. \quad (3.16.4.6.1\text{-}1)$$

where: W' – нормативний момент опору поперечного перерізу наприкінці строку служби доку, см^3, що визначається за формулою:

$$W' = M \cdot 10^3 / (k_\sigma\,\sigma_n), \quad (3.16.4.6.1\text{-}2)$$

where: M – maximum bending moment determined by Formula (3.1c.4.6.3), in kN·m;

ω_c – factor which takes account of corrosion allowance to the section modulus for wear determined by the formula

$$\omega_c = \left[1 - F^{-1}\sum_i \Delta f_i \varphi_i\right]^{-1}; \quad (3.16.4.6.1\text{-}3)$$

F – sectional area of the floating dock hull, in cm^2, corresponding to the required section modulus;

Δf_i – addition to the sectional area of the i-th plate strake, which takes account of corrosion allowance to be determined by the formula

$$\Delta f_i = 10\Delta s_i\, b_i, \quad (3.16.4.6.1\text{-}4)$$

$\Delta s_i = u_i T$ – thickness reduction of the i-th plate member due to wear during service life T (years), with a corrosion rate u_i, in mm/year, taken according to Table 3.12.1.4.2, in mm;

b_i – width of the i-th member, in m.

Additions to the sectional area of the floating dock hull which take account of corrosive wear of framing members shall be not less than those determined by the following formulae:

for framing members of tee sections or flat

$$\Delta f_i = 0{,}1 n_i\,(b_{0i} + h_{0i})\,u_{fri}T, \quad (3.16.4.6.1\text{-}5)$$

where: n_i – number of framing members of the i-th group;

b_{0i}, h_{0i} – face plate width and web depth of T-beam, respectively, in cm (for members of flat, b_{0i} = 0);

for framing members of bulb flat

$\Delta f_i = 0{,}86 n_i f_{0i} u_{fri} T / s_{0i}$, (3.16.4.6.1-6)

where: f_{0i} – sectional area of bulb flat section proper, in cm^2;

u_{fri} – corrosion rate of framing members of the i-th group, in mm/year;

s_{0i} – web thickness of bulb flat;

φ_i – multiplier taking account of the effect of changing sectional area of the *i*-th member on the section modulus *W*, to be determined by the formula

$\varphi_i = c_i^2 (F/I) + c_i / z_0$, (3.16.4.6.1-7)

where: *I* – hull inertia moment, in cm^2/m^2, of the dock, corresponding to the required section modulus;

z_0, c_i – distance of the point at the level of which section modulus is determined and centre of gravity of sectional area of the *i*-th member (*i*-th group of longitudinal members) from the neutral axis, the position of which corresponds to *W* and *I*; in determination of z_0 and c_i their sign shall be taken into account: positive downwards and negative upwards from the neutral axis.

3.16.4.6.2 Wing wall and pontoon longitudinals continuous in the middle region of the dock shall be included in the design cross-section of a caisson-type floating dock.

To be included in the design section of a pontoon dock are wing wall longitudinals continuous in the middle region of the dock.

3.16.4.6.3 The design bending moment *M*, in kNm, shall be determined for the cases referred to in 3.16.4.3, by the formula

$$M = -0{,}125 q \Delta L_{p.d} \left(1 - \frac{3\varphi - 1}{2\varphi} \frac{L_s}{L_{p.d}}\right) . \quad (3.16.4.6.3)$$

Рекомендації щодо вибору розрахункових значень φ and L_s are given in **3.16.3.3.2**.

3.16.4.6.4 The coefficient of permissible stresses due to longitudinal bending referred to in Formula (3.16.4.6.1-2) shall be taken as k_σ = 1,0.

3.16.4.6.5 For caisson-type docks the following condition shall be fulfilled:

$\sigma_1 + \sigma_2 \le k_\sigma \sigma_n$, (3.16.4.6.5-1)

д where е: σ_1 – stresses in primary longitudinal members of the pontoon due to longitudinal bending of the dock;

σ_2 – stresses in primary longitudinal members of the pontoon due to longitudinal bending of the pontoon.

Stresses σ_1, in MPa, shall be determined by the formula:

$\sigma_1 = Mz \cdot 10^5 / I'$, (3.16.4.6.5-2)

where: *M* – as defined in **3.16.4.6.3**;

z – distance of the point under consideration from the neutral axis of the dock, in m;

I' – inertia moment of the dock to the end of the service life, in cm^4.

Stresses σ_2, in MPa, shall be determined by the formula:

$\sigma_2 = M_y z' \cdot 10^5 / I_y'$, (3.16.4.6.5-3)

where M_y – as defined in **3.16.4.5.6**;

z' – distance of the point under consideration from the neutral axis of the section of the primary longitudinal, in m;

I_y' – inertia moment of primary longitudinal, determined with regard to the wear of the members to the end of the service life of the dock and provisions of **3.16.4.5.4**, in cm^4.

3.16.4.6.6 In design of the dock hull, the requirements for buckling strength under the action of longitudinal bending of plate structures, girders and longitudinals, such as wall sides and deck plating, shell plating, longitudinal bulkhead plating of the pontoon and pontoon deck plating of caisson-type docks, bottom shell of pontoon dock wings shall be met in the middle region within $0{,}4L_{p.d}$.

The scantlings of top deck beams where transverse framing is adopted, top deck transverses in case of longitudinal framing shall be adequate to provide buckling strength of deck structure portions between deck girders, deck girders and wall sides or between wall sides where deck girders are omitted.

3.16.4.6.7 The design compressive stresses σ_{c_i}, in MPa, obtained in estimation of the buckling strength shall be not less than:

$$\sigma_{c_i} = \frac{M}{I'} z_i \cdot 10^5, \qquad (3.16.4.6.7\text{-}1)$$

where: M – = design bending moment causing the compression of the i-th member under consideration (refer to **3.16.4.6.3**), in kNm;

I' – actual central inertia moment of the hull girder with regard to wear to the end of the service life, in cm^4;

z_i – distance of the member under consideration from the neutral axis, in m (z_i is measured from the edge most distant from the neutral axis for a plate structure; from the middle of the thickness of the effective flange for a beam member of the deck and bottom; from the middle of the thickness of the beam web for a beam of the wall side, side plating and longitudinal bulkhead of the pontoon).

As a first approximation I', in cm^4, may be determined by the formula:

$$I' = W'_d (D_0 - e) \cdot 10^2, \qquad (3.16.4.6.7\text{-}2)$$

where: W'_d – required section modulus of the hull girder at a level of the lower edge of the top deck plating determined according to the requirements of, in cm^3;

D_0 – depth of wing walls (for pontoon docks), in m;

$D_0 = D$ – for caisson-type docks;

e – distance of the neutral axis from the base line for caisson-type docks; distance of the neutral axis from the abutment line of the pontoon deck to the inner wall sides for pontoon docks, in m.

As a first approximation, it may be assumed that:

$e = 0{,}32D$ – for caisson-type docks;

$e = 0{,}5D_0$ – for pontoon docks;

3.16.4.6.8 The buckling strength conditions shall comply with **1.6.5.2** and **1.6.5.3**. Factor k in Formula (1.6.5.2-1) shall be taken equal to 0,8 for the top deck plating and wall sides; for the bottom and side plating of the pontoon and pontoon deck plating of caisson-type docks, girders and longitudinals.

3.16.4.6.9 Euler stresses for plate structures shall be determined according to **1.6.5.5**, and for girders and longitudinals as required by **1.6.5.4** taking $s' = s - \Delta s$, where Δs is obtained as given in **3.16.1.4**.

3.16.4.6.10 The inertia moment of beams of the transversely framed top deck shall meet the requirements of **2.6.4.3**.

The inertia moment of top deck transverses shall be as required by **2.6.4.9**.

3.16.4.6.11 The assumed scantlings of wing wall structures shall provide buckling strength in simple bending of the wing wall in design cases of dock sagging. The procedure of supporting buckling strength in simple bending shall be agreed with the Register.

3.16.4.7 Requirements for dock towing.

3.16.4.7.1 The minimum section modulus $W_{\min}$, in cm^3, required to ensure the strength of the dock during towing shall be determined by the formula:

$$W_{\min} = \frac{M}{\sigma_{perm}} \cdot 10^3, \qquad (3.16.4.7.1\text{-}1)$$

where: M – design bending moment, in kN·m, determined by the formula:

$$M = 5{,}03 k_w h_d B L^2_{p.d}, \qquad (3.16.4.7.1\text{-}2)$$

where: k_w – factor of wave bending moment determined by the formula:

$$k_w = 7{,}93 \cdot 10^{-3} + 4{,}13 \cdot 10^{-3} (L_{p.d}/B) - 0{,}125 (d_{tow}/L_{p.d}); \qquad (3.16.4.7.1\text{-}3)$$

where: d_{tow} – dock draught amidships during voyage in tow, in m;

h_d – design wave height, in m, determined depending on the length of the dock:

$$h_p = 10{,}9 - \left(\frac{300 - L_{p.d}}{100}\right)^2$$ for $L_{p.d} < 300$ m; (3.16.4.7.1-4)

$H_d = 10{,}9$ for $L_{p.d} \geq 300$ m;

σ_{perm} – permissible normal stresses in longitudinal bending of the dock, in MPa, taken equal to:
150 – for docks under 100 m in length;
150 + 0,75($L_{p.d}$ –100) – for docks between 100 and 200 m in length;
225 – for docks over 200 m in length.

3.16.4.7.2 The still water bending moment M, in kN·m, in the midship section of the dock during the voyage in tow shall be reduced to the minimum possible level by suitable ballasting.

3.16.4.7.3 Sea state considered permissible for voyage in tow is that corresponding to a wave height of 3 per cent probability of exceeding level $h_{3\%}$, in m, determined by the formula:

$$h_{3\%} = h^0_{3\%} + m(\lambda_1^2 / \lambda_2^2 - 1)\,, \quad (3.16.4.7.3\text{-}1)$$

де: $h^0_{3\%}$ – rated wave height, in m, permissible for voyage of a floating dock, with a relationship $L_{p.d}/B$ =4,25, determined by the formulae:

$h^0_{3\%}$ = 0,313+ 0,0438 $L_{p.d}$, for $L_{p.d} < 130$ m;
$h^0_{3\%}$ = 3,10+ 0, $L_{p.d}$, for 130м ≤ $L_{p.d}$ ≤ 260 m; (3.16.4.7.3-2)
$h^0_{3\%}$ = 0,422 + 0, $L_{p.d}$, for $L_{p.d} > 260$ m;

m – factor determined by the formulae:

m = 0,483 + 0,0218 $L_{p.d}$, for $L_{p.d} < 130$ m;
m = 2,42 + 0,00685 $L_{p.d}$, for 130м ≤ $L_{p.d}$ ≤ 260 m; (3.16.4.7.3-3)
m = 0,356 + 0,0148 $L_{p.d}$, for $L_{p.d} > 260$ m;

factors λ_1 and λ_2 are determined by the formulae:

$\lambda_1 = M/M^0$;
$\lambda_2 = 1{,}276 - 0{,}065(L_{сп}/B)$; (3.16.4.7.3-4)

where: M^0 – basic bending moment, in kNm, determined by the formula:

$$M^0 = 0{,}77 \cdot 10^{-2} L_{p.d}^{3{,}65} / \eta\,; \quad (3.16.4.7.3\text{-}5)$$

where for η – refer to **1.1.4.3**,

M – bending moment, in kNm, corresponding to the actual section modulus of the floating dock hull, determined by the formula:

$M = k_\sigma \sigma_n W \cdot 10^{-3}$; (3.16.4.7.3-6)

W – actual minimum section modulus of the dock hull to the moment of voyage;
k_σ = 0,8 – is a factor of permissible normal stresses;
σ_n – as defined in **1.1.4.3**.

3.16.4.7.4 Correspondence between permissible sea state during voyage and waves heights of 3 % probability of exceeding level shall be determined according to Table 3.16.4.7.4.

Table 3.16.4.7.4

Permissible sea state	$h_{3\%}$
5	2,0 ÷ 3,5
6	3,5 ÷ 6,0
7	6,0 ÷ 8,5
8	8,5 ÷ 11,0
9	11,0

3.16.4.7.5 A possibility of voyage of a dock in tow whose architecture and relationships of the dimensions differ from those referred to in **3.16.1.1** shall be supported using the procedure agreed with the Register..

3.16.4.7.6 Voyage of a dock in tow within the limits of one and the same sea is permitted when the environmental conditions (sea state) corresponding to the requirements of **3.16.4.7.3** ÷ **3.16.4.7.5** are expected.

3.17 TUGS – PUSHERS, PUSHED BARGES

3.17.1 The requirements of this paragraph apply to tugs - pushers, pushed barges of all purposes of mixed "sea - river" navigation with sign **R3-RS** in the ship's class notation**.**

3.17.2 In addition to the requirements of **3.9** and Sections **1** and **2**, the hull structure of the tugs - pushers and pushed barges shall comply with additional requirementsof **3.7.3**, **3.7.4**, Part II "Hull" of the Rules for the classification and construction of mixed navigation ships.

APPENDIX 1

TESTING PROCEDURES OF WATERTIGHT COMPARTMENTS.

Part A _ Ships Covered by SOLAS (SOLAS Ships)

1. GENERAL

1.1 These test procedures shall confirm the watertightness of tanks and watertight boundaries and the structural adequacy of tanks which consist of the watertight subdivisions[1] of ships. These procedures may also be applied to verify the weathertightness of structures and shipboard outfitting. The tightness of all tanks and watertight boundaries of ships during new construction and those relevant to major conversions or major repairs2 shall be confirmed by these test procedures prior to the delivery of the ship.

1.2 Testing procedures of watertight compartments for SOLAS ships (including bulk carriers and oil tankers covered by the requirements of Part XVII «General rules for the construction of bulk carriers and oil tankers» (hereinafter – oil tankers and bulk carriers, built on the IMO targeted standards)), shall be carried out in accordance with Part A of this Appendix, unless:

a) the shipyard provides documentary evidence of the shipowner's agreement to a request to the Administration for an exemption from the application of SOLAS Chapter **II-1**, regulation **11**, or for an equivalency agreeing that the content of Part B is equivalent to SOLAS Chapter **II-1**, regulation **11**; and

b) the above-mentioned exemption/equivalency has been granted by the responsible Administration.

[1] Watertight subdivision means the transverse and longitudinal subdivisions of the ship required to satisfy the subdivision requirements of SOLAS Chapter **II-1**.

[2] Major repair means a repair affecting structural integrity.

2. APPLICATION

All gravity tanks and other boundaries required to be watertight or weathertight shall be tested in accordance with this Appendix and proven to be tight and structurally adequate as follows:

gravity tanks for their tightness and structural adequacy;

watertight boundaries other than tank boundaries for their watertightness; and

weathertight boundaries for their weathertightness.

The testing of cargo containment systems of liquefied gas carriers shall be in accordance with the testing requirements in **4.21** - **4.26** of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code) and standards deemed appropriate by the Register.

Tests of structures not listed in Table 4.1-1 or Table 4.1-2 should be considered separately.

Note.

Gravity tank means a tank that is subject to vapour pressure not greater than 70 kPa.

3. TEST TYPES AND DEFINITIONS

3.1 The following two types of tests are specified in this Appendix:

Structural test is a test to verify the structural adequacy of tank construction. This may be a hydrostatic test or, where the situation warrants, a hydropneumatic test;

Leak test is a test to verify the tightness of a boundary.

Unless a specific test is indicated, this may be a hydrostatic/hydropneumatic test or an air test. A hose test may be considered an acceptable form of leak test for certain boundaries, as indicated by Footnote 9 of Table 4.1-1.

3.2 Definition of each type of test is given in Table 3.2.

Table 3.2

Test types	Test procedures
Hydrostatic test: (Leak and structural)	A test wherein a space is filled with a liquid to a specified head.
Hydropneumatic test: (Leak and structural)	A test combining a hydrostatic test and an air test, wherein a space is partially filled with a liquid and pressurized with air.
Hose test: (Leak)	A test to verify the tightness of a joint by a jet of water with the joint visible from the opposite side.
Air tests: (Leak)	A test to verify tightness by means of air pressure differential and leak indicating solution. It includes tank air test and joint air tests, such as compressed air fillet weld tests and vacuum box tests.
Compressed air fillet weld test: (Leak)	An air test of fillet welded tee joints wherein leak indicating solution is applied on fillet welds.
Vacuum box test: (Leak)	A box over a joint with leak indicating solution applied on the welds. A vacuum is created inside the box to detect any leaks.
Ultrasonic test: (Leak)	A test to verify the tightness of the sealing of closing devices such as hatch covers by means of ultrasonic detection techniques.
Penetration test: (Leak)	A test to verify that no visual dye penetrant indications of potential continuous leakages exist in the boundaries of a compartment by means of low surface tension liquids (i.e. dye penetrant test).

4. TEST PROCEDURES

4.1 General.

Tests shall be carried out in the presence of the Register surveyor at a stage sufficiently close to the completion of work with all hatches, doors, windows, etc., installed and all penetrations including pipe connections fitted, and before any ceiling and cement work is applied over the joints.

Specific test requirements are given in **4.4**, Tables 4.1-1 and 4.1-2.

For the timing of the application of coating and the provision of safe access to joints, refer to **4.5**, **4.6** and Table 4.1-3.

Table 4.1-1 **Test requirements for tanks and boundaries**

Nos.	Tank or boundary to be tested	Test type	Test head or pressure	Remarks
1	2	3	4	5
1	Double bottom tanks[1]	Leak and structural[2]	The greater of: top of the overflow; or to 2,4 m above top of tank[3] ; or to bulkhead deck	
2	Double bottom voids[4]	Leak	Refer to **4.4.4** through 4.4.6, as applicable	Including pump room double bottom and bunker tank protection double hull required by MARPOL Annex **I**
3	Double side tanks	Leak and structural[2]	The greater of: top of the overflow, to 2,4 m above top of tank[3] ; or to bulkhead deck	
4	Double side voids	Leak	Refer to **4.4.4** through 4.4.6, as applicable	
5	Deep tanks other than those listed elsewhere in this table	Leak and structural[2]	The greater of: top of the overflow; or to 2,4 m above top of tank[3]	
6	Cargo oil tanks	Leak and structural[2]	The greater of: top of the overflow; or to 2,4 m above top of tank[3] ; or to top of tank[3] plus setting of any pressure relief valve	
7	Ballast hold of bulk carriers	Leak and structural[2]	Top of cargo hatch coaming	
8	Peak tanks	Leak and structural[2]	The greater of: top of the overflow; or to 2,4 m above top of tank[3]	After peak to be tested after installation of stern tube
9	**.1** Fore peak spaces with equipment	Leak	Refer to **4.4.4** through **4.4.6**, as applicable	
	.2 Fore peak voids	Leak	Refer to **4.4.4** through **4.4.6**, as applicable	
	.3 Aft peak spaces with equipment	Leak	Refer to **4.4.3** through **4.4.6**, as applicable	

Continue of Table 4.1-1

Nos.	Tank or boundary to be tested	Test type	Test head or pressure	Remarks
1	2	3	4	5
9	**.4** Aft peak voids	Leak	Refer to **4.4.3** through **4.4.6**, as applicable	After peak to be tested after installation of stern tube
10	Cofferdams	Leak	Refer to **4.4.3** through **4.4.6**, as applicable	
11	**.1** Watertight bulkheads	Leak [6]	Refer to **4.4.3** through **4.4.6**, as applicable	
	.2 Superstructure end bulkheads	Leak	Refer to **4.4.3** through **4.4.6**, as applicable	
12	Watertight doors below freeboard or bulkhead deck	Leak [7,8]	Refer to **4.4.3** through **4.4.6**, as applicable	
13	Double plate rudder blades	Leak	Refer to **4.4.4** through **4.4.6**, as applicable	
14	Shaft tunnels clear of deep tanks	Leak [9]	Refer to **4.4.3** through **4.4.6**, as applicable	
15	Shell doors	Leak [9]	Refer to **4.4.3** through **4.4.6**, as applicable	
16	Weathertight hatch covers and closing appliances	Leak [7,9]	Refer to **4.4.3** through **4.4.6**, as applicable	Hatch covers closed by tarpaulins and battens excluded
17	Dual purpose tanks/dry cargo hatch covers	Leak [7,9]	Refer to **4.4.3** through **4.4.6**, as applicable	In addition to structural test in item 6 or 7
18	Chain lockers	Leak and structural[2]	Top of chain pipe	
19	Lubricating oil sump. tanks and other similar tanks/spaces under main engines	Leak [5]	Refer to **4.4.3** through **4.4.6**, as applicable	
20	Ballast ducts	Leak and structural[2]	The greater of: ballast pump maximum pressure; or setting of any pressure relief valve	
21	Fuel oil tanks	Leak and structural[2]	The greater of: top of the overflow; or to 2,4 m above top of tank[3] ; or to top of tank[3] plus setting of any pressure relief valves; or to bulkhead deck	
22	Sea chests and ice boxes	Leak and structural[1,2]	The greater of: head to 1,25 m depthwise; or equal to blow system pressure	When testing ice boxes fitted with steam heating system, the test head shall in any case be below the heating system design pressure. Where air pipes are led through ice boxes and sea chests, the tests are carried out by applying the hydraulic head to top of the overflow

[1] Including tanks arranged in accordance with the provisions of SOLAS regulation **II-1/9.4**.

[2] Refer to **4.2.2**.

[3] The top of a tank is the deck forming the top of the tank, excluding any hatchways.

[4] Including duct keels and dry compartments arranged in accordance with the provisions of SOLAS regulation **II-1/11.2** and **II-1/9.4** respectively, and/or oil fuel tank protection and pump room bottom protection arranged in accordance with the provisions of MARPOL Annex **I**, Chapter **3**, Part A regulation **12** and Chapter **4**, Part A, regulation **22** respectively.

[5] Where lubricating oil sump tanks and other similar spaces under main engines intended to hold liquid form part of the watertight subdivision of the ship, they shall be tested as per the requirements of item 5 "Deep tanks other than those listed elsewhere in this table".

[6] A "Leak and structural test", refer to **4.2.2** shall be carried out for a representative cargo hold if intended for in-port ballasting. The filling level requirement for testing cargo holds intended for in-port ballasting shall be the maximum loading that will occur in-port as indicated in the Loading Manual.

[7]As an alternative to the hose testing, other testing methods listed in **4.4.7** through **4.4.9** may be applicable subject to adequacy of such testing methods being verified. Refer to SOLAS regulation **II-l/11.1**. For watertight bulkheads (refer to **11.1**) alternatives to the hose testing may only be used where a hose test is not practicable.

[8]Where water tightness of a watertight door has not been confirmed by prototype test, testing by filling watertight spaces with water shall be carried out. Refer to SOLAS regulation **II-1/16.2**.

[9]Hose test may also be considered as a medium of the test. Refer to **3.2**.

Table 4.1-2 **Additional test requirements for special service ships/tanks**

Nos.	Type of ship/tank	Structures to be tested	Type of tes	Test head or pressure	Remarks
1	2	3	4	5	6
1	Liquefied gas carriers[3]	Integral tanks	Leak and structural	Refer to IACS UR Gl	
		Hull structure supporting membrane or semimembrane tanks	Refer to IACS UR Gl	Refer to IACS UR Gl	
		Independent tanks type A	Refer to IACS UR Gl	Refer to IACS UR Gl	
		Independent tanks type B	Refer to IACS UR Gl	Refer to IACS UR Gl	
		Independent tanks type C	Refer to IACS UR G2	Refer to IACS UR G2	
2	Edible liquid tanks	Independent tanks	Leak and structural [1]	Напір стовпа води: до верху повітряної труби; або на від стань 0,9 м вище верхньої границі цистерни, в залежності від того, що більше	
3	Chemical tankers[4]	Integral or independent cargo tanks	Leak and structural [1]	The greater of: to 2.4 m above top of tank[2] ; or to top of tank[2] plus setting of any pressure relief valve	Where a cargo tanks is designed for the carriage of cargoes with specific gravities larger than 1,0[3], an appropriate additional head shall be considered

[1] Refer to **4.2.2**.
[2] Top of tank is deck forming the top of the tank excluding any hatchways.
[3] Type of cargo tanks in accordance with The International **Code** for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (*IGC Code*).
[4] Type of cargo tanks in accordance with The International **Code** for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (*IBC Code*).

Table 4.1-3 **Application of leak test, coating and provision of safe access for type of welded joints**

Type of welded joints		Leak test	Coating[1]		Safe access[2]	
			Before leak test	After leak test but before structural test	Leak test	Structural test
1	2	3	4	5	6	7
Butt	Automatic	Not required	Allowed[3]	Не застосовується	Not required	Not required
	Manual or semiautomatic[4]	Required	Not allowed	Allowed	Required	Not required
Fillet	Boundary including penetrations	Required	Not allowed	Allowed	Required	Not required

[1] Coating refers to internal (tank/hold coating), where applied, and external (shell/deck) painting. It does not refer to shop primer.
[2] Temporary means of access for verification of the leak test.
[3] The condition applies provided that the welds have been carefully inspected visually to the satisfaction of the Register surveyor.
[4] Flux core arc welding (FCAW) semiautomatic butt welds need not be tested provided that careful visual inspections show continuous uniform weld profile shape, free from repairs, and the results of NDT show no significant defects.

4.2 Structural test procedures.

4.2.1 Type and time of test.

Where a structural test is specified in Table 4.1-1 or 4.1-2, a hydrostatic test in accordance with **4.4.1** will be acceptable. Where practical limitations (strength of building berth, light density of liquid, etc.) prevent the performance of a hydrostatic test, a hydropneumatic test in accordance with **4.4.2** may be accepted instead**.**

A hydrostatic test or hydropneumatic test for the confirmation of structural adequacy may be carried out while the ship is afloat, provided the results of a leak test are confirmed to be satisfactory before the ship is afloat.

4.2.2 Testing schedule for new construction or major structural conversion.

4.2.2.1 Tanks which are intended to hold liquids, and which form part of the watertight subdivision of the ship[1] , hall be tested for tightness and structural strength as indicated in Table 4.1-1 and 4.1-2.

4.2.2.2 The tank boundaries shall be tested from at least one side. The tanks for structural test shall be selected so that all representative structural members are tested for the expected tension and compression.

4.2.2.3 The watertight boundaries of spaces other than tanks for structural testing may be exempted, provided that the watertightness of boundaries of exempted spaces is verified by leak tests and inspections. Structural testing may not be exempt and the requirements for structural testing of tanks in 4.2.2.1 _ 4.2.2.2 shall apply, for ballast holds, chain lockers and a representative cargo hold if intended for in-port ballasting.

4.2.2.4 Tanks which do not form part of the watertight subdivision of the ship1 , may be exempted from structural testing provided that the watertightness of boundaries of exempted spaces is verified by leak tests and inspections.

[1] Watertight subdivision means the transverse and longitudinal subdivisions of the ship required to satisfy the subdivision requirements of SOLAS Chapter **II-1**.

4.3 Leak test procedures.

For the leak tests specified in Table 4.1-1, tank air tests, compressed air fillet weld tests, vacuum box tests in accordance with **4.4.4** through **4.4.6**, or their combination, will be acceptable. Hydrostatic or hydropneumatic tests may also be accepted as leak tests provided that **4.5**, **4.6** and **4.7** are complied with. Hose tests will also be acceptable for such locations as specified in Table 4.1-1, Footnote [9], in accordance with **4.4.3**.

The application of the leak test for each type of welded joint is specified in Table 4.1-3.

Air tests of joints may be carried out in the block stage provided that all work on the block that may affect the tightness of a joint is completed before the test. Refer also to **4.5.1** for the application of final coatings and **4.6** for the safe access to joints and the summary in Table 4.1-3.

4.4 Tests methods.

4.4.1 Hydrostatic test.

Unless another liquid is approved, hydrostatic tests shall consist of filling the space with fresh water or sea water, whichever is appropriate for testing, to the level specified in Table 4.1-1 or 4.1-2. Refer also to 4.7.

In cases where a tank is designed for cargo densities greater than sea water and testing is with fresh water or sea water, the testing pressure height shall simulate the actual loading for those greater cargo densities as far as practicable.

All external surfaces of the tested space shall be examined for structural distortion, bulging and buckling, other related damage and leaks.

4.4.2 Hydropneumatic test.

Hydropneumatic tests, where approved, shall be such that the test condition, in conjunction with the approved liquid level and supplemental air pressure, will simulate the actual loading as far as practicable.

The requirements and recommendations for tank air tests in **4.4.4** will also apply to hydropneumatic tests. Refer also to **4.7**.

All external surfaces of the tested space shall be examined for structural distortion, bulging and buckling, other related damage and leaks.

4.4.3 Hose test.

Hose tests shall be carried out with the pressure in the hose nozzle maintained at least at $2\cdot10^5$ Pa during the test. The nozzle shall have a minimum inside diameter of 12 mm and be at a perpendicular distance from the joint not exceeding 1,5 m. The water jet shall impinge directly upon the weld.

Where a hose test is not practical because of possible damage to machinery, electrical equipment insulation or outfitting items, it may be replaced by a careful visual examination of welded connections, supported where necessary by means such as a dye penetrant test or ultrasonic leak test or the equivalent.

4.4.4 Tank air tes.

All boundary welds, erection joints and penetrations, including pipe connections, shall be examined in accordance with the approved procedure and under a stabilized pressure differential above atmospheric pressure not less than $0{,}15\cdot10^5$ Pa, with a leak indicating solution such as soapy water/detergent or a proprietary brand applied.

A U-tube with a height sufficient to hold a head of water corresponding to the required test pressure shall be arranged. The cross sectional area of the U-tube shall not be less than that of the pipe supplying air to the tank. Instead of using a U-tube, two calibrated pressure gauges may be acceptable to verify required test pressure. Arrangements involving the use of two calibrated pressure gauges to verify the required test pressure may be accepted taking into account the provisions in **F5.1** and **F7.4** of IACS recommendation No. 140 "Recommendation for Safe Precautions during Survey and Testing of Pressurized Systems".

A double inspection shall be made of tested welds. The first is to be immediately upon applying the leak indication solution; the second shall be after approximately four or five minutes in order to detect those smaller leaks which may take time to appear.

4.4.5 Compressed air fillet weld test.

In this air test, compressed air is injected from one end of a fillet welded joint and the pressure verified at the other end of the joint by a pressure gauge. Pressure gauges shall be arranged so that an air pressure of at least $0{,}15\cdot10^5$ Pa can be verified at each end of all passages within the portion being tested.

Note.

Where a leak test is required for fabrication involving partial penetration welds, a compressed air test shall also be applied in the same manner as to fillet weld where the root face is large, i.e. 6 - 8 mm.

4.4.6 Vacuum box test.

A box (vacuum testing box) with air connections, gauges and an inspection window is placed over the joint with a leak indicating solution applied to the weld cap vicinity. The air within the box is removed by an ejector to create a vacuum of $0{,}20\cdot10^5$ - $0{,}26\cdot10^5$ Pa inside the box.

4.4.7 Utrasonic test.

An ultrasonic echoes transmitter shall be arranged inside of a compartment and a receiver shall be arranged on the outside. The watertight/weathertight boundaries of the compartment are scanned with the receiver in order to detect an ultrasonic leak indication. A location where sound is detectable by the receiver indicates a leakage in the sealing of the compartment.

4.4.8 Penetration test.

A test of butt welds or other weld joints uses the application of a low surface tension liquid at one side of a compartment boundary or structural arrangement.

If no liquid is detected on the opposite sides of the boundaries after expiration of a definite period of time, this indicates tightness of the boundaries. In certain cases, a developer solution may be painted or sprayed on the other side of the weld to aid leak detection.

4.4.9 Other tests.

Other methods of testing may be considered by the Register upon submission of full particulars prior to the commencement of testing.

4.5 Application of coating.

4.5.1 Final coating.

For butt joints welded by an automatic process, the final coating may be applied any time before the completion of a leak test of spaces bounded by the joints, provided that the welds have been carefully inspected visually to the satisfaction of the Register surveyor. For all other joints, the final coating shall be applied after the completion of the leak test of the joint. Refer also to Table 4.1-3.

The Register surveyors reserve the right to require a leak test prior to the application of the final coating over automatic erection butt welds.

4.5.2 Temporary coating.

Any temporary coating which may conceal defects or leaks shall be applied at the time as specified for the final coating (refer to **4.5.1**).

This requirement does not apply to shop primer.

4.6 Safe access to joints.

For leak tests, safe access to all joints under examination shall be provided. Refer also to Table4.1-3.

4.7 Hydrostatic or hydropneumatic tightness test.

In cases where the hydrostatic or hydropneumatic tests are applied instead of a specific leak test, examined boundaries shall be dew-free, otherwise small leaks are not visible.

Part B _ Ships Not Covered by SOLAS (Non-SOLAS Ships) and Ships Granted SOLAS Exemption/Equivalent (SOLAS Exemption/Equivalent Ships)

1. GENERAL

1.1 These test procedures shall confirm the watertightness of tanks and watertight boundaries and the structural adequacy of tanks which consist of the watertight subdivisions[1] of ships. These procedures may also be applied to verify the weathertightness of structures and shipboard outfitting. The tightness of all tanks and watertight boundaries of ships during new construction and those relevant to major conversions or major repairs[2] shall be confirmed by these test procedures prior to the delivery of the ship.

[1] Watertight subdivision means the transverse and longitudinal subdivisions of the ship required to satisfy the subdivision requirements of SOLAS Chapter **II-1**, **1.2**.

[2] Major repair means a repair affecting structural integrity.

1.2 Testing procedures of watertight compartments shall be carried out in accordance with Part B of this Appendix for non-SOLAS ships and those SOLAS ships (including CSR BC and OT) for which :

a) the shipyard provides documentary evidence of the shipowner's agreement to a request to the Administration for an exemption from the application of SOLAS Chapter **II-1**, regulation **11**, or for an equivalency agreeing that the content of Part **B** is equivalent to SOLAS Chapter **II-1**, regulation **11**; and

b) the above-mentioned exemption/equivalency has been granted by the responsible Administration.

2 APPLICATION

2.1 Testing procedures shall be carried out in accordance with the requirements of Part **A** of this Appendix in association with the alternative procedures for **4.2.2** and alternative test requirements for Table 4.1-1, Part **A**.

2.2 The tank boundaries shall be tested from at least one side. The tanks for structural test shall be selected so that all representative structural members are tested for the expected tension and compression.

2.3 Structural tests shall be carried out for at least one tank of a group of tanks having structural similarity (i.e. same design conditions, alike structural configurations with only minor localised differences determined to be acceptable by the attending RU surveyor) on each ship provided all other tanks are tested for leaks by an air test. The acceptance of leak testing using an air test instead of a structural test does not apply to cargo space boundaries adjacent to other compartments in tankers and combination carriers or to the boundaries of tanks for segregated cargoes or pollutant cargoes in other types of ships.

2.4 Additional tanks may require structural testing if found necessary after the structural testing of the first tank.

2.5 Where the structural adequacy of the tanks of a vessel were verified by the structural testing required in Table 4.1-1 of Part A of this Appendix, subsequent ships in the series (i.e. sister ships built from the same plans at the same shipyard) may be exempted from structural testing of tanks, provided that:

.1 watertightness of boundaries of all tanks is verified by leak tests and thorough inspections are carried out;

.2 structural testing is carried out for at least one tank of each type among all tanks of each sister ship;

.3 additional tanks may require structural testing if found necessary after the structural testing of the first tank or if deemed necessary by the attending RU surveyor.

For cargo space boundaries adjacent to other compartments in tankers and combination carriers or boundaries of tanks for segregated cargoes or pollutant cargoes in other types of ships, the provisions of **2.5.2** of Part **B** of this Appendix shall apply in lieu of **2.3** of Part **B**.

2.6 Sister ships built (i.e. keel laid) two years or more after the delivery of the last ship of the series, may be tested in accordance with **2.5** of Part **B** of this Appendix, provided that:

.1 general workmanship has been maintained (i.e. there has been no discontinuity of shipbuilding or significant changes in the construction methodology or technology at the yard, shipyard personnel are appropriately qualified and demonstrate an adequate level of workmanship as determined by the Register); and

.2 an NDT plan is implemented and evaluated by the Register for the tanks not subject to structural tests. Shipbuilding quality standards for the hull structure during new construction shall be reviewed and agreed during the kick-off meeting. Structural fabrication shall be carried out in accordance with IACS recommendation 47 "Shipbuilding and Repair Quality Standard", or a recognised fabrication standard which has been accepted by the Register prior to the commencement of fabrication/construction.

The work shall be carried out in accordance with the RU rules and under the RU technical supervision.

APPENDIX2

REQUIREMENTS TO SHIP LOADING INSTRUMENTS

1. GENERAL

1.1 The present Requirements shall be applied together with those of Part II "Hull" of these Rules and the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships when approving the loading instruments of ships whose instruments are not yet approved.

1.2 The Requirements apply to loading instruments representing a computer-based system consisting of software for ship load calculation and of hardware for its realization. Requirements pertinent to the program and its functional capabilities shall be found in **3.1** and Section **4** of this Appendix respectively. Requirements pertinent to type approval for hardware shall be found in **1.8** and **3.2** of this Appendix.

1.3 A loading instrument shall not substitute for an approved Loading Manual.

1.4 The loading instrument belongs to special equipment carried onboard, and the calculation results obtained by using it apply only to the ship for which it was approved.

1.5 Ships undergoing major modifications or modernization, such as lengthening or deck removal affecting the longitudinal strength of hull, shall be considered new ships for the purpose of the Requirement.

1.6 For each ship, the loading instrument approval procedure shall include the following:

basic data verification and loading conditions approval with issuing of a Report (Form 1.9.28)[1] for subsequent testing of the program;

hardware approval with issuing of a Certificate (Form 3.2.1), where necessary;

handover tests with a subsequent issuing of a Report 1.9.18).

[1] Designations of the corresponding forms - according to the Shipping Register of Ukraine List of documents, which are issued as a result of its supervisory activity.

1.7 The program for the loading instrument shall be type-approved by the Register which shall be confirmed by issuing a Type Approval Certificate for Computer Program (Form 3.4.7). In such cases, certain stages may be omitted in the basic data verification procedure for a particular ship (refer to **2.1.7**).

1.8 Hardware shall be approved, if there is a single computer for which a Type Approval Certificate (Form 3.4.1), was issued in accordance with the requirements of **3.2** of this Appendix, or there are two computers specially installed for the case one of them fails. If there are two computers, no type approval is necessary for them but in this case, each computer shall pass handover tests. Besides, computers being a part of the shipboard net shall be approved by the Register which shall be confirmed by issuing a Certificate (Form 3.2.1) in accordance with the relevant requirements of these and the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

1.9 A Report (Form 1.9.18) shall be issued for the program on the basis of the satisfactory results of handover tests of the loading instrument carried out onboard the ship in accordance with the requirements of **2.3** of this Appendix.

2. APPROVAL PROCEDURE

2.1 Basic data verification and approval. Loading conditions approval for program testing.

2.1.1 Calculation results and the actual ship data used for the program shall be verified onboard the ship for which the program is intended.

2.1.2 On receipt of an application for data verification, the Register shall offer to the applicant four loading conditions as a minimum, borrowed from an approved Loading Manual and to be used for program testing. These loading conditions shall ensure the loading of each ship compartment for one time at least. These loading conditions shall generally cover the whole range of possible ship draughts from the greatest one in the loaded condition to the smallest one in the ballasted condition.

2.1.3 Control points shall generally be positioned on transverse bulkheads or other obvious compartment boundaries. Additional control points may be necessary between the bulkheads of long holds or tanks, or between container stacks.

2.1.4 If the torque on calm water shall be determined, the software shall demonstrate it on a single test loading condition of the ship.

2.1.5 It is important that the basic data included in the program are in agreement with those contained in the approved Loading Manual. Special attention shall be paid to the final mass value of the ship in the light condition and the position of its gravity centre adopted on the basis of inclining test or proceeding from the results of the light ship condition verification.]

2.1.6 The following basic data shall be submitted to the Register by the applicant in order to verify whether they are in agreement with the ship constructed:

principal dimensions, coefficients of fineness of the lines and, where necessary, the lateral projection of the ship;

position of forward and aft perpendiculars and, where necessary, the procedure for determining the forward and stern draughts at actual draught mark locations;

light ship displacement and its distribution through the ship length;

lines drawing and/or tables of offsets, or Bonjean scales including 21st section on the length between perpendiculars;

compartments description including spacing, volume centres and volume tables (tank capacity tables/ tables showing the mass of liquid in a tank filled to different levels) where necessary;

deadweight composition for each loading condition.

Identification details of the program including the version number shall be verified also.

2.1.7 The basic data verification procedure may be considered to be completed, if:

the requirements of **3.1** of this Appendix are fulfilled in respect of the program;

the purpose of the program is clearly formulated and the calculation methods with the algorithm are in accordance with the requirements of these Rules and the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships;

the requirements of Section **4** of this Appendix are fulfilled with regard to the functional capabilities of the program;

the precision of calculations made on the basis of the program is within the tolerances stipulated by **2.5** of this Appendix;

ship particulars are in accordance with the requirements of **2.1.5** of this Appendix;

the Program User's Manual is clear and brief and complies with the requirements of **2.4** of this Appendix and is checked and duly noted by the Register;

data are given concerning the minimal requirements for hardware; ship loading conditions intended for the program testing are approved which is confirmed by the Report (Form 1.9.28).

2.1.8 Type Approval Certificate for Computer Program (Form 3.4.7) shall be issued on the basis of the requirements of **2.2** of this Appendix. Where the program is type approved, the basic data verification procedure may be considered to be completed, if:

it is found that the type-approved program is applicable to the ship in question;

information contained in the valid Certificate (Form 3.4.7), is in compliance with the program being identified and its version number;

the precision of calculations made on the basis of the program is within the tolerances stipulated in **2.5** of this Appendix; ship particulars are in accordance with the requirements of **2.1.5** of this Appendix;

the Program User's Manual is clear and brief and complies with the requirements of **2.4** of this Appendix and is checked and duly noted by the Register;

data are given concerning the minimal requirements for hardware;

ship loading conditions intended for the program testing are approved and there is a Report (Form 1.9.28) on the program operation testing.

2.1.9 Approved loading conditions given in the Loading Manual and the Report (Form 1.9.28) are sent to the Branch Office by the SRU Head Office noting the necessity of handover tests to be held. Where the ship is in service, the approved loading conditions and the Report (Form 1.9.28) are sent to the shipowner who shall ensure that they are delivered onboard and that handover tests are held with the RU surveyor participating.

2.2 Type approval.

2.2.1 A program for the loading instrument may be type approved according to the requirements of this Chapter. If the tests are completed satisfactorily, Type Approval Certificate for Computer Program (Form 3.4.7) shall be issued for the program.

2.2.2 The Certificate (Form 3.4.7) shall be valid for an identified version of the program only.

2.2.3 After the application for the type approval of a program has been submitted, the Register will provide the applicant with data for its testing for two ship types at least. Where programs using basic data on hull shape are concerned, the program test data shall be provided for three ship types. These data shall be used by the applicant for running the program in respect of the tested ships. The results (including the data-of-the-lines-plan curve and the interpolation curve output, if applicable) obtained by using the program shall be submitted to the Register in order the precision of calculations might be assessed. The Register shall make parallel calculations using the same basic data and compare their results with those obtained by means of the program submitted.

2.2.4 The Certificate (Form 3.4.7) may be issued if:

the requirements of **3.1** of this Appendix are fulfilled in respect of the program;

the purpose of the program is clearly formulated and the calculation methods with the algorithm are in accordance with the requirements of these Rules and the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships;

the requirements of Section **4** of this Appendix are fulfilled with regard to the functional capabilities of the program;

the precision of calculations made on the basis of the program is within the tolerances stipulated in **2.5** of this Appendix;

the Program User's Manual is clear and brief, and is submitted to the Register for review; data are given concerning the minimal requirements for hardware.

2.2.5 The Certificate (Form 3.4.7) shall include a detailed description of calculations for which the program is approved and of limitations imposed upon the program.

2.2.6 The Certificate (Form 3.4.7) shall be issued for a maximum period of 5 years. The Certificate may be extended after the developer has confirmed that the algorithm is unchanged in the program.

2.2.7 A valid Certificate (Form 3.4.7) will be invalidated, if the algorithm is changed in the program by the developer without prior agreement with the Register. In such a case, the revised program shall be considered a new one.

2.3 Handover tests.

2.3.1 Handover tests shall be held soon after the loading instrument installation aboard the ship.

2.3.2 During handover tests, the user, one of the senior officers shall use the instrument for calculating a test loading condition of the ship. The operation shall be confirmed by the RU surveyor. Data obtained by means of the instrument shall agree with those stated for the approved test loading conditions. Where the numerical output data given by the instrument do not agree with those stated in the approved test loading conditions, the Report (Form 1.9.18) shall not be issued.

2.3.3 Handover tests shall also be carried out in respect of the second computer specially installed to be used if the first one fails. Data obtained by means of the loading instrument shall agree with those stated for the approved tests loading conditions. Where the output numerical data of the loading instrument do not agree with those stipulated for the approved tests loading conditions, no Report (Form 1.9.18) shall be issued. If handover tests are effected using a computer for which the Type Approval Certificate (Form 3.4.1), was issued, the second specially installed computer need not be tested.

2.3.4 Where hardware is not approved, it shall be demonstrated that handover tests results for the program are satisfactory for both the first and the second specially installed computer, subsequent to which the Report (Form 1.9.18) on the program handover tests may be issued.

2.3.5 After satisfactory completion of handover tests, the RS surveyor shall attach the approved test loading conditions for the ship, as well as the Program Test Report (Form 1.9.28) to the Program User's Manual formerly duly noted by the Register. Then, the Report (Form 1.9.18) on handover tests of the program will be issued by the Register.

2.4 Program User's Manual.

2.4.1 The Manual shall be submitted to the Register for review. In case of satisfactory results of the consideration, the Manual shall be duly noted by the Register.

2.4.2 The Manual shall be drawn up in a brief and clear way and shall be provided preferably with drawings and block diagrams.

2.4.3 The Manual shall include the following information:

general description of the program with indication of its version identification number;

a copy of Type Approval Certificate for Computer Program (Form 3.4.7);

data on minimal required hardware properties necessary for program operation;

description of error messages and warning reports that can be issued by computer and clear instructions concerning the user's subsequent steps in this case;

light ship displacement and gravity centre of the ship coordinates;

full deadweight composition for each test loading condition of the ship;

values of permissible shearing forces and bending moments in calm water given or taken into consideration by the Register;

values of permissible cargo torque, where applicable;

correction factors for shearing forces, where applicable;

local permissible limitations on the loading of particular holds and two adjacent holds proceeding from the maximum cargo mass for each hold in relation to the relevant ship draught, where applicable;

example of ship loading conditions determination with illustrations and computer data out;

example of each display screen data out with explanations.

2.5 Allowance for calculation accuracy.

The accuracy of calculations made using the program shall be within the range of acceptable allowances given in Table 2.5.

The accuracy of calculations can be determined by comparing, at each control point, the results of calculations made using the program to those obtained by using an independent program of the Register or an approved Loading Manual containing the similar basic data.

Table2.5 **Range of allowances for calculation accuracy**

Design value	Allowance (percentage of permissible value)
Shearing force on still water N_{sw}	±5
Bending moment on still water M_{sw}	±5
Torque on still water M_{tsw}	±5

2.6 Hardware approval.

The hardware of a loading instrument shall be in accordance with the requirements of **1.8** and **3.2** of this Appendix if it is type-approved by the Register.

3. REQUIREMENTS TO THE SYSTEM

3.1 Program.

3.1.1 It is recommended that the development and release of the program shall be carried out in accordance with the relevant international quality standards (for instance, ISO 9001 or equivalent ДСТУ EN ISO 9001: 2018).

3.1.2 Software shall be developed so as to render it impossible for the user to modify data files of the ship containing the following information:

lightweight displacement of the ship, lightweight ship mass distribution and the relevant gravity centres;

structural restrictions imposed by the Register;

data essential for hull geometry;

hydrostatic data;

description of compartments including spacing, volume centres and volume tables (tank capacity tables/tables showing the volume of liquid in a tank when filled to different levels) where necessary.

3.1.3 Any changes to software that can influence longitudinal strength shall be introduced by the developer or his appointed representative, and the Register shall be immediately notified accordingly. The absence of a notification of any changes to the program may render the Certificate (Form 3.4.7) issued by the Register invalid. When the Certificate (Form 3.4.7) is found to be invalid by the Register, the modified program will be considered anew in accordance with the requirements of this Appendix.

3.2 Hardware of an independent computer.

3.2.1 Type Approval Certificate (Form 3.4.1), and Hardware Approval Certificate (For 3.2.1) shall be issued by the Register on condition the hardware is in accordance with the requirements contained in **3.2.2** of this Appendix, as well as with the requirements of these Rules and the Rules for Technical Supervision.

3.2.2 The developer shall submit the detailed information on the hardwshall be installed on board. The following information shall be submitted to the Register for review:

hardware specification;

the relevant design drawings with indicated materials, catalogues, data sheets, calculations and functional descriptions;

test program suggested for demonstration, confirming that the operational requirements of the above standards can be fulfilled;

certificates and the relevant test reports obtained for the product earlier.

3.2.3 When considering the documentation mentioned in **3.2.2**, the Register may recognize the validity of certificates and reports issued by another certification body or accredited laboratory.

3.2.4 The operational and climatic tests shall be held in the presence of the Register representative under the standard test conditions so that a type approval could be issued in accordance with Part XV "Automation" of these Rules. The following inspections and tests shall be completed satisfactorily:

external examination;
functional tests;
disturbance in electric power supply;
thermal resistance testing;
moisture resistance testing;
vibration tests;
testing by oscillating and prolonged tilting motion conditions;
testing of insulation electric strength, insulation resistance measurement;
cold resistance tests;
electromagnetic compatibility tests.

3.2.5 The Register shall be notified of any modifications to hardware specification.

4. REQUIREMENTS CONCERNING FUNCTIONAL CAPABILITIES

4.1 General.

4.1.1 The computational functions inherent in the program will depend on the requirements contained in these Rules and in the Rules for Technical Supervision.

4.1.2 2 The program shall be convenient for the user and be developed so as to minimize the possibility of incorrect initial data input by the user.

4.1.3 Calculations of the fore, midlength and after draughts at relevant perpendiculars shall be submitted in a form easily understandable for the user both in files and as hard copies.

4.1.4 For the case of the actual ship loadline positions of the, the fore, midlength and after draughts shall be determined and submitted in a form easily understandable for the user both in files and as hard copies. Provision shall be made for submitting the sagging/hogging data for the hull.

4.1.5 Displacement shall be determined for the particular loading condition of the ship and the corresponding value of the draught, and shall be submitted to the user both in file and as a hard copy.

4.1.6 The loading instrument shall issue printouts containing output data both in digital and graphic form. The output data in digital form shall be represented both in the absolute values and as percentage of permissible values. Printouts shall contain description of the relevant loading condition of the ship.

4.1.7 All the electronic and hard copy data shall be represented in a form easily understandable for the user with indication of the identification number of the program version.

4.2 Forces and moments originating in the hull.

4.2.1 The program shall ensure an analysis of the following forces and moments in the ship hull in accordance with the requirements of this Part of the Rules:

shearing force N_{sw} in still water, with a correction where applicable;
bending moment M_{sw} in still water, with a correction where applicable;
torque M_{tsw} in still water, where applicable.
In case of open ships, particular attention shall be paid to loads under which hull twisting occurs.

4.2.2 Data to be submitted to or duly noted by the Register are included in Table 4.2.2.

Table 4.2.2

Design value	Data to be submitted to or duly noted by the Register
shearing force N_{sw} in still water	1. Control points (frame numbers) for N_{sw} determination. Such points shall generally be chosen on transverse bulkheads or other obvious boundaries of compartments. Additional control points may be indicated between the bulkheads of long holds or tanks, as well as between container stacks. 2. Correction factors for shearing forces and their application procedure. 3. Permissible values [of N_{sw}], at sea and in port, for control points mentioned in item 1. Where necessary, an additional range of permissible values [of N_{sw}] can be specified.

bending moment M_{sw} in still water	1. Control points (frame numbers) for Msw determination. Such points shall generally be chosen on transverse bulkheads, at hold centres or other obvious boundaries of compartments. 2. Permissible values [of M_{sw}], at sea and in port, for control points mentioned in item 1. Where necessary, an additional range of permissible values [of M_{sw}] can be specified.
Torque M_{tsw} on still water (where applicable)	1. Control points (frame numbers) for M_{tsw} determination. 2. Permissible values [of M_{tsw}] for control points mentioned in item 1.

4.2.3 Forces and moments shall be determined in absolute values and as percentage of permissible values, and shall be submitted both in graphical and tabulated form. The forces and moments determined, as well as their permissible values for each of the control points indicated, shall be submitted both in files and as hard copies. Any limitations concerning hull bending in the vertical direction in still water or hull twisting, for instance, may be considered on the basis of the requirements of the Rules.

4.3 Permissible loads, loading and capacity.

4.3.1 The program user shall be timely, clearly and unambiguously informed about the following restrictions imposed by the Register, concerning:

all permissible shearing forces and bending moments in still water;

permissible torques in still water, where applicable;

all local loading restrictions pertinent to both the loading of a particular hold and of the one adjacent thereto, where applicable;

mass of cargo contained in the hold;

ballast tanks and holds capacity;

restrictions on filling.

4.3.2 Violation of any of the restrictions imposed shall be easily detectable by the program user.

5. PERFORMANCE TEST

5.1 General.

When a loading instrument shall be installed on board and Report (Form 1.9.18) or a report on its previous testing by the Register is not available, the RU surveyor shall notify the RU Head Office accordingly.

5.2 Extent of survey.

When a loading instrument is tested, the results obtained on the basis of the program shall be identical to those given in the approved test loading conditions of the ship. If the numerical output data obtained using the loading instrument do not agree with those to be found in the approved test loading conditions, the class assignment requirements shall be applied to the ship and the owner shall be notified accordingly. The program shall be tested on all the computers intended for it (those which are type approved or specially designed for the program).

APPENDIX 3

EVALUATION OF SCANTLINGS OF CORRUGATED TRANSVERSE WATERTIGHT BULKHEADS IN NON-CSR BULK CARRIERS CONSIDERING HOLD FLOODING

1 APPLICATION AND DEFINITIONS [1]

1.1 Application.

This procedure apply to bulk carriers specified in **3.3.4.10** of this Part.

1.2 Definitions.

Definitions and explanations relating to the general terminology of the Rules referred to in **1.1.3** of this part of the Rules.

The following definitions have been adopted in this Annex:

Homogeneous loading condition is a loading condition in which the ratio between the highest and the lowest filling ratio, evaluated for each hold, does not exceed 1,20, to be corrected for different cargo densities.

Net thickness t_{net} is the thickness obtained by applying the strength criteria given in Section 4 of this Appendix.

Required thickness is obtained by adding the corrosion addition t_s, given in Section 6 of this Appendix, to the net thickness t_{net}.

The main structural type of bulk carriers is determined in accordance with **3.3.1.4**, Part II "Hull". The evaluation of scantling of corrugated transverse watertight bulkhead in non CSR bulk carriers considering hold flooding shall be determined in accordance with **3.3.4.10** of this part of the Rules.

2. LOAD MODEL

2.1 General.

Loads t o b e considered a s acting o n the bulkheads are those given by the combination of the cargo loads with those induced by the flooding of one hold adjacent to the bulkhead under examination. In any case, the pressure due to the flooding water alone shall be considered.

The most severe combinations of cargo induced loads and flooding loads are to be used for the check of the scantlings of each bulkhead, depending on the loading conditions included in the Loading Manual:

homogeneous loading conditions;

non homogeneous loading conditions;

considering the individual flooding of both loaded and empty holds.

The specified design load limits for the cargo holds are to be represented by loading conditions defined by the designer in the Loading Manual.

Non homogeneous part loading conditions associated with multiport loading and unloading operations for homogeneous loading conditions need not be considered according to these requirements.

Holds carrying packed cargoes shall be considered as empty holds for this application. Unless the ship is intended to carry, in non homogeneous conditions, only iron ore or cargo having bulk density equal or greater than 1,78 t/m^3 , the maximum mass of cargo which may be carried in the hold shall also be considered to fill that hold up to the upper deck level at centreline.

2.2 Bulkhead corrugation flooding head.

Flooding head h_f (refer to Fig. 2.2) is the distance, in m, measured vertically, with the ship in the upright position, from the calculation point to a level located at a distance d_f, in m, from the base line equal to:

.1 in general D for the foremost transverse corrugated bulkhead;

0,9D for the other bulkheads.

Where the ship shall carry cargoes having bulk density less than 1,78 t/m^3 in non homogeneous loading conditions, the following values can be assumed:

0,95D for the foremost transverse corrugated bulkhead;

0,85D for the other bulkheads;

.2 for ships less than 50000 t deadweight with Type **B** freeboard

0,95D for the foremost transverse corrugated bulkhead;
0,85D for the other bulkheads.

Where the ship is to carry cargoes having bulk density less than 1,78 t/m^3 in non homogeneous loading conditions, the following values can be assumed:

0,9D for the foremost transverse corrugated bulkhead;
0,8D for the other bulkheadsк.

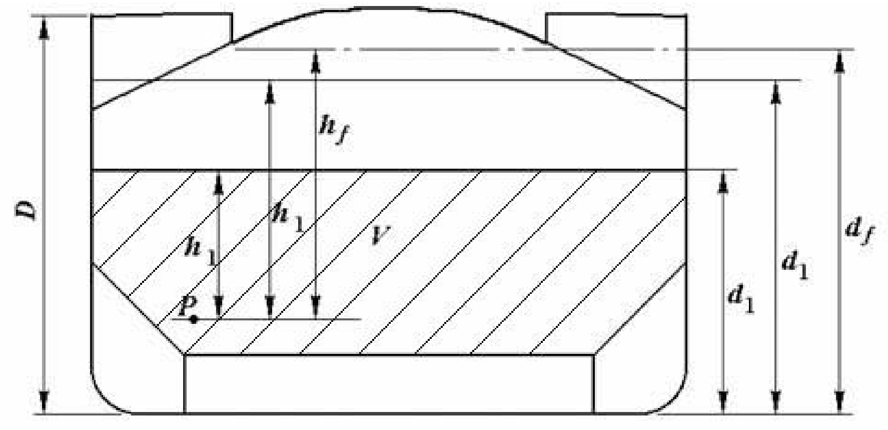


Fig.2.2:

V – volume of cargo, in m^3; P – calculation point; D – distance, in m, from the base line to the freeboard deck at side amidships

2.3 Pressure in the non-flooded bulk cargo loaded holds.

At each point of the bulkhead, the pressure p_c, in kN/m^2, shall be determined by the formula:

$$p_c = \rho_c g h_1 \mathrm{tg}^2\gamma ,$$

where: ρ_c–bulk cargo density, in t/m^3 ;

g – gravity acceleration equal to 9,81 m/s^2 ;

h_1 – vertical distance, in m, from the calculation point to horizontal plane corresponding to the level height of the cargo (refer to Fig. 2.2), located at a distanced d_1, in m, from the base line;

$\gamma = 45° – (\varphi / 2)$;

where: φ – angle of repose of the cargo, in deg., that may generally be taken as 35° for iron ore and 25° for cement.

The force F_c, in kN, acting on a corrugation shall be determined by the formula:

$$F_c = \rho_c \, g \, s_1 \frac{(d_1 - h_{DB} - h_{LS})^2}{2} \mathrm{tg}^2\gamma,$$

where: s_1 – spacing of corrugations, in m (refer to Fig. 2.3);

h_{LS} – mean height of the lower stool, in m, from the inner bottom;

h_{DB} – height of the double bottom, in m.

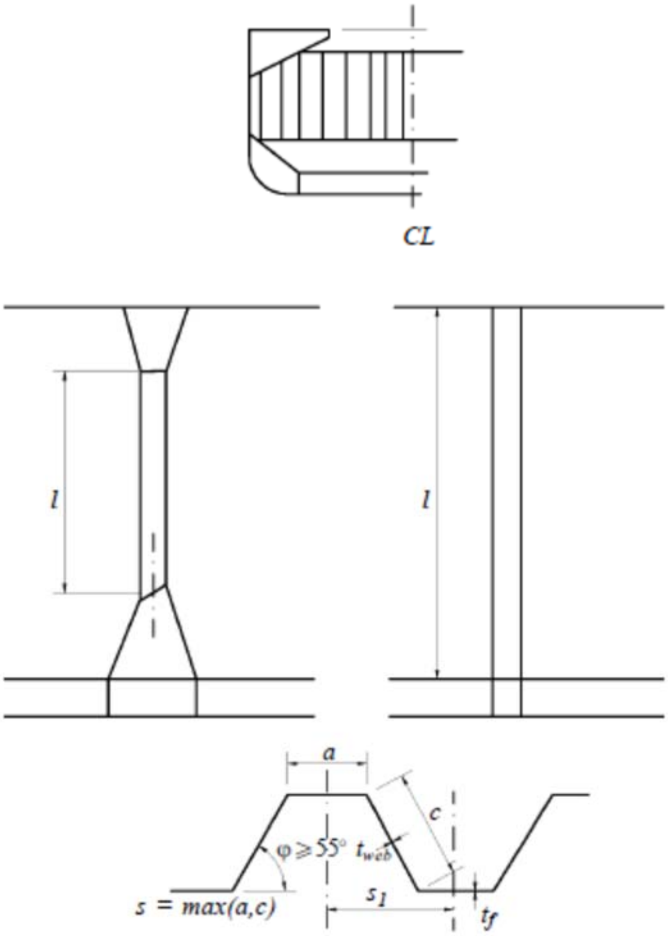


Fig. 2.3:
n – neutral axis of the corrugations;
t_f – net flange thickness, in mm;
t_{web} – corrugation web thickness.

2.4 Pressure in the flooded holds.
2.4.1 Bulk cargo holds.
Two cases shall be considered, depending on the values of d_1 and d_f:

.1 $d_1 \le d_f$.
At each point of the bulkhead located at a distance between d_1 and d_f from the base line, the pressure $p_{c,f}$, in kN/m^2, shall be determined by the formula

$$p_{c,f} = \rho g h_f ,$$

where: ρ – sea water density, in t/m^3;
for g refer to 2.3;
h_f – = flooding head (as defined in **2.2**).

At each point of the bulkhead located at a distance lower than d_1 from the base line, the pressure $p_{c,f}$, in kN/m^2, shall be determined by the formula

$$p_{c,f} = \rho g h_f + [\rho_c - \rho(1 - \text{perm})] g h_1 \text{tg}^2 \gamma ,$$

where for ρ_c, g, h_1, γ – refer to **2.3**;

perm – permeability of cargo, to be taken as 0,3 for ore (corresponding bulk cargo density for iron ore may generally be taken as 3,0 t/m^3), coal cargoes and for cement (corresponding bulk cargo density for cement may generally be taken as 1,3 t/m^3).

The force $F_{c,f}$, in kN, acting on a corrugation shall be determined by the formula

$$F_{c,f} = s_1[\rho g \frac{(d_f - d_1)^2}{2} + \frac{\rho g(d_f - d_1) + (p_{c,f})_{le}}{2} (d_1 - h_{DB} - h_{LS})],$$

where for s_1, g, d_1, h_{DB}, h_{LS} – refer to **2.3**;
for d_f – refer to **2.2**;
$(p_{c,f})_{le}$ – pressure at the lower end of the corrugation, in kN/m^2.

.2 $d_1 > d_f$.
At each point of the bulkhead located at a distance between d_1 and d_f, from the base line, the pressure $p_{c,f}$, in kN/m^2, shall be determined by the formula

$$p_{c,f} = \rho_c g h_1 \mathrm{tg}^2\gamma,$$

where for ρ_c, g, h_1, γ – refer to **2.3**.

At each point of the bulkhead located at a distance lower thand_f, from the base line, the pressure p_c, in kN/m^2, shall be determined by the formula

$$p_{c,f} = \rho g h_f + [\rho_c h_1 - \rho(1 - \mathrm{perm}) h_f] g \,\mathrm{tg}^2\gamma,$$

where for ρ, h_f, perm – refer to **2.4.1.1**;
for ρ_c, g, h_1, γ – refer to **2.3**.

The force$F_{c,f}$, in kN, acting on a corrugation shall be determined by the formula

$$F_{c,f} = s_1[\rho g \frac{(d_1 - d_f)^2}{2} \tan^2\gamma + \frac{\rho_c g(d_1 - d_f)\tan^2\gamma + (p_{c,f})_{le}}{2} (d_f - h_{DB} - h_{LS})],$$

where for s_1, ρ_c, g, d_1, γ, h_{DB}, h_{LS} – refer to **2.3**;
for d_f – refer to **2.2**;
$(p_{c,f})_{le}$ – = pressure at the lower end of the corrugation, in kN/m^2.

2.4.2 Pressure in empty holds due to flooding water alone.
At each point of the bulkhead, the hydrostatic pressure p_f induced by the flooding head h_f shall be considered. The force F_f, in kN, acting on a corrugation shall be determined by the formula

$$F_f = s_1 \rho g \frac{(d_f - h_{DB} - h_{LS})^2}{2},$$

where for s_1, g, h_{DB}, h_{LS} – refer to **2.3**;
for ρ – refer to **2.4.1.1**;
for d_f – refer to **2.2**.

2.5 Resultant pressure and force.
2.5.1 Homogeneous loading conditions.
At each point of the bulkhead structures, the resultant pressure p, in kN/m^2, to be considered for the scantlings of the bulkhead shall be determined by the formula

$$p = p_{c,f} - 0{,}8p_c.$$

The resultant force F, in kN, acting on a corrugation shall be determined by the formula

$F = F_{c,f} - 0{,}8F_c$.

2.5.2 Non homogeneous loading conditions.

At each point of the bulkhead structures, the resultant pressure p, in kN/m^2, to be considered for the scantlings of the bulkhead shall be determined by the formula

$p = p_{c,f}$.

The resultant force F, in kN, acting on a corrugation, shall be determined by the formula

$F = F_{c,f}$.

3. BENDING MOMENT AND SHEAR FORCE IN THE BULKHEAD CORRUGATIONS

The bending moment M and the shear force Q in the bulkhead corrugations shall be determined by the formulae given in **3.1** and **3.2**. The M and Q values shall be used for the checks in **4.5**.

3.1 BENDING MOMENT.

The design bending moment M, in kN/m, for the bulkhead corrugations shall be determined by the formula

$M = Fl/8$,

where: F – resultant force, in kN (refer to 2.5);
l – span of corrugation, in m (refer to Figs. 2.3 and 3.1).

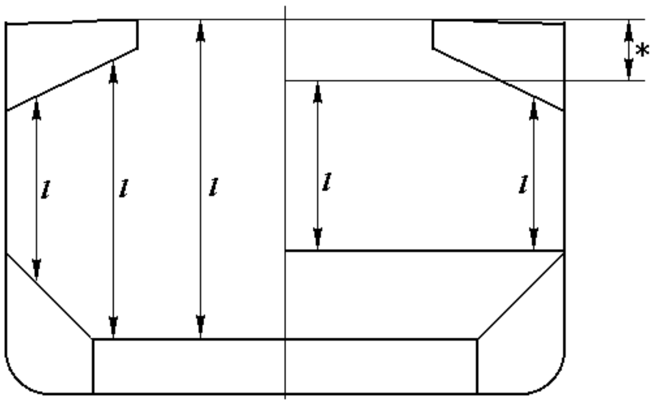


Fig.3.1:

l – span of corrugation;

* – for the definition of l, the internal end of the upper stool shall not be taken more than a distance from the deck at the centerline equal to:

3 times the depth of corrugations, in general;

2 times the depth of corrugations, rectangular stool.

3.2 Shear force.

The shear force Q, in kN, at the lower end of the bulkhead corrugations shall be determined by the formula

$Q = 0{,}8F$,

where for F, refer to **2.5**.

4. STRENGTH CRITERIA

4.1 General.

4.1.1 The following criteria are applicable to transverse bulkheads with vertical corrugations (refer to Fig. 2.3).

For ships of 190 m in length and above, these bulkheads shall be fitted with a lower stool, and generally with an upper stool below deck.

For smaller ships, corrugations may extend from inner bottom to deck; if the stool is fitted, it shall comply with the requirements of this Chapter.

The corrugation angle φ shown in Fig. 2.3 shall not be less than 55°.

Requirements for local net plate thickness are given in **4.7**. In addition, the criteria as given in **4.2** and **4.5** shall be complied with.

The thickness of the lower part of corrugations determined in accordance with **4.2** and **4.3** shall be maintained for a distance from the inner bottom (if no lower stool is fitted) or the top of the lower stool not less than 0,15*l*.

The thickness of the middle part of corrugations determined in accordance with **4.2** and **4.4**, shall be maintained to a distance from the deck (if no upper stool is fitted) or the bottom of the upper stool not greater than 0,3*l*.

The section modulus of the corrugation in the remaining upper part of the bulkhead shall not be less than 75 % of that required for the middle part, corrected for different yield stresses.

4.1.2 Lower stool.

The height of the lower stool is generally shall be not less than 3 times the depth of the corrugations.

The thickness and material of the stool top plate shall not be less than those required for the bulkhead plating as specified in **4.1.1**. The thickness and material of the upper portion of vertical or sloping stool side plating within the depth equal to the corrugation flange width from the stool top shall not be less than the required flange plate thickness and material to meet the bulkhead stiffness requirement at lower end of corrugation. The thickness of the stool side plating and the section modulus of the stool side stiffeners shall not to be less than those required in **3.3** of this Part on the basis of the load model in Section **2** of this Appendix. The ends of stool side vertical stiffeners shall be attached to brackets at the upper and lower ends of the stool.

The distance from the edge of the stool top plate to the surface of the corrugation shall be in accordance with Fig. 4.1.2. The stool bottom shall be installed in line with double bottom floors and shall have a width not less than 2,5 times the mean depth of the corrugation. The stool shall be fitted with diaphragms in line with the longitudinal double bottom girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connections to the stool top plate shall be avoided.

Where corrugations are cut at the lower stool, corrugated bulkhead plating shall be connected to the stool top plate by full penetration welds. The stool side plating shall be connected to the stool top plate and the inner bottom plating by either full penetration or deep penetration welds. The supporting floors shall be connected to the inner bottom by either full penetration or deep penetration welds.

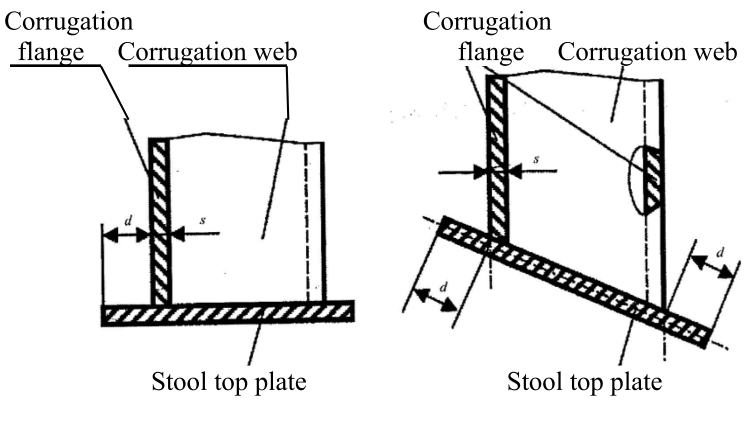


Fig. 4.1.2
s – as-built flange thickness; $d \geq s$

4.1.3 Upper stool.

The upper stool, where fitted, shall have a height generally between 2 and 3 times the depth of corrugations. Rectangular stools shall have a height generally equal to 2 times the depth of corrugations, measured from the deck level and at hatch side girder. The upper stool shall be properly supported by girders or deep brackets between the adjacent hatch-end beams.

The width of the stool bottom plate shall generally be the same as that of the lower stool top plate. The stool top of non rectangular stools shall have a width not less than 2 times the depth of corrugations.

The thickness and material of the stool bottom plate shall be the same as those of the bulkhead plating below.

The thickness of the lower portion of stool side plating shall not be less than 80 % of that required for the upper part of the bulkhead plating where the same material is used. The thickness of the stool side plating and the section modulus of the stool side stiffeners shall not be less than those required by the Register on the basis of the load model in Section **2** of this Appendix.

The ends of stool side stiffeners shall be attached to brackets at upper and lower end of the stool. Diaphragms shall be fitted inside the stool in line with and effectively attached to longitudinal deck girders extending to the hatch end coaming girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connection to the stool bottom plate shall be avoided.

4.1.4 Alignment.

At deck, if no stool is fitted, two transverse reinforced beams shall be fitted in line with the corrugation flanges.

At bottom, if no stool is fitted, the corrugation flanges shall be in line with the supporting floors.

Corrugated bulkhead plating shall be connected to the inner bottom plating by full penetration welds. The plating of supporting floors shall be connected to the inner bottom by either full penetration or deep penetration welds.

The thickness and material properties of the supporting floors shall be at least equal to those provided for the corrugation flanges. Moreover, the cut-outs for connections of the inner bottom longitudinals to double bottom floors shall be closed by collar plates. The supporting floors shall be connected to each other by suitably designed shear plates complying with the requirements of **3.3** of this Part.

Stool side plating shall align with the corrugation flanges and stool side vertical stiffeners and their brackets in lower stool shall align with the inner bottom longitudinals to provide appropriate load transmission between these stiffening members. Stool side plating shall not be knuckled anywhere between the inner bottom plating and the stool top.

4.2 Bending capacity and shear stress τ.

The bending capacity shall comply with the following relationship:

$$[M \cdot 10^3/(0{,}5 \cdot Z_{le} \cdot \sigma_{a,le} + Z_m \cdot \sigma_{a,m})] \le 0{,}95,$$

where: M – bending moment, in kN·m (refer to **3.1**);

Z_{le} – = section modulus of one half pitch corrugation, in cm^3, at the lower end of corrugations, to be calculated according to **4.3**;

Z_m – = section modulus of one half pitch corrugation, in cm^3, at the mid-span of corrugations, to be calculated according to **4.4**;

$\sigma_{a,le}$ – allowable stress, in N/mm^2, as given in **4.5**, for the lower end of corrugations;

$\sigma_{a,m}$ – allowable stress, in N/mm^2, as given in **4.5,** for the midspan of corrugations.

In no case Z_m shall be taken greater than the lesser of $1{,}15Z_{le}$ and$1{,}15Z'_{le}$ for calculation of the bending capacity, Z'_{le} being defined below.

In case shedders plates are fitted which:

are not knuckled;

are welded to the corrugations and the top of the lower stool by one side penetration welds or equivalent;

are fitted with a minimum slope of 45° and their lower edge is in line with the stool side plating;

have thicknesses not less than 75 % of that provided by the corrugation flange;

and material properties at least equal to those provided by the flanges; or gasset plates are fitted which: are in combination with shedder plates having thickness, material properties and welded connections in accordance with the above requirements; have a height not less than half of the flange width;

are fitted in line with the stool side plating;

are generally welded to the top of the lower stool by full penetration welds, and to the corrugations and shedder plates by one side penetration welds or equivalent;

have thickness and material properties at least equal to those provided for the flanges, the section modulusy Z_{le}, in cm^3, shall be taken not larger than the value Z'_{le}, in cm^3, to be determined by the formula

$$Z'_{le} = Z_g + [(Qh_g - 0,5h_g^2 s_1 p)/\sigma_a]10^3,$$

where: Z_g – section modulus of one half pitch corrugation, in cm^3, according to **4.4**, in way of the upper end of shedder or gusset plates, as applicable;

Q – shear force, in kN (refer to **3.2**);

h_g – height, in m, of shedders or gasset plates (refer to Figs. 4.2-1, 4.2-2, 4.2-3 and 4.2-4);

for s_1 – refer to **2.3**;

p – resultant pressure, in kN/m^2, as defined in **2.5**, calculated in way of the middle of the shedders or gusset plates, as applicable;

σ_a – allowable stress, in N/mm^2, in accordance with **4.5**.

Stresses are obtained by dividing the shear force Q by the shear area. The shear area shall be reduced in order to account for possible non-perpendicularity between the corrugation webs and flanges. In general, the reduced shear area may be obtained by multiplying the web sectional area by (sin φ), φbeing the angle between the web and the flange. When calculating the section modulus and the shear area, the net plate thicknesses shall be used. The section modulus of corrugations shall be calculated on the basis of the following requirements given in **4.3** and **4.4**.

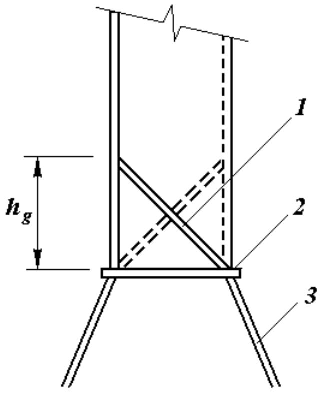


Fig. 4.2-1
Symmetric shedder plates:
1 – shedder plate;
2 – top of the lower stool
3 – vertical or sloping stool side plating

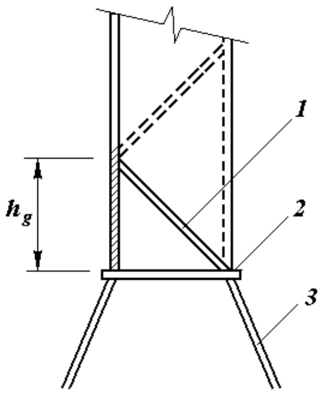


Fig. 4.2-2
Asymmetric shedder plates:
1 – shedder plate;
2 – top of the lower stool
3 – vertical or sloping stool side plating

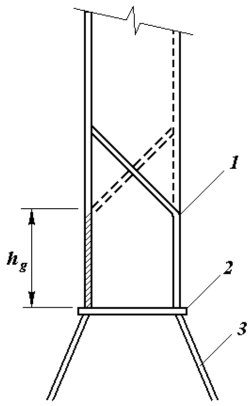


Fig. 4.2-3
Symmetric gasset/shedder plates:
1 – gasset/shedder plate;
2 – top of the lower stool
3 – vertical or sloping stool side plating

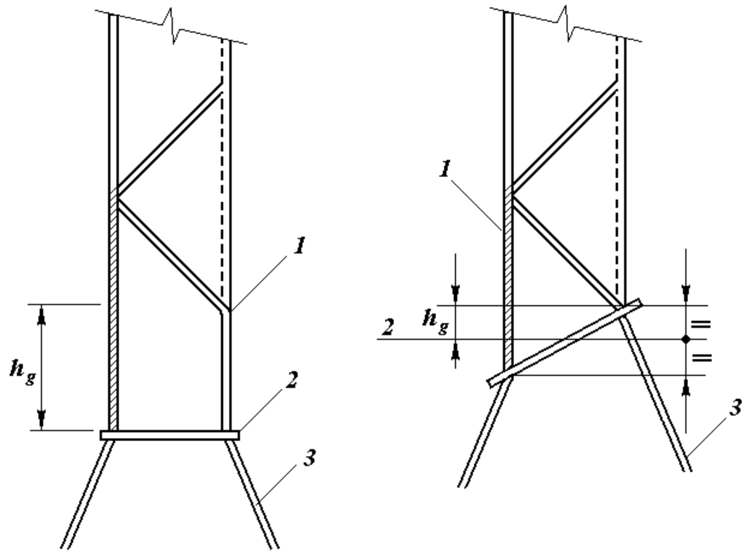


Fig. 4.2-4
Asymmetric gasset/shedder plates:
1 – gasset/shedder plate;
2 – top of the lower stool
3 – vertical or sloping stool side plating

4.3 Section modulus at the lower end of corrugations.

4.3.1 The section modulus shall be calculated with the compression flange having an effective flange width, b_{ef}, not larger than as given in **4.6**.

If the corrugation webs are not supported by local brackets below the stool top (or below the inner bottom) in the lower part, the section modulus of the corrugations shall be calculated considering the corrugation webs 30 % effective.

4.3.2 Provided that effective shedder plates, as defined in **4.2**, are fitted (refer to Figs. 4.2-1 and 4.2-2), when calculating the section modulus of corrugations at the lower end, the area of flange plates, in cm^2, may be increased by:

$$\left(2{,}5a\sqrt{t_f t_{sh}}\right),\ \text{not to be taken greater than } 2{,}5at_f,$$

where: a – width of the corrugation flange, in m (refer to Fig. 2.3);
t_{sh} – net shedder plate thickness, in mm;
t_f – net flange thickness, in mm.

4.3.3 Provided that effective gusset plates, as defined in **4.2**, are fitted (refer to Figs. 4.2-3 and 4.2-4), when calculating the section modulus of corrugations at the lower end, the area of flange plates, in cm^2, may be increased by

$$\left(7h_g t_f\right),$$

where h_g – height of gusset plate, in m (refer to Figs 4.2-3 and 4.2-4), with $h_g \le (10/7)s_{gu}$;
s_{gu} – width of the gusset plates, in m;
t_f – net flange thickness, in mm, based on the as built condition.

4.3.4 If the corrugation webs are welded to a sloping stool top plate which have an angle not less than 45° with the horizontal plane, the section modulus of the corrugations may be calculated considering the corrugation webs fully effective. In case effective gusset plates are fitted, when calculating the section modulus of corrugations the area of flange plates may be increased as specified in **4.3.3**. No credit can be given to shedder plates only.

For angles less than 45°, the effectiveness of the web may be obtained by linear interporation between 30 % for 08 and 100 % for 45°.

4.4 Modulus of corrugations at cross-sections other than the lower end.

The section modulus shall be calculated with the corrugation webs considered effective and the compression flange having an effective flange width b_{ef}, not larger than as given in **4.6.1**.

4.5 Allowable stress check.

The normal and shear stresses σ and τ shall not exceed the allowable values σ_a and τ_a, in N/mm^2, to be determined by the formulae:

$$\sigma_a = R_{eH};$$
$$\tau_a = 0{,}5R_{eH},$$

where: R_{eH} – the minimum upper yield stress of the material, in N/mm^2.

4.6 Effective compression flange width and shear buckling check.

4.6.1 Effective width of the compression flange of corrugations.

The effective width b_{ef} in m, of the corrugation flange shall be determined by the formula

$$b_{ef} = C_e\, a,$$

where: $C_e = 2{,}25 / \beta - 1{,}25 / \beta^2$, for $\beta > 1{,}25$;

$C_e = 1{,}0$, for $\beta \le 1{,}25$;

$$\beta = \frac{a}{t_f}\sqrt{R_{eH} / E}\cdot 10^3;$$

t_f – = net flange thickness, in mm;

a – width of the corrugation flange, in m (refer to Fig. 2.3);

for R_{eH} – refer to **4.5**;

E – modulus of elasticity of the material, in N/mm^2, to be assumed equal to $2{,}06/10^5$ for steel.

4.6.2 Shear.

The buckling check shall performed for the web plates at the corrugation end.

The shear stress shall not exceed the critical value τ_c, in N/mm^2, to be determined by the formulae:

$$\tau_c = \tau_e \quad \text{when} \quad \tau_e \le \tau_f/2;$$
$$\tau_c = \tau_f\,(1 - 0{,}25\tau_f / \tau_e) \quad \text{when} \quad \tau_e > \tau_f/2,$$

where: $\tau_f = R_{eH} / \sqrt{3}$;

for R_{eH} – refer to **4.5**;

$$\tau_e = 0{,}9\, k_t\, E\left(\frac{t}{1000c}\right)^2 \text{ in N/mm}^2;$$

$k_t = 6{,}34$;

E – modulus of elasticity of material as given in **4.6.1**;

t – net thickness of corrugation web, in mm;

c – width of corrugation web, in mm (refer to Fig. 2.3).

4.7 Local net plate thickness.

The bulkhead local net plate thickness t, in mm, shall be determined by the formula

$$t = 14{,}9\, s_w\sqrt{1{,}05\, p / R_{eH}},$$

where s_w = plate width, in m, to be taken equal to the width of the corrugation flange or web, whichever is greater (refer to Fig. 2.3);

p = resultant pressure, in kN/m^2, as defined in **2.5**, at the bottom of each strake of plating; in all cases, the net thickness of the lowest strake shall be determined using the resultant pressure at the top of the lower stool, or at the inner bottom, if no lower stool is fitted or at the top of shedders, if shedder or gusset/shedder plates are fitted;

for R_{eH} – refer to **4.5**.

For built-up corrugation bulkheads, when the thicknesses of the flange and web are different, the net thickness of the narrower plating shall be not less than t_n, in mm, determined by the formula

$$t_n = 14{,}9 s_n \sqrt{1{,}05 p / R_{eH}} \ ,$$

where: s_n – width of the narrower plating, in m.

The net thickness of the wider plating, in mm, shall not be taken less than the maximum of the following:

$$t_w = 14{,}9 s_w \sqrt{1{,}05 p / R_{eH}} \ ;$$
$$t_w = 20{,}98 s_w \sqrt{1{,}05 p / R_{eH} - t_{np}^2} \ ,$$

where: t_{np} ≤ actual net thickness of the narrower plating or shall not be greater than $14{,}9 s_w \sqrt{1{,}05 p / R_{eH}}$ whichever is less.

5. МІСЦЕВІ ПІДКРІПЛЕННЯ

As applicable, the design of local details shall comply with the Register requirements for the purpose of transferring the corrugated bulkhead forces and moments to the boundary structures, in particular to the double bottom and cross-deck structures.

In particular, the thickness and stiffening of effective gusset and shedder plates, as defined in **4.3**, shall comply with the RU requirements, on the basis of the load model in Section **2** of this Appendix. Unless otherwise stated, weld connections or materials shall be dimensioned and selected in accordance with **1.7** of this Part.

6. CORROSION ADDITION AND STEEL RENEWAL

The corrosion addition t_s shall be taken equal to 3,5 mm.

Steel renewal is required where the gauged thickness is less than t_{net}+0,5 mm.

Where the gauged thickness is within the range t_{net} +0,5 mm and t_{net} +1 mm, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal.

APPENDIX 4

EVALUATION OF ALLOWABLE HOLD LOADING FOR NON-CSR BULK CARRIERS CONSIDERING HOLD FLOODING

1. APPLICATION AND DEFINITIONS

The loading in each hold shall not exceed the allowable hold loading in flooded condition, calculated as per Section **4** of this Appendix, using the loads given in Section **2** and the shear capacity of the double bottom given in Section **3**.

In no case the allowable hold loading, considering flooding, shall be greater than the design hold loading in the intact condition.

2. LOADING MODEL

2.1 General.

The loads to be considered as acting on the double bottom are those given by the external sea pressures and the combination of the cargo loads with those induced by the flooding of the hold which the double bottom belongs to.

The most severe combinations of cargo induced loads and flooding loads shall be used, depending on the loading conditions included in the Loading Manual:

homogeneous loading conditions;

non homogeneous loading conditions;

packed cargo conditions (such as steel mill products).

For each loading condition, the maximum bulk cargo density to be carried shall be considered in calculating the allowable hold loading limit.

2.2 INNER BOTTOM FLOODING HEAD.

Flooding head h_f (refer t o Fig. 2.2) is the distance, in m, measured vertically with the ship in the upright position, from the inner bottom to a level located at a distance df, in m, from the base line equal to:

in general *D* for the foremost hold;

0,9*D* for the other holds;

for ships less than 50000 t deadweight with Type **B** freeboard

0,95*D* for the foremost hold;

0,85*D* for the other holds.

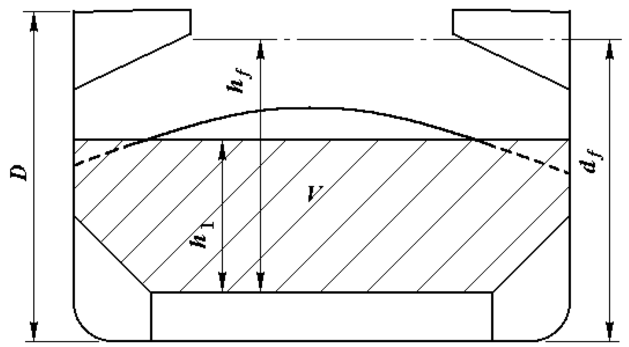


Fig. 2.2:

V – volume of cargo;

D – distance, in m, from the base line to the freeboard deck at side amidship

3. SHEAR CAPACITY OF THE DOUBLE BOTTOM

3.1 The shear capacity.

The shear capacity C of double bottom shall be defined as the sum of the shear force at each end of:

.1 all floors adjacent to both hoppers, less one half of the shear forces of the two floors adjacent to each stool, or transverse bulkhead if no stool is fitted (refer to Fig. 3.1.1);

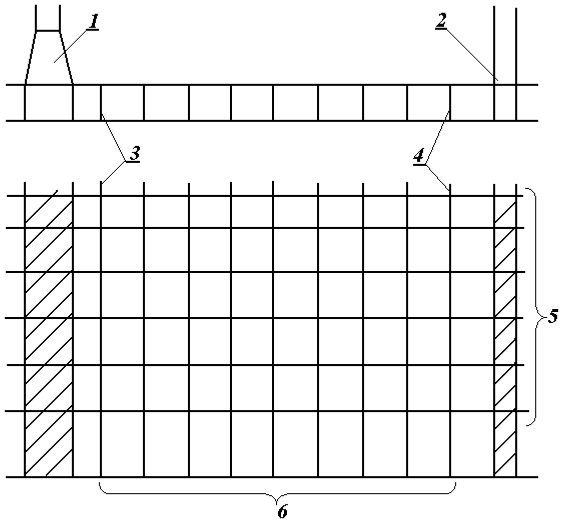


Fig. 3.1.1:
1- lower stool; 2 - transverse bulkhead; 3 - floor adjacent to the stool; 4 - floor adjacent to transverse bulkhead; 5 - girders; 6 - floors

.2 all double bottom girders adjacent to both stools, or transverse bulkheads if no stool is fitted.

Where in the end holds, girders or floors run out and are not directly attached to the boundary stool or hopper girder, their shear force shall be evaluated for the one end only.

Floors and girders t o b e considered are those inside the hold boundaries formed by the hoppers and stools (or transverse bulkheads if no stool is fitted). The hopper side girders and the floors directly below the connection of the bulkhead stools (or transverse bulkheads if no stool is fitted) to the inner bottom shall not be included.

When the geometry and/or the structural arrangement of the double bottom are such to make the above assumptions inadequate, the shear capacity C of double bottom shall be calculated in compliance with the requirements of **3.3** of this Part or according to the Strength Norms for Sea-Going Ships.

In calculating the shear force, the net thickness of floors and girders is to be used. The net thickness t_{net}, in mm, shall be determined by the formula

$$t_{\text{net}} = t - 2,5 ,$$

where: t – thickness of floors and girders, in mm.

3.2 Floor shear force.

The floor shear force in way of the floor panel adjacent to hoppers S_{f1}, in kN, and the floor shear force in way of the openings in the outmost bay (i.e. that bay which is closer to hopper) S_{f2}, in kN, shall be determined by the formulae:

$$S_{f1} = A_f \tau_a \cdot 10^{-3} / \eta_1 ;$$

$$S_{f2} = A_{f,h} \tau_a \cdot 10^{-3} / \eta_2 ,$$

where: A_f – =sectional area of the floor panel adjacent to hoppers, in mm^2;

$A_{f,h}$ – net sectional area of the floor panels in way of the openings in the outmost bay (i.e. that bay which is closer to hopper), in mm²;

τ_a – allowable shear stress, in N/mm², to be taken equal to the lesser of $\tau_a = \dfrac{162 R_{eH}^{0,6}}{(s/t_{\text{net}})^{0,8}}$ and $R_{eH}/\sqrt{3}$

For floors attached to the stools or transverse bulkheads, τ_a may be taken:

$$R_{eH}/\sqrt{3},$$

where: R_{eH} – minimum upper yield stress of the material, in N/mm²;
s – spacing of stiffening members of panel under consideration, in mm;
$\eta_1 = 1{,}10$;
$\eta_2 = 1{,}20$; whereas η_2 may be reduced down to 1,10 where appropriate reinforcements are fitted to comply with the requirements of the Instructions for Determination of the Technical Condition, Renovation and Repair of the Hulls of Sea-Going Ships (refer to Appendix **1** of the Rules for the Classification Surveys of Ships).

3.3 Girder shear force.

The girder shear force in way of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted) S_{g1}, in kN, and the girder shear force in way of the largest opening in the outmost bay (i.e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted) S_{g2}, in kN, shall be determined by the formulae:

$$S_{g1} = A_g \tau_a \cdot 10^{-3} / \eta_1;$$
$$S_{g2} = A_{g,h} \tau_a \cdot 10^{-3} / \eta_2,$$

where: A_g – minimum sectional area of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted), in mm²;
$A_{g,h}$ – net sectional area of the girder panel in way of the largest opening in the outmost bay (i.e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted), in mm²;
τ_a – allowable shear stress, in N/mm², as specified in 3.2;
$\eta_1 = 1{,}10$;
$\eta_2 = 1{,}15$; whereas η_2 may be reduced down to 1,10 where appropriate reinforcements are fitted to comply with the requirements of the Instructions for Determination of the Technical Condition, Renovation and Repair of the Hulls of Sea-Going Ships (refer to Appendix **1** of the Rules for the Classification Surveys of Ships).

4. ALLOWABLE HOLD LOADING

The allowable hold loading W, in t, shall be determined by the formula

$W = \rho_c V/F$,
where: F = 1,10 – in general;
F = 1,05 – for steel mill products;
ρ_c – cargo density for bulk cargoes, in t/m³ (refer to **2.1**). For steel products rc shall be taken as the density of steel;
V – volume, in m3 , occupied by cargo at a level h_1
$h_1 = X/(\rho_c g)$.

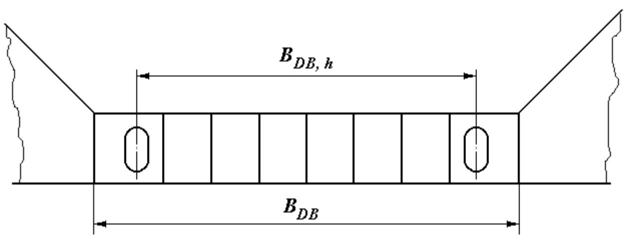


Fig.4

For bulk cargoes, X shall be taken as the lesser of X_1 and X_2 determined by the formulae:

$$X_1 = \frac{Z + \rho g(E - h_f)}{1 + \rho / \rho_c(\text{perm} - 1)};$$

$$X_2 = Z + \rho g(E - h_f \text{perm}),$$

where: $X = X_1$ – for steel products, using perm = 0;

ρ – sea water density, in t/m^3;

g – 9,81 m/s^2, gravity acceleration;

$E = d_f - 0{,}1D$ – ship immersion, in m, for flooded hold condition;

for d_f, D – refer to **2.2**;

h_f – flooding head, in m (refer to **2.2**);

perm – cargo permeability (i.e. the ratio between the voids within the cargo mass and the volume occupied by the cargo), it needs not be taken greater than 0,3;

Z = the lesser of Z_1 or Z_2 whereas:

$$Z_1 = \frac{C_h}{A_{DB,h}};$$

$$Z_2 = \frac{C_e}{A_{DB,e}},$$

where: C_h – shear capacity of the double bottom, in kN, as defined in Section **3** of this Appendix, considering, for each floor, the lesser of the shear forces S_{f1} and S_{f2} (refer to **3.2**) and for each girder, the lesser of the shear forces S_{g1} and S_{g2} (refer to **3.3**);

C_e – shear capacity of the double bottom, in kN, as defined in Section **3** of this Appendix, considering, for each floor, the shear force S_{f1} (refer to **3.2**), and, for each girder, the lesser of the shear forces S_{g1} and S_{g2} shall be determined according to **3.3**;

$$A_{DB,h} = \sum_{i=1}^{i=n} S_i B_{DB,i};$$

$$A_{DB,e} = \sum_{i=1}^{i=n} S_i (B_{DB} - s_1),$$

where: n – number of floors between stools (or transverse bulkheads, if no stool is fitted);

S_i – space of i-th floor, in m; $B_{DB,i} = B_{DB} - s_1$ – for floors whose shear force is determined by S_{f1} (refer to **3.2**);

$B_{DB,i} = B_{DB,h}$ - for floors whose shear force is determined by S_{f2} (refer to **3.2**);

B_{DB} – breadth of double bottom between hoppers, in m (refer to Fig. 4);

$B_{DB,h}$ – = distance between the two considered openings, in m (refer to Fig. 4);

s_1 – spacing of double bottom longitudinals adjacent to hoppers, in m.

PART III. EQUIPMENT, ARRANGEMENTS AND OUTFIT

1. GENERAL

1.1 APPLICATION

1.1.1 1 The requirements of this Part apply to equipment, arrangements and outfit of sea-going ships navigating in a displacement condition. To hydrofoil boats, air cushion vehicles, hydrogliders and other similar ships, unless expressly provided otherwise below, the requirements of this Part are applicable to the extent that is practicable and reasonable.

1.1.2 Ship's equipment, arrangements and outfit designed for special purposes (such as special anchor arrangements of dredgers, a deep-sea anchor arrangement for special purpose ships and similar arrangements) are not subject to the Register supervision.

1.1.3 The requirements of this Part apply, as far as practicable and reasonable, to floating metallic wing-walled docks, unless expressly provided otherwise. These Rules do not specify conditions for mooring of floating docks in a particular place of operation and selection of types and characteristics of the equipment, arrangements and outfit (anchor, mooring, etc.) used for this purpose.

1.1.4 This part of the Rules applies to:

.1 equipment providing effective anti-icing protection of ships having in accordance with provisions of **2.2.13**, Part I "Classification" of the Rules for Classification and Construction of Ships, the additional **DEICE** sign in ship's class notation;

.2 equipment providing the operation of helicopters, of ships which in accordance with the provisions of **2.2.25**, Part I "Classification", have an additional sign: **HELIDECK**, **HELIDECK-F** or **HELIDECK-H** respectively in the ship's class notation;

.3 equipment for tugs intended for escort operations;

.4 equipment of standby ships and ships for anchor handling;

.5 equipment for the long-term operation of shipss at low temperatures, which, in accordance with the provisions of **2.2.30**, Part I "Classification", have an additional sign: **WINTERIZATION (DAT)** in the ship's class notation;

.6 arrangements providing the operation of Baltic ice class ships, which, in accordance with the provisions of 2.2.3.1, Part I “Classification”, have an additional sign: IA Super, IA, IB or IC respectively, in the ship's class notation;

.7 equipment of ships intended for inclusion in pushed convoys.

1.2 DEFINITIONS AND EXPLANATIONS

The definitions and explanations relating to the general terminology of these Rules are given in Part I "Classification".

For the purpose of this Part the following definitions have been adopted.

1.2.1 Waterlines.

Damage waterlines are the waterlines of a damaged ship after flooding of corresponding separate compartments or their combinations as provided in Part **V** "Subdivision".

Mar gin line at docking is the envelope of the waterlines corresponding to the maximum permitted trims of the floating docks and docklift ships when carrying out the docking operations.

Summer load waterline is the waterline indicated by the upper edge of the line which passes through the centre of the ring of the load line mark for a ship in upright position.

Summer timber load waterline is the waterline indicated by the upper edge of the assigned summer timber load line.

Deepest load waterline is the waterline indicated by the upper edge of the assigned uppermost regional or seasonal load line, including fresh water load lines.

Deepest subdivision load waterline is the uppermost waterline at which the requirements of Part **V** "Subdivision" are still fulfilled.

1.2.2 Dimensions and draught of the ship.

Length o f ship L is taken as 96 % of the total length on a waterline at 85 % of the least moulded depth or as the length from the fore side of the stem to the axis of the rudder stock on that waterline, if that be greater.

Where the stem contour is concave above that waterline, the length of the ship shall be measured from the vertical projection to that waterline of the aftermost point of the stem contour (above that waterline).

In ships designed with a rake of keel the waterline on which this length is measured shall be parallel to the design waterline.

Length of floating dock L is the distance measured along the pontoon deck and parallel to the base line, between the inner sides of the pontoon end bulkheads.

Moulded draught d is the vertical distance measured amidships from the top of the plate keel or from the point where the inner surface of the shell (outer surface in a ship with a non-metal shell) abuts upon the bar keel, to the summer load waterline.

Moulded depth D is the vertical distance measured amidships from the top of the plate keel, or from the point where the inner surface of the shell abuts upon the bar keel, to the top of the freeboard deck beam at side.

In ships having rounded gunwales, the moulded depth shall be measured to the point of intersection of the moulded lines of the freeboard deck and side, the lines extending as though the gunwale were of angular design.

Where the freeboard deck is stepped in the longitudinal direction and the raised part of the deck extends over the point at which the moulded depth shall be determined, the moulded depth shall be measured to a line of reference extending from the lower part of the deck along a line parallel with the raised part.

Moulded breadth B is the maximum breadth measured amidships from outside of frame to outside of frame in a ship with a metal shell and to the outer surface of the hull in a ship with a shell of any other material.

1.2.3 Superstructures, deckhouses.

Superstructure is a decked structure on the freeboard deck, extending from side to side of the ship or with the side plating not being inboard of the shell plating more than 4 % of the breadth *B*.

The superstructure may be either complete, i.e. extending over the entire ship's length *L*, or detached, i.e. extending only over a definite part of this length. Both complete and detached superstructures may be arranged either in a single or several tiers.

Deckhouse is a decked structure on the freeboard or superstructure deck which is set in from the sides of the ship for more than 4 % of the breadth *B* and has doors, windows or other similar openings in the outer bulkheads. The deckhouses may be arranged in a single or several tiers.

Trunk is a decked structure on the freeboard deck which is set in from the sides of the ship for more than 4 % of the breadth *B* and has no doors, windows or other similar openings in the outer bulkheads.

1.2.4 Tightness.

Tight under pressure head up to... is the term pertaining to closing appliances of openings, which means that under specified pressure the liquid will not penetrate through the openings inside the ship.

Weathertight is the term pertaining to closing appliances of openings in the above-water hull, which means that in any sea conditions water will not penetrate through the openings inside the ship. The above closing appliances shall undergo tests according to the requirements of **4.4.3**, Appendix **1** to Part II "Hull".

It is allowed that the specialized organizations recognized by the Register carry out tests by means of the ultrasonic equipment as well as other test methods approved by the Register.

1.2.5 Decks.

Weather deck is the deck which is completely exposed to the weather from above and from at least two sides.

Upper deck is the uppermost continuous deck extending for the full length of the ship.

The upper deck may be stepped.

Raised quarter deck is the after upper part of a stepped deck, the forward lower part of which is taken as a portion of the freeboard deck.

Freeboard deck is the deck from which the freeboard is measured.

In a ship having a discontinuous deck the lowest line of this deck and the continuation of that line parallel to upper part of the deck is taken as a freeboard deck.

Superstructure deck, deckhouse top or trunk deck is the deck forming the top of a superstructure, deckhouse or trunk, respectively.

Superstructure deck or deckhouse top of the first, second, etc. tiers is the deck forming the top of the superstructure or deckhouse of the first, second, etc. tiers, counting from the freeboard deck.

Bulkhead deck is the deck up to which the main transverse watertight subdivision bulkheads are carried.

The bulkhead deck may be discontinuous, i.e. with a step or steps formed both by main transverse watertight bulkheads reaching the keel and transverse watertight bulkheads not reaching the keel.

Lower decks are the decks below the upper deck.

Pontoon deck of the dock is the deck on which the ship to be docked is fitted.

Top deck of the dock is the uppermost deck of the dock (the uppermost deck of the wing walls).

1.2.6 Perpendiculars and amidships.

Amidships is at the middle of the ship's length *L*.

Forward and after perpendiculars are the vertical lines passing in the centreline at the fore and after ends of the ship's length *L,* respectively.

1.2.7 Ships.

Type "A" ship is a ship designed to carry only liquid cargoes in bulk, and in which cargo tanks have only small access openings closed by gasketed covers tight under an appropriate inner pressure of liquid which is carried in the tanks. Furthermore, a type "A" ship shall have some other features, as defined in the Load Line Rules for Sea-Going Ships which permit this ship to be assigned a freeboard based on Tables 4.1.2.3, 6.4.2.2 or 6.4.3.2 of the above Rules.

Type "B" ship is a ship which does not comply with the requirements regarding type "A" ships and which is assigned a freeboard based on Table 4.1.3.2, 6.4.2.3 or 6.4.3.3 of the Load Line Rules for SeaGoing Ships.

A type "B" ship may not be classified as a type "A" ship even though, as a result of her features detailed in the Load Line Rules, a reduction in tabular freeboard is permitted up to the total difference between the values given in Tables 4.1.2.3, 6.4.2.2, 6.4.3.2 and those in Tables 4.1.3.2, 6.4.2.3, 6.4.3.3, respectively, of the above Rules.

Docklift ship is a dry cargo ship adapted to carry out cargo handling operations using the docking principle in ports and protected water areas.

1.2.8 *Active means of the ship's steering (AMSS)* are special propulsion and steering units and any combination of them or with the main propulsion devices, capable of producing thrust or traction force both at a fixed angle to the centreline of the ship and at a variable angle, either under all running conditions or part thereof including small and zero speed.

The active means of the ship's steering comprise steerable propellers including retractable units of all types, active rudders, vertical-axis propellers, waterjets, propellers in transverse tunnel (athwartship thrusters), separate steering nozzles and other devices of similar purpose.

Design and construction requirements to *AMSS*, except for separate nozzles and the steering part of the active rudders, set forth in part VII "Machinery Installations".

Requirements to AMSS of systems for dynamic positioning of mobile offshore drilling units (MODU) shall be carried out taking into account the Rules for the classification, construction and equipment of mobile offshore drilling units and offshore stationary platforms.

1.2.9 Steering gear.

Main steering gear is the machinery, rudder actuators, steering gear power units, if any, ancillary equipment and the means of applying torque to the rudder stock (e.g. tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the ship under normal service conditions.

Auxiliary steering gear is the equipment other than any part of the main steering gear necessary to steer the ship in the event of failure of the main steering gear, but not including the tiller, quadrant or components serving the same purpose.

Steering gear power unit is:

in the case of electric steering gear an electric motor and its associated electrical equipment;

in the case of electrohydraulic steering gear an electric motor and its associated equipment and connected pump;

in the case of other hydraulic steering gear a driving engine and connected pump.

Power actuating system is the hydraulic equipment provided for supplying power to turn the rudder stock, comprising a steering gear power unit or units, together with the associated pipes and fittings, and a rudder actuator. The power actuating systems may share common mechanical components, i.e. tiller, quadrant and rudder stock, or components serving the same purpose.

Steering gear control system is the equipment by which orders are transmitted from the navigation bridge to the steering gear power units. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables.

1.3 SCOPE OF SURVEY

1.3.1 General provisions on survey of ship's equipment, arrangements and outfit are given in General Regulations for the Classification and Other Activity and in Part I "Classification".

1.3.2 The following items included into ship's equipment, arrangements and outfit are subject to the survey by the Register during their manufacture:

1.3.2.1 Rudder and steering gear:

.1 rudder stocks;

.2 rudder blade;

.3 steering nozzles;

.4 rudder axles;

.5 pintles of rudders and steering nozzles;

.6 bushes of pintles;

.7 fastenings of rudder stocks, rudder stock with rudder blade or steering nozzle, and also of rudder axle with sternframe (muff couplings, keys, bolts, nuts, etc.);

.8 parts of the system of rudder stops;

.9 rudder stock bearings;

.10 active means of the ship's steering (only in the case specified in **2.1.4.2**).

1.3.2.2 Anchor arrangement:

.1 anchors;

.2 chain cables or ropes;

.3 anchor stoppers;

.4 devices for securing and releasing the inboard end of chain cable or rope;

.5 anchor hawse pipes.

1.3.2.3 Mooring arrangement:

.1 mooring lines;

.2 mooring bollards, belaying cleats, fairleaders, chocks, rollers and stoppers..

1.3.2.4 Towing arrangement:

.1 tow lines;

.2 towing bollards, bitts, fairleaders, chocks and stoppers;

.3 tow hooks and towing rails with fastenings for their securing to ship's hull;

.4 towing snatch-blocks;

1.3.2.5 Masts and rigging:

.1 metal, wooden and fiber-reinforced plastic spars;

.2 standing ropes;

.3 permanent attachments to masts and decks (eyeplates, hoops, etc.);

.4 loose gear of masts and rigging (shackles, turnbuckles, etc.).

1.3.2.6 Closing appliances of openings in hull, superstructures and deckhouses:

.1 side and deck scuttles;

.2 doors of bow, side and stern openings in the shell plating;

.3 doors in superstructures and deckhouses;

.4 companion hatches, skylights and ventilating trunks;

.5 ventilators;

.6 manholes to deep and other tanks;

.7 hatchway covers in dry cargo ships and tankers;

.8 cargo tank hatchway covers in tankers;

.9 doors in subdivision bulkheads.

1.3.2.7 Equipment of ship's spaces:

.1 ceiling and battens in cargo holds;

.2 exit doors from ship's spaces in escape routes;

.3 stairways and vertical ladders;

.4 guard rails, bulwark and gangways;

.5 cellular guide members in the holds of container ships.

1.3.2.8 Emergency outfit:

.1 collision mats;

.2 tools;

.3 materials.

1.3.2.9 Equipment for receiving helicopters:

.1 light signals and illuminating means of the helideck;

.2 VHF radio station for communication with helicopter;

.3 portable VHF radio headset with headphones.

1.3.3 The Register survey of the manufacture of items specified in **1.3.2.1.7**, **1.3.2.1.8**, **1.3.2.5**, **1.3.2.7.1**, **1.3.2.7.5**, **1.3.2.8.2** and **1.3.2.8.3** is confined to consideration of the relevant technical documentation.

1.3.4 For items specified in **1.3.2** (except for **1.3.2.9.3** and **1.2.3.9.4**), the following documents shall be submitted to the Register:

.1 assembly drawing;

.2 calculations (no approval stamps are needed);

.3 detail drawings if parts or assemblies are not manufactured in accordance with standards and specifications approved by the Register.

For items specified in **1.3.2.9.3** and **1.2.3.9.4** the Register shall be provided with documentation in the scope of the requirements of **1.3.4**, Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships.

1.3.5 Materials used for items specified in **1.3.2.1.1 ÷ 1.3.2.1.5**, **1.3.2.2.1**, **1.3.2.2.2**, **1.3.2.4.3**, **1.3.2.6.2** and **1.3.2.6.7 ÷ 1.3.2.6.9** are subject to the Register survey during manufacture.

1.3.6 The following equipment, arrangements and outfit are subject to the Register survey when the ship is under construction:

.1 rudder and steering gear;

.2 anchor arrangement;

.3 mooring arrangement;

.4 towing arrangement;

.5 masts and rigging;

.6 openings in hull, superstructures and deckhouses and their closing appliances;

.7 arrangement and equipment of ship's spaces;

.8 emergency outfit;

.9 cellular guide members in the holds of container ships;

.10 active means of the ship's steering (refer to **2.1.4**).

1.4 GENERAL

1.4.1 In ships intended to carry in bulk flammable liquids with the flash point 60°C and below no deck machinery shall be fitted directly on the decks being the top of cargo and fuel tanks.

In this case, the deck machinery shall be fitted on special foundations, the construction of which provides for free circulation of air underneath the machinery.

1.4.2 Towing and mooring arrangements plan containing the relevant information shall be available on board for the guidance of the master.

The information provided on the plan in respect of shipboard equipment shall include:

type and location on the ship;

safe working load (SWL);

purpose (mooring/harbour towing/escort service);

manner of applying tow line or mooring line load including limiting fleet angles.

Also the number of mooring lines together with the breaking strength of each mooring line shall be indicated on the plan.

This information shall be incorporated into the pilot card in order to provide the pilot with the proper information on harbour operations/escort service.

1.5 WORKING AND ALLOWABLE STRESSES

1.5.1 Wherever the working stresses are mentioned in the text of the present Part of the Rules, they mean equivalent stress(es) σ_{eq}, in MPa, determined by the formula

$$\sigma_{eq} = \sqrt{\sigma^2 + 3\tau^2}, \qquad (1.5.1)$$

where: σ – normal stresses in the section under consideration, in MPa;
τ – shear stresses in the section under consideration, in MPa.

The strength conditions shall be checked against these stresses.

1.5.2 Allowable stresses with which the combined stresses shall be compared when verifying the strength conditions are specified in the present Part in fractions of the upper yield stress of the material used; the upper yield stress shall not be taken as more than 0,7 times the tensile strength of this material, unless expressly provided otherwise.

1.6 MATERIALS AND WELDING

1.6.1 Steel forgings and castings, steel plates, sections and bars and also chain steel used for items specified in **1.3.2.1.1–1.3.2.1.5**, **1.3.2.1.7**, **1.3.2.2.1**, **1.3.2.2.2**, **1.3.2.4.3**, **1.3.2.6.2**, **1.3.2.6.7** and **1.3.2.6.9**, shall meet the relevant requirements of Part XIII "Materials".

Materials for other items of equipment, arrangements and outfit shall meet the requirements specified in the design documentation approved by the Register, unless expressly provided otherwise in these Rules.

1.6.2 The grades of steel plates and sections (refer to Tables 3.2.2-1 and 3.2.2-2, Part XIII "Materials") for items specified in **1.3.2.1.2** and **1.3.2.1.3**, shall be selected according to **1.2.3.1**, Part II "Hull" in the same manner as for hull structural members of category II; in this case, for ships of ice class **Ice4** and higher, Polar classes, Baltic ice classes **IA Super** ÷ **IC** and for icebreakers steel not lower than Grade B shall be adopted, and for rudder blades of icebreakers, not lower than Grade D. For items specified in **1.3.2.6.2** the grades of steel plates and sections of the main carrying framing members and plating of cover structures ensuring fixing of items when stowed for sea, as well as essential parts of drivers intended for opening at sea shall be selected according to **1.2.3.1**, Part II "Hull" as for hull structural members of category II.

1.6.3 Welding of structural elements of ship's equipment, arrangements and outfit shall be performed in accordance with the requirements of Part XIV "Welding"; besides, welded structures and joints of items specified in **1.3.2.6.2**, **1.3.2.6.7** and **1.3.2.6.9** shall comply with the applicable requirements of **1.7**, Part II "Hull".

1.7 DESIGN ACCELERATIONS DUE TO HEAVE OF THE SEA

1.7.1 The dimensionless, gravity related, design accelerations due to heave of the sea as described in this Chapter shall be applied when determining the loads upon equipment, arrangements and batches of cargo items carried by ships of unrestricted service and those of restricted area of navigation **R1** and **A-R1**.

With regard to ships of other areas of navigation, accelerations may be applied different from those required herein which shall be substantiated by calculations approved by the Register.

1.7.2 The dimensionless acceleration a_z due to heave, pitch and roll normal to the water planes of the ship shall be determined by the formula

$$a_z = \pm a_0 \sqrt{1 + \left(5{,}3 - \frac{45}{L}\right)^2 \left(\frac{x}{L} - 0{,}45\right)^2 \left(\frac{0{,}6}{C_B}\right)^{3/2}}, \qquad (1.7.2\text{-}1)$$

where: $a_0 = 0{,}2\dfrac{V}{\sqrt{L}} + \dfrac{34 - 600/L}{L}$; (1.7.2-2)

V – maximum ahead speed, in knots, with the ship on summer load waterline on still water;
L – ship's length, in m;
x – longitudinal distance from the centre of gravity of equipment, arrangement or batch of cargo items in question to the aft perpendicular;
C_B – block coefficient.

a_z does not include the component of the static weight.

1.7.3 The dimensionless acceleration a_y due to transverse displacement, yaw and roll normal to the centreline of the ship shall be determined by the formula

$$a_y = \pm a_0 \sqrt{0,6 + 2,5\left(\frac{x}{L} - 0,45\right)^2 + k_1\left(1 + 0,6k_1\frac{z}{B}\right)^2}, \tag{1.7.3-1}$$

where: k_1 – coefficient of stability to be determined by the formula

$$k_1 = \frac{13\overline{GM}}{B}. \tag{1.7.3-2}$$

If k_1 as determined by Formula (1.7.3-2), is below 1,0, k_1 = 1,0 shall be assumed for calculating a_y;

$\overline{GM}$ – transverse metacentric height of loaded ship when the volume and distribution of stores are such as to yield maximum $\overline{GM}$, i;

B – ship's breadth, in m;

z – vertical distance, in m, from the summer load waterline to the centre of gravity of equipment, arrangement or batch of cargo items in question; z is positive above and negative below the summer load waterline.

a_y includes the component of the static weight in the transverse direction due to rolling.

1.7.4 The dimensionless acceleration a_x due to longitudinal displacement and pitch normal to the midship section plane shall be determined by the formula

$$a_x = \pm a_0 \sqrt{0,06 + k_2^2 - 0,25k_2}, \tag{1.7.4-1}$$

w: k_2 – =factor determined from the formula:

$$k_2 = \left(0,7 - \frac{L}{1200} + 5\frac{z}{L}\right)\frac{0,6}{C_B}. \tag{1.7.4-2}$$

a_x includes the component of the static weight in the longitudinal direction due to pitching.

1.7.5 When determining loads it shall be considered that the accelerations calculated using a_x, a_y and a_z act independently of each other.

2. RUDDER AND STEERING GEAR

2.1 GENERAL

2.1.1 Every ship, except for shipborne barges, shall be provided with a reliable device ensuring her steering and course-keeping facilities (refer to 2.10). Such devices may be rudder, steering nozzle, etc., approved by the Register. For non-propelled vessels of the dredging fleet with regard to the area of navigation and service conditions it may be allowed to omit such device or provide only stabilizers.

For towed barges the Register may allow installation of stabilizers.

2.1.2 The requirements of this Section apply only to ordinary streamlined rudders or steering nozzles with streamlined profiles and rigidly fixed stabilizers.

2.1.3 Steering gears may be designed compliant to IACS unified requirement (UR) S10.Rev.5.

2.1.4 Active means of the ship's steering.

2.1.4.1 The active means of the ship's steering may be both the means supplementary to the regulated minimum (refer to **2.1.1**) and the main means of the ship's steering.

2.1.4.2 Taking into account the ship's purpose, design features and intended service conditions it may be permitted that the regulated steerability of the ship shall be provided at the low speed by simultaneous operation of the devices specified in **2.1.1** and the active means of the ship's steering.

In case where the AMSS are the main means of the ship's steering the regulated steerability shall be ensured under those running conditions of the ship for which the means are intended.

In any case, it shall be demonstrated by the method recognized by the Register that the steerability will not then be at least worse than that ensured in case of fulfilment of the requirements of **2.10**.

2.1.4.3 3 Requirements for AMSS construction and design, exclusive of the separate steering nozzles and rudder section of the active rudders are outlined in Part VII "Machinery Installations". Requirements for

AMSS used in the dynamic positioning systems of mobil offshore drilling units shall be fulfilled with consideration for Rules for the Classification and Construction of Mobile Offshore Drilling Units.

2.1.5 The number of rudder pintles supporting the rudder is not regulated by the Register, except for icebreakers, Polar class ships, Baltic ice classes **IA Super** ÷ **IC** ships (refer to **2.11**) and ships of ice class and higher for which this number shall be not less than that given in Table 2.1.5.

In exceptional cases, in icebreakers the number of rudder pintles indicated in Table 2.1.5 may be reduced to two provided the calculations proving the strength of the structure during the operation in appropriate ice conditions have been submitted.

In icebreakers and Polar class ships the steering nozzles shall not be fitted.

In ships of ice classes **Ice4** and **Ice5**, Baltic ice classes **IA Super** ÷ **IC** ships the arrangement of the steering nozzle without the lower pintle in the solepiece is not permitted.

Table 2.1.5

Ice class	Number of rudder pintles
Icebreaker4, Icebreaker3, PC1÷PC3	4
Icebreaker2, Icebreaker1, PC4	3
Ice6, Ice5, PC5, PC6, IA Super	2
Ice4, PC7, IA,	1

2.1.6 Wherever the upper yield stress R_{eH}, of the material used enters into the formulae of this Section, the provisions of **1.5.2** shall be taken into account, but in all cases the upper yield stress R_{eH} of the material shall not be taken more than 390 MPa.

2.1.7 When checking the rudder or steering nozzle pintles and rudder stock bearings for surface pressure, the latter shall not exceed the values indicated in Table 2.1.7.

Table 2.1.7

Materials	Surface pressure p, in MPa	
	Water lubrication	Oil lubrication
Stainless steel or bronze against lignum vitae	2,4	–
Stainless steel or bronze against textolite or synthetic materials	On agreed manufacture's specification	-
Stainless steel against bronze or vice versa	6,9	–
Steel against white metal	–	4,4

2.1.8 In ships of ice classes **Ice5, Ice6, PC5, PC6, IA Super** the arrangement of two steering nozzles (in case of twin-screw ships) shall be verified by strength calculation as well as by taking measures to ensure protection against ice impact.

2.1.9 In ships of Polar classes, Baltic ice classes **IA** and **IA Super** and **Ice4 class** and higher the measures to ensure protection of steering nozzles against ice impact shall be submitted by the designer.

2.1.10 For passenger ships and special purpose ships carrying more than 60 persons having length of 120 m or more or having three or more main vertical zones, the steering gear shall comply with the requirements of **2.2.6.8**, Part VI "Fire Protection" (refer also to **2.2.6.7.2** of the above Part).

2.1.11 Steering room shall be:

.1 readily accessible and, as far as practicable, separated from the machinery spaces; and

.2 equipped with appropriate means to provide operational access to the steering gear and controls. Such means shall include handrails and lattices or other non-slip plating, which shall ensure proper working conditions in the event of hydraulic fluid leakage.

2.2. INITIAL DESIGN DATA

2.2.1 The initial design data specified in this Chapter are valid only for the choice of scantlings of ordinary rudders and steering nozzles with rigidly fixed stabilizers and cannot be used for determination of steering gear output characteristics.

Methods of determination of these characteristics are not regulated by the Register, and the relevant calculations are not subject to approval by the Register. The steering gear is checked by the Register during sea trials of the ship to make sure that the steering gear output characteristics comply with the requirements of **2.9.2**, **2.9.3** and **2.9.8**.

2.2.2 Rudder force and rudder torque.

2.2.2.1 The rudder blade force F, in kN, for the ahead condition shall be determined by the formula

$$F = F_1 + F_2 . \quad (2.2.2.1\text{-}1)$$

where

$$F_1 = 5{,}59 \cdot 10^{-3} k_1 k_2 (6{,}5 + \lambda)(b_1 - C_B)^2 A v^2, \quad (2.2.2.1\text{-}2)$$

$$F_2 = 0{,}177 k_1 (6{,}5 + \lambda) \frac{T}{D_p^2} A_p \quad (2.2.2.1\text{-}3)$$

where: k_1 – factor equal to:

1,0 for rectangular and trapezoidal rudders, except for rudders behind the rudder post;

0,95 for semispade rudders (rudders of types I, II, VII and VIII in Fig. 2.2.4.1);

0,89 for rudders behind the rudder post (rudders of types IV, X and XIII in Fig. 2.2.4.1);

k_2 – factor equal to:

1,0 for rudders operating directly behind the propeller;

1,25 for rudders not operating directly behind the propeller;

λ – value determined by the formula:

$$\lambda = h_r^2 / A_t , \quad (2.2.2.1\text{-}4)$$

where: h_p – mean height of the rudder blade part abaft the centreline of the rudder stock, in m;

A_t – sum of the rudder area and lateral area of the rudder horn or rudder post, if any, within the height h_p, in m^2. In case of no rudder horn or rudder post, the value of A_t is taken as A in the calculations;

A – rudder area, in m^2;

A_p– portion of the rudder area in the wake of the propeller when the rudder is in the non-reversed position, in m^2;

b_1 – value equal to:

2,2 for rudders situated at the centreline of the ship;

2,32 for side rudders;

C_B – block coefficient with the ship on the summer load waterline;

V – maximum ahead speed with the ship on the summer load waterline, in knots;

T – propeller thrust at the speed V, in kN, (refer to **2.2.2.6**);

D_p– propeller diameter, in m.

2.2.2.2 The value of the force $\boldsymbol{F}$ specified in 2.2.2.1 shall not be taken less than $\boldsymbol{F}_3$, in kN, determined by the formula

$$F_3 = k_3 A , \quad (2.2.2.2)$$

where: k_3 – factor equal to:

171 – for icebreakers of ice class **Icebreaker4** and Polar classes **PC1 ÷ PC3** and Polar class;

150 – for icebreakers of ice class **Icebreaker3**;

130 – for icebreakers of ice class **Icebreaker2** and Polar class **PC4** ships;

110 – for icebreakers of ice class **Icebreaker1** and Polar class **PC5** ships;

95 – for ships of Polar class **PC6;**

75 – for ships of ice class **Ice6** and Polar class **PC7** ships;

66 – for ships of ice class **Ice5** and Baltic ice class **IA Super** ships;

53 – for ships of ice class **Ice4** and Baltic ice class **IA** ships;

18 – _ for other ships.

When the value of the force F_3 is greater than that of the force $\boldsymbol{F}$ specified in 2.2.2.1, in subsequent calculations the value of $\boldsymbol{F}_3$ is taken instead of $\boldsymbol{F}$ and the value $\boldsymbol{F}_2$ is taken equal to zero.

2.2.2.3 For the ahead condition the rudder torque M_t, in kN/m, shall not be taken less than determined by the formula

$$M_t = F \frac{A}{h_r} \left(0{,}35 - \frac{A_1}{A} \right), \quad (2.2.2.3\text{-}1)$$

where: A_1 – part of the rudder blade area forward of its centreline, in m^2.

For single-plate solid-cast rudders with the leading edge aft of the rudder stock centre line, A_1 is taken as the negative value of the area formed by the leading edge of the rudder blade and the rudder stock centre line.

For icebreakers, Polar class ships, Baltic ice classes **IA Super** and **IA** ships and **Ice4, Ice5, Ice6** ice class ships the rudder torque M_t, in kN·m, due to the force F_3, specified in **2.2.2.2**, shall not be taken less than determined by the formula

$$M_t = 0{,}35 F_3 b_r, \quad (2.2.2.3\text{-}2)$$

where: b_p – distance from the centre line to the rear edge of the rudder blade at the level of the midheight of the rudder blade, in m.

2.2.2.4 For the astern condition the rudder torque M_{as}, in kN/m, shall not be taken less than determined by the formula

$$M_{as} = k_4 \frac{A^2}{h_r}\left(0{,}7 - \frac{A_1}{A}\right) v_{as}^2, \quad (2.2.2.4)$$

where: k_4 – factor equal to:

0,185 – for rudders operating directly behind the propeller;
0,139 – for rudders not operating directly behind the propeller;
V_{as}– maximum specification speed of the ship for the astern condition, but not less than 0,5V, in knots.

2.2.2.5 For the astern condition the rudder blade force F_{as}, in kN, shall be determined by the formula

$$F_{as} = M_{as} \frac{h_r}{A\left(0{,}7 - \frac{A_1}{A}\right)}. \quad (2.2.2.5)$$

When determining the bending moments and reactions of the supports according to the provisions of **2.2.4** – **2.2.7** for the astern condition, the force F_{as} shall be considered as the force F_1, and the value of F_2 is then taken equal to zero.

2.2.2.6 In case reliable data are not available on the value of the propeller thrust mentioned in **2.2.2.1**, the value of T, in kN, may be determined by the formulae:

for fixed-pitch propellers

$$T = 0{,}0441\left(\frac{30{,}6 N_e}{n H_1 \sqrt[3]{z\theta}} - n^2 D_p^4\right); \quad (2.2.2.6\text{-}1)$$

for controllable-pitch propellers

$$T = 0{,}0441\left(\frac{110 N_e}{v(b_1 - C_B)\sqrt[3]{z}} - n^2 D_p^4\right), \quad (2.2.2.6\text{-}2)$$

where: N_e – nominal total output of the propulsion plant of the ship divided by the number of the propellers, in kW;

n – number of propeller revolutions per second, in s^{-1};
H_1 – propeller pitch at the zero thrust, in m, determined by the formula:

$$H_1 = H + \frac{0{,}055 D_p}{\theta + 0{,}3}, \quad (2.2.2.6\text{-}3)$$

where: H – design propeller pitch, in m;
θ – blade area ratio;
z – number of propeller blades.

2.2.3 Steering nozzle rudder force and torque.

2.2.3.1 The total force F, in kN, acting on the steering nozzle and stabilizer shall not be taken less than determined by the formula:

$$F = F_n + F_{st}, \quad (2.2.3.1\text{-}1)$$

where: F_n– force acting on the steering nozzle, in kN;

F_{st} – force acting on the stabilizer, in kN.

F_n and F_{st} – are determined by the formulae:

$$F_n = 9{,}81 \cdot 10^{-3} p D_n l_n v_1^2 \qquad (2.2.3.1\text{-}2)$$

$$F_{st} = 9{,}81 \cdot 10^{-3} q m A_{st} v_1^2; \qquad (2.2.3.1\text{-}3)$$

where: D_n– inner minimum steering nozzle bore, in m;

l_n– steering nozzle length, in m;

A_{st} – area of steering nozzle stabilizer, in m^2;

V_1 – speed, in knots, determined by the formula:

$$V_1 = V(1 - W); \qquad (2.2.3.1\text{-}4)$$

where: W – average wake factor. In case reliable experimental data are not available, the wake factor may be determined by the formula:

$$W = 0{,}165 C_B^n \sqrt{\sqrt[3]{\Delta}/D_p}\ , \qquad (2.2.3.1\text{-}5)$$

where: C_B– block coefficient of the ship;

Δ – volume displacement, in m^3, with the ship on summer load waterline;

n – number of propellers;

D_p– propeller diameter, in m;

V – maximum ahead speed, in knots, with the ship on summer load waterline; this speed shall not be taken less than:

20 knots for ships of Baltic ice class **IA Super** (refer to **2.11**);

18 knots for ships of Baltic ice class **IA** (refer to **2.11**);

17 knots for ships of ice classes **Ice5**;

14 knots for ships of ice classes **Ice4**;

11 knots for other ships;

p, q – coefficients determined by the formulae:

$$p = 78{,}4 - 55{,}6\sqrt{\lambda_n} + (44{,}0 - 33{,}4\sqrt{\lambda_n})C_{HB}; \qquad (2.2.3.1\text{-}6)$$

$$q = 7{,}43 - 5{,}72\lambda_n + (2{,}82 - 2{,}2\lambda_n)C_{HB}; \qquad (2.2.3.1\text{-}7)$$

C_{HB} being determined by the formula:

$$C_{HB} = 9{,}38 T/(D_p^2 v_1^2)\ , \qquad (2.2.3.1\text{-}8)$$

where: T – propeller thrust at speed V, in kN;

D_p – propeller diameter, in m;

λ_n is determined by the formula:

$\lambda_n = l_n/D_p$; (2.2.3.1-9)

m – coefficient determined by the formula:

$$m = 4{,}5 - 0{,}12(\lambda_{st} - 5{,}43)^2; \qquad (2.2.3.1\text{-}10)$$

λ_{st} is determined by the formula:

$\lambda_{st} = h_{st}/l_{st}$, (2.2.3.1-11)

h_{st} – =height of steering nozzle stabilizer, in m;

l_{st} – length of steering nozzle stabilizer, in m.

2.2.3.2 A point situated at the level of the longitudinal axis of the steering nozzle at the distance rn from the steering nozzle leading edge shall be considered as a point of application of force F_n. The distance r_n, in m, shall not be less than determined by the formula

$$r_n = l_n(bk + c), \qquad (2.2.3.2\text{-}1)$$

where: k – coefficient determined by the formula

$k = l_{r.s}/l_n$; (2.2.3.2-2)

$l_{r.s}$– distance between the centre line of the rudder stock and the leading edge of the steering nozzle, in m;;
b, c – coefficients determined by the formulae

$$b = 0{,}796 - 0{,}011\left(C_{\text{HB}} - 7{,}18\right)^2 ; \quad (2.2.3.2\text{-}3)$$

$$c = 0{,}1585 - 0{,}0916\sqrt{C_{\text{HB}}} . \quad (2.2.3.2\text{-}4)$$

A point situated at the level of the steering nozzle longitudinal axis at the distance r_{st} from the stabilizer leading edge shall be considered as a point of application of force F_{st}. The distance r_{st}, in m, shall not be less than determined by the formula

$$r_{st} = 0{,}25 l_{st}. \quad (2.2.3.2\text{-}5)$$

2.2.3.3 The total torque M_t, in kN·m, for the steering nozzle shall be determined by the formula

$$M_t = M_n - M_{st} , \quad (2.2.3.3\text{-}1)$$

where: M_n – torque of force F_n, in kN·m;
M_{st}–torque of force F_{st}, in kN·m;
M_n and M_{st} are determined by the formulae:

$$M_n = F_n(l_{r.s} - r_n) , \quad (2.2.3.3\text{-}2)$$

$$M_{st} = F_{st}(a + r_{st}); \quad (2.2.3.3\text{-}3)$$

a – distance between the centre line of the rudder stock and the leading edge of the stabilizer, in m.

In any case, the total torque M_t for the steering nozzle shall not be taken less than the minimum value of torque M_{min}, in kN/m, determined by the formula:

$$M_{\text{min}} = \frac{28{,}1F_n}{p}(0{,}72l_n - l_{r.s}) + \frac{7{,}8F_{st}}{qm}(l_n - l_{r.s} + 0{,}5l_{st}) \quad (2.2.3.3\text{-}4)$$

2.2.4 Bending moments and reactions of supports for rudders of types I _ IV, VI _ XII and steering nozzles of type V (refer to Fig. 2.2.4.1).

2.2.4.1 The design values of the bending moments and reactions of supports shall be determined from the formulae of this Chapter depending on the types of the rudders shown in Fig. 2.2.4.1 having regard to the provisions of Table 2.2.4.1 as well as the type and location of the steering gear as specified in **2.2.4.2.**

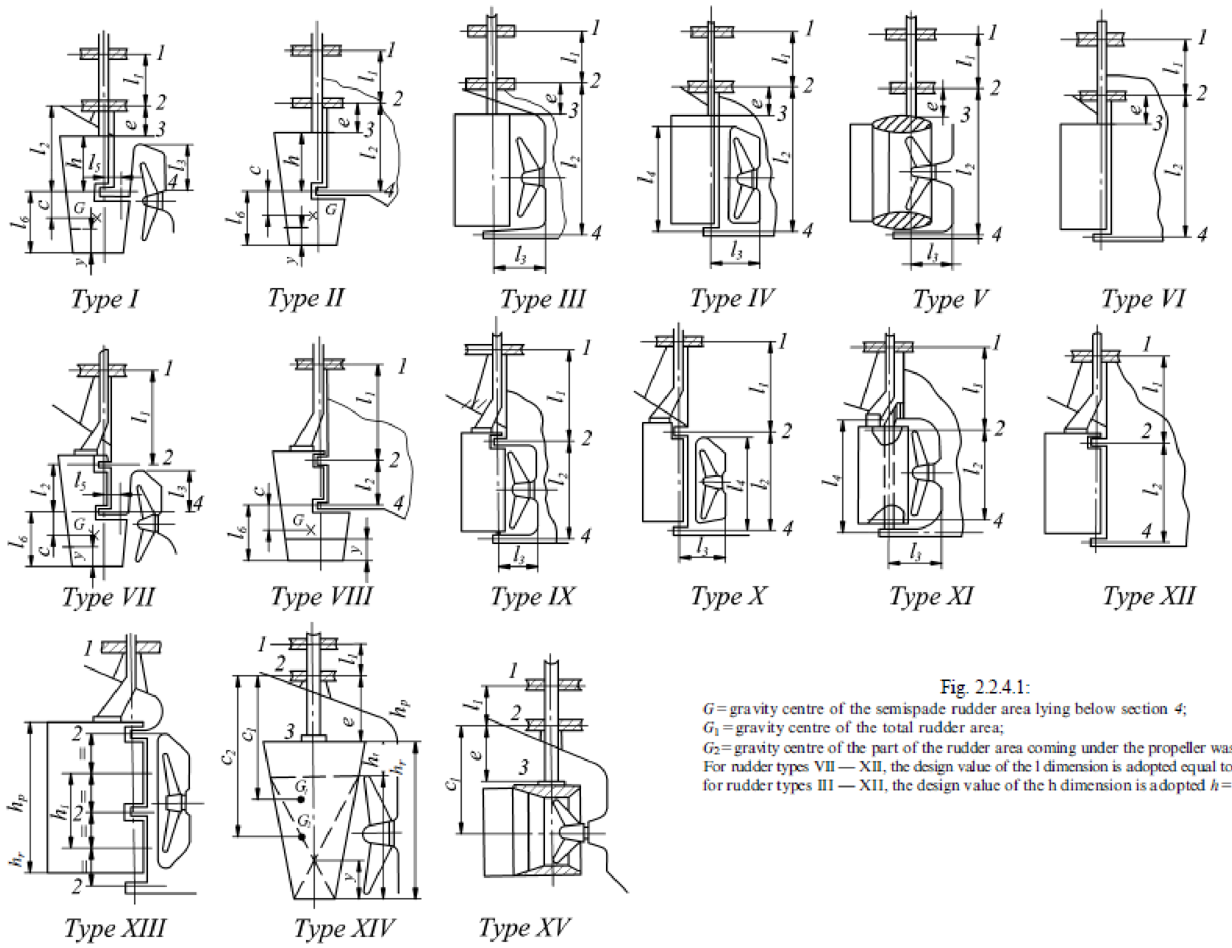


Fig. 2.2.4.1:
G = gravity centre of the semispade rudder area lying below section 4;
G_1 = gravity centre of the total rudder area;
G_2 = gravity centre of the part of the rudder area coming under the propeller wash.
For rudder types VII — XII, the design value of the l dimension is adopted equal to zero;
for rudder types III — XII, the design value of the h dimension is adopted $h = l_2 - e$

Table 2.2.4.1

Type of rudder (refer to Fig. 2.2.4.1)	Design value of loadQ_2	Design value of loadQ_1
I, II, VII i VIII	$Q_2 = \left(\frac{F_1}{A} + \frac{F_2}{A_p}\right)A_l$	Q_1=F- Q_2
III–VI i IX–XII	Q_2=0	
Notes: 1. The value of A_l is the portion the semispade rudder area below the lower pintle (below section 4 in Fig. 2.2.4.1), in m^2. 2. For steering nozzles of type V the design value of the ratio $I_{r.s}/I_r$ is taken equal to zero. 3. The force F is taken in accordance with the provisions of 2.2.2 for rudders and of 2.2.3 for steering nozzles.		

2.2.4.2 The transverse force P, in kN, created on the rudder stock by steering gear (quadrant steering gears, steering gears with single-arm tillers and similar steering gears) is determined by the formula:

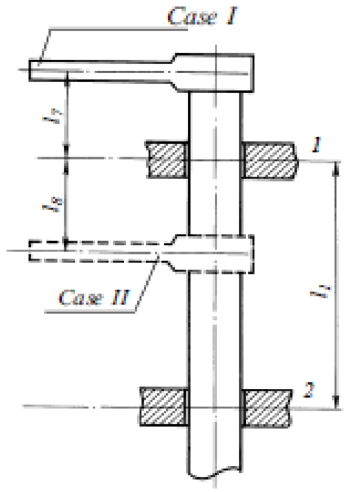
$$P = M_t/r_1, \qquad (2.2.4.2)$$

where: M_t – rudder torque, in kN/m, specified in 2.2.2.3 and 2.2.3.3. When considering the astern running of the ship, the rudder torque M_t is taken as the value M_{as} specified in **2.2.2.4**;

r_1 – =radius of the steering gear quadrant or tiller resultant force arm measured from the centre line of the rudder stock, in m.

Depending on the location of the steering gear quadrant or tiller indicated in Fig. 2.2.4.2 the value P for Case I is taken as P_I and the value P_{II} is taken equal to zero. For Case II the value of P is taken as P_{II} and the value of PI is taken equal to zero. The values of P_I or P_{II} are assumed to be positive when the quadrant or tiller are located forward of the rudder stock centre line and they are assumed to be negative when the quadrant or tiller are located aft of the rudder stock centre line.

For steering gears the rudder torque of which is transmitted to the rudder stock by a pair (or pairs) of forces (four-piston, rotary vane steering gears or similar) the values of P_I and P_{II} are taken equal to zero.



Fig

2.2.4.3 In the formulae of this Chapter the numerical indices of symbols of the bending moments (M_1, M_2, M_3 i M_4) and reactions of supports (R_1, R_2, R_3 i R_4) correspond to the number of the support or section given in Figs. 2.2.4.1 and 2.2.4.2 for the relevant type of the rudder.

2.2.4.4 Unless expressly provided otherwise, in the formulae of this Chapter the linear dimensions shown in Figs. 2.2.4.1 and 2.2.4.2 shall be taken in metres, and the forces, in kN.

2.2.4.5 The design values of the bending moments and reactions of supports may be taken less than those specified in **2.2.4.1** on condition that the detailed calculation is submitted where due consideration is given to the flexibility of the rudder supports and to the non-uniformity of the force distribution over the rudder blade area.

2.2.4.6 For Case I of the quadrant steering gear or tiller location (refer to Fig. 2.2.4.2) the design value of bending moment M_I , in kN·m, in section 1 of the rudder stock (at the upper bearing) shall be determined by the formula:

$$M_1 = P_1 l_7 , \qquad (2.2.4.6)$$

Where for P_1, l_7 – refer to **2.2.4.2** i **2.2.4.4**.

For Case II of the steering gear quadrant or tiller location M_I is taken equal to zero.

2.2.4.7 The design value of the bending moment M_2, in kN·m, acting in section 2 of the rudder stock (at the lower bearing for rudders of types I - VI; in the rudder stock and rudder blade coupling for rudders of types VII - XII) shall be determined by the formula:

$$M_2 = \frac{1}{8} Q_1 h \frac{k_5}{k_7} - \frac{1}{2} Q_2 c \frac{k_6}{k_7} - \frac{1}{2} P_I l_7 \frac{k_8}{k_7} + \frac{1}{2} P_{II} l_8 \frac{k_9}{k_7} , \qquad (2.2.4.7\text{-}1)$$

where: Q_1 and Q_2 – loads determined in accordance with Table2.2.4.1;

P_I and P_{II} – =forces determined in accordance with **2.2.4.2**;

h, c, l_7, l_8 – linear dimensions (refer to**2.2.4.4**);

$k_5 - k_9$ – factors determined by the formulae:

$$k_5 = 2\left(\frac{e}{h}\right)^2\left(3 + \frac{e}{h}\right) + \left(1 + 5\frac{e}{h}\right)\frac{I_{r.s}}{I_r} + 12\left(1 + 2\frac{e}{h}\right)\frac{I_{r.s}\alpha_4}{h^3} \qquad (2.2.4.7\text{-}2)$$

$$k_6 = \left(\frac{e}{h}\right)^2\left(3 + \frac{e}{h}\right) + \left(1 + 3\frac{e}{h}\right)\frac{I_{r.s}}{I_r} - 6\left(1 + \frac{l_2}{c}\right)\frac{I_{r.s}\alpha_4}{h^3} \qquad (2.2.4.7\text{-}3)$$

$$k_7 = \left(1 + \frac{e}{h}\right)^2 \left(1 + \frac{e}{h} + \frac{l_1}{h}\right) - 1 + \frac{I_{r.s}}{I_r} + 3\frac{I_{r.s}\alpha_4}{h^3} \tag{2.2.4.7-4}$$

$$k_8 = l_1 l_2^2 / h^3; \tag{2.2.4.7-5}$$

$$k_9 = \frac{l_1 l_2^2}{h^3}\left(1 - \frac{l_8^2}{l_1^2}\right), \tag{2.2.4.7-6}$$

where: e, l_1 and l_2 – linear dimensions (refer to **2.2.4.4**);

$I_{r.s}$ – mean moment of inertia of the rudder stock cross-section, in cm^4;

I_r – mean moment of inertia of the rudder cross-section at the portion between sections 3 - 4 (rudder types I - VI) or between sections 2 - 4 (rudder types VII - XII), in cm^4;

α_4 – coefficient determined in accordance with the provisions of **2.2.4.17**, **2.2.4.18**, **2.2.4.19**, **2.2.4.20** or **2.2.4.21** depending on the type of the rudder, in m^3/cm^4.

2.2.4.8 The design value of the bending moment M_3, in kN·m, acting in section 3 of the rudder stock (in the rudder stock and rudder blade coupling for rudders of types I to VI) shall be determined by the formula

$$M_3 = M_2\frac{h}{l_2} + Q_2 c\frac{e}{l_2} - \frac{1}{2}Q_1 h\frac{e}{l_2}. \tag{2.2.4.8}$$

2.2.4.9 The design value of the bending moment M_4, in kN·m, acting in section 4 of the rudder blade for rudders of types I, II, VII and VIII shall be determined by the formula

$$M_4 = Q_2 c. \tag{2.2.4.9}$$

For rudders of these types the value of M_4 4 is taken as the bending moment acting in any rudder crosssection above support 4 of the rudder.

For other rudders the value of the bending moment M_4 is taken equal to zero.

2.2.4.10 The design value of the reaction R_1 in kN, of support 1 of the rudder (of the upper bearing) shall be determined by the formula

$$R_1 = \frac{M_2}{l_1} - P_1\left(1 + \frac{l_7}{l_1}\right) - P_{II}\left(1 - \frac{l_8}{l_1}\right) \tag{2.2.4.10}$$

2.2.4.11 The design value of the reaction R_2, in kN, of support 2 of the rudder (of the lower bearing for rudder types I – VI, of the upper bearing of the rudder axle for rudder type XI, of the upper pintle of rudders for types VII – X and XII) shall be determined by the formula

$$R_2 = -M_2\left(\frac{1}{l_1} + \frac{1}{l_2}\right) + Q_2\frac{c}{l_2} - \frac{1}{2}Q_1\frac{h}{l_2} + P_I\frac{l_7}{l_1} - P_{II}\frac{l_8}{l_1}. \tag{2.2.4.11}$$

2.2.4.12 The design value of the reaction R_4, in kN, of support 4 of the rudder (of the lower pintle) shall be determined by the formula

$$R_4 = \frac{M_2}{l_2} - \frac{1}{2}Q_1\left(1 + \frac{e}{l_2}\right) - Q_2\left(1 + \frac{c}{l_2}\right). \tag{2.2.4.12}$$

2.2.4.13 The design value of the bending moment M_r, in kN·m, acting in the considered section of the lower part of the semispade rudder body (below section 4 shown in Fig. 2.2.4.1 for rudder types I, II, VII and VIII) shall be determined by the formula

$$M_r = \frac{1}{2} Q_2 \frac{y^2}{l_6},\qquad (2.2.4.13)$$

where: y and l_6 – linear dimensions (refer to **2.2.4.4**.

2.2.4.14 The design value of the bending moment M_r, in kN·m, acting in any cross-section of the rudder blade for rudders of types III, IV, VI and IX – XII shall be determined by the formula:

$$M_r = \frac{1}{2} M_2 \frac{h}{l_2}\left(2 - \frac{h}{l_2} - \frac{M_2}{Q_1 l_2}\right) - \frac{1}{8} Q_1 h\left(2 - \frac{h}{l_2}\right)^2 \qquad (2.2.4.14)$$

2.2.4.15 The design value of the bending moment $M_{r\cdot a}$, in kN·m, acting in the section of the rudder axle near its flange shall be determined by the formula:

$$M_{ra} = R_4 l_4\left[0{,}42\frac{(l_4 - l_2)}{l_4} + 0{,}24\frac{l_3}{l_4}\frac{I_{rp}}{I_s} + 0{,}15\left(\frac{l_3}{l_4}\right)^2\right] \qquad (2.2.4.15)$$

where: l_3 and l_4 – linear dimensions (refer to **2.2.4.4**);

$I_{r\cdot p}$– mean moment of inertia of the rudder axle or rudder post cross-section, in cm^4;

I_s– mean moment of inertia of the solepiece cross-section, in cm^4.

2.2.4.16 For Case II of the steering gear quadrant or tiller location (refer to Fig. 2.2.4.2) the design value of the bending moment M_s, in kN·m m, acting in the section of the rudder stock in way of the quadrant or tiller location shall be determined by the formula

$$M_s = R_1 l_8. \qquad (2.2.4.16)$$

For Case I of the steering gear quadrant or tiller location M_s is taken equal to zero.

2.2.4.17 The coefficient α_4 in m^3/cm^4, for rudders of types I and VII (for the horn of the semispade rudder) shall be determined by the formula

$$\alpha_4 = \frac{1{,}07 l_3^3}{3 I_1}\left(4 - 3\frac{b_{h0}}{b_{h1}}\right) + \frac{1{,}3 l_5^2 l_3}{I_2}\left(1 + \frac{b_{h1}}{b_{h0}}\right)\frac{b_{h1}}{b_{h0}} \qquad (2.2.4.17\text{-}1)$$

where: l_5 – linear dimension (refer to **2.2.4.4**);

I_1 – moment of inertia of the rudder horn cross-section at its root about the axis parallel to the centreline of the ship, in cm^4;

b_{h0} – maximum width of the horizontal section of the rudder horn at the lower pintle (section 4 in Fig. 2.2.4.1), in m;

b_{h1} – maximum width of the horizontal section of the rudder horn at its root, in m;

I_2 – polar moment of inertia of the rudder horn cross-section at its root, in cm^4, determined by the formula

$$I_2 = \frac{4 A_{rh}^2}{\sum_{i=1}^{n} l_{0i}/s_{0i}},\qquad (2.2.4.17\text{-}2)$$

where: $A_{r\cdot h}$ – = area enclosed by the centre line of the rudder horn plating (with the cross-section at the horn root), in cm^2;

l_{0i} – length of the centre line of the rudder horn plating (in the cross-section at the horn root) of the given thickness, in cm;

S_{0i} – thickness of the considered portion of the rudder horn plating with the length l_{0i}, in cm;

n – number of portions of the rudder horn plating with the length l_{0i} and thickness S_{0i}.

2.2.4.18 The coefficient α_4 in m^3/cm^4, for rudders of types III, V and IX (for the solepiece) shall be determined by the formula

$$\alpha_4 = \frac{l_3^3}{3I_{s1}}\left(4 - 3\frac{b_{s0}}{b_{s1}}\right), \qquad (2.2.4.18)$$

where: I_{sl} – moment of inertia of the solepiece cross-section at its root about the vertical axis, in cm^4;
b_{s0} – width of the solepiece cross-section at the rudder stock or steering nozzle pintle, in cm;
b_{s1} – =width of the solepiece cross-section at its root, in cm.

2.2.4.19 The coefficient α_4 in m^3/cm^4, for rudders of types IV and X (for the rudder post with the solepiece) shall be determined by the formula

$$\alpha_4 = \frac{l_3^3}{3I_s}\left(0{,}075\frac{I_s}{I_{rp}} + 0{,}334\frac{l_4}{l_3}\right). \qquad (2.2.4.19)$$

2.2.4.20 The coefficient α_4 in m^3/cm^4, for rudder of type XI (for rudder axle with the solepiece) shall be determined by the formula

$$\alpha_4 = \frac{l_3^3}{3I_s}\left\{\left(0{,}075\frac{I_s}{I_{rp}} + 0{,}334\frac{l_4}{l_3}\right) - 0{,}282\frac{(l_4 - l_2)}{l_4}\times\left[1{,}55\frac{l_4}{l_3} + 0{,}053\left(\frac{l_4}{l_3}\right)^2 + \frac{(l_4 - l_2)}{l_4}\frac{I_s}{I_{rp}}\right]\right\} \qquad (2.2.4.20)$$

2.2.4.21 The coefficient α_4 for rudders of types II, VI, VIII and XII is taken equal to zero.

2.2.5 Bending moments and reactions of supports for rudder of type XIII (refer to Fig.2.2.4.1).

2.2.5.1 The requirements of **2.2.4.2 - 2.2.4.6** and **2.2.4.16** are also applicable to the rudders of type XIII.

2.2.5.2 The design value of the bending moment acting in way of the rudder stock and rudder blade coupling shall be taken equal to zero.

2.2.5.3 The design value of the bending moment M_r, in kN·m, acting in any cross-section of the rudder blade shall be determined by the formula

$$M_r = 0{,}1\,Fh_i^2/h_r, \qquad (2.2.5.3)$$

where: F – force determined according to the provisions of **2.2.2.1**, **2.2.2.2** and **2.2.2.5**, in kN;
h_i and h_r – =linear dimensions (refer to 2.2.4.4); in this case, the greater of the value h_i shall be taken as the design value.

2.2.5.4 The design value of the reaction R_1 of support 1 of the rudder (of the upper bearing) shall be taken equal to zero.

2.2.5.5 The design value of the reaction R_2 in kN, of support 2 of the rudder (of any pintle) shall be determined by the formula

$$R_2 = Fh_i/h_r. \qquad (2.2.5.5)$$

2.2.6 Bending moments and reactions of supports for rudder of type XIV (refer to Fig. 2.2.4.1).

2.2.6.1 The requirements of **2.2.4.2 - 2.2.4.6** and **2.2.4.16** are also applicable to the rudders of type XIV.

2.2.6.2 The design value of the bending moment M_2, in kN·m, acting in section 2 of the rudder stock (at the lower bearing) shall be determined by the formula

$$M_2 = F_1c_1 + F_2c_2, \qquad (2.2.6.2)$$

where: F_1 and F_2 – forces determined according to the provisions of **2.2.2.1**, **2.2.2.2** and **2.2.2.5**, in kN;
c_1 і c_2 – лінійні розміри (див. **2.2.4.4**), м.

2.2.6.3 The design value of the bending moment M_3, in kN·m, acting in section 3 of the rudder stock (in the rudder stock and rudder blade coupling) shall be determined by the formula

$$M_3 = F_1(c_1 - e) + F_2(c_2 - e), \qquad (2.2.6.3)$$

where: e – linear dimension (refer to **2.2.4.4**), in m.

2.2.6.4 The design value of the bending moment M_r, in kN·m, acting in the considered section of the rudder blade shall be determined by the formulae:

for sections with $y < h_1$

$$M_r = \frac{1}{2}\left(\frac{F_1}{h_r} + \frac{F_2}{h_1}\right)y^2, \qquad (2.2.6.4\text{-}1)$$

for sections with $y \geq h_1$

$$M_r = \frac{1}{2}\frac{F_1}{h_r}y^2 + F_2\left(y - \frac{1}{2}h_1\right), \qquad (2.2.6.4\text{-}2)$$

where h_r, h_1 and y – =linear dimensions (refer to **2.2.4.4**), in m.

2.2.6.5 The design value of the reaction R_1 in kN, of support 1 of the rudder (of the upper bearing) shall be determined by the formula

$$R_1 = F_1\frac{c_1}{l_1} + F_2\frac{c_2}{l_1} - P_{\mathrm{I}}\left(1 + \frac{l_7}{l_1}\right) - P_{\mathrm{II}}\left(1 - \frac{l_8}{l_1}\right), \qquad (2.2.6.5)$$

where: l_1 – linear dimension (refer to **2.2.4.4**), in m.

2.2.6.6 The design value of the reaction R_2 in kN, of support 2 of the rudder (of the lower bearing) shall be determined by the formula

$$R_2 = F_1\left(1 + \frac{c_1}{l_1}\right) + F_2\left(1 + \frac{c_2}{l_1}\right) - P_{\mathrm{I}}\frac{l_7}{l_1} + P_{\mathrm{II}}\frac{l_8}{l_1}. \qquad (2.2.6.6)$$

2.2.7 Bending moments and reactions of supports for steering nozzles of type XV (refer to Fig. 2.2.4.1).

2.2.7.1 The requirements of **2.2.4.2**, **2.2.4.3**, **2.2.4.4**, **2.2.4.6** and **2.2.4.16** are also applicable to the steering nozzle of type XV.

2.2.7.2 The design value of the bending moment M_2, in kN·m, acting in section 2 of the rudder stock (at the lower bearing) shall be determined by the formula

$$M_2 = Fc_1, \qquad (2.2.7.2)$$

where: F – force determined according to the provisions of **2.2.3.1**, in kN;
c_1 – linear dimension (refer to **2.2.4.4**), in m.

2.2.7.3 The design value of the bending moment M_3, in kN·m, acting in section 3 of the rudder stock (at the rudder stock and steering nozzle coupling) shall be determined by the formula

$$M_3 = F(c_1 - e), \qquad (2.2.7.3)$$

where: e – linear dimension (refer to **2.2.4.4**), in m.

2.2.7.4 The design value of the reaction R_1, in kN, of support 1 (of the upper bearing) shall be determined by the formula

$$R_1 = F\frac{c_1}{l_1} - P_1\left(1+\frac{l_7}{l_1}\right) - P_{II}\left(1-\frac{l_8}{l_1}\right), \qquad (2.2.7.4)$$

where: l_1 – linear dimension (refer to **2.2.4.4**), in m.

2.2.7.5 The design value of the reaction R_2 in kN, of support 2 (of the lower bearing) shall be determined by the formula

$$R_2 = F\left(1+\frac{c_1}{l_1}\right) - P_1\frac{l_7}{l_1} + P_{II}\frac{l_8}{l_1}. \qquad (2.2.7.5)$$

2.2.8 The design values of bending moments and reactions of supports for the steering gears which differ from those indicated in Fig. 2.2.4.1 shall be submitted by the designer.

2.3 RUDDER STOCK

2.3.1 The diameter of the rudder stock head d_0, in cm, shall be not less than the greater value determined by the formula

$$d_0 = k_{10}\sqrt[3]{M_t/R_{eH}}, \qquad (2.3.1)$$

where: k_{10} – =factor equal to:
26,1 for the ahead condition;
23,3 for the astern condition;
M_t – torque according to **2.2.2.3**, **2.2.2.4** or **2.2.3.3**, in kN·m;
R_{eH} – upper yield stress of the rudder stock material, in MPa.

2.3.2 Under combined action of the torque and bending moment the working stresses (refer to **1.5.1**) acting in rudder stock sections 1, 2 or 3 shown in Fig. 2.2.4.1 for the appropriate type of the rudder shall not exceed 0,5 times the upper yield stress for the ahead condition and 0,7 times the upper yield stress of the material for the astern condition (refer to **1.5.2** and **2.1.6**). In this case, the normal stress (σ) and the shear stress (τ) in MPa, shall be determined by the formulae:

$$\sigma = 10{,}2\cdot 10^3 M_b/d_i^3, \qquad (2.3.2\text{-}1)$$

$$\tau = 5{,}1\cdot 10^3 M_t/d_i^3, \qquad (2.3.2\text{-}2)$$

where: M_b – bending moment acting in the considered section of the rudder stock (M_1, M_2 or M_3), determined according to the provisions of **2.2.4** to **2.2.7** for the appropriate type of the rudder, in kN·m;
d_i – diameter of the rudder stock in the considered section, in cm.

2.3.3 The change in the rudder stock diameter between the adjacent sections specified in **2.3.1** and **2.3.2** shall not be more sudden than that permitted by the linear law.

Where the change of the rudder stock diameter is stepped, the steps shall be provided with fillets having as large radius as practicable. The transition of the rudder stock into the flange shall be carried out with a radius of fillet of not less than 0,12 times the diameter of the rudder stock in way of the flange.

2.4 RUDDER BLADE AND STEERING NOZZLE

2.4.1 Rudder blade.

2.4.1.1 The thickness of the streamlined rudder blade side plating s, in mm, shall be not less than determined by the formul

$$s = ak_{11}\sqrt{\frac{98d + k_{12}(\frac{F_1}{A} + k_{13}\frac{F_2}{A_p})}{R_{eH}}} + 1{,}5, \qquad (2.4.1.1\text{-}1)$$

where: d – осадка судна, м,

F_1 i F_2 – forces according to **2.2.2.1** and **2.2.2.2**, in kN;

for A and A_p, refer to **2.2.2.1**;

a – distance between horizontal or vertical web plates, whichever is the less, in m;

k_{11} – factor determined by the formula:

$$k_{11} = 10{,}85 - 2{,}516\left(\frac{a}{b}\right)^2; \qquad (2.4.1.1\text{-}2)$$

R_{eH} – upper yield stress of the rudder blade plating material, in MPa;

b – distance between horizontal or vertical web plates whichever is the greater, in m;

k_{12} – factor equal to:

18,6 for the rudder blade plating within 0,35 of the rudder blade length from its leading edge;

8,0 for the rudder blade plating within 0,65 of the rudder length from its rear edge;

k_{13} – factor equal to:

1 for the rudder blade plating in the wake of the propeller (when rudder is in the non-reversed position);

0 for the rudder blade plating beyond the wake of the propeller (when rudder is in the non-reversed position).

2.4.1.2 In any case, the thickness of the streamlined rudder blade side plating $s_{\min}$, in mm, shall be not less than determined by the formulae:

for ships of less than 80 m in length

$$s_{\min} = 21{,}5\frac{L + 51}{L + 240}, \qquad (2.4.1.2\text{-}1)$$

for ships of 80 m in length and over

$$s_{\min} = 24\frac{L + 37}{L + 240}, \qquad (2.4.1.2\text{-}2)$$

where: L – length of the ship, in m.

2.4.1.3 For ice class ships the thickness of the rudder blade side plating in way of the ice belt shall be not less than that of the ice belt of the shell plating in the after part of the ship, specified in **3.10.4.1**, Part II "Hull", with the frame spacing being equal to the distance between the vertical web plates of the rudder blade.

The thickness s, in mm, of the rudder blade side plating for the icebreakers shall be not less than determined by the formula

$$s = 9{,}2k_{16}a\sqrt{\frac{p_a}{R_{eH}}} + 6, \qquad (2.4.1.3\text{-}1)$$

where: a – distance between horizontal or vertical web plates, whichever is the less, for streamlined welded rudders; distance between rudder arms for single-plate steel solid-cast rudders, m.

In any case, in the calculations the value a shall not be taken less than 0,6 m;

p_a – =intensity of ice pressure in the CI region determined according to **3.10.3.5.2**, Part II "Hull", in kPa;

R_{eH} – upper yield stress of the material of the rudder blade plating, in MPa;

k_{16} – factor determined for streamlined welded rudders by the formula

$$k_{16} = 1 - 0{,}38(a/b)^2; \qquad (2.4.1.3\text{-}2)$$

where: b – distance between horizontal or vertical web plates, whichever is the greater, in m.

For single-plate steel solid-cast rudders the value of k_{16} shall be taken in the calculations equal to 1.

2.4.1.4 The streamlined rudder blade side plating shall be stiffened from the inside by horizontal and vertical web plates. The thickness of the web plates shall be not less than that of the rudder blade side plating.

The side plating and web plates shall be welded together by fillet or plug welds with slots of linear form. Dimensions of elements of plug welds are selected according to **1.7.5.13**, Part II "Hull".

The horizontal and vertical web plates shall be provided with sufficient number of openings for free drainage of water which may penetrate inside the rudder blade.

The rear edge of the rudder blade shall be rigidly fixed in the proper way.

2.4.1.5 The streamlined rudder blade shall be provided with top and bottom plates, the thickness of which shall be not less than 1,2 times the greater value of the side plating thickness according to **2.4.1.1**.

The top and bottom plates shall be fitted with drain plugs of corrosion-resistant metal.

2.4.1.6 The corners of the openings (in way of the pintles) in the side plating of the semispade rudder blade shall be rounded off. The radius of curvature shall be not less than 2 times the side plating thickness in this area, and the free edge of the rudder side plating shall be thoroughly stripped.

2.4.1.7 Near the rotation axis of the streamlined rudder one or several vertical web plates shall be provided ensuring the general strength of the rudder blade. The section modulus of these web plates, including the effective flanges, shall be such that the normal stresses in the considered section are not more than 0,5 times the upper yield stress of the material of the rudder blade side plating (refer to **1.5.2**).

The normal stresses σ, in MPa, shall be calculated by the formula

$$\sigma = 1000 M_b / W, \qquad (2.4.1.7)$$

where: M_b – bending moment in the considered section of the rudder blade (M_4 or M_r) determined according to the provisions of **2.2.4** – **2.2.6** for the appropriate type of the rudder, in kN·m;

W – section modulus of the considered section of the web plates, including the effective flanges, about the axis of symmetry of the rudder blade profile, in cm^3.

The dimensions of the effective flanges of the web plates shall be as follows:

the thickness equal to that of the rudder blade side plating;

the width equal to 1/6 of the rudder blade height or 1/2 of the distance between the nearest web plates located on both sides of the considered web plate, whichever is the less.

2.4.1.8 Special care shall be given to the reliable securing to the rudder blade of the flange for coupling the rudder blade and the rudder stock and of the gudgeons for pintles.

2.4.1.9 At the leading edge of the single-plate steel solid-case rudders of the icebreakers the rudder piece shall be provided over the entire height of the rudder blade. The equivalent stress σ_{eq}, in MPa, developed in any horizontal section of the rudder piece and determined by the formula given below shall not exceed 0,5 times the upper yield stress of the rudder blade material

$$\sigma_{eq} = 1000\sqrt{\left(\frac{M_r}{W}\right)^2 + 3\left(\frac{M_t y}{h_r \rho S}\right)^2}, \qquad (2.4.1.9)$$

where: M_r – bending moment determined according to the provisions of **2.2.5.3**, in kN·m;

M_t – torque according to **2.2.2.3**, in kN·m;

h_r – height of the rudder measured on the rudder stock centre line, in m;

y – distance between the considered section and the lower edge of the rudder (refer to Fig. 2.4.1.9), in m;

W – section modulus of the considered cross-section of the rudder piece about the axis $O_1 - O_1$, ignoring the rudder blade plating (the rudder piece section taken into account in the calculation of W is hatched in section *I – I* of Fig. 2.4.1.9), in cm^3;

S – area of the considered cross-section of the rudder piece (refer to hatched area in section *I – I* of Fig. 2.4.1.9), in cm^2;

ρ – distance between the centroid of the area S and the rudder blade centre line, in cm.

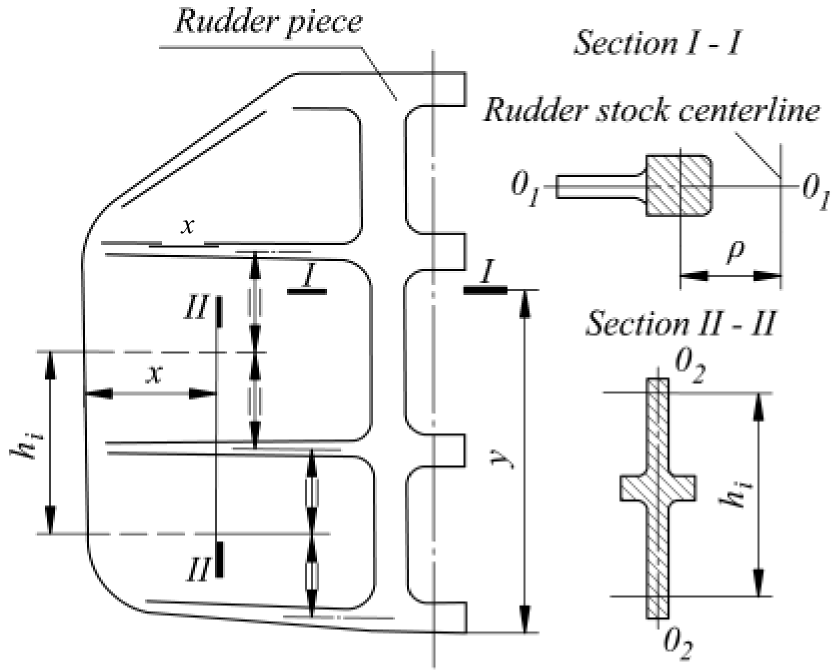


Fig. 2.4.1.9

2.4.1.10 The single-plate steel solid-case rudder shall be stiffened by the rudder arms founded on both sides of the rudder blade at the level of each gudgeon (refer to Fig. 2.4.1.9). The section modulus of the considered cross-section of the rudder arms W, in cm^3, (including the body of the rudder blade within the dimension hi, refer to section II - II in Fig. 2.4.1.9) about the axis O_2 - O_2 shall be not less than determined by the formula

$$W = \frac{1000 h_i x^2 F}{A R_{eH}}, \qquad (2.4.1.10)$$

where: F – force determined according to the provisions of **2.2.2.2**, kN;
A – rudder area, in m^2;
h_i – linear dimension, in m (refer to Fig. 2.4.1.9);
x – distance between the considered section and the rear edge of the rudder, in m (refer to Fig. 2.4.1.9);
R_{eH} – upper yield stress of the rudder material, in MPa.

2.4.2 Steering nozzle rudder.

2.4.2.1 The thickness s_o, in mm, of the steering nozzle outside plating shall be not less than determined by the formula

$$s_o = k_{14} l_1 \sqrt{\frac{98 D_n l_n d + 20 F_n}{D_n l_n R_{eH}}} + 2, \qquad (2.4.2.1\text{-}1)$$

where
D_n= inner minimum nozzle bore, in m;
l_n= length of the steering nozzle, in m;
d=draught of the ship, in m;

F_n= force acting on the steering nozzle according to **2.2.3.1**, in kN;

R_{eH}=upper yield stress of the material of the steering nozzle outside plating, in MPa;

k_{14}=factor determined by the formula

$$k_{14} = 7{,}885 - 2{,}221(l_1/u_1)^2; \qquad (2.4.2.1\text{-}2)$$

where:

l_1 – distance between transverse web plates or between the transverse web plate and the nearest edge of the steering nozzle, in m. This distance shall not exceed 600 mm;

u_1 – distance between the longitudinal web plates measured along the length of the steering nozzle outside plating, in m. This distance shall not exceed 1000 mm.

2.4.2.2 The thickness s_{in}, in mm, of the steering nozzle inside plating, except for its middle belt, shall be not less than

$$s_{in} = 6{,}39\frac{l_1}{D_n}\sqrt{T}, \qquad (2.4.2.2\text{-}1)$$

where: T – propeller thrust at speed V, in kN.

The thickness s_m, in mm, of the middle belt of the steering nozzle inside plating shall be not less than

$$s_m = 7{,}34\frac{l_2}{D_n}\sqrt{T} + 0{,}51\frac{T}{D_n^2}, \qquad (2.4.2.2\text{-}2)$$

where: l_2 – =distance between transverse web plates situated in way of the middle belt of the inside plating, in m.

2.4.2.3 In any case, the thickness of the outside and inside plating of the steering nozzle shall be not less than that given in **2.4.1.2**.

2.4.2.4 The middle belt of the steering nozzle inside plating shall extend not less than $0{,}05D_n$ forward and not less than $0{,}1D_n$ aft of the propeller blade tips. Its breadth shall be at least equal to the maximum breadth of the side projection of the propeller blade.

2.4.2.5 The outside and inside plating of the steering nozzle shall be stiffened from the inside by transverse and longitudinal web plates. The spacing of the web plates shall comply with the requirements of **2.4.2.1**. At least four longitudinal web plates shall be provided which are equally spaced around the circumference of the steering nozzle.

The thickness of web plates, except those situated in way of the middle belt of the steering nozzle inside plating, shall be not less than the thickness of the outside plating according to **2.4.2.1** and **2.4.2.3**.

The transverse and longitudinal web plates shall be welded to the steering nozzle inside plating by double side continuous welds with full penetration on the inside of the steering nozzle. When the thickness of the web plates is 10 mm and more, edge preparation shall be carried out.

The outside plating and web plates shall be connected by plug welding with slots of linear form or by backing welding. The dimensions of elements of plug welds with slots of linear form are selected according to **1.7.5.13**, Part II "Hull".

The transverse and longitudinal web plates shall be provided with sufficient number of openings for free drainage of water which might penetrate inside the steering nozzle, and in the lower and upper parts of the outside plating the drain plugs of stainless metal shall be fitted. The distance from the opening edge to the inside and outside plating of the steering nozzle shall be not less than 0,25 times the web plate height.

It is not allowed to weld on doubling plates to the inside plating of the steering nozzle.

2.4.2.6 In way of the middle belt of the steering nozzle inside plating at least two continuous transverse web plates shall be fitted. The thickness of these web plates shall be not less than the thickness of the inside plating off its middle belt as per Formula (2.4.2.2-1).

2.4.2.7 Special care shall be given to the reliable securing of the nozzle flange, welded-in bush and other steering nozzle welded-in parts for connecting the steering nozzle welded-in parts for connecting the steering nozzle with its stock and pintle.

2.4.2.8 The thickness s_{st} of the stabilizer plating, in mm, shall be not less than determined by the formula

$$s_{st}=k_{14}l_1\sqrt{\frac{98A_{st}d+20F_{st}}{A_{st}R_{eH}}}+2 \quad (2.4.2.8)$$

A_{st}=area of the steering nozzle stabilizer, in m^2;
F_{st}=force acting on the stabilizer according to Formula (2.2.3.1-3), in kN;
k_{14}= factor according to **2.4.2.1** when the distance between horizontal web plates equals to u1, in m;
l_1= distance between vertical web plates or between the web plate and fore or aft edge of the stabilizer, in m;
R_{eH}= upper yield stress of material of the stabilizer plating, in MPa.

2.4.2.9 The steering nozzle stabilizer plating shall be stiffened from the inside by horizontal and vertical web plates having the thickness not less than that of the plating in accordance with **2.4.2.8**.

The stabilizer body shall terminate in top and bottom plates. The thickness of top and bottom plates shall not be less than 1,5 times the thickness of the plating according to **2.4.2.8**. Vertical web plates shall be securely connected to top and bottom plates.

The plating and horizontal and vertical web plates shall be welded together by fillet or plug welds. The types of plug welds with slots of linear form are selected according to **1.7.5.13**, Part II "Hull".

The horizontal and vertical web plates shall be provided with sufficient number of openings, and top and bottom plates shall be fitted with drain plugs of corrosion-resistant material.

2.4.2.10 In way of attachment of the stabilizer to the steering nozzle one or several vertical web plates shall be provided ensuring general strength of the stabilizer. The section modulus W_{st}, in cm^3, of these web plates, the effective flange included, shall be not less than determined by the formula

$$W_{st}=1390F_{st}h_{st}/R_{eH}, \quad (2.4.2.10)$$

where F_{st}=force acting on the stabilizer according to Formula (2.2.3.1-3), in kN;
h_{st}= stabilizer height, in m;
R_{eH}= upper yield stress of material of the stabilizer plating, in MPa.

The effective flange dimensions shall be as follows: thickness equal to the stabilizer plating thickness; width equal to 1/5 of the stabilizer height.

2.4.2.11 The steering nozzle and stabilizer shall be so connected that rigid fixation of the latter is ensured.

The force F_{st} determined from Formula (2.2.3.1-3) and uniformly distributed with the height of the stabilizer shall be taken in strength calculations as a force acting on the stabilizer. Depending on the type of connection a torque of force Fst acting on this connection shall be considered with regard to the point of application of this force (refer to Formula (2.2.3.2-3)).

In this case, stresses developed in the connection (refer to **1.5.1**) shall not exceed 0,4 times the upper yield stress of the material.

2.5 COUPLINGS

2.5.1 Horizontal flange coupling.

2.5.1.1 The diameter of the coupling bolts d_1, см, in cm, shall be not less than:

$$d_1=0{,}62\sqrt{\frac{d_2^3R_{eH1}}{z_1r_2R_{eH2}}}, \quad (2.5.1.1\text{-}1)$$

where d_2=diameter of the rudder stock at the coupling flange, in cm;
z_1=number of coupling bolts;
r_2=mean distance from the centre of the bolts to the centre of the system of the flange bolt holes, in cm;
R_{eH1} =upper yield stress of the rudder stock material,in MPa;
R_{eH2} =upper yield stress of the bolt material, in MPa.

The coupling bolt diameter at the bottom of threads d_3, in cm, shall be not less than determined by the formula

$$d_3 = 76{,}84\sqrt{\frac{M_b}{z_1 r_3 R_{eH_2}}},\qquad (2.5.1.1\text{-}2)$$

where M_b=bending moment acting in the rudder stock section at the flange (M_2 or M_3) determined according to the provisions of **2.2.4** - **2.2.7** for the appropriate type of the rudder, in kN·m;

r_3=mean distance from the centre of the bolts to the longitudinal axis of symmetry of the flange, in cm.

The number of bolts z_1 shall be not less than 6.

The mean distance from the centre of the bolts to the centre of the system of the flange bolt holes shall be not less than 0,9 times the rudder stock diameter according to **2.3.1**. When the coupling is under the action of the bending moment, the mean distance from the centre of the bolts to the longitudinal axis of symmetry of the flange shall be not less than 0,6 times the rudder stock diameter at the flange.

2.5.1.2 Only fitted bolts shall be employed, except the cases of a key setting when it is sufficient to have only two fitted bolts. The nuts shall have standard sizes. The bolts and nuts shall be efficiently secured.

2.5.1.3 The thickness of the coupling flanges shall not be less than the diameter of the bolts. The centres of the holes for bolts shall be distant from the outside edges of the flange by not less than 1,15 times the diameter of the bolts.

2.5.1.4 When coupling flanges of steering nozzles are not built into the steering nozzle body but connected to it by the structure formed of sheets, the strength of this structure shall be equivalent to that of the rudder stock in accordance with **2.3.2**.

In this case, the calculated equivalent stress shall not exceed 0,4 times the upper yield stress of the material used.

2.5.2 Keyed cone coupling.

2.5.2.1 The cone length of the rudder stock fitted to the rudder blade or steering nozzle shall not be less than 1,5 times the diameter of the rudder stock according to *2.3.2*; the cone on the diameter shall be 1:10. The cone shall change into cylindrical portion without any step in the diameter.

2.5.2.2 A key shall be set on the cone generatrix. The ends of the key shall be fairly rounded. The working sectional area of the key A_k (product of the key length by its width), in cm^2, shall be not less than the greater value determined by the formula

$$A_k = \frac{k_{15} M_t}{d_m R_{eH}},\qquad (2.5.2.2)$$

where k_{15}=factor equal to:

6920 for rudders for the ahead condition and for steering nozzles;

4950 for rudders for the astern condition;

M_t=torque according to **2.2.2.3**, **2.2.2.4** or **2.2.3.3**, in kN·m;

d_m=diameter of the cone section at the middle of the key length, in cm;

R_{eH}=upper yield stress of the key material, in MPa.

The height of the key shall be not less than half its width.

The keyway of the rudder stock shall be confined to the cone coupling.

2.5.2.3 The external diameter of the rudder stock threaded portion shall not be less than 0,9 times the minimum diameter of the cone. The thread shall be fine. The outer diameter and height of the nut shall not be less than 1,5 and 0,8 times the external diameter of the rudder stock threaded portion, respectively. To prevent self-unscrewing, the nut shall be securely fastened at least by two welded-on strips or one weldedon strip and a split pin.

2.5.3 Keyless cone coupling.

2.5.3.1 The requirements of **2.5.3** are applicable to a keyless fitting of the rudder stock to the rudder blade or steering nozzle which is made by oil injection method.

2.5.3.2 The cone length of the rudder stock fitted to the rudder blade or steering nozzle shall not be less than 1,5 times the diameter of the rudder stock according to **2.3.2**; the cone on the diameter shall be 1:15.

2.5.3.3 The rudder blade or steering nozzle boss shall be a good fit on the rudder stock cone. During the fit up, and before the push-up load is applied, an area of contact of at least 70 % of the theoretical area of contact shall be achieved, and this shall be distributed evenly.

The relationship of the rudder stock and boss cones at which this occurs shall be marked, and push-up length then measured from that point.

In well-founded cases another method of determining the original position of the rudder stock and boss cones relationship can be used.

2.5.3.4 To ensure the required interference in the cone coupling the push-up length of the rudder stock (refer to **2.5.3.3**) during its fitting shall be not less than determined by the formula

$$s_1 = \frac{1{,}1q}{EK}\left[\frac{2d_m}{1-\left(\frac{d_m}{d_c}\right)^2} + 35{,}7\right], \qquad (2.5.3.4\text{-}1)$$

where s_1=push-up length of the rudder stock, in mm;

d_m=mean diameter of the rudder stock cone, in mm;

d_c=outer diameter (or minimum outer dimension) of rudder blade boss or steering nozzle (in the mean section), in mm;

E=modulus of elasticity of rudder stock material, in MPa;

K= taper of conical coupling, on the diameter;

q=required contact pressure applied to mating surfaces during the push-up, in MPa, determined by the formula

$$q = \frac{4{,}25\cdot 10^6 n M_t}{d_m^2 L_a}\sqrt{1 + \left(\frac{5\cdot 10^{-6} Q d_m}{M_t}\right)^2} \times \left(1 + 0{,}257\frac{L_a}{d_m}\frac{M_b}{M_t}\right) \qquad (2.5.3.4\text{-}2)$$

where n= safety factor against friction slip under the action of rated torque;

M_t= maximum value of design torque according to **2.2.2.3**, **2.2.2.4** or **2.2.3.3**, in kN·m;

L_a= actual length of the contact part of cone, excluding the oil distribution grooves and similar devices, in mm;

Q= mass of rudder blade or steering nozzle, in kg;

M_b= maximum bending moment in way of cone coupling determined according to **2.2.4.8**, **2.2.6.3** or **2.2.7.3**, in kN·m.

The spade rudders and steering nozzles of types XIVand XV (refer to Fig. 2.2.4.1) the value n shall be taken not less than 2,5; for other types of rudders and steering nozzles this value shall be not less than 2,0.

If the contact pressure q determined by Formula (2.5.3.4-2) is less than 40 MPa, then q=40 MPa shall be taken in the calculations.

2.5.3.5 The strength of the maximum loaded part of the coupling shall be checked: the combined stress on the inside of the rudder blade or steering nozzle boss shall not exceed 0,85 of the yield stress of the boss material. The combined stress σ_{com}, on the inside of the boss shall be determined by the formula

$$\sigma_{com} = \sqrt{0{,}5(\sigma_1 - \sigma_2)^2 + 0{,}5(\sigma_2 - \sigma_3)^2 + 0{,}5(\sigma_3 - \sigma_1)^2}, \qquad (2.5.3.5\text{-}1)$$

where:

$$\sigma_1 = q_1\frac{d_c^2 + d_3^2}{d_c^2 - d_3^2}; \qquad (2.5.3.5\text{-}2)$$

$$q_1 = q + 5{,}73\frac{M_b\cdot 10^6}{d_3 L_{s.t}^2}; \qquad (2.5.3.5\text{-}3)$$

$$\sigma_2 = -q_1; \qquad (2.5.3.5\text{-}4)$$

$$\sigma_3 = \frac{40Q}{\pi(d_c^2 - d_3^2)} + \frac{M_b\cdot 10^7}{d_3^3}; \qquad (2.5.3.5\text{-}5)$$

q_1= contact pressure between mating cone surfaces in way of maximum diameter of the rudder stock cone under combined action of torque and bending moments, in MPa;

d_3=maximum diameter of rudder stock cone, in mm;

$L_{s.t}$= length of rudder stock cone, in mm.

2.5.3.6 The value of oil pressure applied to the mating cone surfaces of the rudder stock and rudder blade boss during mounting and dismounting of the coupling shall not exceed p_{max}, in MPa, determined by the formula

$$p_{\max} = 0{,}55 R_{eH}\left[1 - \left(\frac{d_m}{d_c}\right)^2\right], \tag{2.5.3.6}$$

where R_{eH} =yield stress of material of the rudder blade or steering nozzle boss, in MPa.

2.5.4 Where the rudder stock is not made of a solid piece, its parts shall be joined by means of a muff coupling or by other method which shall ensure a strength equivalent to that of the rudder stock.

2.6 RUDDER PINTLES

2.6.1 The diameter d_4, in cm, of pintles without liners, as well as of pintles with liners, but before their setting, shall be not less than determined by the formula

$$d_4 = 18\sqrt{R_i / R_{eH}}\ , \tag{2.6.1}$$

where R_i=design value of the reaction of the considered pintle (R_2 or R_4) determined according to the provisions of **2.2.4** and **2.2.5** for the appropriate type of the rudder, in kN;
R_{eH}= upper yield stress of the pintle material, in MPa.

2.6.2 The length of the cone part of the pintle in rudder gudgeon, in welded-in bush of the steering nozzle or in the solepiece shall not be less than the diameter of the pintle according to **2.6.1**; the cone on the diameter shall not exceed 1:10. The cone shall change into cylindrical portion without any step in the diameter.

The external diameter of the pintle threaded portion shall not be less than 0,8 times the minimum diameter of the cone. The outer diameter and height of the nut shall not be less than 1,5 and 0,6 times the external diameter of the pintle threaded portion, respectivel.

2.6.3 The ratio of bearing height to diameter measured outside the pintle liners, where fitted, shall not be less than 1, nor more than 1,3.

2.6.4 The width of material in the rudder gudgeons and welded-in bushes of the steering nozzle measured outside the hole for the pintle bush shall not be less than 0,5 times the diameter of the pintle without liner. For rudder pintles of 200 mm and over in diameter it is allowed to reduce the specified width of the gudgeon from 0,5 times the diameter of the gudgeon down to 0,35 times the diameter of the pintle without liner in case the requirements of 2.6.2 and 2.6.3 are met, the following relation is obtained:

$$\frac{l_7}{d_4'} \geq \frac{R_{eH(p)}}{R_{eH(g)}}, \tag{2.6.4}$$

where l_7=height of the pintle bush, in cm;
d_4'=diameter of the pintle, in cm, including its liner, where fitted;
$R_{eH(p)}$=upper yield stress of the pintle material, in MPa;
$R_{eH(g)}$=upper yield stress of the gudgeon material, in MPa.

2.6.5 To prevent self-unscrewing, the nut shall be securely fastened by means of at least two welded-on strips or one welded-on strip and a split pin, and the pintles shall be securely fastened in gudgeons of the rudder or sternframe.

2.6.6 The chosen dimensions of the pintles shall be checked by the surface loading p, in MPa, this being taken as

$$p = 10 R_i / \left(d_4' l_7\right), \tag{2.6.6}$$

where for R_i – refer to **2.6.1**;

d'_4 =diameter of the pintle, in cm, including its liner, where fitted;

l_7 =height of the pintle bush, in cm.

This surface loading shall not exceed the values specified in Table 2.1.7.

2.7 RUDDER AXLE

2.7.1 The diameter of the rudder axle directly at the flangeshall be such that the normal stresses σ developed in its sections do not exceed 0,5 times the upper yield stress of the rudder axle material. The normal stress σ , , in MPa, shall be determined by the formula

$$\sigma = 10^4 M_{r\cdot a}/d_5^3 \quad (2.7.1)$$

where

$M_{r\cdot a}$= design value of the bending moment determined according to the provisions of **2.2.4.15**, in kN·m;

d_5=diameter of the rudder axle at the flange, in cm.

The diameter of the rudder axle in way of the rudder bearings shall be not less than the diameter d_5 . The diameter of the rudder axle between the rudder blade bearings may be reduced by 10%.

2.7.2 As regards the cone and threaded portions of the rudder axle and also its nut, the requirements are as stipulated in **2.6.2** for the pintles.

2.7.3 The diameter of bolts of the rudder axle flange coupling d6 , in cm, shall be not less than determined by the formula

$$d_6 = 6{,}77\sqrt{\frac{R_2 + \frac{M_{r\cdot a}}{r_4}\sqrt{1 + \left(0{,}17 + 0{,}6\frac{R_2 r_5}{M_{r\cdot a}}\right)^2}}{z_2 R_{eH}}} \quad (2.7.3)$$

where R_2= design value of the reaction of the rudder axle upper bearing determined according to **2.2.4.11**, in kN;

$M_{r\cdot a}$=design value of the bending moment acting in the rudder axle section near its flange determined according to **2.2.4.15**, in kN·m;

r_4=mean distance from the centre of the bolts to the centre of the system of the flange bolt holes, in m;

r_5=distance from the centre line of the rudder stock to the contact plane of the rudder axle flanges and the sternframe, in m;

z_2=number of the bolts of the flange coupling;

R_{eH}=upper yield stress of the bolt material, in MPa.

The number of the bolts z_2 shall be not less than 6.

The distance from the centre of any bolt to the centre of the system of the flange bolt holes shall be not less than 0,7, and to the vertical axis of symmetry of the flange plane, not less than 0,6 times the diameter d_5 , of the rudder axle given in **2.7.1**.

2.7.4 Only fitted bolts shall be employed, except the cases of a key setting when it is sufficient to have only two fitted bolts. The nuts shall have standard sizes, and they shall be securely fastened by split pins or weld-on strips.

2.7.5 The thickness of the coupling flange shall not be less than the diameter of the bolts. The centres of the holes for bolts shall be distant from the outside edges of the flange by not less than 1,15 times the diameter of the bolts.

2.7.6 Where the diameter of the rudder axle changes, sufficient fillets shall be provided. At transition from the rudder axle to the flange a fillet shall be provided with a radius of not less than 0,12 times the rudder axle diameter.

2.7.7 To prevent self-unscrewing, the nut of the rudder axle shall be securely fastened at least by two weld-on strips or one weld-on strip and a split pin.

2.7.8 The requirements of **2.6.6** for pintles are applicable to the rudder blade bearings on the rudder axl.

2.8 RUDDER STOCK BEARINGS

2.8.1 The requirements of **2.6.6** for pintles are applicable to the rudder stock bearings taking lateral load.

2.8.2 A rudder carrier shall be installed to take the mass of the rudder blade or steering nozzle and rudder stock. The deck shall be efficiently strengthened in way of the rudder carrier. Measures shall be taken against axial displacement of the rudder blade or steering nozzle and rudder stock upwards by a value exceeding that permitted by the construction of the steering gear; furthermore, for steering nozzle measures shall be taken to provide for guaranteed clearance between propeller blades and nozzle under service conditions.

2.8.3 A stuffing box shall be fitted in way of passage of the rudder stock through the top of a rudder trunk which is open to sea to prevent water from entering the ship's space. The stuffing box shall be fitted in a place accessible for inspection and maintenance at all times.

2.9 STEERING GEAR

2.9.1 Ships shall be provided with a main steering gear and an auxiliary steering gear, unless expressly provided otherwise.

2.9.2 The main steering gear and rudder stock shall be capable of putting the rudder or steering nozzle over from 35° on one side to 35° on the other side with the ship at its deepest seagoing draught and running ahead at maximum ahead service speed and under the same conditions, from 35° on either side to 30° on the other side in not more than 28 s.

2.9.3 The auxiliary steering shall be capable of putting the rudder or steering nozzle over from 15° on one side to 15° on the other side in not more than 60 s with the ship at its deepest sea going draught and running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greate.

2.9.4 In oil tankers, oil tankers (>60° C), combination carriers, gas carriers and chemical tankers of 10000 gross tonnage and upwards, in all nuclear ships and in other ships of 70 000 gross tonnage and upwards the main steering gear shall comprise two or more identical power units satisfying the requirements of **2.9.5** (refer also to **6.2.1.8** and **6.2.1.9**, Part IX "Machinery").

2.9.5 Where the main steering gear comprises two or more power units, an auxiliary steering gear need not be fitted if:

.1 in passenger and nuclear ships as well as in special purpose ships having more than 240 persons on board the main steering gear is capable of operating as required in **2.9.2** while any one of the power units is out of operation;

.2 in cargo ships as well as in special purpose ships having 240 or less persons on board the main steering gear is capable of operating as required in **2.9.2** while all power units are in operation;

.3 the main steering gear is so arranged that after a single failure in its piping system or in any one of the power units the defect can be isolated so that steering capability can be maintained or speedily regained.

2.9.6 Where according to 2.3.1 the diameter of the rudder head is required to be over 230 mm, excluding strengthening for navigation in ice, provision shall be made for an additional source of electrical power as prescribed in **5.5.6**, Part XI "Electrical Equipment" sufficient to ensure operation of the steering gear power unit in compliance with the requirements of **2.9.3**.

2.9.7 The main steering gear may be hand-operated provided it meets the requirements of **6.2.3.2**, Part IX "Machinery" and the rudder stock and steering nozzle diameter specified in **2.3.1** does not exceed 120 mm (excluding strengthening for navigation in ice). In all other cases, the main steering gear shall be operated by power.

2.9.8 The auxiliary steering gear may be handoperated provided it meets the requirements of **6.2.3.3**, Part IX "Machinery" and the rudder stock or steering nozzle diameter specified in **2.3.1** does not exceed 230 mm (excluding strengthening for navigation in ice). In all other cases, the auxiliary steering gear shall be operated by power.

2.9.9 The main and auxiliary steering gears shall act on the rudder stock independently of one another, but it is allowed that the main and auxiliary steering gears have some common parts (such as tiller, quadrant, gear box, cylinder block, etc.) provided the respective scantlings of these parts are increased in accordance with **6.2.8.2**, Part IX "Machinery".

2.9.10 The rudder tackle may be considered as an auxiliary steering gear only in the following cases:

.1 in self-propelled ships of less than 500 gross tonnage;

.2 in non-propelled ships. In other cases, the rudder tackle is not considered as a steering gear and shall not necessarily be fitted in ships.

2.9.11 The rudder shall be provided with a system of stops permitting to put the rudder over either side only to an angle β°:

$$(\alpha^\circ + 1^\circ) \le \beta^\circ \le (\alpha^\circ + 1{,}5^\circ), \qquad (2.9.11\text{-}1)$$

where: α° – maximum hard-over angle to which the steering gear control system is adjusted but not over 358; technical background for the greater hard-over angle, based on the constructional features of the steering gear, shall be submitted by the designer.

All the parts of the system of stops, including those which are at the same time the parts of the steering gear, shall be calculated to take forces corresponding to an ultimate reverse torque M_{ult}, in kN·m, from the rudder of not less than:

$$M_{ult} = 1{,}135 R_{eH} d^3 \cdot 10^{-4}, \qquad (2.9.11\text{-}2)$$

where: d – actual diameter of the rudder stock head, in cm;
R_{eH} – upper yield stress of the rudder stock material, in MPa.

The stresses in these parts shall not exceed 0,95 times the upper yield stress of their material.

The rudder stops of the system may be fitted on the sternframe, deck platform, bulkhead or other structural members of the ship's hull.

Where an active rudder is installed and putting the rudder over to an angle exceeding the maximum one is required, arrangement of stops at an angle provided by the rudder design may be allowed.

2.9.12 Control of the main steering gear shall be provided both on the navigation bridge and in the steering gear compartment.

2.9.13 When the main steering gear is arranged according to **2.9.4** or **2.9.5**, two independent steering gear control systems shall be provided, each of which shall be operable separately from the navigation bridge. These systems may have a common steering wheel or level. If the control system comprises a hydraulic telemotor, the Register may waive the requirement for a second independent control system of the steering gear for the ship (with the exception of oil tankers, oil tankers (>60°C), combination carriers, gas carriers and chemical tankers of 10 000 gross tonnage and upwards, of other ships of 70 000 gross tonnage and upwards and of nuclear ships).

2.9.14 The auxiliary steering gear control shall be provided in the steering gear compartment.

For the auxiliary steering gear which is power operated, control shall also be provided from the navigation bridge and shall be independent of the control system for the main steering gear.

For ships of less than 500 gross tonnage and fishing vessels, the auxiliary steering gear control may not be provided from the steering gear compartment.

2.9.15 A rudder or steering nozzle angle indicator shall be fitted in the vicinity of each control station of the main and auxiliary steering gears and in the steering gear compartment.

The difference between the indicated and actual positions of the rudder or steering nozzle shall be not more than:

1° when the rudder or steering nozzle is in the centre line or parallel to it;

1,5° for rudder or steering nozzle angles from 0° - 5°;

2,5° for rudder or steering nozzle angles from 5° - 35°.

The rudder or steering nozzle angle indication shall be independent of the steering gear control system.

2.9.16 In all other respects the steering gear shall meet the requirements of Part IX "Machinery" and Part XI "Electrical Equipment".

2.9.17 Where compliance with the requirements of **2.9.2** and **2.9.3**, when conducting sea trials, is impossible, the ship, regardless of the date of construction, can confirm compliance with the requirements of **2.9.2** and **2.9.3** by other methods (refer to Resolution MSC.365 (93) of 22.05 .2014).

2.9.18 If the steering gear is mechanically driven, then in case of damage or malfunction of the control device, the second control device or manual drive shall be automatically actuated within 5 s.

If the other control unit or manual drive is not automatically actuated, it shall be possible for the helmsman to actuate it in a quick and easy way in one operation.

2.10 EFFICIENCY OF RUDDERS AND STEERING NOZZLES

2.10.1 General.

2.10.1.1 The choice of the ship's main characte-ristics affecting the steerability and the characteristics of the rudder and steering nozzle is made at the discretion of the designer and shipowner considering the necessity to ensure the proper steerability of the ship according to its purpose and service conditions and to ensure the correspondence between relative areas of rudders and steering nozzles of the ship under design and the prototype ship provided the total efficiency of the chosen rudders and/or steering nozzles is not less than that required in this Chapter.

2.10.1.2 The requirements of this Chapter apply to stern rudders and steering nozzles (refer to **2.1.2**) provided according to **2.1.1** in self-propelled ships (other than icebreakers) of 20 m and over in length of unrestricted service **A** and restricted areas of navigation **R1** and **A-R1** sailing in the displacement condition.

For ships of restricted areas of navigation **R2**, **A-R2**, **R2-S**, **A-R2-S**, **B-R3-S**, **C-R3-S**, **R3-S** and **R3** the standards set forth in **2.10.3** shall be considered as recommendations.

For ships of river-sea navigation **R2-RS**, **A-R2-RS**, **B-R3-RS**, **C-R3-RS**, **R3-RS**, **D-R3-RS**, **R3-IN** the standards set forth in **2.10.3** shall also be considered as recommendations, and the fulfilment of these standards does not give the grounds for exemption from the fulfilment of the current standards of steerability for ships of inland navigation, complying with **14**, Part III «Equipment, Arrangements and Outfit. Signal Means» of the Rules for the classification and construction of inland navigation ships pursuant to Chapter 20 of UNECE Resolution No. 61 (Revision 2).

2.10.1.3 The requirements of this Chapter apply to ships having the geometric characteristics of the hull within the following limits:

$L_1/B = 3{,}2...8{,}0$;

$L_1/d = 8{,}3...28{,}6$;

$B/d = 1{,}5...3{,}5$;

$C_B = 0{,}45...0{,}85$;

$C_p = 0{,}55...0{,}85$;

$\sigma_a = 0{,}80…0{,}99$,

where B= breadth of the ship, in m;
for C_B, d, L_1, C_p and s_a, refer to **2.2.2.1**, **2.4.1.1** and **2.10.3.3**, respectively.

2.10.1.4 The requirements of this Chapter apply to catamarans with two identical hulls (symmetric about the centreline of the hulls), each having geometric characteristics according to the provisions of **2.10.1.3**, and with two identical rudders and/or steering nozzles arranged in the centre plane of each hull.

2.10.1.5 The active means of the ship's steering which are not the main means of the ship's steering (thrusters, active rudders, etc.) are considered as means supplementing the required minimum and are not taken into account when meeting the requirements of this Chapter (refer also to **2.1.4.2**).

2.10.2 Estimation of efficiency of rudders and steering nozzles.

2.10.2.1 The efficiency of the chosen rudder E_r, other than rudders of types IV, X and XIII (refer to Fig. 2.2.4.1), shall be determined by the formula

$$E_r = \mu_1 \frac{A}{A_2}\left(1 + C_{HB}\frac{A_P}{A}\right)(1 - W)^2, \qquad (2.10.2.1\text{-}1)$$

where: $$\mu_1 = \frac{6{,}28}{1 + \frac{2A}{h_r^2}}; \qquad (2.10.2.1\text{-}2)$$

W – coefficient: for rudder arranged in the centreline behind the propeller,

$W = 0{,}3C_B$; (2.10.2.1-3)

for rudder arranged in the centreline with no propeller fitted forward of it

$W = 0$; (2.10.2.1-4)

for side rudders

$W = 0{,}4C_B - 0{,}13$; (2.10.2.1-5)

A_2 – lateral underwater area at the summer load waterline draught, in m^2;

for A, A_p, h_r, C_B – refer to **2.2.2.1**;

C_{HB} – value determined by Formula (2.2.3.1-8) with regard to Formula (2.2.3.1-4) at W as specified in this para with regard to **2.2.2.6**; for rudders not operating directly behind the propeller the thrust is taken as $T = 0$.

2.10.2.2 The efficiency of the chosen rudder E_{rr} of types IV, X or XIII (refer to Fig. 2.2.4.1) shall be determined by the formula

$$E_{rr} = 1{,}3\mu_2 \frac{A_t}{A_2}(1 - W)^2, \quad (2.10.2.2\text{-}1)$$

where:

$$\mu_2 = \frac{6{,}28\sqrt{b_r/b_t}}{1 + \frac{2b_t^2}{A_t}} + \frac{1{,}4C_{HB}}{1 + 0{,}5\left(\frac{b_t^2}{A_t}\right)^2}. \quad (2.10.2.2\text{-}2)$$

where: b_r= breadth of the rudder, in m;
b_t=total breadth of the rudder and rudder post, in m;
for A_t, refer to **2.2.2.1**;
for A_2, C_{HB}, W, refer to **2.10.2.1**.

2.10.2.3 The efficiency of the chosen steering nozzle E_n with or without a stabilizer shall be determined by the formula

$$E_n = 2{,}86\mu_3 \frac{D_o l_n}{A_2}(1 - W)^2, \quad (2.10.2.3\text{-}1)$$

where:

$$\mu_3 = \left(0{,}175 + 0{,}275\frac{D_n}{l_n}\right)\left[1 + 0{,}25\left(1 + \sqrt{1 + C_{HB}}\right)^2\right] + 0{,}25C_{HB}\frac{D_n}{l_n}; \quad (2.10.2.3\text{-}2)$$

W – coefficient:
for steering nozzle arranged in the centreline of the ship

$W = 0{,}2C_B$; (2.10.2.3-3)

for side steering nozzle

$W = 0{,}1C_B$; (2.10.2.3-4)

D_0 – outside diameter of the steering nozzle in the plane of the propeller disk, in m;

for C_B, D_n, l_n and A_2, refer to **2.2.2.1**, **2.2.3.1** and **2.10.2.1**, respectively;

C_{HB}=value determined by Formula (2.2.3.1-8) with regard to Formula (2.2.3.1-4) at W as specified in this para with regard to **2.2.2.6.**

2.10.3 Standards for efficiency of rudders and steering nozzles.

2.10.3.1 The total efficiency of all rudders and steering nozzles (refer to **2.10.2**) fitted in the ship (other than catamaran) shall not be less than the greater of the values E_1, E_2 or E_3, given below.

2.10.3.2 The efficiency of the single rudder or steering nozzle fitted in the catamaran which is determined according to **2.10.2** shall not be less than the greater of the values E_1, E_2 and E_3, estimated according to the provisions specified below considering each hull of the catamaran as an independent single-screw ship.

When determining the side-projected area (windage area), all the above-water structures of the catamaran and the deck cargo (if intended to be carried) are considered as belonging to one hull.

2.10.3.3 For all ships, other than tugs, rescue and fishing vessels, the value of E1 is determined depending on the values of C_p and σ_a:

for single-screw ships - according to Fig. 2.10.3.3-1;

for twin-screw and triple-screw ships - according to Fig. 2.10.3.3-2.

For intermediate values of C_p p the value of E_1 is determined by linear interpolation between the curves for two nearest values of C_p, given in Figs. 2.10.3.3-1 and 2.10.3.3-2 where C_p – is prismatic coefficient of the underwater part of the hull at the summer load waterline draught as determined by the formula:

$$C_p = C_B / C_m, \quad (2.10.3.3\text{-}1)$$

where: C_m – coefficient of fineness of midship section at the summer load waterline draught;

σ_a – afterbody lateral area coefficient at the summer load waterline draught as determined by the formula:

$$\sigma_a = 1 - \frac{2(f - f_0)}{L_1 d} \quad (2.10.3.3\text{-}2)$$

L_1 – length of the ship measured on the summer load waterline from the fore side of the stem to the after side of the after end of the ship, in m;

f – area of side projection of the stern counter, in m^2, calculated as the area of the figure bounded by the extension line of the keel lower edge, by the perpendicular to this line from the point of intersection of the summer load waterline and the outline of the centreline section of the ship's after end and by the sternframe after edge line drawn ignoring the rudder post, solepiece or rudder horn, if any;

f_0 – for twin-screw ships - area of the side projection of the propeller cone (or its part) superimposed on the area of the figure f, in m^2. In all other cases f_0 shall be taken as zero;

for d – refer to **2.4.1.1**.

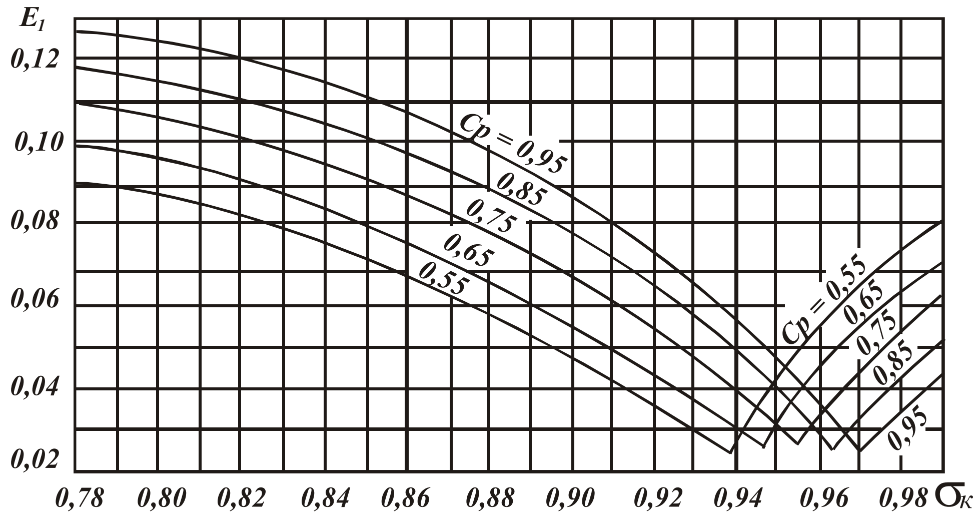


Fig. 2.10.3.3-1

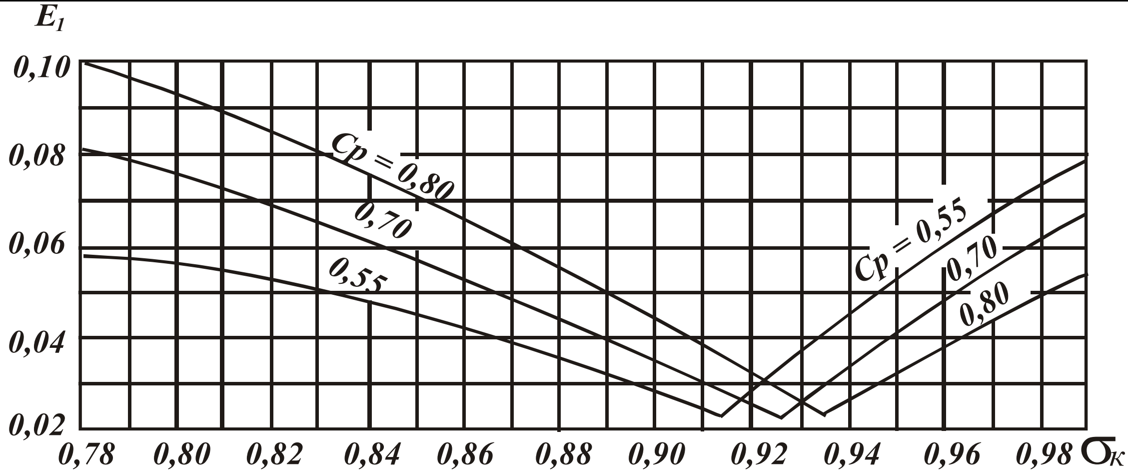


Fig. 2.10.3.3-2

2.10.3.4 For tugs, rescue ships and fishing vessels the value E1 is determined according to Fig. 2.10.3.4 depending on the value σ_a

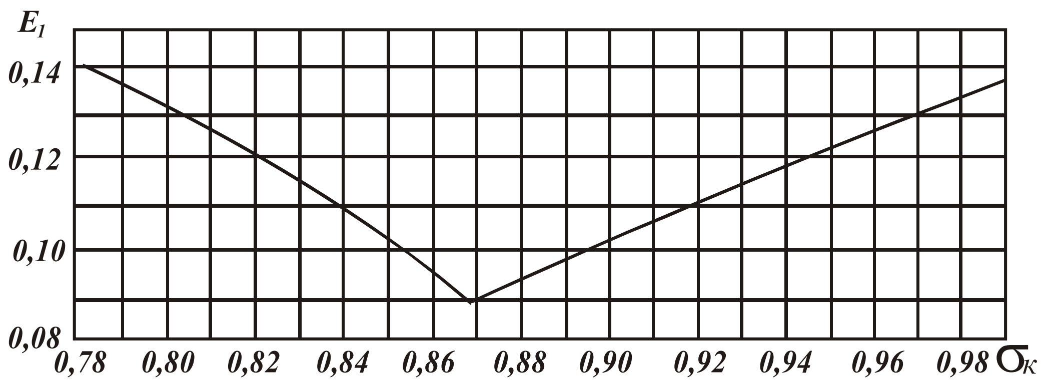


Fig. 2.10.3.4

2.10.3.5 The value E_2 is determined by the formula:

$$E_2=\frac{3{,}8A_3}{v^2A_4}\left(1-0{,}0667\frac{A_3}{A_4}\right)\{1+(\lambda_r-1)[0{,}33+0{,}015\times(v-7{,}5)]-5\frac{x_0}{L_1}\quad, \qquad (2.10.3.5\text{-}1)$$

where: A_3 – = side-projected area at such a minimum draught at which the rudder blade or steering nozzle is fully immersed (at the upright position of the ship), in m^2, to be determined according to 1.4.6, Part IV "Stability";

A_4 – lateral underwater area at such a minimum draught at which the rudder blade or steering nozzle is fully immersed (at the upright position of the ship), in m^2;

x_0 – horizontal distance from the midship frame (middle of the length L1) to the centroid of the area A3, in m.

The value of x_0 is taken to be positive in case the centroid is forward of the midship frame, and negative in case of aft position;

λ_r– coefficient determined by the formulae:

for all rudders, other than rudders of types IV, X and XIII (refer to Fig.2.2.4.1)

$$\lambda_r = h_r^2/A; \qquad (2.10.3.5\text{-}2)$$

for rudders of types IV, X, XIII (refer to Fig.2.2.4.1)

$$\lambda_r = h_r^2/A_t; \qquad (2.10.3.5\text{-}3)$$

for steering nozzles

$$\lambda_r = D_n/l_n; \qquad (2.10.3.5\text{-}4)$$

where for v, h_r, A, A_t, refer to **2.2.2.1**;
for D_n, l_n, refer to **2.2.3.1**.

2.10.3.6 For ships of 70 m in length and more the value E_3 is determined by the formula

$$E_3 = 0{,}03 + 0{,}01(\lambda_r - 1) + 0{,}01\frac{A_5}{A_2}\left(1 - 3\frac{x}{L_1}\right) \qquad (2.10.3.6)$$

where: A_5 – side-projected area of the ship at the summer load waterline draught, in m^2, to be determined according to **1.4.6**, Part IV "Stability";
x – horizontal distance from the midship frame (middle of the length L_1) to the centroid of the area A_5, in m;
for A_2 – refer to **2.10.2.1**;
for λ_r – refer to **2.10.3.5**.

The value of x is taken to be positive in case the centroid is forward of the midship frame and negative in case of aft position.

For ships of less than 70 m in length E_3=0 is taken in the calculations.

2.10.3.7 For all ships (other than rescue and fishing vessels and tugs, with σ_a>0,865), it is permitted in the calculations to take E_1 as zero (if the value of E_1 is greater than any of the values of E_2 or E_3) provided it is proved by the test of a self-propelled model not less than 2 m in length (at the speed of the model conforming to the ship's speed V, refer to **2.2.2.1**) that:

.1 the steady turning diameter of the ship with the rudder (rudders) or steering nozzle (rudders) put over to 35° on either side is not more than four lengths of the ship;

.2 the steady spontaneous turning diameter of the ship with non-reversed rudder (rudders) or steering nozzle (rudders) D_s determined by the formula

$$D_s = (D_{ss} + D_{sp})/2, \qquad (2.10.3.7)$$

is not less than $3{,}35\ (D_{ts} + D_{tp})$

where: D_{ts} and D_{tp} = steady turning diameter of the ship with the rudder or steering nozzle put over to 358 on starboard or port side, respectively;
D_{ss} and D_{sp}= diameter of steady spontaneous turning starboard or port, respectively, with the non-reversed rudder or steering nozzle.

2.10.3.8 For ships with the displacement exceeding 60000 t and block coefficient exceeding 0,75 at the summer load waterline draught, the compliance with the requirements of **2.10.3.7.1** and **2.10.3.7.2** shall be proved by testing a self-propelled model of not less than 2 m in length (at the speed of the model conforming to the ship's speed V, refer to **2.2.2.1**), notwithstanding the fulfilment of the requirements of **2.10.3.**1.

2.11 ADDITIONAL REQUIREMENTS FOR BALTIC ICE CLASS SHIPS

The scantlings of rudder post, rudder stock, pintles, steering engine etc. as well as the capability of the steering engine shall be determined according to the requirements of this Chapter. The steering gear of Baltic ice class **IA** and **IA Super** ships shall comply with the requirements to **Ice4** and **Ice5** ships respectively.

The maximum service speed of the ship to be used in these calculations shall, however, not be taken as less than stated below:

IA Super – 20 knots;
IA – 18 knots;
IB – 16 knots;
IC – 14 knots.

If the actual maximum service speed of the ship is higher, that speed shall be used.

The scantlings of structural elements of the rudder blade shall be determined on the basis that the steering gear is completely located in the ice zone of the ship. The scantlings of rudder blade plate elements and stiffeners shall be determined at an ice load intensity p, which corresponds to the intensity of the ice load on the plate and beam elements in the midship.

For the ice classes **IA Super** and **IA** the rudder stock and the upper edge of the rudder shall be protected against ice pressure by an ice knife or equivalent means, located aft of the rudder, which in its dimensions shall extend beyond the lower ice waterline (LIWL see 3.12, Part “Hull”), to the extent possible for this design, or with the help of other measures equivalent in degree of protection.

When using a rudder with a flap, the design of an ice knife shall provide the necessary strength of the rudder blade.

For the ice classes **IA Super** and **IA** due regard shall be paid to the excessive load caused by the rudder being forced out of the midship position when backing into an ice ridge. Where possible, rudder stoppers working on the blade or rudder head shall be fitted.

Relief valves for hydraulic pressure shall be effective.

The components of the steering gear shall be dimensioned to stand the yield torque of the rudder stock, at which a stress arises for the calculated diameter of the rudder equal to the minimum value of the conditional yield strength of the material.

3. ANCHOR ARRANGEMENT

3.1 GENERAL

3.1.1 Each ship shall be provided with anchoring equipment and also with chain stoppers for securing the bower anchors in hawse pipes, devices for securing and releasing the inboard ends of the chain cables and machinery for dropping and hoisting the bower anchors as well as for holding the ship at the bower anchors dropped.

Besides, in cases specified in **3.6.1.1** each bower anchor chain cable shall be provided with a stopper for riding the ship at anchor.

The requirements of this Section for selection of anchoring equipment do not apply to oil tankers of 150 m in length and above as well as bulk carriers of 90 m in length and above, contracted for construction on or after 1 July 2015. The requirements for anchoring equipment of the said ships are regulated by Common Structural Rules for Bulk Carriers and Oil Tankers

3.1.2 If a ship in addition to the anchor arrangement or anchoring equipment specified in 3.1.1 is provided with some other anchor arrangement or anchoring equipment (for example, special anchors and winches on dredgers, mooring anchors on lightships, etc.), such anchor arrangement or anchoring equipment is regarded as special one and is not subject to the Register survey.

The use of anchor arrangement specified in **3.1.1** as a working special arrangement for moving the dredgers and also for holding the dredgers in place in the course of dredging carried out by grabs may be allowed; in so doing the required data characterizing the conditions of work of anchor arrangement elements (the value and degree of dynamics of acting forces, the degree of intensity of work and wear rate of the anchor arrangement elements, etc.) shall be submitted.

3.1.3 For all ships other than fishing vessels, the anchoring equipment shall be selected from Table 3.1.3-1, for fishing vessels – from Table 3.1.3-2.

For fishing vessels, when Equipment Number exceeds 720, the anchoring equipment shall be selected from Table 3.1.3-1 based on Equipment Number determined in compliance with 3.2 in the case of ships of unrestricted service and of restricted area of navigation **R1** and **A-R1** and based on Equipment Number reduced:

by 15 % in the case of ships of restricted areas of navigation **R2**, **A-R2, R2-S, A-R2-S, A-R2-RS, B-R3-S, B-R3-RS, C-R3-S, C-R3-RS, R3-S, R3-RS;**

by 25 % in the case of ships of restricted area navigation **R3** і **R3-IN, D-R3-S, D-R3-RS** з taking into account of the provisions specified in **3.1.4, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 3.4.3, 3.4.7 і 3.4.10**.

Table 3.1.3-1

Equipment Number EN		Bower anchors		Mass of stream anchor, in kg	Chain cables for bower anchors				Stream wire or chain		Tow line		Mooring lines		
Exceeding	Not exceeding	Number	Mass of anchor, in kg		Total length of both chain cables, in m	Diameter			Length, in m	Chain cable breaking load or breaking strength of wire	Length, in m	Minimum breaking strength, in kN	Number	Length of each line, in m	Minimum breaking strength, in kN
						Ordinary (grade 1), in mm	Special quality (grade 2), in mm	Extra special quality (grade 3), in mm							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
10	15	2	35	-	110	1)	-	-	-	-	-	-	2	30	29
15	20	2	50	–	137,5	1)	–	–	–	–	–	–	2	30	29
20	25	2	65	–	165	1)	–	–	–	–	–	–	2	40	29
25	30	2	80	–	165	11,0	–	–	–	–	–	–	2	50	29
30	40	2	105	35	192,5	11,0	–	–	55	55	120	65	2	50	29
40	50	2	135	45	192,5	12,5	–	–	70	60	150	81	2	60	29
50	70	2	180	60	220	14	12,5	-	80	65	180	98	3	80	37
70	90	2	240	80	220	16	14	–	85	74	180	98	3	100	40
90	110	2	300	100	247,5	17,5	16	–	85	81	180	98	3	110	42
110	130	2	360	120	247,5	19	17,5	-	90	89	180	98	3	110	48
130	150	2	420	140	275	20,5	17,5	–	90	98	180	98	3	120	53
150	175	2	480	165	275	22	19	–	90	108	180	98	3	120	59
175	205	2	570	190	302,5	24	20,5	–	90	118	180	112	3	120	64
205	240	2	660	–	302,5	26	22	20,5	–	–	180	129	4	120	69
240	280	2	780	–	330	28	24	22	–	–	180	150	4	120	75
280	320	2	900	–	357,5	30	26	24	–	–	180	174	4	140	80
320	360	2	1020	–	357,5	32	28	24	–	–	180	207	4	140	85
360	400	2	1140	–	385	34	30	26	–	–	180	224	4	140	96
400	450	2	1290	–	385	36	32	28	–	–	180	250	4	140	107
450	500	2	1440	–	412,5	38	34	30	–	–	180	276	4	140	117
500	550	2	1590	–	412,5	40	34	30	–	–	190	306	4	160	134
550	600	2	1740	–	440	42	36	32	–	–	190	338	4	160	143
600	660	2	1920	–	440	44	38	34	–	–	190	371	4	160	160
660	720	2	2100	–	440	46	40	36	–	–	190	406	4	160	171
720	780	2	2280	–	467,5	48	42	36	–	–	190	441	4	170	187
780	840	2	2460	–	467,5	50	44	38	–	–	190	480	4	170	202
840	910	2	2640	–	467,5	52	46	40	–	–	190	518	4	170	218
910	980	2	2850	–	495	54	48	42	–	–	190	559	4	170	235
980	1060	2	3060	–	495	56	50	44	–	–	200	603	4	180	250
1060	1140	2	3300	–	495	58	50	46	–	–	200	647	4	180	272
1140	1220	2	3540	–	522,5	60	52	46	–	–	200	691	4	180	293
1220	1300	2	3780	–	522,5	62	54	48	–	–	200	738	4	180	309
1300	1390	2	4050	–	522,5	64	56	50	–	–	200	786	4	180	336
1390	1480	2	4320	–	550	66	58	50	–	–	200	836	4	180	352
1480	1570	2	4590	–	550	68	60	52	–	–	220	888	5	190	352
1570	1670	2	4890	–	550	70	62	54	–	–	220	941	5	190	362
1670	1790	2	5250	–	577,5	73	64	56	–	–	220	1024	5	190	384
1790	1930	2	5610	–	577,5	76	66	58	–	–	220	1109	5	190	411
1930	2080	2	6000	–	577,5	78	68	60	–	–	220	1168	5	190	437
2080	2230	2	6450	–	605	81	70	62	–	–	240	1259	2)	200	2)
2230	2380	2	6900	–	605	84	73	64	–	–	240	1356	2)	200	2)
2380	2530	2	7350	–	605	87	76	66	–	–	240	1453	2)	200	2)
2530	2700	2	7800	–	632,5	90	78	68	–	–	260	1471	2)	200	2)
2700	2870	2	8300	–	632,5	92	81	70	–	–	260	1471	2)	200	2)

2870	3040	2	8700	–	632,5	95	84	73	–	–	260	1471	2)	200	2)
3040	3210	2	9300	–	660	97	84	76	–	–	280	1471	2)	200	2)
3210	3400	2	9900	–	660	100	87	78	–	–	280	1471	2)	200	2)
3400	3600	2	10500	–	660	102	90	78	–	–	280	1471	2)	200	2)
3600	3800	2	11100	–	687,5	105	92	81	–	–	300	1471	2)	200	2)
3800	4000	2	11700	–	687,5	107	95	84	–	–	300	1471	2)	200	2)
4000	4200	2	12300	–	687,5	111	97	87	–	–	300	1471	2)	200	2)
4200	4400	2	12900	–	715	114	100	87	–	–	300	1471	2)	200	2)
4400	4600	2	13500	–	715	117	102	90	–	–	300	1471	2)	200	2)
4600	4800	2	14100	–	715	120	105	92	–	–	300	1471	2)	200	2)
4800	5000	2	14700	–	742,5	122	107	95	–	–	300	1471	2)	200	2)
5000	5200	2	15400	–	742,5	124	111	97	–	–	300	1471	2)	200	2)
5200	5500	2	16000	–	742,5	127	111	97	–	–	300	1471	2)	200	2)
5500	5800	2	16900	–	742,5	130	114	100	–	–	300	1471	2)	200	2)
5800	6100	2	17800	–	742,5	132	117	102	–	–	300	1471	2)	200	2)
6100	6500	2	18800	–	742,5	–	120	107	–	–			2)	200	2)
6500	6900	2	20000	–	770	–	124	111	–	–	Tow lines are not required when ship's length exceeds 180 m		2)	200	2)
6900	7400	2	21500	–	770	–	127	114	–	–			2)	200	2)
7400	7900	2	23000	–	770	–	132	117	–	–			2)	200	2)
7900	8400	2	24500	–	770	–	137	122	–	–			2)	200	2)
8400	8900	2	26000	–	770	–	142	127	–	–			2)	200	2)
8900	9400	2	27500	–	770	–	147	132	–	–			2)	200	2)
9400	10000	2	29000	–	770	–	152	132	–	–			2)	200	2)
10000	10700	2	31000	–	770	–	–	137	–	–			2)	200	2)
10700	11500	2	33000	–	770	–	–	142	–	–			2)	200	2)
11500	12400	2	35500	–	770	–	–	147	–	–			2)	200	2)
12400	13400	2	38500	–	770	–	–	152	–	–			2)	200	2)
13400	14600	2	42000	–	770	–	–	157	–	–			2)	200	2)
14600	16000	2	46000	–	770	–	–	162	–	–			2)	200	2)

1) Chain cables or wire ropes may be used, chain cable breaking load or breaking strength of wire rope being not less than 44 kN.

2) Refer to **2.1.2** of IACS recommendation No.10 (Corr.1 Dec 2016).

Table 3.1.3-2

Equipment Number EN		Bower anchors		Chain cables for bower anchors			Mooring lines		
					Diameter				
Exceeding	Not exceeding	Number	Mass per. anchor, in kg	Total length, in мм	grade 1, in mm	grade 2, in mm	Number	Length of each line, in m	Minimum breaking strength, in kN
1	2	3	4	5	6	7	8	9	10
10	15	1	30	55	1)	–	2	30	29
15	20	1	40	55	1)	–	2	30	29
20	25	1	50	82,5	1)	–	2	40	29
25	30	1	60	82,5	1)	–	2	50	29
30	40	2	80	165	11,0	–	2	50	29
40	50	2	100	192,5	11,0	–	2	60	29
50	60	2	120	192,5	12,5	–	2	60	29
60	70	2	140	192,5	12,5	–	2	80	29
70	80	2	160	220	14	12,5	2	100	34
80	90	2	180	220	14	12,5	2	100	37
90	100	2	210	220	16	14	2	110	37
100	110	2	240	220	16	14	2	110	39
110	120	2	270	247,5	17,5	16	2	110	39
120	130	2	300	247,5	17,5	16	2	110	44
130	140	2	340	275	19	17,5	2	120	44
140	150	2	390	275	19	17,5	2	120	49
150	175	2	480	275	22	19	2	120	54
175	205	2	570	302,5	24	20,5	2	120	59
205	240	2	660	302,5	26	22	2	120	64
240	280	2	780	330	28	24	3	120	71
280	320	2	900	357,5	30	26	3	140	78
320	360	2	1020	357,5	32	28	3	140	86
360	400	2	1140	385	34	30	3	140	93
400	450	2	1290	385	36	32	3	140	100
450	500	2	1440	412,5	38	34	3	140	108
500	550	2	1590	412,5	40	34	4	160	113
550	600	2	1740	440	42	36	4	160	118
600	660	2	1920	440	44	38	4	160	123
660	720	2	2100	440	46	40	4	160	128

1) Chain cables or wire ropes may be used, chain cable breaking load or breaking strength of wire rope being not less than 44 kN.

3.1.4 For non-propelled ships the anchoring equipment shall be selected based on Equipment Number increased by 25 % as against that calculated in compliance with provisions specified in **3.1.3** of this Part of the Rules. For self-propelled ships having the maximum ahead speed not more than 6 knots at the draught to the summer load waterline, the anchoring equipment shall be selected as in the case of non-propelled ships.

The anchor arrangement of shipborne barges and berth-connected ships shall comply with the requirements of Section **3**, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Inland Navigation Ships (for European Inland Waterways). For the case of sea passage of berth-connected ships having no permanent anchor arrangement, provision shall be made for anchors and anchor chains to be arranged on board.

For non-propelled ships, the anchor arrangement may not be provided. In this case, for temporary holding of the non-propelled ships, the towing ship anchor arrangement may be considered. At that, technical background for ensuring holding anchorage under stormy conditions including Equipment Numbers for supply vessels, safety factors, environmental effects and loads, shall be submitted to the Register.

For non-propelled ships, the position mooring system may be used as anchor arrangement.

3.1.5 For remote control systems of the anchor arrangements, if any, the type, extent of automated control and scope of remote control operations are determined by the shipowner.

The additional requirements for the remote-controlled anchor arrangements are given in **3.6.5** of this Part, **6.3.6**, Part IX "Machinery", and also in **5.1.3**, Part XI "Electrical Equipment".

3.2 EQUIPMENT NUMBER

3.2.1 The Equipment Number *EN* for all ships other than floating cranes and tugs, is determined by the formula

$$EN = \Delta^{2/3} + 2Bh + 0{,}1A, \qquad (3.2.1\text{-}1)$$

where: Δ – moulded displacement, in t, to the summer load waterline[3];

B – breadth of the ship, in m;

h – effective height, in m, from the summer load waterline to the top of the uppermost deckhouse; for the lowest tier h shall be measured at centreline from the upper deck or from a notional deck line where there is local discontinuity in the upper deck, refer to Fig. 3.2.1 for an example, which is determined by the formula:

$$h = a + \sum h_i\ , \qquad (3.2.1\text{-}2)$$

where: *a* – distance, in m, from the summer load waterline amidships to the top of the upper deck plating at side;

h_i – height, in m, at the centreline of each tier of superstructures or deckhouses having a breadth greater than 0,25B.

In case of ships with two or more superstructures or deckhouses along the length, only one superstructure or deckhouse of the considered tier with the greatest breadth is taken into account.

For the lowest tier hi shall be measured at the centreline from the upper deck or, in case of a stepped upper deck, from a notional line which is a continuation of the upper deck. When calculating h, sheer and trim shall be ignored. Refer also to **3.2.3**;

A – side-projected area, in m^2, of the hull, superstructures and deckhouses above the summer load waterline which are within the ship's length *L* and also have a breadth greater than 0,25*B* (refer also to **3.2.3**).

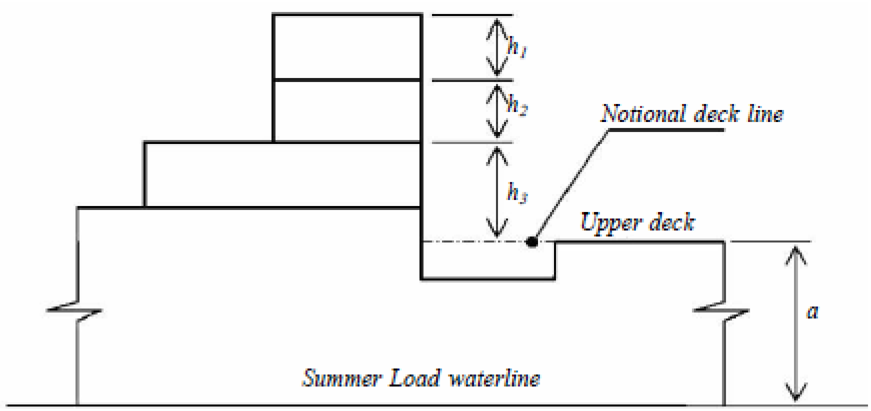


Рис. 3.2.1

3.2.2. The Equipment Number EN for tugs is determined by the formula

$$EN = \Delta^{2/3} + 2(Ba + \Sigma h_i b_i) + 0{,}1A,$$

(3.2.2)

where: Δ, B, a, h_i and A are taken according to **3.2.1**;

b_i – breadth of the appropriate tier of superstructure or deckhouse, in m. In case of ships with two or more superstructures or deckhouses along the length, the relevant provisions of 3.2.1 shall be followed **3.2.1**.

3.2.3 Containers or other similar cargoes carried on decks and on hatchway covers, masts, derrick booms, rigging, guard rails and other similar structures may be ignored when determining *h* and *A*; bulwarks and hatch coamings less than 1,5 m in height may also be ignored. Screens, bulwarks and hatch coamings more than 1,5 m in height shall be regarded as deckhouses or superstructures.

Main gallows, ladders and pile drivers for lifting the ladders of dredgers may be ignored when determining *h*; when determining the value *A*, the side-projected area of these structures shall be calculated as the area limited by the contour of the structure.

3.2.4 The Equipment Number *EN* for floating cranes is determined by the formula:

$$EN = 1{,}5\Delta^{2/3} + 2Bh + 2S + 0{,}1A, \qquad (3.2.4)$$

where: Δ, B, h and A are taken according to **3.2.1**; when determining the value of *A*, account shall be taken of the sideprojected area of the upper structure of floating crane (stowed for sea) which is calculated as the area limited by the outer contour of the structure;

S – projection on the mid-section of the front area, in m^2, of the upper structure of the floating crane (stowed for sea) situated above the deck of the uppermost deckhouse taken into account in determination of *h*, the front area being determined, in this case, as the area limited by the outer contour of the structure.

3.2.5 For ships with an equipment length of not less than 135 m and intended to anchor in deep and unsheltered water, the anchoring equipment shall be selected according to **1.2** of IACS recommendation No. 10 (Corr.1 Dec 2016).

3.3 BOWER AND STREAM ANCHORS

3.3.1 The mass and number of anchors shall be selected in accordance with **3.1.3**. Anchors of the following types are permitted to be used in ships:

1 ordinary stockless anchors and stock anchors (Hall's, Gruson's, admiralty anchors);

.2 high holding power (HHP) anchors;

.3 super high holding power (SHHP) anchors in accordance with **3.3.4**.

Ships with Equipment Number of 205 and less may have the second bower anchor as a spare one on condition that provision is made for its quick getting ready for use.

Ships of restricted area of navigation **R3, R3-IN** with Equipment Number of 35 and less, if they are not passenger ships, may have only one bower anchor.

3.3.2 Ships of restricted areas of navigation **R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **R3-RS, R3-S**, **B-R3-S**, **B-R3-RS, C-R3-S**, **C-R3-RS** and **D-R3-S**, **D-R3-RS** with Equipment Number in excess of 205 except the values stated in Table 3.1.3-1, shall be equipped with a stream anchor whose mass is at least 75 % of that required for a bower anchor.

For ships of restricted area of navigation **R3, R3-IN** stream anchor may be omitted.

In case the installation of stream anchors on board will affect the proper operation of the ship according to its intended purpose, a stream anchor may be omitted.

3.3.3 When HPP anchors of proven superior holding power are used as bower anchors, the mass of each anchor shall be 75 % of the mass required for ordinary stockless bower anchors in Table 3.1.3-1 or 3.1.3-2. When SHHP anchor of proven holding power are used as bower anchors, the mass of each anchor shall be reduced to not less than 50 % of the mass required for ordinary stockless bower anchors in Table 3.1.3-1 or 3.1.3-2. For fishing vessels with Equipment Number up to 980, where anchor chain cable is replaced with ropes, the mass of the anchor shall be increased by 25 % of the mass of the chosen anchor type.

For approval and/or acceptance as a HPP anchor satisfactory full scale tests in accordance with A1.4.2 of IACS UR A1 shall be done confirming that the anchor has a holding power at least twice that of an ordinary stockless anchor of the same mass.

For approval and/or acceptance as a SHPP anchor satisfactory full scale tests in accordance with A1.4.2 of IACS UR A1 shall be done confirming that the anchor has a holding power at least four times that of an ordinary stockless anchor of the same mass. Similar full scale tests shall be done for HPP anchor confirming that the SHHP anchor has a holding power at least twice that of a previously approved HPP anchor of the same mass.

The scope and procedure for such tests are specified in A1.4.2 of IACS UR A1.

3.3.4 SHHP anchors are suitable for use in ships of restricted areas of navigation **R2**, **A-R2**, **R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS, R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS.**

The SHHP anchor mass shall not generally exceed 1500 kg.

3.4 CHAIN CABLES AND ROPES FOR BOWER ANCHORS

3.4.1 Ship's with Equipment Number 205 and less, in which the second bower anchor is permitted to be a spare one, and also ships with Equipment Number 35 and less and provided according to **3.3.1** with only one bower anchor may be equipped with only one chain cable the length of which is two times less than that required in the relevant Equipment Table for two chain cables. For ships of restricted area of navigation **R3**, **R3-IN** chain cables or wire ropes for a stream anchor may be omitted.

3.4.2 For ships having a descriptive notation Supply vessel in their class notation, the total length of both chain cables for bower anchors shall be taken 165 m greater than the value specified in Table 3.1.3-1, and the diameter of these chain cables shall be taken not less than that given in Table 3.1.3-1 two lines below the Equipment Number for the considered ship (having regard to the provisions of **3.1.3** and **3.1.4**).

For supply vessels having a distinguishing mark for ships fitted with a dynamic positioning system in their class notation, this requirement may be waived.

For supply vessels having Equipment Number over 720 at the specification depth of the anchorage over 250 m and for those having Equipment Number 720 and less at the specification depth of the anchorage over 200 m, the length and diameter of chain cables for bower anchors shall be increased taking account of the specification depths and conditions of the anchorage.

3.4.3 For hopper barges and dredgers not having hoppers to transport spoil, the diameter of chain cables for bower anchors shall be taken not less than that specified in Table 3.1.3-1 two lines below the Equipment Number of the considered ship, and for dredgers having hoppers to transport spoil, one line below (taking account of the provisions of **3.1.3** and **3.1.4**).

3.4.4 Chain cables of bower anchors shall be graded dependent on their strength as specified in **7.1**, Part XIII "Materials".

3.4.5 Tables 3.1.3-1 and 3.1.3-2 specify the diameters of chain cables on the assumption that the links of these chain cables are provided with studs, with the exception of the chain cables less than 15 mm in diameter which are assumed to have no studs.

3.4.6 The chain cables shall be composed of separate chain lengths, except for the chains less than 15 mm in diameter which need not be divided into chain lengths. The lengths of chains shall be interconnected with joining links.

Depending on their location in the chain cable the lengths are divided into:

anchor length fastened to the anchor;

intermediate lengths;

inboard end chain length secured to the chain cable releasing device.

3.4.7 The anchor length of chain shall consist of a swivel, an end link and a minimum quantity of common and enlarged links required to form an independent length of chains.

The anchor length of chains may consist only of a swivel, an end link and a joining link provided the relation between the dimensions of the chain cable parts allows to form such a length. In chain cables which are not divided into lengths of chains the swivel shall be included into each chain cable as near to the anchor as practicable. In all cases, the pins of swivels shall face the middle of the chain cable.

The anchor length shall be connected with the anchor shackle with the aid of an end shackle the pin of which shall be inserted into the anchor shackle.

3.4.8 The intermediate lengths of chains shall be not less than 25 m and not over 27,5 m, the chains consisting of the odd number of links. The total length of two chain cables given in the Equipment Tables is a sum of intermediate lengths of chains only without the anchor and inboard end lengths of chains.

If the number of intermediate lengths of chains is odd, the starboard chain cable shall have one intermediate length of chains more than the port chain cable.

3.4.9 The inboard end length of chains shall consist of a special link of enlarged size (provided, however, that this link is capable of passing freely through the wildcat of the anchor machinery) being secured to the chain cable releasing device, and of minimum number of common and enlarged links required for forming an independent chain length. The inboard end length of chains may consist of one end link only provided the relation between the dimensions of the chain cable parts and the chain cable releasing device allows to form such a length.

3.4.10 In all other respects, the chain cables for bower anchors shall comply with the requirements of **7.1**, Part XIII "Materials".

3.4.11 For ships under 40 m in length the chain cables may be replaced with wire ropes.

For fishing vessels with Equipment Number up to 980, independently of their length, chain cables may be replaced with ropes, taking account of the requirements of **3.3.3**.

Minimum breaking strength of such ropes shall be not less than the breaking load of the corresponding chain cables, and the length shall be at least 1,5 times the length of chain cables.

Wire ropes of trawl winches complying with this requirement may be used as anchor cables.

Ships having Equipment Number 130 and less may be equipped with synthetic fibre ropes instead of chain cables or wire ropes.

3.4.12 The end of each wire rope shall be spliced into a thimble, clamp or socket and connected to the anchor by means of a chain cable section having a length equal to the distance between the anchor (in stowed for sea position) and the anchor machinery or 12,5 m, whichever is the less; a breaking load of the above chain section shall be not less than the breaking strength of the wire rope. The chain cable section shall be secured to the wire rope fitting and the anchor shackle by means of joining shackles being equal to the wire ropes in strength.

The length of the chain cable sections may be included into 1,5 times the length of wire ropes specified in **3.4.11**.

3.4.13 The wire ropes for anchors shall have at least 114 wires and one natural fibre core. The wires of the ropes shall have a zinc coating according to recognized standards. In all other respects, the wire ropes for anchors shall meet the requirements of **3.15**, Part XIII "Materials".

3.5 CHAIN CABLE OR WIRE ROPE FOR STREAM ANCHOR

3.5.1 Stream anchor chain cables shall meet the applicable requirements of **3.4**.

Ships of restricted areas of navigation**R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS** and **D-R3-S**, **D-R3-RS** with Equipment Number in excess of 205 shall be equipped with a stream anchor chain cable whose length is at least 60 % of that required for a bower anchor chain cable. The chain cable diameter shall be taken not less than that mentioned in Table 3.1.3-1 two lines above the Equipment Number of the ship in question (taking into account **3.1.3** and **3.1.4**).

Ships having Equipment Number below 205 may be equipped with studless chain cables.

3.5.2 The requirements of **3.4.12** and **3.4.13** are applicable to the wire rope for the stream anchor.

3.6 ANCHOR APPLIANCES

3.6.1 Stoppers.

3.6.1.1 Each bower anchor chain cable or rope and each stream anchor chain cable having a mass of 200 kg and above shall be provided with a stopper holding the anchor in the hawse pipe when stowed for sea or, in addition, intended for riding the ship at anchor.

In ships having no anchor machinery or having the anchor machinery, which is not in compliance with the requirements of **6.3.2.3.2**, Part IX "Machinery" provision of stoppers for riding the ship at anchor is obligatory.

3.6.1.2 Where the stoppers is intended only for securing the anchor in the hawse pipe when stowed for sea, its parts shall be calculated to withstand the chain cable strain equal to twice the weight of the anchor, the stresses in the stopper parts not exceeding 0,4 times the upper yield stress of their material. Where the stopper comprises a chain cable or rope, this shall have safety factor 5 in relation to the breaking load of the chain cable or minimum breaking strength of the rope under the action of a force equal to twice the weight of the anchor.

3.6.1.3 Where the stopper is intended for riding the ship at anchor, its parts shall be calculated on assumption that the stopper will be subjected to a force in the chain cable equal to 0,8 times its breaking load. The stresses in the stopper parts shall not exceed 0,95 times the upper yield stress of their material. Where the stopper comprises a chain cable or rope, they shall have strength equal to that of the chain cable for which they are intended.

3.6.1.4 In fiber-reinforced plastic ships the stoppers shall be fastened by bolts with the use of steel gaskets or wooden pads on the deck and under deck flooring between the framing. Bolt connections shall comply with the requirements of **1.7.4**, Part XVI "Structure and Strength of Fiber-Reinforced Plastic Ships".

3.6.2 Device for securing and releasing the inboard end of the chain cable.

3.6.2.1 The parts of the device for securing and releasing the inboard end of the chain cable shall be calculated for strength under the force acting on the device which is equal to 0,6 times the chain breaking load, stresses in these parts not exceeding 0,95 times the upper yield stress of their material.

3.6.2.2 In ships with Equipment Number of more than 205 the device for securing and releasing the inboard end of the chain cable shall be provided with a drive from the deck on which the anchor machinery is fitted or from other deck, in a place which gives quick and ready access at all times. The screw of the drive shall be self-braking.

3.6.2.3 The design of the device for securing and releasing the inboard end of the chain cable shall ensure the efficiency of its operation both under the action of and without the strain of the chain cable referred to in **3.6.2.1**.

3.6.2.4 In fiber-reinforced plastic ships the device for securing and releasing the inboard end of the chain cable shall be fastened by bolts with the use of steel gaskets on both sides of the bulkhead. Bolt connections shall comply with the requirements of **1.7.4**, Part XVI "Structure and Strength of FiberReinforced Plastic Ships".

3.6.3 Laying of chain cables.

3.6.3.1 Laying of chain cables shall provide for their free run when dropping or hoisting the anchors.

In ships with a bulbous bow laying of chain cables shall comply with the requirements of 2.8.2.4, Part II "Hull".

3.6.3.2 The anchor shank shall easily enter the hawse pipe under the mere action of the chain cable tension and shall readily take off the hawse pipe when the chain cable is released.

3.6.3.3 The thickness of the hawse pipe shall not be less than 0,4 times the diameter of the chain cable passing through the hawse pipe.

3.6.3.4 In fiber-reinforced plastic ships galvanized or stainless steel plates shall be fitted on the outside plating under the hawse pipes; the plates shall be fastened by countersunk bolts. Bolt connections shall comply with the requirements of **1.7.4**, Part XVI "Structure and Strength of Fiber-Reinforced Plastic Ships".

3.6.4 Chain lockers.

3.6.4.1 For stowage of each bower anchor chain lockers shall be provided.

When one chain locker is designed for two chains, it shall be provided with an internal permeable or watertight division so that separate stowage of each chain is ensured.

3.6.4.2 The chain locker shall be of shape, capacity and depth adequate to provide an easy direct lead of the cables through the chain pipes, an easy self-stowing of the cables and their free veering away when dropping the anchors.

3.6.4.3 The chain locker design, as well as chain and hawse pipes shall be watertight up to the weather deck. Upper openings of such pipes shall be fitted with the permanent buckler plates. These may be made both of steel with the relevant cutouts for a chain cable diameter and of canvas with the relevant fastenings to keep the plate closed down.

The openings for access to the chain locker shall be fitted with covers secured with closely spaced bolts.

3.6.4.4 Drainage of chain lockers shall comply with the requirements in **7.12.**1, Part VIII "Systems and Piping", and lighting - with the requirements of **6.7**, Part XI "Electrical Equipment".

3.6.5 Additional requirements for remote-controlled anchor appliances.

3.6.5.1 Stoppers and other anchor appliances for which remote control is provided (refer to **3.1.5**) shall also be fitted with means of local manual control.

3.6.5.2 The anchor appliances and the associated means of local manual control shall be so designed that normal operation is ensured in case of failure of separate elements or the whole of the remote control system (refer also to **5.1.3**, Part XI "Electrical Equipment").

3.7 ANCHOR MACHINERY

3.7.1 Anchor machinery shall be fitted on the deck in the fore part of the ship for dropping and hoisting the anchors, as well as for holding the ship with the bower anchors dropped if the mass of the anchor exceeds

35 kg.

Ships of restricted area of navigation **R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS** and **D-R3-S**, **D-R3-RS**, shall be fitted with the anchor machinery for dropping and hoisting the stream anchor if its mass exceeds 200 kg.

Ships having Equipment Number 205 and less may be fitted with hand-operated anchor machinery and may also use other deck machinery for dropping and hoisting the anchors.

The requirements for the design and power of anchor machinery are given in 6.3, Part IX "Machinery".

In fiber-reinforced plastic ships fastening of the anchor machinery shall comply with the requirements of **3.6.1.4**.

3.8 SPARE PARTS

3.8.1 Each ship carrying a spare anchor and equipped with a chain cable (cables) for bower anchor (anchors) accordance with the provisions of **3.3.1** and **3.4** shall have: spare anchor length of chain - 1 pc, spare joining link - 2 pcs, spare end shackle - 1 pc.

3.8.2 Each ship equipped with a spare anchor and wire rope (ropes) for bower anchor (anchors) in accordance with the provisions of **3.3.1** and **3.4.11** shall have a spare set of parts for joining the wire rope and anchor shackle.

4. MOORING ARRANGEMENT

4.1 GENERAL

4.1.1 Each ship shall be supplied with mooring arrangement for warping to coastal or floating berths and for reliable fastening of the ship to them. For shipborne barges the mooring arrangement shall comply with the requirements of Section 4, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Inland Navigation Ships (for European Inland Waterways).

For shipboard fittings not selected from an industry standard accepted (approved) by the Register, the corrosion addition, t_c and the wear allowance t_w, given in **4.3.5**, respectively, shall be considered.

The requirements of this Section for selection of mooring arrangement do not apply to oil tankers of 150 m in length and above as well as bulk carriers of 90 m in length and above, contracted for construction on or after 1 July 2015. The requirements for mooring lines and mooring arrangements of the said ships are regulated by Common Structural Rules for Bulk Carriers and Oil Tankers.

4.1.2 For all ships other than fishing vessels, the number, length and minimum breaking strength of mooring lines shall be as recommended values given in Table 3.1.3-1, and for fishing values – in Table 3.1.3-2.

For fishing vessels, when Equipment Number exceeds 720, the number, length and minimum breaking strength of mooring lines, given as recommended values, shall be selected from Table 3.1.3-1 based on Equipment Number determined in compliance with **3.2**.

4.1.3 For ships with Equipment Number EN of less than or equal to 2000 and having the ratio A/EN more than 0,9, the following number of mooring lines shall be added to the number of mooring lines as given by Table 3.1.3-1:

one line where $0{,}9 < A/N_э \le 1{,}1$;

two lines where $1{,}1 < A/N_э \le 1{,}2$;

three lines where $A/N_э > 1{,}2$,

where *EN* and *A* = Equipment Number and side-projected area, respectively, specified in **3.2**.

For ships with an Equipment Number EN > 2000, the mooring lines may be selected according to **2.1.2** of IACS recommendation No. 10 (Corr.1 Dec 2016).

4.1.4 For individual mooring lines with breaking strength above 490 kN according to Table 3.1.3-1 the latter may be reduced with corresponding increase of the number of mooring lines, provided that the total breaking strength of all mooring lines aboard the ship is not less than the value selected from Table 3.1.3-1 with regard to **4.1.3** and **4.1.6**. The number of lines shall be not less than 6 and none of the lines shall have the breaking strength less than 490 kN.

4.1.5 The length of individual mooring lines may be reduced by up to 7 % as against the prescribed value provided that the total length of all mooring lines is not less than that specified in Table 3.1.3-1 and **4.1.3** or Table 3.1.3-2.

4.1.6 In case mooring line made of synthetic fibre material is used, its actual breaking strength F_s, in kN, shall not be less than determined by the formula

$$F_s = 0{,}0742\delta_m F_t^{8/9}, \qquad (4.1.6)$$

where δ_m= mean elongation at breaking of a synthetic fibre rope, in %, but not less than 30 %.
Where no data on δ_m are available, it shall be assumed equal to:
45 % for polyamide ropes;
35 % for polypropylene ropes;
F_t= minimum breaking strength of the mooring line specified in Table 3.1.3-1 or 3.1.3-2, in kN.

4.2 MOORING LINES

4.2.1 Mooring lines may be of steel wire, natural fibre or synthetic fibre material, with the exception of the lines intended for ships carrying in bulk flammable liquids with the flash point 60 8C and below. In these ships the operations with steel wire ropes are allowed only on the superstructure decks which are not the top of liquid cargo tanks and on condition that no pipelines for loading and unloading the cargo are carried through these decks.

Notwithstanding the breaking strength specified in Tables 3.1.3-1 or 3.1.3-2 or determined by Formula (4.1.6), the diameter of the mooring rope made from natural or synthetic fibre material shall not be less than 20 mm.

4.2.2 Steel wire ropes shall have at least 144 wires and not less than 7 fibre cores. The exception is made for wire ropes for automatic mooring winches which may have only one fibre core but the number of wires in such ropes shall be not less than 216. The wires of the ropes shall have a zinc coating according to recognized standards.

In all other respects, the steel wire ropes shall meet the requirements of **3.15**, Part XIII "Materials".

4.2.3 Natural fibre ropes shall be either manilla or sizal. The ships having Equipment Number 205 and less are permitted to use hemp ropes. In all other respects, the natural fibre ropes shall meet the requirements of **6.6**, Part XIII "Materials".

4.2.4 The synthetic fibre ropes shall be manufactured from approved homogeneous materials (polypropylene, capron, nylon, etc.).

In all other respects, the ropes of synthetic fibre material shall meet the requirements of **6.6**, Part XIII "Materials".

4.3 MOORING EQUIPMENT

4.3.1 The number and position of mooring bollards, fairleaders and other mooring equipment depend on the constructional features, purpose and general arrangement of the ship.

Shipboard fittings may be selected from an industry standard accepted (approved) by the Register in accordance with recommended minimum breaking strength of the mooring lines selected from Table 3.1.3-1.

When the shipboard fitting is not selected from an accepted (approved) industry standard, the strength of the fitting and of its attachment to the ship shall be in accordance with **4.3.4** and **4.3.5**.

Mooring bitts (double bollards) are required to resist the loads caused by the mooring line attached in figure-of-eight fashion (refer to Note). For strength assessment beam theory or finite element analysis using net scantlings (without corrosion additions and wear down allowances specified in **4.3.5**) shall be applied, as appropriate. Load tests may be accepted as alternative to strength assessment by calculations.

Note. With the line attached to a mooring bitt in the usual way (figure-of-eight fashion), either of the two posts of the mooring bitt can be subjected to a force twice as large as that acting on the mooring line. Disregarding this effect, depending on the applied industry standard and fitting size, overload may occur.

4.3.2 Bollards may be of steel or cast iron. Small ships equipped only with natural fibre or synthetic fibre ropes are permitted to use the bollards made of light alloys. As to the method of manufacture, the bollards may be welded or cast.

It is not permitted to use bollards cut directly in the deck which is the top of cargo tanks intended for carriage or stowage of flammable liquids with the flash point 60 8C and below.

4.3.3 The outside diameter of the bollard column shall be not less than 10 diameters of the steel wire rope, not less than 5,5 diameters of the synthetic fibre rope, and not less than one circumference of the natural fibre rope for which the bollard is designed. The distance between the axes of bollard columns shall not be less than 25 diameters of the steel wire rope or 3 circumferences of the natural fibre rope.

4.3.4 Shipboard fittings, winches and capstans for mooring shall be located on stiffeners and/or girders, which are part of the deck construction so as to facilitate efficient distribution of the mooring load.

4.3.4.1 The minimum design load applied to supporting hull structures for shipboard fittings shall be 1,15 times the minimum breaking strength of the mooring line according to Table 3.1.3-1.

4.3.4.2 The minimum design load applied to supporting hull structures for winches shall be 1,25 times the intended maximum brake holding load, where the maximum brake holding load shall be assumed not less than 80 % of the minimum breaking strength of the mooring line according to Table 3.1.3-1; for supporting hull structures of capstans, 1,25 times the maximum hauling-in force shall be taken as the minimum design load.

4.3.4.3 When a safe working load (SWL) greater than that determined according to 4.3.6 is specified by the designer/shipowner, then the design load shall be increased accordingly. 4.3.4.4 The design load shall be applied to fittings in all directions that may occur by taking into account the arrangement shown on the towing and mooring arrangements plan.

However, in no case does the design load applied to the fitting need to be greater than twice the design load on the line.

Note. **1.** If not otherwise specified by IACS recommendation No. 10, side-projected area including that of deck cargoes as given by the Loading Manual shall be taken into account for selection of mooring lines and the loads applied to shipboard fittings and supporting hull structure.

2. The increase of the minimum breaking strength for synthetic ropes according to IACS recommendation No. 10 needs not to be taken into account for the loads applied to shipboard fittings and supporting hull structure.

The arrangement of reinforced members beneath shipboard fittings, winches and capstans shall consider any variation of direction (horizontally and vertically) of the mooring forces acting upon the shipboard fittings, refer to Fig. 5.3.6. Proper alignment of fitting and supporting hull structure shall be ensured.

The acting point of the mooring force on shipboard fittings shall be taken at the attachment point of a mooring line or at a change in its direction. For bollards and bitts the attachment point of the mooring line shall be taken not less than 4/5 of the tube height above the base, refer to Fig. 4.3.4, *a*.

However, if fins are fitted to the bollard tubes to keep the mooring line as low as possible, the attachment point of the mooring line may be taken at the location of the fins, refer to Fig. 4.3.4, *b*.

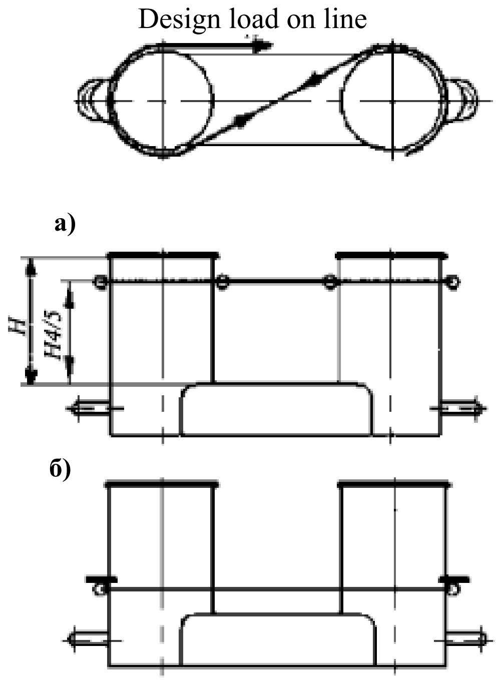


Fig.4.3.4

4.3.5 Allowable stresses in supporting hull structures under the design load conditions as specified in **4.3.4** are as follows:

.1 for strength assessment with beam theory or grillage analysis:

normal stress: 100 % of the specified minimum yield point of the material;

shear stress: 60 % of the specified minimum yield point of the material.

Normal stress is the sum of bending stress and axial stress with the corresponding shear stress acting perpendicular to the normal stress.

No stress concentration factors being taken into account.

.2 for strength assessment with finite element analysis: equivalent stress:

100 % of the specified minimum yield point of the material.

For strength calculations by means of finite elements, the geometry shall be idealized as realistically as possible.

The ratio of element length to width shall not exceed 3. Girders shall be modelled using shell or plane stress elements.

Symmetric girder flanges may be modelled by beam or truss elements.

The element height of girder webs shall not exceed one-third of the web height.

In way of small openings in girder webs the web thickness shall be reduced to a mean thickness over the web height.

Large openings shall be modelled.

Stiffeners may be modelled by using shell, plane stress, or beam elements. Stresses shall be read from the centre of the individual element.

For shell elements the stresses shall be evaluated at the mid plane of the element.

The corrosion addition t_c, shall not be less than the following values: for ships covered by Common Structural Rules for Bulk Carriers and Oil Tankers:

total corrosion addition shall be as defined in these Rules;

other ships: for the supporting hull structure, according to Part II "Hull" for the surrounding structure (e.g. deck structures, bulwark structures);

for pedestals and foundations on deck which are not part of a fitting according to an accepted (approved) industry standard, 2,0 mm;

for shipboard fittings not selected from an accepted (approved) industry standard, 2,0 mm.

Wear allowance:

in addition to the corrosion addition the wear allowance t_w, for shipboard fittings not selected from an accepted (approved) industry standard shall not be less than 1,0 mm, added to surfaces which are intended to regularly contact the line.

4.3.6 SWL of details of mooring appliances shall not exceed 0,8 design load determined in accordance with **4.3.4**.

All details of the mooring appliances shall be marked with the value of SWL by means of welding or other equivalent method.

4.4 MOORING MACHINERY

4.4.1 Special mooring machinery (mooring capstans, mooring winches, etc.) as well as other deck machinery (windlasses, cargo winches, etc.) fitted with mooring drums may be used for warping the hawsers.

4.4.2 The choice of the number and type of mooring machinery is within the owner's and designer's discretion, however, the rated pull of the machinery shall not exceed 1/3 of the breaking strength of the mooring ropes used in the ship and, besides, the requirements of **6.4**, Part IX "Machinery" shall be satisfied.

4.5 TOWING AND MOORING ARRANGEMENTS PLAN

4.5.1 The SWL (Safe Working Load) and TOW (Safe Towing Load) for the intended use for each shipboard fitting shall be noted in the towing and mooring arrangements plan available on board for the guidance of the master.

TOW is the load limit for towing purpose and SWL that for mooring purpose. If not otherwise chosen, for towing bitts it should be noted that TOW is the load limit for a towing line attached with eye-splice.

4.5.2 Information provided on the plan shall include in respect of each shipboard fitting:

location on the ship;

fitting type;

SWL/TOW;

purpose (mooring/harbour towing/other towing);

manner of applying towing or mooring line load including limiting fleet angles.

Furthermore, information provided on the plan shall include:

the arrangement of mooring lines showing number of lines (N);

the minimum breaking strength of each mooring line (MBL);

the acceptable environmental conditions as given in IACS recommendation No. 10, for the recommended minimum breaking strength of mooring lines for ships with Equipment Number EN>2000:

30 s mean wind speed from any direction (v_W or v^*_W according to IACS recommendation No. 10); maximum current speed acting on bow or stern (± 10°).

4.5.3 The information as given in **4.5.2** shall be incorporated into the pilot card in order to provide the pilot proper information on harbour and other towing operations.

5. TOWING ARRANGEMENT

5.1 GENERAL

5.1.1 Each ship shall be provided with towing arrangement which satisfies the requirements of **5.2** and **5.3**.

Besides, the ships having the descriptive notation **Tug** added to the character of classification shall comply with the requirements of **5.4** ÷ **5.6**.

5.1.2 Oil tankers, oil tankers (>60 8C), combination carriers, gas carriers and chemical tankers of 20 000 t deadweight and over shall comply with the requirements of **5.7**.

assenger and cargo ships shall be provided with an emergency towing procedure in accordance with **5.7.11**.

5.1.3. The towing arrangements of berth-connected ships shall comply with the requirements of **5.3**, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Inland Navigation Ships.

5.1.4 The requirements of this Section for selection of towing arrangement do not apply to oil tankers of

150 m in length and above as well as bulk carriers of 90 m in length and above, contracted for construction on or after 1 July 2015. The requirements for tow lines and towing arrangements of the said ships are regulated by Common Structural Rules for Bulk Carriers and Oil Tankers.

5.2 TOW LINE

5.2.1 The length and the minimum breaking strength of the tow line shall be as recommended values given in Table 3.1.3-1 based on an Equipment Number calculated in compliance with **3.2**.
For shipborne barges the actual breaking strength of the tow line F_b, in kN, shall be calculated by the formula

$$F_b = 16nBd \qquad (5.2.1)$$

where n= number of barges intended to be towed in the wake of the tug in tandem;
B= breadth of the barge, in m;
d=draught of the barge, in m.

The breaking strength of the tow line is used in the strength calculations of the towing appliances of the shipborne barges. At the discretion of the shipowner the tow lines of the shipborne barges may be stored in the barge carrier or tug, and they do not form a part of the equipment of the shipborne barge.

5.2.2 The tow lines may be of steel wire, natural fibre or synthetic fibre material. The requirements of **4.1.6**, **4.2.1 - 4.2.4** for mooring ropes are also applicable to the tow line.

5.3 TOWING EQUIPMENT

5.3.1 The number and location of towing bollards and chocks depend on the constructional features, purpose and general arrangement of the ship.

Ships having the descriptive notation Tug added to the character of classification, and equipped with a bow towing winch with a tow line may have no towing bitts provided the technical characteristics of this winch, its foundation and tow line comply with the requirements of **5.3.3** ÷ **5.3.6**.

5.3.2 Requirements of **4.3.2** and **4.3.3** introduced for the mooring bollards also apply to towing bollards.

5.3.3 Shipboard fittings for towing shall be located on longitudinals, which are part of the deck construction so as to facilitate efficient distribution of the towing load.

5.3.4 The minimum design load applied to supporting hull structures for shipboard fittings shall be:

.1 for normal towing operations - 1,25 times the intended maximum towing load (e.g. static bollard pull) as indicated on the towing and mooring arrangements plan;

.2 for other towing service - the minimum breaking strength of the tow line according to Table 3.1.3-1 for the ship's corresponding Equipment Number;

.3 for fittings intended to be used for, both, normal and other towing operations, the greater of the design loads according to **5.3.4.1** and **5.3.4.2**.

5.3.5 The design load applied to supporting hull structure shall be in accordance with **5.3.4**.

The reinforced members beneath shipboard fittings shall be effectively arranged for any variation of direction (horizontally and vertically) of the towing forces acting upon the shipboard fittings, refer to Fig. 5.3.5-1.

Proper alignment of fitting and supporting hull structure shall be ensured.

The acting point of the towing force on shipboard fittings shall be taken at the attachment point of a towing line or at a change in its direction.

For bollards and bitts the attachment point of the towing line shall be taken not less than 4/5 of the tube height above the base, refer to Fig 5.3.5.2.

For strength assessment using beam theory or grillage analysis, as well as finite element analysis, the stresses in supporting hull structures shall be determined in the same manner as specified in **4.3.5**.

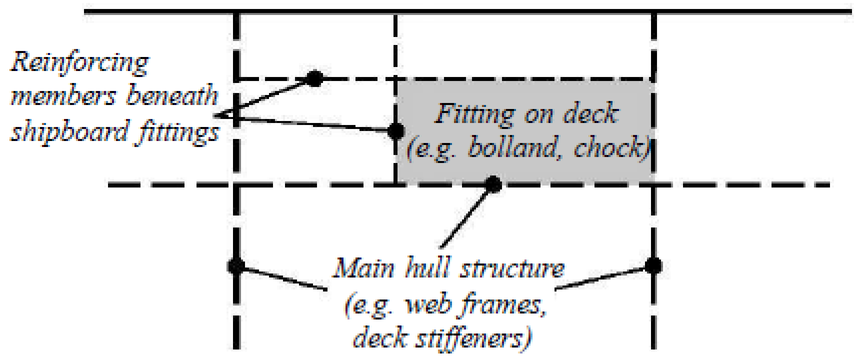


Fig. 5.3.5.1

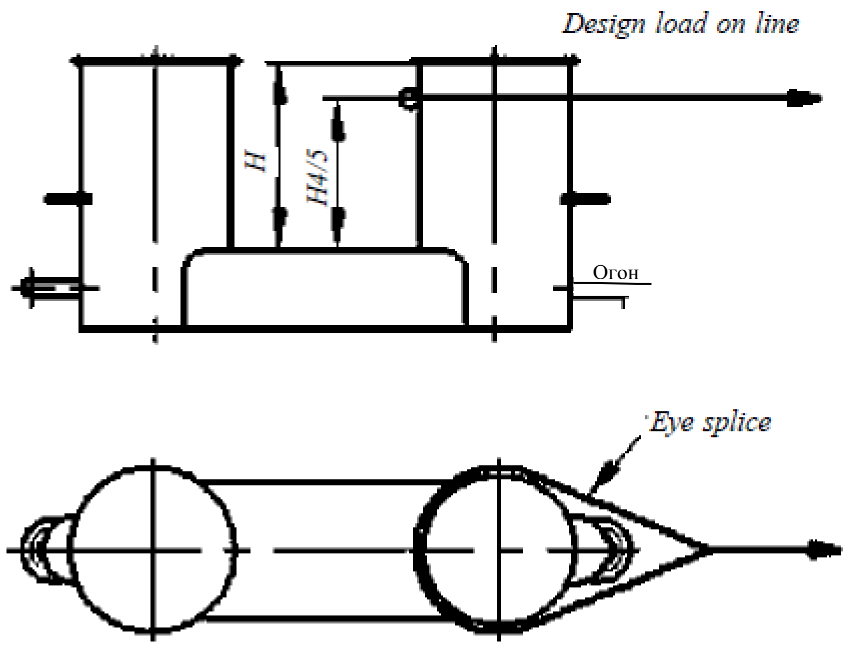


Fig. 5.3.5.2

5.3.6 When a safe towing load (TOW) greater than that determined according to **5.3.8** is specified by the designer/shipowner, then the design load shall be increased in accordance with the appropriate TOW/design load relationship given by **5.3.4** and **5.3.8**.]

The design load shall be applied to fittings in all directions that may occur by taking into account the arrangement shown on the towing and mooring arrangements plan. Where the towing line takes a turn at a fitting the total design load applied to the fitting is equal to the resultant of the design loads acting on the line, refer to Fig. 5.3.6. However, in no case does the design load applied to the fitting need to be greater than twice the design load on the line.

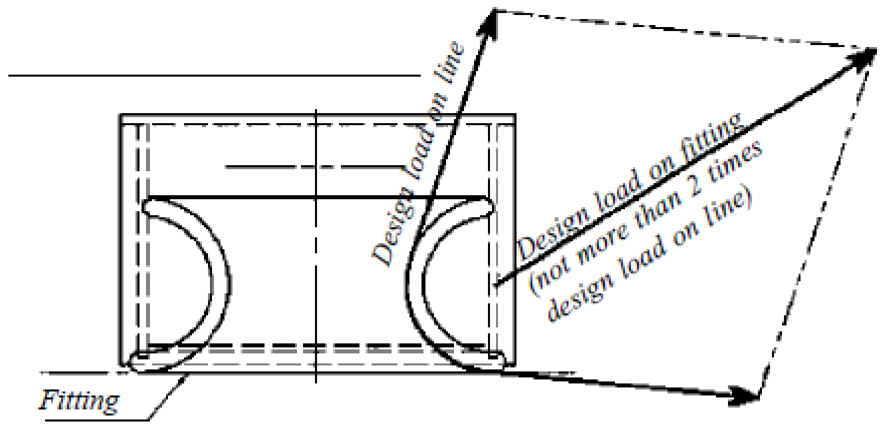


Fig. 5.3.6

5.3.7 Shipboard fittings.

Shipboard fittings may be selected from an industry standard accepted (approved) by the Register and at least based on the following loads:

.1 for normal towing operations, the intended maximum towing load (e.g. static bollard pull) as indicated on the towing and mooring arrangements plan;

.2 for other towing service, the minimum breaking strength of the tow line according to IACS recommendation No. 10 (refer to Notes in **4.3.4**);

.3 for fittings intended to be used for, both, normal and other towing operations, the greater of the loads according to **5.3.7.1** and **5.3.7.2.**

When the shipboard fitting is not selected from an accepted (approved) industry standard, the strength of the fitting and of its attachment to the ship shall be in accordance with **5.3.4** and **5.3.5**.

Towing bitts (double bollards) are required to resist the loads caused by the towing line attached with eye splice.

For strength assessment, beam theory or finite element analysis using net scantlings (without corrosion additions and wear down allowances specified in **4.3.5**) shall be applied, as appropriate.

Load tests may be accepted as alternative to strength assessment by calculations.

5.3.8 Safe Towing Load (TOW).

5.3.8.1 *TOW* is the load limit for towing purpose.

5.3.8.2 *TOW* used for normal towing operations shall not exceed 80 % of the design load per **5.3.4.1.**

5.3.8.3 *TOW* used for other towing operations shall not exceed 80 % of the design load according to **5.3.4.2.**

5.3.8.4 For fittings used for both normal and other towing operations, the greater of the safe towing loads according to **5.3.8.2** and **5.3.8.3** shall be used.

5.3.8.5 Fittings intended to be used for, both, towing and mooring, shall comply with the requirements of Section **4**.

5.3.8.6 TOW, in t, of each shipboard fitting shall be marked (by weld bead or equivalent) on the deck fittings used for towing. For fittings intended to be used for, both, towing and mooring SWL, in t, shall be marked in addition to TOW.

5.3.8.7 The above requirements on TOW apply for the use with no more than one line.

If not otherwise chosen, for towing bitts (double bollards) TOW is the load limit for a towing line attached with eye-splice.

5.4 SPECIAL ARRANGEMENT FOR TUGS

5.4.1 The number and type of equipment and outfit forming special arrangement for tugs which ensures towing operations under different service conditions are determined by the shipowner considering that such equipment and outfit shall satisfy the requirements of this Chapter.

5.4.2 The main determining factor in providing the tugs with a special arrangement is a bollard pull (BP).

5.4.2.1 The numerical value of the rated towing pull in modes, specified in **5.4.2**, is within the shipowner's and designer's discretion, and all calculations pertaining to the determination of this value are not subject to agreement with the Register. Nevertheless, during mooring and sea trials of the tug, the Register will check this value, and, if the parts of the special arrangement prove to be calculated from a smaller value, the Register may require the strengthening of these parts or may introduce restriction of power during towing operations.

5.4.2.2 Minimum breaking strength (MBL) of the tow line shall be in accordance with Table **5.4.2.2**:

Table 5.4.2.2

BP, in t	< 40	40 – 90	> 90
MBL, in t	3,0 · *BP*	(3,8 – *BP* / 50) · *BP*	2,0 · *BP*

The tow line for towing operations on the hook may be of steel wire, natural fibre or synthetic fibre material. The requirements of **4.2** for mooring lines are also applicable to the tow line for towing operations on the hook.

5.4.3 All stressed parts of the towing arrangement (such as the tow hook, towing rails, etc.) as well as the fastenings for securing these parts to the ship's hull shall be designed to take the breaking load of the tow line. The stresses in these parts shall not exceed 0,95 times the upper yield stress of their material.

5.4.4 The cramp iron of the tow hook shall be calculated as a curvilinear bar. Where such calculations are not carried out, i.e. the formulae for a rectilinear bars are used, permissible stresses shall be reduced by 35 %.

5.4.5 All parts of the towing arrangement which are subjected to tension or bending under the hull of the tow line shall not be manufactured of cast iron.

5.4.6 The cramp iron of the tow hook shall be either solid forged or manufactured of a solid rolled blank. Percentage elongation of the cramp iron material shall not be less than 18 % on a fivefold sample.

5.4.7 Tow hooks shall be of slip-type and have a tow line releasing device operating efficiently in the range of loads on the tow hook from zero to three times the rated towing pull and at any practically possible deflection of the tow line from the centreline of the ship.

The device shall be controlled both at the tow hook and from the navigation bridge. Where the ship is fitted with a spshallw hook, in addition to the main one, this hook need not be of slip-type and have a device for releasing the tow line.

5.4.8 When applying tow hooks with shock absorbers, their ultimate damping load shall not be less than 1,3 times the rated towing pull.

5.4.9 Prior to installation on board the ship the tow hooks shall be tested by application of a proof load equal to twice the rated towing pull.

5.4.10 The wire stopper and its fastenings shall be such that their breaking load is not less than 1,5 times the rated towing pull.

5.4.11 The requirements of **3.7**, Part IV "Stability" shall be taken into consideration when assigning the position of the tow hook and towing winch.

5.5 TOWING WINCHES

5.5.1 The requirements for the design of towing winches are specified in **6.5** and **6.6**, Part IX "Machinery".

5.5.2 Provision shall be made for operating the towing winch from a site at the winch; it is recommended to allow for operating the towing winch from the navigation bridge.

When placing the control station on the navigation bridge at the towing winch and having possibility of supervision for its operation, it is allowed not to provide for operating the towing winch directly from the place of its installation.

5.6 TOW LINE FOR TOWING WINCH

5.6.1 The tow line for towing winch shall be selected by the shipowner depending on the structural particulars and purpose of the ship.

The recommended requirements for tow line for towing winch are given in **5.4.2.2**.

5.7 EMERGENCY TOWING ARRANGEMENTS ON SHIPS

5.7.1 Ships referred to in 5.1.2 shall be fitted with emergency towing arrangements forward and aft of the ship. The arrangements shall be capable of rapid deployment in the absence of main power on the ship to be towed and easy connection to the towing ship. At least one of the emergency towing arrangements shall be pre-rigged ready for rapid deployment.

5.7.2 The components of the emergency towing arrangement are listed in Table 5.7.2.

Table 5.7.2 **Emergency towing arrangements.**

Components of emergency towing arrangement	Non pre-rigged	Pre-rigged
Pick-up gear	Optional	Yes
Towing pennant	Optional	Yes
Chafing gear	Yes	Depending on design
Fairlead	Yes	Yes
Strongpoint	Yes	Yes
Roller pedestal	Yes	Depending on design

5.7.3 Except the pick-up gear and roller pedestal, the components of the emergency towing arrangement specified in Table 5.7.2 shall have a working strength of at least:

1000 kN for ships of 20 000 t deadweight and over, but less than 50 000 t deadweight,

2000 kN for ships of 50 000 t deadweight and over.

Under the above forces, the stresses shall not exceed 0,5 of the ultimate strength.

The strength shall be sufficient for all relevant angles of towline, i.e. up to 90° from the ship's centreline to port and starboard and 30° vertically downwards.

5.7.4 The towing pennant shall have a length of at least twice the lightest seagoing ballast freeboard at the fairlead plus 50 m. The towing pennant shall have a hard eye-formed termination allowing connection to a standard shackle.

The bow and stern strongpoints and fairleads shall be located so as to facilitate towing from either side of the bow or stern and minimize the stress on the towing system.

The inboard end fastening shall be a stopper or bracket or other fitting of equivalent strength. The strongpoint can be designed integral with the fairlead.

5.7.5 Fairleads shall have an opening large enough to pass the largest portion of the chafing gear, towing pennant or towing line.

The fairlead shall give adequate support for the towing pennant during towing operation which means bending 90° to port and to starboard side and 308 vertically downwards. The bending ratio (towing pennant bearing surface diameter to towing pennant diameter) shall be not less than 7:1.

The fairlead shall be located as close as possible to the deck and, in any case, in such a position that the chafing chain is approximately parallel to the deck when it is under strain between the strongpoint and the fairlead.

5.7.6 The chafing gear shall be fitted at the forward and, depending on design, aft ends of the ship. A chafing chain or another design approved by the Register may be used as the chafing gear. The chafing chain shall be a stud link chain.

The chafing chain shall be long enough to ensure that the towing pennant remains outside the fairlead during the towing operation. A chain extending from the strongpoint to a point at least 3 m beyond the fairlead shall meet this criterion.

5.7.7 One end of the chafing chain shall be suitable for connection to the strongpoint. The other end shall be fitted with a standard pear-shaped open link allowing connection to a standard bow shackle.

The chafing chain shall be stowed in such a way that it can be rapidly connected to the strongpoint.

5.7.8 The pre-rigged pick-up gear shall be designed for manual operation by one person taking into account the absence of power and the potential for adverse environmental conditions that may prevail during such emergency towing operations. The pick-up gear shall be protected against the weather and other adverse conditions that may prevail.

5.7.9 The non pre-rigged emergency towing arrangement shall be capable of being deployed in harbour conditions in not more than 1 h. To facilitate connection of the towing pennant to the chafing gear and to prevent chafing of the pennant, a suitably positioned pedestal roller may be used.

Pre-rigged emergency towing arrangements at both ends of the ship may be accepted.

A type emergency towing arrangement is shown in Fig. 5.7.9.

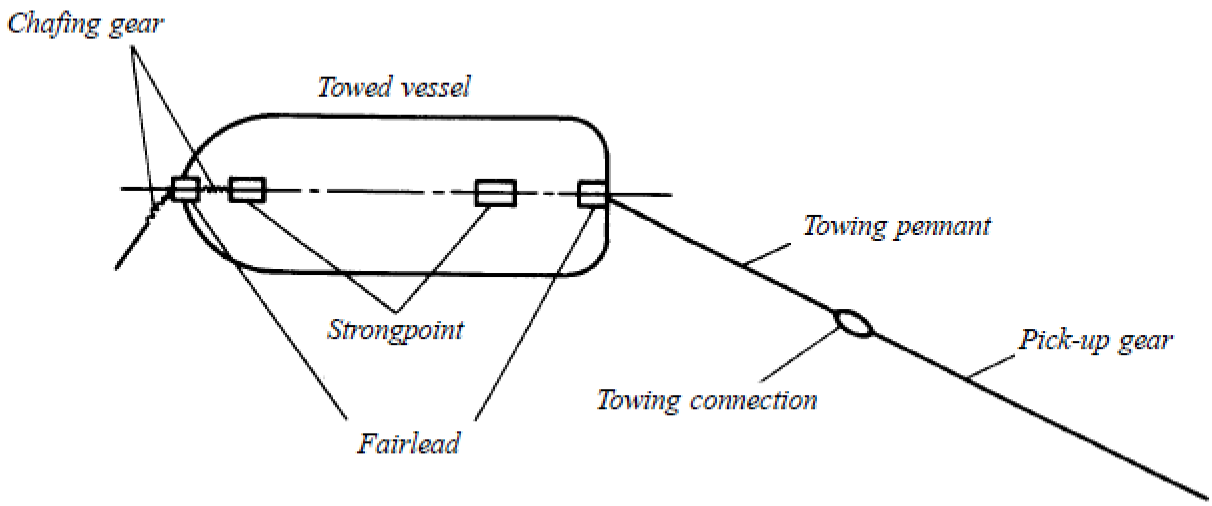


Fig. 5.7.9

5.7.10 All emergency towing arrangements shall be clearly marked to facilitate safe and effective use even in darkness and poor visibility.

5.7.11 Ships shall be provided with a ship-specific emergency towing procedure. Such a procedure shall be carried aboard the ship for use in emergency situations and shall be based on existing arrangements and equipment available on board the ship.

The procedure shall include:

drawings of fore and aft deck showing possible emergency towing arrangements;

inventory of equipment on board that can be used for emergency towing;

means and methods of communication;

sample procedures to facilitate the preparation for and conducting of emergency towing operations.

[1] refer to IMO MSC.1/Circ.1255/.

6. SIGNAL MASTS

6.1 GENERAL

6.1.1 The requirements given in the present Section refer only to the signal masts, i.e. the masts which are intended for carrying the signal means: navigation lights, day signals, aerials, etc. Where the masts or their parts carry derrick booms or other cargo handling gear in addition to the signal means, such masts or their parts shall comply with the requirements of the Rules for the Cargo Handling Gear of Sea-Going Ships.

The requirements of **6.2** ÷ **6.4**, do not apply to berth-connected ships. The signal masts of berthconnected ships shall be designed to carry prescribed signal means.

6.1.2 Arrangement, height and provision of signal means on the signal masts shall comply with the requirements of Part III "Signal Means" of the Rules for the Equipment of Sea-Going Ships.

6.1.3 If in ships of restricted areas of navigation **R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS, R3**, **R3-IN** and **D-R3-S**, **D-R3-RS** the signal masts are collapsible, special machinery shall be installed for their operation or provision shall be made for appropriate connection with other deck machinery. The drive of the machinery may be hand-operated provided the machinery is self-braking and the load on the handle is not more than 160 N at any moment of jackknifing or hoisting the mast.

6.2 STAYED MASTS

6.2.1 The outside diameter *d* and the plate thickness *t*, in mm, at the heel of the masts made of steel having the upper yield stress from 215 up to 255 MPa and stayed by two shrouds on each side of the ship, shall not be less than:

$$d = 22l\,; \tag{6.2.1-1}$$

$$t = 0{,}2l + 3\,, \tag{6.2.1-2}$$

where: l – mast length, in m, from the heel to the shroud eyeplates.

The diameter of the mast may be gradually decreased upwards to a value of 0,75d at the shroud eyeplates, while the thickness of the mast plates is maintained constant throughout the length *l*.

The mast length from the shroud eyeplates to the top shall not exceed 1/3 of *l*.

The mast shall be stayed by the shrouds as follows:

.1 horizontal distance *a*, in m, from the deck (or bulwark) stay eyeplate to the transverse plane through the mast stay eyeplate shall not be less than

$$a = 0{,}15h\,, \tag{6.2.1.1}$$

where: *h* – vertical distance, in m, from the mast stay eyeplate to the deck (or bulwark) stay eyeplate;

.2 horizontal distance *b*, in m, from the deck (or bulwark) stay eyeplate to the longitudinal plane through the mast stay eyeplate shall not be less than

$$b = 0{,}30h\,; \tag{6.2.1.2}$$

.3 the value *a* shall not exceed the value *b*.

6.2.2 Breaking strength *F* of the ropes, in kN, used for the mast shrouds as specified in **6.2.1** shall not be less than

$$F = 0{,}49\left(l^2 + 10l + 25\right). \tag{6.2.2}$$

In other respects, the ropes for shroud shall comply with the requirements of **3.15**, Part XIII "Materials".

The loose gear of shrouds (shackles, turnbuckles, etc.) shall be such that their safe working load is not less than 0,25 times the breaking strength of the ropes referred to above.

6.2.3 Where:

the mast is made of high tensile steel, light alloys, fiber-reinforced plastics or wood (the wood shall be of the 1st grade);

the mast is stayed in a way other than that specified in **6.2.1**;

in addition to a yard arm, lights and day signals, the mast is fitted with other equipment having considerable weight, such as radar reflectors with platforms for their servicing, "crow's nests", etc., proceed as specified in **6.4**.

6.2.4 The wires of shrouds shall have a zinc coating according to recognized standards.

6.3 UNSTAYED MASTS

6.3.1 The outside diameter d and the plate thickness t, in mm, at the heel of masts made of steel having the upper yield stress from 215 to 255 MPa shall not be less than

$$d = 3l^2(0{,}674l+a+13) \times \left(1+\sqrt{1+\frac{51{,}5\cdot 10^4}{l^2(0{,}674l+a+13)^2}}\right)\cdot 10^{-2}; \quad (6.3.1\text{-}1)$$

$$t = \frac{1}{70}d, \quad (6.3.1\text{-}2)$$

where: l – length of the mast from heel to top, in m;
a – elevation of the mast heel above centre of gravity of the ship, in m.

The outside diameter of the mast may be gradually decreased upwards to a value 0,5d at the distance 0,75l from the heel.

In no case the thickness of the mast plate shall be less than 4 mm.

The mast heel shall be rigidly fixed in all directions.

6.3.2 Where:

the mast is made of high tensile steel, light alloys, fiber-reinforced plastics or wood (the wood shall be of the 1st grade);

in addition to a yard arm, lights and day signals, the mast is fitted with other equipment having considerable weight, such as radar reflectors with platforms for their servicing, "crow's nests", etc. proceed as provided in y **6.4**.

6.4 MASTS OF SPECIAL CONSTRUCTION

6.4.1 In the cases specified in **6.2.3** and **6.3.2** as well as where bipod, tripod and other similar masts are installed, detailed strength calculations of these masts shall be carried out. These calculations shall be submitted to the Register for review.

6.4.2 The calculations shall be performed on the assumption that each part of the mast is affected by a horizontal force F_i, in kN

$$F_i = \left[m_i \frac{4\pi^2}{T^2}(\theta z_i + r\sin\theta) + m_i g\sin\theta + pA_i\cos\theta\right]\cdot 10^{-3}, \quad (6.4.2)$$

where: m_i – mass of each part, in kg;
z_i – elevation of the centre of gravity of each part above that of the ship, in m;
A_i– side-projected area of each part, in m ^{2};
T– rolling or pitching period, in s;
θ – amplitude of roll or pitch, in rad.;
r – wave half-height, in m;
g = 9,81– acceleration due to gravity, in m/s ^{2};
p – 1960 Pa - specific wind pressure.

The calculations shall be carried out both for rolling and pitching of the ship, r being taken as equal to

L/40 where *L* is the ship's length, in m, and y, in rad., as corresponding to an angle of 40° at roll and of 5° at pitch.

6.4.3 Under the loads specified in **6.4.2** of this Part, the stresses in the parts of the mast shall not exceed 0,7 times the upper yield stress of their material where they are made of metal, and 12 MPa where they are made of wood. The safety factor of the standing ropes under the same loads shall not be less than 3.

For fiber-reinforced plastic masts under the loads specified in **6.4.2** of this Part the stresses in the parts of the mast shall not exceed the allowable stress value indicated in Table 3 of Appendix **3**, Part XVI "Structure and Strength of Fiber-Reinforced Plastic Ships" for the case of short-time action of the load for the relevant type of deformation.

7. OPENINGS IN HULL, SUPERSTRUCTURES AND DECKHOUSES AND THEIR CLOSING APPLIANCES

7.1 GENERAL

7.1.1 The requirements of this Section apply to ships of unrestricted service **A** as well as to ships of restricted areas of navigation **R1**, **R2**, **A-R1**, **A-R2**, **R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, engaged on international voyages.

The requirements for ships of restricted areas of navigation **R1**, **R2**, **A-R1**, **A-R2**, **R2-RS, R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, not engaged on international voyages, as well as for ships of restricted areas of navigation **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS** may be relaxed; the extent of relaxation shall be confirmed by technical background.

7.1.2 The requirements of this Section apply to ships to which a minimum freeboard is assigned. Deviation from these requirements may be permitted for the ships to which a greater than minimum freeboard is assigned on condition that the Register is satisfied with safety conditions provided.

7.1.3 The arrangement of openings and their closing appliances in the hull, superstructures and deckhouses shall also comply with the requirements of Part VI "Fire Protection" and Part XI "Electrical Equipment".

7.1.4 As far as deck openings are concerned, the following two positions are distinguished in this Section.

7.1.4.1 Position 1: Upon exposed freeboard and raised quarter decks, and upon exposed superstructure decks situated forward of a point located a quarter of the ship's length from the forward perpendicular.

7.1.4.2 Position 2: Upon exposed superstructure decks situated abaft a quarter of the ship's length from the forward perpendicular and located at least at one standard height of superstructure above the freeboard deck.

Upon exposed superstructure decks situated forward of a point located a quarter of the ship's length from the forward perpendicular and located at least two standard heights of superstructure above the freeboard deck.

7.1.5 The height of coamings specified in this Section is measured from the upper surface of the steel deck plating or from the upper surface of the wood or other sheathing, if fitted.

7.1.6 In supply vessels the access to the spaces situated below the open cargo deck shall preferably be provided from the location inside the enclosed superstructure or deckhouse or from the location above the superstructure deck or deckhouse top.

The arrangement of companion or other hatches on the open cargo deck leading to the spaces below this deck may be allowed when adequate degree of protection of these hatches from possible damage during cargo handling operations is provided.

7.1.7 The requirements of the present Section for floating docks apply to openings and their closing appliances arranged above the margin line at docking.

7.1.8 In docklift ships, regardless of the provisions of **7.4** ÷ **7.7**, it is not permitted to arrange openings for doors, companion hatches, skylights, ventilating trunks and other hatches in sides and boundary bulkheads of holds if their lower edges are below the margin line at docking, with the exception of the openings to the watertight spaces of a restricted volume not communicating with other spaces below the level of the margin line at docking.

7.1.9 Doors and hatchways in sides and boundary bulkheads of holds in docklift ships, if their sills are above the margin line at docking by less than 600 mm or 0,05 times the distance between the openings and the centreline whichever is the greater, shall be provided with the light signalling system comprising the indicators installed in the control post of the ship's docking operations. The light indicators shall clearly show the position of the door or hatch cover (secured or open).

7.1.10 The light signals specified in **7.1.9** need not be provided for doors and hatchways to the watertight spaces of a restricted volume not communicating with other spaces below the level which is by 600 mm or 0,05 times the distance between the opening and the centreline, whichever is the greater, above the margin line at docking.

7.1.11 In cargo ships covered by the requirements of Part V "Subdivision", the openings for access, piping, ventilation, electric cables, etc. in watertight internal bulkheads and decks shall be provided with watertight doors or hatch covers normally closed when at sea which, in their turn, shall be provided with indication means, positioned in their close proximity and on the bridge, to indicate whether such doors or hatch covers are open or closed.

On each side of such a door or hatch cover there shall be an inscription to the effect the closure shall not be left open.

7.1.12 In ships mentioned under **7.1.11**, all external openings which do not, by their location, conform to the requirements of **3.4.4**, Part V "Subdivision" shall be fitted with strong enough watertight closures for which, except cargo hatch covers, provision shall be made for bridge indication.

The watertight closures of shell openings located below the bulkhead deck shall be permanently closed at sea shall be fitted with devices preventing their uncontrolled opening. Plates shall be attached to such closures with inscriptions to the effect the openings shall be permanently closed at sea.

7.1.13 In dry cargo ships not covered by the requirements of **7.1.11** and **7.1.12** all the doors of sliding or hinged type in watertight bulkheads shall be fitted up with indication means positioned on the bridge to indicate whether such doors are open or closed. Similar indicators shall be provided for shell doors and other closing appliances which, if left open or not properly secured, can lead to solid flooding of the ship.

7.1.14 The requirements of Section 7 do not apply to berth-connected ships. For these ships, the following provisions apply:

the coaming height of openings of companion hatches, skylights, ventilation trunks and ventilation heads shall not be less than 100 mm;

weathertight hatch covers shall be provided;

the external doors of superstructures shall be watertight, but where the lower edge of an external door is not less than 600 mm away from the waterline corresponding to the maximum draught, such doors may be weathertight;

the lower edge of a side light shall not be less than 150 mm away from the waterline corresponding to the maximum draught;

on the freeboard deck, the superstructure and deckhouse windows shall be watertight.

7.2 SIDE SCUTTLES

7.2.1 Position of side scuttles.

7.2.1.1 The number of side scuttles in the shell plating below the freeboard deck shall be reduced to a minimum compatible with the design and proper working of the ship.

Fishing vessels mooring alongside each other or other ships at sea shall not have side scuttles under freeboard deck in the mooring zone, wherever possible. If in this zone side scuttles are fitted in the shell plating, they shall be so positioned that the possibility of their damage during mooring operations is excluded.

No side scuttles are permitted within the boundaries of the ice belt of the shell plating specified in Part II "Hull" in icebreakers and ice class ships.

7.2.1.2 No side scuttle shall be fitted in a position so that its sill is below a line drawn parallel to the freeboard deck at side and having its lowest point located 0,025 of the ship's breadth B or 500 mm, whichever is the greater, above the summer load waterline or above the summer timber load waterline where timber load lines are assigned to the ship.

In ships of restricted areas of navigation **R2**, **R2-S**, **R2-RS**, **R3-S**, **R3-RS**, **R3-IN** and **R3** (except for passenger ships of length 24 m and over), not engaged on international voyages the specified distance 500 mm may be disregarded.

If the length of the ship is less than 24 m, the specified distance may be reduced to 300 mm for ships of restricted areas of navigation **R2**, **R2-S**, **R2-RS**, **R3-S**, **R3-RS** (except for passenger ships) and to 150 mm for ships of restricted areas of navigation **R3** and **R3-IN**.

7.2.1.3 Side scuttles in the shell plating, below the bulkhead deck of passenger ships and the freeboard deck of cargo ships in front bulkheads of enclosed superstructures and deckhouses of the first tier and also in front bulkheads of enclosed superstructures and deckhouses of the second tier within 0,25*L* from the forward perpendicular shall be of a heavy type and fitted with efficient deadlights hinged inside (refer also to **2.4.5**, Part VI "Fire Protection").

In tugs of restricted areas of navigation **R2, R2-S**, **R2-RS**, **R3-S**, **R3**, **R3-IN** the side scuttles fitted below the bulkhead deck shall be not only of heavy but also of non-opening type.

In ships of restricted areas of navigation **R2**, **R2-S**, **R2-RS**, **R3-S**, **R3-RS** having the length below 24 m and in ships of restricted areas of navigation **R3** and **R3-IN** it is allowed to fit side scuttles of normal type instead of those of heavy type.

In passenger ships of areas of navigation **A**, **A-R1**, **A-R2**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, **D-R3-S**, **D-R3-RS** all side scuttles, the lower edges of which are below the bulkhead deck, shall be of non-opening type.

7.2.1.4 In ships to which the requirements of Part V "Subdivision" apply the side scuttles outside a floodable compartment or a specified group of compartments, fitted in a position so that their sills are by less than 0,3 m or $\left(0{,}1+\frac{L-10}{150}\right)$ m, whichever is less, above the corresponding damage waterline and the side scuttles in the floating cranes the sills of which are by less than 0,3 m above the waterline corresponding to the actual maximum statical heel in case the hook is under load, shall be not only of heavy but also of non-opening type.

In ships of restricted areas of navigation **R2**, **R2-S**, **R2-RS**, **R3-S**, **R3-RS** having the length below 24 m and in ships of restricted areas of navigation **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS** it is allowed to fit side scuttles of normal non-opening type instead of those of heavy non-opening type.

7.2.1.5 Side scuttles in enclosed superstructures and deckhouses of the first tier, except those in their front bulkheads, and also side scuttles in enclosed superstructures and deckhouses of the second tier within 0,25 of the ship's length *L* from the forward perpendicular, except those in their front bulkheads, may be of normal type.

In ships of restricted areas of navigation **R2**, **R2-S**, **R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S** and **C-R3-RS** having the length below 24 m and in ships of restricted areas of navigation **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS** it is allowed to fit side scuttles of light type instead of those of normal type.

Side scuttles shall be fitted with efficient deadlights hinged inside.

7.2.1.6 Side scuttles in enclosed superstructures and deckhouses of the second tier, except those fitted in a position within 0,25 of the ship's length from the forward perpendicular shall be as required in **7.2.1.5**, provided these side scuttles give direct access to an open stairway leading to spaces situated below.

In cabins and similar spaces of enclosed superstructures and deckhouses of the second tier it is allowed that instead of side scuttles specified in **7.2.1.5**, the side scuttles or windows could be fitted without deadlights.

7.2.1.7 On no account shall the side scuttles be fitted in the outer wall sides of the floating docks and in the sides of the docklift ships so that their sills are below the margin line at docking. In the inner wall sides of the floating docks and in the boundary bulkheads of the docklift ships installation of the side scuttles is not permitted.

7.2.1.8 In the outer wall sides of the floating docks and in the sides of the docklift ships the side scuttles, the sills of which are above the margin line at docking by less than 300 mm or 0,025 times the ship's breadth, whichever is the greater, shall be of heavy type, fitted with hinged inside deadlights, and of non-opening type.

7.2.1.9 In the outer wall sides of the floating docks the side scuttles, the sills of which are above the margin line at docking by 300 mm or more, shall be of normal type and fitted with hinged inside deadlights.

7.2.1.10 Ships with distinguishing marks **FF1** and **FF2** in the class notation shall be fitted with side scuttles having deadlights permanently attached to their primary structure, wheelhouse windows shall be fitted with detachable screens, except side scuttles and windows in the wheelhouse, and search and rescue operation control station.

7.2.1.11 On the standby vessel, the front and side scuttles in the wheelhouse shall be equipped with effective protective shields installed on either side of the bulkhead.

The strength of such shields must be equivalent to the strength of the bulkhead.

The shields must provide visibility from the navigation bridge, they can be removable and must be stored in an accessible place for quick and easy installation.

7.2.1.12 All side scuttles below the bulkhead deck on passenger ships and freeboard deck on cargo ships shall be fitted with detachable screens permanently attached to their primary structure, which can be easily and securely sealed and watertight, except, that the side scuttles located 1/8 of the ship's length from the bow perpendicular and above the line parallel to the bulkhead deck and which has its lowest point at a distance of 3.7 m plus 2.5% of the ship's breadth above the draft at the highest subdivision waterline, may be fitted with detachable screens in the passenger spaces, unless the Load Line Rules require that screens shall be permanently attached in fixed positions. Such detachable screens shall be kept close to the side scuttles for which they are intended.

7.2.1.13 The side scuttles below the bulkhead deck on passenger ships and freeboard deck on cargo ships shall not be installed in spaces intended solely for the carriage of cargo.

7.2.1.14 Side scuttles and windows, together with their glass and shields, if installed, shall be of a solid structure approved by the Register. Non-metallic frames are not allowed.

Side scuttles means round or oval openings with clear area of not more than 0.16 m^2. Round or oval openings with clear area of more than 0.16 m^2 are equated to windows.

Windows are usually rectangular openings with rounded corners, commensurate with the dimensions of windows, as well as round or oval openings with clear area of more than 0,16m^2.

7.2.2 Construction and attachment of side scuttles and windows.

7.2.2.1 These Rules distinguish three types of side scuttle construction:

.1 heavy type with the glass thickness of not less than 10 mm for inner diameter of 200 mm and below, not less than 15 mm for inner diameter from 300 mm to 350 mm and not less than 19 mm for inner diameter of 400 mm.

The inner diameter shall not exceed 400 mm. For intermediate inner diameters (from 200 mm to 300 mm and from 350 mm to 400 mm) the glass thickness shall be determined by linear interpolation.

In addition, heavy side scuttles if they are of the opening type shall have a nut (instead of one of the ear-nuts securing their frame) being screwed off with the aid of a special wrench;

.2 normal type with the glass thickness of not less than 8 mm for inner diameter of 250 mm and below, and not less than 12 mm for inner diameter of 350 mm and over, however, the inner diameter shall not exceed 400 mm. For intermediate inner diameters the thickness of the glass shall be determined by linear interpolation;

.3 light type with the glass thickness of not less than 6 mm for inner diameter of 250 mm and below and not less than 10 mm for inner diameter of 400 mm and over, however, the inner diameter shall not exceed 450 mm. For intermediate inner diameters the thickness of the glass shall be determined by linear interpolation.

7.2.2.2 Normal and heavy side scuttles may be of non-opening type, i.e. with the glass fixed in the main frame, or of opening type, i.e. with the glass fixed in the glazing bead efficiently hinged on the main frame.

Exception shall be made for the cases specified in **7.2.1.3**, **7.2.1.4** and **7.2.1.8**, where the side scuttles shall be of non-opening type only.

The glasses of side scuttles shall be reliably and weathertight secured by means of a metal ring provided with screws or by other equivalent device and a gasket.

7.2.2.3 The main frame, glazing bead and deadlight of side scuttles shall have sufficient strength.

The glazing bead and deadlight shall be fitted with gaskets and shall be capable of being effectively closed and secured weathertight by means of ear-nuts or nuts being screwed off with the aid of a special wrench.

7.2.2.4 The main frame, glazing bead, deadlight and ring for securing the glass shall be manufactured from steel, brass or other material approved by the Register.

The ear-nuts and nuts being screwed off by a special wrench shall be made of corrosion-resistant material.

Glass used for the side scuttles shall be hardened.

7.2.2.5 5 In fiber-reinforced plastic ships side scuttles shall be attached to the outside plating and to the bulkheads of superstructures and deckhouses in accordance with the requirements of **1.7.4**, "Structure and Strength of Fiber-Reinforced Plastic Ships".

7.2.2.6 The construction of the windows shall comply with the requirements of **7.2.2.2** ÷ **7.2.2.4**, except for the requirements for the deadlights.

The thickness of the window glass *t*, in mm, shall be not less than determined by the formula

$$t = 0{,}32kb\sqrt{p}\,, \qquad (7.2.2.6\text{-}1)$$

where: b – lesser clear size of the window, in m;

p – pressure head, in kPa, calculated according to 2.12.3, Part II "Hull"; distance z_1 being taken up to the middle of the window height;

k – factor determined by the formula

$$k = 13{,}42 - 5{,}125\left(b/a\right)^2\,; \qquad (7.2.2.6\text{-}2)$$

where: a – greater clear size of the window, in m.

7.3 FLUSH DECK SCUTTLES

7.3.1 Flush deck scuttles in positions 1 and 2 shall be provided with deadlights hinged or attached by other method (for example, by means of a chain) and capable of being easily and efficiently closed and secured.

7.3.2 The largest of clear dimensions of the flush deck scuttles shall not be over 200 mm, with the glass being at least 15 mm thick. The flush deck scuttles shall be attached to the metal deck plating by means of frames.

7.3.3 When secured, the deadlights of the flush deck scuttles shall be weathertight. The tightness shall be ensured by a rubber or other suitable gasket. For the same purpose, along their contour the glasses of the flush deck scuttles shall be provided with a gasket made of rubber or other suitable material.

7.3.4 The strength and materials of the flush deck scuttles parts are governed by applicable requirements specified in **7.2.2.3** and **7.2.2.4**.

As regards attachment of flush deck scuttles in fiberreinforced plastic ships, refer to **7.2.2.5**.

7.4 OPENINGS IN SHELL PLATING AND THEIR CLOSING APPLIANCES

7.4.1 General.

7.4.1.1 This Chapter contains requirements for the arrangement of bow, side and stern doors in the shell plating, strength of structural elements of the doors, securing, locking and supporting devices.

7.4.1.2 The number of doors shall be reduced to a minimum consistent with the structure and normal operational conditions of the ship.

7.4.1.3 When closed and secured, doors in the shell plating shall be weathertight. Weathertightness shall be ensured with a rubber or other suitable packing.

7.4.1.4 The plating thickness of the doors made of steel, irrespective of the fulfilment of the requirements given in **7.4.1.10**, shall be not less than the thicknesses referred to in **2.2.4.8** and **2.12.4.1** of Part II "Hull" for the appropriate position of the door; the minimum plating thickness of the doors made of other materials may be allowed provided it is confirmed by calculations and tests that they have a strength at least equivalent to that of the doors made of steel.

7.4.1.5 Doors with a clear area of 12 m_2 and more shall be secured by means of a power system or by a hand gear used for securing the door from a readily accessible position. Stern, bow and side doors of large dimensions, when manual devices would not be readily accessible, shall be normally secured by means of power systems. Alternative means of securing shall also be provided for emergency use in case of failure of the power systems.

7.4.1.6 When power-operated securing devices or devices with a hand gear are used, it is necessary to ensure that the doors shall remain tight in the secured position and shall remain secured in case of failure of any part of the power system or hand gear of the securing device.

Hydraulically operated securing devices shall be manually or mechanically lockable in the secured position.

7.4.1.7 When power-operated securing devices or devices with a hand gear are used, provision shall be made for the indicators which clearly show whether the door is totally secured or not.

These indicators shall be fitted in a position from which the securing operation is performed, and in case of the power-operated securing device, also on the navigation bridge.

7.4.1.8 If, due to the ship's purpose, it is specially provided to open and close the doors not only in ports but also at sea, arrangements approved by the Register shall be made (with regard to the operational conditions) to ensure closure and complete securing of the open door, even in case of failure of the door gear and securing device gear, or other arrangements approved by the Register shall be made to prevent penetration of water into the ship spaces when the door is open.

Provision shall be made for devices ensuring proper locking of the door in the open position.

The drives of such doors shall comply with the requirements of Part IX "Machinery" and Part XI "Electrical Equipment".

7.4.1.9 There shall be a readily seen notice plate near each door, indicating that the door shall be closed and secured before the ship leaves the port; for doors referred to in **7.4.1.8** provision shall be also made for a notice plate indicating that at sea only the master is allowed to open the door.

7.4.1.10 When doors are under the action of the design loads determined in accordance with **7.4.2** and **7.4.3**, except **7.4.2.5**, stresses, in MPa, in the primary members of the doors as well as of securing, locking and supporting devices shall not exceed the following values:

normal stress

$$\sigma = 120/k\ , \qquad (7.4.1.10\text{-}1)$$

shear stress

$$\tau = 80/k\ , \qquad (7.4.1.10\text{-}2)$$

equivalent stress

$$\sigma_{зв} = \sqrt{\sigma^2 + 3\tau^2} = 150/k\ , \qquad (7.4.1.10\text{-}3)$$

where: $k = 1{,}0$ – for steel with upper yield stress of the material $R_{eH} = 235$ MPa;

$k = 0{,}78$ – for steel with $R_{eH} = 315$ MPa;

$k = 0{,}72$ – for steel with $R_{eH} = 335$ MPa.

7.4.2 Bow doors.

7.4.2.1 Bow doors shall be situated above the freeboard deck.

7.4.2.2 Where the bow door leads to a complete or long forward enclosed superstructure a weathertight inner door shall be installed as part of the collision bulkhead above the freeboard deck of the ship.

Bow and inner doors shall be so arranged as to preclude the possibility of the bow door causing structural damage to the inner door or to the collision bulkhead in case of damage to or detachment of the bow door.

7.4.2.3 The design external pressure P_e, кПа, in kPa, for the scantlings of primary members, securing, locking and supporting devices of the bow doors is determined by the following formula:

$$P_e = C_H(0{,}6+0{,}41\text{tg}\alpha)(0{,}4v\sin\beta+0{,}6\sqrt{L})^2, \qquad (7.4.2.3)$$

where: C_H – is a coefficient equal to:

$0{,}0125L$ – for ships less than 80 m in length;

1,0 – for ships 80 m and more in length;

v – contractual ship's forward speed, in knots;

α and β – angles to be obtained from Fig. 7.4.2.3.

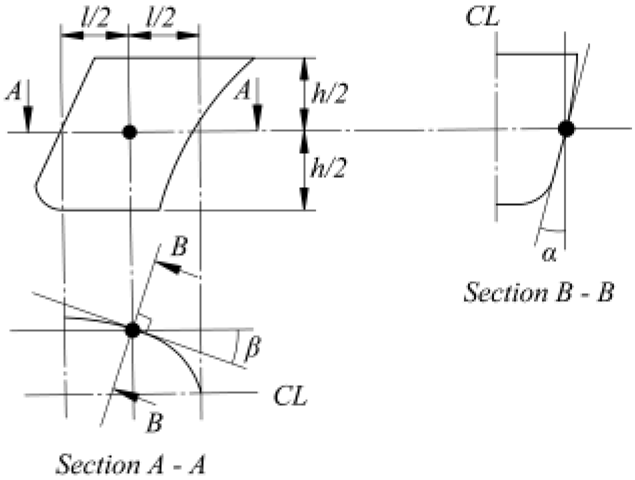


Fig. 7.4.2.3

The design external pressure may be reduced by 20 % for ships of restricted areas of navigation **R2-S**, **R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S** and by 40 % for ships of restricted areas of navigation **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS**.

In any case, the design external pressure P_e shall not be taken less than the values determined according to **1.3.2.2** or **2.8.3.3**, Part II "Hull", whichever is the greater.

7.4.2.4 The design internal pressure P_i, in kPa, for scantlings of primary members, securing, locking and supporting devices of inner doors shall be determined by the formula

$$P_i = 10z, \tag{7.4.2.4}$$

where: z – vertical distance from the centre of gravity of the door area to the deck above, in m.

In all cases, the value of the design internal pressure P_i shall not be less than 25 kPa.

7.4.2.5 The scantlings of primary members of visor doors shall be chosen in accordance with the requirements of **2.8.5.1**, Part II "Hull".

7.4.2.6 Securing and locking devices of bow doors shall be designed to withstand the forces F_e or F_i, in kN, to be determined by the following formulae:

for the doors opening inwards

$$F_e = AP_e + p_p l_p, \tag{7.4.2.6-1}$$

for the doors opening outwards

$$F_i = AP_i + 10Q + p_p l_p, \tag{7.4.2.6-2}$$

where: A – clear area of the door, in m^2;

for P_e – refer to **7.4.2.3**;

for P_i – refer to **7.4.2.4**;

p_p – pressure of the packing when it is compressed for the maximum depth possible, in kN/m, is assumed in calculations equal to at least 5 kN/m;

l_p – length of the packing, in m;

Q – mass of the door, in t.

7.4.2.7 Securing and locking devices, as well as supports of the visor doors shall be designed to withstand forces F_{xf}, F_{xa}, F_y and F_z, in kN.

The forces acting in the longitudinal direction shall be determined by the following formulae**:**

bow

$$F_{xf}=\frac{10Qc + P_{xe}a-P_z b}{d}; \qquad (7.4.2.7\text{-}1)$$

stern

$$F_{xa}=\frac{10Qc-P_{xi}a}{d}. \qquad (7.4.2.7\text{-}2)$$

The force acting in the transverse direction shall be determined by the formula

$$F_y = P_e A_y. \qquad (7.4.2.7\text{-}3)$$

The force acting in the vertical direction shall be determined by the formula

$$F_z = P_z - 10Q \qquad (7.4.2.7\text{-}4)$$

or

$$F_z = 10(V-Q), \qquad (7.4.2.7\text{-}5)$$

whichever is the greater,

were for Q – refer to **7.4.2.6**;

for P_e – refer to **7.4.2.3**;

$P_{xe} = P_e A_x$ in kN; (7.4.2.7-6)

A_x – area of the transverse vertical projection of the door (refer to Fig. 7.4.2.7), in m^2;

$P_z = P_e A_z$ in kN; (7.4.2.7-7)

A_z – area of horizontal projection of the door (refer to Fig. 7.4.2.7), in m^2;

$P_{xi} = P_i A_x$ in kN; (7.4.2.7-8)

for P_i – refer to **7.4.2.4**;

A_y – area of the longitudinal vertical projection of the door (refer to Fig. 7.4.2.7), in m^2;

a – vertical distance, in m, from visor pivot to the centroid of the transverse vertical projected area of the visor door (refer to Fig. 7.4.2.7);

b – vertical distance, in m, from visor pivot to the centroid of the horizontal projected area of the visor door (refer to Fig. 7.4.2.7);

c – horizontal distance, in m, from visor pivot to the centre of gravity of the visor mass (refer to Fig. 7.4.2.7);

d – vertical distance, in m, from visor pivot to the bottom of the door (refer to Fig. 7.4.2.7);

V – inner volume of the door, in m^3.

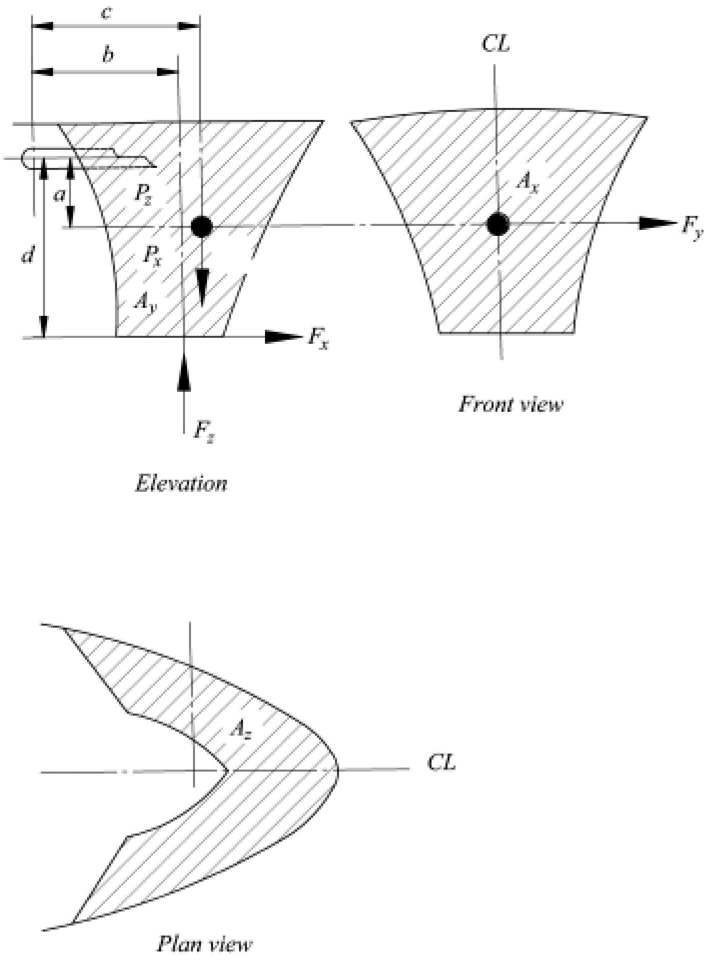


Fig. 7.4.2.7

7.4.2.8 For side-opening doors, thrust bearing shall be provided in way of girder ends at the closing of two leaves to prevent one leaf shifting towards the other one under effect of unsymmetrical pressure (refer to Fig. 7.4.2.8). Each part of the thrust bearing shall be kept secured on the other part by means of securing devices.

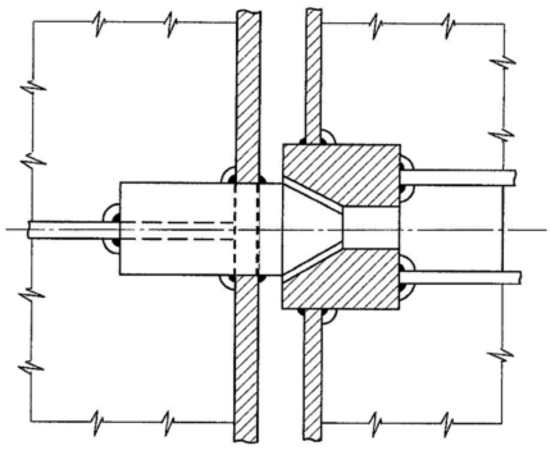


Fig. 7.4.2.8

7.4.2.9 9 Lifting arms of the visor doors and thrust bearing shall be designed to withstand static and dynamic loads arising when the door is opened and closed with due regard to the minimum wind pressure 1,5 kN/m^2.

7.4.3 Side and stern doors.

7.4.3.1 The lower edge of the door openings shall not be lower than the line which is parallel to the freeboard deck and has its lowest point at the uppermost cargo waterline.

The lower edge of side doors of the ships which are not passenger ships, may be lower than that specified above provided it is proved by the designer that safety of the ship will not be thus impaired.

In such cases, provision shall be made for:

the second (inner) doors, strength and tightness of which is equivalent to those of the outer doors;

a device enabling to determine water presence in the space between the doors;

water drainage from this space to bilges or drain wells, controlled by a readily accessible valve or other arrangements approved by the Register.

7.4.3.2 The doors shall open outwards so that forces acting under the effect of the sea press the door against the supporting contour of the sill.

Installation of the doors opening inside may be allowed provided it is proved by the designer that safety of the ship will not be thus impaired.

7.4.3.3 The number of securing devices on each edge of the door shall be not less than two; a securing device shall be provided in the vicinity of each door corner. The distance between securing devices shall not exceed 2,5 m.

7.4.3.4 The design external pressure *P*, in kPa, for structural members of doors shall be determined in accordance with the requirements of **1.3.2**, Part II "Hull". In any case, the value of P shall not be taken less than 25 kPa.

7.4.3.5 Securing and locking devices shall be designed to withstand the forces F_1 or F_2, in kN, determined by the formulae:

for doors opening inwards

$$F_1 = AP + p_p l_p; \quad (7.4.3.5\text{-}1)$$

for doors opening outwards

$$F_2 = F_c + 10Q + p_p l_p, \quad (7.4.3.5\text{-}2)$$

where for A, p_p and l_p – refer to **7.4.2.6**;

for P – refer to **7.4.3.4**;

F_c – an accidental force due to loose cargo, to be uniformly distributed over the area A and to be taken not less than 300 kN or 5A, in kN, whichever is the greater.

For small doors, such as bunker doors or pilot doors, the value of F_c may be reduced based on appropriate technical background. In case the second (inner) door is installed, which is capable to protect the external door from accidental forces due to loose cargoes, F_c =0;

for Q – refer to **7.4.2.6**.

Supporting structures of doors shall be designed to withstand forces F_3 and F_4, кН, in kN, determined by the formulae:

for doors opening inwards

$$F_3 = AP; \quad (7.4.3.5\text{-}3)$$

for doors opening outwards

$$F_4 = F_c + 10Q. \quad (7.4.3.5\text{-}4)$$

7.5 SUPERSTRUCTURES AND DECKHOUSES

7.5.1 Construction, openings and closing appliances.

7.5.1.1 Openings in the freeboard deck other than those defined in **7.3**, **7.6 ÷ 7.11** and **7.13**, shall be protected by the enclosed superstructure or enclosed deckhouse. The similar openings in the deck of enclosed superstructure or enclosed deckhouse shall be protected by enclosed deckhouse of the second tier.

7.5.1.2 Superstructures and deckhouses are considered enclosed if:

their construction complies with the requirements of **2.12**, Part II "Hull";

all access openings comply with the requirements of **7.5.2** and **7.7**;

all other openings in their outside contour comply with requirements of **7.2 ÷ 7.4** and **7.7 ÷ 7.10.**

7.5.2 Doors in enclosed superstructures and enclosed deckhouses..

7.5.2.1 All access openings in the end bulkheads of enclosed superstructures and outside bulkheads of enclosed deckhouses shall be fitted with doors (refer to **2.4.4**, Part VI "Fire Protection").

7.5.2.2 The height of the sills to access openings specified in **7.5.2.1** shall be at least 380 mm. However, the bridge or poop shall not be regarded as enclosed unless access is provided for the crew to machinery and other working spaces inside these superstructures from any place in the uppermost continuous open deck or above it by alternative means which are available at all times when bulkhead openings are closed; the height of the sills of the openings in the bulkheads of such bridge or poop shall be at least 600 mm in position 1 and at least 380 mm in position **2**.

In ships of restricted areas of navigation **R3 i R3-IN** having the length of 24 m and over (except for passenger ships) the specified height of the sills to access openings may be reduced from 600 mm down to 450 mm and from 380 mm down to 230 mm, respectively.

In ships of restricted areas of navigation **R2**, **R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS** having the length below 24 m the height of the above sills may be reduced to 230 mm for all open decks.

7.5.2.3 The doors shall be so designed as to withstand the pressure head *p* calculated according to **2.12.3**, Part II "Hull", the distance z_1 being taken up to the middle of the door height. Under the pressure head *p* the stresses in the door elements shall not exceed 0,8 times the upper yield stress of the material.

Whatever the stresses, the thickness of the steel door plate shall be not less than that specified in **2.12.4.4**, Part II "Hull". For steel doors manufactured by stamping the minimum thickness of the door plate may be reduced by 1 mm.

The minimum thickness of the door plate made of other materials may be allowed provided it is confirmed by calculations and tests that they have a strength at least equivalent to that of the doors made of steel.

7.5.2.4 The doors shall be permanently and strongly attached to the bulkhead and fitted with clamping devices or other equivalent means for expeditiously opening, closing and securing them weathertight; such devices shall be so arranged that they can be operated from both sides of the bulkhead.

The doors shall open outwards, opening of doors inside the superstructure or deckhouse space may be allowed when security against the impact of the sea is provided.

7.5.2.5 The doors shall be weathertight when secured. The tightness shall be ensured by a rubber or other suitable gasket.

7.5.2.6 The doors shall be made of steel or other material approved by the Register.

7.5.2.7 In fiber-reinforced plastic ships the doors shall be attached to the bulkheads of superstructures and deckhouses in the same manner as the side scuttles, in accordance with the requirements of **7.2.2.5**.

7.5.2.8 In floating docks the height of the sills to access openings in superstructures and deckhouses of the top deck shall be at least 200 mm if access is provided from these superstructures and deckhouses into the spaces situated below.

7.5.3 Watertightness of passanger ships of restricted areas of navigation A-R2, A-R2-S, A-R2-RS, B-R3-S, B-R3-RS, C-R3-S, C-R3-RS, D-R3-S, D-R3-RS above the immersion limit line.

7.5.3.1 All reasonable and practicable means are to be taken to restrict the penetration and spread of water above the bulkhead deck. Such means may be hulf bulkheads or web frames.

If watertight hulf bulkheads or web frames are installed on the bulkhead deck above watertight subdivision bulkheads or in the immediate vicinity of such bulkheads, they are to have a watertight connection with the outer skin and the bulkhead deck in order to limit the spread of water on the deck when the ship has a roll in a damaged condition. If the watertight hulf bulkhead does not coincide with the bulkhead below, then the bulkhead deck in the area between them is to be watertight.

7.5.3.2 Storm ports and scuppers shall be fitted where necessary to provide rapid removal of water from the weather deck in all weather conditions.

7.6 ENGINE AND BOILER CASINGS

7.6.1 Engine and boiler space openings in positions 1 and 2 shall be efficiently enclosed by casings of ample strength raised above decks to the extent, which is reasonable and practicable, and being in their turn decked or terminated in skylights. The construction of the casings shall meet the requirements of **2.13**, Part II "Hull", and in case of fiber-reinforced plastic ships, the requirements of Part XVI "Structure and Strength of Fiber-Reinforced Plastic Ships".

7.6.2 Casings shall be made weathertight.

7.6.3 Casings shall be made of steel or other materials approved by the Register (refer also to **2.1.1.2**, Part VI "Fire Protection").

7.6.4 The access openings in the casings shall be fitted with permanently attached doors complying with the requirements of **7.5.2.3** ÷ **7.5.2.6**. The height of the sills to the access openings shall be at least 600 mm in position 1 and at least 380 mm in position 2.

If the length of the ship is less than 24 m, the specified height of the sills may be reduced down to 300 mm for ships of restricted areas of navigation **R2**, **R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS**.

In ships of restricted areas of navigation **R3** and **R3-IN** having the length of 24 m and over (except passenger ships) the specified height of the sills may be reduced from 600 mm down to 450 mm and from 380 mm down to 230 mm, respectively.

7.6.5 In type "A" ships and also in type "B" ships which are permitted to have the tabular freeboard less than that prescribed by Table 4.1.3.2, 6.4.2.3 or 6.4.3.3 of the Load Line Rules for SeaGoing Ships, the engine and boiler casings shall be protected by enclosed poop or bridge of at least standard height, or by a deckhouse of equal height and equivalent strength.

However, engine and boiler casings may be exposed if there are no openings giving direct access from the freeboard deck to the machinery space. A door complying with requirements of **7.5.2.3** ÷ **7.5.2.6**, may, however, be permitted in the machinery casing provided that it leads to a space or passageway which is as strongly constructed as the casing and is separated from the stairway to the engine and boiler room by a second similar door. The opening for the outside door shall be provided with a sill at least 600 mm in height, and that for the inside door with a sill of at least 230 mm in height.

7.6.6 In supply vessels the doors in the casings giving access to the engine or boiler rooms shall be located, where possible, inside the enclosed superstructure or deckhouse.

The door in the casing for access to the engine or boiler room may be fitted directly on the open cargo deck provided that, in addition to the first outside door, the second inside door is fitted; in this case, the outside and inside doors shall satisfy the requirements of **7.5.2.3** ÷ **7.5.2.6**, the height of the outside door sill shall be at least 600 mm, and of the inside door sill, at least 230 mm.

7.6.7 In floating docks the height of sills to the top deck access openings in the engine and boiler casings shall be at least 200 mm.

7.7 COMPANION HATCHES, SKYLIGHTS AND VENTILATING TRUNKS

7.7.1 Design and securing.

7.7.1.1 Deck openings in positions 1 and 2 intended for stairways to the ship's spaces located below, as well as light and air openings to these spaces shall be protected by strong companion hatches, skylights or ventilating trunks.

Where the openings intended for stairways to the ship's spaces located below are protected by superstructures or deckhouses instead of companion hatches, these superstructures and deckhouses shall comply with the requirements of **7.5**.

Hatch covers intended for emergency escape to the lifeboat and liferaft embarkation deck (refer to **8.5.1**), shall be constructed in such a manner that the securing devices shall be of a type which can be opened from both sides of the hatch cover, and the maximum force needed to open the hatch cover shall not exceed 150 N. The use of a spring equalizing, counterbalance or other suitable device on the hinge side to reduce the force needed for opening is acceptable.

For oil tankers of 150 m in length and above as well as bulk carriers of 90 m in length and above, contracted for construction on or after 1 July 2015, the requirements for cargo hatch covers are regulated by Common Structural Rules for Bulk Carriers and Oil Tankers.

7.7.1.2 Height of coamings of companion hatches, skylights and ventilating trunks shall be at least 600 mm in position 1 and at least 450 mm in position 2.

In ships of restricted areas of navigation **R3** and **R3-IN** having the length of 24 m and over (except passenger ships) the specified height of coamings may be reduced from 600 mm down to 450 mm and from 450 mm down to 380 mm, respectively.

If the length of the ship is less than 24 m, the height of the coamings may be reduced down to 380 mm for ships of restricted areas of navigation **R2**, **R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S** and down to 300 mm for ships of restricted areas of navigation **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS**.

Height of a coaming may be reduced if such a height would interfere with the normal operation of the ship, provided the seaworthiness and deck wetness assessment is submitted by the designer. Such assessment verifies the ship safety with sea condition in respect to the assigned area of navigation.

Construction of coamings shall comply with the requirements of **2.6.5.2**, Part II "Hull" and in case of fiber-reinforced plastic ships, with the requirements of Part XVI "Structure and Strength of FiberReinforced Plastic Ships".

7.7.1.3 All the companion hatches, skylights and ventilating trunks shall be provided with covers made of steel or other material approved by the Register and being permanently attached to the coamings.

Where the covers are made of steel, the thickness of their plate shall be equal to at least 0,01 times the spacing of stiffeners, but not less than 6 mm.

For ships of less than 500 gross tonnage, the minimum required thickness of 6 mm may be reduced if the cover is made by stamping in accordance with Fig. 7.7.1.3 and Table 7.7.1.3.

In small ships having the deck thickness less than 6 mm the required minimum thickness 6 mm may be reduced down to the deck thickness regardless of whether the cover is made by stamping, but in no case the plate thickness shall be less than 4 mm.

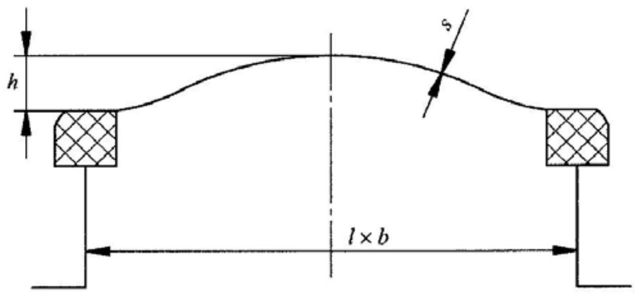


Fig. 7.7.1.3

Table 7.7.1.3 **Necessary minimum height and thickness of the cover**

Clear sizes of hatches *l*x*b*, in mm	Material of cover	Height of stamping *h*, in mm	Minimum thickness *s*, in mm
450x600	Steel	25	4
	Light alloy		
600x600	Steel	28	4
	Light alloy		
700x700	Steel	40	4
	Light alloy		6
800x800	Steel	55	4
	Light alloy		6
800x1200	Steel	55	5
	Light alloy		6
1000x1400	Steel	90	5

7.7.1.4 Covers of companion hatches, skylights and ventilating trunks shall have securing devices workable at least from outside of the hatch. However, where the hatches are used as emergency exits in addition to their primary application, the securing device shall be capable of being operated from each side of the cover.

When secured, the covers shall be weathertight. The tightness shall be provided by a rubber or other suitable gasket.

7.7.1.5 The glass for windows in the covers of skylights shall be hardened and at least 6 mm thick if the inner diameter is 150 mm and below, and at least 12 mm with the inner diameter of 450 mm. For intermediate inner diameters, the thickness of glass shall be determined by linear interpolation.

However, where wire-reinforced glass is used, its thickness may be 5 mm, and the requirement relating to its hardening will not be applicable.

Glass shall be efficiently attached to the covers by means of a frame and have on its contour a weathertight gasket of rubber or other equivalent material.

Skylights installed in the machinery spaces of category A, shall comply with the requirements of **2.1.4.2**, Part VI "Fire Protection".

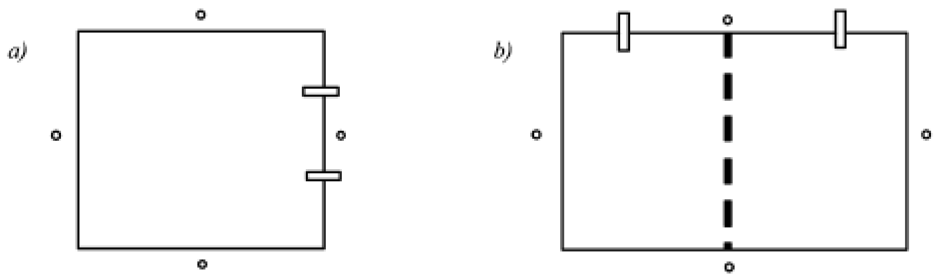
7.7.1.6 Each window or group of adjacent windows shall be provided with portable shields of the same material as the cover being at least 3 mm in thickness and capable of being efficiently fastened outside the cover by means of ear-nuts; such portable shields shall be stowed adjacent to the skylights.

7.7.1.7 In floating docks the height of coamings of companion hatches, skylights and ventilating trunks situated on the top deck shall be at least 200 mm. The portable shields mentioned in **7.7.1.6** need not be provided for covers of skylights situated on the top deck of the floating docks.

7.7.2 Design and securing of small hatches on the exposed for deck.

7.7.2.1 The requirements of **7.7.2** apply to hatches generally having an area of not more than 2,5 m^2 located on the exposed deck at a distance of 0,25*L* from the fore perpendicular of ships of 80 m in length and more, where the height of the exposed deck in way of the hatch is less than 0,1*L* or 22 m above the summer load waterline, whichever is less. The ship length L is determined according to **1.1.3**, Part II "Hull".

7.7.2.2 For rectangular or square steel hatch covers, the plate thickness, stiffener arrangement and scantlings shall be in accordance with Table 7.7.2.2 and Fig. 7.7.2.2. Stiffeners, where fitted, shall be aligned with contact points of the hatch cover edge with the welded pad (metal-to-metal contact points) required in accordance with 7.7.2.6 (refer to Fig. 7.7.2.2). Primary stiffeners shall be continuous. All stiffeners shall be welded to the inner edge stiffener (refer to Fig. 7.7.2.8).



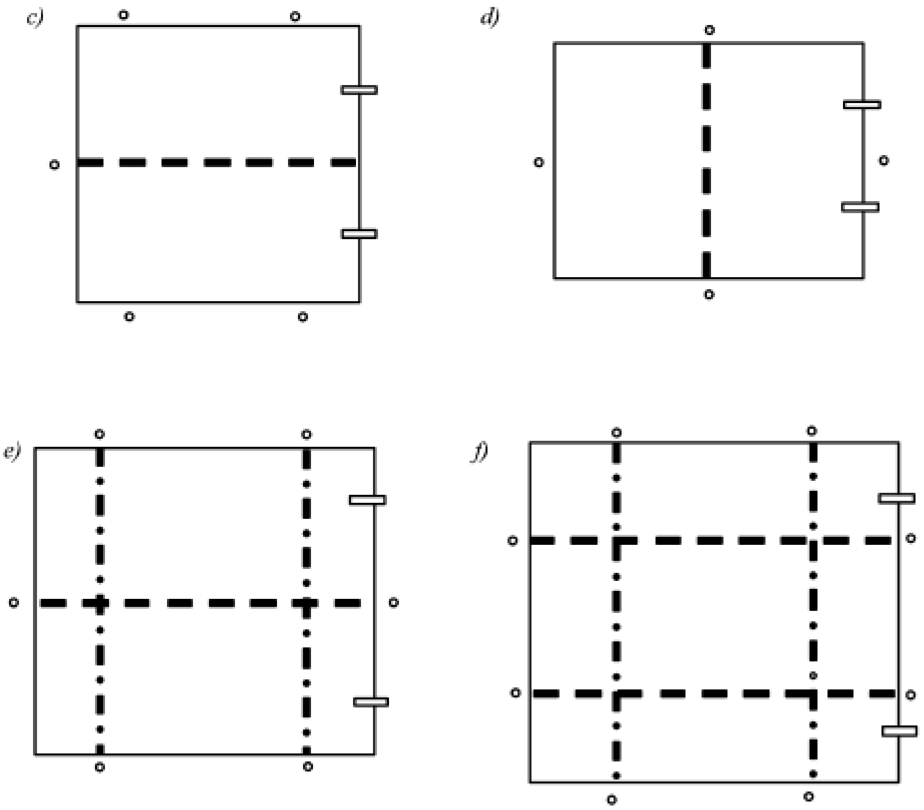


Fig. 7.7.2.2 Nominal sizes of hatch covers:
a = 6306630 mm; *b* = 6306830 mm; c = 8306830 mm; *d* = 8306630 mm; *e* = 103061030 mm; *f* = 133061330 mm

Symbols:
▭ - hinge
• - securing device/metal-to-metal contact;
— — — - primary stiffener;
▪ — ▪ — ▪ - secondary stiffener

Table 7.7.2.2

Nominal size, mm x mm	Cover plate thickness, in mm	Primary stiffeners	Secondary stiffeners
		Flat bar, mm6mm; number	
630×630	8	–	–
630×830	8	100× 8; 1	–
830×630	8	100× 8; 1	–
830×830	8	100× 10; 1	–
1030×1030	8	120× 12; 1	80× 8; 2
1330× 1330	8	150× 12; 2	100× 10; 2

7.7.2.3 The hatchway coaming shall be suitably reinforced by a horizontal flat bar, normally not more than 170 ÷ 190 mm from the upper edge of the coaming.

7.7.2.4 For hatch covers constructed of materials other than steel, the required scantlings shall provide equivalent strength.

7.7.2.5 Weathertightness of hatch covers shall be ensured by securing devices of the following types: butterfly nuts tightening onto forks (clamps); quick acting cleats; central locking device. Dogs (twist tightening handles) with wedges are not acceptable.

Where the hatch covers are also used as emergency exits, they shall be also fitted with the central quick acting locking device designed for handling on both sides.

7.7.2.6 The hatch cover shall be fitted with a gasket of elastic material. This shall be designed to allow a contact of the hatch cover edge to the welded pad (metal-to-metal contact) at a designed compression and to prevent over compression of the gasket by green sea forces that may cause the securing devices to be loosened or dislodged. The contacts of the hatch cover edge to the welded pad (metal-to-metal contact) shall be arranged close to each securing device in accordance with Fig. 7.7.2.2, and shall be of sufficient capacity to withstand the bearing force.

7.7.2.7 The primary securing device shall be designed and manufactured so that the designed compression pressure is achieved by one person without the need of any tools.

7.7.2.8 Where butterfly nuts are used in the primary securing device, the forks (clamps) shall be of the robust design, which minimizes the risk of the butterfly nuts being dislodged while in use. It is ensured by curving the forks upward, a raised surface on the free end, or a similar method (refer to Fig. 7.7.2.8).

The plate thickness of unstiffened steel forks (clamps) shall not be less than 16 mm.

7.7.2.9 For hatch covers located on the exposed deck forward of the fore-most cargo hatch, the hinges shall be fitted such that the predominant direction of green sea will cause the cover to close, which means that the hinges are normally to be located on the fore edge.

7.7.2.10 On hatches located between the cargo hatches, the hinges shall be placed on the fore edge or outboard edge, whichever is practicable for protection from green water in beam sea and bow quartering conditions.

7.7.2.11 Hatches, excepting those which may also be used as emergency exits, shall be fitted with an independent secondary securing device like, e.g. a sliding bolt, a hasp or a backing bar of slack fit, which is capable of keeping the hatch cover in place, even in the event that the primary securing device became loosened or dislodged. It shall be fitted on the side opposite to the hatch cover hinges.

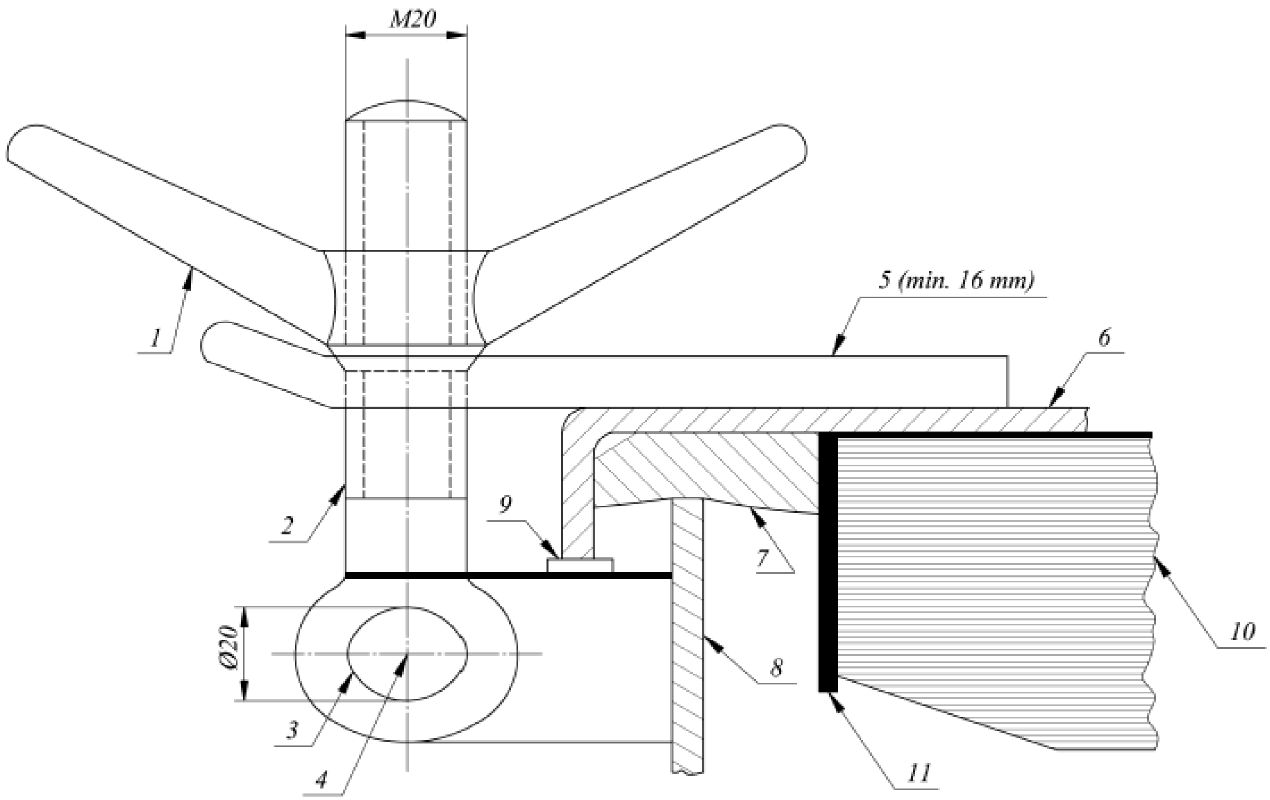


Fig. 7.7.2.8.
1 – butterfly nut; 2 – bolt; 3 – pin; 4 – centre of pin; 5 – fork (damp) plate; 6 – hatch cover; 7 – gasket; 8 – hatch coaming; 9 – bearing pad welded on the bracket for metal-to-metal contact; 10 – stiffener; 11– inner edge stiffener.

7.8 VENTILATORS

7.8.1 Ventilators to spaces below freeboard deck or deck of enclosed superstructures and deckhouses shall be fitted with coamings efficiently connected to the deck.

The coamings of ventilators shall be at least 900 mm in height in position 1 and at least 760 mm in position 2.

In ships of restricted areas of navigation **R3** and **R3-IN** having the length of 24 m and over (except passenger ships) the specified height of the coamings may be reduced from 900 mm down to 760 mm and from 760 mm down to 600 mm, respectively.

In ships of restricted areas of navigation **R2**, **R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS** having the length below 24 m the height of the coamings may be reduced down to 300 mm for all open decks.

Construction of coamings shall comply with the requirements of **2.6.5.2**, Part II "Hull".

The strength of ventilators, connections of ventilators to coamings and connections of ventilator parts, if any, shall be equivalent to that of the coaming.

7.8.2 Ventilators in position 1 the coamings of which extend to more than 4500 mm above the deck and in position 2 the coamings of which extend to more than 2300 mm above the deck need not be fitted with closing appliances.

In all other cases, each ventilator shall be fitted with a strong cover made of steel or other material approved by the Register.

In ships of less than 100 m in length, the covers shall be permanently attached; in ships of 100 m in length and over they may be conveniently stowed near the ventilators to which they shall be fitted.

7.8.3 When secured, the covers of ventilators shall be weathertight. The tightness shall be provided by a rubber or other suitable gasket.

7.8.4 In supply vessels, in order to minimize the possibility of flooding of the spaces situated below, the ventilators shall be positioned in the protected locations where the probability of their damage by cargo is excluded during cargo handling operations. Particular attention shall be given to the arrangement of ventilators of the engine and boiler rooms for which the location is preferable above the deck level of the first tier of superstructures or deckhouses.

7.8.5 In floating docks the height of coamings of ventilators situated on the top deck shall be at least 200 mm.

7.9 MANHOLES

7.9.1 The height of coamings of manholes for deep and other tanks, except for those indicated in **2.4.5.3**, Part II "Hull", air spaces, cofferdams, etc. is not regulated by the Register.

7.9.2 Covers of manholes shall be made of steel or other material approved by the Register.

The thickness of the covers shall not be less than that of the plating on which they are fitted. The thickness of the covers, where the thickness of plating is greater than 12 mm, may be reduced based on appropriate technical background confirming that covers have a sufficient strength.

7.9.3 The covers of manholes shall be efficiently attached to the coaming or doubling ring by means of bolts or pins with nuts.

7.9.4 When secured, the covers shall be tight both for water and liquid cargoes or stores for which the tanks are intended under the inner pressure corresponding to the test pressure of the tank under consideration.

The tightness shall be provided by a rubber or other suitable gasket.

The gasket shall be resistant to the liquids referred to above.

7.10 HATCHWAYS OF DRY CARGO HOLDS

7.10.1 General.

The deck openings through which cargoes or ship's stores are loaded and unloaded shall be protected by strong hatchways. If these hatchways are situated in positions 1 and 2, the hatchway covers shall be weathertight. The tightness shall be provided by one of the following two methods:

.1 by portable covers and tarpaulins as well as battening devices;

.2 by weathertight covers made of steel or other equivalent material fitted with rubber or other suitable gaskets and clamping devices.

7.10.2 Coamings.

7.10.2.1 The height of hatchway coamings in positions 1 and 2 shall be at least 600 mm and 450 mm, respectively.

If the length of the ship is less than 24 m, the height of the coamings may be reduced down to 380 mm for ships of restricted area of navigation **R2**, **R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S** and down to 300 mm for ships of restricted areas of navigation **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS**.

In fishing vessels the height of cargo hatchway coamings in position 2 may be reduced down to 300 mm.

In ships of restricted areas of navigation **R3** і **R3-IN** having the length of 24 m and over (except passenger ships) the specified height of cargo hatchway coamings may be reduced from 600 mm down to 450 mm and from 450 mm down to 380 mm, respectively.

7.10.2.2 The height of coamings of the hatchways specified in **7.10.1.2** may be decreased in relation to that prescribed by **7.10.2.1** or the coamings may be omitted entirely where the efficiency of the cover tightness and securing means will satisfy the Register.

7.10.3 Materials.

7.10.3.1 For steel of top plate, bottom plate and primary supporting members, refer to 1.6.

7.10.3.2 The wood of hatchway covers shall be of good quality and of the type and grade which proved to be satisfactory for this purpose. Wedges shall be of hard wood.

7.10.3.3 Canvas used for making tarpaulins shall be impregnated to make them moisture-resistant and shall not contain jute thread. Mass of 1 m^2 of canvas before impregnation shall be not less than 0,55 kg. Breaking stress of impregnated canvas band 200x50 mm in size shall be at least 3 kN and 2 kN in longitudinal and transverse directions, respectively. When tested for watertightness, the impregnated canvas shall not get wet under water head of 0,15 m acting for 24 h.

7.10.3.4 The rubber for packing gaskets of hatchway covers shall be elastic, strong, and resistant to atmospheric changes. The rubber shall be of sufficient hardness.

7.10.3.5 All internal and external surfaces of steel hatch covers in bulk carriers (except inaccessible spaces in box type covers) shall have effective epoxy or other equivalent protective coating applied in accordance with the recommendations of the manufacturer (refer to **1.1.4.7** and **3.3.5.1**, Part II "Hull").

7.10.4 Design loads.

Hatchway covers shall be designed to sustain deck cargoes which are intended to be carried on these covers. Where operation of the cargo handling cars on hatchways covers is anticipated in the course of the ship's service, during cargo handling operations, the loads induced by such cars shall be taken into consideration. For hatchway covers in positions 1 and 2 the design load shall be calculated in accordance with **3.2.5.2** of the Load Line Rules for Sea-Going Ships; design of hatch covers shall comply with the requirements of **3.2.5.3** – **3.2.5.5** of the above Rules.

For ships of less than 24 m in length of restricted area of navigation engaged on international voyages and for all ships of restricted area of navigation not engaged on international voyages the load intensity reduced by the following values may be used instead of load intensity specified in 3.2.5.2 of the Load Line Rules for Sea-Going Ships:

15 % for ships of restricted areas of navigation **R2**, **R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**;

30 % for ships of restricted areas of navigation **R3**, **R3-IN** та **D-R3-S**, **D-R3-RS**, but not less than the load intensity on the weather deck in the area of hatches installation, determined in accordance with 2.6.3.1, Part II "Hull".

7.10.5 Design of hatch covers specified in 7.10.1.1.

Design of these hatch covers shall meet the requirements of **3.2.4** of the Load Line Rules for Sea-Going Ships.

7.10.6 Structure of hatch covers indicated in 7.10.1.2.

7.10.6.1 Structure of these covers shall meet the requirements of 3.2.5 of the Load Line Rules for SeaGoing Ships.

7.10.6.2 Primary supporting members and secondary stiffeners of hatch covers shall be continuous over the breadth and length of hatch covers, as far as practical. When this is impractical, sniped end connections shall not be used and appropriate arrangements shall be adopted to provide sufficient load carrying capacity.

7.10.6.3 The spacing of primary supporting members parallel to the direction of secondary stiffeners shall not exceed 1/3 of the span of primary supporting members. When strength calculation is carried out by FE analysis using plane strain or shell elements, this requirement can be waived.

Secondary stiffeners of hatch coamings shall be continuous over the breadth and length of hatch coamings.

7.10.6.4 Unless otherwise quoted, the thickness t of the following sections is the net thickness.

Net thickness is the member thickness necessary to obtain the minimum net scantlings.

The required gross thicknesses are obtained by adding corrosion additions t_s.

Strength calculations using beam theory, grillage analysis or FEM shall be performed with net scantlings.

7.10.6.5 Structural assessment of hatch covers and hatch coamings shall be carried out using the design loads, defined in this Chapter and the following definitions shall be used:

L − length of ship, in m, as defined in **1.1.3**, Part II "Hull";

L_{LL} − length of ship, in m, as defined in **1.2.2**;

x − longitudinal coordinate of mid point of assessed structural member measured from aft end of length L or L_{LL}, as applicable;

$D_{\min}$ – the least moulded depth, in m, as defined in **1.2.1** of the Load Line Rules for Sea-Going Ships.

h_N − standard superstructure height, in m,

$h_N = 1,05 + 0,01\ L_{LL}$, and $1,8 \le h_N \le 2,3$.

7.10.6.6 The pressure p_H, in kN/m^2, on the hatch cover panels is given in Table 7.10.6.6. The vertical weather design load needs not to be combined with cargo loads.

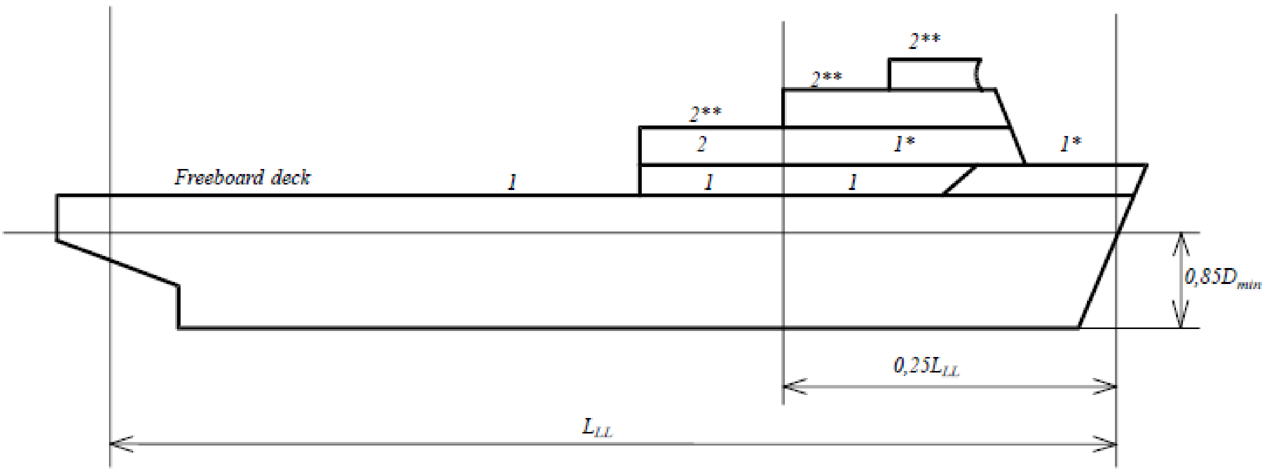
In Fig. 7.10.6.6 positions 1 and 2 are illustrated for an example ship.

***Table 7.10.6.6* Design load p_H of weather deck hatch coveres**

Position	Design loadp_H, in kN/m^2	
	$x/L_{LL} \le 0,75$	$0,75 < x/L_{LL} \le 1,0$
1	for 24 м $\le L_{LL} \le$ 100 m	
	$(9,81/76)(1,5L_{LL}+116)$	on freeboard deck: $(9,81/76)[(4,28L_{LL}+28)(x/L_{LL})-1,71L_{LL}+95]$;
		upon exposed superstructure decks located at least one superstructure standard height above the freeboard deck: $(9,81/76)(1,5L_{LL}+116)$
	for $L_{LL} >$ 100 m	
	$9,81\times 3,5$	on freeboard deck for type B ships according to the International Convention on Load Lines: $9,81[(0,0296L_1+3,04)(x/L_{LL}) - 0,0222L_1+1,22]$;
		on freeboard deck for ships with less freeboard than type B according to the International Convention on Load Lines: $9,81[(0,1452L_1+8,52)(x/L_{LL}) - 0,1089L_1+ 9,89]$, $L_1= L_{LL}$, but not more than 340 m;
		upon exposed superstructure decks located at least on superstructure standard height above the freeboard deck: $9,81\times 3,5$
2	for 24 м $\le L_{LL} \le$ 100 m	
	$(9,81/76)(1,1L_{LL}+87,6)$	
	for $L_{LL} >$ 100 m	
	$9,81\times 2,6$; upon exposed superstructure decks located at least one superstructure standard height above the lowest position 2 deck: $9,81\times 2,1$	

7.10.6.7 Where an increased freeboard is assigned, the design load for hatch covers according to Table 7.10.6.6 on the actual freeboard deck may be as required for a superstructure deck, provided the summer freeboard is such that the resulting draught will not be greater than that corresponding to the minimum freeboard calculated from an assumed freeboard deck situated at a distance at least equal to the standard superstructure height hN below the actual freeboard deck (refer to Fig. 7.10.6.6).

Positions 1 and 2



Positions 1 and 2 for an increased freeboard

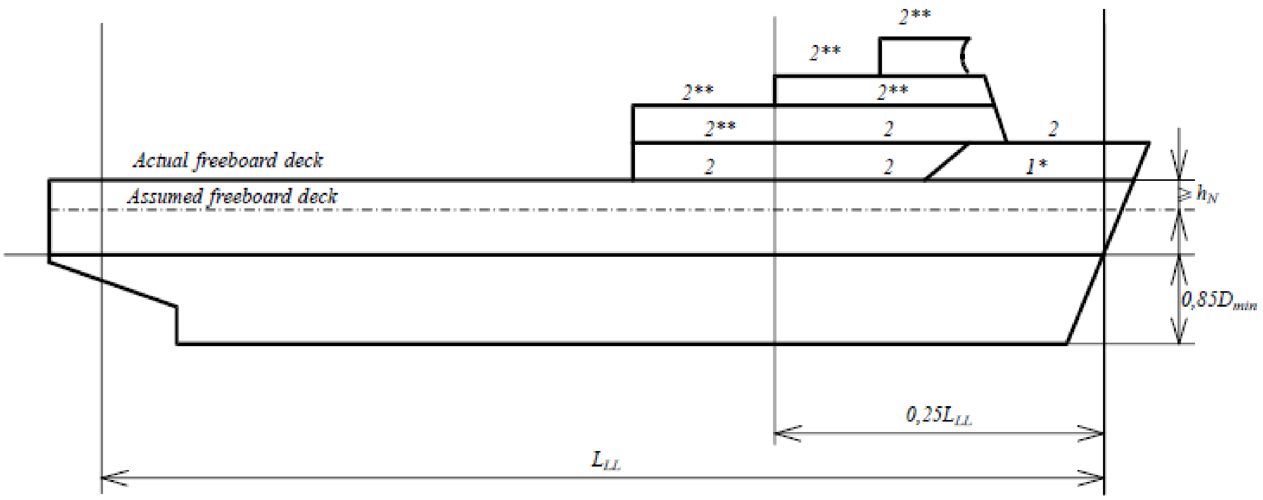


Fig. 7.10.6.6

Примітки: * Reduced load upon exposed superstructure decks located at least one superstructure standard height above the freeboard deck.

** Reduced load upon exposed superstructure decks of ships with L_{LL} > 100 m, located at least one superstructure standard height above the lowest position 2 deck.

7.10.6.8 The horizontal weather design load p_A, in kN/m^2 , for determining the scantlings of outer edge girders (skirt plates) of weather deck hatch covers and of hatch coamings shall be determined by the formula:

$$p_A = ac(bc_L f - z), \qquad (7.10.6.8)$$

where:

$f = L/25 + 4{,}1$, for $L < 90$ m;

$f = 10{,}75 - [(300-L)/100]^{1,5}$, for 90м $\le L <$ 300 m;

$f = 10{,}75$, for 300м $\le L <$ 350 m;

$f = 10{,}75 - [(L - 350)/150]^{1{,}5}$, for $350 \text{ m} \le L < 500$ m;

$c_L = (L/90)^{0{,}5}$, for $L < 90$ m;

$c_L = 1$, for $L \ge 90$ m;

$a = 20 + (L/12)$ for unprotected front coamings and hatch cover skirt plates;

$a = 10 + (L/12)$ for unprotected front coamings and hatch cover skirt plates, where the distance from the actual freeboard deck to the summer load line exceeds the minimum non-corrected tabular freeboard according to the International Convention on Load Lines by at least one standard superstructure height h_N;

$a = 5 + (L/15)$ for side and protected front coamings and hatch cover skirt plates;

$a = 7 + (L/100) - (8x'/L)$ for aft ends of coamings and aft hatch cover skirt plates abaft amidships;

$a = 5 + (L/100) - (4x'/L)$ for aft ends of coamings and aft hatch cover skirt plates forward of amidships;

$L_1 = L$, need not be taken greater than 300 m;

$b = 1{,}0 + \{[(x'/L) - 0{,}45]/(C_B + 0{,}2)\}^2$, for $(x'/L) < 0{,}45$;

$b = 1{,}0 + 1{,}5\{[(x'/L) - 0{,}45]/(C_B + 0{,}2)\}^2$, for $(x'/L) \ge 0{,}45$;

$0{,}6 \le C_B \le 0{,}8$, when determining scantlings of aft ends of coamings and aft hatch cover skirt plates forward of amidships, C_B need not be taken less than 0,8;
x' − distance, in m, between the transverse coaming or hatch cover skirt plate considered and aft end of the length L.

When determining side coamings or side hatch cover skirt plates, the side shall be subdivided into parts of approximately equal length, not exceeding $0{,}15L$ each, and x' shall be taken as the distance between aft end of the length L and the centre of each part considered;

z − vertical distance, in m, from the summer load line to the midpoint of stiffener span, or to the middle of the plate field;

$c = 0{,}3 + 0{,}7(b'/B')$;

b' − breadth of coaming, in m, at the position considered;

B' − actual maximum breadth of ship, in m, on the exposed weather deck at the position considered;

(b'/B') − shall not be taken less than 0,25.

The design load p_A shall not be taken less than the minimum values given in Table 7.10.6.8.

***Table 7.10.6.8.* Minimum design load $p_{A\min}$**

L	$p_{A\min}$, in kN/m^2, for	
	unprotected fronts	elsewhere
≤ 50	30	15
> 50 < 250	$25 + (L/10)$	$12{,}5 + (L/20)$
≥ 250	50	25

Note. The horizontal weather design load need not be included in the direct strength calculation of the hatch cover, unless it is utilized for the design of substructures of horizontal support according to **7.10.6.51**.

7.10.6.9 The load on hatch covers due to distributed cargo loads P_L, in kN/m^2, resulting from heave and pitch (i.e. ship in upright condition) shall be determined according to the following formula:

$$p_1 = p_c\,(1+a_v), \qquad (7.10.6.9)$$

where:
p_c − uniform cargo hold, in kN/m^2;

a_v− vertical acceleration addition as follows:

$a_v = Fm$;

where: $F = 0{,}11 v_0/(L)^{0,5}$;

$m = m_0 - 5(m_0-1)(x/L)$, for $0 \le (x/L) \le 0{,}2$;

$m = 1$, for $0{,}2 < (x/L) \le 0{,}7$;

$m = 1 + [(m_0+1)/0{,}3][(x/L) - 0{,}7]$, for $0{,}7 < (x/L) \le 1{,}0$;

where: $m_0 = 1{,}5 + F$;

v_0− maximum speed at summer load line draught;

v_0 shall not be taken less than $(L)^{0,5}$, in knots.

7.10.6.10 The load P, in kN, due to a concentrated force P_S, in kN, except for container load, resulting from heave and pitch (i.e. ship in upright condition) shall be determined as follows:

$$P = P_S\,(1+ a_v), \qquad (7.10.6.10)$$

where:
a_v– acceleration addition according to **7.10.6.9**.

7.10.6.11 The loads defined in **7.10.6.11.1** shall be applied where containers are stowed on the hatch cover.

7.10.6.11.1 The load P, in kN, applied at each corner of a container stack, and resulting from heave and pitch (i.e. ship in upright condition) shall be determined as follows:

$$P = 9{,}81 \cdot M \cdot (1 + a_v)/4, \qquad (7.10.6.11.1\text{-}1)$$

where: a_v – acceleration addition according to **7.10.6.9**;
M – maximum designed mass of container stack, in t;

7.10.6.11.2 The loads, in kN, applied at each corner of a container stack, and resulting from heave, pitch, and the ship's rolling motion (i.e. ship in heel condition) shall be determined as follows, (refer also to Fig. 7.10.6.11):

$$A_z = 9{,}81(M/2)\,(1+a_v)[0{,}45 - 0{,}42(h_m/b)]; \qquad (7.10.6.11.2\text{-}1)$$

$$B_z = 9{,}81(M/2)\,(1+a_v)[0{,}45+0{,}42(h_m/b)]; \qquad (7.10.6.11.2\text{-}2)$$

$$B_y = 2{,}4M, \qquad (7.10.6.11.2\text{-}3)$$

where:
a_v– acceleration addition according to **7.10.6.9**;
M − maximum designed mass of container stack, in t;
h_m – designed height of centre of gravity of stack above hatch cover top, in m, may be calculated as weighted mean value of the stack, where the centre of gravity of each tier is assumed to be located at the centre of each container,
$h_m = \sum(z_i \cdot W_i)/M$;

z_i – distance from hatch cover top to the centre of ith container, in m;
W_i – weight of *i*-th container, in t;
b – distance between midpoints of foot points, in m, refer to Fig. 7.10.6.11;
A_z, B_z – support forces in *Z*-direction at the forward and aft stack corners;
B_y – support force in y-direction at the forward and aft stack corners.

When strength of the hatch cover structure is assessed by grillage analysis according to **7.10.6.21**, h_m and z_i shall be taken as shown in Fig. 7.10.6.11.

Force B_y does not need to be considered in this case.

Values of A_z and B_z, applied for the assessment of hatch cover strength shall be shown in the drawings of the hatch covers.

Note. It is recommended that container loads as calculated above are considered as limit for foot point loads of container stacks in the calculations of cargo securing (container lashing).

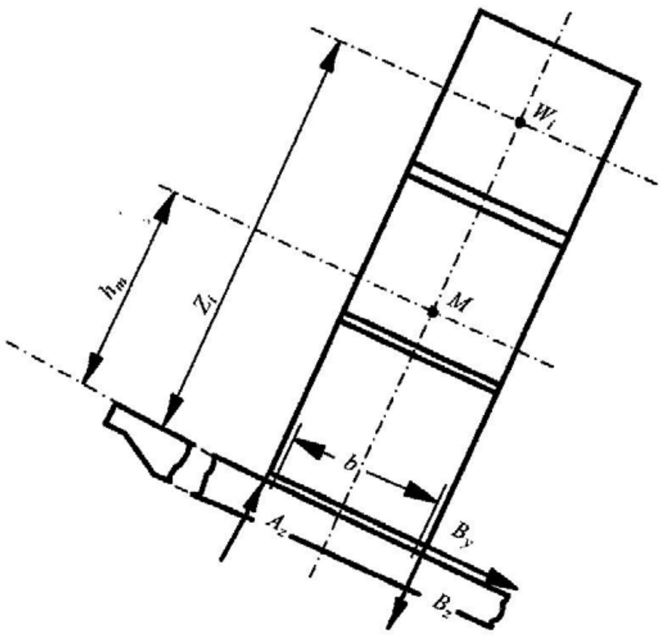


Fig. 7.10.6.11 Forces due to container loads

7.10.6.12 The load cases defined in **7.10.6.11.1** and **7.10.6.11.2**, shall also be considered for partial non homogeneous loading which may occur in practice, e.g. where specified container stack places are empty.

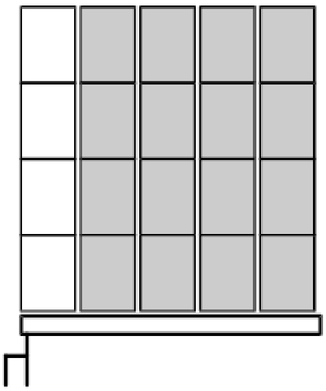
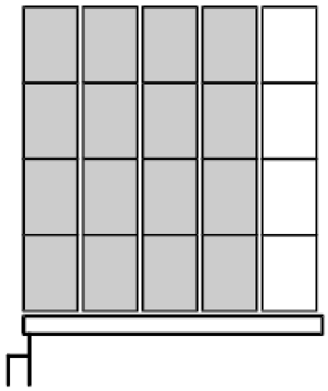
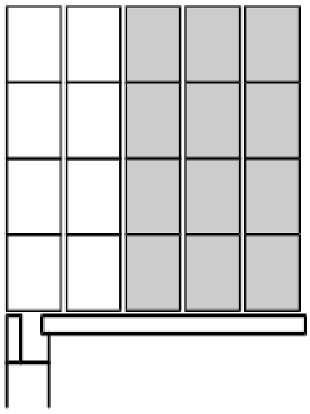
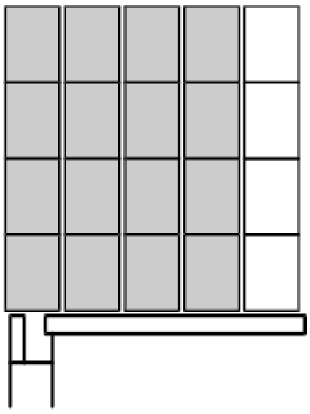
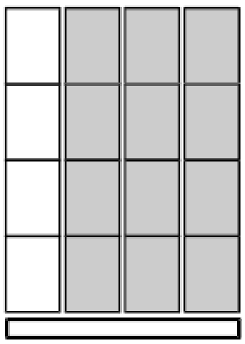
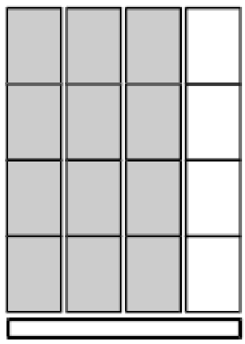
For each hatch cover, the heel directions, as shown in Table 7.10.6.12 shall be considered.

The load case partial loading of container hatch covers can be evaluated using a simplified approach, where the hatch cover is loaded without the outermost stacks that are located completely on the hatch cover.

If there are additional stacks that are supported partially by the hatch cover and partially by container stanchions then the loads from these stacks shall also be neglected, refer to Table 7.10.6.12.

In addition, the case where only the stack places supported partially by the hatch cover and partially by container stanchions are left empty shall be assessed in order to consider the maximum loads in the vertical hatch cover supports.

Table 7.10.6.12 **Partial loading of container hatch covers**

Heel direction	←	→
Hatch covers supported by the longitudinal hatch coaming with all container stacks located completely on the hatch cover		
Hatch covers supported by the longitudinal hatch coaming with the outermost container stack supported partially by the hatch cover and partially by container stanchions		
Hatch covers not supported by the longitudinal hatch coaming (center hatch covers)		

It may be necessary also to consider partial load cases where more or different container stack places are left empty.

In the case of mixed stowage e (20' + 40' container combined stack), the foot point forces at the fore and aft end of the hatch cover shall not be higher than resulting from the design stack weight for 40' containers, and the foot point forces at the middle of the cover shall not be higher than resulting from the design stack weight for 20' containers.

7.10.6.13 Hatch covers, which in addition to the loads according to **7.10.6.6**, **7.10.6.7** and **7.10.6.11**, are loaded in the ship's transverse direction by forces due to elastic deformations of the ship's hull, shall be designed such that the sum of stresses does not exceed the permissible values given in **7.10.6.14**.

7.10.6.14 The equivalent stress σ_V in steel hatch cover structures related to the net thickness shall not exceed $0{,}8\sigma_F$, where σ_F is the minimum yield stress, in N/mm^2.

For design loads according to **7.10.6.8** ÷ **7.10.6.13**, the equivalent stress sv related to the net thickness shall not exceed $0{,}9\sigma_F$, when the stresses are assessed by means of FEM.

For grillage analysis, the equivalent stress may be taken as follows:

$$\sigma_v = \sqrt{\sigma^2 + 3\tau^2}, \text{ Н/мм}^2, \qquad (7.10.6.14\text{-}1)$$

where:
σ – normal stress, in N/mm^2;
τ – shear stress, in N/mm^2.

For FEM calculations, the equivalent stress may be taken as follows:

$$\sigma_v = \sqrt{\sigma_x^2 - \sigma_x\sigma_y + \sigma_y^2 + 3\tau_2}\ , \text{ Н/мм}^2, \qquad (7.10.6.14\text{-}2)$$

where:
σ_x – normal stress, in N/mm^2, in *x*-direction;
σ_y – normal stress, in N/mm^2, in *y*-direction;
τ – shear stress, in N/mm^2, in *x*-*y* plane.
Indices *x* and *y* are coordinates of a two-dimensional Cartesian system in the plane of the considered structural element.

In case of FEM calculations using shell or plane strain elements, the stresses shall be read from the centre of the individual element. It shall be observed that, in particular, at flanges of unsymmetrical girders, the evaluation of stress from element centre may lead to non-conservative results.

Thus, a sufficiently fine mesh shall be applied in these cases or, the stress at the element edges shall not exceed the allowable stress.

Where shell elements are used, the stresses shall be evaluated at the mid plane of the element.

7.10.6.15 5 The vertical deflection of primary supporting members due to the vertical weather design load according to **7.10.6.**6 and **7.10.6.7** shall not be more than $0{,}0056l_g$, where l_g is the greatest span of primary supporting members.

Where hatch covers are arranged for carrying containers and mixed stowage is allowed, i.e., a 40' container stowed on top of two 20' containers, particular attention shall be paid to the deflections of hatch covers. Further the possible contact of deflected hatch covers with in hold cargo shall be observed.

7.10.6.16 The local net plate thickness *t*, in mm, of the hatch cover top plating shall not be less than:

$$t = F_p 15{,}8s(p/0{,}95\sigma_F)^{0{,}5}, \qquad (7.10.6.16)$$

and shall not be less than 1 % of the spacing of the stiffener or 6 mm if that be greater,

where:
p – pressure p_N and p_1, in kN/m^2, as defined in **7.10.6.6** and **7.10.6.9**;
F_p= 1,5 in general;
F_p= $1{,}9\sigma/\sigma_a$ for $\sigma/\sigma_a \geq 0{,}8$ for the attached plate flange of primary supporting members;
s – stiffener spacing, in m;
σ_F – minimum yield stress of the material, in N/mm^2;
σ – maximum normal stress, in N/mm^2, of hatch cover top plating, determined according to Fig.7.10.6.16;
σ_a =0,8 σ_F, , in N/mm^2.

For flange plates under compression sufficient buckling strength according to **7.10.6.24** shall be demonstrated.

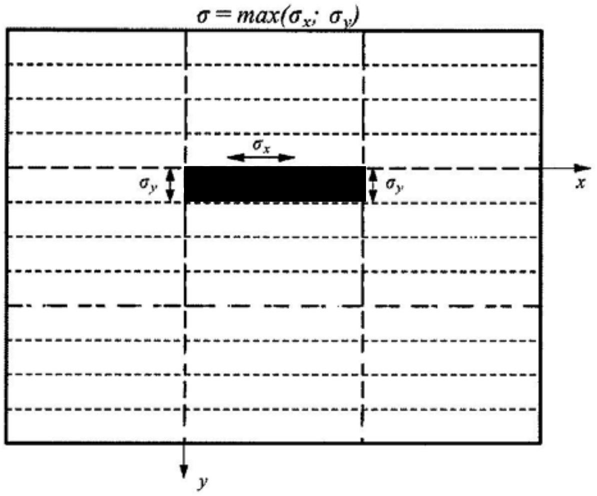


Fig. 7.10.6.16

7.10.6.17 The thickness of lower plating of double skin hatch covers and box girders shall fulfill the strength requirements and shall be obtained from the calculation according to **7.10.6.21** under consideration of permissible stresses according to **7.10.6.14**.

When the lower plating is taken into account as a strength member of the hatch cover, the net thickness, in mm, of lower plating shall be taken not less than 5 mm.

When project cargo is intended to be carried on a hatch cover, the net thickness shall not be less than:

$t = 6{,}5s$, mm; (7.10.6.17)

where:
s − stiffener spacing, in m.

Note. Project cargo means especially large or bulky cargo lashed to the hatch cover. Examples are parts of cranes or wind power stations, turbines, etc. Cargoes that can be considered as uniformly distributed over the hatch cover, e.g., timber, pipes or steel coils need not to be considered as project cargo.

7.10.6.18 The net section modulus Z and net shear area A_s of uniformly loaded hatch cover stiffeners constraints at both ends shall not be less than:

$Z = (104/\sigma_F) \cdot s \cdot l^2 \cdot p$, in cm^3, (7.10.6.18-1)

for design load according to **7.10.6.6**;

$Z = (94/\sigma_F) \cdot s \cdot l^2 \cdot p$, in cm^3, (7.10.6.18-2)

for design load according to **7.10.6.9**;

$A_s = (10{,}8/\sigma_F) \cdot s \cdot l \cdot p$, in cm^2, (7.10.6.18-3)

for design load according to **7.10.6.6**;

$A_s = (9{,}6/\sigma_F) \cdot s \cdot l \cdot p$, in cm^2, (7.10.6.18-4)

for design load according to **7.10.6.9**,

where:
p − pressure p_N and p_1, in kN/m^2, as defined in **7.10.6.6** and **7.10.6.9**;
s − secondary stiffener spacing, in m;
σ_F − minimum yield stress of the material, in N/mm^2;

l − secondary stiffener span, in m, to be taken as the spacing, in m, of primary supporting members or the distance between a primary supporting member and the edge support, as applicable.

For secondary stiffeners of lower plating of double skin hatch covers, requirements mentioned above are not applied due to the absence of lateral loads.

The net thickness, in mm, of the stiffener (except U-beams/trapeze stiffeners) web shall be taken not less than 4 mm.

The net section modulus of the secondary stiffeners shall be determined based on and attached plate width assumed equal to the stiffener spacing.

For flat bar secondary stiffeners and buckling stiffeners, the ratio h/t_w shall not be greater than 15 $k^{0,5}$,

where:
h - height of the stiffener;
t_w - net thickness of the stiffener;
$k = 235/\sigma_F$.

Stiffeners parallel to primary supporting members and arranged within the effective breadth according to **7.10.6.22** shall be continuous at crossing primary supporting member and may be regarded for calculating the cross sectional properties of primary supporting members. It shall be verified that the combined stress of those stiffeners induced by the bending of primary supporting members and lateral pressures does not exceed the permissible stresses according to **7.10.6.14**.

These requirements are not applied to stiffeners of lower plating of double skin hatch covers if the lower plating is not considered as strength member..

For hatch cover stiffeners under compression sufficient safety against lateral and torsional buckling according to **7.10.6.28** ÷ **7.10.6.32** shall be verified.

For hatch covers subject to wheel loading or point loads stiffener scantlings shall be determined under consideration of the permissible stresses according to**7.10.6.14**.

7.10.6.19 Scantlings of primary supporting members are obtained from calculations according to **7.10.6.22** and **7.10.6.23** under consideration of permissible stresses according to **7.10.6.14**.

For all components of primary supporting members sufficient safety against buckling shall be verified according to **7.10.6.24** ÷ **7.10.6.32**.

For biaxial compressed flange plates this shall be verified within the effective widths according to **7.10.6.29**.

The net thickness, in mm, of webs of primary supporting members shall not be less than:

$t = 6,5s$, in mm;
$t_{min} = 5$ in mm,

where:
s − stiffener spacing, in m.

7.10.6.20 Scantlings of edge girders are obtained from the calculations according to **7.10.6.22** and **7.10.6.23** under consideration of permissible stresses according to **7.10.6.14**.

The net thickness, in mm, of the outer edge girders exposed to wash of sea shall not be less than the largest of the following values:

$$t = 15,8s(p_A/0,95\sigma_F)^{0,5}; \quad (7.10.6.20\text{-}1)$$

$t = 8,5s$, in mm;

$t_{min} = 5$ in mm,

where: p_A − horizontal pressure as defined in **7.10.6.8**;
σ_F − minimum yield stress of the material, in N/mm^2;
s − stiffener spacing, in m.

The stiffness of edge girders shall be sufficient to maintain adequate sealing pressure between securing devices.

The moment of inertia I, in cm^4, of edge girders shall not be less than

$$I = 6qs_{SD}^4, \text{ in } cm^4, \qquad (7.10.6.20\text{-}2)$$

where: q − packing line pressure, in N/mm, min = 5 N/mm;
s_{SD} − spacing, in m, of securing devices.

7.10.6.21 Strength calculation for hatch covers may be carried out by either grillage analysis or FEM. Double skin hatch covers or hatch covers with box girders shall be using FEM, refer to **7.10.6.23**.

7.10.6.22 Cross-sectional properties shall be determined considering the effective breadth. Cross sectional areas of secondary stiffeners parallel to the primary supporting member under consideration within the effective breadth can be included, refer to Fig. 7.10.6.29-1.

The effective breadth of plating e_m of primary supporting members shall be determined according to Table 7.10.6.22, considering the type of loading.

Special calculations may be required for determining the effective breadth of one-sided or non-symmetrical flanges.

The effective cross sectional area of plates shall not be less than the cross sectional area of the face plate.

Table 7.10.6.22. **Effective breadthe_m of plating of primary supporting members**

l/e	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**≥ 8**
e_{m1}/e	0	0,36	0,64	0,82	0/91	0,96	0,98	1,00	1,00
e_{m2}/e	0	0,20	0,37	0,52	0,65	0,75	0,84	0,89	0,90

e_{m1}- shall be applied where primary supporting members are loaded by uniformly distributed loads or else by not less than 6 equally spaced single loads.
e_{m2}- shall be applied where primary supporting members are loaded by 3 or less single loads.
Intermediate values may be obtained by direct interpolation.
l − length of zero-points of bending moment curve.
$l = l_0$− for simply supported primary supporting members.
$l = 0{,}6l_0$− for primary supporting members with both ends constraint, where
l_0 is the unsupported length of the primary supporting member:
e − width of plating supported, measured from centre to centre of the adjacent unsupported fields.

For flange plates under compression with secondary stiffeners perpendicular to the web of the primary supporting member, the effective width shall be determined according to **7.10.6.29**.

7.10.6.23 For strength calculations of hatch covers by means of finite elements, the cover geometry shall be idealized as realistically as possible. Element size shall be appropriate to account for effective breadth.

In no case element width shall be larger than stiffener spacing. In way of force transfer points and cutouts the mesh shall be refined, where applicable. The ratio of element length to width shall not exceed 4.

The element height of webs of primary supporting member shall not exceed one-third of the web height.

Stiffeners, supporting plates against pressure loads, shall be included in the idealization. Stiffeners may be modelled by using shell elements, plane stress elements or beam elements.

Buckling stiffeners may be disregarded for the stress calculation.

7.10.6.24 For hatch cover structures sufficient buckling strength shall be demonstrated (refer to Fig. 7.10.6.24).

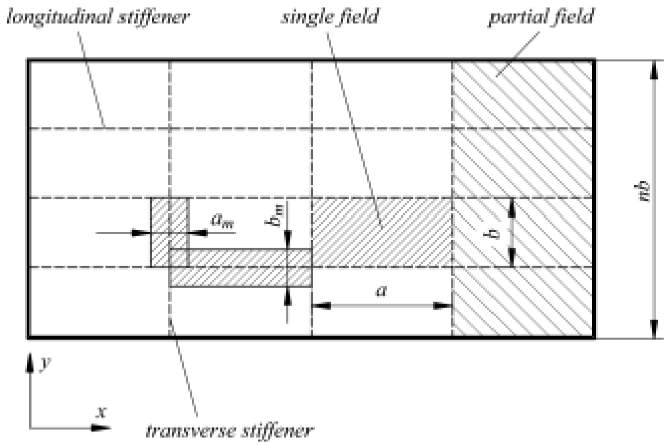


Fig. 7.10.6.24

Definitions in **7.10.6.24 ÷ 7.10.6.32**:

a − = length of the longer side of a single plate field, in mm (*x*-direction);
b − breadth of the shorter side of a single plate field, in mm (*y*-direction);
α − aspect ratio of single plate field $\alpha = a/b$;
n − number of single plate field breadths within the partial or total plate field;
t − net plate thickness, in mm;
σ_x − membrane stress, in N/mm^2, in *x*-direction;
σ_y − membrane stress, in N/mm^2, in *y*-direction;
τ − shear stress, in N/mm^2, in the x-y plane;
E − modulus of elasticity, in N/mm^2, of the material;
$E = 2{,}06\cdot10^5$, in N/mm^2, for steel;
σ_F − minimum yield stress, in N/mm^{2}of the material;
σ_e − reference stress, in N/mm^2, taken equal to:
$\sigma_e = 0{,}6\ E(t/b)^2$;
ψ − edge stress ratio taken equal to
$\psi = \sigma_1/\sigma_2$;
σ_1 − maximum compressive stress;
σ_2 − minimum compressive stress or tension stress
S − safety factor (based on net scantling approach), taken equal to:
S = 1,25 for hatch covers when subjected to the vertical weather design load according to **7.10.6.6**;
S = 1,10 for hatch covers when subjected to loads according to**7.10.6.8** and **7.10.6.14**;
λ − reference degree of slenderness, taken equal to;
$\lambda = (\sigma_F / K\sigma_c)^{0,5}$;
K − buckling factor according to 7.10.6.26.

Compressive and shear stresses shall be taken positive, tension stresses shall be taken negative.

If stresses in the *x*- and *y*-direction already contain the Poisson-effect (calculated using FEM), the following modified stress values may be used.

Both stresses σ_x* and σ_y* shall be compressive stresses, in order to apply the stress reduction according to the following formulae:

$$\sigma_x = (\sigma_x^* - 0{,}3\sigma_y^*)/0{,}91; \quad (7.10.6.24\text{-}1)$$

$$\sigma_y = (\sigma_y^* - 0{,}3\ \sigma_x^*)/0{,}91, \quad (7.10.6.24\text{-}2)$$

where:
σ_x^*, σ_y^* − stresses containing the Poisson-effect.

Where compressive stress fulfils the condition $\sigma_y^* < 0{,}3\ \sigma_x^*$, then $\sigma_y = 0$ and $\sigma_x = \sigma_x^*$.

Where compressive stress fulfils the condition $\sigma_x^* < 0{,}3\ \sigma_y^*$, then $\sigma_x = 0$ and $\sigma_y = \sigma_y^*$.

F_1 − correction factor for boundary condition at the longitudinal stiffeners according to Table 7.10.6.24.

Table 7.10.6.24 **Correction factor F_1**

	Correction factor F_1
Stiffeners sniped at both ends	1,00
Guidance values1 where both ends are effectively connected to adjacent structures	1,05 for flat bars 1,10 for bulb sections 1,20 for angle and tee-sections 1,30 for U-type sections[2] and girders of high rigidity
[1] Exact values may be determined by direct calculations. [2] Higher value may be taken if it is verified by a buckling strength check of the partial plate field using non-linear FEA and deemed appropriate by the individual classification society but not greater than 2,0.	

7.10.6.25 Proof shall be provided that the following condition is complied with for the single plate field *ab*:

$$\left(\frac{|\sigma_x|S}{k_x\sigma_F}\right)^{e1} + \left(\frac{|\sigma_y|S}{k_y\sigma_F}\right)^{e2} - B\left(\frac{\sigma_x\sigma_y S^2}{\sigma_F^2}\right) + \left(\frac{|\tau|S\sqrt{3}}{k_\tau\sigma_F}\right)^{e3} \leqslant 1{,}0. \qquad (7.10.6.25)$$

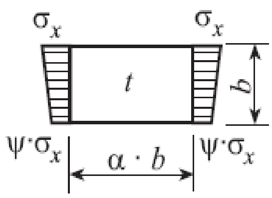
The first two terms and the last term of the above condition shall not exceed 1,0.
The reduction factors k_x, k_y and k_τ, are given in Table 7.10.6.26.
Where $\sigma_x \le 0$ ((tension stress), $k_x = 1{,}0$;
Where $\sigma_y \le 0$ ((tension stress), $k_y = 1{,}0$.
The exponents e_1, e_2, e_3, as well as the factor B shall be taken as given in Table 7.10.6.25.

Table 7.10.6.25. **Coefficients e_1, e_2, e_3 and factor B**

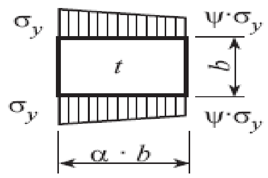
Exponents e_1, e_2, e_3, and factor B	**Plate panel**
e_1	$1+k_x^4$
e_2	$1+k_y^4$
e_3	$1+k_x k_y k_\tau^2$
B σ_x and σ_y − positive (compression stress)	$(k_x k_y)^5$
B σ_x and σ_y − negative (tension stress)	1

7.10.6.26 Buckling and reduction factors for plane elementary plate panels are given in Table 7.10.6.26.

Table 7.10.6.26

Buckling-load case	**Edge stress ratio [2]** ψ	**Factor[1]** $\alpha = a/b$	**Buckling factor[3]** K	**Reduction factor** k
1	**2**	**3**	**4**	**5**
1 	$1 \ge \psi \ge 0$	$\alpha \ge 1$	$K = 8{,}4/(\psi + 1{,}1)$	$k_x = 1$, for $\lambda \le \lambda_c$ $k_x = c[(1/\lambda) - (0{,}22/\lambda^2)]$, for $\lambda > \lambda_c$ $c = (1{,}25 - 0{,}12\psi) \le 1{,}25$ $\lambda_c = 0{,}5c\{1+[1-(0{,}88/c)]^{1/2}\}$
	$0 > \psi > -1$		$K = 7{,}63 - \psi(6{,}26 - 10\psi)$	
	$\psi \le -1$		$K = 5{,}975(1-\psi)^2$	

Continue of Table 7.10.6.26

<table>
<tr><th>Buckling-load case</th><th>Edge stress ratio [2] ψ</th><th>Factor[1] $\alpha = a/b$</th><th>Buckling factor[3] K</th><th>Reduction factor k</th></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td rowspan="5">2
</td><td>$1 \geq \psi \geq 0$</td><td>$\alpha \geq 1$</td><td>$K = F_1 [1+(1/\alpha^2)]^2 \times$
$\times[2,1/(\psi+1,1)]$</td><td rowspan="5">$k_y = c\{(1/\lambda) - \{[R+F^2(H-R)]/\lambda^2\}$

$c = (1,25 - 0,12\psi) \leq 1,25$

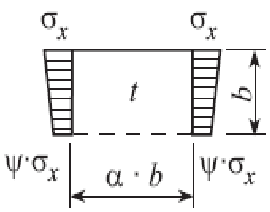
$R = \lambda[1-(\lambda/c)]$, for $\lambda < \lambda_c$

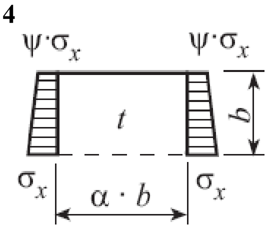
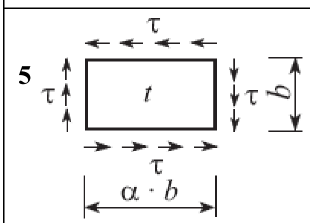
$R = 0,22$, for $\lambda \geq \lambda_c$

$\lambda_c = 0,5c\{1+[1-(0,88/c)]^{1/2}\}$
$F = \{1-\{[(K/0,91)-1]/\lambda_p^2\}\} c_1 \geq 0$

$\lambda_p^2 = \lambda^2 - 0,5$, for $1 \leq \lambda_p^2 \leq 3$;
$c_1 = [1-(F_1/\alpha)] \geq 0$,

$H = \lambda - \{2\lambda/\{c \times [T+(T^2-4)^{1/2}]$

$T = \lambda + (14/15\lambda) + (1/3)$</td></tr>
<tr><td rowspan="2">$0 > \psi > -1$</td><td>$1 \leq \alpha \leq 1,5$</td><td>$K = F_1 \{[1+(1/\alpha^2)]^2 \times$
$\times [2,1(1+\psi)/1,1] -$
$- [(\psi/\alpha^2) \times (13,9-10\psi)]\}$</td></tr>
<tr><td>$\alpha > 1,5$</td><td>$K = F_1 \{[1+(1/\alpha^2)]^2 \times$
$\times [2,1(1+\psi)/1,1] - (\psi/\alpha^2) \times$
$x[5,87+1,87\alpha^2+(8,6/\alpha^2)-10\psi]\}$</td></tr>
<tr><td rowspan="2">$\psi \leq -1$</td><td>$1 \leq \alpha \leq$
$\leq 3(1-\psi)/4$</td><td>$K = F_1[(1-\psi)/\alpha]^2 \times 5,975$</td></tr>
<tr><td>$\alpha >$
$> 3(1-\psi)/4$</td><td>$K = F_1\{[(1-\psi)/\alpha]^2 \times 3,9675 +$
$+0,5375[(1-\psi)/\alpha]^4 + 1,87\}$</td></tr>
<tr><td rowspan="2">3
</td><td>$1 \geq \psi \geq 0$</td><td rowspan="2">$\alpha > 0$</td><td>$K = 4[0,425+(1/\alpha^2)]/(3\psi+1)$</td><td rowspan="3">$K_x = 1$, for $\lambda \leq 0,7$

$K_x = 1/(\lambda^2+0,51)$, for $\lambda > 0,7$</td></tr>
<tr><td>$0 > \psi > -1$</td><td>$K = 4[0,425+(1/\alpha^2)] \times (1+\psi) -$
$-5\psi(1-3,42\psi)$</td></tr>
<tr><td>4
</td><td>$1 \geq \psi \geq -1$</td><td>$\alpha > 0$</td><td>$K = [0,425+(1/\alpha^2)] \times (3-\psi)/2$</td></tr>
<tr><td rowspan="3">5
</td><td rowspan="3">-</td><td></td><td>$K = K_\tau\sqrt{3}$</td><td rowspan="3">$k_\tau = 1$, for $\lambda \leq 0,84$

$k_\tau = 0,84/\lambda$, for $\lambda > 0,84$</td></tr>
<tr><td>$\alpha \geq 1$</td><td>$K_\tau = (5,34 + 4/\alpha^2)$</td></tr>
<tr><td>$0 < \alpha < 1$</td><td>$K_\tau = (4 + 5,34/\alpha^2)$</td></tr>
<tr><td colspan="5">Explanation for boundary conditions: ------- plate edge free
▬▬ plate edge simply supported
[1] Factor $\alpha = a/b$ − dimension ratio $\alpha = a/b$.
[2] Edge stress ratio considering unevenness of plate edge compression.
[3] Buckling factor K depending on the plate loading and side ratio $\alpha = a/b$.</td></tr>
</table>

7.10.6.27 For non-stiffened webs and flanges of primary supporting members not supported by stiffeners, sufficient buckling strength as for the hatch cover top and lower plating shall be demonstrated according to **7.10.6.25**.

7.10.6.28 It shall be demonstrated that the continuous longitudinal and transverse stiffeners of partial and total plate fields comply with the conditions set out in **7.10.6.30** and **7.10.6.31**.

For U-type stiffeners, the proof of torsional buckling strength according to **7.10.6.31** can be omitted.

Single-side welding is not permitted to use for secondary stiffeners except for U-stiffeners.

7.10.6.29 For demonstration of buckling strength according to **7.10.6.30** and **7.10.6.31**, the effective width of plating may be determined by the following formulae:

$b_m = k_x b$ − for longitudinal stiffeners; (7.10.6.29-1)

$a_m = k_y a$ − for transverse stiffeners; (7.10.6.29-2)

refer also to Fig. 7.10.6.24.

The effective width of plating shall not be taken greater than the value obtained from **7.10.6.22**.

The effective width e'_m of stiffened flange plates of primary supporting members may be determined as follows:

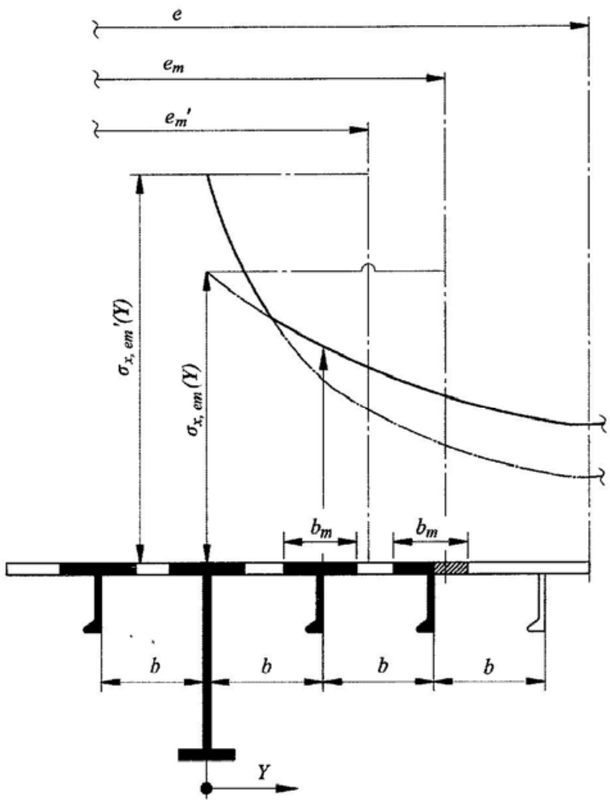


Fig. 7.10.6.29-1. Stiffening parallel to web of primary supporting member

$b < e_m$;

$e'_m = nb_m$;

n − integer number of stiffener spacings b inside the effective breadth e_m according to **7.10.6.22**.

$n = e_m/b$ (is rounded to the nearest integer).

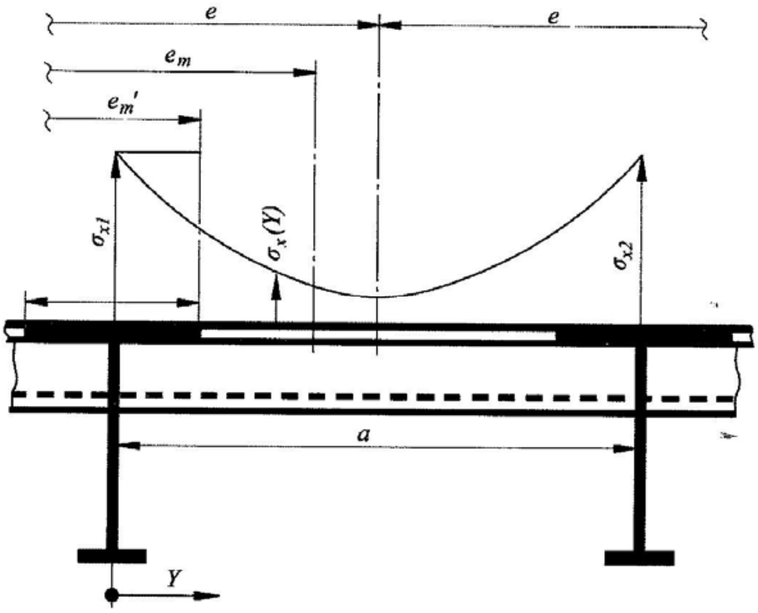


Fig. 7.10.6.29-2. Stiffening perpendicular to web of primary supporting member

$a \geq e_m$;
$e'_m = na_m < e_m$;
$n = 2{,}7(e_m/a) \leq 1$;
e − width of plating supported according to **7.10.6.22**.
For $b \geq e_m$ or $a < e_m$, respectively, b and a shall be exchanged.
a_m and b_m for flange plates shall be in general determined for $\psi = 1$.

Note. Scantlings of plates and stiffeners shall be in general determined according to the maximum stresses $\sigma_x(y)$ at webs of primary supporting member and stiffeners, respectively.

For stiffeners with spacing b under compression arranged parallel to primary supporting members, no value less than $0{,}25\sigma_F$ shall be inserted for $\sigma_x (y = b)$.

The stress distribution between two primary supporting members can be obtained by the following formulae:

$$\sigma_x(y) = \sigma_{x1}\{1 - \frac{y}{e}[3 + c_1 - 4c_2 - 2\frac{y}{e}(1 + c_1 - 2c_2)]\};$$

$$c_1 = \sigma_{x2}/\sigma_{x1};\ 0 \leqslant c_1 \leqslant 1; \qquad (7.10.6.29\text{-}3)$$

$$c_2 = \frac{1{,}5}{e}(e''_{m1} + e''_{m2}) - 0{,}5;$$

where:

e''_{m1} − proportionate effective breadth em1 or proportionate effective width e'_{m1} of primary supporting member 1 within the distance e, as appropriate;

e''_{m2} − proportionate effective breadth e_{m2} or proportionate effective width e'_{m2} of primary supporting member 2 within the distance e, as appropriate;

σ_{x1}, σ_{x2}− normal stresses in flange plates of adjacent primary supporting member 1 and 2 with spacing e, based on cross-sectional properties considering the effective breadth (e_{m1}, e_{m2}) or effective width (e'_{m1}, e'_{m2}), as appropriate;

y - distance of considered location from primary supporting member 1.

Shear stress distribution in the flange plates may be assumed linearly.

7.10.6.30 Lateral buckling of secondary stiffeners shall be the following:

$$(\sigma_a + \sigma_b)(S/\sigma_F) \leq 1, \qquad (7.10.6.30)$$

where: σ_a − uniformly distributed compressive stress, in N/mm^2, in the direction of the stiffener axis;
$\sigma_a = \sigma_x$ − for longitudinal stiffeners;
$\sigma_a = \sigma_y$ − for transverse stiffeners;
σ_b − bending stress, in N/mm^2, in the stiffener;
$\sigma_b = (M_0 + M_1)/Z\cdot 10^3$;

M_0 − bending moment, in N·mm, due to the deformation w of stiffener, taken equal to:

$M_0 = F_{Ki} p_z w/(c_f - p_z)$, with $(c_f - p_z) > 0$;

M_1 − bending moment, in N·mm, due to the lateral load p equal to:

$M_1 = pba^2/(24 \cdot 10^3)$ − for longitudinal stiffeners;
$M_1 = pa(nb)^2/(c_s 8 \cdot 10^3)$ − for transverse stiffeners;
n shall be equal to l for ordinary transverse stiffeners;
p − lateral load, in N/mm^2;
F_{Ki} − = ideal buckling force, in N, of the stiffener;
$F_{Kix} = (\pi^2/a^2) EI_x \cdot 10^4$ − for longitudinal stiffeners;
$F_{Kiy} = [\pi^2/(nb)^2] EI_y \cdot 10^4$ − for transverse stiffeners;
I_x, I_y − net moments of inertia, in cm^4, of the longitudinal or transverse stiffener, including effective width of attached plating according to **7.10.6.29**. I_x and I_y shall comply with the following criteria:

$I_x \geq bt^3/(12 \cdot 10^4)$;

$I_y \geq at^3/(12 \cdot 10^4)$;

p_z − nominal lateral load, in N/mm^2, of the stiffener due to σ_x, σ_y and σ_τ;
$p_{zx} = (t/b)[\sigma_{x1}(\pi b/a)^2 + 2c_y\sigma_y + \sqrt{2\tau_1}]$ − for longitudinal stiffeners;
$p_{zy} = (t/a)[2c_x\sigma_{x1} + \sigma_y(\pi a/nb)^2 \cdot (1 + A_y/at) + \sqrt{2\tau_1}]$ − for transverse stiffeners;
$\sigma_{x1} = \sigma_x [1 + (A_x/bt)]$;
c_x, c_y − factors taking into account the stresses perpendicular to the stiffener's axis and distributed variable along the stiffener's length;
$c_x, c_y = 0{,}5(1+\psi)$ for $0 \leq \psi \leq 1$;
$c_x, c_y = 0{,}5/(1-\psi)$ for $\psi < 0$;
A_x, A_y − net sectional area, in mm^2, of the longitudinal or transverse stiffener, respectively, without attached plating;

$$\tau_1 = [\tau - t\sqrt{\sigma_F E(m_1/a^2 + m_2/b^2)}] \geq 0;$$

− for longitudinal stiffeners:

$a/b \geq 2{,}0$: $m_1 = 1{,}47$ $m_2 = 0{,}49$;
$a/b < 2{,}0$: $m_1 = 1{,}96$ $m_2 = 0{,}37$;
− for transverse stiffeners:

$a/nb \geq 0{,}5$: $m_1 = 0{,}37$ $m_2 = 1{,}96/n^2$;
$a/nb < 0{,}5$: $m_1 = 0{,}49$ $m_2 = 1{,}47/n^2$;
$w = w_0 + w_1$;
w_0 − assumed imperfection, in mm;
$w_{0x} \leq \min(a/250,\ b/250,\ 10)$ − for longitudinal stiffeners;
$w_{0y} \leq \min(a/250,\ nb/250,\ 10)$ − for transverse stiffeners.

Note. For stiffeners sniped at both ends w_0 shall not be taken less than the distance from the midpoint of plating to the neutral axis of the profile including effective width of plating.

w_1 − deformation of stiffener, in mm, at midpoint of stiffener span due to lateral (transverse) load p.
In case of uniformly distributed load the following values for w_1 may be used:

$w_1 = pba^4/(384 \cdot 10^7 EI_x)$ − for longitudinal stiffeners;

$w_1 = 5pa(nb)^4/(384 \cdot 10^7 EI_y c_s^2)$ − for transverse stiffeners;
c_f − elastic support provided by the stiffener, in N/mm^2;

− for longitudinal stiffeners:

$c_{fx} = F_{Kix}(\pi^2/a^2)(1 + c_{px})$;

$$c_{px} = \frac{1}{1 + \frac{0,91\left(\frac{12 \times 10^4 I_x}{t^3 b} - 1\right)}{c_{xa}}};$$

$c_{xa} = [(a/2b) + (2b/a)]^2$, for $a \geq 2b$;
$c_{xa} = [1 + (a/2b)^2]^2$, for $a < 2b$;

− for transverse stiffeners:

$c_{fy} = c_s F_{Kiy} (1 + c_{py})\pi^2/(nb)^2$;

$$c_{py} = \frac{1}{1 + \frac{0,91\left(\frac{12 \times 10^4 I_y}{t^3 a} - 1\right)}{c_{ya}}};$$

$c_{ya} = [(nb/2a) + (2a/nb)]^2$, for $nb \geq 2a$;
$c_{ya} = [1 + (nb/2a)^2]^2$, for $nb < 2a$;
c_s − factor accounting for the boundary conditions of the transverse stiffener;
$c_s = 1,0$ − for simply supported stiffeners;
$c_s = 2,0$ − for partially constraint stiffeners;
z_{st} − net section modulus of stiffener (longitudinal or transverse), in cm^3, including effective width of plating according to **7.10.6.29**.

If no lateral load p is acting, the bending stress σ_b shall be calculated at the midpoint of the stiffener span for that fibre, which results in the largest stress value.

If a lateral load p is acting, the stress calculation shall be carried out for both fibres of the stiffener's cross sectional area (if necessary for the biaxial stress field at the plating side).

7.10.6.31 The longitudinal secondary stiffeners shall comply with the following criteria:

$$(\sigma_x S / k_T \sigma_F) \leq 1,0, \qquad (7.10.6.31)$$

where: k_T − coefficient taken equal to
$k_T = 1,0$, for $\lambda_T \leq 0,2$;
$k_T = 1/[\Phi + (\Phi^2 - \lambda_T^2)^{0,5}]$, for $\lambda_T > 0,2$;
$\Phi = 0,5[1+0,21(\lambda_T - 0,2) + \lambda_T^2]$;
λ_T − reference degree of slenderness taken equal to;
$\lambda_T = (\sigma_F/\sigma_{KiT})^{0,5}$;
$\sigma_{KiT} = (E/I_P)\,[(\pi^2 I_\omega \cdot 10^2/a^2)\varepsilon + 0,385\, I_T]$,Н/мм^2;
for I_P, I_T, I_ω − refer to Fig. 7.10.6.31 and Table 7.10.6.31.
Ip - net polar moment of inertia of the stiffener, in cm^4, related to the point C;
I_T - net St. Venant's moment of inertia of the stiffener, in cm^4;
I_ω − net sectorial moment of inertia of the stiffener, in cm^6, related to the point C;
ε − degree of fixation taken equal to:

$$\varepsilon = 1 + 10^{-3} \sqrt{\frac{a^4}{\frac{3}{4}\pi^4 I_\omega (b/t^3 + 4h_w/3t_w^3)}},$$

h_w − web height, in mm;
t_w − net web thickness, in mm;
b_f − flange breadth, in mm;
t_f − net flange thickness, in mm;
A_w − net web area equal to:
$A_w = h_w \cdot t_w$;
A_f − net flange area equal to:
$A_f = b_f \cdot t_f$;
$e_f = h_w + t_f/2$, in mm.

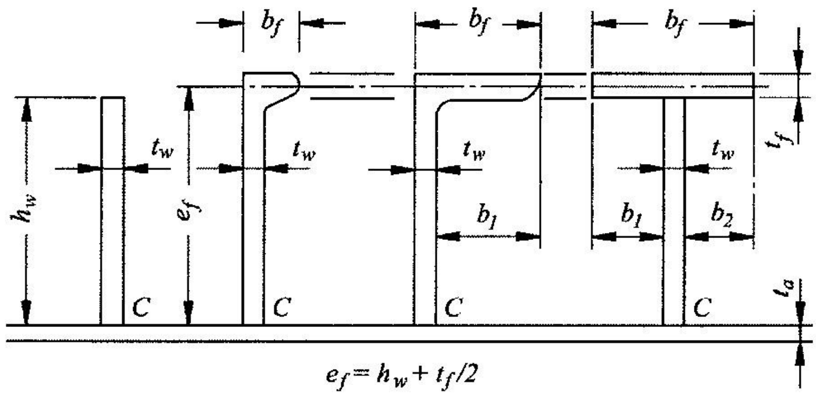


Fig. 7.10.6.31 Dimensions of stiffener

Table 7.10.6.31. **Moments of inertia**

Section	I_p	I_T	I_ω
Flat bar	$(h^3_w t_w)/(3\times10^4)$	$(h_w t^3_w)/(3\times10^4)[1\text{-}0{,}63(t_w/h_w)]$	$(h^3_w t_w)/(36\times10^6)$
Sections with bulb or flange	$[(A_w h^2_w/3)+ A_f e^2_f]10^{-4}$	$(h_w t^3_w)/(3\times10^4)[1\text{-}0{,}63(t_w/h_w)]+$ $(b_f t^3_f)/(3\times10^4)[1\text{-}0{,}63(t_f/b_f)]$	for bulb and angle sections: $\frac{A_f e_f^2 b_f^2}{12\times10^6}\left(\frac{A_f+2{,}6A_W}{A_f+A_W}\right)$ for tee-sections: $(t_f e^2_f b^3_f)/(12\times10^6)$

7.10.6.32 or transverse secondary stiffeners loaded by compressive stresses, which are not supported by longitudinal stiffeners, sufficient torsional buckling strength shall be demonstrated according to**7.10.6.31**.

7.10.6.33 Securing and arrangement of containers on the hatch covers shall comply with the technical requirements for the arrangement and securing of the international standard containers on board the ships intended for container transportation.

Structures under container load shall be calculated according to **7.10.6.5** ÷ **7.10.6.13** using the permissible stresses as per**7.10.6.14**.

7.10.6.34 To ensure weather tightness, the provisions of IACS recommendation No. 14 applicable to hatch covers shall be met.

The packing material of hatch covers gaskets shall be suitable for all expected service conditions of the ship and shall be compatible with the cargoes to be transported.

The packing material shall be selected with regard to dimensions and elasticity in such a way that expected deformations can be carried. Forces shall be carried by the steel structure only.

The packings shall be compressed so as to give the necessary tightness effect for all expected operating conditions. Special consideration shall be given to the packing arrangement in ships with large relative movements between hatch covers and coamings or between hatch cover sections.

7.10.6.35 For hatch covers of cargo holds solely for the transport of containers, at the shipowner's request and subject to compliance with the following conditions, the fitting of weather tight gaskets mentioned in **7.10.6.34** may be dispensed with:

the hatchway coamings shall be not less than 600 mm in height;

the exposed deck, on which the hatch covers are located is situated above a depth $H(x)$,

$H(x)$ shall be shown to comply with the following criteria:

$$H(x) \geq T_{fb} + f_b + h, \text{ м} \qquad (7.10.6.35)$$

wher: T_{fb} − draught, in m, corresponding to the assigned summer load line;

f_b − minimum required freeboard, in m, determined in accordance with regulation **4.1** of the International Load Line Convention, as amended, where applicable;

h = 4,6 m for $x/L_{LL} \leq 0{,}75$;

h = 6,9 m for x/L_{LL} > 0,75.

Labyrinths, gutter bars or equivalents shall be fitted proximate to the edges of each panel in way of the coamings. The clear profile of these openings shall be kept as small as possible.

Where a hatch is covered by several hatch cover panels, the clear opening of the gap in between the panels shall be not wider than 50 mm.

The labyrinths and gaps between hatch cover panels shall be considered as unprotected openings with respect to the requirements of intact and damage stability calculations.

Bilge alarms shall be provided in each hold fitted with non-weathertight covers.

Furthermore, Chapter **3** of IMO circular MSC/Circ. 1087 shall be referred to concerning the stowage and segregation of containers containing dangerous goods.

7.10.6.36 Cross-joints of multi-panel covers shall be provided with efficient drainage arrangements.

7.10.6.37 The net thickness of weather deck hatch coamings shall not be less than that determined by the following formulae:

$$t = 14{,}2s(p_A/0{,}95\sigma_F)^{0,5}, \text{ in mm;} \qquad (7.10.6.37\text{-}1)$$

$$t_{\min} = 6 + L_1/100, \text{ in mm,} \qquad (7.10.6.37\text{-}2)$$

where: s − stiffener spacing, in m;
$L_1 = L$, need not be taken grater than 300 m.

Strength aspects of longitudinal hatch coamings shall meet the requirements of **1.6.5**, Part II "Hull".

7.10.6.38 The stiffeners shall be continuous at the coaming stays. For stiffeners with both ends constraint, the elastic net section modulus Z, in cm^3, and net shear area A_s, in cm^2, calculated on the basis of net thickness, shall not be less than:

$$Z = (83/\sigma_F)\, p_A s l^2; \qquad (7.10.6.38\text{-}1)$$

$$A_s = (10/\sigma_F)\, p_A s l, \qquad (7.10.6.38\text{-}2)$$

where:
s − secondary stiffener span, in m, to be taken as the spacing of coaming stays;
l − = stiffener spacing, in m.

For sniped stiffeners at coaming corners section modulus and shear area at the fixed support shall be increased by 35 %.

The thickness of the coaming plate at the sniped stiffener end shall not be less than those defined as per the formula:

$$t = 19{,}6[(p_A s(l - 0{,}5s)/\sigma_F]^{0,5}, \text{ in mm} \qquad (7.10.6.38\text{-}3)$$

Horizontal stiffeners on hatch coamings, which are part of the longitudinal hull structure, shall be designed according to the requirements in **1.6.5**, Part II "Hull".

7.10.6.39 Coaming stays shall be designed for the loads transmitted through them and permissible stresses according to **7.10.6.14**.

At the connection of the coaming stays with deck (refer to Figs. 7.1.6.39-1 and 7.1.6.39-2), the net section modulus Z, in cm^3, shall be taken not less than:

$$Z = (526/\sigma_F) \cdot p_A \cdot e \cdot h_s^2, \text{ in cm} \qquad (7.10.6.39)$$

where: e − spacing of coaming stays, in m;
h_s – height of coaming stays, in m.

For other designs of coaming stays, such as those shown in Figs. 7.10.6.39-3 and 7.10.6.39-4, the stresses shall be determined through a grillage analysis or FEM. The calculated stresses shall comply with the permissible stresses according to **7.10.6.14**.

Coaming stays shall be supported by appropriate substructures. Face plates may only be included in the calculation if an appropriate substructure is provided and welding provides an adequate joint

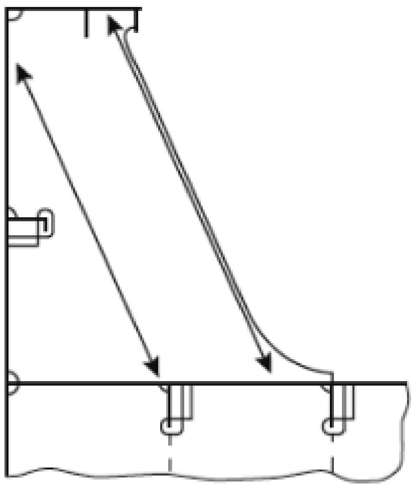


Fig. 7.10.6.39-1

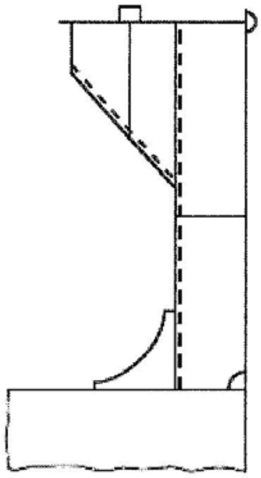


Fig. 7.10.6.39-2

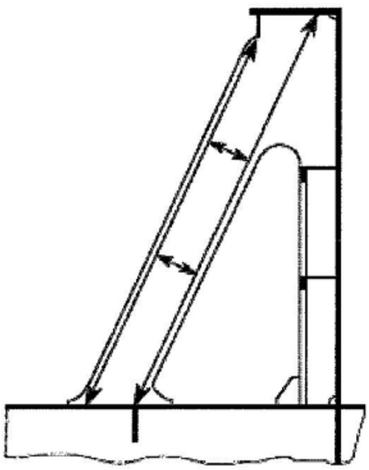


Fig. 7.10.6.39-3

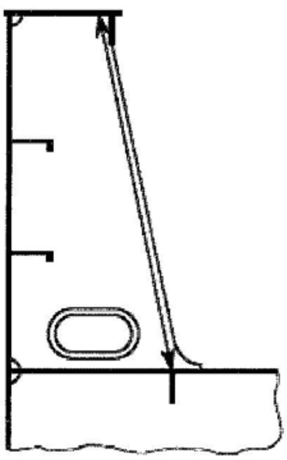


Fig. 7.10.6.39-4

7.10.6.40 0 Web gross thickness t_w, at the root point shall not be less than

$t_w = (2/\sigma_F)(p_A e h_s/h_w) + t_s$, (7.10.6.40)

where: h_w – web height of coaming stay at its lower end, in m;
t_s – corrosion addition, in mm, according to**7.10.6.52**.

Coaming stays shall be connected to the deck by fillet welds on both sides with a throat thickness of a = 0,44 t_w.

7.10.6.41 Hatch coamings which are part of the longitudinal hull structure shall be designed according to the requirements of **1.6.5**, Part II "Hull".

Longitudinal hatch coamings with a length exceeding 0,1L shall be provided with tapered brackets or equivalent transitions and a corresponding substructure at both ends.

At the end of the brackets they shall be connected to the deck by full penetration welds of minimum 300 mm in length.

7.10.6.42 Hatch coamings and supporting structures shall be adequately stiffened to accommodate the loading from hatch covers, in longitudinal, transverse and vertical directions. Structures under deck shall be checked against the load transmitted by the stays.

Structures under deck shall be checked against the load transmitted by the stays.

Unless otherwise stated, weld connections shall be dimensioned according to **1.7**, Part II "Hull" and materials shall be selected according to **2.2**, Part XIV "Welding".

7.10.6.43 On ships carrying cargo on deck, such as timber, coal or coke, the stays shall be spaced not more than 1,5 m apart.

Coaming plates shall extend to the lower edge of the deck beams or hatch side girders shall be fitted that extend to the lower edge of the deck beams. Extended coaming plates and hatch side girders shall be flanged or fitted with face bars or half-round bars. Fig. 7.10.6.43 gives an example.

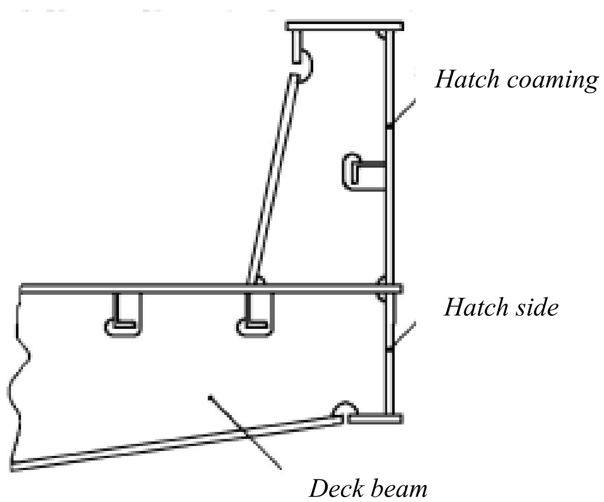


Fig. 7.10.6.43

7.10.6.44 If drain channels are provided inside the line of gasket by means of a gutter bar or vertical extension of the hatch side and end coaming, drain openings shall be provided at appropriate positions of the drain channels.

Drain openings in hatch coamings shall be arranged with sufficient distance to areas of stress concentration (e.g. hatch corners, transitions to crane posts).

Drain openings shall be arranged at the ends of drain channels and shall be provided with non-return valves to prevent ingress of water from outside. It is unacceptable to connect fire hoses to the drain openings for this purpose.

If a continuous outer steel contact between cover and ship structure is arranged, drainage from the space between the steel contact and the gasket shall be also provided.

7.10.6.45 Securing devices between cover and coaming and at cross-joints shall be installed to provide weathertightness.

Securing devices shall be appropriate to bridge displacements between cover and coaming due to hull deformations. These devices shall be of reliable construction and effectively attached to the hatchway coamings, decks or covers. Individual securing devices on each cover shall have approximately the same stiffness characteristics.

Sufficient number of securing devices shall be provided at each side of the hatch cover considering the requirements of **7.10.6.20**; this applies also to hatch covers consisting of several parts.

7.10.6.46 Where rod cleats are fitted, resilient washers or cushions shall be incorporated.

Where hydraulic cleating is adopted, positive means shall be provided so that it remains mechanically locked in the closed position in the event of failure of the hydraulic system.

7.10.6.47 The gross sectional area, in cm^2, shall not be less than that defined by the formula

$$A = 0{,}28 q s_{SD} k_l, \qquad (7.10.6.47)$$

where: q − packing line pressure, in N/mm, minimum 5 N/mm;

s_{SD} − spacing between securing devices, in m, but not less than 2 m;

$k_l = (235/\sigma_F)^e$;

σ_F − minimum yield strength of the material, in N/mm^2, but not greater than $0{,}7\sigma_m$, where σ_m - is the tensile strength of the material, in N/mm^2;

e − 0,75 for $\sigma_F > 235$ N/mm^2;

e − 1,00 for $\sigma_F \le 235$ N/mm^2.

For hatchways exceeding 5 m^2, rods and bolts shall have a gross diameter no less than 19 mm.

Securing devices of special design in which significant bending or shear stresses occur may be designed as anti-lifting devices according to **7.10.6.48**.

As load the packing line pressure q multiplied by the spacing between securing devices s_{SD} shall be applied.

7.10.6.48 The securing devices of hatch covers, on which cargo is lashed, shall be designed for the lifting forces resulting from loads according to **7.10.6.11** ÷ **7.10.6.13**, refer to Fig. 7.10.6.48.

Unsymmetrical loadings, which may occur in practice, shall be considered. Under these loadings the equivalent stress in the securing devices shall not exceed

$$\sigma_V = 150/k_l, \ N/mm^2 \qquad (7.10.6.48)$$

Note. The partial load cases given in Table 7.10.6.12 may not cover all unsymmetrical loadings, critical for hatch cover lifting.

Chapter 5.6 of IACS Recommendation No. 14 shall be referred to for the omission of anti-lifting devices.

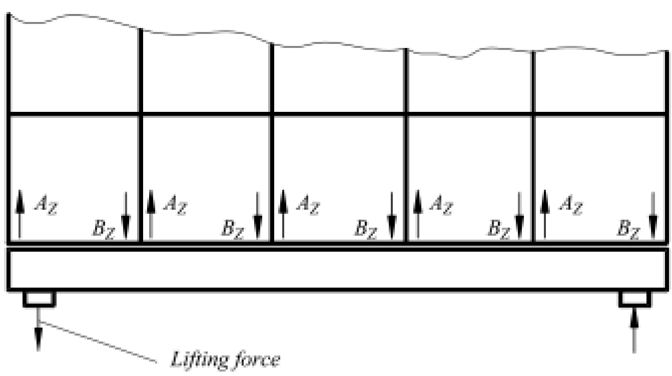


Fig. 7.10.6.48. Lifting forces at a hatch cover

7.10.6.49 For the design of the hatch cover supports, the horizontal mass forces $F_h = ma$ shall be calculated with the following accelerations:

$a_x = 0{,}2g$ in longitudinal direction;

$a_y = 0{,}2g$ in transverse direction;

m – sum of mass of cargo lashed on the hatch cover and mass of hatch cover.

The accelerations in longitudinal direction and in transverse direction do not need to be considered as acting simultaneously.

7.10.6.50 For the transmission of the support forces resulting from the load cases specified in **7.10.6.5** ÷ **7.10.6.13**, and of the horizontal mass forces specified in **7.10.6.49**, supports shall be provided which shall be designed such that the nominal surface pressures in general do not exceed the following values:

$$p_{n\max} = dp_n, \text{ N/mm}^2, \quad (7.10.6.50\text{-}1)$$

where: $d = 3{,}75 - 0{,}015L$;

$d_{\max} = 3{,}0$;

$d_{\min} = 1{,}0$ in general;

$d_{\min} = 2{,}0$ for partial loading conditions, refer to **7.10.6.12**;

p_n– refer to Table 7.10.6.50.

Table 7.10.6.50 . **Permissible nominal surface pressure p_n**

Support material	p_n, in N/mm^2, when loaded by	
	vertical force	horizontal force (on stoppers)
Hull structural steel	25	40
Hardened steel	35	50
Lower friction materials	50	–

For metallic supporting surfaces not subjected to relative displacements, the nominal surface pressure shall be calculated by the formula:

$$p_{n\max} = 3p_n, \text{ N/mm}^2. \quad (7.10.6.50\text{-}2)$$

Where large relative displacements of the supporting surfaces are expected, the use of material having low wear and frictional properties is recommended.

The substructures of the supports shall be of such a design, that a uniform pressure distribution is achieved.

Irrespective of the arrangement of stoppers, the supports shall be able to transmit the following force P_h in the longitudinal and transverse directions:

$$P_h = \mu P_V / \sqrt{d}. \quad (7.10.6.50\text{-}3)$$

where: P_V – vertical supporting force;

μ – frictional coefficient, in general equal to 0,5.

For non-metallic, low-friction support materials on steel, the friction coefficient may be reduced but not to be less than 0,35.

Supports as well as the adjacent structures and substructures shall be designed such that the permissible stresses according to **7.10.6.14** are not exceeded.

7.10.6.51 Hatch covers shall be sufficiently secured against horizontal shifting. Stoppers shall be provided for hatch covers, on which cargo is carried.

The greater of the loads resulting from **7.10.6.8** and **7.10.6.49** shall be applied for the dimensioning of the stoppers and their substructures.

The permissible stress in stoppers, their substructures, in the cover, and of the coamings shall be determined according to **7.10.6.14**; in addition, the provisions in **7.10.6.50** shall be observed.

7.10.6.52 Corrosion additions (corrosion allowance) t_s, in mm, for hatch covers and hatch coamings are given in Table **7.10.6.52**.

Table 7.10.6.52. **Corrosion additions t_s, for hatch covers and hatch coamings**

Application	Structure	t_s, in mm,
Weather deck hatches of container ships, car carriers, paper carriers, passenger vessels	Hatch covers	1,0
	Hatch coamings	According to **1.1.5.1**, Part II "Hull"
Weather deck hatches of all other ship types	Hatch covers in general	2,0
	Weather exposed plating and bottom plating of double skin hatch covers	1,5
	Internal structure of double skin hatch covers and closed box girders (hollow beams)	1,0
	Hatch coamings not part of the longitudinal hull structures	1,5
	Hatch coamings part of the longitudinal hull structures	According to **1.1.5.1**, Part II "Hull"
	Coaming stays and stiffeners	1,5

7.10.6.53 Steel renewal is required where the gauged thickness is less than t_{net} + 0,5 mm for:
single skin hatch covers;
the plating of double skin hatch covers, and
coaming structures the corrosion additions t_s of which are provided in Table 7.10.6.52.

Where the gauged thickness is within the range t_{net} + 0,5 mm to t_{net} + 1,0 mm, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal. Coating shall be maintained in GOOD condition, as defined in 1.2, IACS UR Z10.2 (Rev.36 May 2019).

For the internal structure of double skin hatch covers, thickness gauging is required when hatch cover top or bottom plating renewal shall be carried out or when this is deemed necessary, at the discretion of the surveyor to the Register, on the basis of the plating corrosion or deformation condition. In these cases, steel renewal for the internal structures is required where the gauged thickness is less than t_{net}.

For corrosion addition t_s = 1,0 mm, the thickness for steel renewal is t_{net}, and the thickness for coating or annual gauging is when gauged thickness is between t_{net} and t_{net} + 0,5 mm.

For coaming structures, the corrosion additions t_s of which are not provided in Table 7.10.6.52 shall be in compliance with the requirements of **1.1.5** Part II "Hull".

7.11 HATCHWAYS OF CARGO TANKS IN TYPE "A" SHIPS, OIL TANKERS, OIL TANKERS (>60ºC), OIL RECOVERY SHIPS AND OIL RECOVERY SHIPS (>60ºC)

7.11.1 Height of the coamings of cargo tank hatchways intended for the carriage liquid cargoes is not regulated by the Register. Construction of the coamings of cargo tank hatchways shall comply with the requirements of **3.5.5.1**, Part II "Hull".

7.11.2 Covers of hatches and tank cleaning openings shall be made of steel, bronze or brass.

7.11.3 Covers of the cargo tank hatchways shall be permanently attached or fixed with closely spaced bolts and tight, when secured, under the inner pressure of liquid carried in tanks to a head of not less than 2,5 m. Tightness shall be provided by a rubber or other suitable gasket being resistant to the liquids which are carried in the cargo tanks.

7.12 OPENINGS IN WATERTIGHT SUBDIVISION BULKHEADS AND THEIR CLOSING APPLIANCES

7.12.1 General.

7.12.1.1 Unless expressly provided otherwise, this Chapter covers ships to which the requirements of

Part V "Subdivision" apply.

For other ships, the requirements of this Chapter apply to bulkheads which installation is covered by **2.7.1.3** of Part II "Hull"; for these ships, the requirements may be relaxed provided the analysis confirming safety of the ship has been submitted.

In ships indicated in **7.12.6.1**, the requirements of **7.12.2** ÷ **7.12.5** may be relaxed for doors fitted in watertight subdivision bulkheads dividing a cargo space from an adjoining cargo space provided the requirements of **7.12.6** are met.

7.12.1.2 The number of openings in watertight bulkheads shall be reduced to a minimum compatible with the design and normal service conditions of the ship.

7.12.1.3 Where piping and electric cables are carried through watertight subdivision bulkheads, the requirements of **5.1**, Part VIII "Systems and Piping" and of **16.8.6**, Part XI "Electrical Equipment" shall be taken into consideration.

7.12.2 Doors in watertight subdivision bulkheads. General.

7.12.2.1 The doors shall be made of steel. The use of other materials may be allowed provided it is confirmed by calculations and tests that they have a strength at least equivalent to that of the doors made of steel.

7.12.2.2 Doors shall withstand the pressure of a water head of the height measured from the lower edge of a doorway at the place of its location to the underside of bulkhead deck plating, the freeboard or the most adverse damage waterline, whichever is greater.

7.12.2.3 Under the effect of water head specified in **7.12.2.2**, the stresses in the door frame and door plate shall not exceed 0,6 times the upper yield stress of their material.

7.12.2.4 When closed, the doors shall be tight under the pressure of a water head of the height specified in **7.12.2.2**.

7.12.2.5 Each means of operation of the doors shall alone ensure closure of the door with the ship listed 15° either way and with a trim up to 5°.

Doors closed by dropping or by the effect of a dropping weight are not permitted. Portable plates secured by bolts only are not permitted.

7.12.3 Regulations concerning the positioning of doors.

7.12.3.1 No doors are permitted in:

collision bulkhead below the bulkhead deck of ships having a subdivision distinguishing mark in the class notation and below the freeboard deck of all other ships;

watertight subdivision bulkheads dividing a cargo space from an adjoining cargo space except where the Register is satisfied that such doors are essential. In this case, the doors may be hinged, sliding or of another equivalent type, but they shall not be remotely controlled.

In passenger ships and special purpose ships, as well as in ships with subdivision distinguishing mark in the class notation, the outboard vertical edges of the doors shall not be located at less than 0,2 of the ship breadth. This distance shall be measured at right angles to the centreline of the ship at the level of the deepest subdivision loadline.

7.12.3.2 In addition to doors at entrances to propeller shaft tunnels, not more than one door may be provided in each watertight subdivision bulkhead within spaces containing main engines, boilers and auxiliary machinery.

Where two or more propeller shafts are fitted, their tunnels shall be connected by a passageway. In a twinscrew ship, there shall only be one door between the engine room and tunnel spaces, and if the propellers are more than two, only two doors shall be provided. All the doors shall be located as high as practicable.

Hand gear for operating the doors from above the bulkhead deck and for operating doors at entrances to shaft tunnels shall be fitted outside the engine room.

7.12.4 Doors in cargo ships.

7.12.4.1 The requirements of **7.12.4** apply to doors fitted in the subdivision bulkheads of cargo ships except the doors of special purpose ships and those mentioned under **7.12.6**.

7.12.4.2 The doors shall be sliding doors with horizontal or vertical motion, they shall be both handand power-operated.

If hand-operated, it shall be possible to open and close the door from both sides of the bulkhead.

If power-operated, closing of the doors from the control station on the navigation bridge shall be possible.

7.12.4.3 At the door control stations, visual indicators shall be provided to show whether the doors are open or closed. An alarm shall be provided to control the door closing.

Power source, control station and indicators shall be operable in the case of main power source failure. Special attention shall be paid to minimizing the effects of the control system failure.

7.12.5 Doors in passenger ships and special purpose ships.

7.12.5.1 The requirements of **7.12.5** apply to doors fitted in the subdivision bulkheads of passenger ships and special purpose ships except those mentioned in **7.12.6**.

7.12.5.2 The doors shall be sliding doors with horizontal or vertical motion, they shall be both handand power-operated.

The maximum width of the door aperture shall not exceed 1,2 m. Installation of doors with the aperture width in excess of 1,2 m shall be substantiated by calculations confirming their equivalent strength to the bulkhead in which they are fitted.

7.12.5.3 If the door is hand-operated, it shall be possible to manually open and close the door from both sides in the close proximity of the door and, in addition, close the door from an assessable place above the bulkhead deck by means of a hand wheel, handle or any other similar gear ensuring the same degree of safety. The force applied to the hand wheel, knob or similar gear while the door is in motion shall not exceed 157 N.

If the door is not visible from the position above the bulkhead deck where the gear is fitted, indicators shall be provided showing the positions of the hand wheel, knob and similar gear at which the door is open or closed.

When hand-operated, the time necessary for a complete closure of the door shall not exceed 90 s with the ship upright.

7.12.5.4 Door control knobs shall be fitted on either side of the bulkhead at a minimum height of 1,6 m above deck plating and so arranged as to enable persons passing through the doorway to hold both the knobs in a position preventing door closure.

The direction of movement of the handles in opening and closing the door shall be in the direction of door movement and shall be clearly indicated.

7.12.5.5 The power gear shall be controllable (i.e. door opening and closing shall be possible) by local control stations on either side of the bulkhead.

Besides being controlled directly at the door, the power gear shall also be controllable (for door closure) from the main control station.

Remote opening of any door from the main control station shall not be possible.

The main control station for doors shall be located in the wheelhouse.

7.12.5.6 The power gear shall ensure door closure in not more than 40 s and not less than 20 s with the ship upright, as well as a simultaneous closure of all doors within not more than 60 s.

7.12.5.7 The power gear of the doors shall have either:

.1 a centralized hydraulic system with two independent power sources each consisting of a motor and pump capable of simultaneously closing all doors.

In addition, there shall be for the whole installation hydraulic accumulators of sufficient capacity to operate all the doors at least three times, i.e. closed - open - closed at unfavourable conditions of heel up to 15°; or

.2 an independent hydraulic system for each door with each power source consisting of a motor and pump capable of opening and closing the door. In addition, there shall be a hydraulic accumulator of sufficient capacity to operate the door at least three times, i.e. closed - open - closed at unfavourable conditions of heel up to 15°; or

.3 an independent electrical system and motor for each door with each power source consisting of a motor capable of opening and closing the door. The power source shall be capable of being automatically supplied by a transitional emergency source of electrical power, as required by **19.1.2.7**, Part XI "Electrical Equipment" in the event of failure of either the main or emergency source of electrical power and with sufficient capacity to operate the door at least three times, i.e. closed - open - closed at unfavourable conditions of heel up to 15°.

7.12.5.8 Door controls, including hydraulic piping and electric cables, shall be kept as close as practicable to the bulkhead in which the doors are fitted, in order to minimize the likelihood of them being involved in any damage which the ship may sustain.

7.12.5.9 Each door shall be provided with an audible alarm, distinct from any other alarm in the area, which will sound whenever the door is closed remotely by power and which shall sound for at least five seconds, but not more than ten seconds, before the door begins to more, and shall continue sounding until the door is completely closed. In the case of remote hand operation it is sufficient for the audible alarm to sound only when the door is moving.

In passenger areas and areas of high ambient noise the Register may require the audible alarm to be supplemented by an intermittent visual signal at the door.

7.12.5.10 The central operating console at the navigation bridge shall have a switch with two modes of control:

a "local control" mode which shall allow any door to be locally opened and closed without automatic closure and

a "doors closed" mode which shall allow doors to be opened locally and shall automatically reclose the doors upon release of the local control mechanism.

The switch shall normally be in the "local control" position. The "doors closed" position shall only be used in an emergency or for testing purposes.

7.12.5.11 The central operating console at the navigation bridge shall be provided with a diagram showing the location of each door, with visual indicators to show whether each door is open or closed. A red light shall indicate a door fully open and a green light shall indicate a door fully closed. When a door is closed remotely, the red light shall indicate the intermediate position by flashing. The indicating circuit shall be independent of the control circuit for each door.

It shall not be possible to remotely open any door from the central operating console.

7.12.5.12 Where trunkways or tunnels for access from crew accommodation to the stokehold, for piping, or for any other purpose are carried through main transverse watertight bulkheads, they shall be watertight. The access to at least one end of each such tunnel or trunkway, if used as a passage at sea, shall be through a trunk extending watertight to a height sufficient to permit access above the margin line. The access to the other end of the trunkway or tunnel may be through a watertight door of the type required by its location in the ship. Such trunkways or tunnels shall not extend through first subdivision bulkhead abaft the collision bulkhead.

7.12.5.13 Where ventilating trunks in connection with refrigerated cargo and ventilation or forced draught trunks are carried through more than one watertight bulkhead, the means of closure at such openings shall be operated by power and be capable of being closed from the main control station situated above the bulkhead deck.

7.12.5.14 If the Register is satisfied that such doors are essential, watertight doors of satisfactory construction may be fitted in watertight bulkheads dividing cargo between deck spaces. Such doors may be hinged, rolling or sliding doors but shall not be remotely controlled. They shall be fitted at the highest level and as far from the shell plating as practicable, but in no case shall the outboard vertical edges be situated at a distance from the shell plating which is less than 0,2 of the breadth of the ship, as defined in **7.12.3.1**.

If any of such doors shall be accessible during the voyage, they shall be fitted with a device, which prevents unauthorized opening.

7.12.5.15 Portable plates on bulkheads shall not be permitted except in machinery spaces. The Register may permit not more than one power-operated sliding watertight door in each watertight bulkhead larger than those specified in **7.12.5.2** to be substituted for these portable plates, provided these doors are intended to remain closed during navigation except in case of urgent necessity at the discretion of master. These doors need not meet the requirements of **7.12.5.3** regarding complete closure by handoperated gear in 90 s.

7.12.5.16 For passenger ships and special purpose ships carrying more than 60 persons having length of 120 m or more or having three or more main vertical zones, the power operated doors shall comply with the requirements of **2.2.6.8**, Part VI "Fire Protection" (refer also to **2.2.6.7.3** of the above Part).

7.12.5.17 Plates with instructions on doors operation are to be provided on both sides of the door. Plates with text or pictures that warning of the danger of remaining in the doorway when the doors begin to close.

These plates are to be of reliable material and properly secured. The text of the instruction or warning plate shall include information about the closing of these doors.

7.12.5.18 In passenger ships of restricted areas of navigation **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS** and **D-R3-S**, **D-R3-RS**:

.1 with length less than 24 m slide doors may be only with manual drive or both with manual and mechanical drive;

with length 24 m and over, where the total number of watertight doors does not exceed two and these doors are located in the engine room or in bukheads separating this room, only doors with manual drive are allowed.

If sliding doors with a manual drive are installed, such doors are to be closed before the beginning of the voyage with passengers on board, and remain closed during the whole voyage;

.2 with length less than 24 m watertight doors that do not comply with the requirements of **7.12.2.5** , **7.12.5.2** and **7.12.5.18.1** may be installed provided that they are to be closed before the the voyage and remain closed during the whole voyage; The time of such doors opening in the port and closing before leaving the port is to be entered in the logbook;

7.12.6 Doors in ships designed for the carriage of vehicles.

7.12.6.1 The requirements of **7.12.6** apply to doors fitted in watertight subdivision bulkheads separating a cargo space from an adjacent cargo space in ships designed for the carriage of vehicles and covered by the requirements of Part V "Subdivision", if the total number of persons on board (excluding the master and the members of the crew or other persons employed or engaged in any capacity on board a ship on the business of that ship, and also a child under one year of age) is not greater than the value N determined by the formula

$$N = 12 + 0{,}04A, \tag{7.12.6.1}$$

where: A – total deck area, in m^2, of spaces available for the stowage of vehicles where the clear height at the stowage position and at the entrances to such spaces is not less than 4 m.

7.12.6.2 The doors specified in **7.12.6.1** may be fitted at any level if the Register is satisfied that such doors are essential for the movement of the vehicles in the ship.

7.12.6.3 The doors specified in **7.12.6.1** shall be fitted as far from the shell plating as practicable, but in no case shall the outboard vertical edge of the door be situated at a distance from the shell plating that is less than 0,2 of the breadth of the ship, such distance being measured at right angles to the centreline of the ship at the level of the subdivision loadline.

7.12.6.4 The doors specified in **7.12.6.1** may be of the following types: hinged, sliding or rolling but they shall not be controlled remotely.

The doors shall be fitted with devices ensuring watertightness, securing and locking. When the sealing material of the door is not classed as non-combustible (refer to **1.6.3.1**, Part VI "Fire Protection"), the gasket shall be suitably protected from the effects of fire by a method approved by the Register.

The doors shall be fitted with a device which prevents unauthorized opening.

7.12.6.5 The doors specified in 7.12.6.1 shall be so designed that they could be opened and closed both in case of unloaded and loaded decks, the deck deflections under the effect of the stowed cargo being taken into account.

The securing devices of the door shall be so designed that account is taken of the deck deflections under the effect of the stowed cargo resulting in relative displacement of the structural elements of the bulkhead and the door.

7.12.6.6 Where watertightness is ensured by rubber or other suitable gaskets and securing devices, at each corner of the door or door section (if any) the securing devices shall be fitted.

The securing devices of such doors shall be designed to withstand the following forces, in kN:

F_1 – for securing devices fitted at the lower edge of the door;

F_2 – for securing devices fitted at the upper edge of the door;

F_3 – for securing devices fitted at the vertical edge of the door.

These forces shall be determined by the formulae

$$F_1 = \frac{9{,}81A}{n_1}\left(\frac{H_1}{2} - \frac{h}{6}\right) + 29{,}42; \tag{7.12.6.6-1}$$

$$F_2 = \frac{9{,}81A}{n_2}\left(\frac{H_1}{2} - \frac{h}{3}\right) + 29{,}42; \tag{7.12.6.6-2}$$

$$F_3 = \frac{a}{A}\left[F_1(n_1 - 1)h_i + F_2(n_2 - 1)(h - h_i)\right], \tag{7.12.6.6-3}$$

where: A – clear area of the door, in m^2,

H_1 – vertical distance from the lower edge of the door opening to the lower edge of the plating of the bulkhead deck at the centreline of the ship, in m, but not less than 5 m;

h – clear height of the door, in m;

h_i – vertical distance from the securing device considered to the upper edge of the door, in m;

a – half the sum of the vertical distances from the securing device considered to the nearest upper and lower securing devices, in m;

n_1 – =number of the securing devices fitted on the lower edge of the door;

n_2 – =number of the securing devices fitted on the upper edge of the door.

When the securing device is under the effect of the design force F_1, F_2 or F_3 the stresses in its parts shal not exceed 0,5 times the upper yield stress of material.

7.12.6.7 The operation of the doors specified in **7.12.6.1** shall be by means of local control only. On the bridge indicators shall be provided to show automatically that each door is closed and all door fastenings are secured.

7.12.6.8 The requirements of **7.12.2.2** ÷ **7.12.2.4** are also applicable to doors specified under **7.12.6.1**.

7.12.7 Manholes in watertight subdivision bulkheads.

7.12.7.1 The requirements of **7.9** relating to the manholes located on the freeboard deck, raised quarter deck or the first tier of superstructures are generally applicable to the manholes fitted in the watertight subdivision bulkheads.

No manholes are permitted:

.1 in the collision bulkhead below the bulkhead deck for ships having subdivision distinguishing mark in the class notation, and below the freeboard deck for other ships;

.2 in watertight subdivision bulkheads separating a cargo space from an adjacent cargo space or a fuel oil tank.

7.13 CARGO HATCH COVERS OF BULK CARRIERS, ORE CARRIERS AND COMBINATION CARRIERS

7.13.1 The design of cargo hatch covers for bulk carriers, ore carriers and combination carriers shall comply with the requirements in **7.10.1**, **7.10.2**, **7.10.3.4**, **7.10.3.5** and **7.10.4**.

For bulk carriers of 90 m in length and above, contracted for construction on or after 1 July 2015, the requirements for cargo hatch covers are regulated by Common Structural Rules for Bulk Carriers and Oil Tankers.

7.13.2 Cargo hatch covers shall be made of steel. The use of other materials may be allowed provided it is confirmed by calculations and tests that they have a strength at least equivalent to that of the hatch covers made of steel.

7.13.3 The pressure P, in kPa, on the hatch cover panels located on the freeboard deck is determined by the formulae:

for ships of 100 m in length and above

$$P = 34{,}3 + \frac{P_{FP} - 34{,}3}{0{,}25}\left(0{,}25 - \frac{X}{L}\right) \geq 34{,}3 \qquad (7.13.3\text{-}1)$$

where: P_{FP} – pressure at the fore perpendicular to be determined by the formula

P_{FP} = 49,1+(L-100)a ;

a = 0,0726 – for type "B" freeboard ships;

a = 0,356 – for ships with reduced freeboard;

L – ship's length, but not more than 340 m;

X – distance, in m, of the midlength of the hatch cover under consideration from the forward end of L.

Where a position 1 hatchway is located at least one superstructure standard height higher than the freeboard deck, the pressure P may be taken equal to 34,3 kPa;

for ships less than 100 m in length

$$P = 15{,}8 + \frac{L}{3}\left(1 - \frac{5X}{3L}\right) \geq 0{,}195L + 14{,}9, \qquad (7.13.3\text{-}2)$$

Where two or more panels are connected by hinges, each individual panel shall be considered separately.

7.13.4 The normal σ_a and shear τ_a stresses in the hatch cover structures shall not exceed the permissible values:

$\sigma_a = 0{,}8\,R_{eH}$;

$\tau_a = 0{,}46\,R_{eH}$;

where: R_{eH} – upper yield stress of the hatch cover material.

The normal stressing compression of the attached flange of primary supporting members shall not exceed 0,8 times the critical buckling stress of the structure according to the calculations given in **7.13.9** ÷ **7.13.11**.

The stresses in hatch covers that are designed as a grillage of longitudinal and transverse primary supporting members shall be determined by a grillage or a finite element analysis.

When a beam or a grillage analysis is used, the secondary stiffeners shall not be included in the attached flange area of the primary members.

When calculating the stresses σ and τ the net scantlings (no allowance for corrosion and wear) of hatch cover structure elements shall be used.

7.13.5 The effective flange area A_F, in cm^2, of the attached plating, to be considered for the yielding and buckling checks of primary supporting members or grillages, is obtained as the sum of the effective flange areas of each side of the girder web:

$$A_F = \sum_{nf} (10 b_{ef} t) \qquad (7.13.5)$$

where: nf = 2 if attached plate flange extends on both sides of a girder web;

nf = 1 – 1 if attached plate flange extends on one side of a girder web only;

t – thickness of attached plate, in mm;

b_{ef} – effective breadth, in m, of attached plate flange on each side of a girder web assumed equal to b_p, but not more than 0,165l;

b_p – half distance, in m, between the considered primary supporting member and the adjacent one;

l – span, in m, of primary supporting members.

7.13.6 The net thickness t, in mm, of the hatch cover top plating shall be not less than

$$t = F_p 15{,}8 s \sqrt{\frac{p}{0{,}95\sigma_F}} \qquad (7.13.6)$$

where: F_p - =factor equal to:

1,9 – if ratio $\sigma/\sigma_a \geq 0{,}8$;

1,5 – in other cases;

s – stiffener spacing, in m;

p – pressure, in kPa, according to **7.13.3**;

σ – according to **7.13.8**;

σ_a - according to **7.13.4**,

and not less than 1 % of the stiffener spacing or 6 mm, whichever is greater.

7.13.7 The required minimum section modulus Z, in cm^3, of secondary stiffeners of the hatch cover top plates, based on stiffener net member thickness, are given by

$$Z = \frac{l^2 sp}{12\sigma_a} 10^3 \tag{7.13.7}$$

where: l – secondary stiffener span, in m, to be taken as the spacing of primary supporting members or the distance between a primary supporting member and the edge support, as applicable.

When brackets are fitted at both ends of all secondary stiffener spans, the secondary stiffener span may be reduced by an amount equal to 2/3 of the minimum brackets arm length, but not greater than 10 % of the gross span, for each bracket

s – secondary stiffener spacing, in m;

p – pressure, in kPa, according to **7.13.3**;

σ_a – according to **7.13.4**.

The net section modulus of the secondary stiffeners shall be determined based on an attached plate width assumed equal to the stiffener spacing.

7.13.8 The section modulus value and web thickness of primary supporting members, based on member net thickness, shall be such that the normal stress σ in both flanges and the shear stress τin the web do not exceed the permissible values σ_a i τ_a, respectively, defined according to**7.13.4**.

The width of the primary supporting members flange shall be not less than 40 % of their depth for laterally unsupported spans greater than 3,0 m.

Tripping brackets attached to the flange may be considered as a lateral support for primary supporting members.

The flange outstand shall not exceed 15 times the flange thickness.

7.13.9 The compressive stress s in the hatch cover plate panels, induced by the bending of primary supporting members parallel to the direction of secondary stiffeners, shall not exceed 0,8 times the critical buckling stress σ_{C1}, to be evaluated as follows:

$\sigma_{C1} = \sigma_{E1}$, when $\sigma_{E1} \le \sigma_F/2$; or

$$\sigma_{C1} = \sigma_F \left[1 - \frac{\sigma_F}{4\sigma_{E1}}\right] \quad \text{when } \sigma_{E1} > \sigma_F/2 , \tag{7.13.9-1}$$

where: σ_F - minimum upper yield stress of the material, in N/mm^2;

$$\sigma_{E1} = 3{,}6E\left(\frac{t}{1000s}\right)^2 \quad ;$$

where: E – modulus of elasticity, in N/mm^2 to be assumed $2{,}06 \cdot 10^5$ N/mm^2 for steel.

t - net thickness of plate panel, in mm;

s - pacing of secondary stiffeners, in m.

The mean compressive stress σ in each of the hatch cover plate panels, induced by the bending of primary supporting members perpendicular to the direction of secondary stiffeners, shall not exceed 0,8 times the critical buckling stress σ_{C2}, to be evaluated as follows:

$\sigma_{C2} = \sigma_{E2}$, when $\sigma_{E2} \le \sigma_F/2$, or

$$\sigma_{C2} = \sigma_F \left[1 - \frac{\sigma_F}{4\sigma_{E2}}\right], \quad \text{when } \sigma_{E2} > \sigma_F/2 , \tag{7.13.9-2}$$

where: σ_F - minimum upper yield stress of the material, in N/mm^2;

$$\sigma_{E2} = 0{,}9mE\left(\frac{t}{1000s_s}\right)^2 \quad ;$$

де: $m = c\left[1+\left(s_s/l_s\right)^2\right]^2 \dfrac{2{,}1}{\psi+1{,}1}$;

E – modulus of elasticity, in N/mm^2;
t – net thickness of plate panel, in mm;
s_s – length of the shorter side of the plate panel, in m;
l_s – length of the longer side of the plate panel, in m;
ψ - ratio between the smallest and largest compressive stress;
c - коефіцієнт, що дорівнює:
1,3 when plating is stiffened by primary supporting members;
1,21 when plating is stiffened by secondary stiffeners of angle or T-type;
1,1 when plating is stiffened by secondary stiffeners of bulb type;
1,05 when plating is stiffened by flat bar.

7.13.10 The compressive stress in the top flange of secondary stiffeners, induced by the bending of primary supporting members parallel to the direction of secondary stiffeners, shall not exceed 0,8 times the critical buckling stress σ_{CS}, to be evaluated as follows:

$$\sigma_{CS} = \sigma_{ES}, \text{ when } \sigma_{ES} \le \sigma_F/2 \text{ , or}$$

$$\sigma_{CS} = \sigma_F\left[1-\frac{\sigma_F}{4\sigma_{ES}}\right], \quad \text{when } \sigma_{ES} > \sigma_F/2 \qquad (7.13.10)$$

where: σ_F - minimum upper yield stress of the material, in N/mm^2;

σ_{ES} - ideal elastic buckling stress, in N/mm^2, of the secondary stiffener to be assumed as the minimum between σ_{E3} and σ_{E4};

$$\sigma_{ES} = \frac{EI_a}{Al^2}10^{-3} \; ;$$

E – modulus of elasticity, in N/mm^2;

I_a - moment of inertia, in cm^4, of the secondary stiffener, including an effective flange equal to the spacing of secondary stiffeners;

A - cross-sectional area, in cm^2, of the secondary stiffener, including an effective flange equal to the spacing of secondary stiffeners;

l - span, in m, of the secondary stiffener;

$$\sigma_{E4} = \frac{\pi^2 EI_w}{10^4 I_p l^2}\left(m^2 + \frac{K}{m^2}\right) + 0{,}385\,E\,\frac{I_t}{I_p},$$

where:

$$K = \frac{Cl^4}{\pi^4 EI_w}\cdot 10^6;$$

m – number of half waves, given by the following table 7.13.10;

Table 7.13.10

$0 < K \le 4$	$4 < K \le 36$	$36 < K \le 144$	$(m-1)^2 m^2 < K \le m^2(m+1)^2$
$m = 1$	$m = 2$	$m = 3$	m, being determined according to K value

l_W - sectional moment of inertia, in cm^6, of the secondary stiffener about its connection with the plating;

$$l_W = \frac{h_W^3 t_W^3}{36} 10^{-6}$$ - for flat bar secondary stiffeners;

$$l_W = \frac{f_t b_f^3 h_W^3}{36} 10^{-6}$$ - for T-section secondary stiffeners;

$$I_w = \frac{b_f^3 h_w^2}{12(b_f + h_w)^2} [t_f(b_f^2 + 2b_f h_w + 4h_w^2) + 3t_w b_f h_w] 10^{-6}$$ - for angles and bulb secondary stiffener;

I_P - polar moment of inertia, in cm^4, of the secondary stiffener about its connection with the plating;

$$I_P = \frac{h_W^3 t_W}{3} 10^{-4}$$ - for flat bar secondary stiffeners;

$$I_P = \left(\frac{h_W^3 t_W}{3} + h_W^2 b_f t_f\right) 10^{-4}$$ - for flanged secondary stiffeners;

I_t - moment of inertia, in cm^4, of the secondary stiffener without an effective flange;

$$I_t = \frac{h_W t_W^3}{3} 10^{-4}$$ - for flat bar secondary stiffeners;

$$I_t = \frac{1}{3} [h_w t_w^3 + b_f t_f^3 (1 - 0{,}63 \frac{t_f}{b_f})] 10^{-4}$$ - for flanged secondary stiffeners;

where: h_W, t_W - height and net thickness, in mm, of the secondary stiffener, respectively;
b_f, t_f - width and net thickness, in mm, of the secondary stiffener bottom flange, respectively;
s - spacing of secondary stiffeners, in m;

$$C = \left[\frac{k_p E t_p^3}{3s\left(1 + \dfrac{1{,}33 k_p h_W t_p^3}{1000\, s t_W^3}\right)} \right] 10^{-3} ;$$

where: $k_p = 1 - \eta_p$, but not less than 0. For flanged secondary stiffeners, k_p need not be taken less than 0,1;

$$\eta_p = \frac{\sigma}{\sigma_{E1}} ;$$

for σ - refer to **7.13.8**;
for σ_{E1} - refer to **7.13.9**;
t_p - net thickness, in mm, of the hatch cover plate panel.

For flat bar secondary stiffeners and buckling stiffeners, the ratio h/t_W shall not be greater than $15k^{0,5}$,

where: h, t_w – height and net thickness of the stiffener, respectively;
$k = 235 / \sigma_F$;
σ_F - minimum upper yield stress of the material, in N/mm^2;

7.13.11 The shear stress τ in the hatch cover primary supporting members web panels shall not exceed 0,8 times the critical buckling stress τ_c, to be determined as follows:

$$\tau_2 = \tau_2 \text{ when } \tau_E \le \tau_F/2 \text{ , or}$$

$$\tau_2 = \tau \left[1 - \frac{\tau_F}{4\tau_E}\right] \text{, when } \tau_E > \tau_F/2$$

where: σ_F - minimum upper yield stress of the material, in N/mm²;

$\tau_F = \sigma_F/\sqrt{3}$;

$$\tau_E = 0{,}9k_t E\left(\frac{t_{пр,н}}{1000d}\right)^2 ;$$

where: E – E – modulus of elasticity, in N/mm² to be assumed $2{,}06 \cdot 10^5$ N/mm² for steel.

$t_{pr,n}$ - net thickness, in mm, of primary supporting member;

$k_t = 5{,}35 + 4{,}0/(a/d)^2$;

a – =greater dimension, in m, of web panel of primary supporting member;

d – smaller dimension, in m, of web panel of primary supporting member.

For primary supporting members perpendicular to the direction of secondary stiffeners or for hatch covers built without secondary stiffeners, a presumed square panel of dimension *d* determination of the stress τ_c. In such a case, the average shear stress τ_c between the values calculated at the ends of this panel shall be considered.

7.13.12 The vertical deflection of primary supporting members shall be not more than 0,0056*l*, where *l* is the greatest span of primary supporting members.

7.13.13 The free sectional area *A*, in cm², of the securing device shall not be less than determined by the formula

$$A = 1{,}4a/f, \qquad (7.13.13\text{-}1)$$

where: a - distance between securing devices, in m, which in any case shall not be adopted less than 2 m;

f — factor determined by the formula

$$f = (R_{eH} / 235)^e ; \qquad (7.13.13\text{-}2)$$

where: R_{eH} — the upper yield strength of the securing device material, in MPa, and shall not be adopted greater than 0,7 of the tensile strength of the material;

e — index equal to:

0,75 for $R_{eH} > 235$ MPa;

1,00 for $R_{eH} \le 235$ MPa.

For hatch covers and hatch cover sections having an area in excess of 5 m², the active diameter of bars and bolts of the securing devices shall not be less than 19 mm.

7.13.14 Where the packing gasket is compressed to the maximum depth possible and its pressure exceeds 5000 N/m, the area of securing devices as determined in accordance with **7.13.13**, shall be increased in a relevant proportion.

7.13.15 The stiffness of the cover corners shall be sufficient to maintain an adequate pressure of the packing gasket between the securing devices. The cross-sectional inertia moment of the corner members of the covers *I*, in cm⁴, shall be not less than that determined by the formula

$$I = 6pa^4 \cdot 10^{-3}, \qquad (7.13.15)$$

where: p– pressure of the packing gasket when compressed to the maximum depth possible for the accepted design, in N/m, but not less than 5000 N/m;

a – distance between securing devices, in m.

7.13.16 Where hydraulic securing devices are applied, the securing devices shall be mechanically lockable in closed position in the event of loss of the hydraulic fluid.

7.13.17 Hatch covers shall be fitted with stoppers designed for longitudinal and transverse design loads of 175 kPa.

Where the design and arrangement of the forecastle on a ship do not meet the requirements in **3.3.5.4.1**, Part II "Hull", the stoppers of the foremost hatch cover (hatch No. 1) shall be designed for a longitudinal load of 230 kPa acting on the forward end of the No. 1 hatch cover.

7.13.18 The stresses in stoppers and their adjacent structures shall not exceed the permissible values equal to $0,8\sigma_F$, where σ_F is minimum upper yield stress of the material.

7.13.19 For the plating and stiffeners of all type hatch covers, excepting the double skin, the corrosion addition shall be assumed equal to 2 mm.

For double skin hatch covers, the corrosion addition shall be 2 mm for the top and bottom plating and 1,5 mm for the internal structures.

7.13.20 In bulk carriers of 150 m in length and upwards, carrying solid bulk cargoes having a density of 1000 kg/$m^3$and above, contracted for construction before 1 April 2006, the protection of the structure of cargo holds from grab wire damage during loading and unloading operations shall be achieved by structural design features:

wire rope grooving in way of cargo holds openings shall be prevented by fitting suitable protection such as half-round bar on the hatch side girders (i.e. upper portion of top side tank plates)/hatch end beams in cargo hold or upper portion of hatch coamings.

Such ships shall have the distinguishing mark GRAB(X) in the class notation (refer to **2.2.37.1**, Part I "Classification").

7.14 ACCESS TO SPACES IN THE CARGO AREA OF OIL TANKERS AND BULK CARRIERS

7.14.1 The requirements of **7.14** apply to oil tankers of 500 gross tonnage and above and to bulk carriers of 20 000 gross tonnage and above.

7.14.2 Means of access and passages on ships referred to in **7.14.1** shall comply with the requirements of IMO resolutions IMO MSC.133(76), MSC.158(78) taking into account MSC.1/Circ.1464/Rev.1, as well as IACS UI SC191 (Rev.8 Apr 2019) and in accordance with II-1/3-6 SOLAS-74 «Access to spaces in the cargo area of oil tankers and bulk carriers», the safety access requirements for which are set out in Annex 2 to this part of the Rules the safety access requirements for which are set out in Annex 2 to this part of the Rules.

Note. Unified requiremets IACS (UR), unified interpretations IACS (UI), IACS Recommendations are published on the IACS website.

7.15 ADDITIONAL REQUIREMENTS FOR OPENINGS AND THEIR CLOSING APPLIANCES IN RO-RO SHIPS

7.15.1 Where vehicle ramps are installed to give access to spaces below the bulkhead deck, their openings shall be able to be closed weathertight to prevent ingress of water below, alarmed and indicated to the navigation bridge.

7.15.2 The Register may permit the fitting of particular accesses to spaces below the bulkhead deck provided they are necessary for the essential working of the ship, e.g. the movement of machinery and stores, subject to such accesses being made watertight, alarmed and indicated to the navigation bridge.

7.15.3 Subject to provisions of **7.15.1** and **7.15.2** all accesses that lead to spaces below the bulkhead deck shall have a lowest point which is not less than 2,5 m above the bulkhead deck.

7.15.4 Indicators shall be provided on the navigating bridge for all shell doors, loading doors and other closing appliances which, if left open or not properly secured, could lead to flooding of a special category space or ro-ro cargo space.

The indicator system shall be designed on the fail safe principle and shall show by light alarms if the door is not fully closed or if any of the securing arrangements is not in place and fully locked, and by audible alarms if such door or closing appliances become open or the securing arrangements become unsecured.

The indicator panel on the navigation bridge shall be equipped with a mode selection function "harbour/sea voyage" so arranged that an audible alarm is given on the navigation bridge if the ship leaves harbour with the bow doors, inner doors, stern ramp or any other side shell doors not closed or any closing device not in the correct position.

The power supply for the indicator system shall be independent of the power supply for operating and securing the doors.

7.15.5 Television surveillance and a water leakage system shall be arranged to provide an indication to the navigation bridge and to the engine control station of any leakage through inner and outer bow doors, stern doors or any other shell doors which could lead to flooding of special category spaces or ro-ro cargo spaces.

7.15.6 Special category spaces and ro-ro cargo spaces shall be continuously patrolled or monitored by effective means, such as television surveillance, so that any movement of vehicles in adverse weather conditions and unauthorized access of passengers thereto can be detected whilst the ship is underway.

7.15.7 Documented operating procedures for closing and securing all shell doors, loading doors and other closing appliances which, if left open or not properly secured could lead to flooding of special category space or ro-ro cargo space, shall be kept on board and posted at an appropriate place.

7.15.8 Besides specified in **7.15.7** the Manual on operation and repair of doors in shell plating shall be kept onboard containing the following information:

main particulars and structural drawings of doors;

door operation safety precautions;

ship characteristics;

door design loads;

manufacturer's recommendations for equipment testing;

description of equipment of bow, side and stern doors, internal bow doors, central power station, indication panel on navigation bridge, control panel in engine room;

operating characteristics:

permissible angles of heel/trim with/without cargo as well as permissible angles of heel/trim during use of doors;

door operating instruction;

door operating instruction in case of emergency;

operation and repair of doors:

description and deadlines of current repair, occuring failures and their acceptable elimination, manufacturer's instructions for operation and repair of doors;

record book of examinations including survey of securing, locking and supporting devices, repair and replacement.

The above manual on operation and repair of doors in shell plating shall be submitted for the Register approval.

8. ARRANGEMENT AND EQUIPMENT OF SHIP'S SPACES, VARIOUS EQUIPMENT, ARRANGEMENTS AND OUTFIT

8.1 GENERAL

8.1.1 The requirements for the arrangement and equipment of machinery spaces are specified in Part VII "Machinery Installations" and those relating to refrigerating machinery spaces, refrigerant storerooms, as well as refrigerated cargo spaces are set forth in Part XII "Refrigerating Plants".

8.1.2 In berth-connected ships, the arrangement and equipment of spaces, various devices and equipment shall comply with the relevant requirements of **8.5** and **8.6**.

Furthermore, berth-connected ships which are used as hotels or hostels shall comply with the requirements set out in **8.5** as in the case of passenger ships.

Besides, a berth-connected ship shall have at least two companion ladders fitted as far away from each other as possible.

The companion ladders shall be not less than 0,2 m wide where the total of passengers and crew on board does not exceed 50.

For each 10 persons above 50, the companion ladder breadth shall be increased by 5 cm.

8.2 LOCATION OF SPACES

8.2.1 The chart room shall be located in a space adjacent to the wheelhouse. The chart room and the wheelhouse may be situated in a common space.

8.2.2 No accommodation spaces shall be arranged forward of the collision bulkhead and abaft of the afterpeak bulkhead below the bulkhead deck.

8.3 NAVIGATION BRIDGE

8.3.1 General

8.3.1.1 The ship's control station shall be located in an enclosed space of the wheelhouse on the navigation bridge.

The navigation bridge shall be located so as to ensure:

proper visual control of the ship's running; good visibility with maximum view of water surface;

good audibility of sound signals of the approaching ships;

for tugs, possibility of visual control of tow line during towing operations.

It is recommended to arrange the steering control station at the ship's centreline.

8.3.1.2 Visibility from the navigation bridge shall comply with requirements of **3.2**, Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships.

8.4 EQUIPMENT OF DRY CARGO HOLDS

8.4.1 When in ships not having double bottom wooden ceiling is placed on top of the floors, it shall be solid and shall extend up to the bilge. The ceiling is recommended to be made of portable sections of such dimensions and so constructed as to allow of their ready removal at any place.

The thickness of a ceiling shall be:

at least 40 mm for ships of 30 m in length and less;

at least 60 mm for ships over 30 m in length;

at least 70 mm under cargo hatchways.

8.4.2 When in ships having double bottom wooden ceiling is fitted, it shall have a thickness as follows:

at least 50 mm for ships of 60 m in length and less;

at least 65 mm for ships over 60 m in length.

8.4.3 Where cargo is discharged by grabs or other mechanisms, the thickness of the wooden ceiling fitted under cargo hatchways shall be doubled.

8.4.4 In holds intended for carriage of grain and other bulk cargoes the wooden ceiling on the inner bottom or, in case the latter is omitted, on the top of floors, shall be fitted so as to prevent wells, bilges and suction pipes of the bilge system from clogging.

8.4.5 The wooden ceiling shall not be laid directly on the inner bottom metal plating, but shall be embedded in a bituminuous or epoxy composition approved by the Register, or placed on battens of 25 ÷ 30 mm, mm in thickness along the floors.

The wooden ceiling over the bilges shall be placed so as to be readily removable (refer also to **7.6.9**, Part VIII "Systems and Piping").

8.4.6 It is recommended that the cargo battens made of wood or metal shall be fitted on sides in holds and spaces intended for carriage of general cargoes.

The thickness of wooden battens shall be as follows:

at least 40 mm for ships of 70 m in length and less;

at least 50 mm for ships of length exceeding 70 m.

The distance between adjacent battens shall not exceed 305 mm.

The battens shall be attached to side framing so as to be readily removable and replaceable.

8.4.7 All projecting parts of various equipment in the holds (manholes, air pipes, sounding pipes, etc.) shall be protected with wooden screens, grids, chutes, etc. in places subject to impacts of cargoes, grabs or other hoisting devices.

Requirements for laying pipe lines in cargo holds are given in **5.3**, Part VIII "Systems and Piping".

8.4.8 Cellular guide members for the carriage of containers in holds.

8.4.8.1 The requirements of **8.4.8** apply to the cellular guide members used for the carriage of containers, manufactured in accordance with the Rules for the Construction of Containers, in the holds of cargo ships.

8.4.8.2 Cellular guide members comprise uprights and horizontal shores arranged breadthwise and lengthwise. In the holds, the cellular guide members may be removable or permanent.

8.4.8.3 Cellular guide members shall not be integrated in the hull structure. They shall be so designed that no stresses are exerted on them when the hull comes under bending or torsion.

8.4.8.4 Cellular guide members shall be designed to withstand stresses due to the forces F_x and F_y affecting the gravity centre of each container, which shall be determined by the formulae:

lengthwise

$$F_x = mga_x; \qquad (8.4.8.4\text{-}1)$$

breadthwise

$$F_y = mga_y, \qquad (8.4.8.4\text{-}2)$$

where: m – maximum gross mass of container, in kg;

g – gravity acceleration, g=9,81 m/s^2;

a_x, a_y – dimensionless accelerations to be determined in accordance with **1.7**, the coordinates of x and z being determined up to the gravity centre of each container volume.

The forces F_x and F_y shall be determined for each container, and through the four relevant corner fittings of the end or side wall they are uniformly distributed among the uprights. By way of simplification, maximum F_x and F_y values may be adopted for each container. Where a number of adjoining containers are supported by a pair of uprights, the F_x and F_y values for the particular container tier shall be summed up and distributed among the respective uprights.

Friction forces arising where the corner fittings of containers touch each other or the inner bottom shall be ignored.

8.4.8.5 The forces resultant from loads to be determined in accordance with 8.4.8.4, where the container corner fittings rest upon the uprights, shall not exceed 150 kN per fitting breadthwise or 75 kN per fitting lengthwise.

8.4.8.6 Where the attachment of uprights to the hull structures is not considered as firm fixing (free resting, flexible fixing, etc.), the cellular guide members shall be calculated as three-dimensional frames.

Where the attachment of uprights to the hull structures can be considered as firm fixing, particular vertical surfaces of cellular guide members may be calculated as plane frames.

The stresses in the cellular guide member components shall not exceed 0,8 times the upper yield stress of their material.

The terms of calculating the stability of cellular guide member components shall be found under **8.4.8.14**.

8.4.8.7 In view of the requirements under **8.4.8.6**, the displacement of the resting points of corner fittings upon the uprights shall not exceed 25 mm breadthwise or 40 mm lengthwise.

8.4.8.8 When determining the thickness of the uprights components, the thickness of those especially subject to wear shall be increased by 5 mm and equal to at least 12 mm.

8.4.8.9 Where the uprights comprise separate angular sections, they shall be firmly secured to each other with horizontal plates at the resting points of container corner fittings and at least halfway between those points.

8.4.8.10 At the upper ends of the uprights, devices shall be fitted to facilitate the insertion of containers into the stowage frames. 8.4.8.11 Uprights shall, so far as possible without notches, be attached to transverse and longitudinal bulkheads by means of shear- and bend-stiff members.

8.4.8.12 The total margin between the external scantlings of containers and the internal uprights surfaces shall not exceed 25 mm breadthwise or 40 mm lengthwise.

When fitting the uprights, the deviation from the straight line shall not exceed 5 mm.

8.4.8.13 Transverse horizontal and longitudinal horizontal shores serve to connect the stand-alone uprights to each other and to secure them to vertical hull structures. The horizontal shores shall, as far as possible, be fitted on the level of the corner fitting rest points and be torsion- and bend-stiff connected to the uprights.

8.4.8.14 The stability of transverse horizontal and longitudinal horizontal shores and, where necessary, that of uprights shall be checked by a procedure approved by the Register.

When determining the permissible buckling stresses, the relevant safety factor may be adopted equal to 2,0.

The free length of buckling shall be adopted span-equal in the case of a bolted joint or 0,7 times the shore or uprights span in the case of a welded joint. The flexibility shall not exceed 250.

For other types of bar-end fixing, the free length shall be established according to the procedure approved by the Register.

8.4.8.15 The container rest points on the inner bottom and areas containing the connections and attachments of container stowage frames in way of hull structures shall be strengthened in conformity with the requirements of Part II "Hull".

8.4.9 Movable decks, platforms, ramps and other similar structures.

8.4.9.1 The requirements of **8.4.9** apply to the movable decks, platforms, ramps and other similar structures designed to be installed in two positions:

in working position when they are used for carriage, loading or unloading of vehicles or other cargoes;

in non-working position when they are not used for carriage, loading or unloading of vehicles or other cargoes.

8.4.9.2 The movable decks, platforms, ramps and other similar structures and also their supporting elements at ship's sides, decks and bulkheads. the pillars or suspensions for decks and platforms ensuring their proper installation in the working position shall be designed in accordance with the requirements of Part II "Hull".

8.4.9.3 Arrangements shall be provided for reliable securing of the movable decks, platforms ramps and other similar structures in the non-working position.

8.4.9.4 When the movable decks, platforms, ramps and other similar structures are secured in the nonworking position, the hoisting gear and elements thereof shall not generally be kept under the load.

It is not permitted to secure the movable decks, platforms, ramps and other similar structures by suspending them on ropes.

8.4.9.5 The structural elements of the arrangements mentioned in **8.4.9.3** and also the associated supporting structures shall be designed to withstand the forces resulting form the application of the load P_x, P_y and P_z, as determined by the formulae given below, to the centres of gravity of the considered section of the deck, platform, ramp or other similar structures:

$$P_x = mga_x, \quad (8.4.9.5\text{-}1)$$

$$P_y = mga_y, \quad (8.4.9.5\text{-}2)$$

$$P_z = mg(1 + a_z), \quad (8.4.9.5\text{-}3)$$

where: P_x – horizontal load parallel to the centreline of the ship, in N. Consideration shall be given to the cases when the load P_x is directed both forward and af;

P_y – = horizontal load parallel to the midstation plane, in N. Consideration shall be given to the cases when the load P_y is directed both to the nearest ship's side and to the opposite side;

P_z – vertical load directed downward, in N;

m – mass of the considered section of the deck, platform, ramp or other similar structure, in kg;

g – acceleration due to gravity equal to 9,81 m/s^2;

a_x, a_y, a_z – dimensionless accelerations to be determined in accordance with **1.7**.

8.4.9.6 When determining the forces affecting the structural elements of the arrangements specified in **8.4.9.3** and the associated supporting structures with regard to the provisions of **8.4.9.5**, the loads P_x, P_y and P_z are regarded as separately applied, i.e. no account is taken of their combined action and of the frictional forces originating on the surfaces of the considered sections of decks, platforms, ramps or other similar structures which are in contact with the associated supporting structures.

8.4.9.7 When the structural elements of the arrangements specified in **8.4.9.3** and the associated supporting structures are under the effect of the loads determined according to the provisions of **8.4.9.5** and **8.4.9.6**, the stresses in their parts shall not exceed 0,8 times the upper yield stress of material.

Under the effect of these loads the safety factor of the wire ropes in relation to their breaking strength shall be not less than 4;

the safety factor of the chain cables in relation to the proof load of the chain shall be not less than 2;

the margin of safety against buckling of the elements subjected to the compression stress shall be not less than 2.

8.4.9.8 Wire ropes used in the arrangements specified in **8.4.9.3** shall satisfy the requirements of **3.15** and chain cables, those of **7.1**, Part XIII "Materials".

8.5 EXITS, DOORS, CORRIDORS, STAIRWAYS AND VERTICAL LADDERS

8.5.1 General.

8.5.1.1 Location and arrangement of exits, doors, corridors, stairways and vertical ladders shall ensure the possibility of quick, safe and free access from spaces to the embarkation stations of lifeboats and liferafts.

Additional means for outdoor escape shall be clearly marked, where necessary, to ensure accessibility, and be provided with a proper design to be used in emergency.

8.5.1.2 In passenger ships, access protection of the stairway enclosures to lifeboats and liferafts embarkation areas shall be provided both directly and through protected internal evacuation routes, which stairway enclosures shall be fire resistant and insulated, as appropriate, as shown in Tables 2.2. 1.3- 1, 2.2.1.3-2, 2.2.1.5-1, 2.2.1.5-2 of Part VI "Fire Protection".

8.5.2 Exits and doors.

8.5.2.1 In passenger ships and in special purpose ships each watertight compartment or similarly restricted space or group of spaces situated below the bulkhead deck shall have at least two means of escape, in any case one of which shall be independent of the door in the subdivision bulkhead.

At least one of the evacuation routes shall comply with the requirements of **2.2.2.4.5**, Part VI "Fire Protection" to the appropriate lifeboats or life rafts embarkation decks or to the upper deck if the life-saving applinces embarkation deck does not extend to the main vertical fire zone.

In the latter case, direct access to the life-saving appliances embarkation deck shall be provided by means of external open ladders and passages, which shall be provided with lighting in accordance with **8.5.5**, and also nonsliding surface. Limiting structures facing open ladders and passages that are part of the evacuation route and limiting structures located in a place where their damage by fire may obstruct the passage to the embarkation deck shall be fireresistant and have an insulation value, as appropriate, according to Tables 2.2.1.3- 1, 2.2.1.3-2, 2.2.1.5-1, 2.2.1.5-2, Part VI "Fire Protection".

In passenger ships of restricted areas of navigation **B-R3-RS**, **B-R3-RS**, **C-R3-S**, **C-R3-RS** та **D-R3-S**, **D-R3-RS,** in exceptional cases, taking into account the purpose of the room and the number of persons usually accommodated in them, only one exit, which shall ensure safe evacuation, may be provided.

Two ways of evacuation from the main machinery control room located in the engine room shall be provided; at least one of them shall provide continuous protection from fire to a safe place outside the engine room (refer to **2.1.4.5**, Part VI "Fire Protection").

8.5.2.2 In passenger ships and in special purpose ships above the bulkhead deck each main vertical fire zone (refer to **2.2.1.2**, Part VI "Fire Protection") or similarly restricted space or group of spaces shall have at least two means of escape one of which shall give access to a stairway forming a vertical means of escape to the places of embarkation into lifeboats and liferafts.

8.5.2.3 In passenger ships the number and location of means of escape from special category spaces (refer to **1.5.9**, Part VI "Fire Protection") depend on the degree of safety; the degree of safety for escape from these spaces to the embarkation stations of lifeboats and liferafts shall at least correspond to that specified in **8.5.2.1** and **8.5.2.2**.

For cargo ships in all ro-ro cargo spaces where the crew is normally employed, at least two widely separated escape routes shall be provided.

8.5.2.4 In cargo ships of 500 gross tonnage and upwards at each level of accommodation spaces there shall be at least two means of escape, as widely separated as possible, from each restricted space or group of spaces; from the spaces situated below the open deck the main means of escape shall be formed by a stairway, the other means of escape may be formed by a casing with a vertical ladder or by a stairway; from spaces above the open deck the means of escape shall be stairways or doors to an open deck or a combination thereof.

The open deck stated above shall be a category (10) (in accordance with **2.2.1.5**, Part VI "Fire Protection").

8.5.2.5 Spaces may be dispensed with one of the means of escape required under **8.5.2.1** or **8.5.2.4**, due regard being paid to the nature and location of the spaces and to the number of persons normally employed therein.

8.5.2.6 Stairways serving only a space and a balcony in that space, as well as lifts shall not be considered as means of escape specified in **8.5.2.1** ÷ **8.5.2.4**.

8.5.2.7 Each cinema hall shall be provided with at least two means of escape. Both exits shall be spaced from each other as wide as practicable. A readily seen inscription "Exit" or "Emergency exit" shall be provided above every such exit.

8.5.2.8 In case of open bridge wings, the wheelhouse shall have two exits, one to each side of the navigation bridge, with a passageway through the house from side to side.

8.5.2.9 The total width of exits from cinema halls shall be determined on the basis of 0,8 m per 50 persons, however, the width of each exit shall be not less than 1,1 m, when the number of seats is more than 50, and not less than 0,8 m when the number of seats is not more than 50. The width of each exit from accommodation and service spaces shall be not less than 0,6 m.

The sizes of the ladderways from cargo holds shall be not less than 0,6x0,6 m.

8.5.2.10 The exit doors and ladderway covers shall be so arranged that they can be operated from both sides. Doors shall open as follows:

.1 doors of accommodation, excluding public, and service spaces giving access to a corridor inside the spaces;

.2 doors of public rooms, outwards or each side;

.3 doors in the end bulkheads of superstructures and in external transverse bulkheads of deckhouses, outwards in the direction of the nearest side;

.4 doors in the external longitudinal bulkheads of deckhouses, outwards in the forward direction.

In cargo ships the inner doors duplicating the doors specified in **8.5.2.10.3** and **8.5.2.10.4** may open inside the space.

In ships of 31 m in length and less the doors indicated in **8.5.2.10.1** may open outwards (to the corridor) if they are situated at the end of blind corridors and do not hinder the exits from other spaces.

No sliding doors shall be fitted at exits and means of escape, except for doors of the wheelhouse.

The doors referred to in **8.5.2.10.1** shall not be provided with hooks for holding the door open. It is permitted that such doors be fitted with buffers and spring catchers to fix the door in the open position and to allow for its closure without entering the space.

The doors specified in **8.5.2.10.3** and **8.5.2.10.4** may open in a different direction when security against the impact of the sea and safe passage are provided.

8.5.2.11 Doors of accommodation spaces specified in **1.5.2.1** and **1.5.2.2**, Part VI "Fire Protection" shall have in their lower portions detachable panels 0,4 x 0,5 m in size, these panels of the passenger cabin doors shall be provided with the following inscription: "Means of escape — knock out in case of emergency".

The detachable panels need not be fitted where the spaces are provided with opening type side scuttles of at least 400 mm in diameter of windows the smaller side of which being at least 400 mm and on condition that persons may get to the corridor or open deck through these side scuttles or windows.

The appropriate means shall be provided, if necessary, to facilitate exit through side scuttles or windows.

8.5.2.12 In arrangement and disposition of exits and doors in dangerous zones, spaces and areas of oil tankers and oil recovery ships, as well as of ships carrying dangerous goods requirements shall be considered with respect to the safe-type electrical equipment to be used in spaces adjacent to dangerous zones with the doors open into such spaces (refer to **19.2** and **19.11**, Part XI "Electrical Equipment").

8.5.2.13 The doors of evacuation routes from public premises, which usually stopped, shall be equipped with means for their quick release. Such means shall consist of a stopper device of the doors, which is combined with a device that quickly releases the stopper when applying force in the direction of movement to the outside.

Stopper quick release device:

.1 shall consist of a bolt or panel, the effective part of which is located at least half the width of the door plate, but not less than 760 mm, and not more than 1120 mm above the deck;

.2 shall release the door stopper when using force of not more than 67 N; and

.3 shall not be equipped with any locking device, locking screw or other device preventing the release of the stopper under the force that is applied to the door release device.

8.5.2.14 The aggregate width of exits from premises intended for use by people with reduced mobility shall not be less than 0.9 m. The aggregate width of exits commonly used for embarking and disembarking people with reduced mobility shall not be less than 1.5 m.

Minimum clearance of 0.6 m between the door end of the door frame and the side of the lock and the adjacent perpendicular wall shall pe provided for doors intended for people with reduced mobility.

8.5.3 Corridors and passageways.

8.5.3.1 All corridors and passageways shall ensure free movement of persons along them. On passenger ships and special purpose ships carrying more than 60 persons, a lobby, corridor or part of a corridor shall have more than one means of escape.

Cargo ships and special purpose ships carrying not more than 60 persons shall have no dead-end corridors more than 7 m long.

By a dead-end corridor, a corridor or part of a corridor is meant which has only one means of escape.

Corridors used as means of escape on cargo ships shall be at least 700 mm wide and shall be fitted with a handrail on either side. Corridors with a width of 1800 mm and more shall be fitted with handrails on each side. Width of a corridor is determined as a distance between a handrail and opposite bulkhead or as a distance between handrails.

8.5.3.2 The width of main corridors in way of passengers' and crew's accommodation spaces shall not be less than 0,9 m, and that of side corridors shall be at least 0,8 m. Where the number of passengers and crew using the corridor surpasses 50 persons, the widths referred to above shall be increased by 0,1 m.

In ships (including the tugs) below 500 gross tonnage and in tugs of less than 370 kW the width of the main corridors and side corridors may be reduced down to 0,8 and 0,6 m, respectively.

8.5.3.3 The widths of passageways in the cinema hall and in the entrance hall shall not be less than 1,1 m and 1,4 m, respectively.

The width of the main passageways in the restaurant or dining room and also the messroom shall not be less than 0,9 m and that of the side passageways shall be at least 0,65 m.

In ships of less than 500 gross tonnage the width of main passageways in the messroom may be reduced down to 0,65 m.

8.5.3.4 The width of the main passageway in the seating passenger space shall be at least 1 m with number of passengers up to 50 and at least 1,1 m with number of passengers in excess of 50.

8.5.3.5 In passenger ships the main corridors adjacent to engine and boiler casings shall be at least 1,2 m in width, however, in ships of less than 500 gross tonnage this width may be reduced down to 0,9 m.

8.5.3.6 The width of passageway on the bridge shall not be less than 0,8 m in ships of 500 gross tonnage and over and at least 0,6 m in ships of less than 500 gross tonnage.

8.5.3.7 In passenger ships and special purpose ships the width of the deck passageways providing access to the lifeboat and liferaft embarkation deck shall not be less than:

0,9 m if the number of seats in lifeboats is not more than 50 on each side of ship;

1,0 m if the number of seats in lifeboats is 50 and over, but less than 100 on each side of ship;

1,2 m if the number of seats in lifeboats is 100 and over, but less than 200 on each side of ship.

If number of seats in lifeboats is 200 and over on each side, the width of the passageways shall be determined according to the procedure approved by the Register.

In other ships the width of the passageways referred to above shall not be less than 0,8 m.

8.5.3.8 The width of openings for embarkation and disembarkation of people with reduced mobility shall not be less than 1.5 m.

Overall width of areas intended for use by passengers with reduced mobility shall not be less than 1.3 m and shall be free of thresholds greater than 0.025 m high. Walls in passage areas intended for passengers with reduced mobility shall be equipped with handrails at a distance 0.9 m above the floor.

The width of connecting passages intended for people with reduced mobility shall be not less than 1.30 m. Connecting passages with width in excess of 1.5 m shall be provided with handrails on both sides.

Passages to such access routes shall be indicated on other access routes to the ship and in other appropriate places throughout the ship.

8.5.4 Stairways and vertical ladder.

8.5.4.1 All between deck stairways shall be of steel frame construction or of equivalent material on agreement with the Register (refer to **1.2**, Part VI "Fire Protection"). Special requirements for arrangement of stairway enclosures and protection of means of escape are specified in **2.1.4.3**, **2.1.4.5**, **2.2.2.4**, Part VI "Fire Protection".

The back side of the stairways in machinery space is to be provided with metal binder.

8.5.4.2 On passenger ships and special purpose ships carrying more than 60 persons, the following conditions shall be met:

.1 the width of stairways shall be not less than 900 mm, with handrails on each side. The minimum width of stairways shall be increased by 10 mm for every one person in excess of 90 persons. The maximum width between handrails where stairways are wider than 900 mm shall be 1800 mm. The total number of persons to be evacuated by such stairways shall be assumed to be two-thirds of the crew and the total number of passengers in the areas served by such stairways;

.2 all stairways sized for more than 90 persons shall be aligned fore and aft;

.3 the doorways, corridors and intermediate landings included in means of escape shall be sized in the same manner as stairways;

.4 stairways shall not exceed 3,5 m in vertical rise without the provision of a landing and shall not have an angle of inclination greater than 45°;

.5 with the exception of intermediate landings, the landings at each deck level shall not be less than 2 m^2in area and shall increase by 1 m2 for every 10 persons provided for in excess of 20 persons but need not exceed 16 m^2, except for those landings servicing public spaces having direct access onto the stairway enclosure;

.6 in any case, the stairway width shall be in accordance with the requirements of the Appendix 1 to this Part;

.7 Stairways intended for people with reduced mobility shall meet the following requirements: the angle of inclination shall not exceed 32°;

the width of stairways shall be not less than 0.9 m;

spiral staircases are not allowed; stairways shall not be located in the direction perpendicular to the ship's center line;

stairways handrails are to extend approximately 0,3 m beyond the limits of its upper and lower parts without any restriction of passage;

handrails, the front parts of at least the first and last steps, as well as the floor covering at the ends of the steps, shall be painted in bright colors;

elevators for people with reduced mobility and lifting equipment, such as escalators or lifting platforms, shall comply with standards approved by the Register.

8.5.4.3 Stairways used as means of escape on cargo ships shall be at least 700 mm wide and shall be fitted with a handrail on either side.

Stairways with a width of 1800 mm and more shall be fitted with handrails on each side. In cargo ships of less than 500 gross tonnage the width of stairways may be 600 mm.

Angle of slope of ladders shall be usually 45° but not greater than 50°, in the machinery and in small spaces - not greater than 60°.

In ships of less than 500 gross tonnage in case of insufficient space at egress from the stairway with angle of slope of ladders of 55° in accommodation and service spaces, with 60° - on decks.

The size of doors providing an access to any stairway shall be of the same size as the stairway.

8.5.4.4 Vertical ladders and ladder steps in cargo holds, tanks, etc. shall be at least 300 mm wide.

8.5.5 Low location lighting (LLL) on passenger ships carrying more than 36 passengers and special purpose ships carrying more than 240 persons.

8.5.5.1 In addition to the emergency lighting stipulated by **19.1.2**, Part XI "Electrical Equipment", the means of escape, including stairways and exits, of passenger ships carrying more than 36 passengers and special purpose ships carrying more than 240 persons shall be marked by LLL at all points of the escape route including angles and intersections.

8.5.5.2 Provision shall be made for the following LLL systems: .1 photoluminescent system which uses photoluminescent material containing a chemical (example: zinc sulfide) that has the quality of storing power when illuminated by visible light;

.2 electrically powered systems which use incandescent bulbs, light emitting diodes, electroluminescent strips or lamps, electrofluorescent lamps, etc. (refer also to **19.1.4**, Part XI "Electrical Equipment").

8.5.5.3 The LLL system shall function at all times for at least 1 h after its activation. All systems, including those automtically activated or continuously operating, shall be capable of being manually activated by a single action from the main control station.

8.5.5.4 In all passageways, the LLL shall be continuous except as interrupted by corridors and cabin doors in order to provide a visible delineation along the escape route. The LLL shall be installed at least on one side of the corridor, either on the bulkhead within 300 mm of the deck, or on the deck within 150 mm of the bulkhead. In corridors more than 2 m wide, LLL shall be installed on both sides. In dead-end corridors, LLL shall have arrows placed at intervals of no more than 1 m, or equivalent direction indicators, pointing away from the dead-end.

8.5.5.5 In all stairways, LLL shall be installed on at least one side at a height less than 300 mm above the steps. LLL shall be installed on both sides if the width of the stairway is two metres or more. The top and bottom of each set of stairs shall be identified to show that there are no further steps.

8.5.5.6 In all passenger cabins, a placard explaining the LLL system shall be installed on the inside of the cabin door. It shall also have a diagram showing the location of, and the way to, the two closest exits with respect to the cabin. Materials used in the manufacture of LLL products shall not contain radioactive or toxic materials.

8.5.5.7 LLL shal indicate the exit door handle; other doors shall not be indicated so.

Sliding, fire-proof and watertight doors shall be provided with LLL sign showing the way of the door opening.

LLL signs shall be also provided at all doors and means of escape. The signs shall be located at a height of 300 mm above the deck or the bottom of the door and be contrast in colour to the background on which they are marked.

All exit door and escape route signs shall be of photoluminescent materials or marked appropriately by lighting.

8.5.5.8 Photoluminescent (PL) material strips shall be not less than 75 mm wide. The strips having a width less than that stated herein shall be used only if their luminance is increased proportionally to compensate for their width. PL materials shall provide at least 15 mcd/m^2 measured 10 min after removal of all external illuminating sources. The system shall ensure luminance values greater than 2,0 mcd/m2 for 1 h. Any PL system shall be provided with not less than the minimum level of ambient light necessary to charge the PL material to meet the above luminance requirements.

8.5.5.9 Electrically powered LLL system shall comply with the requirements of **2.2.8.6.6**, Part VI "Fire Protection".

For ships having length of 120 m or more or having three or more main vertical zones the electrically powered LLL system shall also comply with the requirements of **2.2.7.4.3**, Part VI "Fire Protection".

8.5.5.10 In passenger ships, the passenger and crew cabins shall be fitted with LLL.

8.5.6 Additional requirements for means of escape on ro-ro passenger ships.

8.5.6.1 Handrails or other handholds shall be provided in all corridors along entire escape route, so that a firm handhold is available every step of the way, where possible, to the assembly stations and embarkation stations. Such handrails shall be provided on both sides of longitudinal corridors more than 1,8 m in width and transverse corridors more than 1 m in width. Particular attention shall be paid to the need to be able to cross lobbies, atriums and other large open spaces along escape routes. Handrails and other handholds shall be of such strength as to withstand a distributed horizontal load of 750 N/m applied in the direction of the centre of the corridor or space, and a distributed vertical load of 750 N/m applied in downward direction. There is no need to apply the two loads simultaneously.

8.5.6.2 Means of escape shall not be obstructed by furniture and other obstructions, with the exception of tables and chairs which may be cleared away to provide open space. Cabinets and other heavy pieces of furniture in public spaces and along escape routes shall be secured in place to prevent shifting if the ship rools or lists. Floor coverings shall also be secured in place. When the ship is underway, means of escape shall be kept clear of obstructions..

8.5.6.3 Means of escape shall be provided from every normally occupied space on the ship. These means of escape shall be arranged so as to provide the shortest route possible to the assembly stations and survival craft embarkation stations and shall be marked with appropriate symbols.

8.5.6.4 Where enclosed spaces adjoin an open deck, openings from the enclosed space to the open deck shall, where it is practicable, be capable of being used as an emergency exit.

8.5.6.5 Decks shall be sequentially numbered, starting with "1" at the tank top or the lowest deck. These numbers shall be prominently displayed at stair landings and lifts in the lobbies. Decks may also be named, but the deck number shall always be displayed along with the name.

8.5.6.6 Simple and clear plans showing the "you are here" position and means of escape marked by arrows shall be prominently displayed on the inside of each cabin door and in public spaces.

8.5.6.7 Cabin and stateroom doors shall not require keys to be unlocked from the inside. Neither shall there be any doors along any designed escape route which require keys to be unlocked.

8.5.6.8 The lowest 0,5 m of bulkheads along escape routes shall be able to sustain a load of 750 N/m to allow them to be used as walking surfaces with the ship at large angles of heel.

8.5.6.9 The escape routes from cabins to stairway enclosures shall be as direct as possible, with a minimum number of direction changes. It shall not be necessary to cross from one side of the ship to the other to reach means of escape. It shall not be necessary to climb more than two decks up or down to reach an assembly station or open deck from any passenger space.

8.5.6.10 External means of escape to the survival craft embarkation stations shall be provided from all open decks, referred to in **8.5.6.9**.

8.5.6.11 Lifting ramps for entering / leaving on decks, platforms, ramps, when they are in the lowered position, shall not block the evacuation routes.

8.5.6.12 On passenger roll-on roll-off ships (such as ro-ro), evacuation routes are to be assessed on the basis of evacuation analysis at the design stage. The analysis is to be used to identify and warn, as far as possible, places of congestion that may occur when the ship is abandoned due to the usual movement of passengers and crew along escape routes, including the possibility that the crew may need to move these routes in the direction , opposite to the movement of passengers. In addition, an analysis is to be used to demonstrate that the organization of evacuation routes is sufficiently flexible to ensure that certain evacuation routes, muster stations, embarkation stations, life-saving appliances themselves may not be accessible due to an emergency.

8.6 GUARD RAILS, BULWARK AND GANGWAYS

8.6.1 All exposed parts of the freeboard decks, superstructure decks and deckhouse tops shall be provided with efficient guard rails or bulwarks; in case of ships intended for carriage of timber deck cargo collapsible railing or storm rails shall be fitted on this cargo.

8.6.2 The height of the bulwark or guard rails above the deck shall not be less than 1 m. However, where this height would interfere with the normal operation of the ship, a lesser height may be approved provided the adequate protection of passengers and crew is ensured to the satisfaction of the Register.

8.6.3 The distance between the stanchions of the guard rails shall be not more than 1,5 m. At least every third stanchion shall be supported by a stay.

Removable and hinged stanchions shall be capable of being locked in the upright position. For deck plating exceeding 20 mm the support may be omitted.

In places of such stanchions weld to the deck, the deck shall be supported by a minimum 100x12 mm stiffener.

It is allowed to use flat steel stanchions with increased breadth at the stanchion weld to the deck.

Fig. 8.6.3 shows the installation diagram and the spacing between the stanchions depending on the breadth of the lower edge to be welded to the deck.

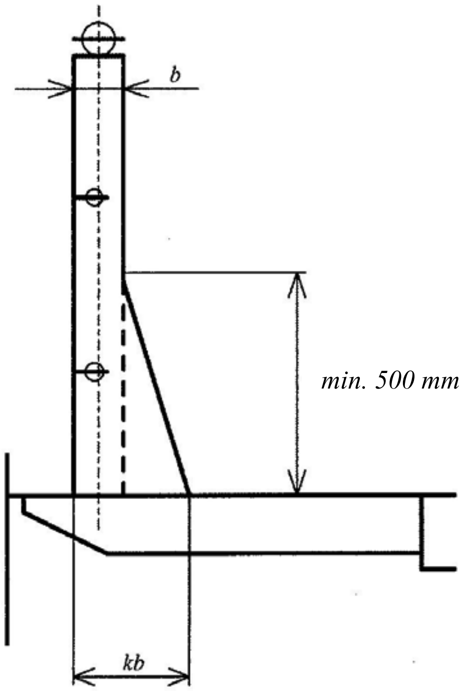


Fig.8.6.3

1. Where $kb \geq 2{,}9b$ - at least every third stanchion shall be of increased breadth.
2. Where $2{,}4b \leq kb < 2{,}9b$ - at least every second stanchion shall be of increased breadth.
3. Where $1{,}9b \leq kb < 2{,}4b$ - at least every stanchion shall be of increased breadth.

The stanchion breadth *b*, shall be chosen according to the design standards.

8.6.4 The gunwale, hand rails and guard rails shall be generally of rigid construction; wire ropes may only be accepted in lieu of guard rails in special circumstances and then only in limited lengths; wire ropes shall be made taut by means of turn-buckles.

Lengths of chains may only be accepted in lieu of rigid guard rails if they are fitted between two fixed stanchions or between the fixed stanchion and bulwark.

8.6.5 The opening below the lowest course of the guard rails shall not exceed 230 mm. The other courses of rails shall not be more than 380 mm apart. An exception is made for the guard rails above the timber deck cargo where the height from the base to the lowest course and other course spacings shall not exceed 330 mm. In the case of ships with rounded gunwale, the guard rail supports shall be placed on the flat of the deck.

8.6.6 Type "A" ships with bulwarks as well as type "B" ships with a freeboard reduced to that required for type "A" ships shall have open rails fitted for at least half the length of the exposed parts of the weather deck, or other effective water freeing arrangements. The upper edge of the sheerstrake shall be kept as low as practicable.

Where superstructures are connected by trunks, open rails shall be fitted for the whole length of the exposed parts of the freeboard deck.

8.6.7 The bulwark, if arranged, shall comply with the requirements of **2.14**, Part II "Hull"..

8.6.8 Satisfactory means (in the form of life lines, gangways, underdeck passages, etc.) shall be provided for the protection of the crew in getting to and from their accomodation spaces, the machinery space and all other parts used in the necessary work of the ship.

8.6.9 A fore and aft permanent gangway shall be provided on type "A" ships at the level of the superstructure deck between the poop and the midship superstructure or deckhouse, where fitted, or equivalent means of access shall be provided to carry out the purpose of the gangway, such as underdeck passages. The width of the passages shall be not less than 1 m. The gangways over the entire length of the plating on either side shall be fitted with longitudinal guarding bars. Reliable guard rails, the dimensions of which shall comply with the requirements of **8.6.2**, **8.6.3** and **8.6.5** of this Part, and **3.5.5.2**, Part II "Hull" shall be provided.

The gangways shall be constructed of a fire-resisting material, and the plating shall be made, in addition, of a non-slip material.

The plating may be manufactured of fibre reinforced plastic provided it complies with the requirements of 6.9, Part XIII "Materials".

In ships not having a midship superstructure arrangements to the satisfaction of the Register shall be made to safeguard the crew in reaching all parts of the ship while at sea.

8.6.10 Safe and convenient ladders from the level of the gangways to the deck shall be provided; they shall not be spaced more than 40 m apart.

Where the length of the deck is more than 70 m, special tripartite shelters (bow - sides) shall be provided along the gangways or other means of access for protection of the crew from bad weather. Such shelters shall be designed for at least one person and shall be spaced not more than 45 m apart. Pipes or other deck equipment shall not impede safe passage.

8.6.11 Requirements of Part VI «Fire Protection» and **8.6.1** ÷ **8.6.10** are not applied to the shipborne barges (lighters), barges and other non-self-propelled ships unmanned.

8.6.12 On ships open decks where access of passengers is allowed, bulwarks or guard rails shall be at least 1.1 m high above the deck and be fitted with a structure that prevents passengers from climbing over guard railing and accidental falling off the deck.

Stairways and ladders on such decks are to be equipped with a guard railing of a similar construction.

8.6.13 Deck bulwarks and railings intended for use by persons with reduced mobility shall not be less than 1.1 m high.

The width of openings, which are usually used for embarkation and disembarkation of persons with reduced mobility shall not be at less than 1.5 m.

8.7 HOISTING GEAR OF SHIPBORNE BARGES

8.7.1 The elements of the hoisting gear of the shipborne barges to be lifted by the crane on board the barge carrier (lugs, eye plates, rings, shackles, grips, etc.) shall be designed to withstand the forces resulting from lifting the shipborne barge uniformly loaded with the specification cargo and gripped in two points diagonally positioned. Under these forces the stresses in the elements of the hoisting gear shall not exceed 0,7 times the upper yield stress of material.

8.8 PILOT TRANSFER ARRANGEMENTS, MEANS OF EMBARKATION AND DISEMBARKATION

8.8.1 Ships engaged on voyages in the course of which pilots are likely to be employed shall be provided with pilot transfer arrangements. Construction and position of pilot transfer arrangements shall comply with the requirements specified in regulation V/23 of SOLAS-74, as amended (hereinafter, SOLAS), and IMO resolutions A.1045(27) and A.1108(29).

Interpretation: sub-paragraphs 1 and 2 of SOLAS regulation V/23.3.3 address two different and distinct arrangements

- the former when only a pilot ladder is used;

- the latter when a combined arrangement of "an accommodation ladder used in conjunction with the pilot ladder" is used.

1. SOLAS regulation V/23.3.3.1 limits the length of climb on a single ladder shall be not more than 9 m regardless of the trim or list of the ship.

2. SOLAS regulation V/23.3.3.2 and Section 3 of IMO resolution A.1045(27) apply to a combined arrangement of "an accommodation ladder used in conjunction with the pilot ladder" for "safe and convenient access to, and egress from, the ship" for which a 158 list requirement does not apply.

8.8.2 The construction of means of embarkation and disembarkation shall comply with the requirements of IMO circular MSC.1/Circ.1331 «Guidance on the construction, installation, maintenance and inspection/survey of means of embarkation and disembarkation».

8.8.3 Passenger ships equipped for the carriage of persons with reduced mobility shall be designed and equipped to facilitate embarkation and disembarkation of persons with reduced mobility.

The structure of the accommodation ladders and gangways of passenger ships shall comply with the requirements of the IMO Circular MSC/Circ.735 “Recommendation on the design and operation of passenger ships to respond to elderly and disabled persons' needs”.

8.8.4 Recovery of persons from the water

8.8.4.1 All vessels engaged in international voyages shall be provided with ship specific schemes and procedures for recovery of people from the water, taking into account the guidance developed by IMO (Guidelines for the development of plans and procedures for recovery of persons from the water, MSC.1/Circ.1447).

Schemes and procedures shall specify equipment intended for use in recovery, as well as measures to minimize the risk to ship personnel involved in recovery operations.

Ships constructed before 1 July 2018 shall comply with this requirement before the date of the first periodic survey or the first renewal survey to renew the ship safety equipment certificate, which is to be performed after 1 July 2018, whichever is earlier.

Passenger ships with sign **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, **D-R3-S** and **D-R3-RS** constructed before 1 January 2018 shall comply with this requirement before the date of the first periodic survey or the first renewal survey to renew the ship safety equipment certificate after 1 July 2018.

8.8.4.2 Passenger ro-ro ships, which comply with **3.4.4** Part II “Life-Saving Appliances”of the Rules for the equipment of seagoing ships shall meet the requirements of **8.8.4.1**.

8.9 NOISE, PRODUCED BY THE SHIP. NOISE PROTECTION.

8.9.1 The noise level on the ship, protection of the crew (personnel) against noise shall comply with requirements applicable to this subsection subject to the provisions of the Code on noise levels on board ships adopted by the Maritime Safety Committee by the Resolution MSC.337(91).

8.9.2 This regulation shall apply:

8.9.2.1 To ships of 1,600 gross tonnage and above:

.1 for which the building contract is placed on or after 1 July 2014; or

.2 in the absence of a building contract, the keels of which are laid or which are at a similar stage of construction on or after 1 January 2015; or

.3 the delivery of which is on or after 1 July 2018,

unless the Administration deems that compliance with a particular provision is unreasonable or impractical;

.4 Passenger ships with sign **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, **D-R3-S** and **D-R3-RS** constructed on or after 1 January 2018;

unless the Administration deems that compliance with a particular provision is unreasonable or impractical.

8.9.2.2 On ships of 1,600 gross tonnage and above delivered before 1 July 2018 and:

.1 contracted for construction before 1 July 2014 and the keels of which are laid or which are at a similar stage of construction on or after 1 January 2009 but before 1 January 2015; or

.2 in the absence of a building contract, the keels of which are laid or which are at a similar stage of construction on or after 1 January 2009 but before 1 January 2015 measures shall be taken to reduce machinery noise in machinery spaces to acceptable levels as determined by the Administration. If this noise cannot be sufficiently reduced the source of excessive noise shall be suitably insulated or isolated or a refuge from noise shall be provided if the space required to be manned.

Ear protectors shall be provided for personnel required to enter such spaces, if necessary;

.3 in passenger ships with sign **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, **D-R3-S** and **D-R3-RS** of 1600 grosss tonnage and over, constructed on or after 1 January 2018, measures shall be taken to reduce machinery noise in machinery spaces to acceptable levels. If this noise cannot be sufficiently reduced the source of excessive noise shall be suitably insulated or isolated or a refuge from noise shall be provided if the space required to be manned.

Ear protectors shall be provided for personnel required to enter such spaces, if necessary.

8.9.3 Requirements **8.9.1** do not apply to:

.1 dynamically supported craf*;

.2 highspeed craft;

.3 pleasure yachts not engaged in trade;

.4 fishing vessels;

.5 floating cranes, crane barges;

.6 mobile offshore drilling units and MSP;

.7 hopper dredgers/dredgers, dredging ships, ships for piling, pipe-laying barges, ships of the technical fleet, etc;

.8 ships not propelled by machinery, and

.9 passenger cabins and other passenger accommodation **, unless they are working premises and fall within the definition: «Accommodation» or «Working places».

* Dyn amically supported craft (DSC) - a craft which is operable on or above water and which has characteristics different from those of conventional displacement ships.

Within the aforementioned generality, a craft which complies with either of the following characteristics:

.1 the weight, or a significant part thereof, is balanced in one mode of operation by other than hydrostatic forces;

.2 the ships may move at a speed at which the ratio $[V/(gL)^{0,5}] \geq 0,9$,

the craft is able to operate at speeds such that the function where V is the maximum speed;

L is the water-line length;

g is the acceleration due to gravity, all in consistent units.

** The noise level in passenger cabins and other passenger areas shall comply with the requirements of the Sanitary Standards adopted by the Flag State Administration.

8.9.4 The Flag State Administration may, in special circumstances, grant exemption from certain requirements if it is documented that their compliance is not possible, despite the implementation of appropriate technical measures to reduce noise. Such exemptions shalld not apply to cabins, except in exceptional circumstances.

When granting exemption from certain requirements, it is to be ensured that the Codex objective on noise levels on ships *** is fulfilled, and the limitation of the influence of noise should be considered together with Chapter 5 of this Code.

*** Refer to IMO A.468(XII), Resolution MSC.338(91).

8.9.5 For ships designed for and employed on voyages of short duration, or on other services involving short periods of operation of the ship, sections 3 and 4 of Table 8.9.9.2 (which are applicable) may be applied only with the ship in the port condition, provided that the periods under such conditions are adequate for seafarers' rest and recreation.

8.9.6 Definitions.

For the purposes of this paragraph, in addition to the definitions and explanations specified in **1.2**, Part I “Classification” and in **1.2**, Part III “Equipment, arrangements and outfit”, the following definitions apply:

.1 *Hearing loss* is hearing loss is evaluated in relation to a reference auditory threshold defined conventionally in ISO Standard 389-1 (1998).

The hearing loss corresponds to the difference between the auditory threshold of the subject being examined and the reference auditory threshold.

A hearing loss, originating in the nerve cells within the cochlea, attributable to the effects of sound.

Occasional exposures: those exposures typically occurring once per week, or less frequently.

Potentially hazardous noise levels those levels at and above which persons exposed to them without protection are at risk of sustaining a noise induced hearing loss.

.2 *Accommodation* are cabins, offices (for carrying out ship's business), hospitals, mess rooms, recreation rooms (such as lounges, smoke rooms, cinemas, libraries and hobbies and games rooms) and open recreation areas to be used by seafarers.

.3 *Ear protector* is a device worn to reduce the level of noise heard by the wearer.

.4 *Sound* is an energy that is transmitted by pressure waves in air or other materials and is the objective cause of the sensation of hearing.

.5 *Existing ship – a ship which is not a new vessel.*

.6 *Voyages of short duration* are voyages where the ship is not generally underway for periods long enough for seafarers to require sleep, or long off-duty periods, during the voyages.

.7 *Machinery spaces* for the purpose of this paragraph are any spaces containing propulsion machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and airconditioning machinery and similar spaces, and trunks to such spaces.

.8 *Navigation spaces* are navigation bridge / wheelhouse, chart room, watch stations, including wings and wheelhouse windows, radio rooms (with radio equipment operating but not generating sound signals), radar.

.9 *New ship* is a ship to which the requirements of this paragrapg apply in accordance with **8.9.2.1**.

.10 *Attended spaces* are spaces requiring a permanent or prolonged presence of the crew during normal operating periods.

.11 *Repair, re-equipment and modification of substantial nature* means the re-equipment of the ship, resulting in a substantial change in particulars, power capacity of the ship's engine(s), change in the type of ship, other changes of the ship in such a way that, the relevant provisions would apply to it as for the new ship.

.12 *Sound pressure level Lp* is the level of sound pressure, expressed in decibels (dB), which is determined by the following formula:

$$Lp = 10 \log(p^2/p_o^2),$$

where: p – – sound pressure, in Pa;
p_o = 20 μPa (zero level).

.13 *Working places* are premises where the main navigation equipment, ship radio equipment or emergency source of energy are located or where the means of controlling fire extinguishing systems or fire detection alarms are concentrated, as well as premises used as galley, main refreshments, storerooms (except for isolated cupboards and cabinets), postal offices, storehouses of valuables, workshops, which are not a part of the machinery spaces and other similar premises.

.14 *Port condition* is the condition in which all machinery solely required for propulsion is stopped.

.15 *Noise* for the purpose of the Code are all sounds which can result in hearing impairment, or which can be harmful to health or be otherwise dangerous.

8.9.7 Noise produced by the ship.

8.9.7.1 Noise of the ship under way, and in particular the noise produced by the receiving and discharge openings / devices for air and gas exhaust piping / devices shall be limited by appropriate means.

The noise level produced by the ship shall not exceed 75 dB (A) at a distance of 25 m from the ship's side.

8.9.7.2 Without taking into account loading and unloading operations, the noise level produced by the ship at berth should not exceed 65 dB (A) at a distance of 25 m from the ship's side.

8.9.7.3 The noise level is taken into account only from noise sources related to the ship, such as machinery and propulsion system, but no account is taken of wind / wave / ice noise, alarms, public address systems, etc.

8.9.8 Noise protection.

8.9.8.1 Limit values of noise levels shall be set and its impact on the crew shall be reduced to:

.1 ensure safe working conditions, taking into account the need for oral negotiations and audition of sound signals in control stations, navigational spaces and their machinery spaces serviced by the crew;

.2 protect the crew from excessively high levels of noise that may induce hearing loss and

.3 provide necessary degree of comfort in the premises for rest and entertainment and other premises, as well as to provide conditions for the removal of the effects of high-level noise.

8.9.8.2 Where the noise level in machinery spaces (or other spaces) is greater than 85 dB(A), entrances to such spaces should carry a warning notice comprising symbol and supplementary sign in the working language of the ship's crew / English (refer to Fig. **8.9.8.2**).

If only a minor portion of the space has such noise levels the particular location(s) or equipment shall be identified at eye level, visible from each direction of access.

	Warning sign	Symbol
Warning Sign (Symbol)		
Warning inscription	Warning Noise hazard zone	Ear protection must be worn

Fig. 8.9.8.2 Example of warning sign / symbol and the inscription.
The color of the warning sign field and inscription is yellow.
The color of the symbol field and inscription is blue.

8.9.9 Noise exposure limits.

.1 The limits specified in this paragraph shall be considered as maximum permissible levels, but not as desirable levels. Where practicable, it is desirable that the noise level shall be below the specified maximum permissible values.

.2 Noise exposure limits (dB (A)) for different rooms are shown in Table 8.9.9.2.

Table 8.9.9.2

Nos	Spaces	Ship dimension	
		Gross tonna ge from 1600 to 10000	Gross tonna ge ≥ 10000
1	2	3	4
1	Working space [1]		
1.1	Machinery space[2]	110	110
1.2	Machinery control stations	75	75
1.3	Workshops which not included in machinery spaces	85	85
1.4	Working spaces not specified separately (other workplaces)[3]	85	85
2	Navigation facilities		
2.1	Navigation bridge and chart rooms	65	65
2.2	Radio rooms (with running but not producing audio signals radio equipment)	60	60
2.3	Radar room	65	65
3	Accomoddation		
3.1	Hospital cabins and rooms[4]	60	55
3.2	Mess rooms	65	60
3.3	Rest rooms	65	60
3.4	Open rest areas (outdoor recreation areas)	75	75
3.5	Offices	65	60
4	Service rooms		
4.1	The galley with non-working equipment for processing the products	75	75
4.2	Handouts and buffets	75	75
5	Normally unattended spaces		
5.1	Spaces with high noise levels, where the crew can be exposed to it even for relatively short periods of time, as well as the location of the machinery used periodically	90	90

[1] A limit of 110 dB (A) assumes that hearing protectors are worn to provide protection that meets the requirements for hearing protection set out in **8.9.8**.

[2] If the maximum noise levels are exceeded during operation (only permitted in the case of an exemption in accordance with paragraph **8.9.4**), being in the room shall be limited to very short periods or prohibited. This area shall be designated in accordance with **8.9.8.2**.

[3] For example: working places on open decks that are not machinery spaces, as well as working places on open decks, where communication is important.

[4] Hospital: facilities for treatment provided with beds.

8.9.10 Noise resting areas.

.1 Alternatively, when designing ships with a gross tonnage of less than 1600 or icebreakers, noise resting areas may be provided.

.2 Noise resting areas shall be provided in the event that no other technical or organizational solution is possible to reduce the excessive noise produced by sound sources.

8.9.11 In the event of repair, reequipment and modification of the essential nature and associated changes in the equipment of existing ships, it shall be ensured that all areas in which the changes are made comply with the requirements of this subsection for new ships to the extent that the Flag State Administration deems practicable and feasible.

8.9.12 Tests of ships for compliance with the noise level limit requirements shall be carried out according to the program and test methodology approved by the Register in the presence of a representative of the Register.

The program and test procedures shall comply with the provisions of the Code on noise levels on board ships.

8.10 ADDITIONAL REQUIREMENTS TO STANDBY VESSELS

8.10.1 Each side shall be provided with evacuation areas (*rescue zones*) of at least 5 m in length with appropriate marking. Evacuation areas shall be spaced sufficiently from the propulsion gear, as well as from any side outlets, which are less than 2 m below the load line.

8.10.2 The sides of the vessel in the area of the rescue zones shall be free from protruding parts (fenders, etc.).

8.10.3 Spaces for the recovered.

8.10.3.1 The ship shall be fitted with a first aid room for the rescued in an emergency (treatment room), a wellness room with beds and a closed room for the rescued. These premises must be equipped with lighting and temperature and humidity controls, taking into account the possible operating area.

8.10.3.2 The space for the rescued shall be calculated at $0.75m^2$ per person. This space includes free space, removable furniture, fixed seats and/or beds. Other stationary furniture, toilets and baths are not included in the specified area.

8.10.3.3 A toilet equipped with a shower and sink shall be provided for each 50 rescued persons.

8.10.4 Passages from rescue areas to rooms for rescued and to the helicopter winching area, if provided, shall be fitted with non-slip or wooden cover.

8.10.5 The deck within the rescue areas should be as clear as possible from obstructions (air pipes, fittings, hatches, etc.). If available, adequate protection against personnel injury should be provided.

8.10.6 The bulwark or railing in the rescue zones area shall be removable or easily opened.

8.10.7 In the area of each rescue zone, a net must be provided for recovery of rescued people from water (scrambling net), which is made of corrosion-resistant and non-slip material with a width of at least five meters and a length exceeding 1 m from the place of deployment in the rescue zone to the water line at the lowest operational draft.

8.10.8 The ship shall be fitted with machinery for the accurate recovery of rescued people with restricted mobility from the water.

8.11 ADDITIONAL REQUIREMENTS TO ANCHOR HANDLING SHIPS

8.11.1 The design loads of the anchor handling winch devices, namely: for the anchor chain stopper, tow bitens and stern rolls, shall be taken in accordance with **5.4.2.2**. In this case, the stresses in these elements shall not exceed 0.8 the yield stress of their material.

8.11.2 Anchor handling winch shall be fitted with a cable tension measuring device.

9. REQUIREMENTS TO ESCORT TUGS

9.1 GENERAL. APPLICATION

9.1.1 The technical requirements for escort tugs apply to tugs intended for escort service.

These requirements are additional to the relevant requirements of Parts IV "Stability", VII "Machinery Installations" and VIII "Systems and Piping".

Tugs complying with the requirements of **2.2.37** of Part I "Classification" may be assigned the descriptive notation Escort tug added to the character of classification**.**

9.1.2 Definitions and explanations.

9.1.2.1 Definitions have been adopted in this section, the following (in addition to those indicated in 1.2):

Escort tug means a tug which in addition to towing and ship handling operations is intended for escort services.

Full scale trials mean sea trials of the escort tug to determine escort characteristics.

Escort service means steering, braking and otherwise controlling the assisted ship.

Escort characteristics :

- maximum steering pull of the tug F_s, in t, escort test speed V , in knots, (refer to Fig. 9.1.2.1);
- maneuvering time t, in s.

Maximum steering pull of the tug means the maximum transverse steering force, in t, exerted by the tug on the stern of the assisted ship at the escort test speed of 8 and/or 10 knots.

Assisted ship means the ship being escorted by the escort tug.

Maneuvering time means a minimum manoeuvring time, in s, from maintained oblique position of the tug (from the centerline of the assisted ship) giving the maximum transverse steering force on one side of the assisted ship to mirror position on the other side.

Escort test speed means the speed, in knots, of the assisted ship during full scale trials.

9.1.3 Technical documentation.

9.1.3.1 The following technical documentation (in addition to the requirements of **4.2** and **4.3**, Part I "Classification") shall be provided for the approval of the Register:

.1 towing arrangement plan required for escort service including towing line path and minimum breaking strength of towing line components and strength of appropriate structures;

.2 preliminary calculation of maximum steering pull of the tug at the escort test speed of 8 and/or 10 knots including propulsion components of the escort tug for balancing of oblique angular position of the tug.

.3 preliminary tug stability calculations for escorting service;

.4 plan of full scale trials.

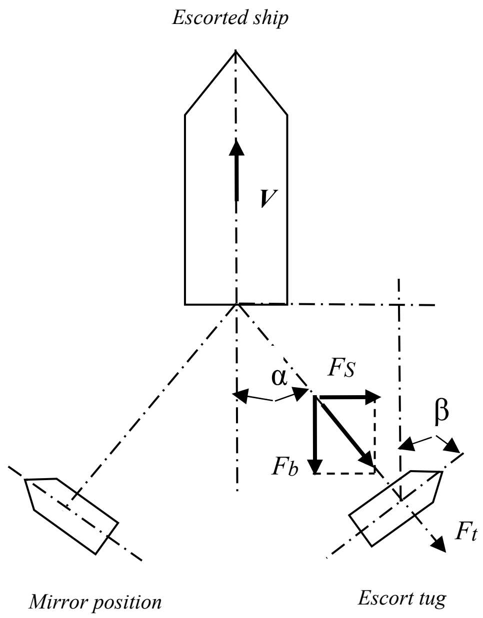


Fig. 9.1.2.1 Typical escort configuration.
F_S – steering force; F_b – breaking force;
F_t – towline force; V – assisted ship speed;
α – the angle between the towline and the centreline of the escorted ship.
β – the angle between the centreline of the tug and the centreline of the escorted ship.

9.2 TECHNICAL REQUIREMENTS

9.2.1 Arrangement and design.

9.2.1.1 A bulwark shall be fitted all around the exposed weather deck.

9.2.1.2 The towing winch intended for escort service shall be fitted with a load reducing system in order to prevent overload caused by dynamic oscillation in the towing line, and shall be capable of paying out the towing line if the pull exceeds 50 per cent of the breaking strength of the towing line.

9.2.1.3 The towing line components shall have a minimum breaking strength of at least 2,2 times the maximum towing pull as measured during the full scale trials (refer to **9.3**).

9.2.1.4 In case of escort service of oil tankers and/or oil recovery vessels, supply vessels, ships intended for the carriage of explosives and inflammable cargoes, the requirements of **11.1.3**, Part VIII "Systems and Piping" shall be complied with.

9.2.2 Stability.

9.2.2.1 The escort tug shall comply with the criteria specified in **3.7.4**, Part IV "Stability".

9.3 FULL SCALE TRIALS

9.3.1 Full scale trials program.

9.3.1.1 Prior to the full scale trials the program of trials, the approved Stability Information, as well as preliminary calculations of the ship's escort characteristics and the tug's stability during escort service shall be submitted to the Register.

9.3.1.2 The program of full scale trials shall stipulate determination of the tug's maximum transverse steering force with the assisted ship speed of 8 and/or 10 knots, the maximum angle of static heel at the specified modes, as well as the tug's manoeuvring time.

9.3.1.3 The program shall include a list of measuring instruments, description of mandatory manoeuvres, a towing arrangement scheme for expected escort modes, design loads of strong points of the tug, as well as data of the safe working load of the strong points of the assisted ship.

9.3.2 Trial procedure.

9.3.2.1 The trials shall be carried out in favourable weather (recommended limitation of wind force is 10 m/s, sea state 2), with the operating load of the tug equal to 50 — 10 per cent of provisions.

Current velocity in the area of the trials (if any) shall be measured both upstream and down stream.

9.3.2.2 Displacement of the assisted ship shall be sufficient to maintain the heading and speed with the help of the autopilot during the necessary tug manoeuvring.

9.3.2.3 The following data shall be recorded continuously in real time mode during trials for later analysis:

.1 position of the assisted ship in relation to the escort tug;

.2 towing line tension;

.3 escort test speed;

.4 angle of the tug heel during escort service;

.5 length and angle of the towing line from the centerline of the assisted ship;

.6 manoeuvring time from maintained oblique position of the tug on one side of the assisted ship to mirror position on the other side at the maximum tension value of towing line and the maximum towing line angle from the centerline of the assisted ship (but not more than 60°);

.7 angle of heel due to sudden loss of thrust.

10. REQUIREMENTS FOR THE EQUIPMENT OF SHIPS WITH ICING PROTECTION

10.1 GENERAL. APPLICATION

10.1.1 The requirements for the equipment of ships with icing protection apply to ships the design and equipment of which provide effective icing protection.

These requirements are additional to the requirements of Part VIII “Systems and Piping” and Part XI “Electrical Equipment” of these Rules, as well as Part II “Life-Saving Appliances”, Part III “Signal means”, Part IV “Radio Equipment” and Part V “Navigational Equipment” of the Rules for the Equipment of Sea-Going Ships.

10.1.2 Ships complying with the requirements of the present Section may be assigned with the distinguishing mark **DEICE** added to the character of classification in accordance with **2.2.13**, Part I "Classification".

10.1.3 Definitions and explanations.

10.1.3.1 For the purpose of the present Section the following definitions and explanations have been adopted (in addition to adopted in **1.2**:

D e - i c i n g is removal of ice appearing on the ship's hull, structures and equipment.

I c i n g p r o t e c t i o n is a set of design and organizational measures aimed at reduction of the ship's icing and reduction of labour input into ice removal during operation of the ship.

A n t i - i c i n g is prevention of ice formation on the ship's structures and equipment by means of their heating or relevant covering.

I c i n g is a process of ice accretion on the ship's hull, structures and equipment due to sea water splashes or freezing of moisture conden sating on the hull from the atmosphere.

I c i n g P r o t e c t i o n M a n u a l is a document describing actions of the ship's crew to provide icing protection. The scope of the Manual (content) depend on the ship's type, purpose and area of navigation; they shall be chosen in the most efficient way and agreed with the Register.

10.1.4 Technical documentation.

10.1.4.1 The following technical documentation shall be submitted to the Register for approval (in addition to required in **4.2** and **4.3** Part I "Classification") to assign the distinguishing mark **DEICE** in the class notation:

.1 arrangement plan of anti-icing means with indication of their heating capacity;

.2 calculation of heating capacity of anti-icing systems equipment;

.3 electrical single-line diagram of anti-icing systems with heating cables (if any);

.4 circuit diagram of steam and/or thermal liquids anti-icing systems (if any);

.5 arrangement diagram of de-icing means;

.6 test program for anti-icing systems.

10.1.4.2 Icing Protection Manual approved by the Register shall be kept onboard.

10.2 TECHNICAL REQUIREMENTS FOR ASSIGNING THE DISTINGUISHING MARK DEICE IN THE CLASS NOTATION

10.2.1 Ships with the distinguishing mark **DEICE** in the class notation shall, as a rule, be fitted with a tank of a shape providing effective water flow under all operating loading cases.

Assignment of the distinguishing mark **DEICE** in the class notation to flush deck ships is subject to special consideration by the Register in each particular case.

10.2.2 The following anti-icing means may be used:

.1 heating of structures and equipment by means of steam, thermal liquid or heating cables;

.2 use of permanent (awnings, casings) or removable (covers) protective covers;

.3 the use of lattice structures for platforms, steps of external gangways, walkways, etc.

10.2.3 The following de-icing means may be used besides heating of structures:

.1 washing and firing of ice by means of hot water or steam;

.2 anti-icing liquids;

.3 manual mechanical means including pneumatic instrument.

10.2.4 If steam systems are used for anti-icing the requirements of Section **18**, Part VIII "Systems and Piping" shall be complied with.

10.2.5 If thermal liquid systems are used for antiicing the requirements of Section **20**, Part VIII "Systems and Piping" shall be complied with.

10.2.6 If systems with heating cables are used for anti-icing the requirements of 15.4, Part XI "Electrical Equipment" shall be complied with.

10.3 EQUIPMENT, ARRANGEMENTS AND OUTFIT

10.3.1 Platforms of outer ladders as well as platforms for servicing arrangements and equipment fitted on open decks shall have a grid structure or be equipped with heating elements.

10.3.2 Outer ladders located on the escape routes to life-saving appliances as well as muster stations to lifesaving appliances (including guard rails) shall be equipped with anti-icing means.

10.3.3 Coamings of outer doors leading to the accomodation superstructure spaces and to spaces providing the ship's operation in accordance with its main purpose shall be heated.

Decks in areas of exit from the said spaces shall be equipped with anti-icing means.

10.3.4 A passage from the accomodation superstructure spaces to the equipment fitted in the fore part of the ship shall be provided on tankers, including chemical tankers and gas carriers. This passage shall be provided with antiicing means.

10.3.5 Side scuttles in the wheelhouse providing the arc of visibility required by 3.2, Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships according to the ship's class shall be heated.

Windshield wipers on the said side scuttles (if any) shall be heated as well..

These requirements also apply to side scuttles in cargo operations control stations.

10.3.6 Shell doors, cargo doors and other closing appliances in the fore part of the ship providing the ship's operation in accordance with its main purpose shall be fitted with means for effective ice removal or other means to provide working capacity of the said appliances in case of icing (for example, with ice-breaking hydraulic cylinders).

10.3.7 Design of packing of cargo hatches, shell doors and other closing appliances providing the ship's operation in accordance with its main purpose shall preclude freezing of condensate inside seals.

10.3.8 Anti-icing shall be provided for the following arrangements and equipment:

.1 anchor and mooring equipment including (but not limited to) winches, capstans, windlasses, chain stoppers, drums, control panels;

.2 arrangements for emergency towing of tankers, including chemical tankers and gas carriers;

.3 hook releasing devices of lifeboats;

.4 launching appliances of survival craft (falls on drums, sheaves, winches of launching appliances, winch breaks and other elements engaged in launching);

.5 liferafts, including hydrostatic releasing devices. The Register may require taking measures to prevent icing of additional equipment and arrangements in accordance with the ship's main purpose.

10.3.9 Lifeboats shall be of enclosed type and be equipped with the relevant heating elements to prevent icing and blocking of access hatches and/or doors.

10.3.10 Proper locations shall be provided on board for at-sea storage of removable covers used to prevent icing of equipment and fittings.

10.3.11 In addition to the emergency outfit specified in Section **12**, ships with the distinguishing mark **DEICE** in the class notation shall have the necessary de-icing outfit (crowbars, ice-axes, axes, shovels, spades) kept in places of permanent storage and having the relevant marking.

10.4 SYSTEMS AND PIPING

10.4.1 Sufficient number of scuppers and freeing ports shall be provided for the effective water flow from open decks.

Scuppers and freeing ports shall be located so as to preclude water stagnation on decks under all operating loading cases.

10.4.2 Air heads of ballast tanks and fresh water tanks shall be fitted with the relevant heating devices.

10.4.3 Design of air intakes of main, auxiliary and emergency power plants as well as of ventilation of spaces, which are of great importance for the ship's safety, shall preclude their icing that may cause air duct blockage.

10.4.4 Measures shall be taken to preclude freezing of liquid in the pipelines of fire extinguishing systems by means of their effective drying or heating.

Fire hydrants, monitors, valves and other equipment of fire extinguishing systems fitted on open decks shall be protected from icing by means of heating or removable covers.

Cut-off valve of water and foam fire extinguishing systems shall be fitted in enclosed heated spaces or shall be heated.

10.4.5 Hot water or steam supply shall be provided for de-icing on weather decks.

10.4.6 In addition to **10.4.1** ÷ **10.4.5**, the following items shall be heated on tankers, including chemical tankers and gas carriers:

.1 ventilation valves and pressure/vacuum valves (PA/ valves) of cargo tanks and secondary barriers;

.2 level, pressure, temperature gauges and gas analysers in cargo tanks located on open decks, if necessary;

.3 inert gas system elements containing water and located on open decks;

.4 emergency shut-down system (ESD) on gas carriers.

10.4.7 Drives of remotely operated fittings of tankers, including chemical tankers and gas carriers, fitted on open decks shall be equipped with anti-icing devices.

10.4.8 Pipelines equipped with electrical heating shall comply with the requirements of **5.8**, Part VIII "Systems and Piping".

10.5 ELECTRICAL EQUIPMENT, SIGNAL MEANS, RADIO AND NAVIGATIONAL EQUIPMENT

10.5.1 The following electrical equipment, signal means, radio and navigational equipment located on open decks shall be designed so that to prevent icing or shall be heated:

.1 aerials of radio and navigational equipment (excluding rod aerials), aerial matching devices (if fitted on open decks);

.2 navigation lights;

.3 whistles;

.4 satellite emergency positionindicating radio beacons;

.5 main and emergency lighting of open decks; .6 TV cameras used during operation of the ship in accordance with its main purpose;

.7 aerials of telemetric and dynamic positioning systems;

.8 means (buttons) for the remote stop of pumps for the discharge of oil-containing and waste water to reception facilities.

10.5.2 If consumers, which according to 9.3.1, Part XI "Electrical Equipment" shall be supplied from the emergency source of electrical power, are fitted with electrical heating, their heating elements shall be also fed from the emergency source of electrical power.

10.6 TESTING

10.6.1 Prior to testing an Ice Protection Manual (only for ships without the additional distinguishing mark **WINTERIZATION** (**DAT**) in class notation) shall be submitted to the Register.

10.6.2 Anti-icing means are tested with a demonstration of their intended use and taking measurements of heat output.

11. REQUIREMENTS FOR HELICOPTER FACILITIES

11.1 GENERAL. APPLICATION

11.1.1 Requirements for helicopter facilities are additional to those of Part I "Classification", Part II "Hull", Part HI "Equipment, Arrangements and Outfit", Part VI "Fire Protection", Part VIII "Systems and Piping", Part XI "Electrical Equipment" of the Rules for the Classification and Construction of Sea-Going Ships and Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships.

Passenger roller ships (ro-ro passenger ships) with a length of 130 m or more with a sign **A**, **A-R1**, **A-R2**, **A-R2-RS**, **A-R2-S**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, **D-R3-S**, **D-R3-RS** in the character of classification, shall be fitted with helicopter decks complying with requirements of these Rule.

11.1.2 Ships that meet the requirements of this section, in accordance with **2.2.25**, Part I «Classification», may be assigned with the following distinguishing marks added to the character of classification:

.1 HELIDECK –for ships fitted with helidecks and complying with the requirements specified in **11.2**, **11.3**, **11.6**, **11.7** and **6.1.1** Part IV “Fire Protection”;

.2 HELIDECK-F – for ships fitted with the helicopter refuelling facilities, in addition to those of **11.1.2.1**, complying with the requirements specified in **11.5.1**, **11.5.2** (as applicable) and 6.1.2 (as applicable), Part IV “ Fire Protection ”;

.3 HELIDECK - H – – for ships fitted with a hangar and complying with the requirements of the present Section in a full scope..

11.1.3 All ro-ro passenger ships shall be provided with a place for picking up on board the helicopter.

Passenger ro-ro ships of 130 m in length and over shall be fitted with a helicopter landing area.

Ships shall also meet the requirements of the International Civil Aviation Organization (ICAO) and the Flag State (if any) for the safe operation of helicopters, which shall be confirmed by the relevant conclusion or Certificate of the competent civil aviation authority.

11.1.4 Definitions.

11.1.4.1 For the purpose of the present Section the following definitions and explanations have been adopted (in addition to adopted in 1.2):

H a n g a r is a purpose-built space for helicopter storage and/or maintenance and repair.

H l i c o p t e r is the largest ship's helicopter, for which a safe take-off and landing operation on board a ship is ensured.

H e l i d e c k is a purpose-built helicopter take-off and landing area including all structures, fire-fighting appliances and other equipment necessary for the safe operation of helicopters.

H e l i c o p t e r f a c i l i t y (helicopter facility) is a complex of technical means including a helideck, helicopter refuelling facilities and compressed gas or special liquid filling facilities (if any), as well as hangars and spaces where helicopter maintenance facilities are located (if any).

F i n a l a p p r o a c h a n d t a k e - o f f a r e a (final approach and take-off area, FATO) is the area over which the propeller completes the landing approach maneuver, ending with the transition to the hovering or landing mode, or when performing the maneuver of the take-off begins a progressive flight.

T o u c h d o w n a n d lift - o f f a r e a (T L O F) (touchdown and lift-off area, TLOF) is a dynamic loadbearing area on which a helicopter may touchdown or lift off. For a helideck it is presumed that the FATO and the TLOF will be coincidental.

He l i c o p t e r l a n d i n g a r e a is an area on a ship designated for occasional or emergency landing of helicopters but not designed for routine helicopter operations.

W i n c h i n g a r e a is a pick-up area provided for the transfer by helicopter of personnel or stores to or from the ship, while the helicopter hovers above the deck.

11.1.5 Technical documentation.

10.1.5.1 The following technical documentation shall be submitted to the Register for approval (as applicable) to assign distinguishing marks **HELIDECK-F, HELIDECK-H** or **HELIDECK,** in the class notation (in addition to required in **4.2** and **4.3**, Part I "Classification"):

.1 helideck and hangar deck plans with indication of design loads;

.2 scantlings determination of helideck and hangar deck, as well as of deckand bulkhead stiffeners in way of helicopter tie-down points;

.3 general arrangement plan of a helicopter facility elements with indication of escape routes, tie-down points, location of fire-fighting equipment and lifesaving appliances, arrangement plan and specification of lighting and illumination means;

.4 drawing of helideck safety net;

.5 diagram of power driving gear for the helideck safety net hoisting and lowering, if any;

.6 diagram of helideck drainage system;

.7 diagram of fuel oil loading, transfer, storage and helicopter refuelling system;

.8 diagram of off-grade aviation fuel collection, storage and defueling system;

.9 diagram of nitrogen system for aviation fuel;

.10 electric diagram of main and emergency lighting in the spaces of helicopter facility arrangement;

.11 circuit diagram of helideck lighting and illumination means;

.12 drawings of electrical equipment layout and cable laying on the helideck, in hangar and in other spaces of helicopter facility arrangement;

.13 documentation on helideck and hangar deck covering;

.14 helicopter facility test program;

.15 diagram of obstacle restriction and removal approved by the Flag State Civil Aviation Authority (to be submitted for information);

.16 drawing of helideck and obstacle marking (colour, dimensions and configuration of marks shall be indicated), approved by the Flag State Civil Aviation Authority (to be submitted for information).

11.1.5.2 A Manual for the operation of helicopter maintenance facilities (hereinafter referred to as the Manual), including a description of the equipment, a list of control checks, safety requirements and equipment maintenance procedures shall be provided on board ships. This Manual shall also include procedures and safeguards to be followed during fueling operations of helicopters designed in accordance with recognized safe practices..

11.1.5.3 The Register may require additional documents to those listed in **11.1.5.1** proceeding from the ship design features.

11.2 HELIDECK DESIGN

11.2.1 Helideck arrangement with regard to provision of horizontal and vertical sectors for helicopter approach, landing and take-off shall comply with the requirements of ICAO and the Flag State (if any).

11.2.2 Helideck arrangement shall provide:

.1 free helicopter approach to helideck according to **11.2.2**;

.2 safety of helicopter take-off and landing operations and maintenance personnel;

.3 helideck location at a maximum possible distance from the ship's hazardous spaces and areasa.

11.2.3 Helideck may have any configuration in plan view, generally, circle or regular polygon. In any case FATO shall be of sufficient size to contain an area within which can be drawn a circle of diameter not less than D of the largest helicopter the helideck is intended to serve, where D is the largest dimension of the helicopter when the main and tail rotors are turning.

11.2.4 The helideck shall be provided with both main and emergency means of escape and access for firefighting and rescue personnel. These shall be located as far apart from each other as practicable, and preferably on the opposite sides of the helideck. If more than 50 per cent of the helideck area is projected from the main ship structure, it is recommended to arrange two entrances to helideck within the range of such overhanging parts that is providing at least one exit from helideck to windward side in case of fire.

11.2.5 If the helideck forms the ceiling of a deckhouse or superstructure it shall be of "A-60" class.

11.2.6 Helideck shall be made of steel. Aluminum alloys may be used provided the following:

.1 a helideck, irrespective of its type and location, shall be subject to a survey in case of fire on the helideck or in close proximity;

.2 if a helideck is located above the deckhouse or similar structure, the following conditions shall be additionally satisfied:

.2.1 the deckhouse top and bulkheads below the helideck shall have no openings;

.2.2 windows below the helideck shall be provided with steel covers;

.3 surfaces of the steel and aluminium alloy structures contacting at the point of connection and exposed to sea water shall be separated by gaskets made of nonabsorbent electrically insulating material.

Bolts, nuts and washers connecting the steel and aluminium structures shall be made of stainless steel. Bolts shall be installed in the bushes made of nonabsorbent electrically insulating material which structure shall exclude the contact of aluminium alloy and steel.

The aluminium alloy structure insulated from the steel structure shall be grounded to the ship's hull;

.4 bimetal materials shall be approved by the Register, and certificates shall be issued for them by the Register.

The horizontal component is assumed to be equal to half the vertical component;

.5 bimetallic materials shall be approved and have Certificates of the Register.

11.2.7 Helidecks and helicopter refuelling areas shall be clearly marked and provided with coamings and/or gutters to prevent fuel oil leakage from spreading.

Drainage facilities in way of helidecks shall be constructed of steel or other arrangements providing equivalent fire safety; lead directly overboard independent of any other system; and designed so that drainage does not fall onto any part of the unit.

11.2.8 Helideck plates and supporting structures shall comply with the requirements of **2.12.6**, Part II “Hull”.

11.3 EQUIPMENT OF HELIDECKS

11.3.1 The helideck surface shall be smooth, no steps or recesses in FATO are generally allowed. As an exception, the steps on the FATO perimeter line (outside the helideck white perimeter line) shall not exceed 250 mm in height, and within the FATO (within the helideck white perimeter line) shall not exceed 25 mm in height.

Objects the function of which requires that they be located on the helideck within the FATO shall only be present provided they do not cause a hazard to helicopter operations.

As an exception, for ships which keels are laid before 1 January 2012, the steps within the FATO of height not exceeding 60 mm with the edge slop 1/3 are allowed.

11.3.2 The helideck, including its marking, and hangar deck shall have a skid-resistant surface.

11.3.3 For helicopter operation in winter period easily detachable rope net, rather of natural fiber (sisal), diameter of 20 mm and maximum mesh dimensions 200 x 200 mm, shall be provided along the perimeter of the FATO.

Recommended dimensions of the net, depending on the overall helicopter length, are determined by sufficiency to cover the landing area:

6 x 6 m at helicopter length less than 15 m;

12 x 12 m at helicopter length from 15 to 20 m;

15 x 15 m at helicopter length more than 20 m.

The net shall be reliably secured to the deck along the FATO perimeter and fixed to it in any 1,5 m and shall be tightened with a load not less than 2225 N.

The dismounted net shall be kept onboard.

11.3.4 Outboard edges of the helideck shall be provided with fixed or hinged safety net of at least 1,5 m in width, made of fire-resistant flexible material.

For sea-going ships, which keels are laid before 1 January 2012, outboard edge of the fixed safety net shall not rise above the plane of FATO more than 0,25 m, and the net shall be inclined upwards at an angle of at least 10°.

For sea-going ships, which keels are laid on and after 1 January 2012, outboard edge of the fixed safety net shall not rise above the plane of FATO, and the net shall be inclined upwards at an angle of at least 10°.

Hinged safety net in tumble position shall comply with the same requirements.

The safety net shall be strong enough to withstand, without damage, a 75 kg mass being dropped, and the net shall provide hammock effect for person falling into it rather than the trampoline effect produced by some rigid materials.

11.3.5 In addition to the requirements of 11.3.4 the hinged safety net shall comply with the following requirements:

.1 safety net shall be reliably secured in a hoist position;

.2 safety net shall be reliably fixed in a hinged position so as to prevent its hoist due to the effect of airflow from the helicopter rotor;

.3 safety net hoisting and lowering shall be performed so as to minimize the risk of personnel falling overboard during the operations;

.4 any failure of power driving gear for safety net hoisting shall not prevent from its lowering by hand.

11.3.6 To minimize the risk of personnel or equipment sliding from the helideck, the outboard edges of the helideck shall have coamings of recommended height of 50 mm.

The coamings shall also meet the requirements of **11.2.7**.

11.3.7 The helideck in way of helicopter parking place and maintenance areas, as well as the hangar (if any) shall be equipped with the tie-down points and means for fastening of helicopter maintenance facilities (if any), flush type is preferable.

Connection dimensions, arrangement plan and design forces of tie-down points shall be selected for fastening of one or several types of helicopter taking into account the requirements of **11.3.1**.

11.3.8 Where handrails associated with access/escape points exceed the elevation of the FATO by more than 0,25 m, they shall be made collapsible and removable. They shall be collapsed or removed whilst helicopter manoeuvres are in progress.

11.4 FIRE PROTECTION

11.4.1 Fire protection of Helideck, hangars and premises where the equipment for refueling and maintenance of helicopters is located, shall be arranged in accordance with **6.1**, Part IV "Fire Protection".

11.5 SYSTEMS AND PIPING

11.5.1 Helicopter refuelling systems.

11.5.1.1 All the equipment used in refuelling operations shall be effectively earthed.

All the equipment, arrangements, machinery and deck coverings shall be manufactured and installed so as to prevent spark formation.

11.5.1.2 Tanks used for storage of helicopter fuel shall be located on the open deck in specially designed area, which shall be:

.1 as remote as practicable from accommodation and machinery spaces, escape routes and embarkation stations, as well as from locations containing sources of ignition;

.2 isolated from areas containing sources of vapour ignition;

.3 the fuel storage area shall be provided with arrangements whereby fuel spillage may be collected and drained to off-grade fuel tank;

.4 where tanks for storage of helicopter fuel and offgrade fuel tanks are located in enclosed spaces, such tanks shall be surrounded by cofferdams filled with inert gas;

.5 in cofferdams referred to in **11.5.1.2.4** the length of oil fuel line and the number of its detachable joints shall be kept to a minimum, and its valves shall be located in easily accessible places, generally, on the open deck;

.6 cofferdams referred to in **11.5.1.2.4** shall not be connected to any piping system serving other spaces.

11.5.1.3 Helicoopter fuel tanks and equipment related to them shall be protected from mechanical damage and fire in adjacent rooms or area.

Tanks shall be protected from direct sunlight.

11.5.1.4 When equipping tanks for the storage of helicopter fuel with facilities for their emergency jettisoning precautions shall be taken to prevent the tank jettisoned from impact against ship's structures. The tanks shall be as remote as practicable from survival craft muster and embarkation stations and survival craft launching stations.

11.5.1.5 If transported fuel tanks are used, their construction, fitting and securing devices shall be designed taking into account the purpose of the tank and the feasibility of its inspections.

Electrical earthing of tanks shall be provided.

11.5.1.6 Helicopter refueling system shall comply with the requirements of **13.13**, Part VIII "Systems and Piping".

11.5.1.7 The fuel tanks shall be made of materials which resist attacks by corrosion and helicopter fuel. Fuel may be stored both in transported and fixed tanks.

Tanks shall be efficiently secured, closed and bonded.

The tanks shall be readily accessible for inspection.

Tanks and piping for anticrystallization fluids shall be made of stainless steels.

11.5.1.8 The operating manual for helicopter maintenance facilities, including equipment description, a checklist, safety requirements and equipment maintenance procedures, shall be provided on board.

This manual shall also include the procedures and precautions to be followed during the helicopter fueling operations developed in accordance with recognized safe practice.

11.5.2 Ventilation system of hangars and spaces where helicopter refuelling and maintenance facilities are located.

11.5.2.1 Ventilation system of hangars and spaces where helicopter refuelling and maintenance facilities are located shall meet the requirements of **12.11**, Part VIII "Systems and Piping".

11.6 ELECTRICAL EQUIPMENT

11.6.1 Electrical equipment and electric wiring of hangars and spaces where helicopter refuelling and maintenance facilities are located shall comply with the requirements of **2.9**, Part XI "Electrical Equipment".

11.6.2 Lighting and illumination means for helidecks shall comply with the requirements of **6.9**, Part X I "Electrical Equipment" of the Rules for the Classification and Construction of Sea-Going Ships and the Flag State Civil Aviation requirements.

11.7 COMMUNICATIONS

11.7.1 To ensure helicopter operation the ship shall be equipped with necessary radio and meteorological equipment in compliance with the Flag State Civil Aviation requirements.

11.7.2 To ensure three-way communication between the helicopter, Helicopter deck and wheelhouse, the required number of portable VHF radio-telephone stations with headphones shall be provided.

11.8 TESTING

11.8.1 All systems and components of the helicopter facilities, after their installation on the ship, shall be tested in accordance with the Register approved Program.

11.8.2 On ships, upon request of the civil aviation authorities of the Flag State, flight tests and overflights may be carried out in accordance with the guidance documents of the Flag State.

12. EQUIPMENT OF SHIPS INTENDED TO FORM A PART OF OF A PUSHED CONVOY

12.1 GENERAL

The requirements of this section apply to tugboats-pushers, pushed barges of all purposes, of mixed "sea - river" navigation, which have a sign **R3-RS** in the class notation**.**

Tugboats-pushers and pushed barges, shall comply with the requirements of 3.14, Part II "Hull" and **5.5.1-5.5.6** of Part III of «Equipment, Arrangements and Outfit. Signal Means» of the Rules for the classification and construction of mixed navigation ships.

The anchor gear of the pusher shall comply with the characteristics of provision in accordance with 3.2 (refer also to **3.7**).

12.2 DESIGN LOADS AND PERMISSIBLE STRESSES IN THE PARTS OF COUPLINGS

12.2.1 These requirements are applicable to the double-hinged design of the coupling of pushed convoys operated with a wave height restriction $3{,}0 \le h_{3\%} \le 3{,}5$ m.

With greater wave height restrictions, the requirements of 5.5.7, Part III, «Equipment, Arrangements and Outfit. Signaling aids» of the Rules for the classification and construction of mixed navigation ships.

12.2.2 Design loads, acting at the same time on the hinge coupling device, shall be determined in accordance with **5.5.7** частини III «Equipment, Arrangements and Outfit. Signal Means» of the Rules for the classification and construction of mixed navigation ships using Table **13.2.2** instead of **5.5.7.2.**

Table 12.2.2

Product h x λ, in м	**Coefficient**	**Formula**
1	2	3
3,5 x 50	C_x	$-39{,}2 \cdot (30{,}9 \cdot \overline{p}^{\,2} - 13{,}76 \cdot \overline{p} + 1) \cdot (T_1/B_1) \cdot 10^{-4}$
	C_y	$3{,}3 \cdot (1 - 1{,}56 \cdot \overline{p}) \cdot (T_1/B_1) \cdot 10^{-3}$
	C_z	$4{,}84 \cdot (1 + 5{,}2 \cdot \overline{p}) \cdot (T_1/B_1) \cdot 10^{-3}$

13. REQUIREMENTS FOR THE EQUIPMENT OF SHIPS TO PROVIDE DURABLE OPERATION AT LOW TEMPERATURES

13.1 GENERAL

13.1.1 Application.

13.1.1.1 Requirements for the equipment of ships to ensure long-term operation at low temperatures apply to ships designed for operation in cold climatic conditions (refer to **2.2.3.1.4** of Part I “Classification”), and are additional to the requirements of Part I “Classification”, Part II “Hull”, Part VII “Machinery installations”, Part VIII “Systems and piping”, Part IX “Machinery”, part XI “Electrical equipment” and part XIII “Materials” of the Rules, part II “Life-saving appliances”, Part III “Signal means ", Part I V “Radio equipment” and Part V “Navigation equipment” of the Rules for the equipment of sea-going ships, as well as the Rules for the cargo handling gear of sea-going ships.

13.1.1.2 Ships complying with the specified requirements and the requirements of this Chapter, at the request of the ship-owner, a distinguishing mark **WINTERIZATION (DAT)** may be added to the character of classification (refer to **2.2.30**, Part I “Classification”).

13.1.2 Definitions, explanations and abbriviations.

For the purpose of the present Section the following definitions, explanations and abbriviations have been adopted.

Accommodation are spaces complying with the requirements of 1.5.2, Part VI "Fire protection".

Pollutant is any substance that is subject to restrictions on discharge into the sea in accordance with MARPOL 73/78.

Enclosed space is a space with access to an open deck and fitted with appropriate closure.

IBC Code is the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk.

LSA Code is the International Life-saving appliance Code.

MARPOL 73/78 is the International Convention for the Prevention of Pollution from Ships 1973 as amended by the Protocol 1978 .

Open space is a space with access to an open deck, which is not and fitted with closure or must be open for a long time under the operating conditions of the equipment installed in this space.

Design Ambient Temperature, DAT is an outdoor temperature in degrees Celsius, which is used as a criterion for the selection and testing of materials and equipment that are exposed to low temperatures.

Design Structural Temperature is a temperature in degrees Celsius, which is accepted for the choice of structural material. If there are no additional instructions in the Rules or in this section regarding the design temperature of the structure, the design ambient temperature is adopted.

Operating fluids are fuel and lubricating fluids and hydraulic oils, with the exception of marine fuels necessary for the normal operation of the ship and her equipment.

Harmful liquid substance (HLS) – any substance listed in the pollutant category column of Chapter 17 or 18 of the International Bulk Chemical or provisionally assessed in accordance with the provisions of Appendix **I** of Annex **II** to MARPOL 73/78 relating to Category X, Y or Z.

13.2 DESIGN AMBIENT TEMPERATURES

13.2.1 The design ambient temperature is set by the ship-owner based on the purpose of the ship and her operating conditions.

13.2.2 The following standard values for the design ambient temperature are provided in this section:

-30°C (distinguishing mark **WINTERIZATION(-30)**);

-40°C (distinguishing mark **WINTERIZATION(-40)**); and

-50°C (distinguishing mark **WINTERIZATION(-50)**).

The application of the requirements of this section for design ambient temperature above -30° C, as well as for intermediate values, is determined by the Register in agreement with the ship-owner.

13.2.3 Design ambient temperature cannot be accepted higher than specified in 1.2.3.3, Part II “Hull” for the corresponding ice class of the ship.

13.2.4 Design structural temperature shall be adopted in accordance with 1.2.3.4, Part II “Hull”. In this case, design ambient temperature should be taken as the T_A value.

13.2.5 For the equipment and machinery installed on open decks, as well as in open spaces, the design ambient temperature shall be taken as the design structural temperature . For the equipment and machinery installed in enclosed spaces that are not heated and bordering the external environment and adjacent enclosed unheated spaces the design ambient temperature shall be taken as the design structural temperature.

For the equipment and machinery installed in enclosed unheated rooms bordering the external environment and adjacent to enclosed heated spaces, the temperature 20° C higher than the design ambient temperature shall be taken as the design structural temperature.

13.3 GENERAL REQUIREMENTS

13.3.1 Cargo and slop tanks of tankers with a deadweight of less than 5000 tons over the entire length shall be protected by ballast tanks or compartments not intended for the transport of pollutants, located in accordance with the requirements of regulation **19.6.1** (from the bottom plating) and the requirements for distance w of regulation **19.6. 2** (from the shell plating) Annex I to MARPOL 73/78.

In ships other than tankers, all cargo tanks designed and intended to carry oil shall be located at a distance of at least 0.76 m from the shell plating.

On type 3 chemical carriers specified in 2.1.2 of the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code), or on bulk ships for the carriage of HLS cargo tanks shall be located at a distance of at least 0.76 m from the shell plating.

13.3.2 For ships with a total fuel tank capacity of less than 600m^3, all fuel tanks shall be located at a distance of at least 0.76m from the shell plating. This requirement does not apply to small fuel tanks, the capacity of which does not exceed $30m^3$.

13.3.3 All tanks of oil residues (oil-containing sediments), tanks for the storage of operating fluids, as well as tanks of oil-containing bilge water shall be located at a distance of at least 0.76 m from the shell plating. This requirement does not apply to small fuel tanks, the capacity of which does not exceed $30m^3$.

13.3.4 In addition to the requirements of MARPOL 73/78 Annex I, each ship shall be equipped with a collecting tank (s) for oil residues (sludge), as well as a collecting tank (s) for oil-containing bilge water of sufficient capacity, as agreed with the Register for the complete storage on board ship of accumulated oil residues (oily sediments) and oily bilge water during the voyage in polar waters and their discharge to reception facilities.

13.3.5 Navigating bridge wings shall be enclosed.

The viewing angles shall comply with the requirements of 3.2, Part V, "Navigation Equipment" of the Rules for the Equipment of Sea-Going Ships. The windows of the front, rear and side windows of the bridge (including wings) shall be tilted outwards from the vertical plane to an angle of not less than 10 ° and not more than 25 ° (except for the door glass)..

13.3.6 Exit from the accommodation corridors to the open deck shall be arranged through heated tambours.

13.3.7 A heated deck house shall be provided to cover the crew when performing such functions as monitoring the environment during the movement of the ship or guarding the gangway while in port.

13.4 EQUIPMENT, ARRANGEMENT AND OUTFIT

13.4.1 Anchor gear.

13.4.1.1 Anchor materials shall comply with the requirements of **8**, Part XIII "Materials".

13.4.1.2 Anchor chain cables materials shall comply with the requirements of **11**, Part XIII «Materials».

13.4.1.3 Casting materials for the manufacture of anchor fairleads shall comply with the requirements of **11**, Part XIII «Materials».

The Register documents that are issued for anchor fairleads, installed on ships with the distinguishing marks **WINTERIZATION (-40)** and **WINTERIZATION (-50)**, shall indicate the permissibility of their use at the corresponding design ambient temperature.

13.4.1.4 Anchor chain stoppers comply with the requirements of **3.6.1** of this Part.

The Register documents that are issued for anchor chain stoppers, installed on ships with the distinguishing marks **WINTERIZATION (-40)** and **WINTERIZATION (-50)**, shall indicate the permissibility of their use at the corresponding design ambient temperature.

13.4.2 Mooring gear.

13.4.2.1 Casting materials for the manufacture of bollards, roller chocks and other mooring equipment shall comply with the requirements of **11**, Part XIII «Materials».

The Register documents that are issued for mooring gear, installed on ships with the distinguishing marks **WINTERIZATION (-40)** and **WINTERIZATION (-50)**, shall indicate the permissibility of their use at the corresponding design ambient temperature.

13.4.2.2 Chain stoppers for single point mooring to offshore terminals shall meet the requirements **14.4.1.4**.

13.4.3 Towing gear.

13.4.3.1 Casting materials for the manufacture of bitts, bollards, roller chocks, towing roller fairlead and other towing equipment shall comply with the requirements of **11**, Part XIII «Materials».

The Register documents that are issued for towing gear, installed on ships with the distinguishing marks **WINTERIZATION (-40)** and **WINTERIZATION (-50)**, shall indicate the permissibility of their use at the corresponding design ambient temperature.

13.4.3.2 Emergency towing gear chains shall comply with the requirements of **11**, Part XIII «Materials».

13.4.4 Side scuttles.

13.4.4.1 The side scuttles of the wheelhouse and the cargo operations control station shall be heated in accordance with **10.3.5**.

13.4.4.2 In ships with the distinguishing marks **WINTERIZATION(-40)** and **WINTERIZATION(-50)** double-glazed side scuttles shall be installed in the accommodation.

13.4.4.3 If a view onto the cargo deck is provided through the side scuttles of the Master's cabin, at least one of these side scuttles shall be heated.

13.4.4.4 External access or other equivalent means for cleaning of the bridge and the cargo control station side scuttles shall be provided.

13.4.5 Cargo hatches, shell doors, cargo doors.

13.4.5.1 Materials for the manufacture of cargo holds hatches covers and bulk cargo compartments, shell and cargo doors, including packing, shall comply with the requirements of **11**, Part XIII «Materials».

13.4.5.2 Hydraulic fluids and lubricating oils shall be suitable for use at design ambient temperature.

13.4.5.3 The Register documents that are issued for hatch covers of cargo holds and bulk cargo compartments, shell and cargo doors, installed on ships with the distinguishing marks **WINTERIZATION (-40)** and **WINTERIZATION (-50)**, shall indicate the permissibility of their use at the corresponding design ambient temperature.

14. MANEUVERABILITY

14.1 GENERAL

14.1.1 This section of the Rules sets out the basic minimum requirements for the maneuverability of ships and convoys.

In cases where the convoy consists, for example, of several vessels or of a pusher with one or more barges, the maneuverability requirements apply to the convoy in general according to **2.1.1**.

14.1.2 Ships shall be able to maneuver, that is, be abile to change direction and speed quickly, ensuring the safety of navigation or solving operational tasks, both in inland waterways (not offshore) and in sea areas corresponding to the sign of the area restriction in the ship's character of class.

14.1.3 Ships longer than 100 m, and gas and chemical carriers, regardless of the length, shall be maneuverable, complying with the provisions of IMO Resolution MSC.137 (76) “Standards for ship manoeuviability”, taking into account MSC / Circ.1053 “Explanatory notes to the Standards for shipmanoeuvrability".

14.1.4 The main characteristics of the vessel affecting controllability, the characteristics of the steering gear and the steering nozzle are selected at the discretion of the designer and the shipowner, taking into account the need to ensure proper controllability of the vessel, corresponding to its purpose and operating conditions, the need to ensure compliance of the relative rudder areas or steering nozzles of the designed vessel and prototype vessel, provided, however, that the total efficiency of the selected rudders and (or) steering nozzles shall not be less than assigned in the applicable requirements of **2.10,** Part **III** « Equipment, Arrangements and Outfit» and **14,** Part **III** « Equipment, Arrangements and Outfit. Signal Means» of the Rules for the classification and construction of inland navigation ships.

15. EMERGENCY OUTFIT

15.1 GENERAL

15.1.1 The items listed in Tables 12.2.1, 12.2.2-1, 12.2.2-2 i 12.2.3, may be included into the emergency outfit, provided these items have corresponding markings and their permanent storage places are situated above the bulkhead deck.

15.2 EMERGENCY OUTFIT REQUIRED

15.2.1 All ships exept those specified in **15.2.4** and **15.2.6**, shall have emergency outfit in the scope not less than listed in Table 15.2.1.

For the unmanned non-self-propelled ships no emergency outfit is required. The manned non-selfpropelled ships shall be supplied with the emergency outfit in accordance with **15.2.10** like floating docks with no permanent direct communication with the shore.

Table 15.2.1

Nos.	Item, unit	Розмір	Quantity for ships of length L, in m				Quantity for tankers *
			150 and over	from 150 to 70 incl.	from 70 to 24 incl.	below 24	
1	2	3	4	5	6	7	8

1	Armoured collision mat, pc	4,5x4,5 m	1	–	–	–	–
2	Lightened collision mat, pc	3,0x3,0 m	–	1	–	–	1
3	Thrummed collision mat, pc	2,0x2,0 m	–	–	1	–	–
4	Thrummed pad, pc	0,4x0,5 m	4	3	2	1	2
5	Set of rigging tools.	as per Table 12.2.3	1	1	1	1	1
6	Set of fitter's tools	as per Table 12.2.3	1	1	1	1	1
7	Pine bar, pc	150x150x x4000 mm	8	6	–	–	–
8	Pine bar, pc	80x100x 2000mm	2	2	4	–	4
9	Pine plank, pc	50x200x 4000mm	8	6	2	–	–
10	Pine plank, pc	50x200x2000mm	4	2	2	–	2
11	Pine wedge, pc	30x200x 200mm	10	6	4	–	4
12	Birch wedge, pc	60x200x 400mm	8	6	4	–	4
13	Pine plugs, pc	10x30x150mm	10	6	4	2	4
14	Pine plugs for ships with side scuttles, pc	side scuttle diameter	6	4	2	2	4
15	Unbleached canvas, m^2	–	10	6	4	2	–
16	Coarse felt, m^2	s = 10mm	3	2	1	–	–
17	Rubber plate, ^{2}	s = 5mm	2	1	0,5	–	0,5
18	Tarred tow, kg	–	50	30	20	10	5
19	Wire (low-carbon steel pc 50 m each), pc	∅ 3mm	2	2	1	–	1
20	Construction shackles, pc	d = 12mm	12	8	4	–	4
21	Hexagon-head bolt, pc	M16x400mm	10	6	2	–	–
23	Hexagonal nut, pc	M16	16	10	6	4	–
24	Washer for bolt, pc	M16	32	20	12	8	–
25	Construction nails, kg	l = 70mm	4	3	2	1	1
26	Construction nails, kg	l = 150mm	6	4	2	1	1
27	Cement (quick setting), kg	–	400	300	100	100	100

End of Table 15.2.1

Nos	Item, unit	Розмір	Quantity for ships of length L, in m				Quantity for tankers *
			150 and over	from 150 to 70 incl.	from 70 to 24 incl.	below 24	
1	2	3	4	5	6	7	8
28	Sand, natural, kg	–	400	300	100	100	100
29	Accelerator for concrete setting, kg	–	20	15	5	5	5
30	Minium, kg	–	15	10	5	5	5
31	Technical fat, kg	–	15	10	5	–	5
32	Carpenter's axe, pc.	–	2	2	1	1	1
33	Saw, cross-cut, pc	l = 1200mm	1	1	1	–	–
34	Hack-saw, pc	l = 600mm	1	1	1	1	1
35	Shovel, pc	–	3	2	1	1	1
36	Bucket, pc	–	3	2	1	1	1
37	Sledge hammer, pc	5kg	1	1	1	–	–

38	Lantern of explosionproof type, pc	–	1	1	1	1	1
39	Stop of telescopic type, pc	–	3	2	1	1	1
40	Emergency screw clamp, pc	–	2	1	1	–	–
Note. *Whatever the ship length, ice class and navigation area are.							

15.2.2 Additional set of emergency outfit, above that listed in Table 15.2.1, shall be provided:

in accordance with Table 15.2.2-1 for passenger and special purpose ships, of 70 m in length and over, except for fiber-reinforced plastic ships;

in accordance with Table 15.2.2-2 for fiber-reinforced plastic ships.

Table 15.2.2-1

Nos	Item	Quantity
1	Portable autogenous cutting torch complete with set of fully charged gas cylinders	1
2	Hand jack, hydraulic	1
3	Blacksmith's sledge hammer	1
4	Forge chisel with haft	1
5	Crowbar	2
6	Jack 9,8 kN	1
7	Jack 19,6 kN	1

Table 15.2.2-2

Nos	Item	Quantity
1	Glass fabric	25m^2
2	Glass fabric	3kg
3	Resin binder with hardener	5kg

15.2.3 The sets of rigging and fitter's tools specified in Table 15.2.1, shall be completed according to Table 15.2.3.

Таблиця 15.2.3

Nos	Item	Size	Quantity per set	
			rigging	fitter's
1	Tape measure	l = 2000 mm	1	–
2	Bench hammer	0,5 kg	1	1
3	Sledge hammer	3,0 kg	–	1
4	Rigger's mallet	–	1	–
5	Puncher (dumb iron)	–	1	–
6	Chisel	b = 20 mm l = 200 mm	1	1
7	Marline spike	l = 300 mm	1	–
8	Carpenter's chisel	b = 20 mm	1	–
9	Screw auger	∅ 18 mm	1	–
10	Tongs	l = 200 mm	1	–
11	Hollow punch	∅ 18 mm	–	1
12	Hollow punch	∅ 25 mm	–	1
13	Triangular file	l =300 mm	–	1
14	Half-round file	l = 300 mm	–	1

Nos	Item	Size	Quantity per set	
			rigging	fitter's
15	Multi-purpose tongs	*l*= 200 mm	–	1
16	Screw driver	*b* = 10 mm	–	1
17	Adjustable wrench	Jaw width up to 36 mm	–	1
18	Wrench	Jaw width up to 24 mm	–	1
19	Rigger's knife	–	1	–
20	Hack-saw frame	–	–	1
21	Hack-saw blade	–	–	6
22	Kit-bag	–	1	1

15.2.4 For ships of restricted areas of navigation **R1**, **A-R1, A-R2**, **A-R2-RS**, **A-R2-S**, **R2, R2-S, R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, except those specified in **15.2.5**, equipment with emergency outfit and materials may be laid down as for the nearest lower group of ship's division depending on their length according to Table 15.2.1.

The minimum amount of emergency outfit for ships of restricted areas of navigation **R3, R3-IN** and **D-R3-S, D-R3-RS** shall be determined by the shipowner.

15.2.5 For **Ice5** and **Ice6** ice class ships, Polar class **PC1** ÷ **PC6** and Baltic ice class **IA Super** equipment with emergency outfit and materials shall be established as for the nearest higher group of ship's division according to their length as per 15.2.1.

15.2.6 For glass-reinforced plastic ships provision of emergency outfit listed under items 6, 9, 17, 21–24, 26–29, 31, 35, 36, 39 i 40 of Table 15.2.1 is not required.

15.2.7 In ships intended to carry flammable and explosive cargoes tools of emergency outfit shall be made of nonsparking materials wherever practicable.

15.2.8 The tugs of restricted area of navigation **R3** and **R3-IN** need not be equipped with emergency outfit, except for the sets of rigging and fitter's tools required in accordance with Table 15.2.3.

15.2.9 For tugs of unrestricted service and restricted area of navigation **R1** with ice class **Ice5,** category equipment with emergency outfit and materials shall be established as for the nearest higher group according to Table 15.2.1.

15.2.10 The floating docks which are not in permanent direct communication with the shore shall have emergency outfit as indicated under items 5, 6, 19 - 26, 32 - 34 and 37 of Table 15.2.1, length of the floating dock *L* being taken in this case instead of the ship's length *L*.

The floating docks which are in permanent direct communication with the shore need not be provided with emergency outfit.

15.2.11 For berth-connected ships, the emergency outfit shall be chosen by the owner.

15.2.12 Ships having a distinguishing mark **FF1**, **FF1WS**, **FF2**, **FF2WS** and **FF3WS** in the class notation shall have two searchlights capable of providing an efficient horizontal and vertical range of illumination of a surface not less than 10 m in diameter at a distance up to 250 m at the minimum illumination intensity up to 50 lx at dark time and clear atmosphere.

15.3 STORAGE OF EMERGENCY OUTFIT

15.3.1 The emergency outfit indicated in **15.2** shall be stored at least in two emergency stations, one of which shall be situated in the machinery space.

Emergency stations may be special spaces, boxes or places allocated on the deck or in spaces.

In the emergency station of the machinery space the outfit necessary for carrying out the emergency operations inside the space shall be stored; the rest of the emergency outfit shall generally be stored in the emergency stations located above the bulkhead deck;

in ships of less than 45 m in length it is allowed to locate the emergency station below the bulkhead deck on condition that free access to this station is provided at all times.

In ships of 31 m in length and below it is allowed to store the emergency outfit only in one emergency station.

15.3.2 A free passage shall be provided in front of the emergency station; the passage width shall be selected depending on the overall dimensions of the outfit stored in the station but not less than 1,2 m. In ships of less than 70 m in length the passage width is allowed to be reduced to 0,8 m and in ships of 31 m in length and below to 0,6 m.

The passages to the emergency stations shall be as straight and short as practicable.

15.4 MARKING

15.4.1 Items of the emergency outfit and cases for their storage (apart from collision mats) shall be painted blue either entirely or in a stripe.

The cases for emergency equipment storage shall have the distinct inscription to indicate the name of the material, weight and warranted storage period.

15.4.2 The emergency stations shall be provided with distinct inscriptions "Emergency Station". Moreover, in the passages and on the decks notices shall be posted showing location of the emergency stations.

15.5 COLLISION MATS

15.5.1 Collision mats shall be made of water-resistant canvas or other equivalent fabric and be provided with either a soft or wire interlayer depending on the type of the collision mat. The collision mats shall be edged by a leech rope with four thimbles fitted into its corners. Moreover, cringles shall be provided according to the number of ropes specified in Table 15.5.1.

Basic data on the collision mats are given in Table 15.5.1 and Fig. 15.5.1.

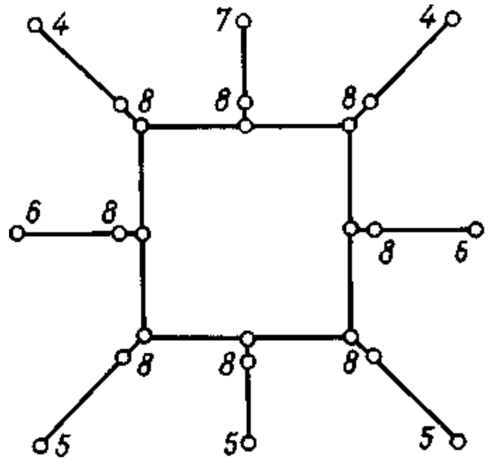


Fig.15.5.1

Table 15.5.1

Nos	Item	Quantity		
		Armoured collision mat, 4,564,5 m	Lightened collision mat, 3,063,0 m	Thrummed collision mat, 2,062,0 m
1	Canvas layers	4	2	2
2	Interlayer	wire net with leech rope	felt padding	1 pad
3	Fastening of stiffeners	–	In pockets (pieces of wire rope or pipes)	–
4	Sheets	2	2	2
5	Hogging lines	3	2	2
6	Guys	2	2	–
7	Control lanyard with marking	1	1	1
8	Shackles	12	9	6

Nos	Item	Quantity		
		Armoured collision mat, 4,564,5 m	Lightened collision mat, 3,063,0 m	Thrummed collision mat, 2,062,0 m
9	Tackles (safe working load)	4 (14,7 kN)	2 (9,8 kN)	2 (9,8 kN)
10	Snatch blocks (safe working load)	4 (14,7 kN)	2 (9,8 kN)	2 (9,8 kN)

15.5.2 The pads shall be made of natural fibre rope strands and be thrummed with natural fibre spun yarn. A canvas shall be sewn on the bottom side of the pad.

15.5.3 Sheets and guys of armoured collision mats shall be made of flexible steel wire ropes, control lanyards - of natural fibre ropes and hogging lines for all collision mats - of flexible steel wire ropes or chains having suitable diameter.

Wires of steel ropes shall have heavy zinc coating in accordance with the national standards.

The length of the sheets shall be chosen so that a hole may be shut up in any place of the shell plating and the ends of the ropes may be efficiently secured on the deck.

Breaking strength of the whole sheets shall exceed that of the leech ropes by not less than 25 %.

15.5.4 The blocks of emergency outfit may have hooks as hangers. The permissible load of the shackles joining the ropes shall not be less than 0,25 times the breaking load of the whole ropes referred to above.

APPENDIX 1

CALCULATION OF THE WIDTH OF STAIRWAYS SORMING MEANS OF ESCAPE ON PASSENGER SHIPS AND ON SPECIAL PURPOSE SHIPS CARRYING MORE THAN 60 PERSONS

1. The calculation method considers evacuation from enclosed spaces within each main vertical zone individually and takes into account all of the persons using the stairway enclosures in each zone, even if they **enter that stairway from another main vertical zone.**

2. For each main vertical zone the calculation shalld be completed for the night time (case 1) and day time (case 2) and the largest dimension from either case used for determining the stairway width for each deck under consideration.

3. For multi-deck ships, the total stairway width *W*, in mm, which allows for the timely flow of persons evacuating from adjacent decks is determined using the following calculation method:

when joining two decks:

$$W = (N_1 + N_2) \cdot 10 ; \quad (3\text{-}1)$$

when joining three decks

$$W = (N_1 + N_2 + 0{,}5N_3) \cdot 10 ; \quad (3\text{-}2)$$

when joining four decks

$$W = (N_1 + N_2 + 0{,}5N_3 + 0{,}25N_4) \cdot 10 , \quad (3\text{-}3)$$

where: N_1 – the number of persons to be evacuated from deck with the largest number of persons using the stairway;

N_2 – the number of persons to be evacuated from the deck with the next largest number of persons directly entering the stairway etc., i.e. $N_1 > N_2 > N_3 > N_4$.

When joining five or more decks, the total stairway width shall be determined by Formula (3-3) with regard for the number of tiers and their capacity (refer to Fig. 3-1).

The calculated value of *W* may be reduced where available landing area is provided in stairways at the deck level (refer to Fig. 3-2).

The doors to the muster station shall have an aggregate width of at least

D = 900+9355 = 10255

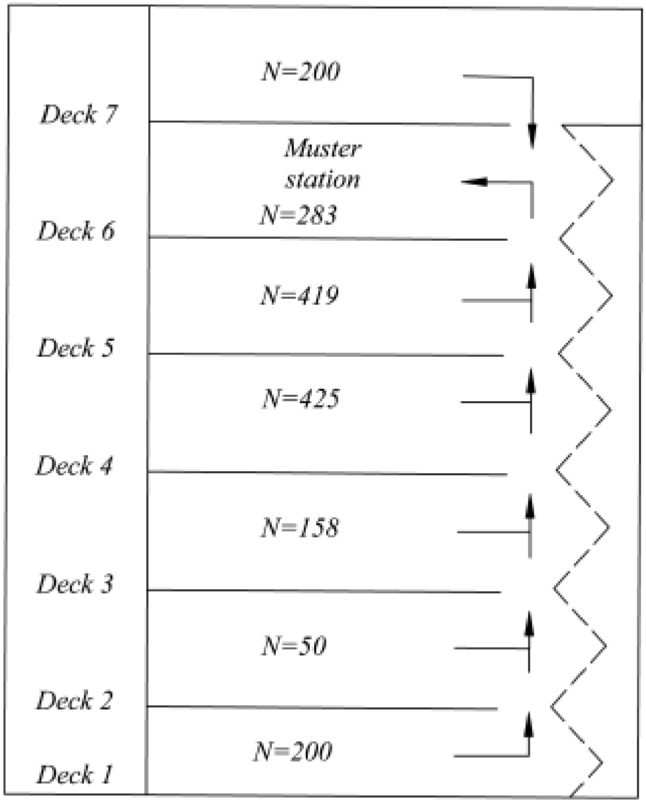


Fig.3-1 Minimum stairway width calculation example:

Deck 1:

$N_1 = 200$, $W = 200 \cdot 10 = 2000$;

Deck 2:

$N_1 = 200$, $N_2 = 50$,

$W = (200 + 50) \cdot 10 = 2500$;

Deck 3:

$N_1 = 200$, $N_2 = 158$, $N_3 = 50$,

$W = (200 + 158 + 0{,}5 \cdot 50) \cdot 10 = 3830$;

Deck 4:

$N_1 = 425$, $N_2 = 200$,

$N_3 = 158$, $N_4 = 50$,

$W = (425 + 200 + 0{,}5 \cdot 158 + +0{,}25 \cdot 50) \cdot 10 = 7165$;

Deck 5:

$N_1 = 425$, $N_2 = 419$, $N_3 = 158$, $N_4 = 50$,

$W = (425 + 419 + 0{,}5 \cdot 158 + 0{,}25 \cdot 50) \cdot 10 = 9355$;

Deck 7:

$N_1 = 200$, $W = 900$.

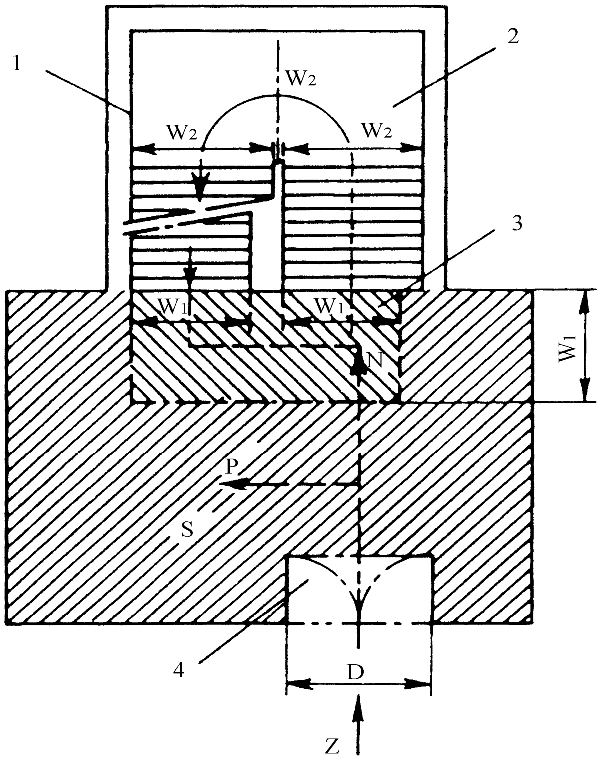


Fig.3-2 Landing calculation for stairway width reduction:

1 – handrail on both sides of the stairway;
2 – intermediate landing;
3 – necessary flow area for accessing the flow on the stairs;
4 – door area;
$P = S$ x 3 persons/m^2 – the number of persons taking refuge on the landing to a maximum value of $P_{max} = 0{,}25Z$;
$N = Z – P$ – the number of persons directly entering the stairway flow from a given deck;
Z – the number of persons to be evacuated from the deck considered;
S – available landing area, in m^2, after subtracting the surface area necessary for movement and subtracting the space taken by the door swing area;
D – width of exit doors to the stairway landing area, in mm.

4. The stairway shall not decrease in width in the direction of evacuation to the muster station, except in the case of several muster stations in one main vertical zone the stairway width shall not decrease in the direction of the evacuation to the most distant muster station.

5. Where the passengers and crew are held at a muster station which is not at the survival craft embarkation position the dimensions of stairway width and doors from the muster station to this position shall be based on the number of persons in the controlled groups. The width of these stairways and doors need not exceed 1500 mm unless larger dimensions are required for evacuation from these spaces under normal conditions.

6. The calculations of stairway width shall be based upon the crew and passenger load on each deck. For the purpose of the calculation the maximum capacity of a public space shall be defined by either of the following two values: the number of seats or similar arrangements, or the number obtained by assigning 2 m^2 of gross deck surface area to each person.

7. The dimensions of the means of escape shall be calculated on the basis of the total number of persons expected to escape by the stairway and through doorways, corridors and landing (refer to Fig. 7).

Calculations shall be made separately for the two cases of occupancy of the spaces specified below. For each component part of the escape route, the dimension taken shall not be less than the largest dimension determined for each case.

Case 1:

passengers in cabins with maximum berthing capacity fully occupied;

members of the crew in cabins occupied to 2/3 of maximum berthing capacity;

service spaces occupied by 1/3 of the crew.

Case 2:

passengers in public spaces occupied to 3/4 of maximum capacity;
members of the crew in public spaces occupied to 1/3 of maximum capacity;
service spaces occupied by 1/3 of the crew;
crew accommodation occupied by 1/3 of the crew.

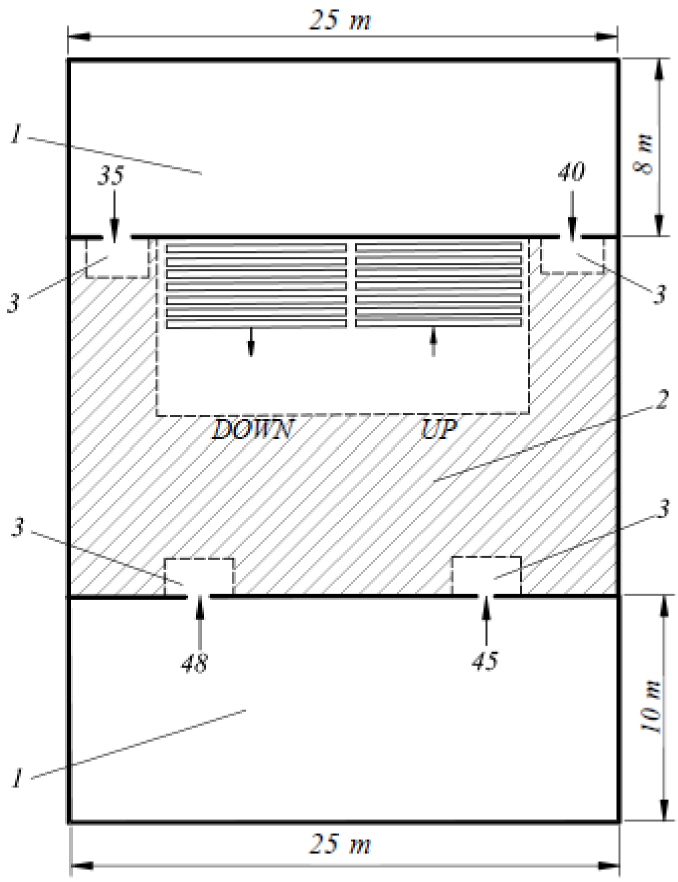


Fig.7 Occupant loading calculation example:
1 – public space;
2 – landing credit area;
3 – door area;
DOWN, UP – stairway flow path for upper space:

$$Z_{(pers.)} = \frac{25\text{ m} \cdot 8\text{ m}}{2\text{ m}^2} = 100;\ N_{(pers.)} = 100 \cdot 0{,}75 = 75;$$

for lower space:

$$Z_{(pers.)} = \frac{25\text{ m} \cdot 10\text{ m}}{2\text{ m}^2} = 125;\ N_{(pers.)} = 125 \cdot 0{,}75 = 93$$

8. The maximum number of persons contained in a vertical zone including persons entering stairways from another main vertical zone shall not be assumed to be higher than the maximum number of persons authorized to be carried on board for the calculation of the stairway width only.

ADDITIONAL REQUIREMENTS

1. The aggregate width of stairway exit doors to the muster station shall not be less than the aggregate width of stairways serving this deck.

2. Means of escape plans shall be provided indicating the following:

.1 the number of crew and passengers in all normally occupied spaces;

.2 the number of crew and passengers expected to escape by the stairway and through doorways, corridors and landing;

.3 muster stations and survival craft embarkation positions;

.4 primary and secondary means of escape;

.5 width of stairways, doors, corridors and landing areas.

3. Means of escape plans shall be accompanied by detailed calculations for determining the width of escape stairways, doors, corridors and landing areas.

APPENDIX 2

SAFE ENTERING INTO CARGO HOLDS, CARGO AND BALLAST TANKS AND OTHER SPACES

1. Safe access[1] to cargo holds, cargo and ballast tanks and other premises of the cargo area shall be directly from the open deck and shall be such as to ensure full inspection of these premises.

Safe access to the double bottom or forepeak is possible through the pump room, deep cofferdam, pipeline tunnel, cargo hold, double hull or similar compartment, which is not intended for the carriage of oil or hazardous goods.

2. Tanks and tank compartments of 35 m in length or more shall be equipped with at least two access hatches and access ladders, located as far as possible from each other.

Tanks less than 35m in length shall be equipped with at least one hatch and ladder for access.

If a tank is divided by one or more baffle bulkheads or similar obstacles that do not provide easy access to other parts of the tank, it shall be fitted with at least two access hatches and ladders.

3. Each cargo hold shall be equipped with at least two access means, as far as practicable, as far apart as possible.

As a rule, these means for access are located diagonally, for example, one in the nasal forward bulkhead from the port side, and the second in the aft bulkhead from the starboard side.

[1] Refer to IMO A.1050(27) – «Revised Recommendations for Entering Enclosed Spaces aboard Ships».

PART III. EQUIPMENT, ARRANGEMENTS AND OUTFIT

1. GENERAL

1.1 APPLICATION

1.1.1 1 The requirements of this Part apply to equipment, arrangements and outfit of sea-going ships navigating in a displacement condition. To hydrofoil boats, air cushion vehicles, hydrogliders and other similar ships, unless expressly provided otherwise below, the requirements of this Part are applicable to the extent that is practicable and reasonable.

1.1.2 Ship's equipment, arrangements and outfit designed for special purposes (such as special anchor arrangements of dredgers, a deep-sea anchor arrangement for special purpose ships and similar arrangements) are not subject to the Register supervision.

1.1.3 The requirements of this Part apply, as far as practicable and reasonable, to floating metallic wing-walled docks, unless expressly provided otherwise. These Rules do not specify conditions for mooring of floating docks in a particular place of operation and selection of types and characteristics of the equipment, arrangements and outfit (anchor, mooring, etc.) used for this purpose.

1.1.4 This part of the Rules applies to:

.1 equipment providing effective anti-icing protection of ships having in accordance with provisions of **2.2.13**, Part I "Classification" of the Rules for Classification and Construction of Ships, the additional **DEICE** sign in ship's class notation;

.2 equipment providing the operation of helicopters, of ships which in accordance with the provisions of **2.2.25**, Part I "Classification", have an additional sign: **HELIDECK**, **HELIDECK-F** or **HELIDECK-H** respectively in the ship's class notation;

.3 equipment for tugs intended for escort operations;

.4 equipment of standby ships and ships for anchor handling;

.5 equipment for the long-term operation of shipss at low temperatures, which, in accordance with the provisions of **2.2.30**, Part I "Classification", have an additional sign: **WINTERIZATION (DAT)** in the ship's class notation;

.6 arrangements providing the operation of Baltic ice class ships, which, in accordance with the provisions of 2.2.3.1, Part I “Classification”, have an additional sign: IA Super, IA, IB or IC respectively, in the ship's class notation;

.7 equipment of ships intended for inclusion in pushed convoys.

1.2 DEFINITIONS AND EXPLANATIONS

The definitions and explanations relating to the general terminology of these Rules are given in Part I "Classification".

For the purpose of this Part the following definitions have been adopted.

1.2.1 Waterlines.

Damage waterlines are the waterlines of a damaged ship after flooding of corresponding separate compartments or their combinations as provided in Part **V** "Subdivision".

Mar gin line at docking is the envelope of the waterlines corresponding to the maximum permitted trims of the floating docks and docklift ships when carrying out the docking operations.

Summer load waterline is the waterline indicated by the upper edge of the line which passes through the centre of the ring of the load line mark for a ship in upright position.

Summer timber load waterline is the waterline indicated by the upper edge of the assigned summer timber load line.

Deepest load waterline is the waterline indicated by the upper edge of the assigned uppermost regional or seasonal load line, including fresh water load lines.

Deepest subdivision load waterline is the uppermost waterline at which the requirements of Part **V** "Subdivision" are still fulfilled.

1.2.2 Dimensions and draught of the ship.

Length o f ship L is taken as 96 % of the total length on a waterline at 85 % of the least moulded depth or as the length from the fore side of the stem to the axis of the rudder stock on that waterline, if that be greater.

Where the stem contour is concave above that waterline, the length of the ship shall be measured from the vertical projection to that waterline of the aftermost point of the stem contour (above that waterline).

In ships designed with a rake of keel the waterline on which this length is measured shall be parallel to the design waterline.

Length of floating dock L is the distance measured along the pontoon deck and parallel to the base line, between the inner sides of the pontoon end bulkheads.

Moulded draught d is the vertical distance measured amidships from the top of the plate keel or from the point where the inner surface of the shell (outer surface in a ship with a non-metal shell) abuts upon the bar keel, to the summer load waterline.

Moulded depth D is the vertical distance measured amidships from the top of the plate keel, or from the point where the inner surface of the shell abuts upon the bar keel, to the top of the freeboard deck beam at side.

In ships having rounded gunwales, the moulded depth shall be measured to the point of intersection of the moulded lines of the freeboard deck and side, the lines extending as though the gunwale were of angular design.

Where the freeboard deck is stepped in the longitudinal direction and the raised part of the deck extends over the point at which the moulded depth shall be determined, the moulded depth shall be measured to a line of reference extending from the lower part of the deck along a line parallel with the raised part.

Moulded breadth B is the maximum breadth measured amidships from outside of frame to outside of frame in a ship with a metal shell and to the outer surface of the hull in a ship with a shell of any other material.

1.2.3 Superstructures, deckhouses.

Superstructure is a decked structure on the freeboard deck, extending from side to side of the ship or with the side plating not being inboard of the shell plating more than 4 % of the breadth *B*.

The superstructure may be either complete, i.e. extending over the entire ship's length *L*, or detached, i.e. extending only over a definite part of this length. Both complete and detached superstructures may be arranged either in a single or several tiers.

Deckhouse is a decked structure on the freeboard or superstructure deck which is set in from the sides of the ship for more than 4 % of the breadth *B* and has doors, windows or other similar openings in the outer bulkheads. The deckhouses may be arranged in a single or several tiers.

Trunk is a decked structure on the freeboard deck which is set in from the sides of the ship for more than 4 % of the breadth *B* and has no doors, windows or other similar openings in the outer bulkheads.

1.2.4 Tightness.

Tight under pressure head up to... is the term pertaining to closing appliances of openings, which means that under specified pressure the liquid will not penetrate through the openings inside the ship.

Weathertight is the term pertaining to closing appliances of openings in the above-water hull, which means that in any sea conditions water will not penetrate through the openings inside the ship. The above closing appliances shall undergo tests according to the requirements of **4.4.3**, Appendix **1** to Part II "Hull".

It is allowed that the specialized organizations recognized by the Register carry out tests by means of the ultrasonic equipment as well as other test methods approved by the Register.

1.2.5 Decks.

Weather deck is the deck which is completely exposed to the weather from above and from at least two sides.

Upper deck is the uppermost continuous deck extending for the full length of the ship.

The upper deck may be stepped.

Raised quarter deck is the after upper part of a stepped deck, the forward lower part of which is taken as a portion of the freeboard deck.

Freeboard deck is the deck from which the freeboard is measured.

In a ship having a discontinuous deck the lowest line of this deck and the continuation of that line parallel to upper part of the deck is taken as a freeboard deck.

Superstructure deck, deckhouse top or trunk deck is the deck forming the top of a superstructure, deckhouse or trunk, respectively.

Superstructure deck or deckhouse top of the first, second, etc. tiers is the deck forming the top of the superstructure or deckhouse of the first, second, etc. tiers, counting from the freeboard deck.

Bulkhead deck is the deck up to which the main transverse watertight subdivision bulkheads are carried.

The bulkhead deck may be discontinuous, i.e. with a step or steps formed both by main transverse watertight bulkheads reaching the keel and transverse watertight bulkheads not reaching the keel.

Lower decks are the decks below the upper deck.

Pontoon deck of the dock is the deck on which the ship to be docked is fitted.

Top deck of the dock is the uppermost deck of the dock (the uppermost deck of the wing walls).

1.2.6 Perpendiculars and amidships.

Amidships is at the middle of the ship's length *L*.

Forward and after perpendiculars are the vertical lines passing in the centreline at the fore and after ends of the ship's length *L,* respectively.

1.2.7 Ships.

Type "A" ship is a ship designed to carry only liquid cargoes in bulk, and in which cargo tanks have only small access openings closed by gasketed covers tight under an appropriate inner pressure of liquid which is carried in the tanks. Furthermore, a type "A" ship shall have some other features, as defined in the Load Line Rules for Sea-Going Ships which permit this ship to be assigned a freeboard based on Tables 4.1.2.3, 6.4.2.2 or 6.4.3.2 of the above Rules.

Type "B" ship is a ship which does not comply with the requirements regarding type "A" ships and which is assigned a freeboard based on Table 4.1.3.2, 6.4.2.3 or 6.4.3.3 of the Load Line Rules for SeaGoing Ships.

A type "B" ship may not be classified as a type "A" ship even though, as a result of her features detailed in the Load Line Rules, a reduction in tabular freeboard is permitted up to the total difference between the values given in Tables 4.1.2.3, 6.4.2.2, 6.4.3.2 and those in Tables 4.1.3.2, 6.4.2.3, 6.4.3.3, respectively, of the above Rules.

Docklift ship is a dry cargo ship adapted to carry out cargo handling operations using the docking principle in ports and protected water areas.

1.2.8 *Active means of the ship's steering (AMSS)* are special propulsion and steering units and any combination of them or with the main propulsion devices, capable of producing thrust or traction force both at a fixed angle to the centreline of the ship and at a variable angle, either under all running conditions or part thereof including small and zero speed.

The active means of the ship's steering comprise steerable propellers including retractable units of all types, active rudders, vertical-axis propellers, waterjets, propellers in transverse tunnel (athwartship thrusters), separate steering nozzles and other devices of similar purpose.

Design and construction requirements to *AMSS*, except for separate nozzles and the steering part of the active rudders, set forth in part VII "Machinery Installations".

Requirements to AMSS of systems for dynamic positioning of mobile offshore drilling units (MODU) shall be carried out taking into account the Rules for the classification, construction and equipment of mobile offshore drilling units and offshore stationary platforms.

1.2.9 Steering gear.

Main steering gear is the machinery, rudder actuators, steering gear power units, if any, ancillary equipment and the means of applying torque to the rudder stock (e.g. tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the ship under normal service conditions.

Auxiliary steering gear is the equipment other than any part of the main steering gear necessary to steer the ship in the event of failure of the main steering gear, but not including the tiller, quadrant or components serving the same purpose.

Steering gear power unit is:

in the case of electric steering gear an electric motor and its associated electrical equipment;

in the case of electrohydraulic steering gear an electric motor and its associated equipment and connected pump;

in the case of other hydraulic steering gear a driving engine and connected pump.

Power actuating system is the hydraulic equipment provided for supplying power to turn the rudder stock, comprising a steering gear power unit or units, together with the associated pipes and fittings, and a rudder actuator. The power actuating systems may share common mechanical components, i.e. tiller, quadrant and rudder stock, or components serving the same purpose.

Steering gear control system is the equipment by which orders are transmitted from the navigation bridge to the steering gear power units. Steering gear control systems comprise transmitters, receivers, hydraulic control pumps and their associated motors, motor controllers, piping and cables.

1.3 SCOPE OF SURVEY

1.3.1 General provisions on survey of ship's equipment, arrangements and outfit are given in General Regulations for the Classification and Other Activity and in Part I "Classification".

1.3.2 The following items included into ship's equipment, arrangements and outfit are subject to the survey by the Register during their manufacture:

1.3.2.1 Rudder and steering gear:

.1 rudder stocks;

.2 rudder blade;

.3 steering nozzles;

.4 rudder axles;

.5 pintles of rudders and steering nozzles;

.6 bushes of pintles;

.7 fastenings of rudder stocks, rudder stock with rudder blade or steering nozzle, and also of rudder axle with sternframe (muff couplings, keys, bolts, nuts, etc.);

.8 parts of the system of rudder stops;

.9 rudder stock bearings;

.10 active means of the ship's steering (only in the case specified in **2.1.4.2**).

1.3.2.2 Anchor arrangement:

.1 anchors;

.2 chain cables or ropes;

.3 anchor stoppers;

.4 devices for securing and releasing the inboard end of chain cable or rope;

.5 anchor hawse pipes.

1.3.2.3 Mooring arrangement:

.1 mooring lines;

.2 mooring bollards, belaying cleats, fairleaders, chocks, rollers and stoppers..

1.3.2.4 Towing arrangement:

.1 tow lines;

.2 towing bollards, bitts, fairleaders, chocks and stoppers;

.3 tow hooks and towing rails with fastenings for their securing to ship's hull;

.4 towing snatch-blocks;

1.3.2.5 Masts and rigging:

.1 metal, wooden and fiber-reinforced plastic spars;

.2 standing ropes;

.3 permanent attachments to masts and decks (eyeplates, hoops, etc.);

.4 loose gear of masts and rigging (shackles, turnbuckles, etc.).

1.3.2.6 Closing appliances of openings in hull, superstructures and deckhouses:

.1 side and deck scuttles;

.2 doors of bow, side and stern openings in the shell plating;

.3 doors in superstructures and deckhouses;

.4 companion hatches, skylights and ventilating trunks;

.5 ventilators;

.6 manholes to deep and other tanks;

.7 hatchway covers in dry cargo ships and tankers;

.8 cargo tank hatchway covers in tankers;

.9 doors in subdivision bulkheads.

1.3.2.7 Equipment of ship's spaces:

.1 ceiling and battens in cargo holds;

.2 exit doors from ship's spaces in escape routes;

.3 stairways and vertical ladders;

.4 guard rails, bulwark and gangways;

.5 cellular guide members in the holds of container ships.

1.3.2.8 Emergency outfit:

.1 collision mats;

.2 tools;

.3 materials.

1.3.2.9 Equipment for receiving helicopters:

.1 light signals and illuminating means of the helideck;

.2 VHF radio station for communication with helicopter;

.3 portable VHF radio headset with headphones.

1.3.3 The Register survey of the manufacture of items specified in **1.3.2.1.7**, **1.3.2.1.8**, **1.3.2.5**, **1.3.2.7.1**, **1.3.2.7.5**, **1.3.2.8.2** and **1.3.2.8.3** is confined to consideration of the relevant technical documentation.

1.3.4 For items specified in **1.3.2** (except for **1.3.2.9.3** and **1.2.3.9.4**), the following documents shall be submitted to the Register:

.1 assembly drawing;

.2 calculations (no approval stamps are needed);

.3 detail drawings if parts or assemblies are not manufactured in accordance with standards and specifications approved by the Register.

For items specified in **1.3.2.9.3** and **1.2.3.9.4** the Register shall be provided with documentation in the scope of the requirements of **1.3.4**, Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships.

1.3.5 Materials used for items specified in **1.3.2.1.1 ÷ 1.3.2.1.5**, **1.3.2.2.1**, **1.3.2.2.2**, **1.3.2.4.3**, **1.3.2.6.2** and **1.3.2.6.7 ÷ 1.3.2.6.9** are subject to the Register survey during manufacture.

1.3.6 The following equipment, arrangements and outfit are subject to the Register survey when the ship is under construction:

.1 rudder and steering gear;

.2 anchor arrangement;

.3 mooring arrangement;

.4 towing arrangement;

.5 masts and rigging;

.6 openings in hull, superstructures and deckhouses and their closing appliances;

.7 arrangement and equipment of ship's spaces;

.8 emergency outfit;

.9 cellular guide members in the holds of container ships;

.10 active means of the ship's steering (refer to **2.1.4**).

1.4 GENERAL

1.4.1 In ships intended to carry in bulk flammable liquids with the flash point 60°C and below no deck machinery shall be fitted directly on the decks being the top of cargo and fuel tanks.

In this case, the deck machinery shall be fitted on special foundations, the construction of which provides for free circulation of air underneath the machinery.

1.4.2 Towing and mooring arrangements plan containing the relevant information shall be available on board for the guidance of the master.

The information provided on the plan in respect of shipboard equipment shall include:

type and location on the ship;

safe working load (SWL);

purpose (mooring/harbour towing/escort service);

manner of applying tow line or mooring line load including limiting fleet angles.

Also the number of mooring lines together with the breaking strength of each mooring line shall be indicated on the plan.

This information shall be incorporated into the pilot card in order to provide the pilot with the proper information on harbour operations/escort service.

1.5 WORKING AND ALLOWABLE STRESSES

1.5.1 Wherever the working stresses are mentioned in the text of the present Part of the Rules, they mean equivalent stress(es) σ_{eq}, in MPa, determined by the formula

$$\sigma_{eq} = \sqrt{\sigma^2 + 3\tau^2}, \tag{1.5.1}$$

where: σ – normal stresses in the section under consideration, in MPa;
τ – shear stresses in the section under consideration, in MPa.

The strength conditions shall be checked against these stresses.

1.5.2 Allowable stresses with which the combined stresses shall be compared when verifying the strength conditions are specified in the present Part in fractions of the upper yield stress of the material used; the upper yield stress shall not be taken as more than 0,7 times the tensile strength of this material, unless expressly provided otherwise.

1.6 MATERIALS AND WELDING

1.6.1 Steel forgings and castings, steel plates, sections and bars and also chain steel used for items specified in **1.3.2.1.1–1.3.2.1.5**, **1.3.2.1.7**, **1.3.2.2.1**, **1.3.2.2.2**, **1.3.2.4.3**, **1.3.2.6.2**, **1.3.2.6.7** and **1.3.2.6.9**, shall meet the relevant requirements of Part XIII "Materials".

Materials for other items of equipment, arrangements and outfit shall meet the requirements specified in the design documentation approved by the Register, unless expressly provided otherwise in these Rules.

1.6.2 The grades of steel plates and sections (refer to Tables 3.2.2-1 and 3.2.2-2, Part XIII "Materials") for items specified in **1.3.2.1.2** and **1.3.2.1.3**, shall be selected according to **1.2.3.1**, Part II "Hull" in the same manner as for hull structural members of category II; in this case, for ships of ice class **Ice4** and higher, Polar classes, Baltic ice classes **IA Super ÷ IC** and for icebreakers steel not lower than Grade B shall be adopted, and for rudder blades of icebreakers, not lower than Grade D. For items specified in **1.3.2.6.2** the grades of steel plates and sections of the main carrying framing members and plating of cover structures ensuring fixing of items when stowed for sea, as well as essential parts of drivers intended for opening at sea shall be selected according to **1.2.3.1**, Part II "Hull" as for hull structural members of category II.

1.6.3 Welding of structural elements of ship's equipment, arrangements and outfit shall be performed in accordance with the requirements of Part XIV "Welding"; besides, welded structures and joints of items specified in **1.3.2.6.2**, **1.3.2.6.7** and **1.3.2.6.9** shall comply with the applicable requirements of **1.7**, Part II "Hull".

1.7 DESIGN ACCELERATIONS DUE TO HEAVE OF THE SEA

1.7.1 The dimensionless, gravity related, design accelerations due to heave of the sea as described in this Chapter shall be applied when determining the loads upon equipment, arrangements and batches of cargo items carried by ships of unrestricted service and those of restricted area of navigation **R1** and **A-R1**.

With regard to ships of other areas of navigation, accelerations may be applied different from those required herein which shall be substantiated by calculations approved by the Register.

1.7.2 The dimensionless acceleration a_z due to heave, pitch and roll normal to the water planes of the ship shall be determined by the formula

$$a_z = \pm a_0 \sqrt{1 + \left(5{,}3 - \frac{45}{L}\right)^2 \left(\frac{x}{L} - 0{,}45\right)^2 \left(\frac{0{,}6}{C_B}\right)^{3/2}}, \tag{1.7.2-1}$$

where: $a_0 = 0{,}2\frac{V}{\sqrt{L}} + \frac{34 - 600/L}{L}$; (1.7.2-2)

V – maximum ahead speed, in knots, with the ship on summer load waterline on still water;
L – ship's length, in m;
x – longitudinal distance from the centre of gravity of equipment, arrangement or batch of cargo items in question to the aft perpendicular;
C_B – block coefficient.

a_z does not include the component of the static weight.

1.7.3 The dimensionless acceleration a_y due to transverse displacement, yaw and roll normal to the centreline of the ship shall be determined by the formula

$$a_y = \pm a_0 \sqrt{0{,}6 + 2{,}5\left(\frac{x}{L} - 0{,}45\right)^2 + k_1\left(1 + 0{,}6k_1\frac{z}{B}\right)^2}\,, \qquad (1.7.3\text{-}1)$$

where: k_1 – coefficient of stability to be determined by the formula

$$k_1 = \frac{13\overline{GM}}{B}\,. \qquad (1.7.3\text{-}2)$$

If k_1 as determined by Formula (1.7.3-2), is below 1,0, k_1 = 1,0 shall be assumed for calculating a_y;

$\overline{GM}$ – transverse metacentric height of loaded ship when the volume and distribution of stores are such as to yield maximum $\overline{GM}$, i;

B – ship's breadth, in m;

z – vertical distance, in m, from the summer load waterline to the centre of gravity of equipment, arrangement or batch of cargo items in question; z is positive above and negative below the summer load waterline.

a_y includes the component of the static weight in the transverse direction due to rolling.

1.7.4 The dimensionless acceleration a_x due to longitudinal displacement and pitch normal to the midship section plane shall be determined by the formula

$$a_x = \pm a_0 \sqrt{0{,}06 + k_2^2 - 0{,}25k_2}\,, \qquad (1.7.4\text{-}1)$$

w: k_2 – =factor determined from the formula:

$$k_2 = \left(0{,}7 - \frac{L}{1200} + 5\frac{z}{L}\right)\frac{0{,}6}{C_B}\,. \qquad (1.7.4\text{-}2)$$

a_x includes the component of the static weight in the longitudinal direction due to pitching.

1.7.5 When determining loads it shall be considered that the accelerations calculated using a_x, a_y and a_z act independently of each other.

2. RUDDER AND STEERING GEAR

2.1 GENERAL

2.1.1 Every ship, except for shipborne barges, shall be provided with a reliable device ensuring her steering and course-keeping facilities (refer to 2.10). Such devices may be rudder, steering nozzle, etc., approved by the Register. For non-propelled vessels of the dredging fleet with regard to the area of navigation and service conditions it may be allowed to omit such device or provide only stabilizers.

For towed barges the Register may allow installation of stabilizers.

2.1.2 The requirements of this Section apply only to ordinary streamlined rudders or steering nozzles with streamlined profiles and rigidly fixed stabilizers.

2.1.3 Steering gears may be designed compliant to IACS unified requirement (UR) S10.Rev.5.

2.1.4 Active means of the ship's steering.

2.1.4.1 The active means of the ship's steering may be both the means supplementary to the regulated minimum (refer to **2.1.1**) and the main means of the ship's steering.

2.1.4.2 Taking into account the ship's purpose, design features and intended service conditions it may be permitted that the regulated steerability of the ship shall be provided at the low speed by simultaneous operation of the devices specified in **2.1.1** and the active means of the ship's steering.

In case where the AMSS are the main means of the ship's steering the regulated steerability shall be ensured under those running conditions of the ship for which the means are intended.

In any case, it shall be demonstrated by the method recognized by the Register that the steerability will not then be at least worse than that ensured in case of fulfilment of the requirements of **2.10**.

2.1.4.3 3 Requirements for AMSS construction and design, exclusive of the separate steering nozzles and rudder section of the active rudders are outlined in Part VII "Machinery Installations". Requirements for

AMSS used in the dynamic positioning systems of mobil offshore drilling units shall be fulfilled with consideration for Rules for the Classification and Construction of Mobile Offshore Drilling Units.

2.1.5 The number of rudder pintles supporting the rudder is not regulated by the Register, except for icebreakers, Polar class ships, Baltic ice classes **IA Super** ÷ **IC** ships (refer to **2.11**) and ships of ice class and higher for which this number shall be not less than that given in Table 2.1.5.

In exceptional cases, in icebreakers the number of rudder pintles indicated in Table 2.1.5 may be reduced to two provided the calculations proving the strength of the structure during the operation in appropriate ice conditions have been submitted.

In icebreakers and Polar class ships the steering nozzles shall not be fitted.

In ships of ice classes **Ice4** and **Ice5**, Baltic ice classes **IA Super** ÷ **IC** ships the arrangement of the steering nozzle without the lower pintle in the solepiece is not permitted.

Table 2.1.5

Ice class	Number of rudder pintles
Icebreaker4, Icebreaker3, PC1÷PC3	4
Icebreaker2, Icebreaker1, PC4	3
Ice6, Ice5, PC5, PC6, IA Super	2
Ice4, PC7, IA,	1

2.1.6 Wherever the upper yield stress R_{eH}, of the material used enters into the formulae of this Section, the provisions of **1.5.2** shall be taken into account, but in all cases the upper yield stress R_{eH} of the material shall not be taken more than 390 MPa.

2.1.7 When checking the rudder or steering nozzle pintles and rudder stock bearings for surface pressure, the latter shall not exceed the values indicated in Table 2.1.7.

Table 2.1.7

Materials	Surface pressure p, in MPa	
	Water lubrication	Oil lubrication
Stainless steel or bronze against lignum vitae	2,4	–
Stainless steel or bronze against textolite or synthetic materials	On agreed manufacture's specification	-
Stainless steel against bronze or vice versa	6,9	–
Steel against white metal	–	4,4

2.1.8 In ships of ice classes **Ice5, Ice6, PC5, PC6, IA Super** the arrangement of two steering nozzles (in case of twin-screw ships) shall be verified by strength calculation as well as by taking measures to ensure protection against ice impact.

2.1.9 In ships of Polar classes, Baltic ice classes **IA** and **IA Super** and **Ice4 class** and higher the measures to ensure protection of steering nozzles against ice impact shall be submitted by the designer.

2.1.10 For passenger ships and special purpose ships carrying more than 60 persons having length of 120 m or more or having three or more main vertical zones, the steering gear shall comply with the requirements of **2.2.6.8**, Part VI "Fire Protection" (refer also to **2.2.6.7.2** of the above Part).

2.1.11 Steering room shall be:

.1 readily accessible and, as far as practicable, separated from the machinery spaces; and

.2 equipped with appropriate means to provide operational access to the steering gear and controls. Such means shall include handrails and lattices or other non-slip plating, which shall ensure proper working conditions in the event of hydraulic fluid leakage.

2.2. INITIAL DESIGN DATA

2.2.1 The initial design data specified in this Chapter are valid only for the choice of scantlings of ordinary rudders and steering nozzles with rigidly fixed stabilizers and cannot be used for determination of steering gear output characteristics.

Methods of determination of these characteristics are not regulated by the Register, and the relevant calculations are not subject to approval by the Register. The steering gear is checked by the Register during sea trials of the ship to make sure that the steering gear output characteristics comply with the requirements of **2.9.2**, **2.9.3** and **2.9.8**.

2.2.2 Rudder force and rudder torque.

2.2.2.1 The rudder blade force F, in kN, for the ahead condition shall be determined by the formula

$$F = F_1 + F_2 . \quad (2.2.2.1\text{-}1)$$

where

$$F_1 = 5{,}59 \cdot 10^{-3} k_1 k_2 (6{,}5 + \lambda)(b_1 - C_B)^2 A v^2 , \quad (2.2.2.1\text{-}2)$$

$$F_2 = 0{,}177 k_1 (6{,}5 + \lambda) \frac{T}{D_p^2} A_p \quad (2.2.2.1\text{-}3)$$

where: k_1 – factor equal to:

1,0 for rectangular and trapezoidal rudders, except for rudders behind the rudder post;

0,95 for semispade rudders (rudders of types I, II, VII and VIII in Fig. 2.2.4.1);

0,89 for rudders behind the rudder post (rudders of types IV, X and XIII in Fig. 2.2.4.1);

k_2 – factor equal to:

1,0 for rudders operating directly behind the propeller;

1,25 for rudders not operating directly behind the propeller;

λ – value determined by the formula:

$$\lambda = h_r^2 / A_t , \quad (2.2.2.1\text{-}4)$$

where: h_p – mean height of the rudder blade part abaft the centreline of the rudder stock, in m;

A_t – sum of the rudder area and lateral area of the rudder horn or rudder post, if any, within the height h_p, in m². In case of no rudder horn or rudder post, the value of A_t is taken as A in the calculations;

A – rudder area, in m²;

A_p– portion of the rudder area in the wake of the propeller when the rudder is in the non-reversed position, in m²;

b_1 – value equal to:

2,2 for rudders situated at the centreline of the ship;

2,32 for side rudders;

C_B – block coefficient with the ship on the summer load waterline;

V – maximum ahead speed with the ship on the summer load waterline, in knots;

T – propeller thrust at the speed V, in kN, (refer to **2.2.2.6**);

D_p– propeller diameter, in m.

2.2.2.2 The value of the force ***F*** specified in 2.2.2.1 shall not be taken less than $\boldsymbol{F_3}$, in kN, determined by the formula

$$F_3 = k_3 A , \quad (2.2.2.2)$$

where: k_3 – factor equal to:

171 – for icebreakers of ice class **Icebreaker4** and Polar classes **PC1 ÷ PC3** and Polar class;

150 – for icebreakers of ice class **Icebreaker3**;

130 – for icebreakers of ice class **Icebreaker2** and Polar class **PC4** ships;

110 – for icebreakers of ice class **Icebreaker1** and Polar class **PC5** ships;

95 – for ships of Polar class **PC6;**

75 – for ships of ice class **Ice6** and Polar class **PC7** ships;

66 – for ships of ice class **Ice5** and Baltic ice class **IA Super** ships;

53 – for ships of ice class **Ice4** and Baltic ice class **IA** ships;

18 – _ for other ships.

When the value of the force F_3 is greater than that of the force ***F*** specified in 2.2.2.1, in subsequent calculations the value of $\boldsymbol{F_3}$ is taken instead of ***F*** and the value $\boldsymbol{F_2}$ is taken equal to zero.

2.2.2.3 For the ahead condition the rudder torque M_t, in kN/m, shall not be taken less than determined by the formula

$$M_t = F \frac{A}{h_r} \left(0{,}35 - \frac{A_1}{A} \right) , \quad (2.2.2.3\text{-}1)$$

where: A_1 – part of the rudder blade area forward of its centreline, in m².

For single-plate solid-cast rudders with the leading edge aft of the rudder stock centre line, A_1 is taken as the negative value of the area formed by the leading edge of the rudder blade and the rudder stock centre line.

For icebreakers, Polar class ships, Baltic ice classes **IA Super** and **IA** ships and **Ice4, Ice5, Ice6** ice class ships the rudder torque M_t, in kN·m, due to the force F_3, specified in **2.2.2.2**, shall not be taken less than determined by the formula

$$M_t = 0{,}35 F_3 b_r, \qquad (2.2.2.3\text{-}2)$$

where: b_p – distance from the centre line to the rear edge of the rudder blade at the level of the midheight of the rudder blade, in m.

2.2.2.4 For the astern condition the rudder torque M_{as}, in kN/m, shall not be taken less than determined by the formula

$$M_{as} = k_4 \frac{A^2}{h_r}\left(0{,}7 - \frac{A_1}{A}\right) v_{as}^2, \qquad (2.2.2.4)$$

where: k_4 – factor equal to:

0,185 – for rudders operating directly behind the propeller;

0,139 – for rudders not operating directly behind the propeller;

V_{as}– maximum specification speed of the ship for the astern condition, but not less than 0,5V, in knots.

2.2.2.5 For the astern condition the rudder blade force F_{as}, in kN, shall be determined by the formula

$$F_{as} = M_{as} \frac{h_r}{A\left(0{,}7 - \frac{A_1}{A}\right)}. \qquad (2.2.2.5)$$

When determining the bending moments and reactions of the supports according to the provisions of **2.2.4** – **2.2.7** for the astern condition, the force F_{as} shall be considered as the force F_1, and the value of F_2 is then taken equal to zero.

2.2.2.6 In case reliable data are not available on the value of the propeller thrust mentioned in **2.2.2.1**, the value of T, in kN, may be determined by the formulae:

for fixed-pitch propellers

$$T = 0{,}0441\left(\frac{30{,}6 N_e}{n H_1 \sqrt[3]{z\theta}} - n^2 D_p^4\right); \qquad (2.2.2.6\text{-}1)$$

for controllable-pitch propellers

$$T = 0{,}0441\left(\frac{110 N_e}{v(b_1 - C_B)\sqrt[3]{z}} - n^2 D_p^4\right), \qquad (2.2.2.6\text{-}2)$$

where: N_e – nominal total output of the propulsion plant of the ship divided by the number of the propellers, in kW;

n – number of propeller revolutions per second, in s^{-1};

H_1 – propeller pitch at the zero thrust, in m, determined by the formula:

$$H_1 = H + \frac{0{,}055 D_p}{\theta + 0{,}3}, \qquad (2.2.2.6\text{-}3)$$

where: H – design propeller pitch, in m;

θ – blade area ratio;

z – number of propeller blades.

2.2.3 Steering nozzle rudder force and torque.

2.2.3.1 The total force F, in kN, acting on the steering nozzle and stabilizer shall not be taken less than determined by the formula:

$$F = F_n + F_{st}, \qquad (2.2.3.1\text{-}1)$$

where: F_n– force acting on the steering nozzle, in kN;

F_{st} – force acting on the stabilizer, in kN.

F_n and F_{st} – are determined by the formulae:

$$F_n = 9{,}81 \cdot 10^{-3} p D_n l_n V_1^2 \quad (2.2.3.1\text{-}2)$$

$$F_{st} = 9{,}81 \cdot 10^{-3} q m A_{st} V_1^2; \quad (2.2.3.1\text{-}3)$$

where: D_n– inner minimum steering nozzle bore, in m;

l_n– steering nozzle length, in m;

A_{st} – area of steering nozzle stabilizer, in m^2;

V_1 – speed, in knots, determined by the formula:

$$V_1 = V(1 - W); \quad (2.2.3.1\text{-}4)$$

where: W – average wake factor. In case reliable experimental data are not available, the wake factor may be determined by the formula:

$$W = 0{,}165 C_B^n \sqrt{\sqrt[3]{\Delta}/D_p}, \quad (2.2.3.1\text{-}5)$$

where: C_B– block coefficient of the ship;

Δ – volume displacement, in m^3, with the ship on summer load waterline;

n – number of propellers;

D_p– propeller diameter, in m;

V – maximum ahead speed, in knots, with the ship on summer load waterline; this speed shall not be taken less than:

20 knots for ships of Baltic ice class **IA Super** (refer to **2.11**);

18 knots for ships of Baltic ice class **IA** (refer to **2.11**);

17 knots for ships of ice classes **Ice5**;

14 knots for ships of ice classes **Ice4**;

11 knots for other ships;

p, q – coefficients determined by the formulae:

$$p = 78{,}4 - 55{,}6\sqrt{\lambda_n} + (44{,}0 - 33{,}4\sqrt{\lambda_n})C_{HB}; \quad (2.2.3.1\text{-}6)$$

$$q = 7{,}43 - 5{,}72\lambda_n + (2{,}82 - 2{,}2\lambda_n)C_{HB}; \quad (2.2.3.1\text{-}7)$$

C_{HB} being determined by the formula:

$$C_{HB} = 9{,}38T/(D_p^2 V_1^2), \quad (2.2.3.1\text{-}8)$$

where: T – propeller thrust at speed V, in kN;

D_p – propeller diameter, in m;

λ_n is determined by the formula:

$$\lambda_n = l_n/D_p; \quad (2.2.3.1\text{-}9)$$

m – coefficient determined by the formula:

$$m = 4{,}5 - 0{,}12(\lambda_{st} - 5{,}43)^2; \quad (2.2.3.1\text{-}10)$$

λ_{st} is determined by the formula:

$$\lambda_{st} = h_{st}/l_{st}, \quad (2.2.3.1\text{-}11)$$

h_{st} – =height of steering nozzle stabilizer, in m;

l_{st} – length of steering nozzle stabilizer, in m.

2.2.3.2 A point situated at the level of the longitudinal axis of the steering nozzle at the distance rn from the steering nozzle leading edge shall be considered as a point of application of force F_n. The distance r_n, in m, shall not be less than determined by the formula

$$r_n = l_n(bk + c), \quad (2.2.3.2\text{-}1)$$

where: k – coefficient determined by the formula

$k = l_{r.s}/l_n$; (2.2.3.2-2)

$l_{r.s}$– distance between the centre line of the rudder stock and the leading edge of the steering nozzle, in m;;

b, c – coefficients determined by the formulae

$$b = 0{,}796 - 0{,}011(C_{HB} - 7{,}18)^2; \quad (2.2.3.2\text{-}3)$$

$$c = 0{,}1585 - 0{,}0916\sqrt{C_{HB}}. \quad (2.2.3.2\text{-}4)$$

A point situated at the level of the steering nozzle longitudinal axis at the distance r_{st} from the stabilizer leading edge shall be considered as a point of application of force F_{st}. The distance r_{st}, in m, shall not be less than determined by the formula

$$r_{st} = 0{,}25 l_{st}. \quad (2.2.3.2\text{-}5)$$

2.2.3.3 The total torque M_t, in kN·m, for the steering nozzle shall be determined by the formula

$$M_t = M_n - M_{st}, \quad (2.2.3.3\text{-}1)$$

where: M_n – torque of force F_n, in kN·m;

M_{st}–torque of force F_{st}, in kN·m;

M_n and M_{st} are determined by the formulae:

$$M_n = F_n(l_{r.s} - r_n), \quad (2.2.3.3\text{-}2)$$

$$M_{st} = F_{st}(a + r_{st}); \quad (2.2.3.3\text{-}3)$$

a – distance between the centre line of the rudder stock and the leading edge of the stabilizer, in m.

In any case, the total torque M_t for the steering nozzle shall not be taken less than the minimum value of torque M_{min}, in kN/m, determined by the formula:

$$M_{min} = \frac{28{,}1F_n}{p}(0{,}72l_n - l_{r.s}) + \frac{7{,}8F_{st}}{qm}(l_n - l_{r.s} + 0{,}5l_{st}) \quad (2.2.3.3\text{-}4)$$

2.2.4 Bending moments and reactions of supports for rudders of types I _ IV, VI _ XII and steering nozzles of type V (refer to Fig. 2.2.4.1).

2.2.4.1 The design values of the bending moments and reactions of supports shall be determined from the formulae of this Chapter depending on the types of the rudders shown in Fig. 2.2.4.1 having regard to the provisions of Table 2.2.4.1 as well as the type and location of the steering gear as specified in **2.2.4.2.**

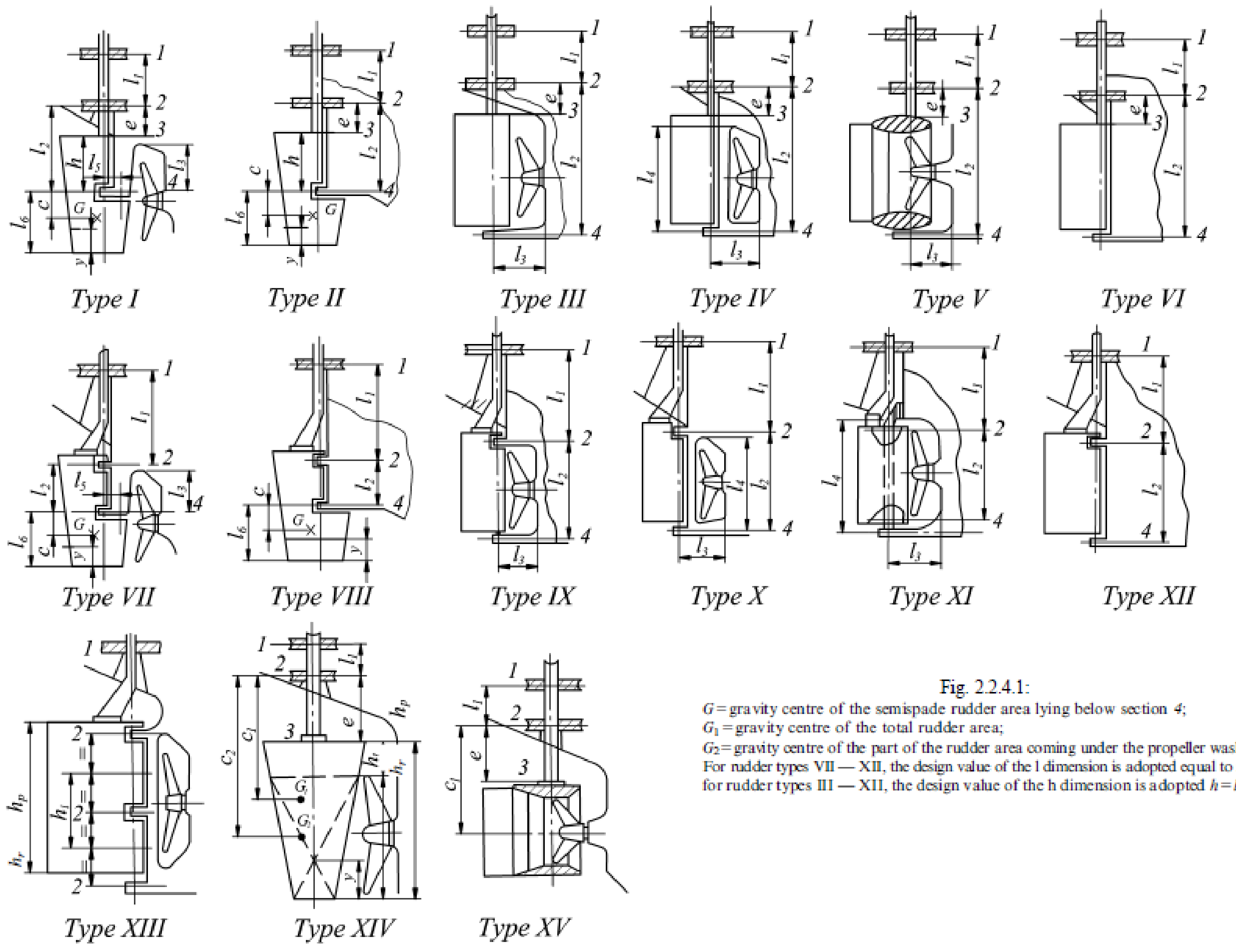


Fig. 2.2.4.1:
G = gravity centre of the semispade rudder area lying below section 4;
G_1 = gravity centre of the total rudder area;
G_2 = gravity centre of the part of the rudder area coming under the propeller wash.
For rudder types VII — XII, the design value of the l dimension is adopted equal to zero;
for rudder types III — XII, the design value of the h dimension is adopted $h = l_2 - e$

Table 2.2.4.1

Type of rudder (refer to Fig. 2.2.4.1)	Design value of load Q_2	Design value of load Q_1
I, II, VII i VIII	$Q_2 = \left(\frac{F_1}{A} + \frac{F_2}{A_p}\right)A_l$	$Q_1 = F - Q_2$
III–VI i IX–XII	$Q_2 = 0$	

Notes: 1. The value of A_l is the portion the semispade rudder area below the lower pintle (below section 4 in Fig. 2.2.4.1), in m^2.
2. For steering nozzles of type V the design value of the ratio $I_{r.s}/I_r$ is taken equal to zero.
3. The force F is taken in accordance with the provisions of 2.2.2 for rudders and of 2.2.3 for steering nozzles.

2.2.4.2 The transverse force P, in kN, created on the rudder stock by steering gear (quadrant steering gears, steering gears with single-arm tillers and similar steering gears) is determined by the formula:

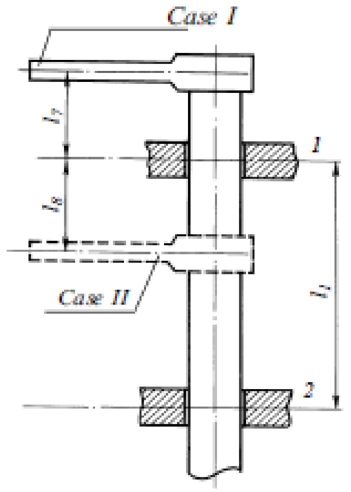
$$P = M_t/r_1, \qquad (2.2.4.2)$$

where: M_t – rudder torque, in kN/m, specified in 2.2.2.3 and 2.2.3.3. When considering the astern running of the ship, the rudder torque M_t is taken as the value M_{as} specified in **2.2.2.4**;

r_1 – =radius of the steering gear quadrant or tiller resultant force arm measured from the centre line of the rudder stock, in m.

Depending on the location of the steering gear quadrant or tiller indicated in Fig. 2.2.4.2 the value P for Case I is taken as P_I and the value P_{II} is taken equal to zero. For Case II the value of P is taken as P_{II} and the value of PI is taken equal to zero. The values of P_I or P_{II} are assumed to be positive when the quadrant or tiller are located forward of the rudder stock centre line and they are assumed to be negative when the quadrant or tiller are located aft of the rudder stock centre line.

For steering gears the rudder torque of which is transmitted to the rudder stock by a pair (or pairs) of forces (four-piston, rotary vane steering gears or similar) the values of P_I and P_{II} are taken equal to zero.



Fig

2.2.4.3 In the formulae of this Chapter the numerical indices of symbols of the bending moments (M_1, M_2, M_3 i M_4) and reactions of supports (R_1, R_2, R_3 i R_4) correspond to the number of the support or section given in Figs. 2.2.4.1 and 2.2.4.2 for the relevant type of the rudder.

2.2.4.4 Unless expressly provided otherwise, in the formulae of this Chapter the linear dimensions shown in Figs. 2.2.4.1 and 2.2.4.2 shall be taken in metres, and the forces, in kN.

2.2.4.5 The design values of the bending moments and reactions of supports may be taken less than those specified in **2.2.4.1** on condition that the detailed calculation is submitted where due consideration is given to the flexibility of the rudder supports and to the non-uniformity of the force distribution over the rudder blade area.

2.2.4.6 For Case I of the quadrant steering gear or tiller location (refer to Fig. 2.2.4.2) the design value of bending moment M_I , in kN·m, in section 1 of the rudder stock (at the upper bearing) shall be determined by the formula:

$$M_1 = P_1 \, l_7 , \qquad (2.2.4.6)$$

Where for P_1, l_7 – refer to **2.2.4.2** i **2.2.4.4**.

For Case II of the steering gear quadrant or tiller location M_I is taken equal to zero.

2.2.4.7 The design value of the bending moment M_2, in kN·m, acting in section 2 of the rudder stock (at the lower bearing for rudders of types I - VI; in the rudder stock and rudder blade coupling for rudders of types VII - XII) shall be determined by the formula:

$$M_2 = \frac{1}{8} Q_1 h \, \frac{k_5}{k_7} - \frac{1}{2} Q_2 c \, \frac{k_6}{k_7} - \frac{1}{2} P_I l_7 \frac{k_8}{k_7} + \frac{1}{2} \, P_{II} l_8 \frac{k_9}{k_7} , \qquad (2.2.4.7\text{-}1)$$

where: Q_1 and Q_2 – loads determined in accordance with Table2.2.4.1;

P_I and P_{II} – =forces determined in accordance with **2.2.4.2**;

h, c, l_7, l_8 – linear dimensions (refer to**2.2.4.4**);

$k_5 - k_9$ – factors determined by the formulae:

$$k_5 = 2\left(\frac{e}{h}\right)^2\left(3 + \frac{e}{h}\right) + \left(1 + 5\frac{e}{h}\right)\frac{I_{r.s}}{I_r} + 12\left(1 + 2\frac{e}{h}\right)\frac{I_{r.s}\alpha_4}{h^3} \qquad (2.2.4.7\text{-}2)$$

$$k_6 = \left(\frac{e}{h}\right)^2\left(3 + \frac{e}{h}\right) + \left(1 + 3\frac{e}{h}\right)\frac{I_{r.s}}{I_r} - 6\left(1 + \frac{l_2}{c}\right)\frac{I_{r.s}\alpha_4}{h^3} \qquad (2.2.4.7\text{-}3)$$

$$k_7 = \left(1 + \frac{e}{h}\right)^2\left(1 + \frac{e}{h} + \frac{l_1}{h}\right) - 1 + \frac{I_{r.s}}{I_r} + 3\frac{I_{r.s}\alpha_4}{h^3} \qquad (2.2.4.7\text{-}4)$$

$$k_8 = l_1 l_2^2/h^3; \qquad (2.2.4.7\text{-}5)$$

$$k_9 = \frac{l_1 l_2^2}{h^3}\left(1 - \frac{l_8^2}{l_1^2}\right), \qquad (2.2.4.7\text{-}6)$$

where: e, l_1 and l_2 – linear dimensions (refer to **2.2.4.4**);

$I_{r.s}$ – mean moment of inertia of the rudder stock cross-section, in cm^4;

I_r – mean moment of inertia of the rudder cross-section at the portion between sections 3 - 4 (rudder types I - VI) or between sections 2 - 4 (rudder types VII - XII), in cm^4;

α_4 – coefficient determined in accordance with the provisions of **2.2.4.17**, **2.2.4.18**, **2.2.4.19**, **2.2.4.20** or **2.2.4.21** depending on the type of the rudder, in m^3/cm^4.

2.2.4.8 The design value of the bending moment M_3, in kN·m, acting in section 3 of the rudder stock (in the rudder stock and rudder blade coupling for rudders of types I to VI) shall be determined by the formula

$$M_3 = M_2\frac{h}{l_2} + Q_2 c\frac{e}{l_2} - \frac{1}{2}Q_1 h\frac{e}{l_2}. \qquad (2.2.4.8)$$

2.2.4.9 The design value of the bending moment M_4, in kN·m, acting in section 4 of the rudder blade for rudders of types I, II, VII and VIII shall be determined by the formula

$$M_4 = Q_2 c. \qquad (2.2.4.9)$$

For rudders of these types the value of M_4 4 is taken as the bending moment acting in any rudder crosssection above support 4 of the rudder.

For other rudders the value of the bending moment M_4 is taken equal to zero.

2.2.4.10 The design value of the reaction R_1 in kN, of support 1 of the rudder (of the upper bearing) shall be determined by the formula

$$R_1 = \frac{M_2}{l_1} - P_1\left(1 + \frac{l_7}{l_1}\right) - P_{II}\left(1 - \frac{l_8}{l_1}\right) \qquad (2.2.4.10)$$

2.2.4.11 The design value of the reaction R_2, in kN, of support 2 of the rudder (of the lower bearing for rudder types I – VI, of the upper bearing of the rudder axle for rudder type XI, of the upper pintle of rudders for types VII – X and XII) shall be determined by the formula

$$R_2 = -M_2\left(\frac{1}{l_1} + \frac{1}{l_2}\right) + Q_2\frac{c}{l_2} - \frac{1}{2}Q_1\frac{h}{l_2} + P_I\frac{l_7}{l_1} - P_{II}\frac{l_8}{l_1}. \qquad (2.2.4.11)$$

2.2.4.12 The design value of the reaction R_4, in kN, of support 4 of the rudder (of the lower pintle) shall be determined by the formula

$$R_4 = \frac{M_2}{l_2} - \frac{1}{2}Q_1\left(1 + \frac{e}{l_2}\right) - Q_2\left(1 + \frac{c}{l_2}\right). \qquad (2.2.4.12)$$

2.2.4.13 The design value of the bending moment M_r, in kN·m, acting in the considered section of the lower part of the semispade rudder body (below section 4 shown in Fig. 2.2.4.1 for rudder types I, II, VII and VIII) shall be determined by the formula

$$M_r = \frac{1}{2} Q_2 \frac{y^2}{l_6},\qquad (2.2.4.13)$$

where: y and l_6 – linear dimensions (refer to **2.2.4.4**.

2.2.4.14 The design value of the bending moment M_r, in kN·m, acting in any cross-section of the rudder blade for rudders of types III, IV, VI and IX – XII shall be determined by the formula:

$$M_r = \frac{1}{2} M_2 \frac{h}{l_2}\left(2 - \frac{h}{l_2} - \frac{M_2}{Q_1 l_2}\right) - \frac{1}{8} Q_1 h \left(2 - \frac{h}{l_2}\right)^2 \qquad (2.2.4.14)$$

2.2.4.15 The design value of the bending moment $M_{r\cdot a}$, in kN·m, acting in the section of the rudder axle near its flange shall be determined by the formula:

$$M_{ra} = R_4 l_4 \left[0{,}42 \frac{(l_4 - l_2)}{l_4} + 0{,}24 \frac{l_3}{l_4} \frac{I_{rp}}{I_s} + 0{,}15 \left(\frac{l_3}{l_4}\right)^2\right] \qquad (2.2.4.15)$$

where: l_3 and l_4 – linear dimensions (refer to **2.2.4.4**);

$I_{r\cdot p}$– mean moment of inertia of the rudder axle or rudder post cross-section, in cm^4;

I_s– mean moment of inertia of the solepiece cross-section, in cm^4.

2.2.4.16 For Case II of the steering gear quadrant or tiller location (refer to Fig. 2.2.4.2) the design value of the bending moment M_s, in kN·m m, acting in the section of the rudder stock in way of the quadrant or tiller location shall be determined by the formula

$$M_s = R_1 l_8. \qquad (2.2.4.16)$$

For Case I of the steering gear quadrant or tiller location M_s is taken equal to zero.

2.2.4.17 The coefficient α_4 in m^3/cm^4, for rudders of types I and VII (for the horn of the semispade rudder) shall be determined by the formula

$$\alpha_4 = \frac{1{,}07 l_3^3}{3 I_1}\left(4 - 3\frac{b_{h0}}{b_{h1}}\right) + \frac{1{,}3 l_5^2 l_3}{I_2}\left(1 + \frac{b_{h1}}{b_{h0}}\right)\frac{b_{h1}}{b_{h0}} \qquad (2.2.4.17\text{-}1)$$

where: l_5 – linear dimension (refer to **2.2.4.4**);

I_1 – moment of inertia of the rudder horn cross-section at its root about the axis parallel to the centreline of the ship, in cm^4;

b_{h0} – maximum width of the horizontal section of the rudder horn at the lower pintle (section 4 in Fig. 2.2.4.1), in m;

b_{h1} – maximum width of the horizontal section of the rudder horn at its root, in m;

I_2 – polar moment of inertia of the rudder horn cross-section at its root, in cm^4, determined by the formula

$$I_2 = \frac{4 A_{rh}^2}{\sum_{i=1}^{n} l_{0i}/s_{0i}},\qquad (2.2.4.17\text{-}2)$$

where: $A_{r\cdot h}$ – = area enclosed by the centre line of the rudder horn plating (with the cross-section at the horn root), in cm^2;

l_{0i} – length of the centre line of the rudder horn plating (in the cross-section at the horn root) of the given thickness, in cm;

S_{0i} – thickness of the considered portion of the rudder horn plating with the length l_{0i}, in cm;

n – number of portions of the rudder horn plating with the length l_{0i} and thickness S_{0i}.

2.2.4.18 The coefficient α_4 in m^3/cm^4, for rudders of types III, V and IX (for the solepiece) shall be determined by the formula

$$\alpha_4 = \frac{l_3^3}{3I_{s1}}\left(4 - 3\frac{b_{s0}}{b_{s1}}\right), \quad (2.2.4.18)$$

where: I_{sl} – moment of inertia of the solepiece cross-section at its root about the vertical axis, in cm^4;
b_{s0} – width of the solepiece cross-section at the rudder stock or steering nozzle pintle, in cm;
b_{s1} – =width of the solepiece cross-section at its root, in cm.

2.2.4.19 The coefficient α_4 in m^3/cm^4, for rudders of types IV and X (for the rudder post with the solepiece) shall be determined by the formula

$$\alpha_4 = \frac{l_3^3}{3I_s}\left(0{,}075\frac{I_s}{I_{rp}} + 0{,}334\frac{l_4}{l_3}\right). \quad (2.2.4.19)$$

2.2.4.20 The coefficient α_4 in m^3/cm^4, for rudder of type XI (for rudder axle with the solepiece) shall be determined by the formula

$$\alpha_4 = \frac{l_3^3}{3I_s}\left\{\left(0{,}075\frac{I_s}{I_{rp}} + 0{,}334\frac{l_4}{l_3}\right) - 0{,}282\frac{(l_4 - l_2)}{l_4}\times\left[1{,}55\frac{l_4}{l_3} + 0{,}053\left(\frac{l_4}{l_3}\right)^2 + \frac{(l_4 - l_2)}{l_4}\frac{I_s}{I_{rp}}\right]\right\} \quad (2.2.4.20)$$

2.2.4.21 The coefficient α_4 for rudders of types II, VI, VIII and XII is taken equal to zero.

2.2.5 Bending moments and reactions of supports for rudder of type XIII (refer to Fig.2.2.4.1).

2.2.5.1 The requirements of **2.2.4.2 - 2.2.4.6** and **2.2.4.16** are also applicable to the rudders of type XIII.

2.2.5.2 The design value of the bending moment acting in way of the rudder stock and rudder blade coupling shall be taken equal to zero.

2.2.5.3 The design value of the bending moment M_r, in kN·m, acting in any cross-section of the rudder blade shall be determined by the formula

$$M_r = 0{,}1\,Fh_i^2/h_r, \quad (2.2.5.3)$$

where: F – force determined according to the provisions of **2.2.2.1**, **2.2.2.2** and **2.2.2.5**, in kN;
h_i and h_r – =linear dimensions (refer to 2.2.4.4); in this case, the greater of the value h_i shall be taken as the design value.

2.2.5.4 The design value of the reaction R_1 of support 1 of the rudder (of the upper bearing) shall be taken equal to zero.

2.2.5.5 The design value of the reaction R_2 in kN, of support 2 of the rudder (of any pintle) shall be determined by the formula

$$R_2 = Fh_i/h_r. \quad (2.2.5.5)$$

2.2.6 Bending moments and reactions of supports for rudder of type XIV (refer to Fig. 2.2.4.1).

2.2.6.1 The requirements of **2.2.4.2 - 2.2.4.6** and **2.2.4.16** are also applicable to the rudders of type XIV.

2.2.6.2 The design value of the bending moment M_2, in kN·m, acting in section 2 of the rudder stock (at the lower bearing) shall be determined by the formula

$$M_2 = F_1c_1 + F_2c_2, \quad (2.2.6.2)$$

where: F_1 and F_2 – forces determined according to the provisions of **2.2.2.1**, **2.2.2.2** and **2.2.2.5**, in kN;
c_1 і c_2 – лінійні розміри (див. **2.2.4.4**), м.

2.2.6.3 The design value of the bending moment M_3, in kN·m, acting in section 3 of the rudder stock (in the rudder stock and rudder blade coupling) shall be determined by the formula

$$M_3 = F_1(c_1 - e) + F_2(c_2 - e), \quad (2.2.6.3)$$

where: e – linear dimension (refer to **2.2.4.4**), in m.

2.2.6.4 The design value of the bending moment M_r, in kN·m, acting in the considered section of the rudder blade shall be determined by the formulae:

for sections with $y < h_1$

$$M_r = \frac{1}{2}\left(\frac{F_1}{h_r} + \frac{F_2}{h_1}\right)y^2, \qquad (2.2.6.4\text{-}1)$$

for sections with $y \geq h_1$

$$M_r = \frac{1}{2}\frac{F_1}{h_r}y^2 + F_2\left(y - \frac{1}{2}h_1\right), \qquad (2.2.6.4\text{-}2)$$

where h_r, h_1 and y – =linear dimensions (refer to **2.2.4.4**), in m.

2.2.6.5 The design value of the reaction R_1 in kN, of support 1 of the rudder (of the upper bearing) shall be determined by the formula

$$R_1 = F_1\frac{c_1}{l_1} + F_2\frac{c_2}{l_1} - P_I\left(1 + \frac{l_7}{l_1}\right) - P_{II}\left(1 - \frac{l_8}{l_1}\right), \qquad (2.2.6.5)$$

where: l_1 – linear dimension (refer to **2.2.4.4**), in m.

2.2.6.6 The design value of the reaction R_2 in kN, of support 2 of the rudder (of the lower bearing) shall be determined by the formula

$$R_2 = F_1\left(1 + \frac{c_1}{l_1}\right) + F_2\left(1 + \frac{c_2}{l_1}\right) - P_I\frac{l_7}{l_1} + P_{II}\frac{l_8}{l_1}. \qquad (2.2.6.6)$$

2.2.7 Bending moments and reactions of supports for steering nozzles of type XV (refer to Fig. 2.2.4.1).

2.2.7.1 The requirements of **2.2.4.2**, **2.2.4.3**, **2.2.4.4**, **2.2.4.6** and **2.2.4.16** are also applicable to the steering nozzle of type XV.

2.2.7.2 The design value of the bending moment M_2, in kN·m, acting in section 2 of the rudder stock (at the lower bearing) shall be determined by the formula

$$M_2 = Fc_1, \qquad (2.2.7.2)$$

where: F – force determined according to the provisions of **2.2.3.1**, in kN;
c_1 – linear dimension (refer to **2.2.4.4**), in m.

2.2.7.3 The design value of the bending moment M_3, in kN·m, acting in section 3 of the rudder stock (at the rudder stock and steering nozzle coupling) shall be determined by the formula

$$M_3 = F(c_1 - e), \qquad (2.2.7.3)$$

where: e – linear dimension (refer to **2.2.4.4**), in m.

2.2.7.4 The design value of the reaction R_1, in kN, of support 1 (of the upper bearing) shall be determined by the formula

$$R_1 = F\frac{c_1}{l_1} - P_1\left(1+\frac{l_7}{l_1}\right) - P_{II}\left(1-\frac{l_8}{l_1}\right), \qquad (2.2.7.4)$$

where: l_1 – linear dimension (refer to **2.2.4.4**), in m.

2.2.7.5 The design value of the reaction R_2 in kN, of support 2 (of the lower bearing) shall be determined by the formula

$$R_2 = F\left(1+\frac{c_1}{l_1}\right) - P_1\frac{l_7}{l_1} + P_{II}\frac{l_8}{l_1}. \qquad (2.2.7.5)$$

2.2.8 The design values of bending moments and reactions of supports for the steering gears which differ from those indicated in Fig. 2.2.4.1 shall be submitted by the designer.

2.3 RUDDER STOCK

2.3.1 The diameter of the rudder stock head d_0, in cm, shall be not less than the greater value determined by the formula

$$d_0 = k_{10}\sqrt[3]{M_t/R_{eH}}, \qquad (2.3.1)$$

where: k_{10} – =factor equal to:
26,1 for the ahead condition;
23,3 for the astern condition;
M_t – torque according to **2.2.2.3**, **2.2.2.4** or **2.2.3.3**, in kN·m;
R_{eH} – upper yield stress of the rudder stock material, in MPa.

2.3.2 Under combined action of the torque and bending moment the working stresses (refer to **1.5.1**) acting in rudder stock sections 1, 2 or 3 shown in Fig. 2.2.4.1 for the appropriate type of the rudder shall not exceed 0,5 times the upper yield stress for the ahead condition and 0,7 times the upper yield stress of the material for the astern condition (refer to **1.5.2** and **2.1.6**). In this case, the normal stress (σ) and the shear stress (τ) in MPa, shall be determined by the formulae:

$$\sigma = 10{,}2\cdot10^3 M_b/d_i^3, \qquad (2.3.2\text{-}1)$$

$$\tau = 5{,}1\cdot10^3 M_t/d_i^3, \qquad (2.3.2\text{-}2)$$

where: M_b – bending moment acting in the considered section of the rudder stock (M_1, M_2 or M_3), determined according to the provisions of **2.2.4** to **2.2.7** for the appropriate type of the rudder, in kN·m;
d_i – diameter of the rudder stock in the considered section, in cm.

2.3.3 The change in the rudder stock diameter between the adjacent sections specified in **2.3.1** and **2.3.2** shall not be more sudden than that permitted by the linear law.

Where the change of the rudder stock diameter is stepped, the steps shall be provided with fillets having as large radius as practicable. The transition of the rudder stock into the flange shall be carried out with a radius of fillet of not less than 0,12 times the diameter of the rudder stock in way of the flange.

2.4 RUDDER BLADE AND STEERING NOZZLE

2.4.1 Rudder blade.

2.4.1.1 The thickness of the streamlined rudder blade side plating s, in mm, shall be not less than determined by the formul

$$s = ak_{11}\sqrt{\frac{98d + k_{12}(\frac{F_1}{A} + k_{13}\frac{F_2}{A_p})}{R_{eH}}} + 1{,}5 \quad (2.4.1.1\text{-}1)$$

where: d – осадка судна, м,

F_1 i F_2 – forces according to **2.2.2.1** and **2.2.2.2**, in kN;

for A and A_p, refer to **2.2.2.1**;

a – distance between horizontal or vertical web plates, whichever is the less, in m;

k_{11} – factor determined by the formula:

$$k_{11} = 10{,}85 - 2{,}516\left(\frac{a}{b}\right)^2; \quad (2.4.1.1\text{-}2)$$

R_{eH} – upper yield stress of the rudder blade plating material, in MPa;

b – distance between horizontal or vertical web plates whichever is the greater, in m;

k_{12} – factor equal to:

18,6 for the rudder blade plating within 0,35 of the rudder blade length from its leading edge;

8,0 for the rudder blade plating within 0,65 of the rudder length from its rear edge;

k_{13} – factor equal to:

1 for the rudder blade plating in the wake of the propeller (when rudder is in the non-reversed position);

0 for the rudder blade plating beyond the wake of the propeller (when rudder is in the non-reversed position).

2.4.1.2 In any case, the thickness of the streamlined rudder blade side plating $s_{\min}$, in mm, shall be not less than determined by the formulae:

for ships of less than 80 m in length

$$s_{\min} = 21{,}5\frac{L + 51}{L + 240}, \quad (2.4.1.2\text{-}1)$$

for ships of 80 m in length and over

$$s_{\min} = 24\frac{L + 37}{L + 240}, \quad (2.4.1.2\text{-}2)$$

where: L – length of the ship, in m.

2.4.1.3 For ice class ships the thickness of the rudder blade side plating in way of the ice belt shall be not less than that of the ice belt of the shell plating in the after part of the ship, specified in **3.10.4.1**, Part II "Hull", with the frame spacing being equal to the distance between the vertical web plates of the rudder blade.

The thickness s, in mm, of the rudder blade side plating for the icebreakers shall be not less than determined by the formula

$$s = 9{,}2k_{16}a\sqrt{\frac{p_a}{R_{eH}}} + 6, \quad (2.4.1.3\text{-}1)$$

where: a – distance between horizontal or vertical web plates, whichever is the less, for streamlined welded rudders; distance between rudder arms for single-plate steel solid-cast rudders, m.

In any case, in the calculations the value a shall not be taken less than 0,6 m;

p_a – =intensity of ice pressure in the CI region determined according to **3.10.3.5.2**, Part II "Hull", in kPa;

R_{eH} – upper yield stress of the material of the rudder blade plating, in MPa;

k_{16} – factor determined for streamlined welded rudders by the formula

$$k_{16} = 1 - 0{,}38(a/b)^2; \quad (2.4.1.3\text{-}2)$$

where: b – distance between horizontal or vertical web plates, whichever is the greater, in m.

For single-plate steel solid-cast rudders the value of k_{16} shall be taken in the calculations equal to 1.

2.4.1.4 The streamlined rudder blade side plating shall be stiffened from the inside by horizontal and vertical web plates. The thickness of the web plates shall be not less than that of the rudder blade side plating.

The side plating and web plates shall be welded together by fillet or plug welds with slots of linear form. Dimensions of elements of plug welds are selected according to **1.7.5.13**, Part II "Hull".

The horizontal and vertical web plates shall be provided with sufficient number of openings for free drainage of water which may penetrate inside the rudder blade.

The rear edge of the rudder blade shall be rigidly fixed in the proper way.

2.4.1.5 The streamlined rudder blade shall be provided with top and bottom plates, the thickness of which shall be not less than 1,2 times the greater value of the side plating thickness according to **2.4.1.1**.

The top and bottom plates shall be fitted with drain plugs of corrosion-resistant metal.

2.4.1.6 The corners of the openings (in way of the pintles) in the side plating of the semispade rudder blade shall be rounded off. The radius of curvature shall be not less than 2 times the side plating thickness in this area, and the free edge of the rudder side plating shall be thoroughly stripped.

2.4.1.7 Near the rotation axis of the streamlined rudder one or several vertical web plates shall be provided ensuring the general strength of the rudder blade. The section modulus of these web plates, including the effective flanges, shall be such that the normal stresses in the considered section are not more than 0,5 times the upper yield stress of the material of the rudder blade side plating (refer to **1.5.2**).

The normal stresses σ, in MPa, shall be calculated by the formula

$$\sigma = 1000 M_b / W, \qquad (2.4.1.7)$$

where: M_b – bending moment in the considered section of the rudder blade (M_4 or M_r) determined according to the provisions of **2.2.4** – **2.2.6** for the appropriate type of the rudder, in kN·m;

W – section modulus of the considered section of the web plates, including the effective flanges, about the axis of symmetry of the rudder blade profile, in cm^3.

The dimensions of the effective flanges of the web plates shall be as follows:

the thickness equal to that of the rudder blade side plating;

the width equal to 1/6 of the rudder blade height or 1/2 of the distance between the nearest web plates located on both sides of the considered web plate, whichever is the less.

2.4.1.8 Special care shall be given to the reliable securing to the rudder blade of the flange for coupling the rudder blade and the rudder stock and of the gudgeons for pintles.

2.4.1.9 At the leading edge of the single-plate steel solid-case rudders of the icebreakers the rudder piece shall be provided over the entire height of the rudder blade. The equivalent stress σ_{eq}, in MPa, developed in any horizontal section of the rudder piece and determined by the formula given below shall not exceed 0,5 times the upper yield stress of the rudder blade material

$$\sigma_{eq} = 1000\sqrt{\left(\frac{M_r}{W}\right)^2 + 3\left(\frac{M_t y}{h_r \rho S}\right)^2}, \qquad (2.4.1.9)$$

where: M_r – bending moment determined according to the provisions of **2.2.5.3**, in kN·m;

M_t – torque according to **2.2.2.3**, in kN·m;

h_r – height of the rudder measured on the rudder stock centre line, in m;

y – distance between the considered section and the lower edge of the rudder (refer to Fig. 2.4.1.9), in m;

W – section modulus of the considered cross-section of the rudder piece about the axis $O_1 - O_1$, ignoring the rudder blade plating (the rudder piece section taken into account in the calculation of W is hatched in section *I* – *I* of Fig. 2.4.1.9), in cm^3;

S – area of the considered cross-section of the rudder piece (refer to hatched area in section *I* – *I* of Fig. 2.4.1.9), in cm^2;

ρ – distance between the centroid of the area *S* and the rudder blade centre line, in cm.

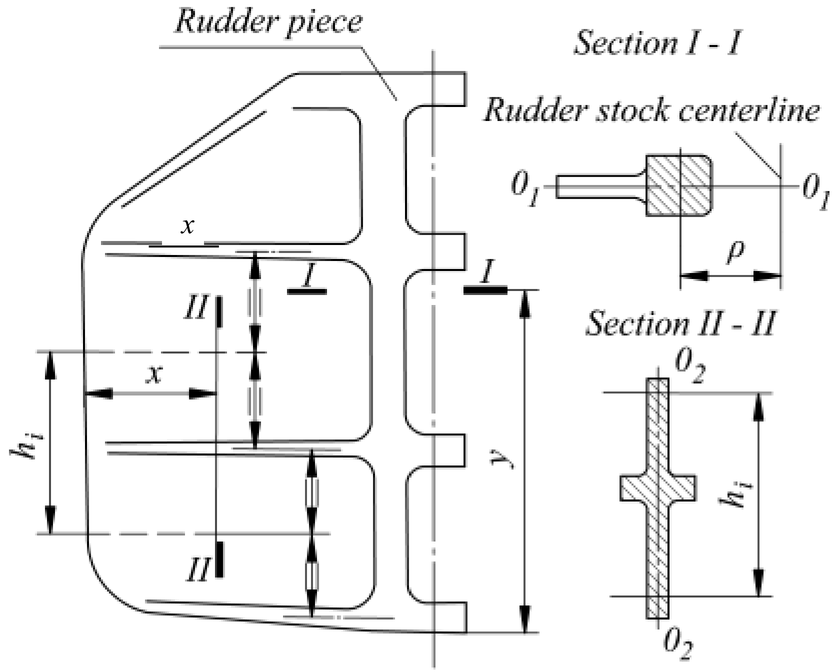


Fig. 2.4.1.9

2.4.1.10 The single-plate steel solid-case rudder shall be stiffened by the rudder arms founded on both sides of the rudder blade at the level of each gudgeon (refer to Fig. 2.4.1.9). The section modulus of the considered cross-section of the rudder arms *W*, in cm^3, (including the body of the rudder blade within the dimension hi, refer to section II - II in Fig. 2.4.1.9) about the axis O_2 - O_2 shall be not less than determined by the formula

$$W = \frac{1000 h_i x^2 F}{A R_{eH}}, \qquad (2.4.1.10)$$

where: F – force determined according to the provisions of **2.2.2.2**, kN;
A – rudder area, in m^2;
h_i – linear dimension, in m (refer to Fig. 2.4.1.9);
x – distance between the considered section and the rear edge of the rudder, in m (refer to Fig. 2.4.1.9);
R_{eH} – upper yield stress of the rudder material, in MPa.

2.4.2 Steering nozzle rudder.

2.4.2.1 The thickness s_o, in mm, of the steering nozzle outside plating shall be not less than determined by the formula

$$s_o = k_{14} l_1 \sqrt{\frac{98 D_n l_n d + 20 F_n}{D_n l_n R_{eH}}} + 2, \qquad (2.4.2.1\text{-}1)$$

where
D_n= inner minimum nozzle bore, in m;
l_n= length of the steering nozzle, in m;
d=draught of the ship, in m;

F_n= force acting on the steering nozzle according to **2.2.3.1**, in kN;

R_{eH}=upper yield stress of the material of the steering nozzle outside plating, in MPa;

k_{14}=factor determined by the formula

$$k_{14} = 7{,}885 - 2{,}221(l_1/u_1)^2; \qquad (2.4.2.1\text{-}2)$$

where:

l_1 – distance between transverse web plates or between the transverse web plate and the nearest edge of the steering nozzle, in m. This distance shall not exceed 600 mm;

u_1 – distance between the longitudinal web plates measured along the length of the steering nozzle outside plating, in m. This distance shall not exceed 1000 mm.

2.4.2.2 The thickness s_{in}, in mm, of the steering nozzle inside plating, except for its middle belt, shall be not less than

$$s_{in} = 6{,}39\frac{l_1}{D_n}\sqrt{T}, \qquad (2.4.2.2\text{-}1)$$

where: T – propeller thrust at speed V, in kN.

The thickness s_m, in mm, of the middle belt of the steering nozzle inside plating shall be not less than

$$s_m = 7{,}34\frac{l_2}{D_n}\sqrt{T} + 0{,}51\frac{T}{D_n^2}, \qquad (2.4.2.2\text{-}2)$$

where: l_2 – =distance between transverse web plates situated in way of the middle belt of the inside plating, in m.

2.4.2.3 In any case, the thickness of the outside and inside plating of the steering nozzle shall be not less than that given in **2.4.1.2**.

2.4.2.4 The middle belt of the steering nozzle inside plating shall extend not less than $0{,}05D_n$ forward and not less than $0{,}1D_n$ aft of the propeller blade tips. Its breadth shall be at least equal to the maximum breadth of the side projection of the propeller blade.

2.4.2.5 The outside and inside plating of the steering nozzle shall be stiffened from the inside by transverse and longitudinal web plates. The spacing of the web plates shall comply with the requirements of **2.4.2.1**. At least four longitudinal web plates shall be provided which are equally spaced around the circumference of the steering nozzle.

The thickness of web plates, except those situated in way of the middle belt of the steering nozzle inside plating, shall be not less than the thickness of the outside plating according to **2.4.2.1** and **2.4.2.3**.

The transverse and longitudinal web plates shall be welded to the steering nozzle inside plating by double side continuous welds with full penetration on the inside of the steering nozzle. When the thickness of the web plates is 10 mm and more, edge preparation shall be carried out.

The outside plating and web plates shall be connected by plug welding with slots of linear form or by backing welding. The dimensions of elements of plug welds with slots of linear form are selected according to **1.7.5.13**, Part II "Hull".

The transverse and longitudinal web plates shall be provided with sufficient number of openings for free drainage of water which might penetrate inside the steering nozzle, and in the lower and upper parts of the outside plating the drain plugs of stainless metal shall be fitted. The distance from the opening edge to the inside and outside plating of the steering nozzle shall be not less than 0,25 times the web plate height.

It is not allowed to weld on doubling plates to the inside plating of the steering nozzle.

2.4.2.6 In way of the middle belt of the steering nozzle inside plating at least two continuous transverse web plates shall be fitted. The thickness of these web plates shall be not less than the thickness of the inside plating off its middle belt as per Formula (2.4.2.2-1).

2.4.2.7 Special care shall be given to the reliable securing of the nozzle flange, welded-in bush and other steering nozzle welded-in parts for connecting the steering nozzle welded-in parts for connecting the steering nozzle with its stock and pintle.

2.4.2.8 The thickness s_{st} of the stabilizer plating, in mm, shall be not less than determined by the formula

$$s_{st} = k_{14} l_1 \sqrt{\frac{98 A_{st} d + 20 F_{st}}{A_{st} R_{eH}}} + 2, \quad (2.4.2.8)$$

A_{st}=area of the steering nozzle stabilizer, in m^2;
F_{st}=force acting on the stabilizer according to Formula (2.2.3.1-3), in kN;
k_{14}= factor according to **2.4.2.1** when the distance between horizontal web plates equals to u1, in m;
l_1= distance between vertical web plates or between the web plate and fore or aft edge of the stabilizer, in m;
R_{eH}= upper yield stress of material of the stabilizer plating, in MPa.

2.4.2.9 The steering nozzle stabilizer plating shall be stiffened from the inside by horizontal and vertical web plates having the thickness not less than that of the plating in accordance with **2.4.2.8**.

The stabilizer body shall terminate in top and bottom plates. The thickness of top and bottom plates shall not be less than 1,5 times the thickness of the plating according to **2.4.2.8**. Vertical web plates shall be securely connected to top and bottom plates.

The plating and horizontal and vertical web plates shall be welded together by fillet or plug welds. The types of plug welds with slots of linear form are selected according to **1.7.5.13**, Part II "Hull".

The horizontal and vertical web plates shall be provided with sufficient number of openings, and top and bottom plates shall be fitted with drain plugs of corrosion-resistant material.

2.4.2.10 In way of attachment of the stabilizer to the steering nozzle one or several vertical web plates shall be provided ensuring general strength of the stabilizer. The section modulus W_{st}, in cm^3, of these web plates, the effective flange included, shall be not less than determined by the formula

$$W_{st} = 1390 F_{st} h_{st} / R_{eH}, \quad (2.4.2.10)$$

where F_{st}=force acting on the stabilizer according to Formula (2.2.3.1-3), in kN;
h_{st}= stabilizer height, in m;
R_{eH}= upper yield stress of material of the stabilizer plating, in MPa.

The effective flange dimensions shall be as follows: thickness equal to the stabilizer plating thickness; width equal to 1/5 of the stabilizer height.

2.4.2.11 The steering nozzle and stabilizer shall be so connected that rigid fixation of the latter is ensured.

The force F_{st} determined from Formula (2.2.3.1-3) and uniformly distributed with the height of the stabilizer shall be taken in strength calculations as a force acting on the stabilizer. Depending on the type of connection a torque of force Fst acting on this connection shall be considered with regard to the point of application of this force (refer to Formula (2.2.3.2-3)).

In this case, stresses developed in the connection (refer to **1.5.1**) shall not exceed 0,4 times the upper yield stress of the material.

2.5 COUPLINGS

2.5.1 Horizontal flange coupling.

2.5.1.1 The diameter of the coupling bolts d_1, см, in cm, shall be not less than:

$$d_1 = 0{,}62 \sqrt{\frac{d_2^3 R_{eH1}}{z_1 r_2 R_{eH2}}}, \quad (2.5.1.1\text{-}1)$$

where d_2=diameter of the rudder stock at the coupling flange, in cm;
z_1=number of coupling bolts;
r_2=mean distance from the centre of the bolts to the centre of the system of the flange bolt holes, in cm;
R_{eH1} =upper yield stress of the rudder stock material,in MPa;
R_{eH2} =upper yield stress of the bolt material, in MPa.

The coupling bolt diameter at the bottom of threads d_3, in cm, shall be not less than determined by the formula

$$d_3 = 76{,}84\sqrt{\frac{M_b}{z_1 r_3 R_{eH_2}}},\qquad (2.5.1.1\text{-}2)$$

where M_b=bending moment acting in the rudder stock section at the flange (M_2 or M_3) determined according to the provisions of **2.2.4** - **2.2.7** for the appropriate type of the rudder, in kN·m;

r_3=mean distance from the centre of the bolts to the longitudinal axis of symmetry of the flange, in cm.

The number of bolts z_1 shall be not less than 6.

The mean distance from the centre of the bolts to the centre of the system of the flange bolt holes shall be not less than 0,9 times the rudder stock diameter according to **2.3.1**. When the coupling is under the action of the bending moment, the mean distance from the centre of the bolts to the longitudinal axis of symmetry of the flange shall be not less than 0,6 times the rudder stock diameter at the flange.

2.5.1.2 Only fitted bolts shall be employed, except the cases of a key setting when it is sufficient to have only two fitted bolts. The nuts shall have standard sizes. The bolts and nuts shall be efficiently secured.

2.5.1.3 The thickness of the coupling flanges shall not be less than the diameter of the bolts. The centres of the holes for bolts shall be distant from the outside edges of the flange by not less than 1,15 times the diameter of the bolts.

2.5.1.4 When coupling flanges of steering nozzles are not built into the steering nozzle body but connected to it by the structure formed of sheets, the strength of this structure shall be equivalent to that of the rudder stock in accordance with **2.3.2**.

In this case, the calculated equivalent stress shall not exceed 0,4 times the upper yield stress of the material used.

2.5.2 Keyed cone coupling.

2.5.2.1 The cone length of the rudder stock fitted to the rudder blade or steering nozzle shall not be less than 1,5 times the diameter of the rudder stock according to *2.3.2*; the cone on the diameter shall be 1:10. The cone shall change into cylindrical portion without any step in the diameter.

2.5.2.2 A key shall be set on the cone generatrix. The ends of the key shall be fairly rounded. The working sectional area of the key A_k (product of the key length by its width), in cm^2, shall be not less than the greater value determined by the formula

$$A_k = \frac{k_{15} M_t}{d_m R_{eH}},\qquad (2.5.2.2)$$

where k_{15}=factor equal to:

6920 for rudders for the ahead condition and for steering nozzles;

4950 for rudders for the astern condition;

M_t=torque according to **2.2.2.3**, **2.2.2.4** or **2.2.3.3**, in kN·m;

d_m=diameter of the cone section at the middle of the key length, in cm;

R_{eH}=upper yield stress of the key material, in MPa.

The height of the key shall be not less than half its width.

The keyway of the rudder stock shall be confined to the cone coupling.

2.5.2.3 The external diameter of the rudder stock threaded portion shall not be less than 0,9 times the minimum diameter of the cone. The thread shall be fine. The outer diameter and height of the nut shall not be less than 1,5 and 0,8 times the external diameter of the rudder stock threaded portion, respectively. To prevent self-unscrewing, the nut shall be securely fastened at least by two welded-on strips or one weldedon strip and a split pin.

2.5.3 Keyless cone coupling.

2.5.3.1 The requirements of **2.5.3** are applicable to a keyless fitting of the rudder stock to the rudder blade or steering nozzle which is made by oil injection method.

2.5.3.2 The cone length of the rudder stock fitted to the rudder blade or steering nozzle shall not be less than 1,5 times the diameter of the rudder stock according to **2.3.2**; the cone on the diameter shall be 1:15.

2.5.3.3 The rudder blade or steering nozzle boss shall be a good fit on the rudder stock cone. During the fit up, and before the push-up load is applied, an area of contact of at least 70 % of the theoretical area of contact shall be achieved, and this shall be distributed evenly.

The relationship of the rudder stock and boss cones at which this occurs shall be marked, and push-up length then measured from that point.

In well-founded cases another method of determining the original position of the rudder stock and boss cones relationship can be used.

2.5.3.4 To ensure the required interference in the cone coupling the push-up length of the rudder stock (refer to **2.5.3.3**) during its fitting shall be not less than determined by the formula

$$s_1 = \frac{1{,}1q}{EK}\left[\frac{2d_m}{1-\left(\frac{d_m}{d_c}\right)^2} + 35{,}7\right], \qquad (2.5.3.4\text{-}1)$$

where s_1=push-up length of the rudder stock, in mm;

d_m=mean diameter of the rudder stock cone, in mm;

d_c=outer diameter (or minimum outer dimension) of rudder blade boss or steering nozzle (in the mean section), in mm;

E=modulus of elasticity of rudder stock material, in MPa;

K= taper of conical coupling, on the diameter;

q=required contact pressure applied to mating surfaces during the push-up, in MPa, determined by the formula

$$q = \frac{4{,}25\cdot 10^6 n M_t}{d_m^2 L_a}\sqrt{1 + \left(\frac{5\cdot 10^{-6} Q d_m}{M_t}\right)^2} \times \left(1 + 0{,}257\frac{L_a}{d_m}\frac{M_b}{M_t}\right) \qquad (2.5.3.4\text{-}2)$$

where n= safety factor against friction slip under the action of rated torque;

M_t= maximum value of design torque according to **2.2.2.3**, **2.2.2.4** or **2.2.3.3**, in kN·m;

L_a= actual length of the contact part of cone, excluding the oil distribution grooves and similar devices, in mm;

Q= mass of rudder blade or steering nozzle, in kg;

M_b= maximum bending moment in way of cone coupling determined according to **2.2.4.8**, **2.2.6.3** or **2.2.7.3**, in kN·m.

The spade rudders and steering nozzles of types XIVand XV (refer to Fig. 2.2.4.1) the value n shall be taken not less than 2,5; for other types of rudders and steering nozzles this value shall be not less than 2,0.

If the contact pressure q determined by Formula (2.5.3.4-2) is less than 40 MPa, then q=40 MPa shall be taken in the calculations.

2.5.3.5 The strength of the maximum loaded part of the coupling shall be checked: the combined stress on the inside of the rudder blade or steering nozzle boss shall not exceed 0,85 of the yield stress of the boss material. The combined stress σ_{com}, on the inside of the boss shall be determined by the formula

$$\sigma_{com} = \sqrt{0{,}5(\sigma_1 - \sigma_2)^2 + 0{,}5(\sigma_2 - \sigma_3)^2 + 0{,}5(\sigma_3 - \sigma_1)^2}, \qquad (2.5.3.5\text{-}1)$$

where:

$$\sigma_1 = q_1\frac{d_c^2 + d_3^2}{d_c^2 - d_3^2}; \qquad (2.5.3.5\text{-}2)$$

$$q_1 = q + 5{,}73\frac{M_b\cdot 10^6}{d_3 L_{s.t}^2}; \qquad (2.5.3.5\text{-}3)$$

$$\sigma_2 = -q_1; \qquad (2.5.3.5\text{-}4)$$

$$\sigma_3 = \frac{40Q}{\pi(d_c^2 - d_3^2)} + \frac{M_b\cdot 10^7}{d_3^3}; \qquad (2.5.3.5\text{-}5)$$

q_1= contact pressure between mating cone surfaces in way of maximum diameter of the rudder stock cone under combined action of torque and bending moments, in MPa;

d_3=maximum diameter of rudder stock cone, in mm;

$L_{s.t}$= length of rudder stock cone, in mm.

2.5.3.6 The value of oil pressure applied to the mating cone surfaces of the rudder stock and rudder blade boss during mounting and dismounting of the coupling shall not exceed p_{max}, in MPa, determined by the formula

$$p_{\max} = 0{,}55 R_{eH} \left[1 - \left(\frac{d_m}{d_c} \right)^2 \right], \tag{2.5.3.6}$$

where R_{eH} =yield stress of material of the rudder blade or steering nozzle boss, in MPa.

2.5.4 Where the rudder stock is not made of a solid piece, its parts shall be joined by means of a muff coupling or by other method which shall ensure a strength equivalent to that of the rudder stock.

2.6 RUDDER PINTLES

2.6.1 The diameter d_4, in cm, of pintles without liners, as well as of pintles with liners, but before their setting, shall be not less than determined by the formula

$$d_4 = 18\sqrt{R_i / R_{eH}}\ , \tag{2.6.1}$$

where R_i=design value of the reaction of the considered pintle (R_2 or R_4) determined according to the provisions of **2.2.4** and **2.2.5** for the appropriate type of the rudder, in kN;
R_{eH}= upper yield stress of the pintle material, in MPa.

2.6.2 The length of the cone part of the pintle in rudder gudgeon, in welded-in bush of the steering nozzle or in the solepiece shall not be less than the diameter of the pintle according to **2.6.1**; the cone on the diameter shall not exceed 1:10. The cone shall change into cylindrical portion without any step in the diameter.

The external diameter of the pintle threaded portion shall not be less than 0,8 times the minimum diameter of the cone. The outer diameter and height of the nut shall not be less than 1,5 and 0,6 times the external diameter of the pintle threaded portion, respectivel.

2.6.3 The ratio of bearing height to diameter measured outside the pintle liners, where fitted, shall not be less than 1, nor more than 1,3.

2.6.4 The width of material in the rudder gudgeons and welded-in bushes of the steering nozzle measured outside the hole for the pintle bush shall not be less than 0,5 times the diameter of the pintle without liner. For rudder pintles of 200 mm and over in diameter it is allowed to reduce the specified width of the gudgeon from 0,5 times the diameter of the gudgeon down to 0,35 times the diameter of the pintle without liner in case the requirements of 2.6.2 and 2.6.3 are met, the following relation is obtained:

$$\frac{l_7}{d_4'} \geqslant \frac{R_{eH(p)}}{R_{eH(g)}}, \tag{2.6.4}$$

where l_7=height of the pintle bush, in cm;
d_4'=diameter of the pintle, in cm, including its liner, where fitted;
$R_{eH(p)}$=upper yield stress of the pintle material, in MPa;
$R_{eH(g)}$=upper yield stress of the gudgeon material, in MPa.

2.6.5 To prevent self-unscrewing, the nut shall be securely fastened by means of at least two welded-on strips or one welded-on strip and a split pin, and the pintles shall be securely fastened in gudgeons of the rudder or sternframe.

2.6.6 The chosen dimensions of the pintles shall be checked by the surface loading p, in MPa, this being taken as

$$p = 10 R_i / (d_4' l_7), \tag{2.6.6}$$

where for R_i – refer to **2.6.1**;

d_4' =diameter of the pintle, in cm, including its liner, where fitted;

l_7 =height of the pintle bush, in cm.

This surface loading shall not exceed the values specified in Table 2.1.7.

2.7 RUDDER AXLE

2.7.1 The diameter of the rudder axle directly at the flangeshall be such that the normal stresses σ developed in its sections do not exceed 0,5 times the upper yield stress of the rudder axle material. The normal stress σ, , in MPa, shall be determined by the formula

$$\sigma = 10^4 M_{r \cdot a}/d_5^3 , \qquad (2.7.1)$$

where
$M_{r \cdot a}$= design value of the bending moment determined according to the provisions of **2.2.4.15**, in kN·m;
d_5=diameter of the rudder axle at the flange, in cm.

The diameter of the rudder axle in way of the rudder bearings shall be not less than the diameter d_5 . The diameter of the rudder axle between the rudder blade bearings may be reduced by 10%.

2.7.2 As regards the cone and threaded portions of the rudder axle and also its nut, the requirements are as stipulated in **2.6.2** for the pintles.

2.7.3 The diameter of bolts of the rudder axle flange coupling d6 , in cm, shall be not less than determined by the formula

$$d_6 = 6{,}77\sqrt{\frac{R_2 + \frac{M_{r \cdot a}}{r_4}\sqrt{1 + \left(0{,}17 + 0{,}6\frac{R_2 r_5}{M_{r \cdot a}}\right)^2}}{z_2 R_{eH}}} \qquad (2.7.3)$$

where R_2= design value of the reaction of the rudder axle upper bearing determined according to **2.2.4.11**, in kN;
$M_{r \cdot a}$=design value of the bending moment acting in the rudder axle section near its flange determined according to **2.2.4.15**, in kN·m;
r_4=mean distance from the centre of the bolts to the centre of the system of the flange bolt holes, in m;
r_5=distance from the centre line of the rudder stock to the contact plane of the rudder axle flanges and the sternframe, in m;
z_2=number of the bolts of the flange coupling;
R_{eH}=upper yield stress of the bolt material, in MPa.

The number of the bolts z_2 shall be not less than 6.

The distance from the centre of any bolt to the centre of the system of the flange bolt holes shall be not less than 0,7, and to the vertical axis of symmetry of the flange plane, not less than 0,6 times the diameter d_5 , of the rudder axle given in **2.7.1**.

2.7.4 Only fitted bolts shall be employed, except the cases of a key setting when it is sufficient to have only two fitted bolts. The nuts shall have standard sizes, and they shall be securely fastened by split pins or weld-on strips.

2.7.5 The thickness of the coupling flange shall not be less than the diameter of the bolts. The centres of the holes for bolts shall be distant from the outside edges of the flange by not less than 1,15 times the diameter of the bolts.

2.7.6 Where the diameter of the rudder axle changes, sufficient fillets shall be provided. At transition from the rudder axle to the flange a fillet shall be provided with a radius of not less than 0,12 times the rudder axle diameter.

2.7.7 To prevent self-unscrewing, the nut of the rudder axle shall be securely fastened at least by two weld-on strips or one weld-on strip and a split pin.

2.7.8 The requirements of **2.6.6** for pintles are applicable to the rudder blade bearings on the rudder axl.

2.8 RUDDER STOCK BEARINGS

2.8.1 The requirements of **2.6.6** for pintles are applicable to the rudder stock bearings taking lateral load.

2.8.2 A rudder carrier shall be installed to take the mass of the rudder blade or steering nozzle and rudder stock. The deck shall be efficiently strengthened in way of the rudder carrier. Measures shall be taken against axial displacement of the rudder blade or steering nozzle and rudder stock upwards by a value exceeding that permitted by the construction of the steering gear; furthermore, for steering nozzle measures shall be taken to provide for guaranteed clearance between propeller blades and nozzle under service conditions.

2.8.3 A stuffing box shall be fitted in way of passage of the rudder stock through the top of a rudder trunk which is open to sea to prevent water from entering the ship's space. The stuffing box shall be fitted in a place accessible for inspection and maintenance at all times.

2.9 STEERING GEAR

2.9.1 Ships shall be provided with a main steering gear and an auxiliary steering gear, unless expressly provided otherwise.

2.9.2 The main steering gear and rudder stock shall be capable of putting the rudder or steering nozzle over from 35° on one side to 35° on the other side with the ship at its deepest seagoing draught and running ahead at maximum ahead service speed and under the same conditions, from 35° on either side to 30° on the other side in not more than 28 s.

2.9.3 The auxiliary steering shall be capable of putting the rudder or steering nozzle over from 15° on one side to 15° on the other side in not more than 60 s with the ship at its deepest sea going draught and running ahead at one half of the maximum ahead service speed or 7 knots, whichever is the greate.

2.9.4 In oil tankers, oil tankers (>60° C), combination carriers, gas carriers and chemical tankers of 10000 gross tonnage and upwards, in all nuclear ships and in other ships of 70 000 gross tonnage and upwards the main steering gear shall comprise two or more identical power units satisfying the requirements of **2.9.5** (refer also to **6.2.1.8** and **6.2.1.9**, Part IX "Machinery").

2.9.5 Where the main steering gear comprises two or more power units, an auxiliary steering gear need not be fitted if:

.1 in passenger and nuclear ships as well as in special purpose ships having more than 240 persons on board the main steering gear is capable of operating as required in **2.9.2** while any one of the power units is out of operation;

.2 in cargo ships as well as in special purpose ships having 240 or less persons on board the main steering gear is capable of operating as required in **2.9.2** while all power units are in operation;

.3 the main steering gear is so arranged that after a single failure in its piping system or in any one of the power units the defect can be isolated so that steering capability can be maintained or speedily regained.

2.9.6 Where according to 2.3.1 the diameter of the rudder head is required to be over 230 mm, excluding strengthening for navigation in ice, provision shall be made for an additional source of electrical power as prescribed in **5.5.6**, Part XI "Electrical Equipment" sufficient to ensure operation of the steering gear power unit in compliance with the requirements of **2.9.3**.

2.9.7 The main steering gear may be hand-operated provided it meets the requirements of **6.2.3.2**, Part IX "Machinery" and the rudder stock and steering nozzle diameter specified in **2.3.1** does not exceed 120 mm (excluding strengthening for navigation in ice). In all other cases, the main steering gear shall be operated by power.

2.9.8 The auxiliary steering gear may be handoperated provided it meets the requirements of **6.2.3.3**, Part IX "Machinery" and the rudder stock or steering nozzle diameter specified in **2.3.1** does not exceed 230 mm (excluding strengthening for navigation in ice). In all other cases, the auxiliary steering gear shall be operated by power.

2.9.9 The main and auxiliary steering gears shall act on the rudder stock independently of one another, but it is allowed that the main and auxiliary steering gears have some common parts (such as tiller, quadrant, gear box, cylinder block, etc.) provided the respective scantlings of these parts are increased in accordance with **6.2.8.2**, Part IX "Machinery".

2.9.10 The rudder tackle may be considered as an auxiliary steering gear only in the following cases:

.1 in self-propelled ships of less than 500 gross tonnage;

.2 in non-propelled ships. In other cases, the rudder tackle is not considered as a steering gear and shall not necessarily be fitted in ships.

2.9.11 The rudder shall be provided with a system of stops permitting to put the rudder over either side only to an angle β°:

$$(\alpha^\circ + 1^\circ) \le \beta^\circ \le (\alpha^\circ + 1{,}5^\circ), \qquad (2.9.11\text{-}1)$$

where: α° – maximum hard-over angle to which the steering gear control system is adjusted but not over 358; technical background for the greater hard-over angle, based on the constructional features of the steering gear, shall be submitted by the designer.

All the parts of the system of stops, including those which are at the same time the parts of the steering gear, shall be calculated to take forces corresponding to an ultimate reverse torque M_{ult}, in kN·m, from the rudder of not less than:

$$M_{ult} = 1{,}135 R_{eH} d^3 \cdot 10^{-4}, \qquad (2.9.11\text{-}2)$$

where: d – actual diameter of the rudder stock head, in cm;
R_{eH} – upper yield stress of the rudder stock material, in MPa.

The stresses in these parts shall not exceed 0,95 times the upper yield stress of their material.

The rudder stops of the system may be fitted on the sternframe, deck platform, bulkhead or other structural members of the ship's hull.

Where an active rudder is installed and putting the rudder over to an angle exceeding the maximum one is required, arrangement of stops at an angle provided by the rudder design may be allowed.

2.9.12 Control of the main steering gear shall be provided both on the navigation bridge and in the steering gear compartment.

2.9.13 When the main steering gear is arranged according to **2.9.4** or **2.9.5**, two independent steering gear control systems shall be provided, each of which shall be operable separately from the navigation bridge. These systems may have a common steering wheel or level. If the control system comprises a hydraulic telemotor, the Register may waive the requirement for a second independent control system of the steering gear for the ship (with the exception of oil tankers, oil tankers (>60°C), combination carriers, gas carriers and chemical tankers of 10 000 gross tonnage and upwards, of other ships of 70 000 gross tonnage and upwards and of nuclear ships).

2.9.14 The auxiliary steering gear control shall be provided in the steering gear compartment.

For the auxiliary steering gear which is power operated, control shall also be provided from the navigation bridge and shall be independent of the control system for the main steering gear.

For ships of less than 500 gross tonnage and fishing vessels, the auxiliary steering gear control may not be provided from the steering gear compartment.

2.9.15 A rudder or steering nozzle angle indicator shall be fitted in the vicinity of each control station of the main and auxiliary steering gears and in the steering gear compartment.

The difference between the indicated and actual positions of the rudder or steering nozzle shall be not more than:

1° when the rudder or steering nozzle is in the centre line or parallel to it;

1,5° for rudder or steering nozzle angles from 0° - 5°;

2,5° for rudder or steering nozzle angles from 5° - 35°.

The rudder or steering nozzle angle indication shall be independent of the steering gear control system.

2.9.16 In all other respects the steering gear shall meet the requirements of Part IX "Machinery" and Part XI "Electrical Equipment".

2.9.17 Where compliance with the requirements of **2.9.2** and **2.9.3**, when conducting sea trials, is impossible, the ship, regardless of the date of construction, can confirm compliance with the requirements of **2.9.2** and **2.9.3** by other methods (refer to Resolution MSC.365 (93) of 22.05 .2014).

2.9.18 If the steering gear is mechanically driven, then in case of damage or malfunction of the control device, the second control device or manual drive shall be automatically actuated within 5 s.

If the other control unit or manual drive is not automatically actuated, it shall be possible for the helmsman to actuate it in a quick and easy way in one operation.

2.10 EFFICIENCY OF RUDDERS AND STEERING NOZZLES

2.10.1 General.

2.10.1.1 The choice of the ship's main characte-ristics affecting the steerability and the characteristics of the rudder and steering nozzle is made at the discretion of the designer and shipowner considering the necessity to ensure the proper steerability of the ship according to its purpose and service conditions and to ensure the correspondence between relative areas of rudders and steering nozzles of the ship under design and the prototype ship provided the total efficiency of the chosen rudders and/or steering nozzles is not less than that required in this Chapter.

2.10.1.2 The requirements of this Chapter apply to stern rudders and steering nozzles (refer to **2.1.2**) provided according to **2.1.1** in self-propelled ships (other than icebreakers) of 20 m and over in length of unrestricted service **A** and restricted areas of navigation **R1** and **A-R1** sailing in the displacement condition.

For ships of restricted areas of navigation **R2**, **A-R2**, **R2-S**, **A-R2-S**, **B-R3-S**, **C-R3-S**, **R3-S** and **R3** the standards set forth in **2.10.3** shall be considered as recommendations.

For ships of river-sea navigation **R2-RS**, **A-R2-RS**, **B-R3-RS**, **C-R3-RS**, **R3-RS**, **D-R3-RS**, **R3-IN** the standards set forth in **2.10.3** shall also be considered as recommendations, and the fulfilment of these standards does not give the grounds for exemption from the fulfilment of the current standards of steerability for ships of inland navigation, complying with **14**, Part III «Equipment, Arrangements and Outfit. Signal Means» of the Rules for the classification and construction of inland navigation ships pursuant to Chapter 20 of UNECE Resolution No. 61 (Revision 2).

2.10.1.3 The requirements of this Chapter apply to ships having the geometric characteristics of the hull within the following limits:

$L_1/B = 3,2...8,0$;
$L_1/d = 8,3...28,6$;
$B/d = 1,5...3,5$;
$C_B = 0,45...0,85$;
$C_p = 0,55...0,85$;
$\sigma_a = 0,80...0,99$,

where B= breadth of the ship, in m;
for C_B, d, L_1, C_p and s_a, refer to **2.2.2.1**, **2.4.1.1** and **2.10.3.3**, respectively.

2.10.1.4 The requirements of this Chapter apply to catamarans with two identical hulls (symmetric about the centreline of the hulls), each having geometric characteristics according to the provisions of **2.10.1.3**, and with two identical rudders and/or steering nozzles arranged in the centre plane of each hull.

2.10.1.5 The active means of the ship's steering which are not the main means of the ship's steering (thrusters, active rudders, etc.) are considered as means supplementing the required minimum and are not taken into account when meeting the requirements of this Chapter (refer also to **2.1.4.2**).

2.10.2 Estimation of efficiency of rudders and steering nozzles.

2.10.2.1 The efficiency of the chosen rudder E_r, other than rudders of types IV, X and XIII (refer to Fig. 2.2.4.1), shall be determined by the formula

$$E_r = \mu_1 \frac{A}{A_2}\left(1 + C_{HB}\frac{A_P}{A}\right)(1 - W)^2, \quad (2.10.2.1\text{-}1)$$

where: $$\mu_1 = \frac{6,28}{1 + \frac{2A}{h_r^2}}; \quad (2.10.2.1\text{-}2)$$

W – coefficient: for rudder arranged in the centreline behind the propeller,

$$W = 0,3C_B; \quad (2.10.2.1\text{-}3)$$

for rudder arranged in the centreline with no propeller fitted forward of it

$$W = 0; \quad (2.10.2.1\text{-}4)$$

for side rudders

$W = 0{,}4C_B - 0{,}13$; (2.10.2.1-5)

A_2 – lateral underwater area at the summer load waterline draught, in m^2;

for A, A_p, h_r, C_B – refer to **2.2.2.1**;

C_{HB} – value determined by Formula (2.2.3.1-8) with regard to Formula (2.2.3.1-4) at W as specified in this para with regard to **2.2.2.6**; for rudders not operating directly behind the propeller the thrust is taken as $T = 0$.

2.10.2.2 The efficiency of the chosen rudder E_{rr} of types IV, X or XIII (refer to Fig. 2.2.4.1) shall be determined by the formula

$$E_{rr} = 1{,}3\mu_2 \frac{A_t}{A_2}(1 - W)^2, \quad (2.10.2.2\text{-}1)$$

where: $$\mu_2 = \frac{6{,}28\sqrt{b_r/b_t}}{1 + \frac{2b_t^2}{A_t}} + \frac{1{,}4C_{HB}}{1 + 0{,}5\left(\frac{b_t^2}{A_t}\right)^2}. \quad (2.10.2.2\text{-}2)$$

where: b_r= breadth of the rudder, in m;
b_t=total breadth of the rudder and rudder post, in m;
for A_t, refer to **2.2.2.1**;
for A_2, C_{HB}, W, refer to **2.10.2.1**.

2.10.2.3 The efficiency of the chosen steering nozzle E_n with or without a stabilizer shall be determined by the formula

$$E_n = 2{,}86\mu_3 \frac{D_o l_n}{A_2}(1 - W)^2, \quad (2.10.2.3\text{-}1)$$

where:

$$\mu_3 = \left(0{,}175 + 0{,}275\frac{D_n}{l_n}\right)\left[1 + 0{,}25\left(1 + \sqrt{1 + C_{HB}}\right)^2\right] + 0{,}25C_{HB}\frac{D_n}{l_n}; \quad (2.10.2.3\text{-}2)$$

W – coefficient:
for steering nozzle arranged in the centreline of the ship

$W = 0{,}2C_B$; (2.10.2.3-3)

for side steering nozzle

$W = 0{,}1C_B$; (2.10.2.3-4)

D_0 – outside diameter of the steering nozzle in the plane of the propeller disk, in m;

for C_B, D_n, l_n *and* A_2, refer to **2.2.2.1**, **2.2.3.1** and **2.10.2.1**, respectively;

C_{HB}=value determined by Formula (2.2.3.1-8) with regard to Formula (2.2.3.1-4) at W as specified in this para with regard to **2.2.2.6.**

2.10.3 Standards for efficiency of rudders and steering nozzles.

2.10.3.1 The total efficiency of all rudders and steering nozzles (refer to **2.10.2**) fitted in the ship (other than catamaran) shall not be less than the greater of the values E_1, E_2 or E_3, given below.

2.10.3.2 The efficiency of the single rudder or steering nozzle fitted in the catamaran which is determined according to **2.10.2** shall not be less than the greater of the valuesE_1, E_2 and E_3, estimated according to the provisions specified below considering each hull of the catamaran as an independent single-screw ship.

When determining the side-projected area (windage area), all the above-water structures of the catamaran and the deck cargo (if intended to be carried) are considered as belonging to one hull.

2.10.3.3 For all ships, other than tugs, rescue and fishing vessels, the value of E1 is determined depending on the values of C_p and σ_a:

for single-screw ships - according to Fig. 2.10.3.3-1;

for twin-screw and triple-screw ships - according to Fig. 2.10.3.3-2.

For intermediate values of C_p p the value of E_1 is determined by linear interpolation between the curves for two nearest values of C_p, given in Figs. 2.10.3.3-1 and 2.10.3.3-2 where C_p – is prismatic coefficient of the underwater part of the hull at the summer load waterline draught as determined by the formula:

$$C_p = C_B / C_m, \qquad (2.10.3.3\text{-}1)$$

where: C_m – coefficient of fineness of midship section at the summer load waterline draught;

σ_a – afterbody lateral area coefficient at the summer load waterline draught as determined by the formula:

$$\sigma_a = 1 - \frac{2(f - f_0)}{L_1 d} \qquad (2.10.3.3\text{-}2)$$

L_1 – length of the ship measured on the summer load waterline from the fore side of the stem to the after side of the after end of the ship, in m;

f – area of side projection of the stern counter, in m^2, calculated as the area of the figure bounded by the extension line of the keel lower edge, by the perpendicular to this line from the point of intersection of the summer load waterline and the outline of the centreline section of the ship's after end and by the sternframe after edge line drawn ignoring the rudder post, solepiece or rudder horn, if any;

f_0 – for twin-screw ships - area of the side projection of the propeller cone (or its part) superimposed on the area of the figure f, in m^2. In all other cases f_0 shall be taken as zero;

for d – refer to **2.4.1.1**.

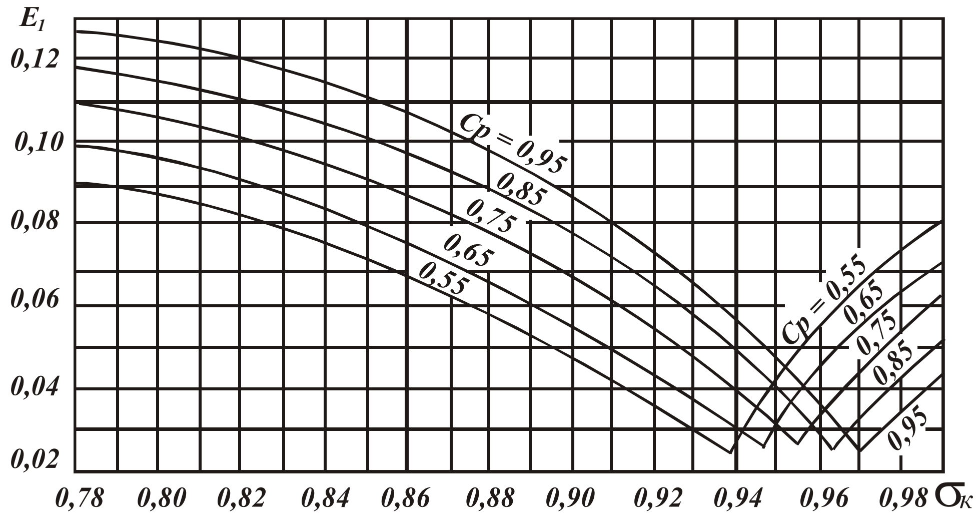


Fig. 2.10.3.3-1

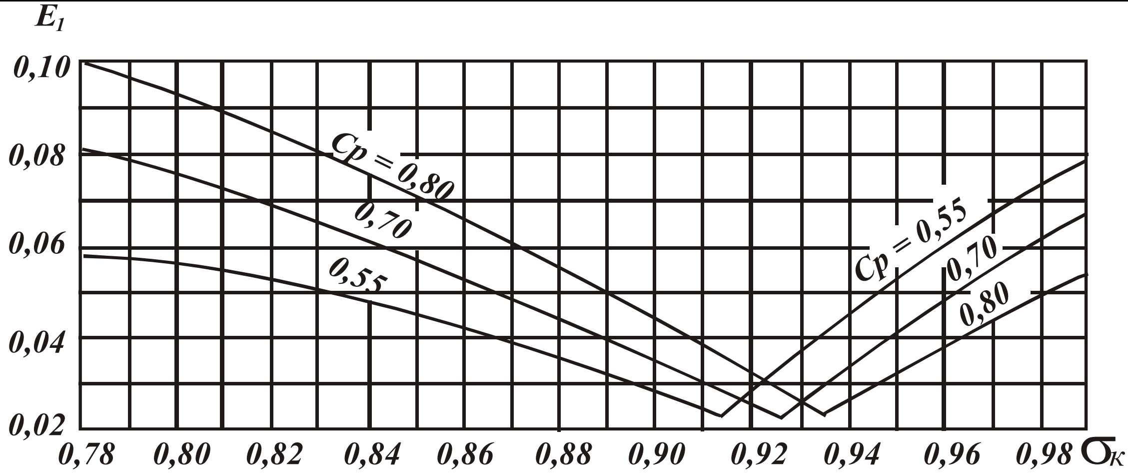


Fig. 2.10.3.3-2

2.10.3.4 For tugs, rescue ships and fishing vessels the value E1 is determined according to Fig. 2.10.3.4 depending on the value σ_a

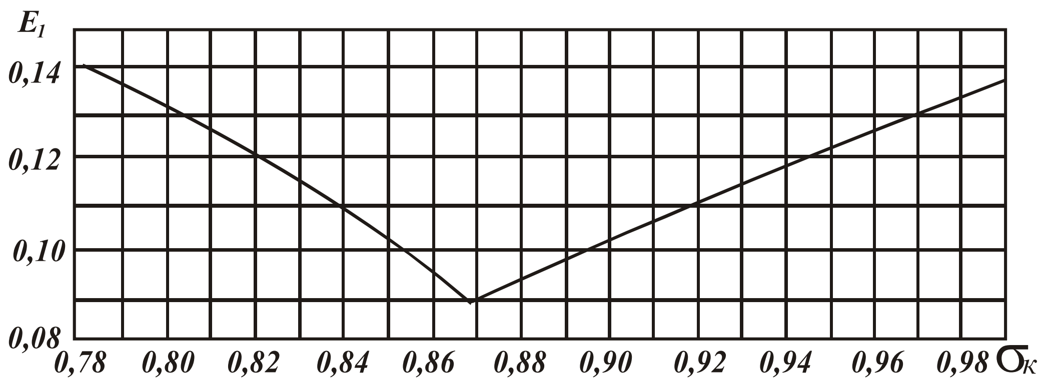


Fig. 2.10.3.4

2.10.3.5 The value E_2 is determined by the formula:

$$E_2 = \frac{3{,}8A_3}{v^2 A_4}\left(1 - 0{,}0667\frac{A_3}{A_4}\right)\{1 + (\lambda_r - 1)[0{,}33 + 0{,}015 \times (v - 7{,}5)] - 5\frac{x_0}{L_1} \quad , \qquad (2.10.3.5\text{-}1)$$

where: A_3 – = side-projected area at such a minimum draught at which the rudder blade or steering nozzle is fully immersed (at the upright position of the ship), in m^2, to be determined according to 1.4.6, Part IV "Stability";

A_4 – lateral underwater area at such a minimum draught at which the rudder blade or steering nozzle is fully immersed (at the upright position of the ship), in m^2;

x_0 – horizontal distance from the midship frame (middle of the length L1) to the centroid of the area A3, in m.

The value of x_0 is taken to be positive in case the centroid is forward of the midship frame, and negative in case of aft position;

λ_r– coefficient determined by the formulae:

for all rudders, other than rudders of types IV, X and XIII (refer to Fig.2.2.4.1)

$$\lambda_r = h_r^2 / A; \qquad (2.10.3.5\text{-}2)$$

for rudders of types IV, X, XIII (refer to Fig.2.2.4.1)

$$\lambda_r = h_r^2 / A_t; \qquad (2.10.3.5\text{-}3)$$

for steering nozzles

$$\lambda_r = D_n / l_n; \qquad (2.10.3.5\text{-}4)$$

where for v, h_r, A, A_t, refer to **2.2.2.1**;
for D_n, l_n, refer to **2.2.3.1**.

2.10.3.6 For ships of 70 m in length and more the value E_3 is determined by the formula

$$E_3 = 0{,}03 + 0{,}01(\lambda_r - 1) + 0{,}01\frac{A_5}{A_2}\left(1 - 3\frac{x}{L_1}\right) \qquad (2.10.3.6)$$

where: A_5 – side-projected area of the ship at the summer load waterline draught, in m^2, to be determined according to **1.4.6**, Part IV "Stability";
x – horizontal distance from the midship frame (middle of the length L_1) to the centroid of the area A_5, in m;
for A_2 – refer to **2.10.2.1**;
for λ_r – refer to **2.10.3.5**.

The value of x is taken to be positive in case the centroid is forward of the midship frame and negative in case of aft position.

For ships of less than 70 m in length E_3=0 is taken in the calculations.

2.10.3.7 For all ships (other than rescue and fishing vessels and tugs, with σ_a>0,865), it is permitted in the calculations to take E_1 as zero (if the value of E_1 is greater than any of the values of E_2 or E_3) provided it is proved by the test of a self-propelled model not less than 2 m in length (at the speed of the model conforming to the ship's speed V, refer to **2.2.2.1**) that:

.1 the steady turning diameter of the ship with the rudder (rudders) or steering nozzle (rudders) put over to 35° on either side is not more than four lengths of the ship;

.2 the steady spontaneous turning diameter of the ship with non-reversed rudder (rudders) or steering nozzle (rudders) D_s determined by the formula

$$D_s = (D_{ss} + D_{sp})/2, \qquad (2.10.3.7)$$

is not less than $3{,}35\,(D_{ts} + D_{tp})$

where: D_{ts} and D_{tp} = steady turning diameter of the ship with the rudder or steering nozzle put over to 358 on starboard or port side, respectively;
D_{ss} and D_{sp}= diameter of steady spontaneous turning starboard or port, respectively, with the non-reversed rudder or steering nozzle.

2.10.3.8 For ships with the displacement exceeding 60000 t and block coefficient exceeding 0,75 at the summer load waterline draught, the compliance with the requirements of **2.10.3.7.1** and **2.10.3.7.2** shall be proved by testing a self-propelled model of not less than 2 m in length (at the speed of the model conforming to the ship's speed V, refer to **2.2.2.1**), notwithstanding the fulfilment of the requirements of **2.10.3.**1.

2.11 ADDITIONAL REQUIREMENTS FOR BALTIC ICE CLASS SHIPS

The scantlings of rudder post, rudder stock, pintles, steering engine etc. as well as the capability of the steering engine shall be determined according to the requirements of this Chapter. The steering gear of Baltic ice class **IA** and **IA Super** ships shall comply with the requirements to **Ice4** and **Ice5** ships respectively.

The maximum service speed of the ship to be used in these calculations shall, however, not be taken as less than stated below:

IA Super – 20 knots;
IA – 18 knots;
IB – 16 knots;
IC – 14 knots.

If the actual maximum service speed of the ship is higher, that speed shall be used.

The scantlings of structural elements of the rudder blade shall be determined on the basis that the steering gear is completely located in the ice zone of the ship. The scantlings of rudder blade plate elements and stiffeners shall be determined at an ice load intensity p, which corresponds to the intensity of the ice load on the plate and beam elements in the midship.

For the ice classes **IA Super** and **IA** the rudder stock and the upper edge of the rudder shall be protected against ice pressure by an ice knife or equivalent means, located aft of the rudder, which in its dimensions shall extend beyond the lower ice waterline (LIWL see 3.12, Part “Hull”), to the extent possible for this design, or with the help of other measures equivalent in degree of protection.

When using a rudder with a flap, the design of an ice knife shall provide the necessary strength of the rudder blade.

For the ice classes **IA Super** and **IA** due regard shall be paid to the excessive load caused by the rudder being forced out of the midship position when backing into an ice ridge. Where possible, rudder stoppers working on the blade or rudder head shall be fitted.

Relief valves for hydraulic pressure shall be effective.

The components of the steering gear shall be dimensioned to stand the yield torque of the rudder stock, at which a stress arises for the calculated diameter of the rudder equal to the minimum value of the conditional yield strength of the material.

3. ANCHOR ARRANGEMENT

3.1 GENERAL

3.1.1 Each ship shall be provided with anchoring equipment and also with chain stoppers for securing the bower anchors in hawse pipes, devices for securing and releasing the inboard ends of the chain cables and machinery for dropping and hoisting the bower anchors as well as for holding the ship at the bower anchors dropped.

Besides, in cases specified in **3.6.1.1** each bower anchor chain cable shall be provided with a stopper for riding the ship at anchor.

The requirements of this Section for selection of anchoring equipment do not apply to oil tankers of 150 m in length and above as well as bulk carriers of 90 m in length and above, contracted for construction on or after 1 July 2015. The requirements for anchoring equipment of the said ships are regulated by Common Structural Rules for Bulk Carriers and Oil Tankers

3.1.2 If a ship in addition to the anchor arrangement or anchoring equipment specified in 3.1.1 is provided with some other anchor arrangement or anchoring equipment (for example, special anchors and winches on dredgers, mooring anchors on lightships, etc.), such anchor arrangement or anchoring equipment is regarded as special one and is not subject to the Register survey.

The use of anchor arrangement specified in **3.1.1** as a working special arrangement for moving the dredgers and also for holding the dredgers in place in the course of dredging carried out by grabs may be allowed; in so doing the required data characterizing the conditions of work of anchor arrangement elements (the value and degree of dynamics of acting forces, the degree of intensity of work and wear rate of the anchor arrangement elements, etc.) shall be submitted.

3.1.3 For all ships other than fishing vessels, the anchoring equipment shall be selected from Table 3.1.3-1, for fishing vessels – from Table 3.1.3-2.

For fishing vessels, when Equipment Number exceeds 720, the anchoring equipment shall be selected from Table 3.1.3-1 based on Equipment Number determined in compliance with 3.2 in the case of ships of unrestricted service and of restricted area of navigation **R1** and **A-R1** and based on Equipment Number reduced:

by 15 % in the case of ships of restricted areas of navigation **R2**, **A-R2, R2-S, A-R2-S, A-R2-RS, B-R3-S, B-R3-RS, C-R3-S, C-R3-RS, R3-S, R3-RS;**

by 25 % in the case of ships of restricted area navigation **R3** і **R3-IN, D-R3-S, D-R3-RS** з taking into account of the provisions specified in **3.1.4, 3.3.1, 3.3.2, 3.4.1, 3.4.2, 3.4.3, 3.4.7 і 3.4.10**.

Table 3.1.3-1

Equipment Number EN		Bower anchors		Mass of stream anchor, in kg	Chain cables for bower anchors				Stream wire or chain		Tow line		Mooring lines		
						Diameter									
Exceeding	Not exceeding	Number	Mass of anchor, in kg		Total length of both chain cables, in m	Ordinary (grade 1), in mm	Special quality (grade 2), in mm	Extra special quality (grade 3), in mm	Length, in m	Chain cable breaking load or breaking strength of wire	Length, in m	Minimum breaking strength, in kN	Number	Length of each line, in m	Minimum breaking strength, in kN
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
10	15	2	35	-	110	1)	-	-	-	-	-	-	2	30	29
15	20	2	50	–	137,5	1)	–	–	–	–	–	–	2	30	29
20	25	2	65	–	165	1)	–	–	–	–	–	–	2	40	29
25	30	2	80	–	165	11,0	–	–	–	–	–	–	2	50	29
30	40	2	105	35	192,5	11,0	–	–	55	55	120	65	2	50	29
40	50	2	135	45	192,5	12,5	–	–	70	60	150	81	2	60	29
50	70	2	180	60	220	14	12,5	-	80	65	180	98	3	80	37
70	90	2	240	80	220	16	14	–	85	74	180	98	3	100	40
90	110	2	300	100	247,5	17,5	16	–	85	81	180	98	3	110	42
110	130	2	360	120	247,5	19	17,5	-	90	89	180	98	3	110	48
130	150	2	420	140	275	20,5	17,5	–	90	98	180	98	3	120	53
150	175	2	480	165	275	22	19	–	90	108	180	98	3	120	59
175	205	2	570	190	302,5	24	20,5	–	90	118	180	112	3	120	64
205	240	2	660	–	302,5	26	22	20,5	–	–	180	129	4	120	69
240	280	2	780	–	330	28	24	22	–	–	180	150	4	120	75
280	320	2	900	–	357,5	30	26	24	–	–	180	174	4	140	80
320	360	2	1020	–	357,5	32	28	24	–	–	180	207	4	140	85
360	400	2	1140	–	385	34	30	26	–	–	180	224	4	140	96
400	450	2	1290	–	385	36	32	28	–	–	180	250	4	140	107
450	500	2	1440	–	412,5	38	34	30	–	–	180	276	4	140	117
500	550	2	1590	–	412,5	40	34	30	–	–	190	306	4	160	134
550	600	2	1740	–	440	42	36	32	–	–	190	338	4	160	143
600	660	2	1920	–	440	44	38	34	–	–	190	371	4	160	160
660	720	2	2100	–	440	46	40	36	–	–	190	406	4	160	171
720	780	2	2280	–	467,5	48	42	36	–	–	190	441	4	170	187
780	840	2	2460	–	467,5	50	44	38	–	–	190	480	4	170	202
840	910	2	2640	–	467,5	52	46	40	–	–	190	518	4	170	218
910	980	2	2850	–	495	54	48	42	–	–	190	559	4	170	235
980	1060	2	3060	–	495	56	50	44	–	–	200	603	4	180	250
1060	1140	2	3300	–	495	58	50	46	–	–	200	647	4	180	272
1140	1220	2	3540	–	522,5	60	52	46	–	–	200	691	4	180	293
1220	1300	2	3780	–	522,5	62	54	48	–	–	200	738	4	180	309
1300	1390	2	4050	–	522,5	64	56	50	–	–	200	786	4	180	336
1390	1480	2	4320	–	550	66	58	50	–	–	200	836	4	180	352
1480	1570	2	4590	–	550	68	60	52	–	–	220	888	5	190	352
1570	1670	2	4890	–	550	70	62	54	–	–	220	941	5	190	362
1670	1790	2	5250	–	577,5	73	64	56	–	–	220	1024	5	190	384
1790	1930	2	5610	–	577,5	76	66	58	–	–	220	1109	5	190	411
1930	2080	2	6000	–	577,5	78	68	60	–	–	220	1168	5	190	437
2080	2230	2	6450	–	605	81	70	62	–	–	240	1259	2)	200	2)
2230	2380	2	6900	–	605	84	73	64	–	–	240	1356	2)	200	2)
2380	2530	2	7350	–	605	87	76	66	–	–	240	1453	2)	200	2)
2530	2700	2	7800	–	632,5	90	78	68	–	–	260	1471	2)	200	2)
2700	2870	2	8300	–	632,5	92	81	70	–	–	260	1471	2)	200	2)

2870	3040	2	8700	–	632,5	95	84	73	–	–	260	1471	2)	200	2)
3040	3210	2	9300	–	660	97	84	76	–	–	280	1471	2)	200	2)
3210	3400	2	9900	–	660	100	87	78	–	–	280	1471	2)	200	2)
3400	3600	2	10500	–	660	102	90	78	–	–	280	1471	2)	200	2)
3600	3800	2	11100	–	687,5	105	92	81	–	–	300	1471	2)	200	2)
3800	4000	2	11700	–	687,5	107	95	84	–	–	300	1471	2)	200	2)
4000	4200	2	12300	–	687,5	111	97	87	–	–	300	1471	2)	200	2)
4200	4400	2	12900	–	715	114	100	87	–	–	300	1471	2)	200	2)
4400	4600	2	13500	–	715	117	102	90	–	–	300	1471	2)	200	2)
4600	4800	2	14100	–	715	120	105	92	–	–	300	1471	2)	200	2)
4800	5000	2	14700	–	742,5	122	107	95	–	–	300	1471	2)	200	2)
5000	5200	2	15400	–	742,5	124	111	97	–	–	300	1471	2)	200	2)
5200	5500	2	16000	–	742,5	127	111	97	–	–	300	1471	2)	200	2)
5500	5800	2	16900	–	742,5	130	114	100	–	–	300	1471	2)	200	2)
5800	6100	2	17800	–	742,5	132	117	102	–	–	300	1471	2)	200	2)
6100	6500	2	18800	–	742,5	–	120	107	–	–			2)	200	2)
6500	6900	2	20000	–	770	–	124	111	–	–	Tow lines are not required when ship's length exceeds 180 m		2)	200	2)
6900	7400	2	21500	–	770	–	127	114	–	–			2)	200	2)
7400	7900	2	23000	–	770	–	132	117	–	–			2)	200	2)
7900	8400	2	24500	–	770	–	137	122	–	–			2)	200	2)
8400	8900	2	26000	–	770	–	142	127	–	–			2)	200	2)
8900	9400	2	27500	–	770	–	147	132	–	–			2)	200	2)
9400	10000	2	29000	–	770	–	152	132	–	–			2)	200	2)
10000	10700	2	31000	–	770	–	–	137	–	–			2)	200	2)
10700	11500	2	33000	–	770	–	–	142	–	–			2)	200	2)
11500	12400	2	35500	–	770	–	–	147	–	–			2)	200	2)
12400	13400	2	38500	–	770	–	–	152	–	–			2)	200	2)
13400	14600	2	42000	–	770	–	–	157	–	–			2)	200	2)
14600	16000	2	46000	–	770	–	–	162	–	–			2)	200	2)

[1] Chain cables or wire ropes may be used, chain cable breaking load or breaking strength of wire rope being not less than 44 kN.

[2] Refer to **2.1.2** of IACS recommendation No.10 (Corr.1 Dec 2016).

Table 3.1.3-2

Equipment Number EN		Bower anchors		Chain cables for bower anchors			Mooring lines		
Exceeding	Not exceeding	Number	Mass per. anchor, in kg	Total length, in мм	Diameter: grade 1, in mm	Diameter: grade 2, in mm	Number	Length of each line, in m	Minimum breaking strength, in kN
1	2	3	4	5	6	7	8	9	10
10	15	1	30	55	1)	–	2	30	29
15	20	1	40	55	1)	–	2	30	29
20	25	1	50	82,5	1)	–	2	40	29
25	30	1	60	82,5	1)	–	2	50	29
30	40	2	80	165	11,0	–	2	50	29
40	50	2	100	192,5	11,0	–	2	60	29
50	60	2	120	192,5	12,5	–	2	60	29
60	70	2	140	192,5	12,5	–	2	80	29
70	80	2	160	220	14	12,5	2	100	34
80	90	2	180	220	14	12,5	2	100	37
90	100	2	210	220	16	14	2	110	37
100	110	2	240	220	16	14	2	110	39
110	120	2	270	247,5	17,5	16	2	110	39
120	130	2	300	247,5	17,5	16	2	110	44
130	140	2	340	275	19	17,5	2	120	44
140	150	2	390	275	19	17,5	2	120	49
150	175	2	480	275	22	19	2	120	54
175	205	2	570	302,5	24	20,5	2	120	59
205	240	2	660	302,5	26	22	2	120	64
240	280	2	780	330	28	24	3	120	71
280	320	2	900	357,5	30	26	3	140	78
320	360	2	1020	357,5	32	28	3	140	86
360	400	2	1140	385	34	30	3	140	93
400	450	2	1290	385	36	32	3	140	100
450	500	2	1440	412,5	38	34	3	140	108
500	550	2	1590	412,5	40	34	4	160	113
550	600	2	1740	440	42	36	4	160	118
600	660	2	1920	440	44	38	4	160	123
660	720	2	2100	440	46	40	4	160	128

1) Chain cables or wire ropes may be used, chain cable breaking load or breaking strength of wire rope being not less than 44 kN.

3.1.4 For non-propelled ships the anchoring equipment shall be selected based on Equipment Number increased by 25 % as against that calculated in compliance with provisions specified in **3.1.3** of this Part of the Rules. For self-propelled ships having the maximum ahead speed not more than 6 knots at the draught to the summer load waterline, the anchoring equipment shall be selected as in the case of non-propelled ships.

The anchor arrangement of shipborne barges and berth-connected ships shall comply with the requirements of Section **3**, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Inland Navigation Ships (for European Inland Waterways). For the case of sea passage of berth-connected ships having no permanent anchor arrangement, provision shall be made for anchors and anchor chains to be arranged on board.

For non-propelled ships, the anchor arrangement may not be provided. In this case, for temporary holding of the non-propelled ships, the towing ship anchor arrangement may be considered. At that, technical background for ensuring holding anchorage under stormy conditions including Equipment Numbers for supply vessels, safety factors, environmental effects and loads, shall be submitted to the Register.

For non-propelled ships, the position mooring system may be used as anchor arrangement.

3.1.5 For remote control systems of the anchor arrangements, if any, the type, extent of automated control and scope of remote control operations are determined by the shipowner.

The additional requirements for the remote-controlled anchor arrangements are given in **3.6.5** of this Part, **6.3.6**, Part IX "Machinery", and also in **5.1.3**, Part XI "Electrical Equipment".

3.2 EQUIPMENT NUMBER

3.2.1 The Equipment Number *EN* for all ships other than floating cranes and tugs, is determined by the formula

$$EN = \Delta^{2/3} + 2Bh + 0{,}1A, \quad (3.2.1\text{-}1)$$

where: Δ – moulded displacement, in t, to the summer load waterline[3];

B – breadth of the ship, in m;

h – effective height, in m, from the summer load waterline to the top of the uppermost deckhouse; for the lowest tier h shall be measured at centreline from the upper deck or from a notional deck line where there is local discontinuity in the upper deck, refer to Fig. 3.2.1 for an example, which is determined by the formula:

$$h = a + \sum h_i \ , \quad (3.2.1\text{-}2)$$

where: a – distance, in m, from the summer load waterline amidships to the top of the upper deck plating at side;

h_i – height, in m, at the centreline of each tier of superstructures or deckhouses having a breadth greater than 0,25B.

In case of ships with two or more superstructures or deckhouses along the length, only one superstructure or deckhouse of the considered tier with the greatest breadth is taken into account.

For the lowest tier hi shall be measured at the centreline from the upper deck or, in case of a stepped upper deck, from a notional line which is a continuation of the upper deck. When calculating h, sheer and trim shall be ignored. Refer also to **3.2.3**;

A – side-projected area, in m^2, of the hull, superstructures and deckhouses above the summer load waterline which are within the ship's length L and also have a breadth greater than 0,25B (refer also to **3.2.3**).

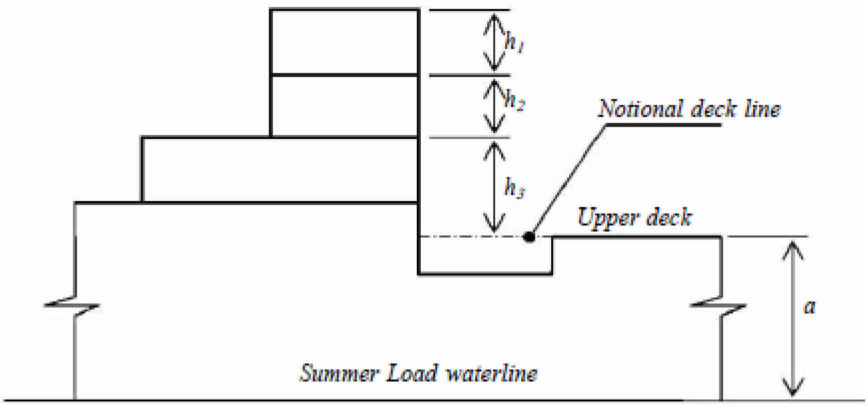


Рис. 3.2.1

3.2.2. The Equipment Number EN for tugs is determined by the formula

$$EN = \Delta^{2/3} + 2(Ba + \Sigma h_i b_i) + 0{,}1A \ ,$$

(3.2.2)

where: Δ, B, a, h_i and A are taken according to **3.2.1**;

b_i – breadth of the appropriate tier of superstructure or deckhouse, in m. In case of ships with two or more superstructures or deckhouses along the length, the relevant provisions of 3.2.1 shall be followed **3.2.1**.

3.2.3 Containers or other similar cargoes carried on decks and on hatchway covers, masts, derrick booms, rigging, guard rails and other similar structures may be ignored when determining *h* and *A*; bulwarks and hatch coamings less than 1,5 m in height may also be ignored. Screens, bulwarks and hatch coamings more than 1,5 m in height shall be regarded as deckhouses or superstructures.

Main gallows, ladders and pile drivers for lifting the ladders of dredgers may be ignored when determining *h*; when determining the value *A*, the side-projected area of these structures shall be calculated as the area limited by the contour of the structure.

3.2.4 The Equipment Number *EN* for floating cranes is determined by the formula:

$$EN = 1{,}5\Delta^{2/3} + 2Bh + 2S + 0{,}1A, \qquad (3.2.4)$$

where: Δ, B, h and A are taken according to **3.2.1**; when determining the value of *A*, account shall be taken of the sideprojected area of the upper structure of floating crane (stowed for sea) which is calculated as the area limited by the outer contour of the structure;

S – projection on the mid-section of the front area, in m^2, of the upper structure of the floating crane (stowed for sea) situated above the deck of the uppermost deckhouse taken into account in determination of *h*, the front area being determined, in this case, as the area limited by the outer contour of the structure.

3.2.5 For ships with an equipment length of not less than 135 m and intended to anchor in deep and unsheltered water, the anchoring equipment shall be selected according to **1.2** of IACS recommendation No. 10 (Corr.1 Dec 2016).

3.3 BOWER AND STREAM ANCHORS

3.3.1 The mass and number of anchors shall be selected in accordance with **3.1.3**. Anchors of the following types are permitted to be used in ships:

1 ordinary stockless anchors and stock anchors (Hall's, Gruson's, admiralty anchors);

.2 high holding power (HHP) anchors;

.3 super high holding power (SHHP) anchors in accordance with **3.3.4**.

Ships with Equipment Number of 205 and less may have the second bower anchor as a spare one on condition that provision is made for its quick getting ready for use.

Ships of restricted area of navigation **R3, R3-IN** with Equipment Number of 35 and less, if they are not passenger ships, may have only one bower anchor.

3.3.2 Ships of restricted areas of navigation **R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **R3-RS, R3-S**, **B-R3-S**, **B-R3-RS, C-R3-S**, **C-R3-RS** and **D-R3-S**, **D-R3-RS** with Equipment Number in excess of 205 except the values stated in Table 3.1.3-1, shall be equipped with a stream anchor whose mass is at least 75 % of that required for a bower anchor.

For ships of restricted area of navigation **R3, R3-IN** stream anchor may be omitted.

In case the installation of stream anchors on board will affect the proper operation of the ship according to its intended purpose, a stream anchor may be omitted.

3.3.3 When HPP anchors of proven superior holding power are used as bower anchors, the mass of each anchor shall be 75 % of the mass required for ordinary stockless bower anchors in Table 3.1.3-1 or 3.1.3-2. When SHHP anchor of proven holding power are used as bower anchors, the mass of each anchor shall be reduced to not less than 50 % of the mass required for ordinary stockless bower anchors in Table 3.1.3-1 or 3.1.3-2. For fishing vessels with Equipment Number up to 980, where anchor chain cable is replaced with ropes, the mass of the anchor shall be increased by 25 % of the mass of the chosen anchor type.

For approval and/or acceptance as a HPP anchor satisfactory full scale tests in accordance with A1.4.2 of IACS UR A1 shall be done confirming that the anchor has a holding power at least twice that of an ordinary stockless anchor of the same mass.

For approval and/or acceptance as a SHPP anchor satisfactory full scale tests in accordance with A1.4.2 of IACS UR A1 shall be done confirming that the anchor has a holding power at least four times that of an ordinary stockless anchor of the same mass. Similar full scale tests shall be done for HPP anchor confirming that the SHHP anchor has a holding power at least twice that of a previously approved HPP anchor of the same mass.

The scope and procedure for such tests are specified in A1.4.2 of IACS UR A1.

3.3.4 SHHP anchors are suitable for use in ships of restricted areas of navigation **R2**, **A-R2**, **R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS, R3-S**, **R3-RS**, **R3**, **R3-IN**, **D-R3-S**, **D-R3-RS.**

The SHHP anchor mass shall not generally exceed 1500 kg.

3.4 CHAIN CABLES AND ROPES FOR BOWER ANCHORS

3.4.1 Ship's with Equipment Number 205 and less, in which the second bower anchor is permitted to be a spare one, and also ships with Equipment Number 35 and less and provided according to **3.3.1** with only one bower anchor may be equipped with only one chain cable the length of which is two times less than that required in the relevant Equipment Table for two chain cables. For ships of restricted area of navigation **R3**, **R3-IN** chain cables or wire ropes for a stream anchor may be omitted.

3.4.2 For ships having a descriptive notation Supply vessel in their class notation, the total length of both chain cables for bower anchors shall be taken 165 m greater than the value specified in Table 3.1.3-1, and the diameter of these chain cables shall be taken not less than that given in Table 3.1.3-1 two lines below the Equipment Number for the considered ship (having regard to the provisions of **3.1.3** and **3.1.4**).

For supply vessels having a distinguishing mark for ships fitted with a dynamic positioning system in their class notation, this requirement may be waived.

For supply vessels having Equipment Number over 720 at the specification depth of the anchorage over 250 m and for those having Equipment Number 720 and less at the specification depth of the anchorage over 200 m, the length and diameter of chain cables for bower anchors shall be increased taking account of the specification depths and conditions of the anchorage.

3.4.3 For hopper barges and dredgers not having hoppers to transport spoil, the diameter of chain cables for bower anchors shall be taken not less than that specified in Table 3.1.3-1 two lines below the Equipment Number of the considered ship, and for dredgers having hoppers to transport spoil, one line below (taking account of the provisions of **3.1.3** and **3.1.4**).

3.4.4 Chain cables of bower anchors shall be graded dependent on their strength as specified in **7.1**, Part XIII "Materials".

3.4.5 Tables 3.1.3-1 and 3.1.3-2 specify the diameters of chain cables on the assumption that the links of these chain cables are provided with studs, with the exception of the chain cables less than 15 mm in diameter which are assumed to have no studs.

3.4.6 The chain cables shall be composed of separate chain lengths, except for the chains less than 15 mm in diameter which need not be divided into chain lengths. The lengths of chains shall be interconnected with joining links.

Depending on their location in the chain cable the lengths are divided into:

anchor length fastened to the anchor;

intermediate lengths;

inboard end chain length secured to the chain cable releasing device.

3.4.7 The anchor length of chain shall consist of a swivel, an end link and a minimum quantity of common and enlarged links required to form an independent length of chains.

The anchor length of chains may consist only of a swivel, an end link and a joining link provided the relation between the dimensions of the chain cable parts allows to form such a length. In chain cables which are not divided into lengths of chains the swivel shall be included into each chain cable as near to the anchor as practicable. In all cases, the pins of swivels shall face the middle of the chain cable.

The anchor length shall be connected with the anchor shackle with the aid of an end shackle the pin of which shall be inserted into the anchor shackle.

3.4.8 The intermediate lengths of chains shall be not less than 25 m and not over 27,5 m, the chains consisting of the odd number of links. The total length of two chain cables given in the Equipment Tables is a sum of intermediate lengths of chains only without the anchor and inboard end lengths of chains.

If the number of intermediate lengths of chains is odd, the starboard chain cable shall have one intermediate length of chains more than the port chain cable.

3.4.9 The inboard end length of chains shall consist of a special link of enlarged size (provided, however, that this link is capable of passing freely through the wildcat of the anchor machinery) being secured to the chain cable releasing device, and of minimum number of common and enlarged links required for forming an independent chain length. The inboard end length of chains may consist of one end link only provided the relation between the dimensions of the chain cable parts and the chain cable releasing device allows to form such a length.

3.4.10 In all other respects, the chain cables for bower anchors shall comply with the requirements of **7.1**, Part XIII "Materials".

3.4.11 For ships under 40 m in length the chain cables may be replaced with wire ropes.

For fishing vessels with Equipment Number up to 980, independently of their length, chain cables may be replaced with ropes, taking account of the requirements of **3.3.3**.

Minimum breaking strength of such ropes shall be not less than the breaking load of the corresponding chain cables, and the length shall be at least 1,5 times the length of chain cables.

Wire ropes of trawl winches complying with this requirement may be used as anchor cables.

Ships having Equipment Number 130 and less may be equipped with synthetic fibre ropes instead of chain cables or wire ropes.

3.4.12 The end of each wire rope shall be spliced into a thimble, clamp or socket and connected to the anchor by means of a chain cable section having a length equal to the distance between the anchor (in stowed for sea position) and the anchor machinery or 12,5 m, whichever is the less; a breaking load of the above chain section shall be not less than the breaking strength of the wire rope. The chain cable section shall be secured to the wire rope fitting and the anchor shackle by means of joining shackles being equal to the wire ropes in strength.

The length of the chain cable sections may be included into 1,5 times the length of wire ropes specified in **3.4.11**.

3.4.13 The wire ropes for anchors shall have at least 114 wires and one natural fibre core. The wires of the ropes shall have a zinc coating according to recognized standards. In all other respects, the wire ropes for anchors shall meet the requirements of **3.15**, Part XIII "Materials".

3.5 CHAIN CABLE OR WIRE ROPE FOR STREAM ANCHOR

3.5.1 Stream anchor chain cables shall meet the applicable requirements of **3.4**.

Ships of restricted areas of navigation**R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS** and **D-R3-S**, **D-R3-RS** with Equipment Number in excess of 205 shall be equipped with a stream anchor chain cable whose length is at least 60 % of that required for a bower anchor chain cable. The chain cable diameter shall be taken not less than that mentioned in Table 3.1.3-1 two lines above the Equipment Number of the ship in question (taking into account **3.1.3** and **3.1.4**).

Ships having Equipment Number below 205 may be equipped with studless chain cables.

3.5.2 The requirements of **3.4.12** and **3.4.13** are applicable to the wire rope for the stream anchor.

3.6 ANCHOR APPLIANCES

3.6.1 Stoppers.

3.6.1.1 Each bower anchor chain cable or rope and each stream anchor chain cable having a mass of 200 kg and above shall be provided with a stopper holding the anchor in the hawse pipe when stowed for sea or, in addition, intended for riding the ship at anchor.

In ships having no anchor machinery or having the anchor machinery, which is not in compliance with the requirements of **6.3.2.3.2**, Part IX "Machinery" provision of stoppers for riding the ship at anchor is obligatory.

3.6.1.2 Where the stoppers is intended only for securing the anchor in the hawse pipe when stowed for sea, its parts shall be calculated to withstand the chain cable strain equal to twice the weight of the anchor, the stresses in the stopper parts not exceeding 0,4 times the upper yield stress of their material. Where the stopper comprises a chain cable or rope, this shall have safety factor 5 in relation to the breaking load of the chain cable or minimum breaking strength of the rope under the action of a force equal to twice the weight of the anchor.

3.6.1.3 Where the stopper is intended for riding the ship at anchor, its parts shall be calculated on assumption that the stopper will be subjected to a force in the chain cable equal to 0,8 times its breaking load. The stresses in the stopper parts shall not exceed 0,95 times the upper yield stress of their material. Where the stopper comprises a chain cable or rope, they shall have strength equal to that of the chain cable for which they are intended.

3.6.1.4 In fiber-reinforced plastic ships the stoppers shall be fastened by bolts with the use of steel gaskets or wooden pads on the deck and under deck flooring between the framing. Bolt connections shall comply with the requirements of **1.7.4**, Part XVI "Structure and Strength of Fiber-Reinforced Plastic Ships".

3.6.2 Device for securing and releasing the inboard end of the chain cable.

3.6.2.1 The parts of the device for securing and releasing the inboard end of the chain cable shall be calculated for strength under the force acting on the device which is equal to 0,6 times the chain breaking load, stresses in these parts not exceeding 0,95 times the upper yield stress of their material.

3.6.2.2 In ships with Equipment Number of more than 205 the device for securing and releasing the inboard end of the chain cable shall be provided with a drive from the deck on which the anchor machinery is fitted or from other deck, in a place which gives quick and ready access at all times. The screw of the drive shall be self-braking.

3.6.2.3 The design of the device for securing and releasing the inboard end of the chain cable shall ensure the efficiency of its operation both under the action of and without the strain of the chain cable referred to in **3.6.2.1**.

3.6.2.4 In fiber-reinforced plastic ships the device for securing and releasing the inboard end of the chain cable shall be fastened by bolts with the use of steel gaskets on both sides of the bulkhead. Bolt connections shall comply with the requirements of **1.7.4**, Part XVI "Structure and Strength of FiberReinforced Plastic Ships".

3.6.3 Laying of chain cables.

3.6.3.1 Laying of chain cables shall provide for their free run when dropping or hoisting the anchors.

In ships with a bulbous bow laying of chain cables shall comply with the requirements of 2.8.2.4, Part II "Hull".

3.6.3.2 The anchor shank shall easily enter the hawse pipe under the mere action of the chain cable tension and shall readily take off the hawse pipe when the chain cable is released.

3.6.3.3 The thickness of the hawse pipe shall not be less than 0,4 times the diameter of the chain cable passing through the hawse pipe.

3.6.3.4 In fiber-reinforced plastic ships galvanized or stainless steel plates shall be fitted on the outside plating under the hawse pipes; the plates shall be fastened by countersunk bolts. Bolt connections shall comply with the requirements of **1.7.4**, Part XVI "Structure and Strength of Fiber-Reinforced Plastic Ships".

3.6.4 Chain lockers.

3.6.4.1 For stowage of each bower anchor chain lockers shall be provided.

When one chain locker is designed for two chains, it shall be provided with an internal permeable or watertight division so that separate stowage of each chain is ensured.

3.6.4.2 The chain locker shall be of shape, capacity and depth adequate to provide an easy direct lead of the cables through the chain pipes, an easy self-stowing of the cables and their free veering away when dropping the anchors.

3.6.4.3 The chain locker design, as well as chain and hawse pipes shall be watertight up to the weather deck. Upper openings of such pipes shall be fitted with the permanent buckler plates. These may be made both of steel with the relevant cutouts for a chain cable diameter and of canvas with the relevant fastenings to keep the plate closed down.

The openings for access to the chain locker shall be fitted with covers secured with closely spaced bolts.

3.6.4.4 Drainage of chain lockers shall comply with the requirements in **7.12.**1, Part VIII "Systems and Piping", and lighting - with the requirements of **6.7**, Part XI "Electrical Equipment".

3.6.5 Additional requirements for remote-controlled anchor appliances.

3.6.5.1 Stoppers and other anchor appliances for which remote control is provided (refer to **3.1.5**) shall also be fitted with means of local manual control.

3.6.5.2 The anchor appliances and the associated means of local manual control shall be so designed that normal operation is ensured in case of failure of separate elements or the whole of the remote control system (refer also to **5.1.3**, Part XI "Electrical Equipment").

3.7 ANCHOR MACHINERY

3.7.1 Anchor machinery shall be fitted on the deck in the fore part of the ship for dropping and hoisting the anchors, as well as for holding the ship with the bower anchors dropped if the mass of the anchor exceeds

35 kg.

Ships of restricted area of navigation **R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS** and **D-R3-S**, **D-R3-RS**, shall be fitted with the anchor machinery for dropping and hoisting the stream anchor if its mass exceeds 200 kg.

Ships having Equipment Number 205 and less may be fitted with hand-operated anchor machinery and may also use other deck machinery for dropping and hoisting the anchors.

The requirements for the design and power of anchor machinery are given in 6.3, Part IX "Machinery".

In fiber-reinforced plastic ships fastening of the anchor machinery shall comply with the requirements of **3.6.1.4**.

3.8 SPARE PARTS

3.8.1 Each ship carrying a spare anchor and equipped with a chain cable (cables) for bower anchor (anchors) accordance with the provisions of **3.3.1** and **3.4** shall have: spare anchor length of chain - 1 pc, spare joining link - 2 pcs, spare end shackle - 1 pc.

3.8.2 Each ship equipped with a spare anchor and wire rope (ropes) for bower anchor (anchors) in accordance with the provisions of **3.3.1** and **3.4.11** shall have a spare set of parts for joining the wire rope and anchor shackle.

4. MOORING ARRANGEMENT

4.1 GENERAL

4.1.1 Each ship shall be supplied with mooring arrangement for warping to coastal or floating berths and for reliable fastening of the ship to them. For shipborne barges the mooring arrangement shall comply with the requirements of Section 4, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Inland Navigation Ships (for European Inland Waterways).

For shipboard fittings not selected from an industry standard accepted (approved) by the Register, the corrosion addition, t_c and the wear allowance t_w, given in **4.3.5**, respectively, shall be considered.

The requirements of this Section for selection of mooring arrangement do not apply to oil tankers of 150 m in length and above as well as bulk carriers of 90 m in length and above, contracted for construction on or after 1 July 2015. The requirements for mooring lines and mooring arrangements of the said ships are regulated by Common Structural Rules for Bulk Carriers and Oil Tankers.

4.1.2 For all ships other than fishing vessels, the number, length and minimum breaking strength of mooring lines shall be as recommended values given in Table 3.1.3-1, and for fishing values – in Table 3.1.3-2.

For fishing vessels, when Equipment Number exceeds 720, the number, length and minimum breaking strength of mooring lines, given as recommended values, shall be selected from Table 3.1.3-1 based on Equipment Number determined in compliance with **3.2**.

4.1.3 For ships with Equipment Number EN of less than or equal to 2000 and having the ratio A/EN more than 0,9, the following number of mooring lines shall be added to the number of mooring lines as given by Table 3.1.3-1:

one line where $0{,}9 < A/N_э \le 1{,}1$;

two lines where $1{,}1 < A/N_э \le 1{,}2$;

three lines where $A/N_э > 1{,}2$,

where *EN* and *A* = Equipment Number and side-projected area, respectively, specified in **3.2**.

For ships with an Equipment Number EN > 2000, the mooring lines may be selected according to **2.1.2** of IACS recommendation No. 10 (Corr.1 Dec 2016).

4.1.4 For individual mooring lines with breaking strength above 490 kN according to Table 3.1.3-1 the latter may be reduced with corresponding increase of the number of mooring lines, provided that the total breaking strength of all mooring lines aboard the ship is not less than the value selected from Table 3.1.3-1 with regard to **4.1.3** and **4.1.6**. The number of lines shall be not less than 6 and none of the lines shall have the breaking strength less than 490 kN.

4.1.5 The length of individual mooring lines may be reduced by up to 7 % as against the prescribed value provided that the total length of all mooring lines is not less than that specified in Table 3.1.3-1 and **4.1.3** or Table 3.1.3-2.

4.1.6 In case mooring line made of synthetic fibre material is used, its actual breaking strength F_s, in kN, shall not be less than determined by the formula

$$F_s = 0{,}0742\delta_m F_t^{8/9}, \qquad (4.1.6)$$

where δ_m= mean elongation at breaking of a synthetic fibre rope, in %, but not less than 30 %.
Where no data on δ_m are available, it shall be assumed equal to:
45 % for polyamide ropes;
35 % for polypropylene ropes;
F_t= minimum breaking strength of the mooring line specified in Table 3.1.3-1 or 3.1.3-2, in kN.

4.2 MOORING LINES

4.2.1 Mooring lines may be of steel wire, natural fibre or synthetic fibre material, with the exception of the lines intended for ships carrying in bulk flammable liquids with the flash point 60 8C and below. In these ships the operations with steel wire ropes are allowed only on the superstructure decks which are not the top of liquid cargo tanks and on condition that no pipelines for loading and unloading the cargo are carried through these decks.

Notwithstanding the breaking strength specified in Tables 3.1.3-1 or 3.1.3-2 or determined by Formula (4.1.6), the diameter of the mooring rope made from natural or synthetic fibre material shall not be less than 20 mm.

4.2.2 Steel wire ropes shall have at least 144 wires and not less than 7 fibre cores. The exception is made for wire ropes for automatic mooring winches which may have only one fibre core but the number of wires in such ropes shall be not less than 216. The wires of the ropes shall have a zinc coating according to recognized standards.

In all other respects, the steel wire ropes shall meet the requirements of **3.15**, Part XIII "Materials".

4.2.3 Natural fibre ropes shall be either manilla or sizal. The ships having Equipment Number 205 and less are permitted to use hemp ropes. In all other respects, the natural fibre ropes shall meet the requirements of **6.6**, Part XIII "Materials".

4.2.4 The synthetic fibre ropes shall be manufactured from approved homogeneous materials (polypropylene, capron, nylon, etc.).

In all other respects, the ropes of synthetic fibre material shall meet the requirements of **6.6**, Part XIII "Materials".

4.3 MOORING EQUIPMENT

4.3.1 The number and position of mooring bollards, fairleaders and other mooring equipment depend on the constructional features, purpose and general arrangement of the ship.

Shipboard fittings may be selected from an industry standard accepted (approved) by the Register in accordance with recommended minimum breaking strength of the mooring lines selected from Table 3.1.3-1.

When the shipboard fitting is not selected from an accepted (approved) industry standard, the strength of the fitting and of its attachment to the ship shall be in accordance with **4.3.4** and **4.3.5**.

Mooring bitts (double bollards) are required to resist the loads caused by the mooring line attached in figure-of-eight fashion (refer to Note). For strength assessment beam theory or finite element analysis using net scantlings (without corrosion additions and wear down allowances specified in **4.3.5**) shall be applied, as appropriate. Load tests may be accepted as alternative to strength assessment by calculations.

Note. With the line attached to a mooring bitt in the usual way (figure-of-eight fashion), either of the two posts of the mooring bitt can be subjected to a force twice as large as that acting on the mooring line. Disregarding this effect, depending on the applied industry standard and fitting size, overload may occur.

4.3.2 Bollards may be of steel or cast iron. Small ships equipped only with natural fibre or synthetic fibre ropes are permitted to use the bollards made of light alloys. As to the method of manufacture, the bollards may be welded or cast.

It is not permitted to use bollards cut directly in the deck which is the top of cargo tanks intended for carriage or stowage of flammable liquids with the flash point 60 8C and below.

4.3.3 The outside diameter of the bollard column shall be not less than 10 diameters of the steel wire rope, not less than 5,5 diameters of the synthetic fibre rope, and not less than one circumference of the natural fibre rope for which the bollard is designed. The distance between the axes of bollard columns shall not be less than 25 diameters of the steel wire rope or 3 circumferences of the natural fibre rope.

4.3.4 Shipboard fittings, winches and capstans for mooring shall be located on stiffeners and/or girders, which are part of the deck construction so as to facilitate efficient distribution of the mooring load.

4.3.4.1 The minimum design load applied to supporting hull structures for shipboard fittings shall be 1,15 times the minimum breaking strength of the mooring line according to Table 3.1.3-1.

4.3.4.2 The minimum design load applied to supporting hull structures for winches shall be 1,25 times the intended maximum brake holding load, where the maximum brake holding load shall be assumed not less than 80 % of the minimum breaking strength of the mooring line according to Table 3.1.3-1; for supporting hull structures of capstans, 1,25 times the maximum hauling-in force shall be taken as the minimum design load.

4.3.4.3 When a safe working load (SWL) greater than that determined according to 4.3.6 is specified by the designer/shipowner, then the design load shall be increased accordingly. 4.3.4.4 The design load shall be applied to fittings in all directions that may occur by taking into account the arrangement shown on the towing and mooring arrangements plan.

However, in no case does the design load applied to the fitting need to be greater than twice the design load on the line.

Note. **1.** If not otherwise specified by IACS recommendation No. 10, side-projected area including that of deck cargoes as given by the Loading Manual shall be taken into account for selection of mooring lines and the loads applied to shipboard fittings and supporting hull structure.

2. The increase of the minimum breaking strength for synthetic ropes according to IACS recommendation No. 10 needs not to be taken into account for the loads applied to shipboard fittings and supporting hull structure.

The arrangement of reinforced members beneath shipboard fittings, winches and capstans shall consider any variation of direction (horizontally and vertically) of the mooring forces acting upon the shipboard fittings, refer to Fig. 5.3.6. Proper alignment of fitting and supporting hull structure shall be ensured.

The acting point of the mooring force on shipboard fittings shall be taken at the attachment point of a mooring line or at a change in its direction. For bollards and bitts the attachment point of the mooring line shall be taken not less than 4/5 of the tube height above the base, refer to Fig. 4.3.4, *a*.

However, if fins are fitted to the bollard tubes to keep the mooring line as low as possible, the attachment point of the mooring line may be taken at the location of the fins, refer to Fig. 4.3.4, *b*.

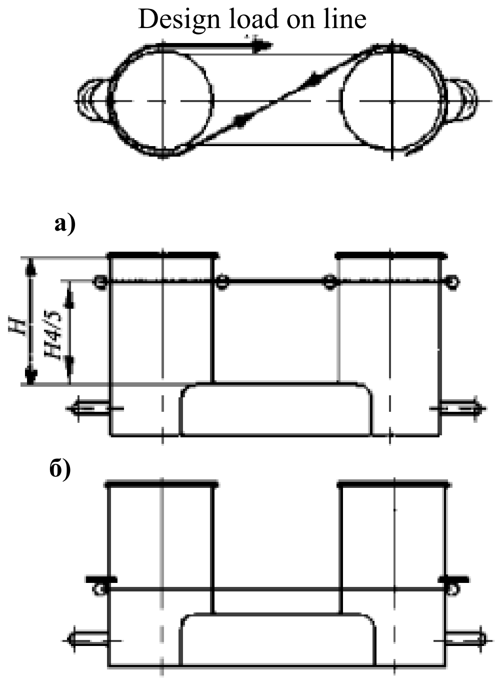


Fig.4.3.4

4.3.5 Allowable stresses in supporting hull structures under the design load conditions as specified in **4.3.4** are as follows:

.1 for strength assessment with beam theory or grillage analysis:

normal stress: 100 % of the specified minimum yield point of the material;

shear stress: 60 % of the specified minimum yield point of the material.

Normal stress is the sum of bending stress and axial stress with the corresponding shear stress acting perpendicular to the normal stress.

No stress concentration factors being taken into account.

.2 for strength assessment with finite element analysis: equivalent stress:

100 % of the specified minimum yield point of the material.

For strength calculations by means of finite elements, the geometry shall be idealized as realistically as possible.

The ratio of element length to width shall not exceed 3. Girders shall be modelled using shell or plane stress elements.

Symmetric girder flanges may be modelled by beam or truss elements.

The element height of girder webs shall not exceed one-third of the web height.

In way of small openings in girder webs the web thickness shall be reduced to a mean thickness over the web height.

Large openings shall be modelled.

Stiffeners may be modelled by using shell, plane stress, or beam elements. Stresses shall be read from the centre of the individual element.

For shell elements the stresses shall be evaluated at the mid plane of the element.

The corrosion addition t_c, shall not be less than the following values: for ships covered by Common Structural Rules for Bulk Carriers and Oil Tankers:

total corrosion addition shall be as defined in these Rules;

other ships: for the supporting hull structure, according to Part II "Hull" for the surrounding structure (e.g. deck structures, bulwark structures);

for pedestals and foundations on deck which are not part of a fitting according to an accepted (approved) industry standard, 2,0 mm;

for shipboard fittings not selected from an accepted (approved) industry standard, 2,0 mm.

Wear allowance:

in addition to the corrosion addition the wear allowance t_w, for shipboard fittings not selected from an accepted (approved) industry standard shall not be less than 1,0 mm, added to surfaces which are intended to regularly contact the line.

4.3.6 SWL of details of mooring appliances shall not exceed 0,8 design load determined in accordance with **4.3.4**.

All details of the mooring appliances shall be marked with the value of SWL by means of welding or other equivalent method.

4.4 MOORING MACHINERY

4.4.1 Special mooring machinery (mooring capstans, mooring winches, etc.) as well as other deck machinery (windlasses, cargo winches, etc.) fitted with mooring drums may be used for warping the hawsers.

4.4.2 The choice of the number and type of mooring machinery is within the owner's and designer's discretion, however, the rated pull of the machinery shall not exceed 1/3 of the breaking strength of the mooring ropes used in the ship and, besides, the requirements of **6.4**, Part IX "Machinery" shall be satisfied.

4.5 TOWING AND MOORING ARRANGEMENTS PLAN

4.5.1 The SWL (Safe Working Load) and TOW (Safe Towing Load) for the intended use for each shipboard fitting shall be noted in the towing and mooring arrangements plan available on board for the guidance of the master.

TOW is the load limit for towing purpose and SWL that for mooring purpose. If not otherwise chosen, for towing bitts it should be noted that TOW is the load limit for a towing line attached with eye-splice.

4.5.2 Information provided on the plan shall include in respect of each shipboard fitting:

location on the ship;

fitting type;

SWL/TOW;

purpose (mooring/harbour towing/other towing);

manner of applying towing or mooring line load including limiting fleet angles.

Furthermore, information provided on the plan shall include:

the arrangement of mooring lines showing number of lines (N);

the minimum breaking strength of each mooring line (MBL);

the acceptable environmental conditions as given in IACS recommendation No. 10, for the recommended minimum breaking strength of mooring lines for ships with Equipment Number EN>2000:

30 s mean wind speed from any direction (v_W or v^*_W according to IACS recommendation No. 10); maximum current speed acting on bow or stern (± 10°).

4.5.3 The information as given in **4.5.2** shall be incorporated into the pilot card in order to provide the pilot proper information on harbour and other towing operations.

5. TOWING ARRANGEMENT

5.1 GENERAL

5.1.1 Each ship shall be provided with towing arrangement which satisfies the requirements of **5.2** and **5.3**.

Besides, the ships having the descriptive notation **Tug** added to the character of classification shall comply with the requirements of **5.4** ÷ **5.6**.

5.1.2 Oil tankers, oil tankers (>60 8C), combination carriers, gas carriers and chemical tankers of 20 000 t deadweight and over shall comply with the requirements of **5.7**.

assenger and cargo ships shall be provided with an emergency towing procedure in accordance with **5.7.11**.

5.1.3. The towing arrangements of berth-connected ships shall comply with the requirements of **5.3**, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Inland Navigation Ships.

5.1.4 The requirements of this Section for selection of towing arrangement do not apply to oil tankers of

150 m in length and above as well as bulk carriers of 90 m in length and above, contracted for construction on or after 1 July 2015. The requirements for tow lines and towing arrangements of the said ships are regulated by Common Structural Rules for Bulk Carriers and Oil Tankers.

5.2 TOW LINE

5.2.1 The length and the minimum breaking strength of the tow line shall be as recommended values given in Table 3.1.3-1 based on an Equipment Number calculated in compliance with **3.2**.
For shipborne barges the actual breaking strength of the tow line F_b, in kN, shall be calculated by the formula

$$F_b = 16nBd \qquad (5.2.1)$$

where n= number of barges intended to be towed in the wake of the tug in tandem;
B= breadth of the barge, in m;
d=draught of the barge, in m.

The breaking strength of the tow line is used in the strength calculations of the towing appliances of the shipborne barges. At the discretion of the shipowner the tow lines of the shipborne barges may be stored in the barge carrier or tug, and they do not form a part of the equipment of the shipborne barge.

5.2.2 The tow lines may be of steel wire, natural fibre or synthetic fibre material. The requirements of **4.1.6**, **4.2.1 - 4.2.4** for mooring ropes are also applicable to the tow line.

5.3 TOWING EQUIPMENT

5.3.1 The number and location of towing bollards and chocks depend on the constructional features, purpose and general arrangement of the ship.

Ships having the descriptive notation Tug added to the character of classification, and equipped with a bow towing winch with a tow line may have no towing bitts provided the technical characteristics of this winch, its foundation and tow line comply with the requirements of **5.3.3** ÷ **5.3.6**.

5.3.2 Requirements of **4.3.2** and **4.3.3** introduced for the mooring bollards also apply to towing bollards.

5.3.3 Shipboard fittings for towing shall be located on longitudinals, which are part of the deck construction so as to facilitate efficient distribution of the towing load.

5.3.4 The minimum design load applied to supporting hull structures for shipboard fittings shall be:

.1 for normal towing operations - 1,25 times the intended maximum towing load (e.g. static bollard pull) as indicated on the towing and mooring arrangements plan;

.2 for other towing service - the minimum breaking strength of the tow line according to Table 3.1.3-1 for the ship's corresponding Equipment Number;

.3 for fittings intended to be used for, both, normal and other towing operations, the greater of the design loads according to **5.3.4.1** and **5.3.4.2**.

5.3.5 The design load applied to supporting hull structure shall be in accordance with **5.3.4**.

The reinforced members beneath shipboard fittings shall be effectively arranged for any variation of direction (horizontally and vertically) of the towing forces acting upon the shipboard fittings, refer to Fig. 5.3.5-1.

Proper alignment of fitting and supporting hull structure shall be ensured.

The acting point of the towing force on shipboard fittings shall be taken at the attachment point of a towing line or at a change in its direction.

For bollards and bitts the attachment point of the towing line shall be taken not less than 4/5 of the tube height above the base, refer to Fig 5.3.5.2.

For strength assessment using beam theory or grillage analysis, as well as finite element analysis, the stresses in supporting hull structures shall be determined in the same manner as specified in **4.3.5**.

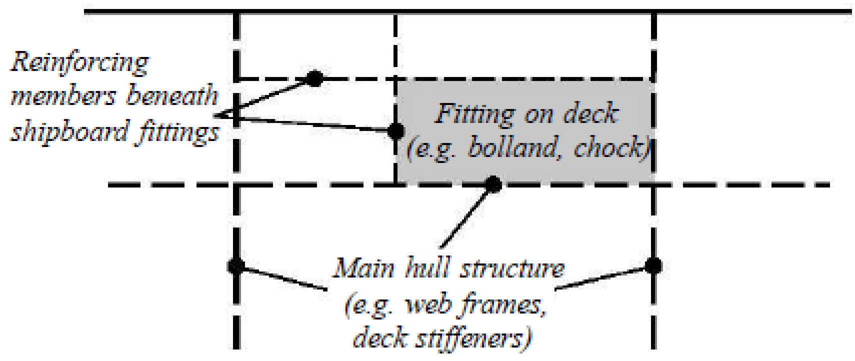


Fig. 5.3.5.1

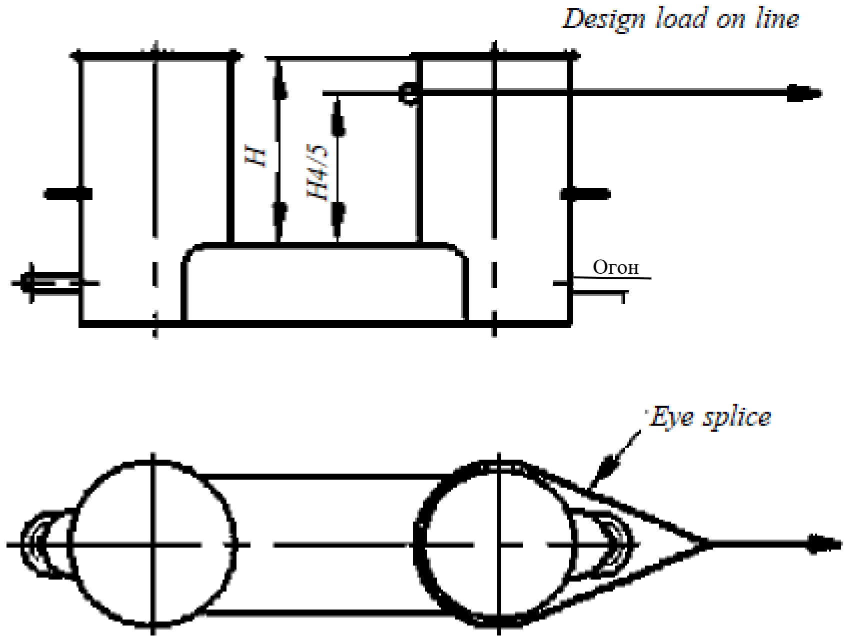


Fig. 5.3.5.2

5.3.6 When a safe towing load (TOW) greater than that determined according to **5.3.8** is specified by the designer/shipowner, then the design load shall be increased in accordance with the appropriate TOW/design load relationship given by **5.3.4** and **5.3.8**.]

The design load shall be applied to fittings in all directions that may occur by taking into account the arrangement shown on the towing and mooring arrangements plan. Where the towing line takes a turn at a fitting the total design load applied to the fitting is equal to the resultant of the design loads acting on the line, refer to Fig. 5.3.6. However, in no case does the design load applied to the fitting need to be greater than twice the design load on the line.

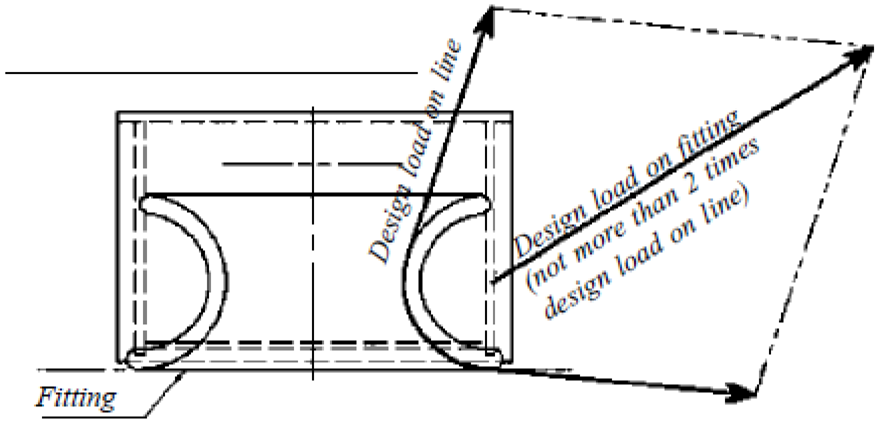


Fig. 5.3.6

5.3.7 Shipboard fittings.

Shipboard fittings may be selected from an industry standard accepted (approved) by the Register and at least based on the following loads:

.1 for normal towing operations, the intended maximum towing load (e.g. static bollard pull) as indicated on the towing and mooring arrangements plan;

.2 for other towing service, the minimum breaking strength of the tow line according to IACS recommendation No. 10 (refer to Notes in **4.3.4**);

.3 for fittings intended to be used for, both, normal and other towing operations, the greater of the loads according to **5.3.7.1** and **5.3.7.2.**

When the shipboard fitting is not selected from an accepted (approved) industry standard, the strength of the fitting and of its attachment to the ship shall be in accordance with **5.3.4** and **5.3.5**.

Towing bitts (double bollards) are required to resist the loads caused by the towing line attached with eye splice.

For strength assessment, beam theory or finite element analysis using net scantlings (without corrosion additions and wear down allowances specified in **4.3.5**) shall be applied, as appropriate.

Load tests may be accepted as alternative to strength assessment by calculations.

5.3.8 Safe Towing Load (TOW).

5.3.8.1 *TOW* is the load limit for towing purpose.

5.3.8.2 *TOW* used for normal towing operations shall not exceed 80 % of the design load per **5.3.4.1.**

5.3.8.3 *TOW* used for other towing operations shall not exceed 80 % of the design load according to **5.3.4.2.**

5.3.8.4 For fittings used for both normal and other towing operations, the greater of the safe towing loads according to **5.3.8.2** and **5.3.8.3** shall be used.

5.3.8.5 Fittings intended to be used for, both, towing and mooring, shall comply with the requirements of Section **4**.

5.3.8.6 TOW, in t, of each shipboard fitting shall be marked (by weld bead or equivalent) on the deck fittings used for towing. For fittings intended to be used for, both, towing and mooring SWL, in t, shall be marked in addition to TOW.

5.3.8.7 The above requirements on TOW apply for the use with no more than one line.

If not otherwise chosen, for towing bitts (double bollards) TOW is the load limit for a towing line attached with eye-splice.

5.4 SPECIAL ARRANGEMENT FOR TUGS

5.4.1 The number and type of equipment and outfit forming special arrangement for tugs which ensures towing operations under different service conditions are determined by the shipowner considering that such equipment and outfit shall satisfy the requirements of this Chapter.

5.4.2 The main determining factor in providing the tugs with a special arrangement is a bollard pull (BP).

5.4.2.1 The numerical value of the rated towing pull in modes, specified in **5.4.2**, is within the shipowner's and designer's discretion, and all calculations pertaining to the determination of this value are not subject to agreement with the Register. Nevertheless, during mooring and sea trials of the tug, the Register will check this value, and, if the parts of the special arrangement prove to be calculated from a smaller value, the Register may require the strengthening of these parts or may introduce restriction of power during towing operations.

5.4.2.2 Minimum breaking strength (MBL) of the tow line shall be in accordance with Table **5.4.2.2**:

Table 5.4.2.2

BP, in t	< 40	40 – 90	> 90
MBL, in t	$3{,}0 \cdot BP$	$(3{,}8 - BP / 50) \cdot BP$	$2{,}0 \cdot BP$

The tow line for towing operations on the hook may be of steel wire, natural fibre or synthetic fibre material. The requirements of **4.2** for mooring lines are also applicable to the tow line for towing operations on the hook.

5.4.3 All stressed parts of the towing arrangement (such as the tow hook, towing rails, etc.) as well as the fastenings for securing these parts to the ship's hull shall be designed to take the breaking load of the tow line. The stresses in these parts shall not exceed 0,95 times the upper yield stress of their material.

5.4.4 The cramp iron of the tow hook shall be calculated as a curvilinear bar. Where such calculations are not carried out, i.e. the formulae for a rectilinear bars are used, permissible stresses shall be reduced by 35 %.

5.4.5 All parts of the towing arrangement which are subjected to tension or bending under the hull of the tow line shall not be manufactured of cast iron.

5.4.6 The cramp iron of the tow hook shall be either solid forged or manufactured of a solid rolled blank. Percentage elongation of the cramp iron material shall not be less than 18 % on a fivefold sample.

5.4.7 Tow hooks shall be of slip-type and have a tow line releasing device operating efficiently in the range of loads on the tow hook from zero to three times the rated towing pull and at any practically possible deflection of the tow line from the centreline of the ship.

The device shall be controlled both at the tow hook and from the navigation bridge. Where the ship is fitted with a spshallw hook, in addition to the main one, this hook need not be of slip-type and have a device for releasing the tow line.

5.4.8 When applying tow hooks with shock absorbers, their ultimate damping load shall not be less than 1,3 times the rated towing pull.

5.4.9 Prior to installation on board the ship the tow hooks shall be tested by application of a proof load equal to twice the rated towing pull.

5.4.10 The wire stopper and its fastenings shall be such that their breaking load is not less than 1,5 times the rated towing pull.

5.4.11 The requirements of **3.7**, Part IV "Stability" shall be taken into consideration when assigning the position of the tow hook and towing winch.

5.5 TOWING WINCHES

5.5.1 The requirements for the design of towing winches are specified in **6.5** and **6.6**, Part IX "Machinery".

5.5.2 Provision shall be made for operating the towing winch from a site at the winch; it is recommended to allow for operating the towing winch from the navigation bridge.

When placing the control station on the navigation bridge at the towing winch and having possibility of supervision for its operation, it is allowed not to provide for operating the towing winch directly from the place of its installation.

5.6 TOW LINE FOR TOWING WINCH

5.6.1 The tow line for towing winch shall be selected by the shipowner depending on the structural particulars and purpose of the ship.

The recommended requirements for tow line for towing winch are given in **5.4.2.2**.

5.7 EMERGENCY TOWING ARRANGEMENTS ON SHIPS

5.7.1 Ships referred to in 5.1.2 shall be fitted with emergency towing arrangements forward and aft of the ship. The arrangements shall be capable of rapid deployment in the absence of main power on the ship to be towed and easy connection to the towing ship. At least one of the emergency towing arrangements shall be pre-rigged ready for rapid deployment.

5.7.2 The components of the emergency towing arrangement are listed in Table 5.7.2.

Table 5.7.2 **Emergency towing arrangements.**

Components of emergency towing arrangement	Non pre-rigged	Pre-rigged
Pick-up gear	Optional	Yes
Towing pennant	Optional	Yes
Chafing gear	Yes	Depending on design
Fairlead	Yes	Yes
Strongpoint	Yes	Yes
Roller pedestal	Yes	Depending on design

5.7.3 Except the pick-up gear and roller pedestal, the components of the emergency towing arrangement specified in Table 5.7.2 shall have a working strength of at least:

1000 kN for ships of 20 000 t deadweight and over, but less than 50 000 t deadweight,

2000 kN for ships of 50 000 t deadweight and over.

Under the above forces, the stresses shall not exceed 0,5 of the ultimate strength.

The strength shall be sufficient for all relevant angles of towline, i.e. up to 90° from the ship's centreline to port and starboard and 30° vertically downwards.

5.7.4 The towing pennant shall have a length of at least twice the lightest seagoing ballast freeboard at the fairlead plus 50 m. The towing pennant shall have a hard eye-formed termination allowing connection to a standard shackle.

The bow and stern strongpoints and fairleads shall be located so as to facilitate towing from either side of the bow or stern and minimize the stress on the towing system.

The inboard end fastening shall be a stopper or bracket or other fitting of equivalent strength. The strongpoint can be designed integral with the fairlead.

5.7.5 Fairleads shall have an opening large enough to pass the largest portion of the chafing gear, towing pennant or towing line.

The fairlead shall give adequate support for the towing pennant during towing operation which means bending 90° to port and to starboard side and 308 vertically downwards. The bending ratio (towing pennant bearing surface diameter to towing pennant diameter) shall be not less than 7:1.

The fairlead shall be located as close as possible to the deck and, in any case, in such a position that the chafing chain is approximately parallel to the deck when it is under strain between the strongpoint and the fairlead.

5.7.6 The chafing gear shall be fitted at the forward and, depending on design, aft ends of the ship. A chafing chain or another design approved by the Register may be used as the chafing gear. The chafing chain shall be a stud link chain.

The chafing chain shall be long enough to ensure that the towing pennant remains outside the fairlead during the towing operation. A chain extending from the strongpoint to a point at least 3 m beyond the fairlead shall meet this criterion.

5.7.7 One end of the chafing chain shall be suitable for connection to the strongpoint. The other end shall be fitted with a standard pear-shaped open link allowing connection to a standard bow shackle.

The chafing chain shall be stowed in such a way that it can be rapidly connected to the strongpoint.

5.7.8 The pre-rigged pick-up gear shall be designed for manual operation by one person taking into account the absence of power and the potential for adverse environmental conditions that may prevail during such emergency towing operations. The pick-up gear shall be protected against the weather and other adverse conditions that may prevail.

5.7.9 The non pre-rigged emergency towing arrangement shall be capable of being deployed in harbour conditions in not more than 1 h. To facilitate connection of the towing pennant to the chafing gear and to prevent chafing of the pennant, a suitably positioned pedestal roller may be used.

Pre-rigged emergency towing arrangements at both ends of the ship may be accepted.

A type emergency towing arrangement is shown in Fig. 5.7.9.

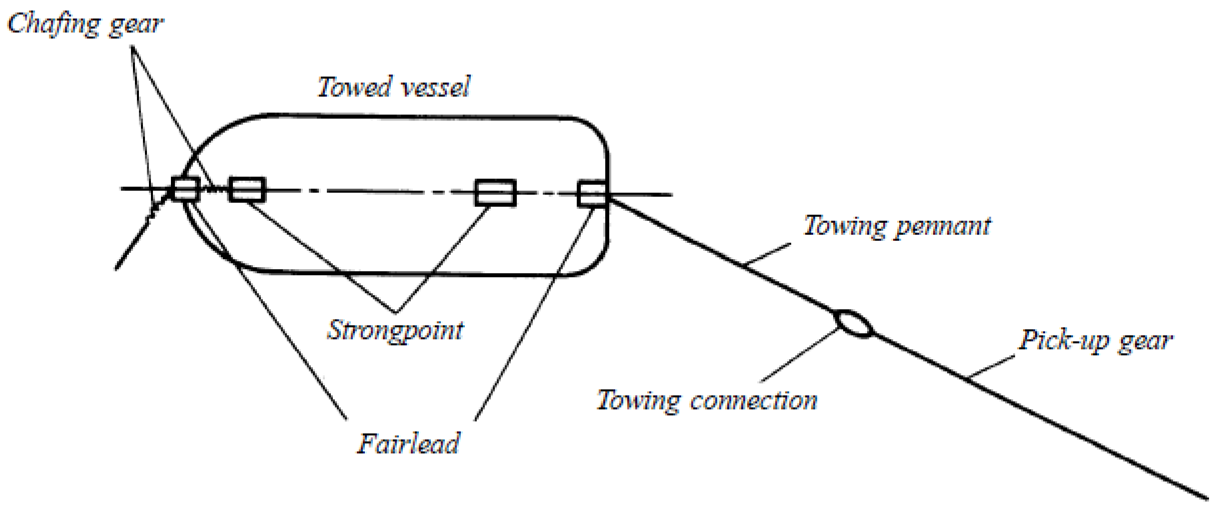


Fig. 5.7.9

5.7.10 All emergency towing arrangements shall be clearly marked to facilitate safe and effective use even in darkness and poor visibility.

5.7.11 Ships shall be provided with a ship-specific emergency towing procedure. Such a procedure shall be carried aboard the ship for use in emergency situations and shall be based on existing arrangements and equipment available on board the ship.

The procedure shall include:

drawings of fore and aft deck showing possible emergency towing arrangements;

inventory of equipment on board that can be used for emergency towing;

means and methods of communication;

sample procedures to facilitate the preparation for and conducting of emergency towing operations.

[1] refer to IMO MSC.1/Circ.1255/.

6. SIGNAL MASTS

6.1 GENERAL

6.1.1 The requirements given in the present Section refer only to the signal masts, i.e. the masts which are intended for carrying the signal means: navigation lights, day signals, aerials, etc. Where the masts or their parts carry derrick booms or other cargo handling gear in addition to the signal means, such masts or their parts shall comply with the requirements of the Rules for the Cargo Handling Gear of Sea-Going Ships.

The requirements of **6.2** ÷ **6.4**, do not apply to berth-connected ships. The signal masts of berthconnected ships shall be designed to carry prescribed signal means.

6.1.2 Arrangement, height and provision of signal means on the signal masts shall comply with the requirements of Part III "Signal Means" of the Rules for the Equipment of Sea-Going Ships.

6.1.3 If in ships of restricted areas of navigation **R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS, R3**, **R3-IN** and **D-R3-S**, **D-R3-RS** the signal masts are collapsible, special machinery shall be installed for their operation or provision shall be made for appropriate connection with other deck machinery. The drive of the machinery may be hand-operated provided the machinery is self-braking and the load on the handle is not more than 160 N at any moment of jackknifing or hoisting the mast.

6.2 STAYED MASTS

6.2.1 The outside diameter *d* and the plate thickness *t*, in mm, at the heel of the masts made of steel having the upper yield stress from 215 up to 255 MPa and stayed by two shrouds on each side of the ship, shall not be less than:

$$d = 22l\,; \tag{6.2.1-1}$$

$$t = 0{,}2l + 3\,, \tag{6.2.1-2}$$

where: l – mast length, in m, from the heel to the shroud eyeplates.

The diameter of the mast may be gradually decreased upwards to a value of 0,75d at the shroud eyeplates, while the thickness of the mast plates is maintained constant throughout the length *l*.

The mast length from the shroud eyeplates to the top shall not exceed 1/3 of *l*.

The mast shall be stayed by the shrouds as follows:

.1 horizontal distance *a*, in m, from the deck (or bulwark) stay eyeplate to the transverse plane through the mast stay eyeplate shall not be less than

$$a = 0{,}15h\,, \tag{6.2.1.1}$$

where: *h* – vertical distance, in m, from the mast stay eyeplate to the deck (or bulwark) stay eyeplate;

.2 horizontal distance *b*, in m, from the deck (or bulwark) stay eyeplate to the longitudinal plane through the mast stay eyeplate shall not be less than

$$b = 0{,}30h\,; \tag{6.2.1.2}$$

.3 the value *a* shall not exceed the value *b*.

6.2.2 Breaking strength *F* of the ropes, in kN, used for the mast shrouds as specified in **6.2.1** shall not be less than

$$F = 0{,}49\left(l^2 + 10l + 25\right). \tag{6.2.2}$$

In other respects, the ropes for shroud shall comply with the requirements of **3.15**, Part XIII "Materials".

The loose gear of shrouds (shackles, turnbuckles, etc.) shall be such that their safe working load is not less than 0,25 times the breaking strength of the ropes referred to above.

6.2.3 Where:

the mast is made of high tensile steel, light alloys, fiber-reinforced plastics or wood (the wood shall be of the 1st grade);

the mast is stayed in a way other than that specified in **6.2.1**;

in addition to a yard arm, lights and day signals, the mast is fitted with other equipment having considerable weight, such as radar reflectors with platforms for their servicing, "crow's nests", etc., proceed as specified in **6.4**.

6.2.4 The wires of shrouds shall have a zinc coating according to recognized standards.

6.3 UNSTAYED MASTS

6.3.1 The outside diameter d and the plate thickness t, in mm, at the heel of masts made of steel having the upper yield stress from 215 to 255 MPa shall not be less than

$$d = 3l^2(0{,}674l+a+13)\times\left(1+\sqrt{1+\frac{51{,}5\cdot10^4}{l^2(0{,}674l+a+13)^2}}\right)\cdot10^{-2}; \qquad (6.3.1\text{-}1)$$

$$t = \frac{1}{70}d, \qquad (6.3.1\text{-}2)$$

where: l – length of the mast from heel to top, in m;

a – elevation of the mast heel above centre of gravity of the ship, in m.

The outside diameter of the mast may be gradually decreased upwards to a value 0,5d at the distance 0,75l from the heel.

In no case the thickness of the mast plate shall be less than 4 mm.

The mast heel shall be rigidly fixed in all directions.

6.3.2 Where:

the mast is made of high tensile steel, light alloys, fiber-reinforced plastics or wood (the wood shall be of the 1st grade);

in addition to a yard arm, lights and day signals, the mast is fitted with other equipment having considerable weight, such as radar reflectors with platforms for their servicing, "crow's nests", etc. proceed as provided in y **6.4**.

6.4 MASTS OF SPECIAL CONSTRUCTION

6.4.1 In the cases specified in **6.2.3** and **6.3.2** as well as where bipod, tripod and other similar masts are installed, detailed strength calculations of these masts shall be carried out. These calculations shall be submitted to the Register for review.

6.4.2 The calculations shall be performed on the assumption that each part of the mast is affected by a horizontal force F_i, in kN

$$F_i = \left[m_i\frac{4\pi^2}{T^2}(\theta z_i+r\sin\theta)+m_i g\sin\theta+pA_i\cos\theta\right]\cdot10^{-3}, \qquad (6.4.2)$$

where: m_i – mass of each part, in kg;

z_i – elevation of the centre of gravity of each part above that of the ship, in m;

A_i– side-projected area of each part, in m^2;

T– rolling or pitching period, in s;

θ – amplitude of roll or pitch, in rad.;

r – wave half-height, in m;

g = 9,81– acceleration due to gravity, in m/s^2;

p – 1960 Pa - specific wind pressure.

The calculations shall be carried out both for rolling and pitching of the ship, r being taken as equal to

L/40 where *L* is the ship's length, in m, and y, in rad., as corresponding to an angle of 40° at roll and of 5° at pitch.

6.4.3 Under the loads specified in **6.4.2** of this Part, the stresses in the parts of the mast shall not exceed 0,7 times the upper yield stress of their material where they are made of metal, and 12 MPa where they are made of wood. The safety factor of the standing ropes under the same loads shall not be less than 3.

For fiber-reinforced plastic masts under the loads specified in **6.4.2** of this Part the stresses in the parts of the mast shall not exceed the allowable stress value indicated in Table 3 of Appendix **3**, Part XVI "Structure and Strength of Fiber-Reinforced Plastic Ships" for the case of short-time action of the load for the relevant type of deformation.

7. OPENINGS IN HULL, SUPERSTRUCTURES AND DECKHOUSES AND THEIR CLOSING APPLIANCES

7.1 GENERAL

7.1.1 The requirements of this Section apply to ships of unrestricted service **A** as well as to ships of restricted areas of navigation **R1**, **R2**, **A-R1**, **A-R2**, **R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, engaged on international voyages.

The requirements for ships of restricted areas of navigation **R1**, **R2**, **A-R1**, **A-R2**, **R2-RS, R2-S**, **R2-RS**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, not engaged on international voyages, as well as for ships of restricted areas of navigation **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS** may be relaxed; the extent of relaxation shall be confirmed by technical background.

7.1.2 The requirements of this Section apply to ships to which a minimum freeboard is assigned. Deviation from these requirements may be permitted for the ships to which a greater than minimum freeboard is assigned on condition that the Register is satisfied with safety conditions provided.

7.1.3 The arrangement of openings and their closing appliances in the hull, superstructures and deckhouses shall also comply with the requirements of Part VI "Fire Protection" and Part XI "Electrical Equipment".

7.1.4 As far as deck openings are concerned, the following two positions are distinguished in this Section.

7.1.4.1 Position 1: Upon exposed freeboard and raised quarter decks, and upon exposed superstructure decks situated forward of a point located a quarter of the ship's length from the forward perpendicular.

7.1.4.2 Position 2: Upon exposed superstructure decks situated abaft a quarter of the ship's length from the forward perpendicular and located at least at one standard height of superstructure above the freeboard deck.

Upon exposed superstructure decks situated forward of a point located a quarter of the ship's length from the forward perpendicular and located at least two standard heights of superstructure above the freeboard deck.

7.1.5 The height of coamings specified in this Section is measured from the upper surface of the steel deck plating or from the upper surface of the wood or other sheathing, if fitted.

7.1.6 In supply vessels the access to the spaces situated below the open cargo deck shall preferably be provided from the location inside the enclosed superstructure or deckhouse or from the location above the superstructure deck or deckhouse top.

The arrangement of companion or other hatches on the open cargo deck leading to the spaces below this deck may be allowed when adequate degree of protection of these hatches from possible damage during cargo handling operations is provided.

7.1.7 The requirements of the present Section for floating docks apply to openings and their closing appliances arranged above the margin line at docking.

7.1.8 In docklift ships, regardless of the provisions of **7.4** ÷ **7.7**, it is not permitted to arrange openings for doors, companion hatches, skylights, ventilating trunks and other hatches in sides and boundary bulkheads of holds if their lower edges are below the margin line at docking, with the exception of the openings to the watertight spaces of a restricted volume not communicating with other spaces below the level of the margin line at docking.

7.1.9 Doors and hatchways in sides and boundary bulkheads of holds in docklift ships, if their sills are above the margin line at docking by less than 600 mm or 0,05 times the distance between the openings and the centreline whichever is the greater, shall be provided with the light signalling system comprising the indicators installed in the control post of the ship's docking operations. The light indicators shall clearly show the position of the door or hatch cover (secured or open).

7.1.10 The light signals specified in **7.1.9** need not be provided for doors and hatchways to the watertight spaces of a restricted volume not communicating with other spaces below the level which is by 600 mm or 0,05 times the distance between the opening and the centreline, whichever is the greater, above the margin line at docking.

7.1.11 In cargo ships covered by the requirements of Part V "Subdivision", the openings for access, piping, ventilation, electric cables, etc. in watertight internal bulkheads and decks shall be provided with watertight doors or hatch covers normally closed when at sea which, in their turn, shall be provided with indication means, positioned in their close proximity and on the bridge, to indicate whether such doors or hatch covers are open or closed.

On each side of such a door or hatch cover there shall be an inscription to the effect the closure shall not be left open.

7.1.12 In ships mentioned under **7.1.11**, all external openings which do not, by their location, conform to the requirements of **3.4.4**, Part V "Subdivision" shall be fitted with strong enough watertight closures for which, except cargo hatch covers, provision shall be made for bridge indication.

The watertight closures of shell openings located below the bulkhead deck shall be permanently closed at sea shall be fitted with devices preventing their uncontrolled opening. Plates shall be attached to such closures with inscriptions to the effect the openings shall be permanently closed at sea.

7.1.13 In dry cargo ships not covered by the requirements of **7.1.11** and **7.1.12** all the doors of sliding or hinged type in watertight bulkheads shall be fitted up with indication means positioned on the bridge to indicate whether such doors are open or closed. Similar indicators shall be provided for shell doors and other closing appliances which, if left open or not properly secured, can lead to solid flooding of the ship.

7.1.14 The requirements of Section 7 do not apply to berth-connected ships. For these ships, the following provisions apply:

the coaming height of openings of companion hatches, skylights, ventilation trunks and ventilation heads shall not be less than 100 mm;

weathertight hatch covers shall be provided;

the external doors of superstructures shall be watertight, but where the lower edge of an external door is not less than 600 mm away from the waterline corresponding to the maximum draught, such doors may be weathertight;

the lower edge of a side light shall not be less than 150 mm away from the waterline corresponding to the maximum draught;

on the freeboard deck, the superstructure and deckhouse windows shall be watertight.

7.2 SIDE SCUTTLES

7.2.1 Position of side scuttles.

7.2.1.1 The number of side scuttles in the shell plating below the freeboard deck shall be reduced to a minimum compatible with the design and proper working of the ship.

Fishing vessels mooring alongside each other or other ships at sea shall not have side scuttles under freeboard deck in the mooring zone, wherever possible. If in this zone side scuttles are fitted in the shell plating, they shall be so positioned that the possibility of their damage during mooring operations is excluded.

No side scuttles are permitted within the boundaries of the ice belt of the shell plating specified in Part II "Hull" in icebreakers and ice class ships.

7.2.1.2 No side scuttle shall be fitted in a position so that its sill is below a line drawn parallel to the freeboard deck at side and having its lowest point located 0,025 of the ship's breadth B or 500 mm, whichever is the greater, above the summer load waterline or above the summer timber load waterline where timber load lines are assigned to the ship.

In ships of restricted areas of navigation **R2**, **R2-S**, **R2-RS**, **R3-S**, **R3-RS**, **R3-IN** and **R3** (except for passenger ships of length 24 m and over), not engaged on international voyages the specified distance 500 mm may be disregarded.

If the length of the ship is less than 24 m, the specified distance may be reduced to 300 mm for ships of restricted areas of navigation **R2**, **R2-S**, **R2-RS**, **R3-S**, **R3-RS** (except for passenger ships) and to 150 mm for ships of restricted areas of navigation **R3** and **R3-IN**.

7.2.1.3 Side scuttles in the shell plating, below the bulkhead deck of passenger ships and the freeboard deck of cargo ships in front bulkheads of enclosed superstructures and deckhouses of the first tier and also in front bulkheads of enclosed superstructures and deckhouses of the second tier within 0,25*L* from the forward perpendicular shall be of a heavy type and fitted with efficient deadlights hinged inside (refer also to **2.4.5**, Part VI "Fire Protection").

In tugs of restricted areas of navigation **R2, R2-S**, **R2-RS**, **R3-S**, **R3**, **R3-IN** the side scuttles fitted below the bulkhead deck shall be not only of heavy but also of non-opening type.

In ships of restricted areas of navigation **R2**, **R2-S**, **R2-RS**, **R3-S**, **R3-RS** having the length below 24 m and in ships of restricted areas of navigation **R3** and **R3-IN** it is allowed to fit side scuttles of normal type instead of those of heavy type.

In passenger ships of areas of navigation **A**, **A-R1**, **A-R2**, **A-R2-S**, **A-R2-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, **D-R3-S**, **D-R3-RS** all side scuttles, the lower edges of which are below the bulkhead deck, shall be of non-opening type.

7.2.1.4 In ships to which the requirements of Part V "Subdivision" apply the side scuttles outside a floodable compartment or a specified group of compartments, fitted in a position so that their sills are by less than 0,3 m or $\left(0{,}1+\frac{L-10}{150}\right)$ m, whichever is less, above the corresponding damage waterline and the side scuttles in the floating cranes the sills of which are by less than 0,3 m above the waterline corresponding to the actual maximum statical heel in case the hook is under load, shall be not only of heavy but also of non-opening type.

In ships of restricted areas of navigation **R2**, **R2-S**, **R2-RS**, **R3-S**, **R3-RS** having the length below 24 m and in ships of restricted areas of navigation **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS** it is allowed to fit side scuttles of normal non-opening type instead of those of heavy non-opening type.

7.2.1.5 Side scuttles in enclosed superstructures and deckhouses of the first tier, except those in their front bulkheads, and also side scuttles in enclosed superstructures and deckhouses of the second tier within 0,25 of the ship's length *L* from the forward perpendicular, except those in their front bulkheads, may be of normal type.

In ships of restricted areas of navigation **R2**, **R2-S**, **R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S** and **C-R3-RS** having the length below 24 m and in ships of restricted areas of navigation **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS** it is allowed to fit side scuttles of light type instead of those of normal type.

Side scuttles shall be fitted with efficient deadlights hinged inside.

7.2.1.6 Side scuttles in enclosed superstructures and deckhouses of the second tier, except those fitted in a position within 0,25 of the ship's length from the forward perpendicular shall be as required in **7.2.1.5**, provided these side scuttles give direct access to an open stairway leading to spaces situated below.

In cabins and similar spaces of enclosed superstructures and deckhouses of the second tier it is allowed that instead of side scuttles specified in **7.2.1.5**, the side scuttles or windows could be fitted without deadlights.

7.2.1.7 On no account shall the side scuttles be fitted in the outer wall sides of the floating docks and in the sides of the docklift ships so that their sills are below the margin line at docking. In the inner wall sides of the floating docks and in the boundary bulkheads of the docklift ships installation of the side scuttles is not permitted.

7.2.1.8 In the outer wall sides of the floating docks and in the sides of the docklift ships the side scuttles, the sills of which are above the margin line at docking by less than 300 mm or 0,025 times the ship's breadth, whichever is the greater, shall be of heavy type, fitted with hinged inside deadlights, and of non-opening type.

7.2.1.9 In the outer wall sides of the floating docks the side scuttles, the sills of which are above the margin line at docking by 300 mm or more, shall be of normal type and fitted with hinged inside deadlights.

7.2.1.10 Ships with distinguishing marks **FF1** and **FF2** in the class notation shall be fitted with side scuttles having deadlights permanently attached to their primary structure, wheelhouse windows shall be fitted with detachable screens, except side scuttles and windows in the wheelhouse, and search and rescue operation control station.

7.2.1.11 On the standby vessel, the front and side scuttles in the wheelhouse shall be equipped with effective protective shields installed on either side of the bulkhead.

The strength of such shields must be equivalent to the strength of the bulkhead.

The shields must provide visibility from the navigation bridge, they can be removable and must be stored in an accessible place for quick and easy installation.

7.2.1.12 All side scuttles below the bulkhead deck on passenger ships and freeboard deck on cargo ships shall be fitted with detachable screens permanently attached to their primary structure, which can be easily and securely sealed and watertight, except, that the side scuttles located 1/8 of the ship's length from the bow perpendicular and above the line parallel to the bulkhead deck and which has its lowest point at a distance of 3.7 m plus 2.5% of the ship's breadth above the draft at the highest subdivision waterline, may be fitted with detachable screens in the passenger spaces, unless the Load Line Rules require that screens shall be permanently attached in fixed positions. Such detachable screens shall be kept close to the side scuttles for which they are intended.

7.2.1.13 The side scuttles below the bulkhead deck on passenger ships and freeboard deck on cargo ships shall not be installed in spaces intended solely for the carriage of cargo.

7.2.1.14 Side scuttles and windows, together with their glass and shields, if installed, shall be of a solid structure approved by the Register. Non-metallic frames are not allowed.

Side scuttles means round or oval openings with clear area of not more than 0.16 m^2. Round or oval openings with clear area of more than 0.16 m^2 are equated to windows.

Windows are usually rectangular openings with rounded corners, commensurate with the dimensions of windows, as well as round or oval openings with clear area of more than 0,16m^2.

7.2.2 Construction and attachment of side scuttles and windows.

7.2.2.1 These Rules distinguish three types of side scuttle construction:

.1 heavy type with the glass thickness of not less than 10 mm for inner diameter of 200 mm and below, not less than 15 mm for inner diameter from 300 mm to 350 mm and not less than 19 mm for inner diameter of 400 mm.

The inner diameter shall not exceed 400 mm. For intermediate inner diameters (from 200 mm to 300 mm and from 350 mm to 400 mm) the glass thickness shall be determined by linear interpolation.

In addition, heavy side scuttles if they are of the opening type shall have a nut (instead of one of the ear-nuts securing their frame) being screwed off with the aid of a special wrench;

.2 normal type with the glass thickness of not less than 8 mm for inner diameter of 250 mm and below, and not less than 12 mm for inner diameter of 350 mm and over, however, the inner diameter shall not exceed 400 mm. For intermediate inner diameters the thickness of the glass shall be determined by linear interpolation;

.3 light type with the glass thickness of not less than 6 mm for inner diameter of 250 mm and below and not less than 10 mm for inner diameter of 400 mm and over, however, the inner diameter shall not exceed 450 mm. For intermediate inner diameters the thickness of the glass shall be determined by linear interpolation.

7.2.2.2 Normal and heavy side scuttles may be of non-opening type, i.e. with the glass fixed in the main frame, or of opening type, i.e. with the glass fixed in the glazing bead efficiently hinged on the main frame.

Exception shall be made for the cases specified in **7.2.1.3**, **7.2.1.4** and **7.2.1.8**, where the side scuttles shall be of non-opening type only.

The glasses of side scuttles shall be reliably and weathertight secured by means of a metal ring provided with screws or by other equivalent device and a gasket.

7.2.2.3 The main frame, glazing bead and deadlight of side scuttles shall have sufficient strength.

The glazing bead and deadlight shall be fitted with gaskets and shall be capable of being effectively closed and secured weathertight by means of ear-nuts or nuts being screwed off with the aid of a special wrench.

7.2.2.4 The main frame, glazing bead, deadlight and ring for securing the glass shall be manufactured from steel, brass or other material approved by the Register.

The ear-nuts and nuts being screwed off by a special wrench shall be made of corrosion-resistant material.

Glass used for the side scuttles shall be hardened.

7.2.2.5 5 In fiber-reinforced plastic ships side scuttles shall be attached to the outside plating and to the bulkheads of superstructures and deckhouses in accordance with the requirements of **1.7.4**, "Structure and Strength of Fiber-Reinforced Plastic Ships".

7.2.2.6 The construction of the windows shall comply with the requirements of **7.2.2.2** ÷ **7.2.2.4**, except for the requirements for the deadlights.

The thickness of the window glass *t*, in mm, shall be not less than determined by the formula

$$t = 0{,}32kb\sqrt{p}\,, \qquad (7.2.2.6\text{-}1)$$

where: b – lesser clear size of the window, in m;

p – pressure head, in kPa, calculated according to 2.12.3, Part II "Hull"; distance z_1 being taken up to the middle of the window height;

k – factor determined by the formula

$$k = 13{,}42 - 5{,}125\left(b/a\right)^2\,; \qquad (7.2.2.6\text{-}2)$$

where: a – greater clear size of the window, in m.

7.3 FLUSH DECK SCUTTLES

7.3.1 Flush deck scuttles in positions 1 and 2 shall be provided with deadlights hinged or attached by other method (for example, by means of a chain) and capable of being easily and efficiently closed and secured.

7.3.2 The largest of clear dimensions of the flush deck scuttles shall not be over 200 mm, with the glass being at least 15 mm thick. The flush deck scuttles shall be attached to the metal deck plating by means of frames.

7.3.3 When secured, the deadlights of the flush deck scuttles shall be weathertight. The tightness shall be ensured by a rubber or other suitable gasket. For the same purpose, along their contour the glasses of the flush deck scuttles shall be provided with a gasket made of rubber or other suitable material.

7.3.4 The strength and materials of the flush deck scuttles parts are governed by applicable requirements specified in **7.2.2.3** and **7.2.2.4**.

As regards attachment of flush deck scuttles in fiberreinforced plastic ships, refer to **7.2.2.5**.

7.4 OPENINGS IN SHELL PLATING AND THEIR CLOSING APPLIANCES

7.4.1 General.

7.4.1.1 This Chapter contains requirements for the arrangement of bow, side and stern doors in the shell plating, strength of structural elements of the doors, securing, locking and supporting devices.

7.4.1.2 The number of doors shall be reduced to a minimum consistent with the structure and normal operational conditions of the ship.

7.4.1.3 When closed and secured, doors in the shell plating shall be weathertight. Weathertightness shall be ensured with a rubber or other suitable packing.

7.4.1.4 The plating thickness of the doors made of steel, irrespective of the fulfilment of the requirements given in **7.4.1.10**, shall be not less than the thicknesses referred to in **2.2.4.8** and **2.12.4.1** of Part II "Hull" for the appropriate position of the door; the minimum plating thickness of the doors made of other materials may be allowed provided it is confirmed by calculations and tests that they have a strength at least equivalent to that of the doors made of steel.

7.4.1.5 Doors with a clear area of 12 m_2 and more shall be secured by means of a power system or by a hand gear used for securing the door from a readily accessible position. Stern, bow and side doors of large dimensions, when manual devices would not be readily accessible, shall be normally secured by means of power systems. Alternative means of securing shall also be provided for emergency use in case of failure of the power systems.

7.4.1.6 When power-operated securing devices or devices with a hand gear are used, it is necessary to ensure that the doors shall remain tight in the secured position and shall remain secured in case of failure of any part of the power system or hand gear of the securing device.

Hydraulically operated securing devices shall be manually or mechanically lockable in the secured position.

7.4.1.7 When power-operated securing devices or devices with a hand gear are used, provision shall be made for the indicators which clearly show whether the door is totally secured or not.

These indicators shall be fitted in a position from which the securing operation is performed, and in case of the power-operated securing device, also on the navigation bridge.

7.4.1.8 If, due to the ship's purpose, it is specially provided to open and close the doors not only in ports but also at sea, arrangements approved by the Register shall be made (with regard to the operational conditions) to ensure closure and complete securing of the open door, even in case of failure of the door gear and securing device gear, or other arrangements approved by the Register shall be made to prevent penetration of water into the ship spaces when the door is open.

Provision shall be made for devices ensuring proper locking of the door in the open position.

The drives of such doors shall comply with the requirements of Part IX "Machinery" and Part XI "Electrical Equipment".

7.4.1.9 There shall be a readily seen notice plate near each door, indicating that the door shall be closed and secured before the ship leaves the port; for doors referred to in **7.4.1.8** provision shall be also made for a notice plate indicating that at sea only the master is allowed to open the door.

7.4.1.10 When doors are under the action of the design loads determined in accordance with **7.4.2** and **7.4.3**, except **7.4.2.5**, stresses, in MPa, in the primary members of the doors as well as of securing, locking and supporting devices shall not exceed the following values:

normal stress

$$\sigma = 120/k\,, \qquad (7.4.1.10\text{-}1)$$

shear stress

$$\tau = 80/k\,, \qquad (7.4.1.10\text{-}2)$$

equivalent stress

$$\sigma_{зв} = \sqrt{\sigma^2 + 3\tau^2} = 150/k\,, \qquad (7.4.1.10\text{-}3)$$

where: $k = 1{,}0$ – for steel with upper yield stress of the material $R_{eH} = 235$ MPa;
$k = 0{,}78$ – for steel with $R_{eH} = 315$ MPa;
$k = 0{,}72$ – for steel with $R_{eH} = 335$ MPa.

7.4.2 Bow doors.

7.4.2.1 Bow doors shall be situated above the freeboard deck.

7.4.2.2 Where the bow door leads to a complete or long forward enclosed superstructure a weathertight inner door shall be installed as part of the collision bulkhead above the freeboard deck of the ship.

Bow and inner doors shall be so arranged as to preclude the possibility of the bow door causing structural damage to the inner door or to the collision bulkhead in case of damage to or detachment of the bow door.

7.4.2.3 The design external pressure P_e, кПа, in kPa, for the scantlings of primary members, securing, locking and supporting devices of the bow doors is determined by the following formula:

$$P_e = C_H(0{,}6+0{,}41\,\mathrm{tg}\alpha)(0{,}4v\sin\beta+0{,}6\sqrt{L})^2, \qquad (7.4.2.3)$$

where: C_H – is a coefficient equal to:
$0{,}0125L$ – for ships less than 80 m in length;
1,0 – for ships 80 m and more in length;
v – contractual ship's forward speed, in knots;
α and β – angles to be obtained from Fig. 7.4.2.3.

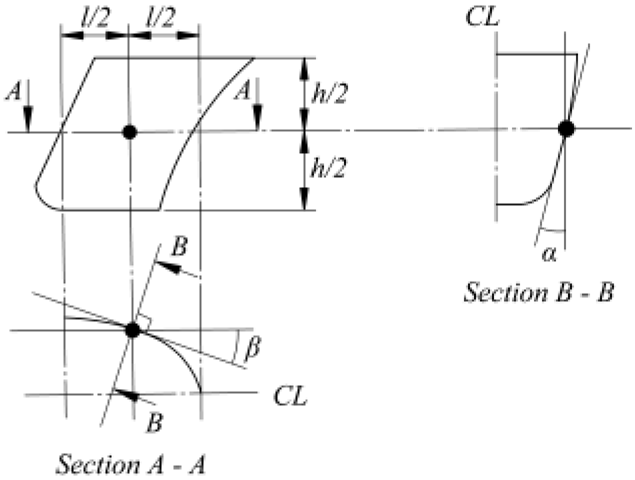


Fig. 7.4.2.3

The design external pressure may be reduced by 20 % for ships of restricted areas of navigation **R2-S**, **R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S** and by 40 % for ships of restricted areas of navigation **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS**.

In any case, the design external pressure P_e shall not be taken less than the values determined according to **1.3.2.2** or **2.8.3.3**, Part II "Hull", whichever is the greater.

7.4.2.4 The design internal pressure P_i, in kPa, for scantlings of primary members, securing, locking and supporting devices of inner doors shall be determined by the formula

$$P_i = 10z, \qquad (7.4.2.4)$$

where: z – vertical distance from the centre of gravity of the door area to the deck above, in m.

In all cases, the value of the design internal pressure P_i shall not be less than 25 kPa.

7.4.2.5 The scantlings of primary members of visor doors shall be chosen in accordance with the requirements of **2.8.5.1**, Part II "Hull".

7.4.2.6 Securing and locking devices of bow doors shall be designed to withstand the forces F_e or F_i, in kN, to be determined by the following formulae:

for the doors opening inwards

$$F_e = AP_e + p_p l_p, \qquad (7.4.2.6\text{-}1)$$

for the doors opening outwards

$$F_i = AP_i + 10Q + p_p l_p, \qquad (7.4.2.6\text{-}2)$$

where: A – clear area of the door, in m^2;

for P_e – refer to **7.4.2.3**;

for P_i – refer to **7.4.2.4**;

p_p – pressure of the packing when it is compressed for the maximum depth possible, in kN/m, is assumed in calculations equal to at least 5 kN/m;

l_p – length of the packing, in m;

Q – mass of the door, in t.

7.4.2.7 Securing and locking devices, as well as supports of the visor doors shall be designed to withstand forces F_{xf}, F_{xa}, F_y and F_z, in kN.

The forces acting in the longitudinal direction shall be determined by the following formulae**:**

bow

$$F_{xf} = \frac{10Qc + P_{xe}a - P_z b}{d}; \tag{7.4.2.7-1}$$

stern

$$F_{xa} = \frac{10Qc - P_{xi}a}{d}. \tag{7.4.2.7-2}$$

The force acting in the transverse direction shall be determined by the formula

$$F_y = P_e A_y. \tag{7.4.2.7-3}$$

The force acting in the vertical direction shall be determined by the formula

$$F_z = P_z - 10Q \tag{7.4.2.7-4}$$

or

$$F_z = 10(V - Q), \tag{7.4.2.7-5}$$

whichever is the greater,

were for Q – refer to **7.4.2.6**;

for P_e – refer to **7.4.2.3**;

$P_{xe} = P_e A_x$ in kN; (7.4.2.7-6)

A_x – area of the transverse vertical projection of the door (refer to Fig. 7.4.2.7), in m^2;

$P_z = P_e A_z$ in kN; (7.4.2.7-7)

A_z – area of horizontal projection of the door (refer to Fig. 7.4.2.7), in m^2;

$P_{xi} = P_i A_x$ in kN; (7.4.2.7-8)

for P_i – refer to **7.4.2.4**;

A_y – area of the longitudinal vertical projection of the door (refer to Fig. 7.4.2.7), in m^2;

a – vertical distance, in m, from visor pivot to the centroid of the transverse vertical projected area of the visor door (refer to Fig. 7.4.2.7);

b – vertical distance, in m, from visor pivot to the centroid of the horizontal projected area of the visor door (refer to Fig. 7.4.2.7);

c – horizontal distance, in m, from visor pivot to the centre of gravity of the visor mass (refer to Fig. 7.4.2.7);

d – vertical distance, in m, from visor pivot to the bottom of the door (refer to Fig. 7.4.2.7);

V – inner volume of the door, in m^3.

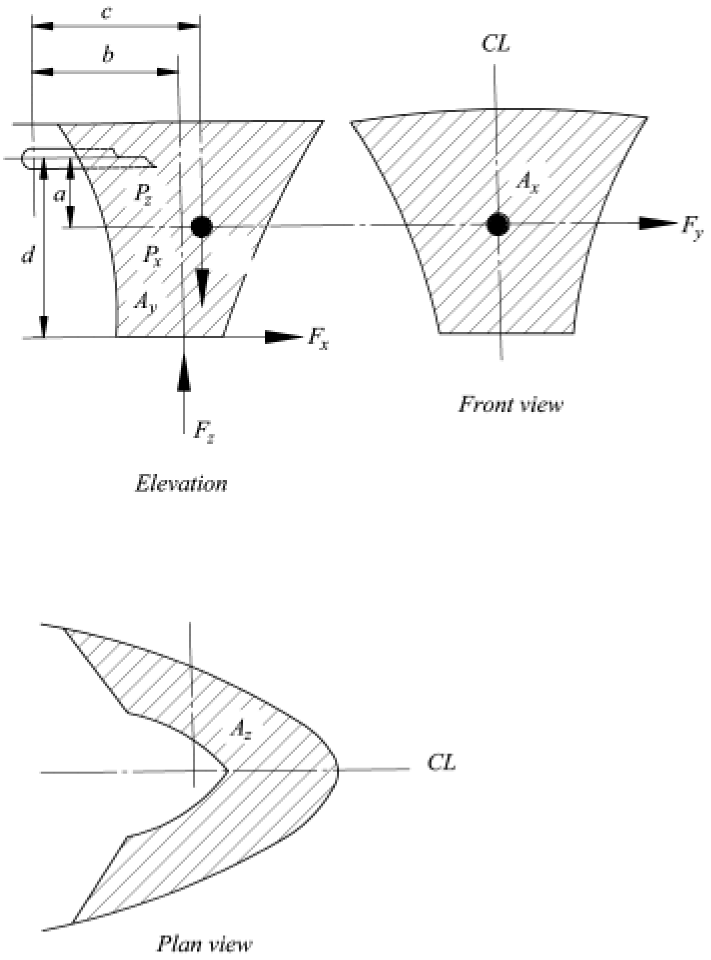


Fig. 7.4.2.7

7.4.2.8 For side-opening doors, thrust bearing shall be provided in way of girder ends at the closing of two leaves to prevent one leaf shifting towards the other one under effect of unsymmetrical pressure (refer to Fig. 7.4.2.8). Each part of the thrust bearing shall be kept secured on the other part by means of securing devices.

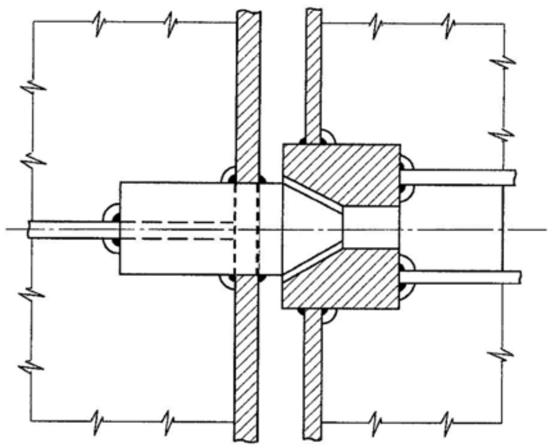


Fig. 7.4.2.8

7.4.2.9 9 Lifting arms of the visor doors and thrust bearing shall be designed to withstand static and dynamic loads arising when the door is opened and closed with due regard to the minimum wind pressure 1,5 kN/m^2.

7.4.3 Side and stern doors.

7.4.3.1 The lower edge of the door openings shall not be lower than the line which is parallel to the freeboard deck and has its lowest point at the uppermost cargo waterline.

The lower edge of side doors of the ships which are not passenger ships, may be lower than that specified above provided it is proved by the designer that safety of the ship will not be thus impaired.

In such cases, provision shall be made for:

the second (inner) doors, strength and tightness of which is equivalent to those of the outer doors;

a device enabling to determine water presence in the space between the doors;

water drainage from this space to bilges or drain wells, controlled by a readily accessible valve or other arrangements approved by the Register.

7.4.3.2 The doors shall open outwards so that forces acting under the effect of the sea press the door against the supporting contour of the sill.

Installation of the doors opening inside may be allowed provided it is proved by the designer that safety of the ship will not be thus impaired.

7.4.3.3 The number of securing devices on each edge of the door shall be not less than two; a securing device shall be provided in the vicinity of each door corner. The distance between securing devices shall not exceed 2,5 m.

7.4.3.4 The design external pressure *P*, in kPa, for structural members of doors shall be determined in accordance with the requirements of **1.3.2**, Part II "Hull". In any case, the value of P shall not be taken less than 25 kPa.

7.4.3.5 Securing and locking devices shall be designed to withstand the forces F_1 or F_2, in kN, determined by the formulae:

for doors opening inwards

$$F_1 = AP + p_p l_p; \quad (7.4.3.5\text{-}1)$$

for doors opening outwards

$$F_2 = F_c + 10Q + p_p l_p, \quad (7.4.3.5\text{-}2)$$

where for A, p_p and l_p – refer to **7.4.2.6**;

for P – refer to **7.4.3.4**;

F_c – an accidental force due to loose cargo, to be uniformly distributed over the area A and to be taken not less than 300 kN or 5A, in kN, whichever is the greater.

For small doors, such as bunker doors or pilot doors, the value of F_c may be reduced based on appropriate technical background. In case the second (inner) door is installed, which is capable to protect the external door from accidental forces due to loose cargoes, $F_c = 0$;

for Q – refer to **7.4.2.6**.

Supporting structures of doors shall be designed to withstand forces F_3 and F_4, кН, in kN, determined by the formulae:

for doors opening inwards

$$F_3 = AP; \quad (7.4.3.5\text{-}3)$$

for doors opening outwards

$$F_4 = F_c + 10Q. \quad (7.4.3.5\text{-}4)$$

7.5 SUPERSTRUCTURES AND DECKHOUSES

7.5.1 Construction, openings and closing appliances.

7.5.1.1 Openings in the freeboard deck other than those defined in **7.3**, **7.6 ÷ 7.11** and **7.13**, shall be protected by the enclosed superstructure or enclosed deckhouse. The similar openings in the deck of enclosed superstructure or enclosed deckhouse shall be protected by enclosed deckhouse of the second tier.

7.5.1.2 Superstructures and deckhouses are considered enclosed if:

their construction complies with the requirements of **2.12**, Part II "Hull";

all access openings comply with the requirements of **7.5.2** and **7.7**;

all other openings in their outside contour comply with requirements of **7.2 ÷ 7.4** and **7.7 ÷ 7.10.**

7.5.2 Doors in enclosed superstructures and enclosed deckhouses..

7.5.2.1 All access openings in the end bulkheads of enclosed superstructures and outside bulkheads of enclosed deckhouses shall be fitted with doors (refer to **2.4.4**, Part VI "Fire Protection").

7.5.2.2 The height of the sills to access openings specified in **7.5.2.1** shall be at least 380 mm. However, the bridge or poop shall not be regarded as enclosed unless access is provided for the crew to machinery and other working spaces inside these superstructures from any place in the uppermost continuous open deck or above it by alternative means which are available at all times when bulkhead openings are closed; the height of the sills of the openings in the bulkheads of such bridge or poop shall be at least 600 mm in position 1 and at least 380 mm in position **2**.

In ships of restricted areas of navigation **R3 i R3-IN** having the length of 24 m and over (except for passenger ships) the specified height of the sills to access openings may be reduced from 600 mm down to 450 mm and from 380 mm down to 230 mm, respectively.

In ships of restricted areas of navigation **R2**, **R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS** having the length below 24 m the height of the above sills may be reduced to 230 mm for all open decks.

7.5.2.3 The doors shall be so designed as to withstand the pressure head *p* calculated according to **2.12.3**, Part II "Hull", the distance z_1 being taken up to the middle of the door height. Under the pressure head *p* the stresses in the door elements shall not exceed 0,8 times the upper yield stress of the material.

Whatever the stresses, the thickness of the steel door plate shall be not less than that specified in **2.12.4.4**, Part II "Hull". For steel doors manufactured by stamping the minimum thickness of the door plate may be reduced by 1 mm.

The minimum thickness of the door plate made of other materials may be allowed provided it is confirmed by calculations and tests that they have a strength at least equivalent to that of the doors made of steel.

7.5.2.4 The doors shall be permanently and strongly attached to the bulkhead and fitted with clamping devices or other equivalent means for expeditiously opening, closing and securing them weathertight; such devices shall be so arranged that they can be operated from both sides of the bulkhead.

The doors shall open outwards, opening of doors inside the superstructure or deckhouse space may be allowed when security against the impact of the sea is provided.

7.5.2.5 The doors shall be weathertight when secured. The tightness shall be ensured by a rubber or other suitable gasket.

7.5.2.6 The doors shall be made of steel or other material approved by the Register.

7.5.2.7 In fiber-reinforced plastic ships the doors shall be attached to the bulkheads of superstructures and deckhouses in the same manner as the side scuttles, in accordance with the requirements of **7.2.2.5**.

7.5.2.8 In floating docks the height of the sills to access openings in superstructures and deckhouses of the top deck shall be at least 200 mm if access is provided from these superstructures and deckhouses into the spaces situated below.

7.5.3 Watertightness of passanger ships of restricted areas of navigation A-R2, A-R2-S, A-R2-RS, B-R3-S, B-R3-RS, C-R3-S, C-R3-RS, D-R3-S, D-R3-RS above the immersion limit line.

7.5.3.1 All reasonable and practicable means are to be taken to restrict the penetration and spread of water above the bulkhead deck. Such means may be hulf bulkheads or web frames.

If watertight hulf bulkheads or web frames are installed on the bulkhead deck above watertight subdivision bulkheads or in the immediate vicinity of such bulkheads, they are to have a watertight connection with the outer skin and the bulkhead deck in order to limit the spread of water on the deck when the ship has a roll in a damaged condition. If the watertight hulf bulkhead does not coincide with the bulkhead below, then the bulkhead deck in the area between them is to be watertight.

7.5.3.2 Storm ports and scuppers shall be fitted where necessary to provide rapid removal of water from the weather deck in all weather conditions.

7.6 ENGINE AND BOILER CASINGS

7.6.1 Engine and boiler space openings in positions 1 and 2 shall be efficiently enclosed by casings of ample strength raised above decks to the extent, which is reasonable and practicable, and being in their turn decked or terminated in skylights. The construction of the casings shall meet the requirements of **2.13**, Part II "Hull", and in case of fiber-reinforced plastic ships, the requirements of Part XVI "Structure and Strength of Fiber-Reinforced Plastic Ships".

7.6.2 Casings shall be made weathertight.

7.6.3 Casings shall be made of steel or other materials approved by the Register (refer also to **2.1.1.2**, Part VI "Fire Protection").

7.6.4 The access openings in the casings shall be fitted with permanently attached doors complying with the requirements of **7.5.2.3** ÷ **7.5.2.6**. The height of the sills to the access openings shall be at least 600 mm in position 1 and at least 380 mm in position 2.

If the length of the ship is less than 24 m, the specified height of the sills may be reduced down to 300 mm for ships of restricted areas of navigation **R2**, **R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS**.

In ships of restricted areas of navigation **R3** and **R3-IN** having the length of 24 m and over (except passenger ships) the specified height of the sills may be reduced from 600 mm down to 450 mm and from 380 mm down to 230 mm, respectively.

7.6.5 In type "A" ships and also in type "B" ships which are permitted to have the tabular freeboard less than that prescribed by Table 4.1.3.2, 6.4.2.3 or 6.4.3.3 of the Load Line Rules for SeaGoing Ships, the engine and boiler casings shall be protected by enclosed poop or bridge of at least standard height, or by a deckhouse of equal height and equivalent strength.

However, engine and boiler casings may be exposed if there are no openings giving direct access from the freeboard deck to the machinery space. A door complying with requirements of **7.5.2.3** ÷ **7.5.2.6**, may, however, be permitted in the machinery casing provided that it leads to a space or passageway which is as strongly constructed as the casing and is separated from the stairway to the engine and boiler room by a second similar door. The opening for the outside door shall be provided with a sill at least 600 mm in height, and that for the inside door with a sill of at least 230 mm in height.

7.6.6 In supply vessels the doors in the casings giving access to the engine or boiler rooms shall be located, where possible, inside the enclosed superstructure or deckhouse.

The door in the casing for access to the engine or boiler room may be fitted directly on the open cargo deck provided that, in addition to the first outside door, the second inside door is fitted; in this case, the outside and inside doors shall satisfy the requirements of **7.5.2.3** ÷ **7.5.2.6**, the height of the outside door sill shall be at least 600 mm, and of the inside door sill, at least 230 mm.

7.6.7 In floating docks the height of sills to the top deck access openings in the engine and boiler casings shall be at least 200 mm.

7.7 COMPANION HATCHES, SKYLIGHTS AND VENTILATING TRUNKS

7.7.1 Design and securing.

7.7.1.1 Deck openings in positions 1 and 2 intended for stairways to the ship's spaces located below, as well as light and air openings to these spaces shall be protected by strong companion hatches, skylights or ventilating trunks.

Where the openings intended for stairways to the ship's spaces located below are protected by superstructures or deckhouses instead of companion hatches, these superstructures and deckhouses shall comply with the requirements of **7.5**.

Hatch covers intended for emergency escape to the lifeboat and liferaft embarkation deck (refer to **8.5.1**), shall be constructed in such a manner that the securing devices shall be of a type which can be opened from both sides of the hatch cover, and the maximum force needed to open the hatch cover shall not exceed 150 N. The use of a spring equalizing, counterbalance or other suitable device on the hinge side to reduce the force needed for opening is acceptable.

For oil tankers of 150 m in length and above as well as bulk carriers of 90 m in length and above, contracted for construction on or after 1 July 2015, the requirements for cargo hatch covers are regulated by Common Structural Rules for Bulk Carriers and Oil Tankers.

7.7.1.2 Height of coamings of companion hatches, skylights and ventilating trunks shall be at least 600 mm in position 1 and at least 450 mm in position 2.

In ships of restricted areas of navigation **R3** and **R3-IN** having the length of 24 m and over (except passenger ships) the specified height of coamings may be reduced from 600 mm down to 450 mm and from 450 mm down to 380 mm, respectively.

If the length of the ship is less than 24 m, the height of the coamings may be reduced down to 380 mm for ships of restricted areas of navigation **R2**, **R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S** and down to 300 mm for ships of restricted areas of navigation **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS**.

Height of a coaming may be reduced if such a height would interfere with the normal operation of the ship, provided the seaworthiness and deck wetness assessment is submitted by the designer. Such assessment verifies the ship safety with sea condition in respect to the assigned area of navigation.

Construction of coamings shall comply with the requirements of **2.6.5.2**, Part II "Hull" and in case of fiber-reinforced plastic ships, with the requirements of Part XVI "Structure and Strength of FiberReinforced Plastic Ships".

7.7.1.3 All the companion hatches, skylights and ventilating trunks shall be provided with covers made of steel or other material approved by the Register and being permanently attached to the coamings.

Where the covers are made of steel, the thickness of their plate shall be equal to at least 0,01 times the spacing of stiffeners, but not less than 6 mm.

For ships of less than 500 gross tonnage, the minimum required thickness of 6 mm may be reduced if the cover is made by stamping in accordance with Fig. 7.7.1.3 and Table 7.7.1.3.

In small ships having the deck thickness less than 6 mm the required minimum thickness 6 mm may be reduced down to the deck thickness regardless of whether the cover is made by stamping, but in no case the plate thickness shall be less than 4 mm.

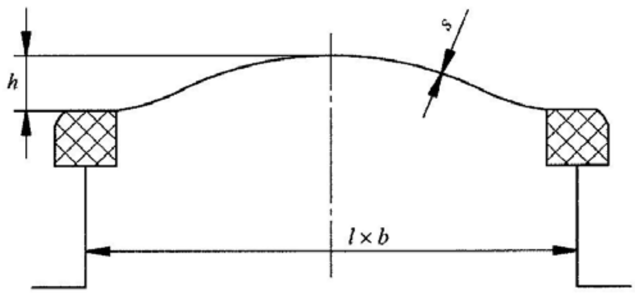


Fig. 7.7.1.3

Table 7.7.1.3 **Necessary minimum height and thickness of the cover**

Clear sizes of hatches *l*x*b*, in mm	Material of cover	Height of stamping *h*, in mm	Minimum thickness *s*, in mm
450x600	Steel	25	4
	Light alloy		
600x600	Steel	28	4
	Light alloy		
700x700	Steel	40	4
	Light alloy		6
800x800	Steel	55	4
	Light alloy		6
800x1200	Steel	55	5
	Light alloy		6
1000x1400	Steel	90	5

7.7.1.4 Covers of companion hatches, skylights and ventilating trunks shall have securing devices workable at least from outside of the hatch. However, where the hatches are used as emergency exits in addition to their primary application, the securing device shall be capable of being operated from each side of the cover.

When secured, the covers shall be weathertight. The tightness shall be provided by a rubber or other suitable gasket.

7.7.1.5 The glass for windows in the covers of skylights shall be hardened and at least 6 mm thick if the inner diameter is 150 mm and below, and at least 12 mm with the inner diameter of 450 mm. For intermediate inner diameters, the thickness of glass shall be determined by linear interpolation.

However, where wire-reinforced glass is used, its thickness may be 5 mm, and the requirement relating to its hardening will not be applicable.

Glass shall be efficiently attached to the covers by means of a frame and have on its contour a weathertight gasket of rubber or other equivalent material.

Skylights installed in the machinery spaces of category A, shall comply with the requirements of **2.1.4.2**, Part VI "Fire Protection".

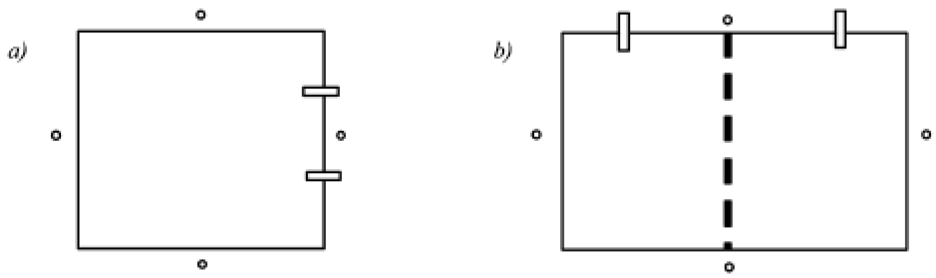
7.7.1.6 Each window or group of adjacent windows shall be provided with portable shields of the same material as the cover being at least 3 mm in thickness and capable of being efficiently fastened outside the cover by means of ear-nuts; such portable shields shall be stowed adjacent to the skylights.

7.7.1.7 In floating docks the height of coamings of companion hatches, skylights and ventilating trunks situated on the top deck shall be at least 200 mm. The portable shields mentioned in **7.7.1.6** need not be provided for covers of skylights situated on the top deck of the floating docks.

7.7.2 Design and securing of small hatches on the exposed for deck.

7.7.2.1 The requirements of **7.7.2** apply to hatches generally having an area of not more than 2,5 m^2 located on the exposed deck at a distance of 0,25L from the fore perpendicular of ships of 80 m in length and more, where the height of the exposed deck in way of the hatch is less than 0,1L or 22 m above the summer load waterline, whichever is less. The ship length L is determined according to **1.1.3**, Part II "Hull".

7.7.2.2 For rectangular or square steel hatch covers, the plate thickness, stiffener arrangement and scantlings shall be in accordance with Table 7.7.2.2 and Fig. 7.7.2.2. Stiffeners, where fitted, shall be aligned with contact points of the hatch cover edge with the welded pad (metal-to-metal contact points) required in accordance with 7.7.2.6 (refer to Fig. 7.7.2.2). Primary stiffeners shall be continuous. All stiffeners shall be welded to the inner edge stiffener (refer to Fig. 7.7.2.8).



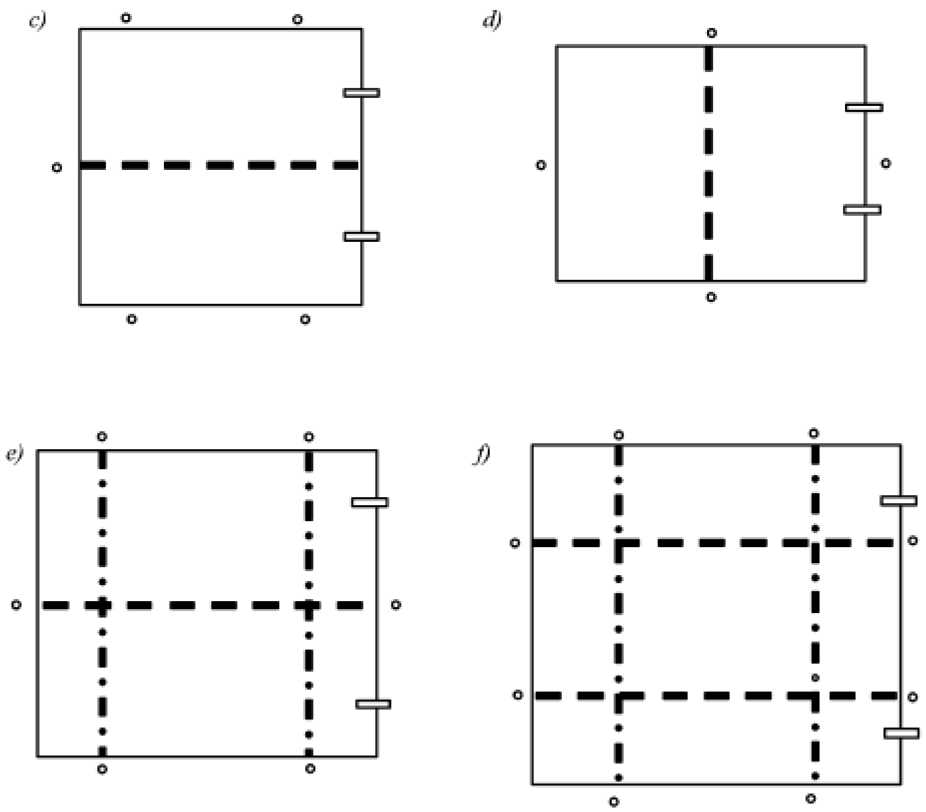


Fig. 7.7.2.2 Nominal sizes of hatch covers:
a = 6306630 mm; *b* = 6306830 mm; c = 8306830 mm; *d* = 8306630 mm; *e* = 103061030 mm; *f* = 133061330 mm

Symbols:
▭ - hinge
• - securing device/metal-to-metal contact;
——— - primary stiffener;
▪—▪—▪ - secondary stiffener

Table 7.7.2.2

Nominal size, mm x mm	Cover plate thickness, in mm	Primary stiffeners	Secondary stiffeners
		Flat bar, mm6mm; number	
630×630	8	–	–
630×830	8	100× 8; 1	–
830×630	8	100× 8; 1	–
830×830	8	100× 10; 1	–
1030×1030	8	120× 12; 1	80× 8; 2
1330× 1330	8	150× 12; 2	100× 10; 2

7.7.2.3 The hatchway coaming shall be suitably reinforced by a horizontal flat bar, normally not more than 170 ÷ 190 mm from the upper edge of the coaming.

7.7.2.4 For hatch covers constructed of materials other than steel, the required scantlings shall provide equivalent strength.

7.7.2.5 Weathertightness of hatch covers shall be ensured by securing devices of the following types: butterfly nuts tightening onto forks (clamps); quick acting cleats; central locking device. Dogs (twist tightening handles) with wedges are not acceptable.

Where the hatch covers are also used as emergency exits, they shall be also fitted with the central quick acting locking device designed for handling on both sides.

7.7.2.6 The hatch cover shall be fitted with a gasket of elastic material. This shall be designed to allow a contact of the hatch cover edge to the welded pad (metal-to-metal contact) at a designed compression and to prevent over compression of the gasket by green sea forces that may cause the securing devices to be loosened or dislodged. The contacts of the hatch cover edge to the welded pad (metal-to-metal contact) shall be arranged close to each securing device in accordance with Fig. 7.7.2.2, and shall be of sufficient capacity to withstand the bearing force.

7.7.2.7 The primary securing device shall be designed and manufactured so that the designed compression pressure is achieved by one person without the need of any tools.

7.7.2.8 Where butterfly nuts are used in the primary securing device, the forks (clamps) shall be of the robust design, which minimizes the risk of the butterfly nuts being dislodged while in use. It is ensured by curving the forks upward, a raised surface on the free end, or a similar method (refer to Fig. 7.7.2.8).

The plate thickness of unstiffened steel forks (clamps) shall not be less than 16 mm.

7.7.2.9 For hatch covers located on the exposed deck forward of the fore-most cargo hatch, the hinges shall be fitted such that the predominant direction of green sea will cause the cover to close, which means that the hinges are normally to be located on the fore edge.

7.7.2.10 On hatches located between the cargo hatches, the hinges shall be placed on the fore edge or outboard edge, whichever is practicable for protection from green water in beam sea and bow quartering conditions.

7.7.2.11 Hatches, excepting those which may also be used as emergency exits, shall be fitted with an independent secondary securing device like, e.g. a sliding bolt, a hasp or a backing bar of slack fit, which is capable of keeping the hatch cover in place, even in the event that the primary securing device became loosened or dislodged. It shall be fitted on the side opposite to the hatch cover hinges.

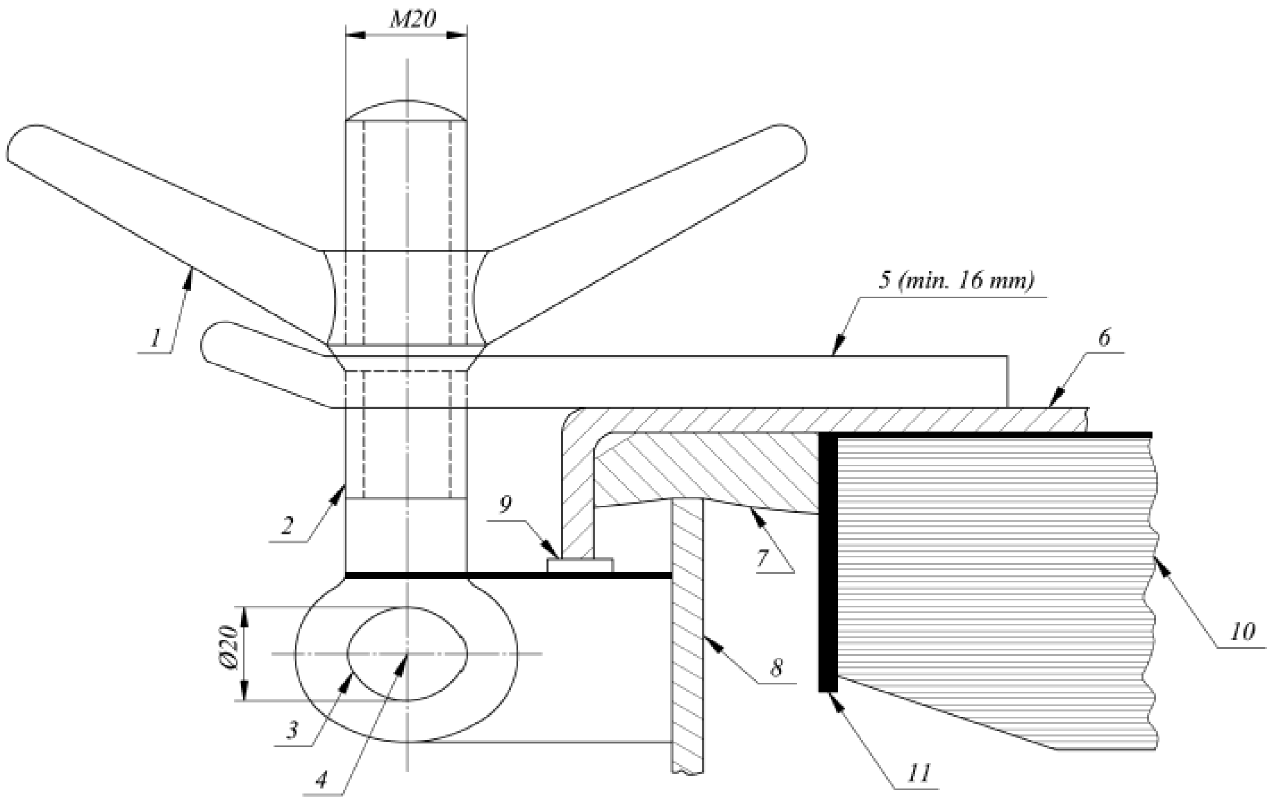


Fig. 7.7.2.8.
1 – butterfly nut; 2 – bolt; 3 – pin; 4 – centre of pin; 5 – fork (damp) plate; 6 – hatch cover; 7 – gasket; 8 – hatch coaming; 9 – bearing pad welded on the bracket for metal-to-metal contact; 10 – stiffener; 11– inner edge stiffener.

7.8 VENTILATORS

7.8.1 Ventilators to spaces below freeboard deck or deck of enclosed superstructures and deckhouses shall be fitted with coamings efficiently connected to the deck.

The coamings of ventilators shall be at least 900 mm in height in position 1 and at least 760 mm in position 2.

In ships of restricted areas of navigation **R3** and **R3-IN** having the length of 24 m and over (except passenger ships) the specified height of the coamings may be reduced from 900 mm down to 760 mm and from 760 mm down to 600 mm, respectively.

In ships of restricted areas of navigation **R2**, **R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS** having the length below 24 m the height of the coamings may be reduced down to 300 mm for all open decks.

Construction of coamings shall comply with the requirements of **2.6.5.2**, Part II "Hull".

The strength of ventilators, connections of ventilators to coamings and connections of ventilator parts, if any, shall be equivalent to that of the coaming.

7.8.2 Ventilators in position 1 the coamings of which extend to more than 4500 mm above the deck and in position 2 the coamings of which extend to more than 2300 mm above the deck need not be fitted with closing appliances.

In all other cases, each ventilator shall be fitted with a strong cover made of steel or other material approved by the Register.

In ships of less than 100 m in length, the covers shall be permanently attached; in ships of 100 m in length and over they may be conveniently stowed near the ventilators to which they shall be fitted.

7.8.3 When secured, the covers of ventilators shall be weathertight. The tightness shall be provided by a rubber or other suitable gasket.

7.8.4 In supply vessels, in order to minimize the possibility of flooding of the spaces situated below, the ventilators shall be positioned in the protected locations where the probability of their damage by cargo is excluded during cargo handling operations. Particular attention shall be given to the arrangement of ventilators of the engine and boiler rooms for which the location is preferable above the deck level of the first tier of superstructures or deckhouses.

7.8.5 In floating docks the height of coamings of ventilators situated on the top deck shall be at least 200 mm.

7.9 MANHOLES

7.9.1 The height of coamings of manholes for deep and other tanks, except for those indicated in **2.4.5.3**, Part II "Hull", air spaces, cofferdams, etc. is not regulated by the Register.

7.9.2 Covers of manholes shall be made of steel or other material approved by the Register.

The thickness of the covers shall not be less than that of the plating on which they are fitted. The thickness of the covers, where the thickness of plating is greater than 12 mm, may be reduced based on appropriate technical background confirming that covers have a sufficient strength.

7.9.3 The covers of manholes shall be efficiently attached to the coaming or doubling ring by means of bolts or pins with nuts.

7.9.4 When secured, the covers shall be tight both for water and liquid cargoes or stores for which the tanks are intended under the inner pressure corresponding to the test pressure of the tank under consideration.

The tightness shall be provided by a rubber or other suitable gasket.

The gasket shall be resistant to the liquids referred to above.

7.10 HATCHWAYS OF DRY CARGO HOLDS

7.10.1 General.

The deck openings through which cargoes or ship's stores are loaded and unloaded shall be protected by strong hatchways. If these hatchways are situated in positions 1 and 2, the hatchway covers shall be weathertight. The tightness shall be provided by one of the following two methods:

.1 by portable covers and tarpaulins as well as battening devices;

.2 by weathertight covers made of steel or other equivalent material fitted with rubber or other suitable gaskets and clamping devices.

7.10.2 Coamings.

7.10.2.1 The height of hatchway coamings in positions 1 and 2 shall be at least 600 mm and 450 mm, respectively.

If the length of the ship is less than 24 m, the height of the coamings may be reduced down to 380 mm for ships of restricted area of navigation **R2**, **R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S** and down to 300 mm for ships of restricted areas of navigation **R3**, **R3-IN** and **D-R3-S**, **D-R3-RS**.

In fishing vessels the height of cargo hatchway coamings in position 2 may be reduced down to 300 mm.

In ships of restricted areas of navigation **R3** і **R3-IN** having the length of 24 m and over (except passenger ships) the specified height of cargo hatchway coamings may be reduced from 600 mm down to 450 mm and from 450 mm down to 380 mm, respectively.

7.10.2.2 The height of coamings of the hatchways specified in **7.10.1.2** may be decreased in relation to that prescribed by **7.10.2.1** or the coamings may be omitted entirely where the efficiency of the cover tightness and securing means will satisfy the Register.

7.10.3 Materials.

7.10.3.1 For steel of top plate, bottom plate and primary supporting members, refer to 1.6.

7.10.3.2 The wood of hatchway covers shall be of good quality and of the type and grade which proved to be satisfactory for this purpose. Wedges shall be of hard wood.

7.10.3.3 Canvas used for making tarpaulins shall be impregnated to make them moisture-resistant and shall not contain jute thread. Mass of 1 m^2 of canvas before impregnation shall be not less than 0,55 kg. Breaking stress of impregnated canvas band 200x50 mm in size shall be at least 3 kN and 2 kN in longitudinal and transverse directions, respectively. When tested for watertightness, the impregnated canvas shall not get wet under water head of 0,15 m acting for 24 h.

7.10.3.4 The rubber for packing gaskets of hatchway covers shall be elastic, strong, and resistant to atmospheric changes. The rubber shall be of sufficient hardness.

7.10.3.5 All internal and external surfaces of steel hatch covers in bulk carriers (except inaccessible spaces in box type covers) shall have effective epoxy or other equivalent protective coating applied in accordance with the recommendations of the manufacturer (refer to **1.1.4.7** and **3.3.5.1**, Part II "Hull").

7.10.4 Design loads.

Hatchway covers shall be designed to sustain deck cargoes which are intended to be carried on these covers. Where operation of the cargo handling cars on hatchways covers is anticipated in the course of the ship's service, during cargo handling operations, the loads induced by such cars shall be taken into consideration. For hatchway covers in positions 1 and 2 the design load shall be calculated in accordance with **3.2.5.2** of the Load Line Rules for Sea-Going Ships; design of hatch covers shall comply with the requirements of **3.2.5.3** – **3.2.5.5** of the above Rules.

For ships of less than 24 m in length of restricted area of navigation engaged on international voyages and for all ships of restricted area of navigation not engaged on international voyages the load intensity reduced by the following values may be used instead of load intensity specified in 3.2.5.2 of the Load Line Rules for Sea-Going Ships:

15 % for ships of restricted areas of navigation **R2**, **R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**;

30 % for ships of restricted areas of navigation **R3**, **R3-IN** та **D-R3-S**, **D-R3-RS**, but not less than the load intensity on the weather deck in the area of hatches installation, determined in accordance with 2.6.3.1, Part II "Hull".

7.10.5 Design of hatch covers specified in 7.10.1.1.

Design of these hatch covers shall meet the requirements of **3.2.4** of the Load Line Rules for Sea-Going Ships.

7.10.6 Structure of hatch covers indicated in 7.10.1.2.

7.10.6.1 Structure of these covers shall meet the requirements of 3.2.5 of the Load Line Rules for SeaGoing Ships.

7.10.6.2 Primary supporting members and secondary stiffeners of hatch covers shall be continuous over the breadth and length of hatch covers, as far as practical. When this is impractical, sniped end connections shall not be used and appropriate arrangements shall be adopted to provide sufficient load carrying capacity.

7.10.6.3 The spacing of primary supporting members parallel to the direction of secondary stiffeners shall not exceed 1/3 of the span of primary supporting members. When strength calculation is carried out by FE analysis using plane strain or shell elements, this requirement can be waived.

Secondary stiffeners of hatch coamings shall be continuous over the breadth and length of hatch coamings.

7.10.6.4 Unless otherwise quoted, the thickness t of the following sections is the net thickness.

Net thickness is the member thickness necessary to obtain the minimum net scantlings.

The required gross thicknesses are obtained by adding corrosion additions t_s.

Strength calculations using beam theory, grillage analysis or FEM shall be performed with net scantlings.

7.10.6.5 Structural assessment of hatch covers and hatch coamings shall be carried out using the design loads, defined in this Chapter and the following definitions shall be used:

L − length of ship, in m, as defined in **1.1.3**, Part II "Hull";

L_{LL} − length of ship, in m, as defined in **1.2.2**;

x − longitudinal coordinate of mid point of assessed structural member measured from aft end of length L or L_{LL}, as applicable;

D_{min} – the least moulded depth, in m, as defined in **1.2.1** of the Load Line Rules for Sea-Going Ships.

h_N − standard superstructure height, in m,

$h_N = 1,05 + 0,01\ L_{LL}$, and $1,8 \le h_N \le 2,3$.

7.10.6.6 The pressure p_H, in kN/m^2, on the hatch cover panels is given in Table 7.10.6.6. The vertical weather design load needs not to be combined with cargo loads.

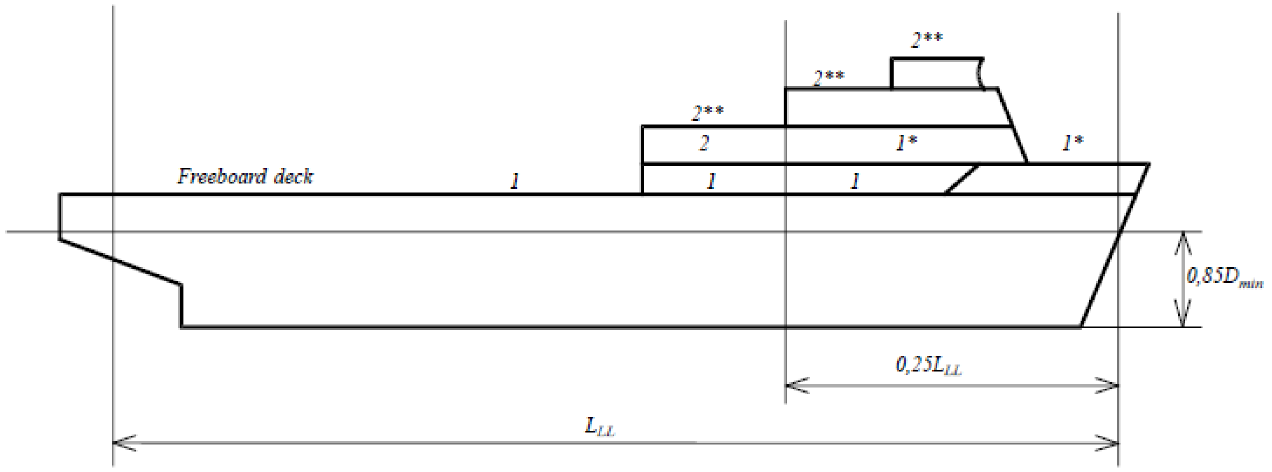
In Fig. 7.10.6.6 positions 1 and 2 are illustrated for an example ship.

Table 7.10.6.6 **Design load p_H of weather deck hatch coveres**

Position	Design loadp_H, in kN/m^2	
	$x/L_{LL} \le 0,75$	$0,75 < x/L_{LL} \le 1,0$
1	for 24 м $\le L_{LL} \le$ 100 m	
	$(9,81/76)(1,5L_{LL}+116)$	on freeboard deck: $(9,81/76)[(4,28L_{LL}+28)(x/L_{LL})-1,71L_{LL}+95]$;
		upon exposed superstructure decks located at least one superstructure standard height above the freeboard deck: $(9,81/76)(1,5L_{LL}+116)$
	for $L_{LL} >$ 100 m	
	$9,81\times 3,5$	on freeboard deck for type B ships according to the International Convention on Load Lines: $9,81[(0,0296L_1+3,04)(x/L_{LL}) - 0,0222L_1+1,22]$;
		on freeboard deck for ships with less freeboard than type B according to the International Convention on Load Lines: $9,81[(0,1452L_1+8,52)(x/L_{LL}) - 0,1089L_1+ 9,89]$, $L_1= L_{LL}$, but not more than 340 m;
		upon exposed superstructure decks located at least on superstructure standard height above the freeboard deck: $9,81\times 3,5$
2	for 24 м $\le L_{LL} \le$ 100 m	
	$(9,81/76)(1,1L_{LL}+87,6)$	
	for $L_{LL} >$ 100 m	
	$9,81\times 2,6$; upon exposed superstructure decks located at least one superstructure standard height above the lowest position 2 deck: $9,81\times 2,1$	

7.10.6.7 Where an increased freeboard is assigned, the design load for hatch covers according to Table 7.10.6.6 on the actual freeboard deck may be as required for a superstructure deck, provided the summer freeboard is such that the resulting draught will not be greater than that corresponding to the minimum freeboard calculated from an assumed freeboard deck situated at a distance at least equal to the standard superstructure height hN below the actual freeboard deck (refer to Fig. 7.10.6.6).

Positions 1 and 2



Positions 1 and 2 for an increased freeboard

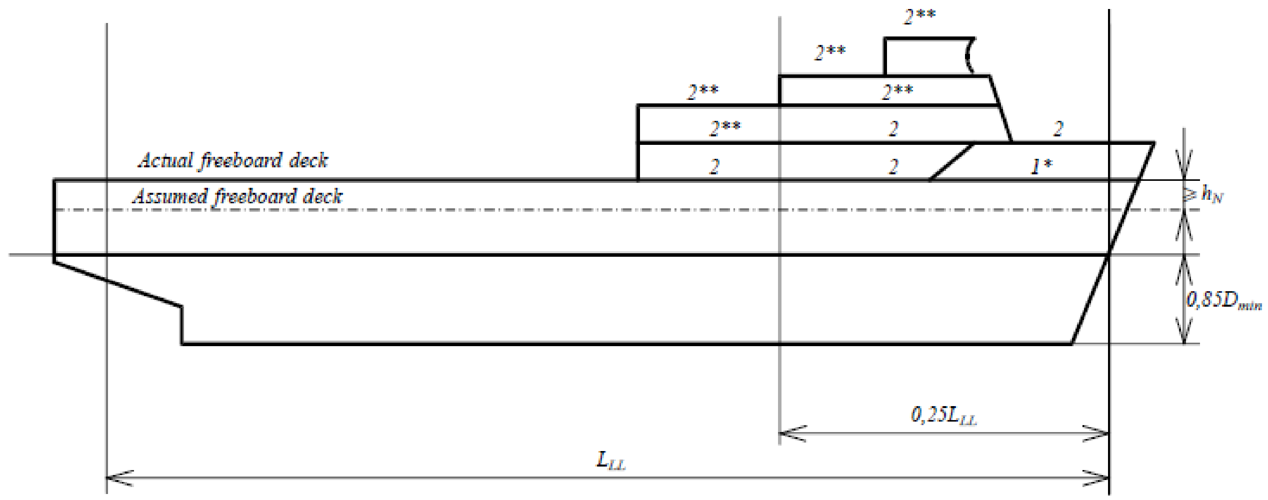


Fig. 7.10.6.6

Примітки: * Reduced load upon exposed superstructure decks located at least one superstructure standard height above the freeboard deck.

** Reduced load upon exposed superstructure decks of ships with L_{LL} > 100 m, located at least one superstructure standard height above the lowest position 2 deck.

7.10.6.8 The horizontal weather design load p_A, in kN/m^2 , for determining the scantlings of outer edge girders (skirt plates) of weather deck hatch covers and of hatch coamings shall be determined by the formula:

$$p_A = ac(bc_L f - z), \qquad (7.10.6.8)$$

where:

$f = L/25 + 4,1$, for $L < 90$ m;

$f = 10,75 - [(300-L)/100]^{1,5}$, for 90м $\leq L < 300$ m;

$f = 10,75$, for 300м $\leq L < 350$ m;

$f = 10{,}75 - [(L - 350)/150]^{1{,}5}$, for 350 m $\leq L <$ 500 m;

$c_L = (L/90)^{0{,}5}$, for $L <$ 90 m;

$c_L = 1$, for $L \geq$ 90 m;

$a = 20 + (L/12)$ for unprotected front coamings and hatch cover skirt plates;

$a = 10 + (L/12)$ for unprotected front coamings and hatch cover skirt plates, where the distance from the actual freeboard deck to the summer load line exceeds the minimum non-corrected tabular freeboard according to the International Convention on Load Lines by at least one standard superstructure height h_N;

$a = 5 + (L/15)$ for side and protected front coamings and hatch cover skirt plates;

$a = 7 + (L/100) - (8x'/L)$ for aft ends of coamings and aft hatch cover skirt plates abaft amidships;

$a = 5 + (L/100) - (4x'/L)$ for aft ends of coamings and aft hatch cover skirt plates forward of amidships;

$L_1 = L$, need not be taken greater than 300 m;

$b = 1{,}0 + \{[(x'/L) - 0{,}45]/(C_B+0{,}2)\}^2$, for $(x'/L) < 0{,}45$;

$b = 1{,}0 + 1{,}5\{[(x'/L) - 0{,}45]/(C_B+0{,}2)\}^2$, for $(x'/L) \geq 0{,}45$;

$0{,}6 \leq C_B \leq 0{,}8$, when determining scantlings of aft ends of coamings and aft hatch cover skirt plates forward of amidships, C_B need not be taken less than 0,8;
x' − distance, in m, between the transverse coaming or hatch cover skirt plate considered and aft end of the length L.

When determining side coamings or side hatch cover skirt plates, the side shall be subdivided into parts of approximately equal length, not exceeding $0{,}15L$ each, and x' shall be taken as the distance between aft end of the length L and the centre of each part considered;

z − vertical distance, in m, from the summer load line to the midpoint of stiffener span, or to the middle of the plate field;

$c = 0{,}3 + 0{,}7(b'/B')$;

b' − breadth of coaming, in m, at the position considered;

B' − actual maximum breadth of ship, in m, on the exposed weather deck at the position considered;

(b'/B') − shall not be taken less than 0,25.

The design load p_A shall not be taken less than the minimum values given in Table 7.10.6.8.

Table 7.10.6.8. **Minimum design load $p_{A\min}$**

L	$p_{A\min}$, in kN/m^2, for	
	unprotected fronts	elsewhere
$\leq$ 50	30	15
> 50 < 250	25 + (L /10)	12,5 + (L/20)
$\geq$250	50	25

Note. The horizontal weather design load need not be included in the direct strength calculation of the hatch cover, unless it is utilized for the design of substructures of horizontal support according to **7.10.6.51**.

7.10.6.9 The load on hatch covers due to distributed cargo loads P_L, in kN/m^2, resulting from heave and pitch (i.e. ship in upright condition) shall be determined according to the following formula:

$$p_1 = p_c\,(1+a_v), \qquad (7.10.6.9)$$

where:
p_c − uniform cargo hold, in kN/m^2;

a_v− vertical acceleration addition as follows:

$a_v = Fm$;

where: $F = 0{,}11 v_0/(L)^{0,5}$;

$m = m_0 - 5(m_0-1)(x/L)$, for $0 \le (x/L) \le 0{,}2$;

$m = 1$, for $0{,}2 < (x/L) \le 0{,}7$;

$m = 1+ [(m_0+1)/0{,}3][(x/L) - 0{,}7]$, for $0{,}7 < (x/L) \le 1{,}0$;

where: $m_0 = 1{,}5 + F$;

v_0− maximum speed at summer load line draught;

v_0 shall not be taken less than $(L)^{0,5}$, in knots.

7.10.6.10 The load P, in kN, due to a concentrated force P_S, in kN, except for container load, resulting from heave and pitch (i.e. ship in upright condition) shall be determined as follows:

$$P = P_S\,(1+ a_v), \qquad (7.10.6.10)$$

where:
a_v– acceleration addition according to **7.10.6.9**.

7.10.6.11 The loads defined in **7.10.6.11.1** shall be applied where containers are stowed on the hatch cover.

7.10.6.11.1 The load P, in kN, applied at each corner of a container stack, and resulting from heave and pitch (i.e. ship in upright condition) shall be determined as follows:

$$P = 9{,}81 \cdot M \cdot (1 + a_v)/4, \qquad (7.10.6.11.1\text{-}1)$$

where: a_v – acceleration addition according to **7.10.6.9**;
M – maximum designed mass of container stack, in t;

7.10.6.11.2 The loads, in kN, applied at each corner of a container stack, and resulting from heave, pitch, and the ship's rolling motion (i.e. ship in heel condition) shall be determined as follows, (refer also to Fig. 7.10.6.11):

$$A_z = 9{,}81(M/2)\,(1+a_v)[0{,}45- 0{,}42(h_m/b)]; \qquad (7.10.6.11.2\text{-}1)$$

$$B_z = 9{,}81(M/2)\,(1+a_v)[0{,}45+0{,}42(h_m/b)]; \qquad (7.10.6.11.2\text{-}2)$$

$$B_y = 2{,}4M, \qquad (7.10.6.11.2\text{-}3)$$

where:
a_v– acceleration addition according to **7.10.6.9**;
M − maximum designed mass of container stack, in t;
h_m – designed height of centre of gravity of stack above hatch cover top, in m, may be calculated as weighted mean value of the stack, where the centre of gravity of each tier is assumed to be located at the centre of each container,
$h_m = \sum(z_i \cdot W_i)/M$;

z_i – distance from hatch cover top to the centre of ith container, in m;
W_i – weight of *i*-th container, in t;
b – distance between midpoints of foot points, in m, refer to Fig. 7.10.6.11;
A_z, B_z – support forces in *Z*-direction at the forward and aft stack corners;
B_y – support force in y-direction at the forward and aft stack corners.

When strength of the hatch cover structure is assessed by grillage analysis according to **7.10.6.21**, h_m and z_i shall be taken as shown in Fig. 7.10.6.11.

Force B_y does not need to be considered in this case.

Values of A_z and B_z, applied for the assessment of hatch cover strength shall be shown in the drawings of the hatch covers.

Note. It is recommended that container loads as calculated above are considered as limit for foot point loads of container stacks in the calculations of cargo securing (container lashing).

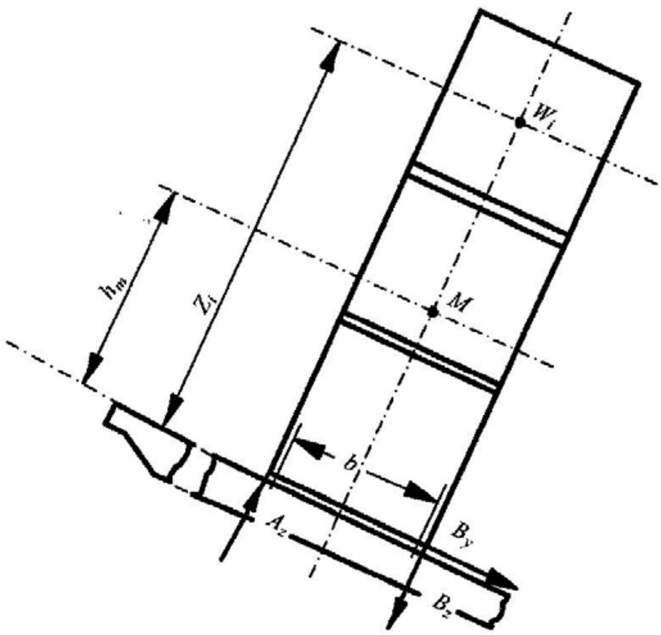


Fig. 7.10.6.11 Forces due to container loads

7.10.6.12 The load cases defined in **7.10.6.11.1** and **7.10.6.11.2**, shall also be considered for partial non homogeneous loading which may occur in practice, e.g. where specified container stack places are empty.

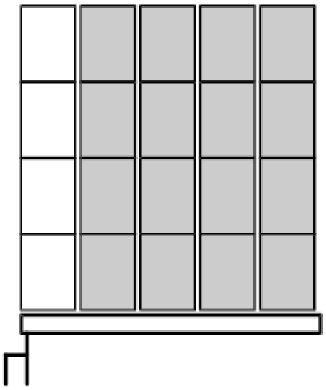
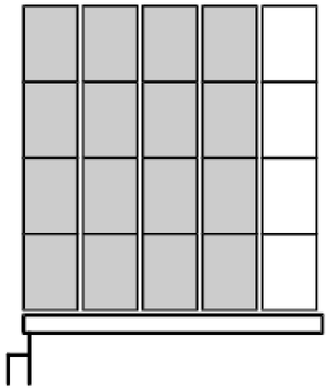
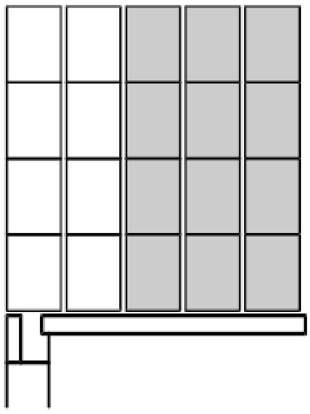
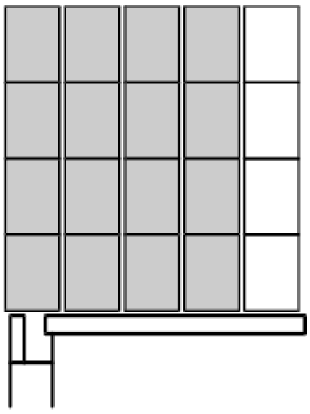
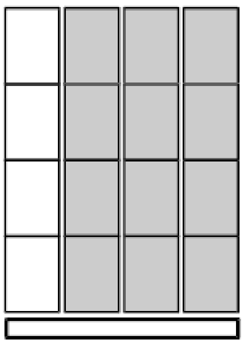
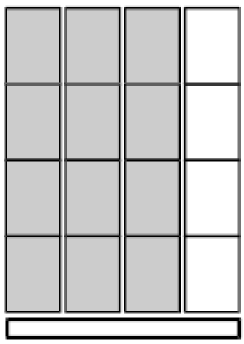
For each hatch cover, the heel directions, as shown in Table 7.10.6.12 shall be considered.

The load case partial loading of container hatch covers can be evaluated using a simplified approach, where the hatch cover is loaded without the outermost stacks that are located completely on the hatch cover.

If there are additional stacks that are supported partially by the hatch cover and partially by container stanchions then the loads from these stacks shall also be neglected, refer to Table 7.10.6.12.

In addition, the case where only the stack places supported partially by the hatch cover and partially by container stanchions are left empty shall be assessed in order to consider the maximum loads in the vertical hatch cover supports.

***Table 7.10.6.12* Partial loading of container hatch covers**

Heel direction	←	→
Hatch covers supported by the longitudinal hatch coaming with all container stacks located completely on the hatch cover		
Hatch covers supported by the longitudinal hatch coaming with the outermost container stack supported partially by the hatch cover and partially by container stanchions		
Hatch covers not supported by the longitudinal hatch coaming (center hatch covers)		

It may be necessary also to consider partial load cases where more or different container stack places are left empty.

In the case of mixed stowage e (20' + 40' container combined stack), the foot point forces at the fore and aft end of the hatch cover shall not be higher than resulting from the design stack weight for 40' containers, and the foot point forces at the middle of the cover shall not be higher than resulting from the design stack weight for 20' containers.

7.10.6.13 Hatch covers, which in addition to the loads according to **7.10.6.6**, **7.10.6.7** and **7.10.6.11**, are loaded in the ship's transverse direction by forces due to elastic deformations of the ship's hull, shall be designed such that the sum of stresses does not exceed the permissible values given in **7.10.6.14**.

7.10.6.14 The equivalent stress σ_V in steel hatch cover structures related to the net thickness shall not exceed $0{,}8\sigma_F$, where σ_F is the minimum yield stress, in N/mm^2.

For design loads according to **7.10.6.8** ÷ **7.10.6.13**, the equivalent stress sv related to the net thickness shall not exceed $0{,}9\sigma_F$, when the stresses are assessed by means of FEM.

For grillage analysis, the equivalent stress may be taken as follows:

$$\sigma_v = \sqrt{\sigma^2 + 3\tau^2}, \text{ Н/мм}^2, \qquad (7.10.6.14\text{-}1)$$

where:
σ – normal stress, in N/mm^2;
τ – shear stress, in N/mm^2.

For FEM calculations, the equivalent stress may be taken as follows:

$$\sigma_v = \sqrt{\sigma_x^2 - \sigma_x\sigma_y + \sigma_y^2 + 3\tau_2}\ , \text{ Н/мм}^2, \qquad (7.10.6.14\text{-}2)$$

where:
σ_x – normal stress, in N/mm^2, in *x*-direction;
σ_y – normal stress, in N/mm^2, in *y*-direction;
τ – shear stress, in N/mm^2, in *x-y* plane.
Indices *x* and *y* are coordinates of a two-dimensional Cartesian system in the plane of the considered structural element.

In case of FEM calculations using shell or plane strain elements, the stresses shall be read from the centre of the individual element. It shall be observed that, in particular, at flanges of unsymmetrical girders, the evaluation of stress from element centre may lead to non-conservative results.

Thus, a sufficiently fine mesh shall be applied in these cases or, the stress at the element edges shall not exceed the allowable stress.

Where shell elements are used, the stresses shall be evaluated at the mid plane of the element.

7.10.6.15 5 The vertical deflection of primary supporting members due to the vertical weather design load according to **7.10.6.**6 and **7.10.6.7** shall not be more than 0,0056l_g, where l_g is the greatest span of primary supporting members.

Where hatch covers are arranged for carrying containers and mixed stowage is allowed, i.e., a 40' container stowed on top of two 20' containers, particular attention shall be paid to the deflections of hatch covers. Further the possible contact of deflected hatch covers with in hold cargo shall be observed.

7.10.6.16 The local net plate thickness *t*, in mm, of the hatch cover top plating shall not be less than:

$$t = F_p 15{,}8 s (p/0{,}95\sigma_F)^{0{,}5}, \qquad (7.10.6.16)$$

and shall not be less than 1 % of the spacing of the stiffener or 6 mm if that be greater,

where:
p – pressure p_N and p_1, in kN/m^2, as defined in **7.10.6.6** and **7.10.6.9**;
F_p= 1,5 in general;
F_p= 1,9σ/σ_a for $\sigma/\sigma_a \geq 0{,}8$ for the attached plate flange of primary supporting members;
s – stiffener spacing, in m;
σ_F – minimum yield stress of the material, in N/mm^2;
σ – maximum normal stress, in N/mm^2, of hatch cover top plating, determined according to Fig.7.10.6.16;
σ_a =0,8 σ_F, , in N/mm^2.

For flange plates under compression sufficient buckling strength according to **7.10.6.24** shall be demonstrated.

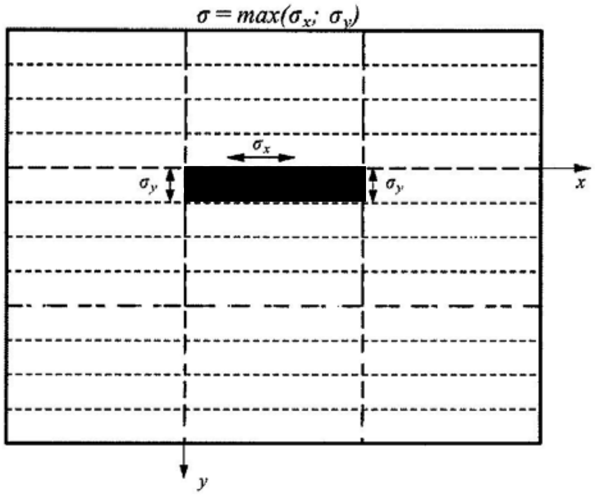


Fig. 7.10.6.16

7.10.6.17 The thickness of lower plating of double skin hatch covers and box girders shall fulfill the strength requirements and shall be obtained from the calculation according to **7.10.6.21** under consideration of permissible stresses according to **7.10.6.14**.

When the lower plating is taken into account as a strength member of the hatch cover, the net thickness, in mm, of lower plating shall be taken not less than 5 mm.

When project cargo is intended to be carried on a hatch cover, the net thickness shall not be less than:

$t = 6{,}5s$, mm; (7.10.6.17)

where:
s − stiffener spacing, in m.

Note. Project cargo means especially large or bulky cargo lashed to the hatch cover. Examples are parts of cranes or wind power stations, turbines, etc. Cargoes that can be considered as uniformly distributed over the hatch cover, e.g., timber, pipes or steel coils need not to be considered as project cargo.

7.10.6.18 The net section modulus Z and net shear area A_s of uniformly loaded hatch cover stiffeners constraints at both ends shall not be less than:

$Z = (104/\sigma_F) \cdot s \cdot l^2 \cdot p$, in cm^3, (7.10.6.18-1)

for design load according to **7.10.6.6**;

$Z = (94/\sigma_F) \cdot s \cdot l^2 \cdot p$, in cm^3, (7.10.6.18-2)

for design load according to **7.10.6.9**;

$A_s = (10{,}8/\sigma_F) \cdot s \cdot l \cdot p$, in cm^2, (7.10.6.18-3)

for design load according to **7.10.6.6**;

$A_s = (9{,}6/\sigma_F) \cdot s \cdot l \cdot p$, in cm^2, (7.10.6.18-4)

for design load according to **7.10.6.9**,

where:
p − pressure p_N and p_1, in kN/m^2, as defined in **7.10.6.6** and **7.10.6.9**;
s − secondary stiffener spacing, in m;
σ_F − minimum yield stress of the material, in N/mm^2;

l − secondary stiffener span, in m, to be taken as the spacing, in m, of primary supporting members or the distance between a primary supporting member and the edge support, as applicable.

For secondary stiffeners of lower plating of double skin hatch covers, requirements mentioned above are not applied due to the absence of lateral loads.

The net thickness, in mm, of the stiffener (except U-beams/trapeze stiffeners) web shall be taken not less than 4 mm.

The net section modulus of the secondary stiffeners shall be determined based on and attached plate width assumed equal to the stiffener spacing.

For flat bar secondary stiffeners and buckling stiffeners, the ratio h/t_w shall not be greater than 15 $k^{0,5}$,

where:
h - height of the stiffener;
t_w - net thickness of the stiffener;
$k = 235/\sigma_F$.

Stiffeners parallel to primary supporting members and arranged within the effective breadth according to **7.10.6.22** shall be continuous at crossing primary supporting member and may be regarded for calculating the cross sectional properties of primary supporting members. It shall be verified that the combined stress of those stiffeners induced by the bending of primary supporting members and lateral pressures does not exceed the permissible stresses according to **7.10.6.14**.

These requirements are not applied to stiffeners of lower plating of double skin hatch covers if the lower plating is not considered as strength member..

For hatch cover stiffeners under compression sufficient safety against lateral and torsional buckling according to **7.10.6.28** ÷ **7.10.6.32** shall be verified.

For hatch covers subject to wheel loading or point loads stiffener scantlings shall be determined under consideration of the permissible stresses according to**7.10.6.14**.

7.10.6.19 Scantlings of primary supporting members are obtained from calculations according to **7.10.6.22** and **7.10.6.23** under consideration of permissible stresses according to **7.10.6.14**.

For all components of primary supporting members sufficient safety against buckling shall be verified according to **7.10.6.24** ÷ **7.10.6.32**.

For biaxial compressed flange plates this shall be verified within the effective widths according to **7.10.6.29**.

The net thickness, in mm, of webs of primary supporting members shall not be less than:

$t = 6{,}5s$, in mm;
$t_{\min} = 5$ in mm,

where:
s − stiffener spacing, in m.

7.10.6.20 Scantlings of edge girders are obtained from the calculations according to **7.10.6.22** and **7.10.6.23** under consideration of permissible stresses according to **7.10.6.14**.

The net thickness, in mm, of the outer edge girders exposed to wash of sea shall not be less than the largest of the following values:

$$t = 15{,}8s(p_A/0{,}95\sigma_F)^{0,5}; \qquad (7.10.6.20\text{-}1)$$

$t = 8{,}5s$, in mm;

$t_{\min} = 5$ in mm,

where: p_A− horizontal pressure as defined in **7.10.6.8**;
σ_F − minimum yield stress of the material, in N/mm^2;
s − stiffener spacing, in m.

The stiffness of edge girders shall be sufficient to maintain adequate sealing pressure between securing devices.

The moment of inertia I, in cm^4, of edge girders shall not be less than

$$I = 6qs_{SD}^4, \text{ in cm}^4, \qquad (7.10.6.20\text{-}2)$$

where: q − packing line pressure, in N/mm, min = 5 N/mm;
s_{SD} − spacing, in m, of securing devices.

7.10.6.21 Strength calculation for hatch covers may be carried out by either grillage analysis or FEM. Double skin hatch covers or hatch covers with box girders shall be using FEM, refer to **7.10.6.23**.

7.10.6.22 Cross-sectional properties shall be determined considering the effective breadth. Cross sectional areas of secondary stiffeners parallel to the primary supporting member under consideration within the effective breadth can be included, refer to Fig. 7.10.6.29-1.

The effective breadth of plating e_m of primary supporting members shall be determined according to Table 7.10.6.22, considering the type of loading.

Special calculations may be required for determining the effective breadth of one-sided or non-symmetrical flanges.

The effective cross sectional area of plates shall not be less than the cross sectional area of the face plate.

Table 7.10.6.22. **Effective breadth e_m of plating of primary supporting members**

l/e	0	1	2	3	4	5	6	7	≥ 8
e_{m1}/e	0	0,36	0,64	0,82	0/91	0,96	0,98	1,00	1,00
e_{m2}/e	0	0,20	0,37	0,52	0,65	0,75	0,84	0,89	0,90

e_{m1}- shall be applied where primary supporting members are loaded by uniformly distributed loads or else by not less than 6 equally spaced single loads.
e_{m2}- shall be applied where primary supporting members are loaded by 3 or less single loads.
Intermediate values may be obtained by direct interpolation.
l − length of zero-points of bending moment curve.
$l = l_0$− for simply supported primary supporting members.
$l = 0{,}6l_0$− for primary supporting members with both ends constraint, where
l_0 is the unsupported length of the primary supporting member:
e − width of plating supported, measured from centre to centre of the adjacent unsupported fields.

For flange plates under compression with secondary stiffeners perpendicular to the web of the primary supporting member, the effective width shall be determined according to **7.10.6.29**.

7.10.6.23 For strength calculations of hatch covers by means of finite elements, the cover geometry shall be idealized as realistically as possible. Element size shall be appropriate to account for effective breadth.

In no case element width shall be larger than stiffener spacing. In way of force transfer points and cutouts the mesh shall be refined, where applicable. The ratio of element length to width shall not exceed 4.

The element height of webs of primary supporting member shall not exceed one-third of the web height.

Stiffeners, supporting plates against pressure loads, shall be included in the idealization. Stiffeners may be modelled by using shell elements, plane stress elements or beam elements.

Buckling stiffeners may be disregarded for the stress calculation.

7.10.6.24 For hatch cover structures sufficient buckling strength shall be demonstrated (refer to Fig. 7.10.6.24).

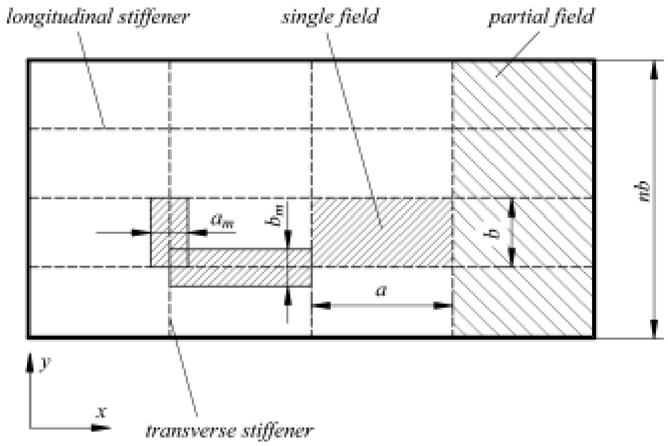


Fig. 7.10.6.24

Definitions in **7.10.6.24 ÷ 7.10.6.32**:

a – = length of the longer side of a single plate field, in mm (*x*-direction);
b – breadth of the shorter side of a single plate field, in mm (*y*-direction);
α – aspect ratio of single plate field $\alpha = a/b$;
n – number of single plate field breadths within the partial or total plate field;
t – net plate thickness, in mm;
σ_x – membrane stress, in N/mm^2, in *x*-direction;
σ_y – membrane stress, in N/mm^2, in *y*-direction;
τ – shear stress, in N/mm^2, in the x-y plane;
E – modulus of elasticity, in N/mm^2, of the material;
$E = 2{,}06\cdot10^5$, in N/mm^2, for steel;
σ_F – minimum yield stress, in N/mm^{2}of the material;
σ_e – reference stress, in N/mm^2, taken equal to:
$\sigma_e = 0{,}6\,E(t/b)^2$;
ψ – edge stress ratio taken equal to
$\psi = \sigma_1/\sigma_2$;
σ_1 – maximum compressive stress;
σ_2 – minimum compressive stress or tension stress
S – safety factor (based on net scantling approach), taken equal to:
S = 1,25 for hatch covers when subjected to the vertical weather design load according to **7.10.6.6**;
S = 1,10 for hatch covers when subjected to loads according to**7.10.6.8** and **7.10.6.14**;
λ – reference degree of slenderness, taken equal to;
$\lambda = (\sigma_F/K\sigma_c)^{0,5}$;
K – buckling factor according to 7.10.6.26.

Compressive and shear stresses shall be taken positive, tension stresses shall be taken negative.

If stresses in the *x*- and *y*-direction already contain the Poisson-effect (calculated using FEM), the following modified stress values may be used.

Both stresses σ_x* and σ_y* shall be compressive stresses, in order to apply the stress reduction according to the following formulae:

$$\sigma_x = (\sigma_x^* - 0{,}3\sigma_y^*)/0{,}91; \qquad (7.10.6.24\text{-}1)$$

$$\sigma_y = (\sigma_y^* - 0{,}3\,\sigma_x^*)/0{,}91, \qquad (7.10.6.24\text{-}2)$$

where:
σ_x^*, σ_y^* – stresses containing the Poisson-effect.

Where compressive stress fulfils the condition $\sigma_y^* < 0{,}3\ \sigma_x^*$, then $\sigma_y = 0$ and $\sigma_x = \sigma_x^*$.

Where compressive stress fulfils the condition $\sigma_x^* < 0{,}3\ \sigma_y^*$, then $\sigma_x = 0$ and $\sigma_y = \sigma_y^*$.

F_1 − correction factor for boundary condition at the longitudinal stiffeners according to Table 7.10.6.24.

***Table 7.10.6.24* Correction factor F_1**

	Correction factor F_1
Stiffeners sniped at both ends	1,00
Guidance values1 where both ends are effectively connected to adjacent structures	1,05 for flat bars 1,10 for bulb sections 1,20 for angle and tee-sections 1,30 for U-type sections[2] and girders of high rigidity
[1] Exact values may be determined by direct calculations. [2] Higher value may be taken if it is verified by a buckling strength check of the partial plate field using non-linear FEA and deemed appropriate by the individual classification society but not greater than 2,0.	

7.10.6.25 Proof shall be provided that the following condition is complied with for the single plate field *ab*:

$$\left(\frac{|\sigma_x|S}{k_x\sigma_F}\right)^{e1}+\left(\frac{|\sigma_y|S}{k_y\sigma_F}\right)^{e2}-B\left(\frac{\sigma_x\sigma_y S^2}{\sigma_F^2}\right)+\left(\frac{|\tau|S\sqrt{3}}{k_\tau\sigma_F}\right)^{e3}\leqslant 1{,}0. \qquad (7.10.6.25)$$

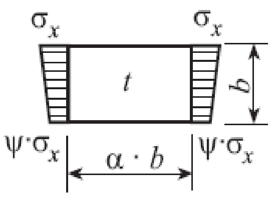
The first two terms and the last term of the above condition shall not exceed 1,0.
The reduction factors k_x, k_y and k_τ, are given in Table 7.10.6.26.
Where $\sigma_x \le 0$ ((tension stress), $k_x = 1{,}0$;
Where $\sigma_y \le 0$ ((tension stress), $k_y = 1{,}0$.
The exponents e_1, e_2, e_3, as well as the factor B shall be taken as given in Table 7.10.6.25.

***Table 7.10.6.25.* Coefficients e_1, e_2, e_3 and factor B**

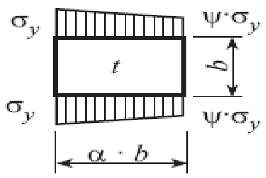
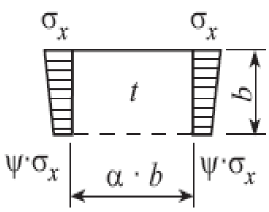
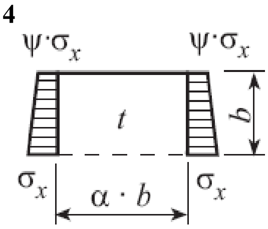
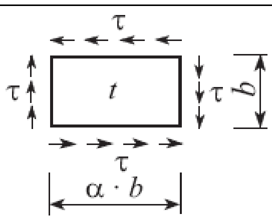
Exponents e_1, e_2, e_3, and factor B	**Plate panel**
e_1	$1+k_x^4$
e_2	$1+k_y^4$
e_3	$1+k_x k_y k_\tau^2$
B σ_x and σ_y − positive (compression stress)	$(k_x k_y)^5$
B σ_x and σ_y − negative (tension stress)	1

7.10.6.26 Buckling and reduction factors for plane elementary plate panels are given in Table 7.10.6.26.

Table 7.10.6.26

Buckling-load case	**Edge stress ratio [2]** ψ	**Factor[1]** $\alpha = a/b$	**Buckling factor[3]** K	**Reduction factor** k
1	**2**	**3**	**4**	**5**
1 	$1 \ge \psi \ge 0$	$\alpha \ge 1$	$K = 8{,}4/(\psi + 1{,}1)$	$k_x = 1$, for $\lambda \le \lambda_c$ $k_x = c[(1/\lambda)-(0{,}22/\lambda^2)]$, for $\lambda > \lambda_c$ $c = (1{,}25-0{,}12\psi) \le 1{,}25$ $\lambda_c = 0{,}5c\{1+[1-(0{,}88/c)]^{1/2}\}$
	$0 > \psi > -1$		$K = 7{,}63-\psi(6{,}26-10\psi)$	
	$\psi \le -1$		$K = 5{,}975(1-\psi)^2$	

Continue of Table 7.10.6.26

Buckling-load case	**Edge stress ratio** [2] ψ	**Factor**[1] $\alpha = a/b$	**Buckling factor**[3] K	**Reduction factor** k
1	**2**	**3**	**4**	**5**
2 	$1 \geq \psi \geq 0$	$\alpha \geq 1$	$K = F_1\,[1+(1/\alpha^2)]^2 \times$ $\times [2{,}1/(\psi+1{,}1)]$	$k_y = c\{(1/\lambda) - \{[R+F^2(H-R)]/\lambda^2\}$ $c = (1{,}25 - 0{,}12\psi) \leq 1{,}25$ $R = \lambda[1-(\lambda/c)]$, for $\lambda < \lambda_c$ $R = 0{,}22$, for $\lambda \geq \lambda_c$ $\lambda_c = 0{,}5c\{1+[1-(0{,}88/c)]^{1/2}\}$ $F = \{1-\{[(K/0{,}91)-1]/\lambda_p^2\}\}\, c_1 \geq 0$ $\lambda_p^2 = \lambda^2 - 0{,}5$, for $1 \leq \lambda_p^2 \leq 3$; $c_1 = [1-(F_1/\alpha)] \geq 0$, $H = \lambda - \{2\lambda/\{c \times [T+(T^2-4)^{1/2}]$ $T = \lambda + (14/15\lambda) + (1/3)$
	$0 > \psi > -1$	$1 \leq \alpha \leq 1{,}5$	$K = F_1\,\{[1+(1/\alpha^2)]^2 \times$ $\times [2{,}1(1+\psi)/1{,}1] -$ $-[(\psi/\alpha^2) \times (13{,}9-10\psi)]\}$	
		$\alpha > 1{,}5$	$K = F_1\,\{[1+(1/\alpha^2)]^2 \times$ $\times [2{,}1(1+\psi)/1{,}1] - (\psi/\alpha^2) \times$ $x[5{,}87+1{,}87\alpha^2+(8{,}6/\alpha^2)-10\psi]\}$	
	$\psi \leq -1$	$1 \leq \alpha \leq$ $\leq 3(1-\psi)/4$	$K = F_1[(1-\psi)/\alpha]^2 \times 5{,}975$	
		$\alpha >$ $> 3(1-\psi)/4$	$K = F_1\{[(1-\psi)/\alpha]^2 \times 3{,}9675 +$ $+0{,}5375[(1-\psi)/\alpha]^4 + 1{,}87\}$	
3 	$1 \geq \psi \geq 0$	$\alpha > 0$	$K = 4[0{,}425+(1/\alpha^2)]/(3\psi+1)$	$K_x = 1$, for $\lambda \leq 0{,}7$ $K_x = 1/(\lambda^2+0{,}51)$, for $\lambda > 0{,}7$
	$0 > \psi > -1$		$K = 4[0{,}425+(1/\alpha^2)] \times (1+\psi) -$ $-5\psi\,(1-3{,}42\psi)$	
4 	$1 \geq \psi \geq -1$	$\alpha > 0$	$K = [0{,}425+(1/\alpha^2)] \times (3-\psi)/2$	
5 	-		$K = K_\tau\sqrt{3}$	$k_\tau = 1$, for $\lambda \leq 0{,}84$ $k_\tau = 0{,}84/\lambda$, for $\lambda > 0{,}84$
		$\alpha \geq 1$	$K_\tau = (5{,}34 + 4/\alpha^2)$	
		$0 < \alpha < 1$	$K_\tau = (4 + 5{,}34/\alpha^2)$	

Explanation for boundary conditions: ------- plate edge free
▬▬▬ plate edge simply supported

[1] Factor $\alpha = a/b$ – dimension ratio $\alpha = a/b$.
[2] Edge stress ratio considering unevenness of plate edge compression.
[3] Buckling factor K depending on the plate loading and side ratio $\alpha = a/b$.

7.10.6.27 For non-stiffened webs and flanges of primary supporting members not supported by stiffeners, sufficient buckling strength as for the hatch cover top and lower plating shall be demonstrated according to **7.10.6.25**.

7.10.6.28 It shall be demonstrated that the continuous longitudinal and transverse stiffeners of partial and total plate fields comply with the conditions set out in **7.10.6.30** and **7.10.6.31**.

For U-type stiffeners, the proof of torsional buckling strength according to **7.10.6.31** can be omitted.

Single-side welding is not permitted to use for secondary stiffeners except for U-stiffeners.

7.10.6.29 For demonstration of buckling strength according to **7.10.6.30** and **7.10.6.31**, the effective width of plating may be determined by the following formulae:

$b_m = k_x b$ − for longitudinal stiffeners; (7.10.6.29-1)

$a_m = k_y a$ − for transverse stiffeners; (7.10.6.29-2)

refer also to Fig. 7.10.6.24.

The effective width of plating shall not be taken greater than the value obtained from **7.10.6.22**.

The effective width e'_m of stiffened flange plates of primary supporting members may be determined as follows:

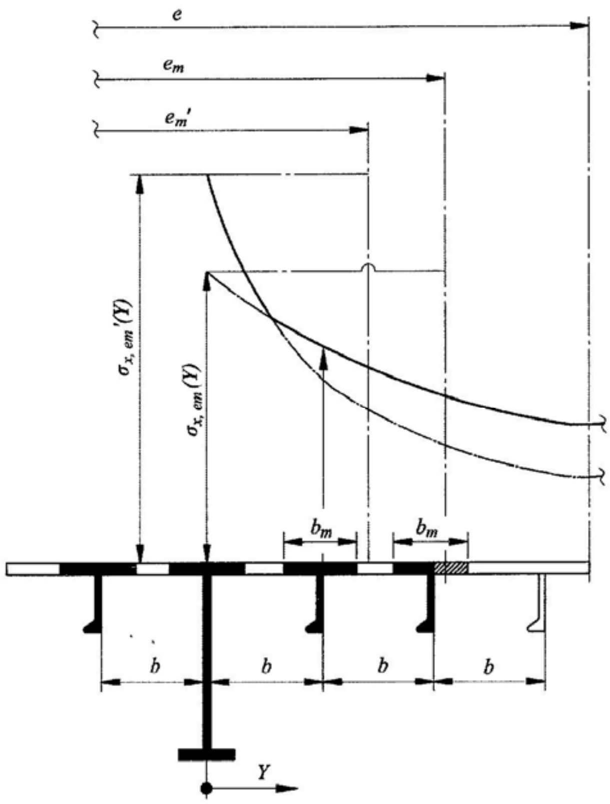


Fig. 7.10.6.29-1. Stiffening parallel to web of primary supporting member

$b < e_m$;

$e'_m = nb_m$;

n − integer number of stiffener spacings b inside the effective breadth e_m according to **7.10.6.22**.

$n = e_m/b$ (is rounded to the nearest integer).

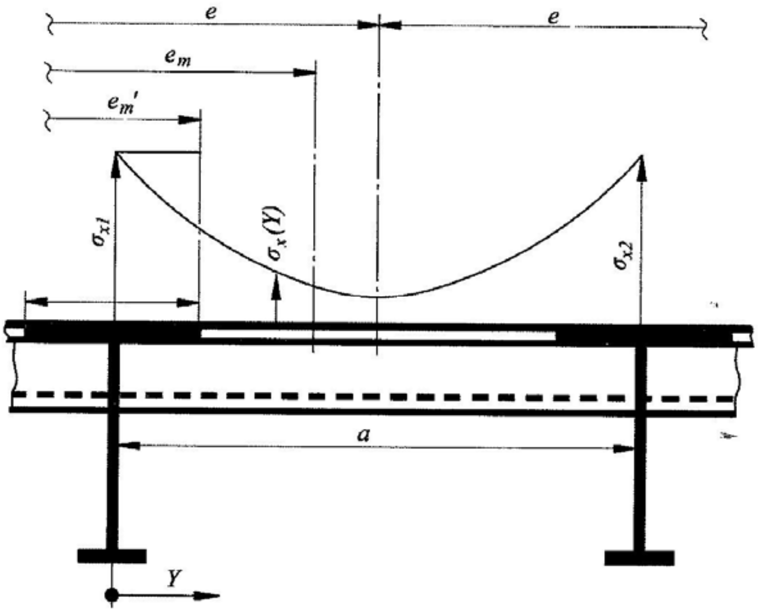


Fig. 7.10.6.29-2. Stiffening perpendicular to web of primary supporting member

$a \geq e_m$;
$e'_m = na_m < e_m$;
$n = 2{,}7(e_m/a) \leq 1$;
e − width of plating supported according to **7.10.6.22**.
For $b \geq e_m$ or $a < e_m$, respectively, b and a shall be exchanged.
a_m and b_m for flange plates shall be in general determined for $\psi = 1$.

Note. Scantlings of plates and stiffeners shall be in general determined according to the maximum stresses $\sigma_x(y)$ at webs of primary supporting member and stiffeners, respectively.

For stiffeners with spacing b under compression arranged parallel to primary supporting members, no value less than $0{,}25\sigma_F$ shall be inserted for $\sigma_x (y = b)$.

The stress distribution between two primary supporting members can be obtained by the following formulae:

$$\sigma_x(y) = \sigma_{x1}\{1 - \frac{y}{e}[3 + c_1 - 4c_2 - 2\frac{y}{e}(1 + c_1 - 2c_2)]\};$$

$$c_1 = \sigma_{x2}/\sigma_{x1};\ 0 \leqslant c_1 \leqslant 1; \qquad (7.10.6.29\text{-}3)$$

$$c_2 = \frac{1{,}5}{e}(e''_{m1} + e''_{m2}) - 0{,}5;$$

where:

e''_{m1} − proportionate effective breadth em1 or proportionate effective width e'_{m1} of primary supporting member 1 within the distance e, as appropriate;

e''_{m2} − proportionate effective breadth e_{m2} or proportionate effective width e'_{m2} of primary supporting member 2 within the distance e, as appropriate;

σ_{x1}, σ_{x2} − normal stresses in flange plates of adjacent primary supporting member 1 and 2 with spacing e, based on cross-sectional properties considering the effective breadth (e_{m1}, e_{m2}) or effective width (e'_{m1}, e'_{m2}), as appropriate;

y - distance of considered location from primary supporting member 1.

Shear stress distribution in the flange plates may be assumed linearly.

7.10.6.30 Lateral buckling of secondary stiffeners shall be the following:

$$(\sigma_a + \sigma_b)(S/\sigma_F) \leq 1, \qquad (7.10.6.30)$$

where: σ_a − uniformly distributed compressive stress, in N/mm^2, in the direction of the stiffener axis;
$\sigma_a = \sigma_x$ − for longitudinal stiffeners;
$\sigma_a = \sigma_y$ − for transverse stiffeners;
σ_b − bending stress, in N/mm^2, in the stiffener;
$\sigma_b = (M_0 + M_1)/Z \cdot 10^3$;

M_0 − bending moment, in N·mm, due to the deformation w of stiffener, taken equal to:

$M_0 = F_{Ki} p_z w/(c_f - p_z)$, with $(c_f - p_z) > 0$;

M_1 − bending moment, in N·mm, due to the lateral load p equal to:

$M_1 = pba^2/(24 \cdot 10^3)$ − for longitudinal stiffeners;
$M_1 = pa(nb)^2/(c_s 8 \cdot 10^3)$ − for transverse stiffeners;
n shall be equal to l for ordinary transverse stiffeners;
p − lateral load, in N/mm^2;
F_{Ki} − = ideal buckling force, in N, of the stiffener;
$F_{Kix} = (\pi^2/a^2)EI_x \cdot 10^4$ − for longitudinal stiffeners;
$F_{Kiy} = [\pi^2/(nb)^2]EI_y \cdot 10^4$ − for transverse stiffeners;
I_x, I_y − net moments of inertia, in cm^4, of the longitudinal or transverse stiffener, including effective width of attached plating according to **7.10.6.29**. I_x and I_y shall comply with the following criteria:

$I_x \geq bt^3/(12 \cdot 10^4)$;

$I_y \geq at^3/(12 \cdot 10^4)$;

p_z − nominal lateral load, in N/mm^2, of the stiffener due to σ_x, σ_y and σ_τ;
$p_{zx} = (t/b)[\sigma_{x1}(\pi b/a)^2 + 2c_y\sigma_y + \sqrt{2\tau_1}]$ − for longitudinal stiffeners;
$p_{zy} = (t/a)[2c_x\sigma_{x1} + \sigma_y(\pi a/nb)^2 \cdot (1 + A_y/at) + \sqrt{2\tau_1}]$ − for transverse stiffeners;
$\sigma_{x1} = \sigma_x [1 + (A_x/bt)]$;
c_x, c_y − factors taking into account the stresses perpendicular to the stiffener's axis and distributed variable along the stiffener's length;
$c_x, c_y = 0,5(1+\psi)$ for $0 \leq \psi \leq 1$;
$c_x, c_y = 0,5/(1-\psi)$ for $\psi < 0$;
A_x, A_y − net sectional area, in mm^2, of the longitudinal or transverse stiffener, respectively, without attached plating;

$$\tau_1 = [\tau - t\sqrt{\sigma_F E(m_1/a^2 + m_2/b^2)}] \geq 0;$$

− for longitudinal stiffeners:

$a/b \geq 2,0$: $m_1 = 1,47$ $m_2 = 0,49$;
$a/b < 2,0$: $m_1 = 1,96$ $m_2 = 0,37$;
− for transverse stiffeners:

$a/nb \geq 0,5$: $m_1 = 0,37$ $m_2 = 1,96/n^2$;
$a/nb < 0,5$: $m_1 = 0,49$ $m_2 = 1,47/n^2$;
$w = w_0 + w_1$;
w_0 − assumed imperfection, in mm;
$w_{0x} \leq \min(a/250,\ b/250,\ 10)$ − for longitudinal stiffeners;
$w_{0y} \leq \min(a/250,\ nb/250,\ 10)$ − for transverse stiffeners.

Note. For stiffeners sniped at both ends w_0 shall not be taken less than the distance from the midpoint of plating to the neutral axis of the profile including effective width of plating.

w_1 − deformation of stiffener, in mm, at midpoint of stiffener span due to lateral (transverse) load p.
In case of uniformly distributed load the following values for w_1 may be used:

$w_1 = pba^4/(384 \cdot 10^7 EI_x)$ − for longitudinal stiffeners;

$w_1 = 5pa(nb)^4/(384 \cdot 10^7 EI_y c_s^2)$ − for transverse stiffeners;
c_f − elastic support provided by the stiffener, in N/mm^2;

− for longitudinal stiffeners:

$c_{fx} = F_{Kix}(\pi^2/a^2)(1 + c_{px})$;

$$c_{px} = \frac{1}{1 + \dfrac{0{,}91\left(\dfrac{12 \times 10^4 I_x}{t^3 b} - 1\right)}{c_{xa}}};$$

$c_{xa} = [(a/2b) + (2b/a)]^2$, for $a \geq 2b$;
$c_{xa} = [1 + (a/2b)^2]^2$, for $a < 2b$;

− for transverse stiffeners:

$c_{fy} = c_s F_{Kiy} (1 + c_{py})\pi^2/(nb)^2$;

$$c_{py} = \frac{1}{1 + \dfrac{0{,}91\left(\dfrac{12 \times 10^4 I_y}{t^3 a} - 1\right)}{c_{ya}}};$$

$c_{ya} = [(nb/2a) + (2a/nb)]^2$, for $nb \geq 2a$;
$c_{ya} = [1 + (nb/2a)^2]^2$, for $nb < 2a$;
c_s − factor accounting for the boundary conditions of the transverse stiffener;
$c_s = 1{,}0$ − for simply supported stiffeners;
$c_s = 2{,}0$ − for partially constraint stiffeners;
z_{st} − net section modulus of stiffener (longitudinal or transverse), in cm^3, including effective width of plating according to **7.10.6.29**.

If no lateral load p is acting, the bending stress σ_b shall be calculated at the midpoint of the stiffener span for that fibre, which results in the largest stress value.

If a lateral load p is acting, the stress calculation shall be carried out for both fibres of the stiffener's cross sectional area (if necessary for the biaxial stress field at the plating side).

7.10.6.31 The longitudinal secondary stiffeners shall comply with the following criteria:

$$(\sigma_x S / k_T \sigma_F) \leq 1{,}0, \qquad (7.10.6.31)$$

where: k_T − coefficient taken equal to
$k_T = 1{,}0$, for $\lambda_T \leq 0{,}2$;
$k_T = 1/[\Phi + (\Phi^2 - \lambda_T^2)^{0{,}5}]$, for $\lambda_T > 0{,}2$;
$\Phi = 0{,}5[1 + 0{,}21(\lambda_T - 0{,}2) + \lambda_T^2]$;
λ_T − reference degree of slenderness taken equal to;
$\lambda_T = (\sigma_F/\sigma_{KiT})^{0{,}5}$;
$\sigma_{KiT} = (E/I_P)\,[(\pi^2 I_\omega \cdot 10^2/a^2)\varepsilon + 0{,}385\, I_T]$,Н/мм^2;
for I_P, I_T, I_ω − refer to Fig. 7.10.6.31 and Table 7.10.6.31.
I_p - net polar moment of inertia of the stiffener, in cm^4, related to the point C;
I_T - net St. Venant's moment of inertia of the stiffener, in cm^4;
I_ω − net sectorial moment of inertia of the stiffener, in cm^6, related to the point C;
ε − degree of fixation taken equal to:

$$\varepsilon = 1 + 10^{-3} \sqrt{\frac{a^4}{\frac{3}{4}\pi^4 I_\omega (b/t^3 + 4h_w/3t_w^3)}},$$

h_w − web height, in mm;
t_w − net web thickness, in mm;
b_f − flange breadth, in mm;
t_f − net flange thickness, in mm;
A_w − net web area equal to:
$A_w = h_w \cdot t_w$;
A_f − net flange area equal to:
$A_f = b_f \cdot t_f$;
$e_f = h_w + t_f/2$, in mm.

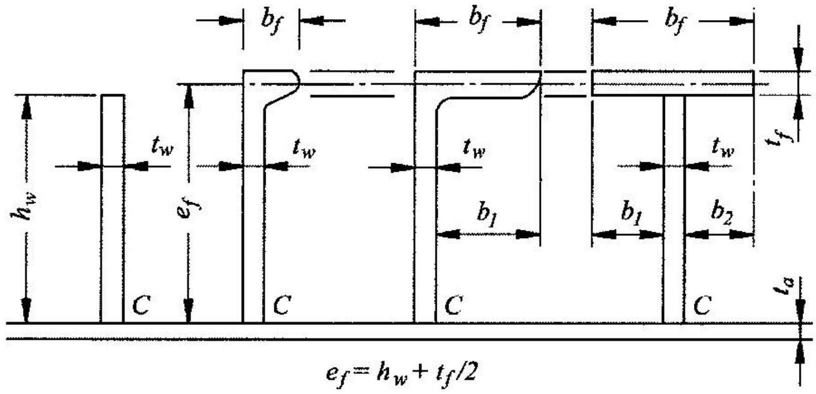


Fig. 7.10.6.31 Dimensions of stiffener

***Table 7.10.6.31.* Moments of inertia**

Section	I_p	I_T	I_ω
Flat bar	$(h^3_w t_w)/(3\times10^4)$	$(h_w t^3_w)/(3\times10^4)[1-0,63(t_w/h_w)]$	$(h^3_w t_w)/(36\times10^6)$
Sections with bulb or flange	$[(A_w h^2_w/3)+A_f e^2_f]10^{-4}$	$(h_w t^3_w)/(3\times10^4)[1-0,63(t_w/h_w)]+$ $(b_f t^3_f)/(3\times10^4)[1-0,63(t_f/b_f)]$	for bulb and angle sections: $\frac{A_f e_f^2 b_f^2}{12\times10^6}\left(\frac{A_f+2,6A_W}{A_f+A_W}\right)$ for tee-sections: $(t_f e^2_f b^3_f)/(12\times10^6)$

7.10.6.32 or transverse secondary stiffeners loaded by compressive stresses, which are not supported by longitudinal stiffeners, sufficient torsional buckling strength shall be demonstrated according to**7.10.6.31**.

7.10.6.33 Securing and arrangement of containers on the hatch covers shall comply with the technical requirements for the arrangement and securing of the international standard containers on board the ships intended for container transportation.

Structures under container load shall be calculated according to **7.10.6.5** ÷ **7.10.6.13** using the permissible stresses as per**7.10.6.14**.

7.10.6.34 To ensure weather tightness, the provisions of IACS recommendation No. 14 applicable to hatch covers shall be met.

The packing material of hatch covers gaskets shall be suitable for all expected service conditions of the ship and shall be compatible with the cargoes to be transported.

The packing material shall be selected with regard to dimensions and elasticity in such a way that expected deformations can be carried. Forces shall be carried by the steel structure only.

The packings shall be compressed so as to give the necessary tightness effect for all expected operating conditions. Special consideration shall be given to the packing arrangement in ships with large relative movements between hatch covers and coamings or between hatch cover sections.

7.10.6.35 For hatch covers of cargo holds solely for the transport of containers, at the shipowner's request and subject to compliance with the following conditions, the fitting of weather tight gaskets mentioned in **7.10.6.34** may be dispensed with:

the hatchway coamings shall be not less than 600 mm in height;

the exposed deck, on which the hatch covers are located is situated above a depth $H(x)$,

$H(x)$ shall be shown to comply with the following criteria:

$$H(x) \geq T_{fb} + f_b + h, \text{ м} \qquad (7.10.6.35)$$

wher: T_{fb} − draught, in m, corresponding to the assigned summer load line;

f_b − minimum required freeboard, in m, determined in accordance with regulation **4.1** of the International Load Line Convention, as amended, where applicable;

h = 4,6 m for $x/L_{LL} \leq 0,75$;

h = 6,9 m for x/L_{LL} > 0,75.

Labyrinths, gutter bars or equivalents shall be fitted proximate to the edges of each panel in way of the coamings. The clear profile of these openings shall be kept as small as possible.

Where a hatch is covered by several hatch cover panels, the clear opening of the gap in between the panels shall be not wider than 50 mm.

The labyrinths and gaps between hatch cover panels shall be considered as unprotected openings with respect to the requirements of intact and damage stability calculations.

Bilge alarms shall be provided in each hold fitted with non-weathertight covers.

Furthermore, Chapter **3** of IMO circular MSC/Circ. 1087 shall be referred to concerning the stowage and segregation of containers containing dangerous goods.

7.10.6.36 Cross-joints of multi-panel covers shall be provided with efficient drainage arrangements.

7.10.6.37 The net thickness of weather deck hatch coamings shall not be less than that determined by the following formulae:

$$t = 14{,}2s(p_A/0{,}95\sigma_F)^{0{,}5}, \text{ in mm;} \qquad (7.10.6.37\text{-}1)$$

$$t_{\min} = 6 + L_1/100, \text{ in mm,} \qquad (7.10.6.37\text{-}2)$$

where: s − stiffener spacing, in m;
$L_1 = L$, need not be taken grater than 300 m.

Strength aspects of longitudinal hatch coamings shall meet the requirements of **1.6.5**, Part II "Hull".

7.10.6.38 The stiffeners shall be continuous at the coaming stays. For stiffeners with both ends constraint, the elastic net section modulus Z, in cm^3, and net shear area A_s, in cm^2, calculated on the basis of net thickness, shall not be less than:

$$Z = (83/\sigma_F)\, p_A s l^2; \qquad (7.10.6.38\text{-}1)$$

$$A_s = (10/\sigma_F)\, p_A s l, \qquad (7.10.6.38\text{-}2)$$

where:
s − secondary stiffener span, in m, to be taken as the spacing of coaming stays;
l − = stiffener spacing, in m.

For sniped stiffeners at coaming corners section modulus and shear area at the fixed support shall be increased by 35 %.

The thickness of the coaming plate at the sniped stiffener end shall not be less than those defined as per the formula:

$$t = 19{,}6[(p_A s(l - 0{,}5s)/\sigma_F]^{0{,}5}, \text{ in mm} \qquad (7.10.6.38\text{-}3)$$

Horizontal stiffeners on hatch coamings, which are part of the longitudinal hull structure, shall be designed according to the requirements in **1.6.5**, Part II "Hull".

7.10.6.39 Coaming stays shall be designed for the loads transmitted through them and permissible stresses according to **7.10.6.14**.

At the connection of the coaming stays with deck (refer to Figs. 7.1.6.39-1 and 7.1.6.39-2), the net section modulus Z, in cm^3, shall be taken not less than:

$$Z = (526/\sigma_F) \cdot p_A \cdot e \cdot h_s^2, \text{ in cm} \qquad (7.10.6.39)$$

where: e − spacing of coaming stays, in m;
h_s – height of coaming stays, in m.

For other designs of coaming stays, such as those shown in Figs. 7.10.6.39-3 and 7.10.6.39-4, the stresses shall be determined through a grillage analysis or FEM. The calculated stresses shall comply with the permissible stresses according to **7.10.6.14**.

Coaming stays shall be supported by appropriate substructures. Face plates may only be included in the calculation if an appropriate substructure is provided and welding provides an adequate joint

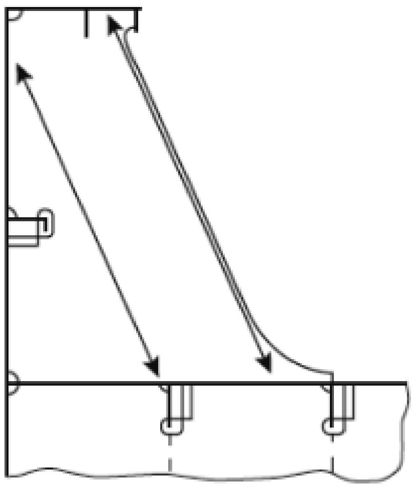


Fig. 7.10.6.39-1

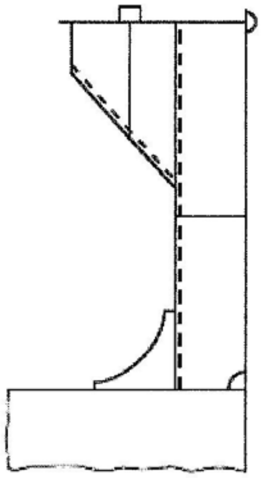


Fig. 7.10.6.39-2

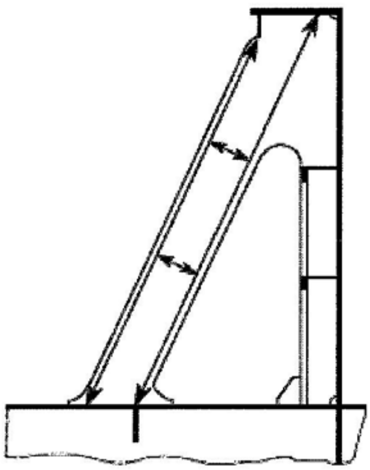


Fig. 7.10.6.39-3

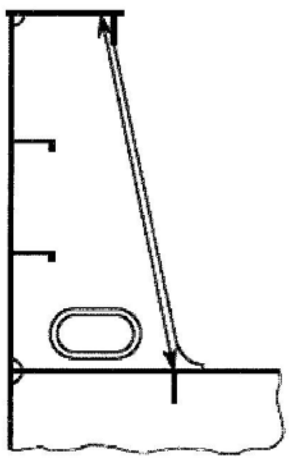


Fig. 7.10.6.39-4

7.10.6.40 0 Web gross thickness t_w, at the root point shall not be less than

$$t_w = (2/\sigma_F)(p_A e h_s/h_w) + t_s, \quad (7.10.6.40)$$

where: h_w – web height of coaming stay at its lower end, in m;
t_s – corrosion addition, in mm, according to**7.10.6.52**.

Coaming stays shall be connected to the deck by fillet welds on both sides with a throat thickness of a = 0,44 t_w.

7.10.6.41 Hatch coamings which are part of the longitudinal hull structure shall be designed according to the requirements of **1.6.5**, Part II "Hull".

Longitudinal hatch coamings with a length exceeding 0,1L shall be provided with tapered brackets or equivalent transitions and a corresponding substructure at both ends.

At the end of the brackets they shall be connected to the deck by full penetration welds of minimum 300 mm in length.

7.10.6.42 Hatch coamings and supporting structures shall be adequately stiffened to accommodate the loading from hatch covers, in longitudinal, transverse and vertical directions. Structures under deck shall be checked against the load transmitted by the stays.

Structures under deck shall be checked against the load transmitted by the stays.

Unless otherwise stated, weld connections shall be dimensioned according to **1.7**, Part II "Hull" and materials shall be selected according to **2.2**, Part XIV "Welding".

7.10.6.43 On ships carrying cargo on deck, such as timber, coal or coke, the stays shall be spaced not more than 1,5 m apart.

Coaming plates shall extend to the lower edge of the deck beams or hatch side girders shall be fitted that extend to the lower edge of the deck beams. Extended coaming plates and hatch side girders shall be flanged or fitted with face bars or half-round bars. Fig. 7.10.6.43 gives an example.

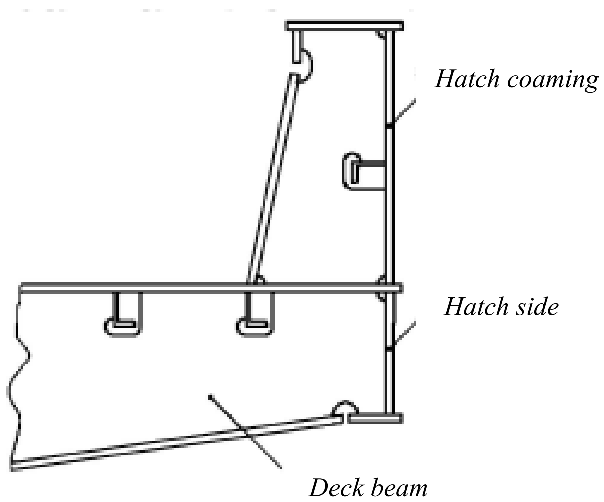


Fig. 7.10.6.43

7.10.6.44 If drain channels are provided inside the line of gasket by means of a gutter bar or vertical extension of the hatch side and end coaming, drain openings shall be provided at appropriate positions of the drain channels.

Drain openings in hatch coamings shall be arranged with sufficient distance to areas of stress concentration (e.g. hatch corners, transitions to crane posts).

Drain openings shall be arranged at the ends of drain channels and shall be provided with non-return valves to prevent ingress of water from outside. It is unacceptable to connect fire hoses to the drain openings for this purpose.

If a continuous outer steel contact between cover and ship structure is arranged, drainage from the space between the steel contact and the gasket shall be also provided.

7.10.6.45 Securing devices between cover and coaming and at cross-joints shall be installed to provide weathertightness.

Securing devices shall be appropriate to bridge displacements between cover and coaming due to hull deformations. These devices shall be of reliable construction and effectively attached to the hatchway coamings, decks or covers. Individual securing devices on each cover shall have approximately the same stiffness characteristics.

Sufficient number of securing devices shall be provided at each side of the hatch cover considering the requirements of **7.10.6.20**; this applies also to hatch covers consisting of several parts.

7.10.6.46 Where rod cleats are fitted, resilient washers or cushions shall be incorporated.

Where hydraulic cleating is adopted, positive means shall be provided so that it remains mechanically locked in the closed position in the event of failure of the hydraulic system.

7.10.6.47 The gross sectional area, in cm^2, shall not be less than that defined by the formula

$$A = 0{,}28 q s_{SD} k_l, \qquad (7.10.6.47)$$

where: q − packing line pressure, in N/mm, minimum 5 N/mm;

s_{SD} − spacing between securing devices, in m, but not less than 2 m;

$k_l = (235/\sigma_F)^e$;

σ_F − minimum yield strength of the material, in N/mm^2, but not greater than $0{,}7\sigma_m$, where σ_m - is the tensile strength of the material, in N/mm^2;

e − 0,75 for $\sigma_F > 235$ N/mm^2;

e − 1,00 for $\sigma_F \leq 235$ N/mm^2.

For hatchways exceeding 5 m^2, rods and bolts shall have a gross diameter no less than 19 mm.

Securing devices of special design in which significant bending or shear stresses occur may be designed as anti-lifting devices according to **7.10.6.48**.

As load the packing line pressure q multiplied by the spacing between securing devices s_{SD} shall be applied.

7.10.6.48 The securing devices of hatch covers, on which cargo is lashed, shall be designed for the lifting forces resulting from loads according to **7.10.6.11** ÷ **7.10.6.13**, refer to Fig. 7.10.6.48.

Unsymmetrical loadings, which may occur in practice, shall be considered. Under these loadings the equivalent stress in the securing devices shall not exceed

$$\sigma_V = 150/k_l, \ \text{N/mm}^2 \qquad (7.10.6.48)$$

Note. The partial load cases given in Table 7.10.6.12 may not cover all unsymmetrical loadings, critical for hatch cover lifting.

Chapter 5.6 of IACS Recommendation No. 14 shall be referred to for the omission of anti-lifting devices.

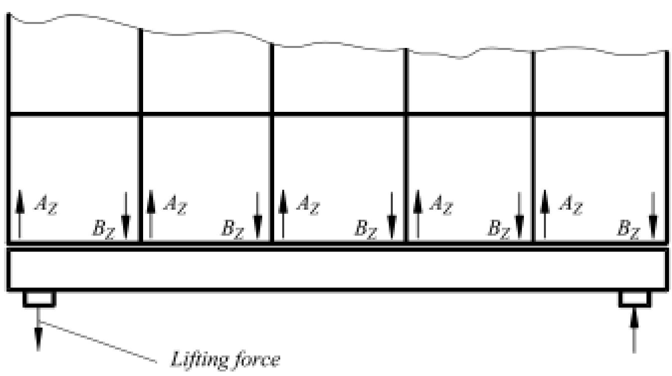


Fig. 7.10.6.48. Lifting forces at a hatch cover

7.10.6.49 For the design of the hatch cover supports, the horizontal mass forces $F_h = ma$ shall be calculated with the following accelerations:

$a_x = 0,2g$ in longitudinal direction;

$a_y = 0,2g$ in transverse direction;

m – sum of mass of cargo lashed on the hatch cover and mass of hatch cover.

The accelerations in longitudinal direction and in transverse direction do not need to be considered as acting simultaneously.

7.10.6.50 For the transmission of the support forces resulting from the load cases specified in **7.10.6.5** ÷ **7.10.6.13**, and of the horizontal mass forces specified in **7.10.6.49**, supports shall be provided which shall be designed such that the nominal surface pressures in general do not exceed the following values:

$$p_{n\max} = dp_n, \text{ N/mm}^2, \quad (7.10.6.50\text{-}1)$$

where: $d = 3,75 - 0,015L$;

$d_{\max} = 3,0$;

$d_{\min} = 1,0$ in general;

$d_{\min} = 2,0$ for partial loading conditions, refer to **7.10.6.12**;

p_n– refer to Table 7.10.6.50.

Table 7.10.6.50 . **Permissible nominal surface pressure p_n**

Support material	p_n, in N/mm^2, when loaded by	
	vertical force	horizontal force (on stoppers)
Hull structural steel	25	40
Hardened steel	35	50
Lower friction materials	50	–

For metallic supporting surfaces not subjected to relative displacements, the nominal surface pressure shall be calculated by the formula:

$$p_{n\max} = 3p_n, \text{ N/mm}^2. \quad (7.10.6.50\text{-}2)$$

Where large relative displacements of the supporting surfaces are expected, the use of material having low wear and frictional properties is recommended.

The substructures of the supports shall be of such a design, that a uniform pressure distribution is achieved.

Irrespective of the arrangement of stoppers, the supports shall be able to transmit the following force P_h in the longitudinal and transverse directions:

$$P_h = \mu\, P_V / \sqrt{d}. \quad (7.10.6.50\text{-}3)$$

where: P_V – vertical supporting force;

μ – frictional coefficient, in general equal to 0,5.

For non-metallic, low-friction support materials on steel, the friction coefficient may be reduced but not to be less than 0,35.

Supports as well as the adjacent structures and substructures shall be designed such that the permissible stresses according to **7.10.6.14** are not exceeded.

7.10.6.51 Hatch covers shall be sufficiently secured against horizontal shifting. Stoppers shall be provided for hatch covers, on which cargo is carried.

The greater of the loads resulting from **7.10.6.8** and **7.10.6.49** shall be applied for the dimensioning of the stoppers and their substructures.

The permissible stress in stoppers, their substructures, in the cover, and of the coamings shall be determined according to **7.10.6.14**; in addition, the provisions in **7.10.6.50** shall be observed.

7.10.6.52 Corrosion additions (corrosion allowance) t_s, in mm, for hatch covers and hatch coamings are given in Table **7.10.6.52**.

Table 7.10.6.52. **Corrosion additions t_s, for hatch covers and hatch coamings**

Application	Structure	t_s, in mm,
Weather deck hatches of container ships, car carriers, paper carriers, passenger vessels	Hatch covers	1,0
	Hatch coamings	According to **1.1.5.1**, Part II "Hull"
Weather deck hatches of all other ship types	Hatch covers in general	2,0
	Weather exposed plating and bottom plating of double skin hatch covers	1,5
	Internal structure of double skin hatch covers and closed box girders (hollow beams)	1,0
	Hatch coamings not part of the longitudinal hull structures	1,5
	Hatch coamings part of the longitudinal hull structures	According to **1.1.5.1**, Part II "Hull"
	Coaming stays and stiffeners	1,5

7.10.6.53 Steel renewal is required where the gauged thickness is less than t_{net} + 0,5 mm for:
single skin hatch covers;
the plating of double skin hatch covers, and
coaming structures the corrosion additions t_s of which are provided in Table 7.10.6.52.

Where the gauged thickness is within the range t_{net} + 0,5 mm to t_{net} + 1,0 mm, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal. Coating shall be maintained in GOOD condition, as defined in 1.2, IACS UR Z10.2 (Rev.36 May 2019).

For the internal structure of double skin hatch covers, thickness gauging is required when hatch cover top or bottom plating renewal shall be carried out or when this is deemed necessary, at the discretion of the surveyor to the Register, on the basis of the plating corrosion or deformation condition. In these cases, steel renewal for the internal structures is required where the gauged thickness is less than t_{net}.

For corrosion addition t_s = 1,0 mm, the thickness for steel renewal is t_{net}, and the thickness for coating or annual gauging is when gauged thickness is between t_{net} and t_{net} + 0,5 mm.

For coaming structures, the corrosion additions t_s of which are not provided in Table 7.10.6.52 shall be in compliance with the requirements of **1.1.5** Part II "Hull".

7.11 HATCHWAYS OF CARGO TANKS IN TYPE "A" SHIPS, OIL TANKERS, OIL TANKERS (>60ºC), OIL RECOVERY SHIPS AND OIL RECOVERY SHIPS (>60ºC)

7.11.1 Height of the coamings of cargo tank hatchways intended for the carriage liquid cargoes is not regulated by the Register. Construction of the coamings of cargo tank hatchways shall comply with the requirements of **3.5.5.1**, Part II "Hull".

7.11.2 Covers of hatches and tank cleaning openings shall be made of steel, bronze or brass.

7.11.3 Covers of the cargo tank hatchways shall be permanently attached or fixed with closely spaced bolts and tight, when secured, under the inner pressure of liquid carried in tanks to a head of not less than 2,5 m. Tightness shall be provided by a rubber or other suitable gasket being resistant to the liquids which are carried in the cargo tanks.

7.12 OPENINGS IN WATERTIGHT SUBDIVISION BULKHEADS AND THEIR CLOSING APPLIANCES

7.12.1 General.

7.12.1.1 Unless expressly provided otherwise, this Chapter covers ships to which the requirements of

Part V "Subdivision" apply.

For other ships, the requirements of this Chapter apply to bulkheads which installation is covered by **2.7.1.3** of Part II "Hull"; for these ships, the requirements may be relaxed provided the analysis confirming safety of the ship has been submitted.

In ships indicated in **7.12.6.1**, the requirements of **7.12.2 ÷ 7.12.5** may be relaxed for doors fitted in watertight subdivision bulkheads dividing a cargo space from an adjoining cargo space provided the requirements of **7.12.6** are met.

7.12.1.2 The number of openings in watertight bulkheads shall be reduced to a minimum compatible with the design and normal service conditions of the ship.

7.12.1.3 Where piping and electric cables are carried through watertight subdivision bulkheads, the requirements of **5.1**, Part VIII "Systems and Piping" and of **16.8.6**, Part XI "Electrical Equipment" shall be taken into consideration.

7.12.2 Doors in watertight subdivision bulkheads. General.

7.12.2.1 The doors shall be made of steel. The use of other materials may be allowed provided it is confirmed by calculations and tests that they have a strength at least equivalent to that of the doors made of steel.

7.12.2.2 Doors shall withstand the pressure of a water head of the height measured from the lower edge of a doorway at the place of its location to the underside of bulkhead deck plating, the freeboard or the most adverse damage waterline, whichever is greater.

7.12.2.3 Under the effect of water head specified in **7.12.2.2**, the stresses in the door frame and door plate shall not exceed 0,6 times the upper yield stress of their material.

7.12.2.4 When closed, the doors shall be tight under the pressure of a water head of the height specified in **7.12.2.2**.

7.12.2.5 Each means of operation of the doors shall alone ensure closure of the door with the ship listed 15° either way and with a trim up to 5°.

Doors closed by dropping or by the effect of a dropping weight are not permitted. Portable plates secured by bolts only are not permitted.

7.12.3 Regulations concerning the positioning of doors.

7.12.3.1 No doors are permitted in:

collision bulkhead below the bulkhead deck of ships having a subdivision distinguishing mark in the class notation and below the freeboard deck of all other ships;

watertight subdivision bulkheads dividing a cargo space from an adjoining cargo space except where the Register is satisfied that such doors are essential. In this case, the doors may be hinged, sliding or of another equivalent type, but they shall not be remotely controlled.

In passenger ships and special purpose ships, as well as in ships with subdivision distinguishing mark in the class notation, the outboard vertical edges of the doors shall not be located at less than 0,2 of the ship breadth. This distance shall be measured at right angles to the centreline of the ship at the level of the deepest subdivision loadline.

7.12.3.2 In addition to doors at entrances to propeller shaft tunnels, not more than one door may be provided in each watertight subdivision bulkhead within spaces containing main engines, boilers and auxiliary machinery.

Where two or more propeller shafts are fitted, their tunnels shall be connected by a passageway. In a twinscrew ship, there shall only be one door between the engine room and tunnel spaces, and if the propellers are more than two, only two doors shall be provided. All the doors shall be located as high as practicable.

Hand gear for operating the doors from above the bulkhead deck and for operating doors at entrances to shaft tunnels shall be fitted outside the engine room.

7.12.4 Doors in cargo ships.

7.12.4.1 The requirements of **7.12.4** apply to doors fitted in the subdivision bulkheads of cargo ships except the doors of special purpose ships and those mentioned under **7.12.6**.

7.12.4.2 The doors shall be sliding doors with horizontal or vertical motion, they shall be both handand power-operated.

If hand-operated, it shall be possible to open and close the door from both sides of the bulkhead.

If power-operated, closing of the doors from the control station on the navigation bridge shall be possible.

7.12.4.3 At the door control stations, visual indicators shall be provided to show whether the doors are open or closed. An alarm shall be provided to control the door closing.

Power source, control station and indicators shall be operable in the case of main power source failure. Special attention shall be paid to minimizing the effects of the control system failure.

7.12.5 Doors in passenger ships and special purpose ships.

7.12.5.1 The requirements of **7.12.5** apply to doors fitted in the subdivision bulkheads of passenger ships and special purpose ships except those mentioned in **7.12.6**.

7.12.5.2 The doors shall be sliding doors with horizontal or vertical motion, they shall be both handand power-operated.

The maximum width of the door aperture shall not exceed 1,2 m. Installation of doors with the aperture width in excess of 1,2 m shall be substantiated by calculations confirming their equivalent strength to the bulkhead in which they are fitted.

7.12.5.3 If the door is hand-operated, it shall be possible to manually open and close the door from both sides in the close proximity of the door and, in addition, close the door from an assessable place above the bulkhead deck by means of a hand wheel, handle or any other similar gear ensuring the same degree of safety. The force applied to the hand wheel, knob or similar gear while the door is in motion shall not exceed 157 N.

If the door is not visible from the position above the bulkhead deck where the gear is fitted, indicators shall be provided showing the positions of the hand wheel, knob and similar gear at which the door is open or closed.

When hand-operated, the time necessary for a complete closure of the door shall not exceed 90 s with the ship upright.

7.12.5.4 Door control knobs shall be fitted on either side of the bulkhead at a minimum height of 1,6 m above deck plating and so arranged as to enable persons passing through the doorway to hold both the knobs in a position preventing door closure.

The direction of movement of the handles in opening and closing the door shall be in the direction of door movement and shall be clearly indicated.

7.12.5.5 The power gear shall be controllable (i.e. door opening and closing shall be possible) by local control stations on either side of the bulkhead.

Besides being controlled directly at the door, the power gear shall also be controllable (for door closure) from the main control station.

Remote opening of any door from the main control station shall not be possible.

The main control station for doors shall be located in the wheelhouse.

7.12.5.6 The power gear shall ensure door closure in not more than 40 s and not less than 20 s with the ship upright, as well as a simultaneous closure of all doors within not more than 60 s.

7.12.5.7 The power gear of the doors shall have either:

.1 a centralized hydraulic system with two independent power sources each consisting of a motor and pump capable of simultaneously closing all doors.

In addition, there shall be for the whole installation hydraulic accumulators of sufficient capacity to operate all the doors at least three times, i.e. closed - open - closed at unfavourable conditions of heel up to 15°; or

.2 an independent hydraulic system for each door with each power source consisting of a motor and pump capable of opening and closing the door. In addition, there shall be a hydraulic accumulator of sufficient capacity to operate the door at least three times, i.e. closed - open - closed at unfavourable conditions of heel up to 15°; or

.3 an independent electrical system and motor for each door with each power source consisting of a motor capable of opening and closing the door. The power source shall be capable of being automatically supplied by a transitional emergency source of electrical power, as required by **19.1.2.7**, Part XI "Electrical Equipment" in the event of failure of either the main or emergency source of electrical power and with sufficient capacity to operate the door at least three times, i.e. closed - open - closed at unfavourable conditions of heel up to 15°.

7.12.5.8 Door controls, including hydraulic piping and electric cables, shall be kept as close as practicable to the bulkhead in which the doors are fitted, in order to minimize the likelihood of them being involved in any damage which the ship may sustain.

7.12.5.9 Each door shall be provided with an audible alarm, distinct from any other alarm in the area, which will sound whenever the door is closed remotely by power and which shall sound for at least five seconds, but not more than ten seconds, before the door begins to more, and shall continue sounding until the door is completely closed. In the case of remote hand operation it is sufficient for the audible alarm to sound only when the door is moving.

In passenger areas and areas of high ambient noise the Register may require the audible alarm to be supplemented by an intermittent visual signal at the door.

7.12.5.10 The central operating console at the navigation bridge shall have a switch with two modes of control:

a "local control" mode which shall allow any door to be locally opened and closed without automatic closure and

a "doors closed" mode which shall allow doors to be opened locally and shall automatically reclose the doors upon release of the local control mechanism.

The switch shall normally be in the "local control" position. The "doors closed" position shall only be used in an emergency or for testing purposes.

7.12.5.11 The central operating console at the navigation bridge shall be provided with a diagram showing the location of each door, with visual indicators to show whether each door is open or closed. A red light shall indicate a door fully open and a green light shall indicate a door fully closed. When a door is closed remotely, the red light shall indicate the intermediate position by flashing. The indicating circuit shall be independent of the control circuit for each door.

It shall not be possible to remotely open any door from the central operating console.

7.12.5.12 Where trunkways or tunnels for access from crew accommodation to the stokehold, for piping, or for any other purpose are carried through main transverse watertight bulkheads, they shall be watertight. The access to at least one end of each such tunnel or trunkway, if used as a passage at sea, shall be through a trunk extending watertight to a height sufficient to permit access above the margin line. The access to the other end of the trunkway or tunnel may be through a watertight door of the type required by its location in the ship. Such trunkways or tunnels shall not extend through first subdivision bulkhead abaft the collision bulkhead.

7.12.5.13 Where ventilating trunks in connection with refrigerated cargo and ventilation or forced draught trunks are carried through more than one watertight bulkhead, the means of closure at such openings shall be operated by power and be capable of being closed from the main control station situated above the bulkhead deck.

7.12.5.14 If the Register is satisfied that such doors are essential, watertight doors of satisfactory construction may be fitted in watertight bulkheads dividing cargo between deck spaces. Such doors may be hinged, rolling or sliding doors but shall not be remotely controlled. They shall be fitted at the highest level and as far from the shell plating as practicable, but in no case shall the outboard vertical edges be situated at a distance from the shell plating which is less than 0,2 of the breadth of the ship, as defined in **7.12.3.1**.

If any of such doors shall be accessible during the voyage, they shall be fitted with a device, which prevents unauthorized opening.

7.12.5.15 Portable plates on bulkheads shall not be permitted except in machinery spaces. The Register may permit not more than one power-operated sliding watertight door in each watertight bulkhead larger than those specified in **7.12.5.2** to be substituted for these portable plates, provided these doors are intended to remain closed during navigation except in case of urgent necessity at the discretion of master. These doors need not meet the requirements of **7.12.5.3** regarding complete closure by handoperated gear in 90 s.

7.12.5.16 For passenger ships and special purpose ships carrying more than 60 persons having length of 120 m or more or having three or more main vertical zones, the power operated doors shall comply with the requirements of **2.2.6.8**, Part VI "Fire Protection" (refer also to **2.2.6.7.3** of the above Part).

7.12.5.17 Plates with instructions on doors operation are to be provided on both sides of the door. Plates with text or pictures that warning of the danger of remaining in the doorway when the doors begin to close.

These plates are to be of reliable material and properly secured. The text of the instruction or warning plate shall include information about the closing of these doors.

7.12.5.18 In passenger ships of restricted areas of navigation **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS** and **D-R3-S**, **D-R3-RS**:

.1 with length less than 24 m slide doors may be only with manual drive or both with manual and mechanical drive;

with length 24 m and over, where the total number of watertight doors does not exceed two and these doors are located in the engine room or in bukheads separating this room, only doors with manual drive are allowed.

If sliding doors with a manual drive are installed, such doors are to be closed before the beginning of the voyage with passengers on board, and remain closed during the whole voyage;

.2 with length less than 24 m watertight doors that do not comply with the requirements of **7.12.2.5**, **7.12.5.2** and **7.12.5.18.1** may be installed provided that they are to be closed before the the voyage and remain closed during the whole voyage; The time of such doors opening in the port and closing before leaving the port is to be entered in the logbook;

7.12.6 Doors in ships designed for the carriage of vehicles.

7.12.6.1 The requirements of **7.12.6** apply to doors fitted in watertight subdivision bulkheads separating a cargo space from an adjacent cargo space in ships designed for the carriage of vehicles and covered by the requirements of Part V "Subdivision", if the total number of persons on board (excluding the master and the members of the crew or other persons employed or engaged in any capacity on board a ship on the business of that ship, and also a child under one year of age) is not greater than the value N determined by the formula

$$N = 12 + 0{,}04A, \qquad (7.12.6.1)$$

where: A – total deck area, in m^2, of spaces available for the stowage of vehicles where the clear height at the stowage position and at the entrances to such spaces is not less than 4 m.

7.12.6.2 The doors specified in **7.12.6.1** may be fitted at any level if the Register is satisfied that such doors are essential for the movement of the vehicles in the ship.

7.12.6.3 The doors specified in **7.12.6.1** shall be fitted as far from the shell plating as practicable, but in no case shall the outboard vertical edge of the door be situated at a distance from the shell plating that is less than 0,2 of the breadth of the ship, such distance being measured at right angles to the centreline of the ship at the level of the subdivision loadline.

7.12.6.4 The doors specified in **7.12.6.1** may be of the following types: hinged, sliding or rolling but they shall not be controlled remotely.

The doors shall be fitted with devices ensuring watertightness, securing and locking. When the sealing material of the door is not classed as non-combustible (refer to **1.6.3.1**, Part VI "Fire Protection"), the gasket shall be suitably protected from the effects of fire by a method approved by the Register.

The doors shall be fitted with a device which prevents unauthorized opening.

7.12.6.5 The doors specified in 7.12.6.1 shall be so designed that they could be opened and closed both in case of unloaded and loaded decks, the deck deflections under the effect of the stowed cargo being taken into account.

The securing devices of the door shall be so designed that account is taken of the deck deflections under the effect of the stowed cargo resulting in relative displacement of the structural elements of the bulkhead and the door.

7.12.6.6 Where watertightness is ensured by rubber or other suitable gaskets and securing devices, at each corner of the door or door section (if any) the securing devices shall be fitted.

The securing devices of such doors shall be designed to withstand the following forces, in kN:

F_1 – for securing devices fitted at the lower edge of the door;

F_2 – for securing devices fitted at the upper edge of the door;

F_3 – for securing devices fitted at the vertical edge of the door.

These forces shall be determined by the formulae

$$F_1 = \frac{9{,}81A}{n_1}\left(\frac{H_1}{2} - \frac{h}{6}\right) + 29{,}42; \qquad (7.12.6.6\text{-}1)$$

$$F_2 = \frac{9{,}81A}{n_2}\left(\frac{H_1}{2} - \frac{h}{3}\right) + 29{,}42; \qquad (7.12.6.6\text{-}2)$$

$$F_3 = \frac{a}{A}\left[F_1(n_1 - 1)h_i + F_2(n_2 - 1)(h - h_i)\right], \qquad (7.12.6.6\text{-}3)$$

where: A – clear area of the door, in m^2,

H_1 – vertical distance from the lower edge of the door opening to the lower edge of the plating of the bulkhead deck at the centreline of the ship, in m, but not less than 5 m;

h – clear height of the door, in m;

h_i – vertical distance from the securing device considered to the upper edge of the door, in m;

a – half the sum of the vertical distances from the securing device considered to the nearest upper and lower securing devices, in m;

n_1 – =number of the securing devices fitted on the lower edge of the door;

n_2 – =number of the securing devices fitted on the upper edge of the door.

When the securing device is under the effect of the design force F_1, F_2 or F_3 the stresses in its parts shal not exceed 0,5 times the upper yield stress of material.

7.12.6.7 The operation of the doors specified in **7.12.6.1** shall be by means of local control only. On the bridge indicators shall be provided to show automatically that each door is closed and all door fastenings are secured.

7.12.6.8 The requirements of **7.12.2.2** ÷ **7.12.2.4** are also applicable to doors specified under **7.12.6.1**.

7.12.7 Manholes in watertight subdivision bulkheads.

7.12.7.1 The requirements of **7.9** relating to the manholes located on the freeboard deck, raised quarter deck or the first tier of superstructures are generally applicable to the manholes fitted in the watertight subdivision bulkheads.

No manholes are permitted:

.1 in the collision bulkhead below the bulkhead deck for ships having subdivision distinguishing mark in the class notation, and below the freeboard deck for other ships;

.2 in watertight subdivision bulkheads separating a cargo space from an adjacent cargo space or a fuel oil tank.

7.13 CARGO HATCH COVERS OF BULK CARRIERS, ORE CARRIERS AND COMBINATION CARRIERS

7.13.1 The design of cargo hatch covers for bulk carriers, ore carriers and combination carriers shall comply with the requirements in **7.10.1**, **7.10.2**, **7.10.3.4**, **7.10.3.5** and **7.10.4**.

For bulk carriers of 90 m in length and above, contracted for construction on or after 1 July 2015, the requirements for cargo hatch covers are regulated by Common Structural Rules for Bulk Carriers and Oil Tankers.

7.13.2 Cargo hatch covers shall be made of steel. The use of other materials may be allowed provided it is confirmed by calculations and tests that they have a strength at least equivalent to that of the hatch covers made of steel.

7.13.3 The pressure P, in kPa, on the hatch cover panels located on the freeboard deck is determined by the formulae:

for ships of 100 m in length and above

$$P = 34{,}3 + \frac{P_{FP} - 34{,}3}{0{,}25}\left(0{,}25 - \frac{X}{L}\right) \geq 34{,}3 \qquad (7.13.3\text{-}1)$$

where: P_{FP} – pressure at the fore perpendicular to be determined by the formula

$P_{FP} = 49{,}1 + (L - 100)a$;

a = 0,0726 – for type "B" freeboard ships;

a = 0,356 – for ships with reduced freeboard;

L – ship's length, but not more than 340 m;

X – distance, in m, of the midlength of the hatch cover under consideration from the forward end of L.

Where a position 1 hatchway is located at least one superstructure standard height higher than the freeboard deck, the pressure P may be taken equal to 34,3 kPa;

for ships less than 100 m in length

$$P=15{,}8+\frac{L}{3}\left(1-\frac{5X}{3L}\right)\geq 0{,}195L+14{,}9, \qquad (7.13.3\text{-}2)$$

Where two or more panels are connected by hinges, each individual panel shall be considered separately.

7.13.4 The normal σ_a and shear τ_a stresses in the hatch cover structures shall not exceed the permissible values:

$\sigma_a = 0{,}8\, R_{eH}$;

$\tau_a = 0{,}46\, R_{eH}$;

where: R_{eH} – upper yield stress of the hatch cover material.

The normal stressing compression of the attached flange of primary supporting members shall not exceed 0,8 times the critical buckling stress of the structure according to the calculations given in **7.13.9** ÷ **7.13.11**.

The stresses in hatch covers that are designed as a grillage of longitudinal and transverse primary supporting members shall be determined by a grillage or a finite element analysis.

When a beam or a grillage analysis is used, the secondary stiffeners shall not be included in the attached flange area of the primary members.

When calculating the stresses σ and τ the net scantlings (no allowance for corrosion and wear) of hatch cover structure elements shall be used.

7.13.5 The effective flange area A_F, in cm^2, of the attached plating, to be considered for the yielding and buckling checks of primary supporting members or grillages, is obtained as the sum of the effective flange areas of each side of the girder web:

$$A_F = \sum_{nf}(10 b_{ef} t) \qquad (7.13.5)$$

where: nf = 2 if attached plate flange extends on both sides of a girder web;

nf = 1 – 1 if attached plate flange extends on one side of a girder web only;

t – thickness of attached plate, in mm;

b_{ef} – effective breadth, in m, of attached plate flange on each side of a girder web assumed equal to b_p, but not more than 0,165l;

b_p – half distance, in m, between the considered primary supporting member and the adjacent one;

l – span, in m, of primary supporting members.

7.13.6 The net thickness t, in mm, of the hatch cover top plating shall be not less than

$$t = F_p 15{,}8 s\sqrt{\frac{p}{0{,}95\sigma_F}} \qquad (7.13.6)$$

where: F_p - =factor equal to:

1,9 – if ratio $\sigma/\sigma_a \geq 0{,}8$;

1,5 – in other cases;

s – stiffener spacing, in m;

p – pressure, in kPa, according to **7.13.3**;

σ – according to **7.13.8**;

σ_a - according to **7.13.4**,

and not less than 1 % of the stiffener spacing or 6 mm, whichever is greater.

7.13.7 The required minimum section modulus Z, in cm^3, of secondary stiffeners of the hatch cover top plates, based on stiffener net member thickness, are given by

$$Z = \frac{l^2 sp}{12\sigma_a} 10^3 \qquad (7.13.7)$$

where: l – secondary stiffener span, in m, to be taken as the spacing of primary supporting members or the distance between a primary supporting member and the edge support, as applicable.

When brackets are fitted at both ends of all secondary stiffener spans, the secondary stiffener span may be reduced by an amount equal to 2/3 of the minimum brackets arm length, but not greater than 10 % of the gross span, for each bracket

s – secondary stiffener spacing, in m;

p – pressure, in kPa, according to **7.13.3**;

σ_a – according to **7.13.4**.

The net section modulus of the secondary stiffeners shall be determined based on an attached plate width assumed equal to the stiffener spacing.

7.13.8 The section modulus value and web thickness of primary supporting members, based on member net thickness, shall be such that the normal stress σ in both flanges and the shear stress τin the web do not exceed the permissible values σ_a i τ_a, respectively, defined according to**7.13.4**.

The width of the primary supporting members flange shall be not less than 40 % of their depth for laterally unsupported spans greater than 3,0 m.

Tripping brackets attached to the flange may be considered as a lateral support for primary supporting members.

The flange outstand shall not exceed 15 times the flange thickness.

7.13.9 The compressive stress s in the hatch cover plate panels, induced by the bending of primary supporting members parallel to the direction of secondary stiffeners, shall not exceed 0,8 times the critical buckling stress σ_{C1}, to be evaluated as follows:

$$\sigma_{C1} = \sigma_{E1} \text{ , when } \sigma_{E1} \le \sigma_F/2 \text{ ; or}$$

$$\sigma_{C1} = \sigma_F \left[1 - \frac{\sigma_F}{4\sigma_{E1}}\right] \quad \text{when } \sigma_{E1} > \sigma_F/2 \text{ ,} \qquad (7.13.9\text{-}1)$$

where: σ_F - minimum upper yield stress of the material, in N/mm²;

$$\sigma_{E1} = 3{,}6E\left(\frac{t}{1000s}\right)^2 \text{ ;}$$

where: E – modulus of elasticity, in N/mm² to be assumed $2{,}06 \cdot 10^5$ N/mm² for steel.

t - net thickness of plate panel, in mm;

s - pacing of secondary stiffeners, in m.

The mean compressive stress σ in each of the hatch cover plate panels, induced by the bending of primary supporting members perpendicular to the direction of secondary stiffeners, shall not exceed 0,8 times the critical buckling stress σ_{C2}, to be evaluated as follows:

$$\sigma_{C2} = \sigma_{E2} \text{ , when } \sigma_{E2} \le \sigma_F/2 \text{ , or}$$

$$\sigma_{C2} = \sigma_F \left[1 - \frac{\sigma_F}{4\sigma_{E2}}\right], \quad \text{when } \sigma_{E2} > \sigma_F/2 \text{ ,} \qquad (7.13.9\text{-}2)$$

where: σ_F - minimum upper yield stress of the material, in N/mm²;

$$\sigma_{E2} = 0{,}9mE\left(\frac{t}{1000s_s}\right)^2 \quad ;$$

де: $m = c\left[1+\left(s_s/l_s\right)^2\right]^2 \dfrac{2{,}1}{\psi+1{,}1}$;

E – modulus of elasticity, in N/mm^2;

t – net thickness of plate panel, in mm;

s_s – length of the shorter side of the plate panel, in m;

l_s – length of the longer side of the plate panel, in m;

ψ - ratio between the smallest and largest compressive stress;

c - коефіцієнт, що дорівнює:

1,3 when plating is stiffened by primary supporting members;

1,21 when plating is stiffened by secondary stiffeners of angle or T-type;

1,1 when plating is stiffened by secondary stiffeners of bulb type;

1,05 when plating is stiffened by flat bar.

7.13.10 The compressive stress in the top flange of secondary stiffeners, induced by the bending of primary supporting members parallel to the direction of secondary stiffeners, shall not exceed 0,8 times the critical buckling stress σ_{CS}, to be evaluated as follows:

$$\sigma_{CS} = \sigma_{ES}, \text{ when } \sigma_{ES} \le \sigma_F/2 \text{ , or}$$

$$\sigma_{CS} = \sigma_F\left[1-\frac{\sigma_F}{4\sigma_{ES}}\right], \quad \text{when } \sigma_{ES} > \sigma_F/2 \qquad (7.13.10)$$

where: σ_F - minimum upper yield stress of the material, in N/mm^2;

σ_{ES} - ideal elastic buckling stress, in N/mm^2, of the secondary stiffener to be assumed as the minimum between σ_{E3} and σ_{E4};

$$\sigma_{ES} = \frac{EI_a}{Al^2}10^{-3} \ ;$$

E – modulus of elasticity, in N/mm^2;

I_a - moment of inertia, in cm^4, of the secondary stiffener, including an effective flange equal to the spacing of secondary stiffeners;

A - cross-sectional area, in cm^2, of the secondary stiffener, including an effective flange equal to the spacing of secondary stiffeners;

l - span, in m, of the secondary stiffener;

$$\sigma_{E4} = \frac{\pi^2 EI_w}{10^4 I_p l^2}\left(m^2 + \frac{K}{m^2}\right) + 0{,}385\,E\,\frac{I_t}{I_p},$$

where:

$$K = \frac{Cl^4}{\pi^4 EI_w}\cdot 10^6;$$

m – number of half waves, given by the following table 7.13.10;

Table 7.13.10

$0 < K \le 4$	$4 < K \le 36$	$36 < K \le 144$	$(m-1)^2 m^2 < K \le m^2(m+1)^2$
$m = 1$	$m = 2$	$m = 3$	m, being determined according to K value

l_W - sectional moment of inertia, in cm^6, of the secondary stiffener about its connection with the plating;

$$l_W = \frac{h_W^3 t_W^3}{36} 10^{-6}$$ - for flat bar secondary stiffeners;

$$l_W = \frac{f_t b_f^3 h_W^3}{36} 10^{-6}$$ - for T-section secondary stiffeners;

$$I_w = \frac{b_f^3 h_w^2}{12(b_f + h_w)^2} [t_f(b_f^2 + 2b_f h_w + 4h_w^2) + 3t_w b_f h_w] 10^{-6}$$ - for angles and bulb secondary stiffener;

I_P - polar moment of inertia, in cm^4, of the secondary stiffener about its connection with the plating;

$$I_P = \frac{h_W^3 t_W}{3} 10^{-4}$$ - for flat bar secondary stiffeners;

$$I_P = \left(\frac{h_W^3 t_W}{3} + h_W^2 b_f t_f\right) 10^{-4}$$ - for flanged secondary stiffeners;

I_t - moment of inertia, in cm^4, of the secondary stiffener without an effective flange;

$$I_t = \frac{h_W t_W^3}{3} 10^{-4}$$ - for flat bar secondary stiffeners;

$$I_t = \frac{1}{3} [h_w t_w^3 + b_f t_f^3 (1 - 0{,}63 \frac{t_f}{b_f})] 10^{-4}$$ - for flanged secondary stiffeners;

where: h_W, t_W - height and net thickness, in mm, of the secondary stiffener, respectively;
b_f, t_f - width and net thickness, in mm, of the secondary stiffener bottom flange, respectively;
s - spacing of secondary stiffeners, in m;

$$C = \left[\frac{k_p E t_p^3}{3s\left(1 + \frac{1{,}33 k_p h_W t_p^3}{1000\, s t_W^3}\right)} \right] 10^{-3} ;$$

where: $k_p = 1 - \eta_p$, but not less than 0. For flanged secondary stiffeners, k_p need not be taken less than 0,1;

$$\eta_p = \frac{\sigma}{\sigma_{E1}} ;$$

for σ - refer to **7.13.8**;
for σ_{E1} - refer to **7.13.9**;
t_p - net thickness, in mm, of the hatch cover plate panel.

For flat bar secondary stiffeners and buckling stiffeners, the ratio h/t_W shall not be greater than $15k^{0,5}$,

where: h, t_w – height and net thickness of the stiffener, respectively;
$k = 235/\sigma_F$;
σ_F - minimum upper yield stress of the material, in N/mm^2;

7.13.11 The shear stress τ in the hatch cover primary supporting members web panels shall not exceed 0,8 times the critical buckling stress τ_c, to be determined as follows:

$$\tau_2 = \tau_2 \text{ when } \tau_E \le \tau_F/2 \text{ , or}$$

$$\tau_2 = \tau\left[1 - \frac{\tau_F}{4\tau_E}\right] \text{, when } \tau_E > \tau_F/2$$

where: σ_F - minimum upper yield stress of the material, in N/mm^2;

$$\tau_F = \sigma_F/\sqrt{3};$$

$$\tau_E = 0{,}9k_t E\left(\frac{t_{пр,н}}{1000d}\right)^2 \;;$$

where: E – E – modulus of elasticity, in N/mm^2 to be assumed $2{,}06\cdot10^5$ N/mm^2 for steel.

$t_{pr,n}$ - net thickness, in mm, of primary supporting member;

$$k_t = 5{,}35 + 4{,}0/(a/d)^2 \;;$$

a – =greater dimension, in m, of web panel of primary supporting member;

d – smaller dimension, in m, of web panel of primary supporting member.

For primary supporting members perpendicular to the direction of secondary stiffeners or for hatch covers built without secondary stiffeners, a presumed square panel of dimension d determination of the stress τ_c. In such a case, the average shear stress τ_c between the values calculated at the ends of this panel shall be considered.

7.13.12 The vertical deflection of primary supporting members shall be not more than 0,0056l, where l is the greatest span of primary supporting members.

7.13.13 The free sectional area A, in cm^2, of the securing device shall not be less than determined by the formula

$$A = 1{,}4a/f, \tag{7.13.13-1}$$

where: a - distance between securing devices, in m, which in any case shall not be adopted less than 2 m;

f — factor determined by the formula

$$f = (R_{eH} / 235)^e \;; \tag{7.13.13-2}$$

where: R_{eH} — the upper yield strength of the securing device material, in MPa, and shall not be adopted greater than 0,7 of the tensile strength of the material;

e — index equal to:

0,75 for $R_{eH} > 235$ MPa;

1,00 for $R_{eH} \le 235$ MPa.

For hatch covers and hatch cover sections having an area in excess of 5 m^2, the active diameter of bars and bolts of the securing devices shall not be less than 19 mm.

7.13.14 Where the packing gasket is compressed to the maximum depth possible and its pressure exceeds 5000 N/m, the area of securing devices as determined in accordance with **7.13.13**, shall be increased in a relevant proportion.

7.13.15 The stiffness of the cover corners shall be sufficient to maintain an adequate pressure of the packing gasket between the securing devices. The cross-sectional inertia moment of the corner members of the covers I, in cm^4, shall be not less than that determined by the formula

$$I = 6pa^4 \cdot 10^{-3}, \tag{7.13.15}$$

where: *p*– pressure of the packing gasket when compressed to the maximum depth possible for the accepted design, in N/m, but not less than 5000 N/m;

a – distance between securing devices, in m.

7.13.16 Where hydraulic securing devices are applied, the securing devices shall be mechanically lockable in closed position in the event of loss of the hydraulic fluid.

7.13.17 Hatch covers shall be fitted with stoppers designed for longitudinal and transverse design loads of 175 kPa.

Where the design and arrangement of the forecastle on a ship do not meet the requirements in **3.3.5.4.1**, Part II "Hull", the stoppers of the foremost hatch cover (hatch No. 1) shall be designed for a longitudinal load of 230 kPa acting on the forward end of the No. 1 hatch cover.

7.13.18 The stresses in stoppers and their adjacent structures shall not exceed the permissible values equal to $0,8\sigma_F$, where σ_F is minimum upper yield stress of the material.

7.13.19 For the plating and stiffeners of all type hatch covers, excepting the double skin, the corrosion addition shall be assumed equal to 2 mm.

For double skin hatch covers, the corrosion addition shall be 2 mm for the top and bottom plating and 1,5 mm for the internal structures.

7.13.20 In bulk carriers of 150 m in length and upwards, carrying solid bulk cargoes having a density of 1000 kg/m^{3}and above, contracted for construction before 1 April 2006, the protection of the structure of cargo holds from grab wire damage during loading and unloading operations shall be achieved by structural design features:

wire rope grooving in way of cargo holds openings shall be prevented by fitting suitable protection such as half-round bar on the hatch side girders (i.e. upper portion of top side tank plates)/hatch end beams in cargo hold or upper portion of hatch coamings.

Such ships shall have the distinguishing mark GRAB(X) in the class notation (refer to **2.2.37.1**, Part I "Classification").

7.14 ACCESS TO SPACES IN THE CARGO AREA OF OIL TANKERS AND BULK CARRIERS

7.14.1 The requirements of **7.14** apply to oil tankers of 500 gross tonnage and above and to bulk carriers of 20 000 gross tonnage and above.

7.14.2 Means of access and passages on ships referred to in **7.14.1** shall comply with the requirements of IMO resolutions IMO MSC.133(76), MSC.158(78) taking into account MSC.1/Circ.1464/Rev.1, as well as IACS UI SC191 (Rev.8 Apr 2019) and in accordance with II-1/3-6 SOLAS-74 «Access to spaces in the cargo area of oil tankers and bulk carriers», the safety access requirements for which are set out in Annex 2 to this part of the Rules the safety access requirements for which are set out in Annex 2 to this part of the Rules.

Note. Unified requiremets IACS (UR), unified interpretations IACS (UI), IACS Recommendations are published on the IACS website.

7.15 ADDITIONAL REQUIREMENTS FOR OPENINGS AND THEIR CLOSING APPLIANCES IN RO-RO SHIPS

7.15.1 Where vehicle ramps are installed to give access to spaces below the bulkhead deck, their openings shall be able to be closed weathertight to prevent ingress of water below, alarmed and indicated to the navigation bridge.

7.15.2 The Register may permit the fitting of particular accesses to spaces below the bulkhead deck provided they are necessary for the essential working of the ship, e.g. the movement of machinery and stores, subject to such accesses being made watertight, alarmed and indicated to the navigation bridge.

7.15.3 Subject to provisions of **7.15.1** and **7.15.2** all accesses that lead to spaces below the bulkhead deck shall have a lowest point which is not less than 2,5 m above the bulkhead deck.

7.15.4 Indicators shall be provided on the navigating bridge for all shell doors, loading doors and other closing appliances which, if left open or not properly secured, could lead to flooding of a special category space or ro-ro cargo space.

The indicator system shall be designed on the fail safe principle and shall show by light alarms if the door is not fully closed or if any of the securing arrangements is not in place and fully locked, and by audible alarms if such door or closing appliances become open or the securing arrangements become unsecured.

The indicator panel on the navigation bridge shall be equipped with a mode selection function "harbour/sea voyage" so arranged that an audible alarm is given on the navigation bridge if the ship leaves harbour with the bow doors, inner doors, stern ramp or any other side shell doors not closed or any closing device not in the correct position.

The power supply for the indicator system shall be independent of the power supply for operating and securing the doors.

7.15.5 Television surveillance and a water leakage system shall be arranged to provide an indication to the navigation bridge and to the engine control station of any leakage through inner and outer bow doors, stern doors or any other shell doors which could lead to flooding of special category spaces or ro-ro cargo spaces.

7.15.6 Special category spaces and ro-ro cargo spaces shall be continuously patrolled or monitored by effective means, such as television surveillance, so that any movement of vehicles in adverse weather conditions and unauthorized access of passengers thereto can be detected whilst the ship is underway.

7.15.7 Documented operating procedures for closing and securing all shell doors, loading doors and other closing appliances which, if left open or not properly secured could lead to flooding of special category space or ro-ro cargo space, shall be kept on board and posted at an appropriate place.

7.15.8 Besides specified in **7.15.7** the Manual on operation and repair of doors in shell plating shall be kept onboard containing the following information:

main particulars and structural drawings of doors;

door operation safety precautions;

ship characteristics;

door design loads;

manufacturer's recommendations for equipment testing;

description of equipment of bow, side and stern doors, internal bow doors, central power station, indication panel on navigation bridge, control panel in engine room;

operating characteristics:

permissible angles of heel/trim with/without cargo as well as permissible angles of heel/trim during use of doors;

door operating instruction;

door operating instruction in case of emergency;

operation and repair of doors:

description and deadlines of current repair, occuring failures and their acceptable elimination, manufacturer's instructions for operation and repair of doors;

record book of examinations including survey of securing, locking and supporting devices, repair and replacement.

The above manual on operation and repair of doors in shell plating shall be submitted for the Register approval.

8. ARRANGEMENT AND EQUIPMENT OF SHIP'S SPACES, VARIOUS EQUIPMENT, ARRANGEMENTS AND OUTFIT

8.1 GENERAL

8.1.1 The requirements for the arrangement and equipment of machinery spaces are specified in Part VII "Machinery Installations" and those relating to refrigerating machinery spaces, refrigerant storerooms, as well as refrigerated cargo spaces are set forth in Part XII "Refrigerating Plants".

8.1.2 In berth-connected ships, the arrangement and equipment of spaces, various devices and equipment shall comply with the relevant requirements of **8.5** and **8.6**.

Furthermore, berth-connected ships which are used as hotels or hostels shall comply with the requirements set out in **8.5** as in the case of passenger ships.

Besides, a berth-connected ship shall have at least two companion ladders fitted as far away from each other as possible.

The companion ladders shall be not less than 0,2 m wide where the total of passengers and crew on board does not exceed 50.

For each 10 persons above 50, the companion ladder breadth shall be increased by 5 cm.

8.2 LOCATION OF SPACES

8.2.1 The chart room shall be located in a space adjacent to the wheelhouse. The chart room and the wheelhouse may be situated in a common space.

8.2.2 No accommodation spaces shall be arranged forward of the collision bulkhead and abaft of the afterpeak bulkhead below the bulkhead deck.

8.3 NAVIGATION BRIDGE

8.3.1 General

8.3.1.1 The ship's control station shall be located in an enclosed space of the wheelhouse on the navigation bridge.

The navigation bridge shall be located so as to ensure:

proper visual control of the ship's running; good visibility with maximum view of water surface;

good audibility of sound signals of the approaching ships;

for tugs, possibility of visual control of tow line during towing operations.

It is recommended to arrange the steering control station at the ship's centreline.

8.3.1.2 Visibility from the navigation bridge shall comply with requirements of **3.2**, Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships.

8.4 EQUIPMENT OF DRY CARGO HOLDS

8.4.1 When in ships not having double bottom wooden ceiling is placed on top of the floors, it shall be solid and shall extend up to the bilge. The ceiling is recommended to be made of portable sections of such dimensions and so constructed as to allow of their ready removal at any place.

The thickness of a ceiling shall be:

at least 40 mm for ships of 30 m in length and less;

at least 60 mm for ships over 30 m in length;

at least 70 mm under cargo hatchways.

8.4.2 When in ships having double bottom wooden ceiling is fitted, it shall have a thickness as follows:

at least 50 mm for ships of 60 m in length and less;

at least 65 mm for ships over 60 m in length.

8.4.3 Where cargo is discharged by grabs or other mechanisms, the thickness of the wooden ceiling fitted under cargo hatchways shall be doubled.

8.4.4 In holds intended for carriage of grain and other bulk cargoes the wooden ceiling on the inner bottom or, in case the latter is omitted, on the top of floors, shall be fitted so as to prevent wells, bilges and suction pipes of the bilge system from clogging.

8.4.5 The wooden ceiling shall not be laid directly on the inner bottom metal plating, but shall be embedded in a bituminuous or epoxy composition approved by the Register, or placed on battens of 25 ÷ 30 mm, mm in thickness along the floors.

The wooden ceiling over the bilges shall be placed so as to be readily removable (refer also to **7.6.9**, Part VIII "Systems and Piping").

8.4.6 It is recommended that the cargo battens made of wood or metal shall be fitted on sides in holds and spaces intended for carriage of general cargoes.

The thickness of wooden battens shall be as follows:

at least 40 mm for ships of 70 m in length and less;

at least 50 mm for ships of length exceeding 70 m.

The distance between adjacent battens shall not exceed 305 mm.

The battens shall be attached to side framing so as to be readily removable and replaceable.

8.4.7 All projecting parts of various equipment in the holds (manholes, air pipes, sounding pipes, etc.) shall be protected with wooden screens, grids, chutes, etc. in places subject to impacts of cargoes, grabs or other hoisting devices.

Requirements for laying pipe lines in cargo holds are given in **5.3**, Part VIII "Systems and Piping".

8.4.8 Cellular guide members for the carriage of containers in holds.

8.4.8.1 The requirements of **8.4.8** apply to the cellular guide members used for the carriage of containers, manufactured in accordance with the Rules for the Construction of Containers, in the holds of cargo ships.

8.4.8.2 Cellular guide members comprise uprights and horizontal shores arranged breadthwise and lengthwise. In the holds, the cellular guide members may be removable or permanent.

8.4.8.3 Cellular guide members shall not be integrated in the hull structure. They shall be so designed that no stresses are exerted on them when the hull comes under bending or torsion.

8.4.8.4 Cellular guide members shall be designed to withstand stresses due to the forces F_x and F_y affecting the gravity centre of each container, which shall be determined by the formulae:

lengthwise

$$F_x = mga_x; \qquad (8.4.8.4\text{-}1)$$

breadthwise

$$F_y = mga_y, \qquad (8.4.8.4\text{-}2)$$

where: m – maximum gross mass of container, in kg;

g – gravity acceleration, g=9,81 m/s^2;

a_x, a_y – dimensionless accelerations to be determined in accordance with **1.7**, the coordinates of x and z being determined up to the gravity centre of each container volume.

The forces F_x and F_y shall be determined for each container, and through the four relevant corner fittings of the end or side wall they are uniformly distributed among the uprights. By way of simplification, maximum F_x and F_y values may be adopted for each container. Where a number of adjoining containers are supported by a pair of uprights, the F_x and F_y values for the particular container tier shall be summed up and distributed among the respective uprights.

Friction forces arising where the corner fittings of containers touch each other or the inner bottom shall be ignored.

8.4.8.5 The forces resultant from loads to be determined in accordance with 8.4.8.4, where the container corner fittings rest upon the uprights, shall not exceed 150 kN per fitting breadthwise or 75 kN per fitting lengthwise.

8.4.8.6 Where the attachment of uprights to the hull structures is not considered as firm fixing (free resting, flexible fixing, etc.), the cellular guide members shall be calculated as three-dimensional frames.

Where the attachment of uprights to the hull structures can be considered as firm fixing, particular vertical surfaces of cellular guide members may be calculated as plane frames.

The stresses in the cellular guide member components shall not exceed 0,8 times the upper yield stress of their material.

The terms of calculating the stability of cellular guide member components shall be found under **8.4.8.14**.

8.4.8.7 In view of the requirements under **8.4.8.6**, the displacement of the resting points of corner fittings upon the uprights shall not exceed 25 mm breadthwise or 40 mm lengthwise.

8.4.8.8 When determining the thickness of the uprights components, the thickness of those especially subject to wear shall be increased by 5 mm and equal to at least 12 mm.

8.4.8.9 Where the uprights comprise separate angular sections, they shall be firmly secured to each other with horizontal plates at the resting points of container corner fittings and at least halfway between those points.

8.4.8.10 At the upper ends of the uprights, devices shall be fitted to facilitate the insertion of containers into the stowage frames. 8.4.8.11 Uprights shall, so far as possible without notches, be attached to transverse and longitudinal bulkheads by means of shear- and bend-stiff members.

8.4.8.12 The total margin between the external scantlings of containers and the internal uprights surfaces shall not exceed 25 mm breadthwise or 40 mm lengthwise.

When fitting the uprights, the deviation from the straight line shall not exceed 5 mm.

8.4.8.13 Transverse horizontal and longitudinal horizontal shores serve to connect the stand-alone uprights to each other and to secure them to vertical hull structures. The horizontal shores shall, as far as possible, be fitted on the level of the corner fitting rest points and be torsion- and bend-stiff connected to the uprights.

8.4.8.14 The stability of transverse horizontal and longitudinal horizontal shores and, where necessary, that of uprights shall be checked by a procedure approved by the Register.

When determining the permissible buckling stresses, the relevant safety factor may be adopted equal to 2,0.

The free length of buckling shall be adopted span-equal in the case of a bolted joint or 0,7 times the shore or uprights span in the case of a welded joint. The flexibility shall not exceed 250.

For other types of bar-end fixing, the free length shall be established according to the procedure approved by the Register.

8.4.8.15 The container rest points on the inner bottom and areas containing the connections and attachments of container stowage frames in way of hull structures shall be strengthened in conformity with the requirements of Part II "Hull".

8.4.9 Movable decks, platforms, ramps and other similar structures.

8.4.9.1 The requirements of **8.4.9** apply to the movable decks, platforms, ramps and other similar structures designed to be installed in two positions:

in working position when they are used for carriage, loading or unloading of vehicles or other cargoes;

in non-working position when they are not used for carriage, loading or unloading of vehicles or other cargoes.

8.4.9.2 The movable decks, platforms, ramps and other similar structures and also their supporting elements at ship's sides, decks and bulkheads. the pillars or suspensions for decks and platforms ensuring their proper installation in the working position shall be designed in accordance with the requirements of Part II "Hull".

8.4.9.3 Arrangements shall be provided for reliable securing of the movable decks, platforms ramps and other similar structures in the non-working position.

8.4.9.4 When the movable decks, platforms, ramps and other similar structures are secured in the nonworking position, the hoisting gear and elements thereof shall not generally be kept under the load.

It is not permitted to secure the movable decks, platforms, ramps and other similar structures by suspending them on ropes.

8.4.9.5 The structural elements of the arrangements mentioned in **8.4.9.3** and also the associated supporting structures shall be designed to withstand the forces resulting form the application of the load P_x, P_y and P_z, as determined by the formulae given below, to the centres of gravity of the considered section of the deck, platform, ramp or other similar structures:

$$P_x = mga_x, \quad (8.4.9.5\text{-}1)$$

$$P_y = mga_y, \quad (8.4.9.5\text{-}2)$$

$$P_z = mg(1 + a_z), \quad (8.4.9.5\text{-}3)$$

where: P_x – horizontal load parallel to the centreline of the ship, in N. Consideration shall be given to the cases when the load P_x is directed both forward and af;

P_y – = horizontal load parallel to the midstation plane, in N. Consideration shall be given to the cases when the load P_y is directed both to the nearest ship's side and to the opposite side;

P_z – vertical load directed downward, in N;

m – mass of the considered section of the deck, platform, ramp or other similar structure, in kg;

g – acceleration due to gravity equal to 9,81 m/s^2;

a_x, a_y, a_z – dimensionless accelerations to be determined in accordance with **1.7**.

8.4.9.6 When determining the forces affecting the structural elements of the arrangements specified in **8.4.9.3** and the associated supporting structures with regard to the provisions of **8.4.9.5**, the loads P_x, P_y and P_z are regarded as separately applied, i.e. no account is taken of their combined action and of the frictional forces originating on the surfaces of the considered sections of decks, platforms, ramps or other similar structures which are in contact with the associated supporting structures.

8.4.9.7 When the structural elements of the arrangements specified in **8.4.9.3** and the associated supporting structures are under the effect of the loads determined according to the provisions of **8.4.9.5** and **8.4.9.6**, the stresses in their parts shall not exceed 0,8 times the upper yield stress of material.

Under the effect of these loads the safety factor of the wire ropes in relation to their breaking strength shall be not less than 4;

the safety factor of the chain cables in relation to the proof load of the chain shall be not less than 2;

the margin of safety against buckling of the elements subjected to the compression stress shall be not less than 2.

8.4.9.8 Wire ropes used in the arrangements specified in **8.4.9.3** shall satisfy the requirements of **3.15** and chain cables, those of **7.1**, Part XIII "Materials".

8.5 EXITS, DOORS, CORRIDORS, STAIRWAYS AND VERTICAL LADDERS

8.5.1 General.

8.5.1.1 Location and arrangement of exits, doors, corridors, stairways and vertical ladders shall ensure the possibility of quick, safe and free access from spaces to the embarkation stations of lifeboats and liferafts.

Additional means for outdoor escape shall be clearly marked, where necessary, to ensure accessibility, and be provided with a proper design to be used in emergency.

8.5.1.2 In passenger ships, access protection of the stairway enclosures to lifeboats and liferafts embarkation areas shall be provided both directly and through protected internal evacuation routes, which stairway enclosures shall be fire resistant and insulated, as appropriate, as shown in Tables 2.2. 1.3- 1, 2.2.1.3-2, 2.2.1.5-1, 2.2.1.5-2 of Part VI "Fire Protection".

8.5.2 Exits and doors.

8.5.2.1 In passenger ships and in special purpose ships each watertight compartment or similarly restricted space or group of spaces situated below the bulkhead deck shall have at least two means of escape, in any case one of which shall be independent of the door in the subdivision bulkhead.

At least one of the evacuation routes shall comply with the requirements of **2.2.2.4.5**, Part VI "Fire Protection" to the appropriate lifeboats or life rafts embarkation decks or to the upper deck if the life-saving applinces embarkation deck does not extend to the main vertical fire zone.

In the latter case, direct access to the life-saving appliances embarkation deck shall be provided by means of external open ladders and passages, which shall be provided with lighting in accordance with **8.5.5**, and also nonsliding surface. Limiting structures facing open ladders and passages that are part of the evacuation route and limiting structures located in a place where their damage by fire may obstruct the passage to the embarkation deck shall be fireresistant and have an insulation value, as appropriate, according to Tables 2.2.1.3- 1, 2.2.1.3-2, 2.2.1.5-1, 2.2.1.5-2, Part VI "Fire Protection".

In passenger ships of restricted areas of navigation **B-R3-RS**, **B-R3-RS**, **C-R3-S**, **C-R3-RS** та **D-R3-S**, **D-R3-RS,** in exceptional cases, taking into account the purpose of the room and the number of persons usually accommodated in them, only one exit, which shall ensure safe evacuation, may be provided.

Two ways of evacuation from the main machinery control room located in the engine room shall be provided; at least one of them shall provide continuous protection from fire to a safe place outside the engine room (refer to **2.1.4.5**, Part VI "Fire Protection").

8.5.2.2 In passenger ships and in special purpose ships above the bulkhead deck each main vertical fire zone (refer to **2.2.1.2**, Part VI "Fire Protection") or similarly restricted space or group of spaces shall have at least two means of escape one of which shall give access to a stairway forming a vertical means of escape to the places of embarkation into lifeboats and liferafts.

8.5.2.3 In passenger ships the number and location of means of escape from special category spaces (refer to **1.5.9**, Part VI "Fire Protection") depend on the degree of safety; the degree of safety for escape from these spaces to the embarkation stations of lifeboats and liferafts shall at least correspond to that specified in **8.5.2.1** and **8.5.2.2**.

For cargo ships in all ro-ro cargo spaces where the crew is normally employed, at least two widely separated escape routes shall be provided.

8.5.2.4 In cargo ships of 500 gross tonnage and upwards at each level of accommodation spaces there shall be at least two means of escape, as widely separated as possible, from each restricted space or group of spaces; from the spaces situated below the open deck the main means of escape shall be formed by a stairway, the other means of escape may be formed by a casing with a vertical ladder or by a stairway; from spaces above the open deck the means of escape shall be stairways or doors to an open deck or a combination thereof.

The open deck stated above shall be a category (10) (in accordance with **2.2.1.5**, Part VI "Fire Protection").

8.5.2.5 Spaces may be dispensed with one of the means of escape required under **8.5.2.1** or **8.5.2.4**, due regard being paid to the nature and location of the spaces and to the number of persons normally employed therein.

8.5.2.6 Stairways serving only a space and a balcony in that space, as well as lifts shall not be considered as means of escape specified in **8.5.2.1** ÷ **8.5.2.4**.

8.5.2.7 Each cinema hall shall be provided with at least two means of escape. Both exits shall be spaced from each other as wide as practicable. A readily seen inscription "Exit" or "Emergency exit" shall be provided above every such exit.

8.5.2.8 In case of open bridge wings, the wheelhouse shall have two exits, one to each side of the navigation bridge, with a passageway through the house from side to side.

8.5.2.9 The total width of exits from cinema halls shall be determined on the basis of 0,8 m per 50 persons, however, the width of each exit shall be not less than 1,1 m, when the number of seats is more than 50, and not less than 0,8 m when the number of seats is not more than 50. The width of each exit from accommodation and service spaces shall be not less than 0,6 m.

The sizes of the ladderways from cargo holds shall be not less than 0,6x0,6 m.

8.5.2.10 The exit doors and ladderway covers shall be so arranged that they can be operated from both sides. Doors shall open as follows:

.1 doors of accommodation, excluding public, and service spaces giving access to a corridor inside the spaces;

.2 doors of public rooms, outwards or each side;

.3 doors in the end bulkheads of superstructures and in external transverse bulkheads of deckhouses, outwards in the direction of the nearest side;

.4 doors in the external longitudinal bulkheads of deckhouses, outwards in the forward direction.

In cargo ships the inner doors duplicating the doors specified in **8.5.2.10.3** and **8.5.2.10.4** may open inside the space.

In ships of 31 m in length and less the doors indicated in **8.5.2.10.1** may open outwards (to the corridor) if they are situated at the end of blind corridors and do not hinder the exits from other spaces.

No sliding doors shall be fitted at exits and means of escape, except for doors of the wheelhouse.

The doors referred to in **8.5.2.10.1** shall not be provided with hooks for holding the door open. It is permitted that such doors be fitted with buffers and spring catchers to fix the door in the open position and to allow for its closure without entering the space.

The doors specified in **8.5.2.10.3** and **8.5.2.10.4** may open in a different direction when security against the impact of the sea and safe passage are provided.

8.5.2.11 Doors of accommodation spaces specified in **1.5.2.1** and **1.5.2.2**, Part VI "Fire Protection" shall have in their lower portions detachable panels 0,4 x 0,5 m in size, these panels of the passenger cabin doors shall be provided with the following inscription: "Means of escape — knock out in case of emergency".

The detachable panels need not be fitted where the spaces are provided with opening type side scuttles of at least 400 mm in diameter of windows the smaller side of which being at least 400 mm and on condition that persons may get to the corridor or open deck through these side scuttles or windows.

The appropriate means shall be provided, if necessary, to facilitate exit through side scuttles or windows.

8.5.2.12 In arrangement and disposition of exits and doors in dangerous zones, spaces and areas of oil tankers and oil recovery ships, as well as of ships carrying dangerous goods requirements shall be considered with respect to the safe-type electrical equipment to be used in spaces adjacent to dangerous zones with the doors open into such spaces (refer to **19.2** and **19.11**, Part XI "Electrical Equipment").

8.5.2.13 The doors of evacuation routes from public premises, which usually stopped, shall be equipped with means for their quick release. Such means shall consist of a stopper device of the doors, which is combined with a device that quickly releases the stopper when applying force in the direction of movement to the outside.

Stopper quick release device:

.1 shall consist of a bolt or panel, the effective part of which is located at least half the width of the door plate, but not less than 760 mm, and not more than 1120 mm above the deck;

.2 shall release the door stopper when using force of not more than 67 N; and

.3 shall not be equipped with any locking device, locking screw or other device preventing the release of the stopper under the force that is applied to the door release device.

8.5.2.14 The aggregate width of exits from premises intended for use by people with reduced mobility shall not be less than 0.9 m. The aggregate width of exits commonly used for embarking and disembarking people with reduced mobility shall not be less than 1.5 m.

Minimum clearance of 0.6 m between the door end of the door frame and the side of the lock and the adjacent perpendicular wall shall pe provided for doors intended for people with reduced mobility.

8.5.3 Corridors and passageways.

8.5.3.1 All corridors and passageways shall ensure free movement of persons along them. On passenger ships and special purpose ships carrying more than 60 persons, a lobby, corridor or part of a corridor shall have more than one means of escape.

Cargo ships and special purpose ships carrying not more than 60 persons shall have no dead-end corridors more than 7 m long.

By a dead-end corridor, a corridor or part of a corridor is meant which has only one means of escape.

Corridors used as means of escape on cargo ships shall be at least 700 mm wide and shall be fitted with a handrail on either side. Corridors with a width of 1800 mm and more shall be fitted with handrails on each side. Width of a corridor is determined as a distance between a handrail and opposite bulkhead or as a distance between handrails.

8.5.3.2 The width of main corridors in way of passengers' and crew's accommodation spaces shall not be less than 0,9 m, and that of side corridors shall be at least 0,8 m. Where the number of passengers and crew using the corridor surpasses 50 persons, the widths referred to above shall be increased by 0,1 m.

In ships (including the tugs) below 500 gross tonnage and in tugs of less than 370 kW the width of the main corridors and side corridors may be reduced down to 0,8 and 0,6 m, respectively.

8.5.3.3 The widths of passageways in the cinema hall and in the entrance hall shall not be less than 1,1 m and 1,4 m, respectively.

The width of the main passageways in the restaurant or dining room and also the messroom shall not be less than 0,9 m and that of the side passageways shall be at least 0,65 m.

In ships of less than 500 gross tonnage the width of main passageways in the messroom may be reduced down to 0,65 m.

8.5.3.4 The width of the main passageway in the seating passenger space shall be at least 1 m with number of passengers up to 50 and at least 1,1 m with number of passengers in excess of 50.

8.5.3.5 In passenger ships the main corridors adjacent to engine and boiler casings shall be at least 1,2 m in width, however, in ships of less than 500 gross tonnage this width may be reduced down to 0,9 m.

8.5.3.6 The width of passageway on the bridge shall not be less than 0,8 m in ships of 500 gross tonnage and over and at least 0,6 m in ships of less than 500 gross tonnage.

8.5.3.7 In passenger ships and special purpose ships the width of the deck passageways providing access to the lifeboat and liferaft embarkation deck shall not be less than:

0,9 m if the number of seats in lifeboats is not more than 50 on each side of ship;

1,0 m if the number of seats in lifeboats is 50 and over, but less than 100 on each side of ship;

1,2 m if the number of seats in lifeboats is 100 and over, but less than 200 on each side of ship.

If number of seats in lifeboats is 200 and over on each side, the width of the passageways shall be determined according to the procedure approved by the Register.

In other ships the width of the passageways referred to above shall not be less than 0,8 m.

8.5.3.8 The width of openings for embarkation and disembarkation of people with reduced mobility shall not be less than 1.5 m.

Overall width of areas intended for use by passengers with reduced mobility shall not be less than 1.3 m and shall be free of thresholds greater than 0.025 m high. Walls in passage areas intended for passengers with reduced mobility shall be equipped with handrails at a distance 0.9 m above the floor.

The width of connecting passages intended for people with reduced mobility shall be not less than 1.30 m. Connecting passages with width in excess of 1.5 m shall be provided with handrails on both sides.

Passages to such access routes shall be indicated on other access routes to the ship and in other appropriate places throughout the ship.

8.5.4 Stairways and vertical ladder.

8.5.4.1 All between deck stairways shall be of steel frame construction or of equivalent material on agreement with the Register (refer to **1.2**, Part VI "Fire Protection"). Special requirements for arrangement of stairway enclosures and protection of means of escape are specified in **2.1.4.3**, **2.1.4.5**, **2.2.2.4**, Part VI "Fire Protection".

The back side of the stairways in machinery space is to be provided with metal binder.

8.5.4.2 On passenger ships and special purpose ships carrying more than 60 persons, the following conditions shall be met:

.1 the width of stairways shall be not less than 900 mm, with handrails on each side. The minimum width of stairways shall be increased by 10 mm for every one person in excess of 90 persons. The maximum width between handrails where stairways are wider than 900 mm shall be 1800 mm. The total number of persons to be evacuated by such stairways shall be assumed to be two-thirds of the crew and the total number of passengers in the areas served by such stairways;

.2 all stairways sized for more than 90 persons shall be aligned fore and aft;

.3 the doorways, corridors and intermediate landings included in means of escape shall be sized in the same manner as stairways;

.4 stairways shall not exceed 3,5 m in vertical rise without the provision of a landing and shall not have an angle of inclination greater than 45°;

.5 with the exception of intermediate landings, the landings at each deck level shall not be less than 2 m^2in area and shall increase by 1 m2 for every 10 persons provided for in excess of 20 persons but need not exceed 16 m^2, except for those landings servicing public spaces having direct access onto the stairway enclosure;

.6 in any case, the stairway width shall be in accordance with the requirements of the Appendix 1 to this Part;

.7 Stairways intended for people with reduced mobility shall meet the following requirements: the angle of inclination shall not exceed 32°;

the width of stairways shall be not less than 0.9 m;

spiral staircases are not allowed; stairways shall not be located in the direction perpendicular to the ship's center line;

stairways handrails are to extend approximately 0,3 m beyond the limits of its upper and lower parts without any restriction of passage;

handrails, the front parts of at least the first and last steps, as well as the floor covering at the ends of the steps, shall be painted in bright colors;

elevators for people with reduced mobility and lifting equipment, such as escalators or lifting platforms, shall comply with standards approved by the Register.

8.5.4.3 Stairways used as means of escape on cargo ships shall be at least 700 mm wide and shall be fitted with a handrail on either side.

Stairways with a width of 1800 mm and more shall be fitted with handrails on each side. In cargo ships of less than 500 gross tonnage the width of stairways may be 600 mm.

Angle of slope of ladders shall be usually 45° but not greater than 50°, in the machinery and in small spaces - not greater than 60°.

In ships of less than 500 gross tonnage in case of insufficient space at egress from the stairway with angle of slope of ladders of 55° in accommodation and service spaces, with 60° - on decks.

The size of doors providing an access to any stairway shall be of the same size as the stairway.

8.5.4.4 Vertical ladders and ladder steps in cargo holds, tanks, etc. shall be at least 300 mm wide.

8.5.5 Low location lighting (LLL) on passenger ships carrying more than 36 passengers and special purpose ships carrying more than 240 persons.

8.5.5.1 In addition to the emergency lighting stipulated by **19.1.2**, Part XI "Electrical Equipment", the means of escape, including stairways and exits, of passenger ships carrying more than 36 passengers and special purpose ships carrying more than 240 persons shall be marked by LLL at all points of the escape route including angles and intersections.

8.5.5.2 Provision shall be made for the following LLL systems: .1 photoluminescent system which uses photoluminescent material containing a chemical (example: zinc sulfide) that has the quality of storing power when illuminated by visible light;

.2 electrically powered systems which use incandescent bulbs, light emitting diodes, electroluminescent strips or lamps, electrofluorescent lamps, etc. (refer also to **19.1.4**, Part XI "Electrical Equipment").

8.5.5.3 The LLL system shall function at all times for at least 1 h after its activation. All systems, including those automtically activated or continuously operating, shall be capable of being manually activated by a single action from the main control station.

8.5.5.4 In all passageways, the LLL shall be continuous except as interrupted by corridors and cabin doors in order to provide a visible delineation along the escape route. The LLL shall be installed at least on one side of the corridor, either on the bulkhead within 300 mm of the deck, or on the deck within 150 mm of the bulkhead. In corridors more than 2 m wide, LLL shall be installed on both sides. In dead-end corridors, LLL shall have arrows placed at intervals of no more than 1 m, or equivalent direction indicators, pointing away from the dead-end.

8.5.5.5 In all stairways, LLL shall be installed on at least one side at a height less than 300 mm above the steps. LLL shall be installed on both sides if the width of the stairway is two metres or more. The top and bottom of each set of stairs shall be identified to show that there are no further steps.

8.5.5.6 In all passenger cabins, a placard explaining the LLL system shall be installed on the inside of the cabin door. It shall also have a diagram showing the location of, and the way to, the two closest exits with respect to the cabin. Materials used in the manufacture of LLL products shall not contain radioactive or toxic materials.

8.5.5.7 LLL shal indicate the exit door handle; other doors shall not be indicated so.

Sliding, fire-proof and watertight doors shall be provided with LLL sign showing the way of the door opening.

LLL signs shall be also provided at all doors and means of escape. The signs shall be located at a height of 300 mm above the deck or the bottom of the door and be contrast in colour to the background on which they are marked.

All exit door and escape route signs shall be of photoluminescent materials or marked appropriately by lighting.

8.5.5.8 Photoluminescent (PL) material strips shall be not less than 75 mm wide. The strips having a width less than that stated herein shall be used only if their luminance is increased proportionally to compensate for their width. PL materials shall provide at least 15 mcd/m^2 measured 10 min after removal of all external illuminating sources. The system shall ensure luminance values greater than 2,0 mcd/m2 for 1 h. Any PL system shall be provided with not less than the minimum level of ambient light necessary to charge the PL material to meet the above luminance requirements.

8.5.5.9 Electrically powered LLL system shall comply with the requirements of **2.2.8.6.6**, Part VI "Fire Protection".

For ships having length of 120 m or more or having three or more main vertical zones the electrically powered LLL system shall also comply with the requirements of **2.2.7.4.3**, Part VI "Fire Protection".

8.5.5.10 In passenger ships, the passenger and crew cabins shall be fitted with LLL.

8.5.6 Additional requirements for means of escape on ro-ro passenger ships.

8.5.6.1 Handrails or other handholds shall be provided in all corridors along entire escape route, so that a firm handhold is available every step of the way, where possible, to the assembly stations and embarkation stations. Such handrails shall be provided on both sides of longitudinal corridors more than 1,8 m in width and transverse corridors more than 1 m in width. Particular attention shall be paid to the need to be able to cross lobbies, atriums and other large open spaces along escape routes. Handrails and other handholds shall be of such strength as to withstand a distributed horizontal load of 750 N/m applied in the direction of the centre of the corridor or space, and a distributed vertical load of 750 N/m applied in downward direction. There is no need to apply the two loads simultaneously.

8.5.6.2 Means of escape shall not be obstructed by furniture and other obstructions, with the exception of tables and chairs which may be cleared away to provide open space. Cabinets and other heavy pieces of furniture in public spaces and along escape routes shall be secured in place to prevent shifting if the ship rools or lists. Floor coverings shall also be secured in place. When the ship is underway, means of escape shall be kept clear of obstructions..

8.5.6.3 Means of escape shall be provided from every normally occupied space on the ship. These means of escape shall be arranged so as to provide the shortest route possible to the assembly stations and survival craft embarkation stations and shall be marked with appropriate symbols.

8.5.6.4 Where enclosed spaces adjoin an open deck, openings from the enclosed space to the open deck shall, where it is practicable, be capable of being used as an emergency exit.

8.5.6.5 Decks shall be sequentially numbered, starting with "1" at the tank top or the lowest deck. These numbers shall be prominently displayed at stair landings and lifts in the lobbies. Decks may also be named, but the deck number shall always be displayed along with the name.

8.5.6.6 Simple and clear plans showing the "you are here" position and means of escape marked by arrows shall be prominently displayed on the inside of each cabin door and in public spaces.

8.5.6.7 Cabin and stateroom doors shall not require keys to be unlocked from the inside. Neither shall there be any doors along any designed escape route which require keys to be unlocked.

8.5.6.8 The lowest 0,5 m of bulkheads along escape routes shall be able to sustain a load of 750 N/m to allow them to be used as walking surfaces with the ship at large angles of heel.

8.5.6.9 The escape routes from cabins to stairway enclosures shall be as direct as possible, with a minimum number of direction changes. It shall not be necessary to cross from one side of the ship to the other to reach means of escape. It shall not be necessary to climb more than two decks up or down to reach an assembly station or open deck from any passenger space.

8.5.6.10 External means of escape to the survival craft embarkation stations shall be provided from all open decks, referred to in **8.5.6.9**.

8.5.6.11 Lifting ramps for entering / leaving on decks, platforms, ramps, when they are in the lowered position, shall not block the evacuation routes.

8.5.6.12 On passenger roll-on roll-off ships (such as ro-ro), evacuation routes are to be assessed on the basis of evacuation analysis at the design stage. The analysis is to be used to identify and warn, as far as possible, places of congestion that may occur when the ship is abandoned due to the usual movement of passengers and crew along escape routes, including the possibility that the crew may need to move these routes in the direction , opposite to the movement of passengers. In addition, an analysis is to be used to demonstrate that the organization of evacuation routes is sufficiently flexible to ensure that certain evacuation routes, muster stations, embarkation stations, life-saving appliances themselves may not be accessible due to an emergency.

8.6 GUARD RAILS, BULWARK AND GANGWAYS

8.6.1 All exposed parts of the freeboard decks, superstructure decks and deckhouse tops shall be provided with efficient guard rails or bulwarks; in case of ships intended for carriage of timber deck cargo collapsible railing or storm rails shall be fitted on this cargo.

8.6.2 The height of the bulwark or guard rails above the deck shall not be less than 1 m. However, where this height would interfere with the normal operation of the ship, a lesser height may be approved provided the adequate protection of passengers and crew is ensured to the satisfaction of the Register.

8.6.3 The distance between the stanchions of the guard rails shall be not more than 1,5 m. At least every third stanchion shall be supported by a stay.

Removable and hinged stanchions shall be capable of being locked in the upright position. For deck plating exceeding 20 mm the support may be omitted.

In places of such stanchions weld to the deck, the deck shall be supported by a minimum 100x12 mm stiffener.

It is allowed to use flat steel stanchions with increased breadth at the stanchion weld to the deck.

Fig. 8.6.3 shows the installation diagram and the spacing between the stanchions depending on the breadth of the lower edge to be welded to the deck.

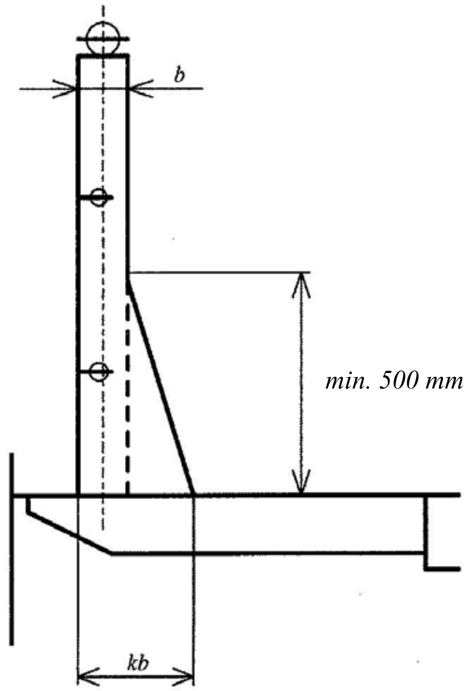


Fig.8.6.3

1. Where $kb \geq 2{,}9b$ - at least every third stanchion shall be of increased breadth.
2. Where $2{,}4b \leq kb < 2{,}9b$ - at least every second stanchion shall be of increased breadth.
3. Where $1{,}9b \leq kb < 2{,}4b$ - at least every stanchion shall be of increased breadth.

The stanchion breadth *b*, shall be chosen according to the design standards.

8.6.4 The gunwale, hand rails and guard rails shall be generally of rigid construction; wire ropes may only be accepted in lieu of guard rails in special circumstances and then only in limited lengths; wire ropes shall be made taut by means of turn-buckles.

Lengths of chains may only be accepted in lieu of rigid guard rails if they are fitted between two fixed stanchions or between the fixed stanchion and bulwark.

8.6.5 The opening below the lowest course of the guard rails shall not exceed 230 mm. The other courses of rails shall not be more than 380 mm apart. An exception is made for the guard rails above the timber deck cargo where the height from the base to the lowest course and other course spacings shall not exceed 330 mm. In the case of ships with rounded gunwale, the guard rail supports shall be placed on the flat of the deck.

8.6.6 Type "A" ships with bulwarks as well as type "B" ships with a freeboard reduced to that required for type "A" ships shall have open rails fitted for at least half the length of the exposed parts of the weather deck, or other effective water freeing arrangements. The upper edge of the sheerstrake shall be kept as low as practicable.

Where superstructures are connected by trunks, open rails shall be fitted for the whole length of the exposed parts of the freeboard deck.

8.6.7 The bulwark, if arranged, shall comply with the requirements of **2.14**, Part II "Hull"..

8.6.8 Satisfactory means (in the form of life lines, gangways, underdeck passages, etc.) shall be provided for the protection of the crew in getting to and from their accomodation spaces, the machinery space and all other parts used in the necessary work of the ship.

8.6.9 A fore and aft permanent gangway shall be provided on type "A" ships at the level of the superstructure deck between the poop and the midship superstructure or deckhouse, where fitted, or equivalent means of access shall be provided to carry out the purpose of the gangway, such as underdeck passages. The width of the passages shall be not less than 1 m. The gangways over the entire length of the plating on either side shall be fitted with longitudinal guarding bars. Reliable guard rails, the dimensions of which shall comply with the requirements of **8.6.2**, **8.6.3** and **8.6.5** of this Part, and **3.5.5.2**, Part II "Hull" shall be provided.

The gangways shall be constructed of a fire-resisting material, and the plating shall be made, in addition, of a non-slip material.

The plating may be manufactured of fibre reinforced plastic provided it complies with the requirements of 6.9, Part XIII "Materials".

In ships not having a midship superstructure arrangements to the satisfaction of the Register shall be made to safeguard the crew in reaching all parts of the ship while at sea.

8.6.10 Safe and convenient ladders from the level of the gangways to the deck shall be provided; they shall not be spaced more than 40 m apart.

Where the length of the deck is more than 70 m, special tripartite shelters (bow - sides) shall be provided along the gangways or other means of access for protection of the crew from bad weather. Such shelters shall be designed for at least one person and shall be spaced not more than 45 m apart. Pipes or other deck equipment shall not impede safe passage.

8.6.11 Requirements of Part VI «Fire Protection» and **8.6.1** ÷ **8.6.10** are not applied to the shipborne barges (lighters), barges and other non-self-propelled ships unmanned.

8.6.12 On ships open decks where access of passengers is allowed, bulwarks or guard rails shall be at least 1.1 m high above the deck and be fitted with a structure that prevents passengers from climbing over guard railing and accidental falling off the deck.

Stairways and ladders on such decks are to be equipped with a guard railing of a similar construction.

8.6.13 Deck bulwarks and railings intended for use by persons with reduced mobility shall not be less than 1.1 m high.

The width of openings, which are usually used for embarkation and disembarkation of persons with reduced mobility shall not be at less than 1.5 m.

8.7 HOISTING GEAR OF SHIPBORNE BARGES

8.7.1 The elements of the hoisting gear of the shipborne barges to be lifted by the crane on board the barge carrier (lugs, eye plates, rings, shackles, grips, etc.) shall be designed to withstand the forces resulting from lifting the shipborne barge uniformly loaded with the specification cargo and gripped in two points diagonally positioned. Under these forces the stresses in the elements of the hoisting gear shall not exceed 0,7 times the upper yield stress of material.

8.8 PILOT TRANSFER ARRANGEMENTS, MEANS OF EMBARKATION AND DISEMBARKATION

8.8.1 Ships engaged on voyages in the course of which pilots are likely to be employed shall be provided with pilot transfer arrangements. Construction and position of pilot transfer arrangements shall comply with the requirements specified in regulation V/23 of SOLAS-74, as amended (hereinafter, SOLAS), and IMO resolutions A.1045(27) and A.1108(29).

Interpretation: sub-paragraphs 1 and 2 of SOLAS regulation V/23.3.3 address two different and distinct arrangements

- the former when only a pilot ladder is used;

- the latter when a combined arrangement of "an accommodation ladder used in conjunction with the pilot ladder" is used.

1. SOLAS regulation V/23.3.3.1 limits the length of climb on a single ladder shall be not more than 9 m regardless of the trim or list of the ship.

2. SOLAS regulation V/23.3.3.2 and Section 3 of IMO resolution A.1045(27) apply to a combined arrangement of "an accommodation ladder used in conjunction with the pilot ladder" for "safe and convenient access to, and egress from, the ship" for which a 158 list requirement does not apply.

8.8.2 The construction of means of embarkation and disembarkation shall comply with the requirements of IMO circular MSC.1/Circ.1331 «Guidance on the construction, installation, maintenance and inspection/survey of means of embarkation and disembarkation».

8.8.3 Passenger ships equipped for the carriage of persons with reduced mobility shall be designed and equipped to facilitate embarkation and disembarkation of persons with reduced mobility.

The structure of the accommodation ladders and gangways of passenger ships shall comply with the requirements of the IMO Circular MSC/Circ.735 “Recommendation on the design and operation of passenger ships to respond to elderly and disabled persons' needs”.

8.8.4 Recovery of persons from the water

8.8.4.1 All vessels engaged in international voyages shall be provided with ship specific schemes and procedures for recovery of people from the water, taking into account the guidance developed by IMO (Guidelines for the development of plans and procedures for recovery of persons from the water, MSC.1/Circ.1447).

Schemes and procedures shall specify equipment intended for use in recovery, as well as measures to minimize the risk to ship personnel involved in recovery operations.

Ships constructed before 1 July 2018 shall comply with this requirement before the date of the first periodic survey or the first renewal survey to renew the ship safety equipment certificate, which is to be performed after 1 July 2018, whichever is earlier.

Passenger ships with sign **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, **D-R3-S** and **D-R3-RS** constructed before 1 January 2018 shall comply with this requirement before the date of the first periodic survey or the first renewal survey to renew the ship safety equipment certificate after 1 July 2018.

8.8.4.2 Passenger ro-ro ships, which comply with **3.4.4** Part II “Life-Saving Appliances”of the Rules for the equipment of seagoing ships shall meet the requirements of **8.8.4.1**.

8.9 NOISE, PRODUCED BY THE SHIP. NOISE PROTECTION.

8.9.1 The noise level on the ship, protection of the crew (personnel) against noise shall comply with requirements applicable to this subsection subject to the provisions of the Code on noise levels on board ships adopted by the Maritime Safety Committee by the Resolution MSC.337(91).

8.9.2 This regulation shall apply:

8.9.2.1 To ships of 1,600 gross tonnage and above:

.1 for which the building contract is placed on or after 1 July 2014; or

.2 in the absence of a building contract, the keels of which are laid or which are at a similar stage of construction on or after 1 January 2015; or

.3 the delivery of which is on or after 1 July 2018,

unless the Administration deems that compliance with a particular provision is unreasonable or impractical;

.4 Passenger ships with sign **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, **D-R3-S** and **D-R3-RS** constructed on or after 1 January 2018;

unless the Administration deems that compliance with a particular provision is unreasonable or impractical.

8.9.2.2 On ships of 1,600 gross tonnage and above delivered before 1 July 2018 and:

.1 contracted for construction before 1 July 2014 and the keels of which are laid or which are at a similar stage of construction on or after 1 January 2009 but before 1 January 2015; or

.2 in the absence of a building contract, the keels of which are laid or which are at a similar stage of construction on or after 1 January 2009 but before 1 January 2015 measures shall be taken to reduce machinery noise in machinery spaces to acceptable levels as determined by the Administration. If this noise cannot be sufficiently reduced the source of excessive noise shall be suitably insulated or isolated or a refuge from noise shall be provided if the space required to be manned.

Ear protectors shall be provided for personnel required to enter such spaces, if necessary;

.3 in passenger ships with sign **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, **D-R3-S** and **D-R3-RS** of 1600 grosss tonnage and over, constructed on or after 1 January 2018, measures shall be taken to reduce machinery noise in machinery spaces to acceptable levels. If this noise cannot be sufficiently reduced the source of excessive noise shall be suitably insulated or isolated or a refuge from noise shall be provided if the space required to be manned.

Ear protectors shall be provided for personnel required to enter such spaces, if necessary.

8.9.3 Requirements **8.9.1** do not apply to:

.1 dynamically supported craf*;

.2 highspeed craft;

.3 pleasure yachts not engaged in trade;

.4 fishing vessels;

.5 floating cranes, crane barges;

.6 mobile offshore drilling units and MSP;

.7 hopper dredgers/dredgers, dredging ships, ships for piling, pipe-laying barges, ships of the technical fleet, etc;

.8 ships not propelled by machinery, and

.9 passenger cabins and other passenger accommodation **, unless they are working premises and fall within the definition: «Accommodation» or «Working places».

* Dyn amically supported craft (DSC) - a craft which is operable on or above water and which has characteristics different from those of conventional displacement ships.

Within the aforementioned generality, a craft which complies with either of the following characteristics:

.1 the weight, or a significant part thereof, is balanced in one mode of operation by other than hydrostatic forces;

.2 the ships may move at a speed at which the ratio $[V/(gL)^{0,5}] \geq 0,9$,

the craft is able to operate at speeds such that the function where V is the maximum speed;

L is the water-line length;

g is the acceleration due to gravity, all in consistent units.

** The noise level in passenger cabins and other passenger areas shall comply with the requirements of the Sanitary Standards adopted by the Flag State Administration.

8.9.4 The Flag State Administration may, in special circumstances, grant exemption from certain requirements if it is documented that their compliance is not possible, despite the implementation of appropriate technical measures to reduce noise. Such exemptions shalld not apply to cabins, except in exceptional circumstances.

When granting exemption from certain requirements, it is to be ensured that the Codex objective on noise levels on ships *** is fulfilled, and the limitation of the influence of noise should be considered together with Chapter 5 of this Code.

*** Refer to IMO A.468(XII), Resolution MSC.338(91).

8.9.5 For ships designed for and employed on voyages of short duration, or on other services involving short periods of operation of the ship, sections 3 and 4 of Table 8.9.9.2 (which are applicable) may be applied only with the ship in the port condition, provided that the periods under such conditions are adequate for seafarers' rest and recreation.

8.9.6 Definitions.

For the purposes of this paragraph, in addition to the definitions and explanations specified in **1.2**, Part I "Classification" and in **1.2**, Part III "Equipment, arrangements and outfit", the following definitions apply:

.1 *Hearing loss* is hearing loss is evaluated in relation to a reference auditory threshold defined conventionally in ISO Standard 389-1 (1998).

The hearing loss corresponds to the difference between the auditory threshold of the subject being examined and the reference auditory threshold.

A hearing loss, originating in the nerve cells within the cochlea, attributable to the effects of sound.

Occasional exposures: those exposures typically occurring once per week, or less frequently.

Potentially hazardous noise levels those levels at and above which persons exposed to them without protection are at risk of sustaining a noise induced hearing loss.

.2 *Accommodation* are cabins, offices (for carrying out ship's business), hospitals, mess rooms, recreation rooms (such as lounges, smoke rooms, cinemas, libraries and hobbies and games rooms) and open recreation areas to be used by seafarers.

.3 *Ear protector* is a device worn to reduce the level of noise heard by the wearer.

.4 *Sound* is an energy that is transmitted by pressure waves in air or other materials and is the objective cause of the sensation of hearing.

.5 *Existing ship – a ship which is not a new vessel.*

.6 *Voyages of short duration* are voyages where the ship is not generally underway for periods long enough for seafarers to require sleep, or long off-duty periods, during the voyages.

.7 *Machinery spaces* for the purpose of this paragraph are any spaces containing propulsion machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and airconditioning machinery and similar spaces, and trunks to such spaces.

.8 *Navigation spaces* are navigation bridge / wheelhouse, chart room, watch stations, including wings and wheelhouse windows, radio rooms (with radio equipment operating but not generating sound signals), radar.

.9 *New ship* is a ship to which the requirements of this paragrapg apply in accordance with **8.9.2.1**.

.10 *Attended spaces* are spaces requiring a permanent or prolonged presence of the crew during normal operating periods.

.11 *Repair, re-equipment and modification of substantial nature* means the re-equipment of the ship, resulting in a substantial change in particulars, power capacity of the ship's engine(s), change in the type of ship, other changes of the ship in such a way that, the relevant provisions would apply to it as for the new ship.

.12 *Sound pressure level Lp* is the level of sound pressure, expressed in decibels (dB), which is determined by the following formula:

$$Lp = 10\log(p^2/p_o^2),$$

where: p – – sound pressure, in Pa;
p_o = 20 μPa (zero level).

.13 *Working places* are premises where the main navigation equipment, ship radio equipment or emergency source of energy are located or where the means of controlling fire extinguishing systems or fire detection alarms are concentrated, as well as premises used as galley, main refreshments, storerooms (except for isolated cupboards and cabinets), postal offices, storehouses of valuables, workshops, which are not a part of the machinery spaces and other similar premises.

.14 *Port condition* is the condition in which all machinery solely required for propulsion is stopped.

.15 *Noise* for the purpose of the Code are all sounds which can result in hearing impairment, or which can be harmful to health or be otherwise dangerous.

8.9.7 Noise produced by the ship.

8.9.7.1 Noise of the ship under way, and in particular the noise produced by the receiving and discharge openings / devices for air and gas exhaust piping / devices shall be limited by appropriate means.

The noise level produced by the ship shall not exceed 75 dB (A) at a distance of 25 m from the ship's side.

8.9.7.2 Without taking into account loading and unloading operations, the noise level produced by the ship at berth should not exceed 65 dB (A) at a distance of 25 m from the ship's side.

8.9.7.3 The noise level is taken into account only from noise sources related to the ship, such as machinery and propulsion system, but no account is taken of wind / wave / ice noise, alarms, public address systems, etc.

8.9.8 Noise protection.

8.9.8.1 Limit values of noise levels shall be set and its impact on the crew shall be reduced to:

.1 ensure safe working conditions, taking into account the need for oral negotiations and audition of sound signals in control stations, navigational spaces and their machinery spaces serviced by the crew;

.2 protect the crew from excessively high levels of noise that may induce hearing loss and

.3 provide necessary degree of comfort in the premises for rest and entertainment and other premises, as well as to provide conditions for the removal of the effects of high-level noise.

8.9.8.2 Where the noise level in machinery spaces (or other spaces) is greater than 85 dB(A), entrances to such spaces should carry a warning notice comprising symbol and supplementary sign in the working language of the ship's crew / English (refer to Fig. **8.9.8.2**).

If only a minor portion of the space has such noise levels the particular location(s) or equipment shall be identified at eye level, visible from each direction of access.

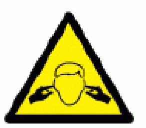
	Warning sign	Symbol
Warning Sign (Symbol)		
Warning inscription	Warning Noise hazard zone	Ear protection must be worn

Fig. 8.9.8.2 Example of warning sign / symbol and the inscription.
The color of the warning sign field and inscription is yellow.
The color of the symbol field and inscription is blue.

8.9.9 Noise exposure limits.

.1 The limits specified in this paragraph shall be considered as maximum permissible levels, but not as desirable levels. Where practicable, it is desirable that the noise level shall be below the specified maximum permissible values.

.2 Noise exposure limits (dB (A)) for different rooms are shown in Table 8.9.9.2.

Table 8.9.9.2

Nos	Spaces	Ship dimension	
		Gross tonna ge from 1600 to 10000	Gross tonna ge ≥ 10000
1	2	3	4
1	Working space [1]		
1.1	Machinery space[2]	110	110
1.2	Machinery control stations	75	75
1.3	Workshops which not included in machinery spaces	85	85
1.4	Working spaces not specified separately (other workplaces)[3]	85	85
2	Navigation facilities		
2.1	Navigation bridge and chart rooms	65	65
2.2	Radio rooms (with running but not producing audio signals radio equipment)	60	60
2.3	Radar room	65	65
3	Accomoddation		
3.1	Hospital cabins and rooms[4]	60	55
3.2	Mess rooms	65	60
3.3	Rest rooms	65	60
3.4	Open rest areas (outdoor recreation areas)	75	75
3.5	Offices	65	60
4	Service rooms		
4.1	The galley with non-working equipment for processing the products	75	75
4.2	Handouts and buffets	75	75
5	Normally unattended spaces		
5.1	Spaces with high noise levels, where the crew can be exposed to it even for relatively short periods of time, as well as the location of the machinery used periodically	90	90

[1] A limit of 110 dB (A) assumes that hearing protectors are worn to provide protection that meets the requirements for hearing protection set out in **8.9.8**.

[2] If the maximum noise levels are exceeded during operation (only permitted in the case of an exemption in accordance with paragraph **8.9.4**), being in the room shall be limited to very short periods or prohibited. This area shall be designated in accordance with **8.9.8.2**.

[3] For example: working places on open decks that are not machinery spaces, as well as working places on open decks, where communication is important.

[4] Hospital: facilities for treatment provided with beds.

8.9.10 Noise resting areas.

.1 Alternatively, when designing ships with a gross tonnage of less than 1600 or icebreakers, noise resting areas may be provided.

.2 Noise resting areas shall be provided in the event that no other technical or organizational solution is possible to reduce the excessive noise produced by sound sources.

8.9.11 In the event of repair, reequipment and modification of the essential nature and associated changes in the equipment of existing ships, it shall be ensured that all areas in which the changes are made comply with the requirements of this subsection for new ships to the extent that the Flag State Administration deems practicable and feasible.

8.9.12 Tests of ships for compliance with the noise level limit requirements shall be carried out according to the program and test methodology approved by the Register in the presence of a representative of the Register.

The program and test procedures shall comply with the provisions of the Code on noise levels on board ships.

8.10 ADDITIONAL REQUIREMENTS TO STANDBY VESSELS

8.10.1 Each side shall be provided with evacuation areas (*rescue zones*) of at least 5 m in length with appropriate marking. Evacuation areas shall be spaced sufficiently from the propulsion gear, as well as from any side outlets, which are less than 2 m below the load line.

8.10.2 The sides of the vessel in the area of the rescue zones shall be free from protruding parts (fenders, etc.).

8.10.3 Spaces for the recovered.

8.10.3.1 The ship shall be fitted with a first aid room for the rescued in an emergency (treatment room), a wellness room with beds and a closed room for the rescued. These premises must be equipped with lighting and temperature and humidity controls, taking into account the possible operating area.

8.10.3.2 The space for the rescued shall be calculated at $0.75 m^2$ per person. This space includes free space, removable furniture, fixed seats and/or beds. Other stationary furniture, toilets and baths are not included in the specified area.

8.10.3.3 A toilet equipped with a shower and sink shall be provided for each 50 rescued persons.

8.10.4 Passages from rescue areas to rooms for rescued and to the helicopter winching area, if provided, shall be fitted with non-slip or wooden cover.

8.10.5 The deck within the rescue areas should be as clear as possible from obstructions (air pipes, fittings, hatches, etc.). If available, adequate protection against personnel injury should be provided.

8.10.6 The bulwark or railing in the rescue zones area shall be removable or easily opened.

8.10.7 In the area of each rescue zone, a net must be provided for recovery of rescued people from water (scrambling net), which is made of corrosion-resistant and non-slip material with a width of at least five meters and a length exceeding 1 m from the place of deployment in the rescue zone to the water line at the lowest operational draft.

8.10.8 The ship shall be fitted with machinery for the accurate recovery of rescued people with restricted mobility from the water.

8.11 ADDITIONAL REQUIREMENTS TO ANCHOR HANDLING SHIPS

8.11.1 The design loads of the anchor handling winch devices, namely: for the anchor chain stopper, tow bitens and stern rolls, shall be taken in accordance with **5.4.2.2**. In this case, the stresses in these elements shall not exceed 0.8 the yield stress of their material.

8.11.2 Anchor handling winch shall be fitted with a cable tension measuring device.

9. REQUIREMENTS TO ESCORT TUGS

9.1 GENERAL. APPLICATION

9.1.1 The technical requirements for escort tugs apply to tugs intended for escort service.

These requirements are additional to the relevant requirements of Parts IV "Stability", VII "Machinery Installations" and VIII "Systems and Piping”.

Tugs complying with the requirements of **2.2.37** of Part I "Classification" may be assigned the descriptive notation Escort tug added to the character of classification**.**

9.1.2 Definitions and explanations.

9.1.2.1 Definitions have been adopted in this section, the following (in addition to those indicated in 1.2):

Escort tug means a tug which in addition to towing and ship handling operations is intended for escort services.

Full scale trials mean sea trials of the escort tug to determine escort characteristics.

Escort service means steering, braking and otherwise controlling the assisted ship.

Escort characteristics :

- maximum steering pull of the tug F_s, in t, escort test speed V , in knots, (refer to Fig. 9.1.2.1);
- maneuvering time t, in s.

Maximum steering pull of the tug means the maximum transverse steering force, in t, exerted by the tug on the stern of the assisted ship at the escort test speed of 8 and/or 10 knots.

Assisted ship means the ship being escorted by the escort tug.

Maneuvering time means a minimum manoeuvring time, in s, from maintained oblique position of the tug (from the centerline of the assisted ship) giving the maximum transverse steering force on one side of the assisted ship to mirror position on the other side.

Escort test speed means the speed, in knots, of the assisted ship during full scale trials.

9.1.3 Technical documentation.

9.1.3.1 The following technical documentation (in addition to the requirements of **4.2** and **4.3**, Part I "Classification") shall be provided for the approval of the Register:

.1 towing arrangement plan required for escort service including towing line path and minimum breaking strength of towing line components and strength of appropriate structures;

.2 preliminary calculation of maximum steering pull of the tug at the escort test speed of 8 and/or 10 knots including propulsion components of the escort tug for balancing of oblique angular position of the tug.

.3 preliminary tug stability calculations for escorting service;

.4 plan of full scale trials.

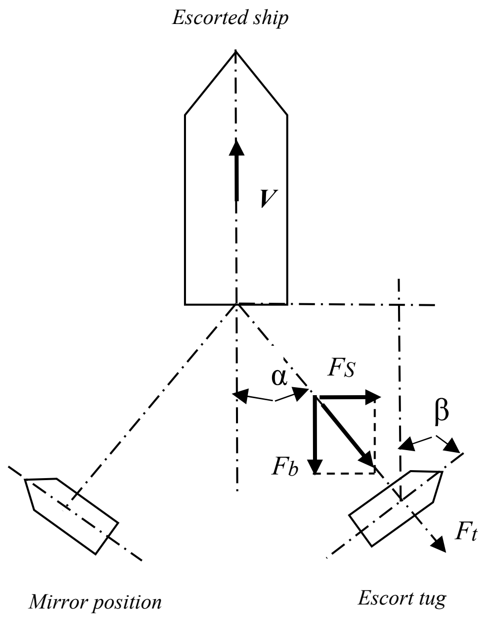


Fig. 9.1.2.1 Typical escort configuration.
F_S – steering force; F_b – breaking force;
F_t – towline force; V – assisted ship speed;
α – the angle between the towline and the centreline of the escorted ship.
β – the angle between the centreline of the tug and the centreline of the escorted ship.

9.2 TECHNICAL REQUIREMENTS

9.2.1 Arrangement and design.

9.2.1.1 A bulwark shall be fitted all around the exposed weather deck.

9.2.1.2 The towing winch intended for escort service shall be fitted with a load reducing system in order to prevent overload caused by dynamic oscillation in the towing line, and shall be capable of paying out the towing line if the pull exceeds 50 per cent of the breaking strength of the towing line.

9.2.1.3 The towing line components shall have a minimum breaking strength of at least 2,2 times the maximum towing pull as measured during the full scale trials (refer to **9.3**).

9.2.1.4 In case of escort service of oil tankers and/or oil recovery vessels, supply vessels, ships intended for the carriage of explosives and inflammable cargoes, the requirements of **11.1.3**, Part VIII "Systems and Piping" shall be complied with.

9.2.2 Stability.

9.2.2.1 The escort tug shall comply with the criteria specified in **3.7.4**, Part IV "Stability".

9.3 FULL SCALE TRIALS

9.3.1 Full scale trials program.

9.3.1.1 Prior to the full scale trials the program of trials, the approved Stability Information, as well as preliminary calculations of the ship's escort characteristics and the tug's stability during escort service shall be submitted to the Register.

9.3.1.2 The program of full scale trials shall stipulate determination of the tug's maximum transverse steering force with the assisted ship speed of 8 and/or 10 knots, the maximum angle of static heel at the specified modes, as well as the tug's manoeuvring time.

9.3.1.3 The program shall include a list of measuring instruments, description of mandatory manoeuvres, a towing arrangement scheme for expected escort modes, design loads of strong points of the tug, as well as data of the safe working load of the strong points of the assisted ship.

9.3.2 Trial procedure.

9.3.2.1 The trials shall be carried out in favourable weather (recommended limitation of wind force is 10 m/s, sea state 2), with the operating load of the tug equal to 50 — 10 per cent of provisions.

Current velocity in the area of the trials (if any) shall be measured both upstream and down stream.

9.3.2.2 Displacement of the assisted ship shall be sufficient to maintain the heading and speed with the help of the autopilot during the necessary tug manoeuvring.

9.3.2.3 The following data shall be recorded continuously in real time mode during trials for later analysis:

.1 position of the assisted ship in relation to the escort tug;

.2 towing line tension;

.3 escort test speed;

.4 angle of the tug heel during escort service;

.5 length and angle of the towing line from the centerline of the assisted ship;

.6 manoeuvring time from maintained oblique position of the tug on one side of the assisted ship to mirror position on the other side at the maximum tension value of towing line and the maximum towing line angle from the centerline of the assisted ship (but not more than 60°);

.7 angle of heel due to sudden loss of thrust.

10. REQUIREMENTS FOR THE EQUIPMENT OF SHIPS WITH ICING PROTECTION

10.1 GENERAL. APPLICATION

10.1.1 The requirements for the equipment of ships with icing protection apply to ships the design and equipment of which provide effective icing protection.

These requirements are additional to the requirements of Part VIII “Systems and Piping” and Part XI “Electrical Equipment” of these Rules, as well as Part II “Life-Saving Appliances”, Part III “Signal means”, Part IV “Radio Equipment” and Part V “Navigational Equipment” of the Rules for the Equipment of Sea-Going Ships.

10.1.2 Ships complying with the requirements of the present Section may be assigned with the distinguishing mark **DEICE** added to the character of classification in accordance with **2.2.13**, Part I “Classification”.

10.1.3 Definitions and explanations.

10.1.3.1 For the purpose of the present Section the following definitions and explanations have been adopted (in addition to adopted in **1.2**:

D e - i c i n g is removal of ice appearing on the ship's hull, structures and equipment.

I c i n g p r o t e c t i o n is a set of design and organizational measures aimed at reduction of the ship's icing and reduction of labour input into ice removal during operation of the ship.

A n t i - i c i n g is prevention of ice formation on the ship's structures and equipment by means of their heating or relevant covering.

I c i n g is a process of ice accretion on the ship's hull, structures and equipment due to sea water splashes or freezing of moisture conden sating on the hull from the atmosphere.

I c i n g P r o t e c t i o n M a n u a l is a document describing actions of the ship's crew to provide icing protection. The scope of the Manual (content) depend on the ship's type, purpose and area of navigation; they shall be chosen in the most efficient way and agreed with the Register.

10.1.4 Technical documentation.

10.1.4.1 The following technical documentation shall be submitted to the Register for approval (in addition to required in **4.2** and **4.3** Part I “Classification”) to assign the distinguishing mark **DEICE** in the class notation:

.1 arrangement plan of anti-icing means with indication of their heating capacity;

.2 calculation of heating capacity of anti-icing systems equipment;

.3 electrical single-line diagram of anti-icing systems with heating cables (if any);

.4 circuit diagram of steam and/or thermal liquids anti-icing systems (if any);

.5 arrangement diagram of de-icing means;

.6 test program for anti-icing systems.

10.1.4.2 Icing Protection Manual approved by the Register shall be kept onboard.

10.2 TECHNICAL REQUIREMENTS FOR ASSIGNING THE DISTINGUISHING MARK DEICE IN THE CLASS NOTATION

10.2.1 Ships with the distinguishing mark **DEICE** in the class notation shall, as a rule, be fitted with a tank of a shape providing effective water flow under all operating loading cases.

Assignment of the distinguishing mark **DEICE** in the class notation to flush deck ships is subject to special consideration by the Register in each particular case.

10.2.2 The following anti-icing means may be used:

.1 heating of structures and equipment by means of steam, thermal liquid or heating cables;

.2 use of permanent (awnings, casings) or removable (covers) protective covers;

.3 the use of lattice structures for platforms, steps of external gangways, walkways, etc.

10.2.3 The following de-icing means may be used besides heating of structures:

.1 washing and firing of ice by means of hot water or steam;

.2 anti-icing liquids;

.3 manual mechanical means including pneumatic instrument.

10.2.4 If steam systems are used for anti-icing the requirements of Section **18**, Part VIII "Systems and Piping" shall be complied with.

10.2.5 If thermal liquid systems are used for antiicing the requirements of Section **20**, Part VIII "Systems and Piping" shall be complied with.

10.2.6 If systems with heating cables are used for anti-icing the requirements of 15.4, Part XI "Electrical Equipment" shall be complied with.

10.3 EQUIPMENT, ARRANGEMENTS AND OUTFIT

10.3.1 Platforms of outer ladders as well as platforms for servicing arrangements and equipment fitted on open decks shall have a grid structure or be equipped with heating elements.

10.3.2 Outer ladders located on the escape routes to life-saving appliances as well as muster stations to lifesaving appliances (including guard rails) shall be equipped with anti-icing means.

10.3.3 Coamings of outer doors leading to the accomodation superstructure spaces and to spaces providing the ship's operation in accordance with its main purpose shall be heated.

Decks in areas of exit from the said spaces shall be equipped with anti-icing means.

10.3.4 A passage from the accomodation superstructure spaces to the equipment fitted in the fore part of the ship shall be provided on tankers, including chemical tankers and gas carriers. This passage shall be provided with antiicing means.

10.3.5 Side scuttles in the wheelhouse providing the arc of visibility required by 3.2, Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships according to the ship's class shall be heated.

Windshield wipers on the said side scuttles (if any) shall be heated as well..

These requirements also apply to side scuttles in cargo operations control stations.

10.3.6 Shell doors, cargo doors and other closing appliances in the fore part of the ship providing the ship's operation in accordance with its main purpose shall be fitted with means for effective ice removal or other means to provide working capacity of the said appliances in case of icing (for example, with ice-breaking hydraulic cylinders).

10.3.7 Design of packing of cargo hatches, shell doors and other closing appliances providing the ship's operation in accordance with its main purpose shall preclude freezing of condensate inside seals.

10.3.8 Anti-icing shall be provided for the following arrangements and equipment:

.1 anchor and mooring equipment including (but not limited to) winches, capstans, windlasses, chain stoppers, drums, control panels;

.2 arrangements for emergency towing of tankers, including chemical tankers and gas carriers;

.3 hook releasing devices of lifeboats;

.4 launching appliances of survival craft (falls on drums, sheaves, winches of launching appliances, winch breaks and other elements engaged in launching);

.5 liferafts, including hydrostatic releasing devices. The Register may require taking measures to prevent icing of additional equipment and arrangements in accordance with the ship's main purpose.

10.3.9 Lifeboats shall be of enclosed type and be equipped with the relevant heating elements to prevent icing and blocking of access hatches and/or doors.

10.3.10 Proper locations shall be provided on board for at-sea storage of removable covers used to prevent icing of equipment and fittings.

10.3.11 In addition to the emergency outfit specified in Section **12**, ships with the distinguishing mark **DEICE** in the class notation shall have the necessary de-icing outfit (crowbars, ice-axes, axes, shovels, spades) kept in places of permanent storage and having the relevant marking.

10.4 SYSTEMS AND PIPING

10.4.1 Sufficient number of scuppers and freeing ports shall be provided for the effective water flow from open decks.

Scuppers and freeing ports shall be located so as to preclude water stagnation on decks under all operating loading cases.

10.4.2 Air heads of ballast tanks and fresh water tanks shall be fitted with the relevant heating devices.

10.4.3 Design of air intakes of main, auxiliary and emergency power plants as well as of ventilation of spaces, which are of great importance for the ship's safety, shall preclude their icing that may cause air duct blockage.

10.4.4 Measures shall be taken to preclude freezing of liquid in the pipelines of fire extinguishing systems by means of their effective drying or heating.

Fire hydrants, monitors, valves and other equipment of fire extinguishing systems fitted on open decks shall be protected from icing by means of heating or removable covers.

Cut-off valve of water and foam fire extinguishing systems shall be fitted in enclosed heated spaces or shall be heated.

10.4.5 Hot water or steam supply shall be provided for de-icing on weather decks.

10.4.6 In addition to **10.4.1** ÷ **10.4.5**, the following items shall be heated on tankers, including chemical tankers and gas carriers:

.1 ventilation valves and pressure/vacuum valves (PA/ valves) of cargo tanks and secondary barriers;

.2 level, pressure, temperature gauges and gas analysers in cargo tanks located on open decks, if necessary;

.3 inert gas system elements containing water and located on open decks;

.4 emergency shut-down system (ESD) on gas carriers.

10.4.7 Drives of remotely operated fittings of tankers, including chemical tankers and gas carriers, fitted on open decks shall be equipped with anti-icing devices.

10.4.8 Pipelines equipped with electrical heating shall comply with the requirements of **5.8**, Part VIII "Systems and Piping".

10.5 ELECTRICAL EQUIPMENT, SIGNAL MEANS, RADIO AND NAVIGATIONAL EQUIPMENT

10.5.1 The following electrical equipment, signal means, radio and navigational equipment located on open decks shall be designed so that to prevent icing or shall be heated:

.1 aerials of radio and navigational equipment (excluding rod aerials), aerial matching devices (if fitted on open decks);

.2 navigation lights;

.3 whistles;

.4 satellite emergency positionindicating radio beacons;

.5 main and emergency lighting of open decks; .6 TV cameras used during operation of the ship in accordance with its main purpose;

.7 aerials of telemetric and dynamic positioning systems;

.8 means (buttons) for the remote stop of pumps for the discharge of oil-containing and waste water to reception facilities.

10.5.2 If consumers, which according to 9.3.1, Part XI "Electrical Equipment" shall be supplied from the emergency source of electrical power, are fitted with electrical heating, their heating elements shall be also fed from the emergency source of electrical power.

10.6 TESTING

10.6.1 Prior to testing an Ice Protection Manual (only for ships without the additional distinguishing mark **WINTERIZATION** (**DAT**) in class notation) shall be submitted to the Register.

10.6.2 Anti-icing means are tested with a demonstration of their intended use and taking measurements of heat output.

11. REQUIREMENTS FOR HELICOPTER FACILITIES

11.1 GENERAL. APPLICATION

11.1.1 Requirements for helicopter facilities are additional to those of Part I "Classification", Part II "Hull", Part HI "Equipment, Arrangements and Outfit", Part VI "Fire Protection", Part VIII "Systems and Piping", Part XI "Electrical Equipment" of the Rules for the Classification and Construction of Sea-Going Ships and Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships.

Passenger roller ships (ro-ro passenger ships) with a length of 130 m or more with a sign **A**, **A-R1**, **A-R2**, **A-R2-RS**, **A-R2-S**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS**, **D-R3-S**, **D-R3-RS** in the character of classification, shall be fitted with helicopter decks complying with requirements of these Rule.

11.1.2 Ships that meet the requirements of this section, in accordance with **2.2.25**, Part I «Classification», may be assigned with the following distinguishing marks added to the character of classification:

.1 HELIDECK –for ships fitted with helidecks and complying with the requirements specified in **11.2**, **11.3**, **11.6**, **11.7** and **6.1.1** Part IV "Fire Protection";

.2 HELIDECK-F – for ships fitted with the helicopter refuelling facilities, in addition to those of **11.1.2.1**, complying with the requirements specified in **11.5.1**, **11.5.2** (as applicable) and 6.1.2 (as applicable), Part IV " Fire Protection ";

.3 HELIDECK - H – – for ships fitted with a hangar and complying with the requirements of the present Section in a full scope..

11.1.3 All ro-ro passenger ships shall be provided with a place for picking up on board the helicopter.

Passenger ro-ro ships of 130 m in length and over shall be fitted with a helicopter landing area.

Ships shall also meet the requirements of the International Civil Aviation Organization (ICAO) and the Flag State (if any) for the safe operation of helicopters, which shall be confirmed by the relevant conclusion or Certificate of the competent civil aviation authority.

11.1.4 Definitions.

11.1.4.1 For the purpose of the present Section the following definitions and explanations have been adopted (in addition to adopted in 1.2):

H a n g a r is a purpose-built space for helicopter storage and/or maintenance and repair.

H l i c o p t e r is the largest ship's helicopter, for which a safe take-off and landing operation on board a ship is ensured.

H e l i d e c k is a purpose-built helicopter take-off and landing area including all structures, fire-fighting appliances and other equipment necessary for the safe operation of helicopters.

H e l i c o p t e r f a c i l i t y (helicopter facility) is a complex of technical means including a helideck, helicopter refuelling facilities and compressed gas or special liquid filling facilities (if any), as well as hangars and spaces where helicopter maintenance facilities are located (if any).

F i n a l a p p r o a c h a n d t a k e - o f f a r e a (final approach and take-off area, FATO) is the area over which the propeller completes the landing approach maneuver, ending with the transition to the hovering or landing mode, or when performing the maneuver of the take-off begins a progressive flight.

T o u c h d o w n a n d lift - o f f a r e a (T L O F) (touchdown and lift-off area, TLOF) is a dynamic loadbearing area on which a helicopter may touchdown or lift off. For a helideck it is presumed that the FATO and the TLOF will be coincidental.

He l i c o p t e r l a n d i n g a r e a is an area on a ship designated for occasional or emergency landing of helicopters but not designed for routine helicopter operations.

W i n c h i n g a r e a is a pick-up area provided for the transfer by helicopter of personnel or stores to or from the ship, while the helicopter hovers above the deck.

11.1.5 Technical documentation.

10.1.5.1 The following technical documentation shall be submitted to the Register for approval (as applicable) to assign distinguishing marks **HELIDECK-F, HELIDECK-H** or **HELIDECK,** in the class notation (in addition to required in **4.2** and **4.3**, Part I "Classification"):

.1 helideck and hangar deck plans with indication of design loads;

.2 scantlings determination of helideck and hangar deck, as well as of deckand bulkhead stiffeners in way of helicopter tie-down points;

.3 general arrangement plan of a helicopter facility elements with indication of escape routes, tie-down points, location of fire-fighting equipment and lifesaving appliances, arrangement plan and specification of lighting and illumination means;

.4 drawing of helideck safety net;

.5 diagram of power driving gear for the helideck safety net hoisting and lowering, if any;

.6 diagram of helideck drainage system;

.7 diagram of fuel oil loading, transfer, storage and helicopter refuelling system;

.8 diagram of off-grade aviation fuel collection, storage and defueling system;

.9 diagram of nitrogen system for aviation fuel;

.10 electric diagram of main and emergency lighting in the spaces of helicopter facility arrangement;

.11 circuit diagram of helideck lighting and illumination means;

.12 drawings of electrical equipment layout and cable laying on the helideck, in hangar and in other spaces of helicopter facility arrangement;

.13 documentation on helideck and hangar deck covering;

.14 helicopter facility test program;

.15 diagram of obstacle restriction and removal approved by the Flag State Civil Aviation Authority (to be submitted for information);

.16 drawing of helideck and obstacle marking (colour, dimensions and configuration of marks shall be indicated), approved by the Flag State Civil Aviation Authority (to be submitted for information).

11.1.5.2 A Manual for the operation of helicopter maintenance facilities (hereinafter referred to as the Manual), including a description of the equipment, a list of control checks, safety requirements and equipment maintenance procedures shall be provided on board ships. This Manual shall also include procedures and safeguards to be followed during fueling operations of helicopters designed in accordance with recognized safe practices..

11.1.5.3 The Register may require additional documents to those listed in **11.1.5.1** proceeding from the ship design features.

11.2 HELIDECK DESIGN

11.2.1 Helideck arrangement with regard to provision of horizontal and vertical sectors for helicopter approach, landing and take-off shall comply with the requirements of ICAO and the Flag State (if any).

11.2.2 Helideck arrangement shall provide:

.1 free helicopter approach to helideck according to **11.2.2**;

.2 safety of helicopter take-off and landing operations and maintenance personnel;

.3 helideck location at a maximum possible distance from the ship's hazardous spaces and areasa.

11.2.3 Helideck may have any configuration in plan view, generally, circle or regular polygon. In any case FATO shall be of sufficient size to contain an area within which can be drawn a circle of diameter not less than D of the largest helicopter the helideck is intended to serve, where D is the largest dimension of the helicopter when the main and tail rotors are turning.

11.2.4 The helideck shall be provided with both main and emergency means of escape and access for firefighting and rescue personnel. These shall be located as far apart from each other as practicable, and preferably on the opposite sides of the helideck. If more than 50 per cent of the helideck area is projected from the main ship structure, it is recommended to arrange two entrances to helideck within the range of such overhanging parts that is providing at least one exit from helideck to windward side in case of fire.

11.2.5 If the helideck forms the ceiling of a deckhouse or superstructure it shall be of "A-60" class.

11.2.6 Helideck shall be made of steel. Aluminum alloys may be used provided the following:

.1 a helideck, irrespective of its type and location, shall be subject to a survey in case of fire on the helideck or in close proximity;

.2 if a helideck is located above the deckhouse or similar structure, the following conditions shall be additionally satisfied:

.2.1 the deckhouse top and bulkheads below the helideck shall have no openings;

.2.2 windows below the helideck shall be provided with steel covers;

.3 surfaces of the steel and aluminium alloy structures contacting at the point of connection and exposed to sea water shall be separated by gaskets made of nonabsorbent electrically insulating material.

Bolts, nuts and washers connecting the steel and aluminium structures shall be made of stainless steel. Bolts shall be installed in the bushes made of nonabsorbent electrically insulating material which structure shall exclude the contact of aluminium alloy and steel.

The aluminium alloy structure insulated from the steel structure shall be grounded to the ship's hull;

.4 bimetal materials shall be approved by the Register, and certificates shall be issued for them by the Register.

The horizontal component is assumed to be equal to half the vertical component;

.5 bimetallic materials shall be approved and have Certificates of the Register.

11.2.7 Helidecks and helicopter refuelling areas shall be clearly marked and provided with coamings and/or gutters to prevent fuel oil leakage from spreading.

Drainage facilities in way of helidecks shall be constructed of steel or other arrangements providing equivalent fire safety; lead directly overboard independent of any other system; and designed so that drainage does not fall onto any part of the unit.

11.2.8 Helideck plates and supporting structures shall comply with the requirements of **2.12.6**, Part II “Hull”.

11.3 EQUIPMENT OF HELIDECKS

11.3.1 The helideck surface shall be smooth, no steps or recesses in FATO are generally allowed. As an exception, the steps on the FATO perimeter line (outside the helideck white perimeter line) shall not exceed 250 mm in height, and within the FATO (within the helideck white perimeter line) shall not exceed 25 mm in height.

Objects the function of which requires that they be located on the helideck within the FATO shall only be present provided they do not cause a hazard to helicopter operations.

As an exception, for ships which keels are laid before 1 January 2012, the steps within the FATO of height not exceeding 60 mm with the edge slop 1/3 are allowed.

11.3.2 The helideck, including its marking, and hangar deck shall have a skid-resistant surface.

11.3.3 For helicopter operation in winter period easily detachable rope net, rather of natural fiber (sisal), diameter of 20 mm and maximum mesh dimensions 200 x 200 mm, shall be provided along the perimeter of the FATO.

Recommended dimensions of the net, depending on the overall helicopter length, are determined by sufficiency to cover the landing area:

6 x 6 m at helicopter length less than 15 m;

12 x 12 m at helicopter length from 15 to 20 m;

15 x 15 m at helicopter length more than 20 m.

The net shall be reliably secured to the deck along the FATO perimeter and fixed to it in any 1,5 m and shall be tightened with a load not less than 2225 N.

The dismounted net shall be kept onboard.

11.3.4 Outboard edges of the helideck shall be provided with fixed or hinged safety net of at least 1,5 m in width, made of fire-resistant flexible material.

For sea-going ships, which keels are laid before 1 January 2012, outboard edge of the fixed safety net shall not rise above the plane of FATO more than 0,25 m, and the net shall be inclined upwards at an angle of at least 10°.

For sea-going ships, which keels are laid on and after 1 January 2012, outboard edge of the fixed safety net shall not rise above the plane of FATO, and the net shall be inclined upwards at an angle of at least 10°.

Hinged safety net in tumble position shall comply with the same requirements.

The safety net shall be strong enough to withstand, without damage, a 75 kg mass being dropped, and the net shall provide hammock effect for person falling into it rather than the trampoline effect produced by some rigid materials.

11.3.5 In addition to the requirements of 11.3.4 the hinged safety net shall comply with the following requirements:

.1 safety net shall be reliably secured in a hoist position;

.2 safety net shall be reliably fixed in a hinged position so as to prevent its hoist due to the effect of airflow from the helicopter rotor;

.3 safety net hoisting and lowering shall be performed so as to minimize the risk of personnel falling overboard during the operations;

.4 any failure of power driving gear for safety net hoisting shall not prevent from its lowering by hand.

11.3.6 To minimize the risk of personnel or equipment sliding from the helideck, the outboard edges of the helideck shall have coamings of recommended height of 50 mm.

The coamings shall also meet the requirements of **11.2.7**.

11.3.7 The helideck in way of helicopter parking place and maintenance areas, as well as the hangar (if any) shall be equipped with the tie-down points and means for fastening of helicopter maintenance facilities (if any), flush type is preferable.

Connection dimensions, arrangement plan and design forces of tie-down points shall be selected for fastening of one or several types of helicopter taking into account the requirements of **11.3.1**.

11.3.8 Where handrails associated with access/escape points exceed the elevation of the FATO by more than 0,25 m, they shall be made collapsible and removable. They shall be collapsed or removed whilst helicopter manoeuvres are in progress.

11.4 FIRE PROTECTION

11.4.1 Fire protection of Helideck, hangars and premises where the equipment for refueling and maintenance of helicopters is located, shall be arranged in accordance with **6.1**, Part IV "Fire Protection".

11.5 SYSTEMS AND PIPING

11.5.1 Helicopter refuelling systems.

11.5.1.1 All the equipment used in refuelling operations shall be effectively earthed.

All the equipment, arrangements, machinery and deck coverings shall be manufactured and installed so as to prevent spark formation.

11.5.1.2 Tanks used for storage of helicopter fuel shall be located on the open deck in specially designed area, which shall be:

.1 as remote as practicable from accommodation and machinery spaces, escape routes and embarkation stations, as well as from locations containing sources of ignition;

.2 isolated from areas containing sources of vapour ignition;

.3 the fuel storage area shall be provided with arrangements whereby fuel spillage may be collected and drained to off-grade fuel tank;

.4 where tanks for storage of helicopter fuel and offgrade fuel tanks are located in enclosed spaces, such tanks shall be surrounded by cofferdams filled with inert gas;

.5 in cofferdams referred to in **11.5.1.2.4** the length of oil fuel line and the number of its detachable joints shall be kept to a minimum, and its valves shall be located in easily accessible places, generally, on the open deck;

.6 cofferdams referred to in **11.5.1.2.4** shall not be connected to any piping system serving other spaces.

11.5.1.3 Helicoopter fuel tanks and equipment related to them shall be protected from mechanical damage and fire in adjacent rooms or area.

Tanks shall be protected from direct sunlight.

11.5.1.4 When equipping tanks for the storage of helicopter fuel with facilities for their emergency jettisoning precautions shall be taken to prevent the tank jettisoned from impact against ship's structures. The tanks shall be as remote as practicable from survival craft muster and embarkation stations and survival craft launching stations.

11.5.1.5 If transported fuel tanks are used, their construction, fitting and securing devices shall be designed taking into account the purpose of the tank and the feasibility of its inspections.

Electrical earthing of tanks shall be provided.

11.5.1.6 Helicopter refueling system shall comply with the requirements of **13.13**, Part VIII “Systems and Piping”.

11.5.1.7 The fuel tanks shall be made of materials which resist attacks by corrosion and helicopter fuel. Fuel may be stored both in transported and fixed tanks.

Tanks shall be efficiently secured, closed and bonded.

The tanks shall be readily accessible for inspection.

Tanks and piping for anticrystallization fluids shall be made of stainless steels.

11.5.1.8 The operating manual for helicopter maintenance facilities, including equipment description, a checklist, safety requirements and equipment maintenance procedures, shall be provided on board.

This manual shall also include the procedures and precautions to be followed during the helicopter fueling operations developed in accordance with recognized safe practice.

11.5.2 Ventilation system of hangars and spaces where helicopter refuelling and maintenance facilities are located.

11.5.2.1 Ventilation system of hangars and spaces where helicopter refuelling and maintenance facilities are located shall meet the requirements of **12.11**, Part VIII “Systems and Piping”.

11.6 ELECTRICAL EQUIPMENT

11.6.1 Electrical equipment and electric wiring of hangars and spaces where helicopter refuelling and maintenance facilities are located shall comply with the requirements of **2.9**, Part XI "Electrical Equipment".

11.6.2 Lighting and illumination means for helidecks shall comply with the requirements of **6.9**, Part X I "Electrical Equipment" of the Rules for the Classification and Construction of Sea-Going Ships and the Flag State Civil Aviation requirements.

11.7 COMMUNICATIONS

11.7.1 To ensure helicopter operation the ship shall be equipped with necessary radio and meteorological equipment in compliance with the Flag State Civil Aviation requirements.

11.7.2 To ensure three-way communication between the helicopter, Helicopter deck and wheelhouse, the required number of portable VHF radio-telephone stations with headphones shall be provided.

11.8 TESTING

11.8.1 All systems and components of the helicopter facilities, after their installation on the ship, shall be tested in accordance with the Register approved Program.

11.8.2 On ships, upon request of the civil aviation authorities of the Flag State, flight tests and overflights may be carried out in accordance with the guidance documents of the Flag State.

12. EQUIPMENT OF SHIPS INTENDED TO FORM A PART OF OF A PUSHED CONVOY

12.1 GENERAL

The requirements of this section apply to tugboats-pushers, pushed barges of all purposes, of mixed "sea - river" navigation, which have a sign **R3-RS** in the class notation**.**

Tugboats-pushers and pushed barges, shall comply with the requirements of 3.14, Part II "Hull" and **5.5.1-5.5.6** of Part III of «Equipment, Arrangements and Outfit. Signal Means» of the Rules for the classification and construction of mixed navigation ships.

The anchor gear of the pusher shall comply with the characteristics of provision in accordance with 3.2 (refer also to **3.7**).

12.2 DESIGN LOADS AND PERMISSIBLE STRESSES IN THE PARTS OF COUPLINGS

12.2.1 These requirements are applicable to the double-hinged design of the coupling of pushed convoys operated with a wave height restriction $3{,}0 \le h_{3\%} \le 3{,}5$ m.

With greater wave height restrictions, the requirements of 5.5.7, Part III, «Equipment, Arrangements and Outfit. Signaling aids» of the Rules for the classification and construction of mixed navigation ships.

12.2.2 Design loads, acting at the same time on the hinge coupling device, shall be determined in accordance with **5.5.7** частини III «Equipment, Arrangements and Outfit. Signal Means» of the Rules for the classification and construction of mixed navigation ships using Table **13.2.2** instead of **5.5.7.2.**

Table 12.2.2

Product h x λ, in м	**Coefficient**	**Formula**
1	2	3
3,5 x 50	C_x	$-39{,}2 \cdot (30{,}9 \cdot \overline{p}^{\,2} - 13{,}76 \cdot \overline{p} + 1) \cdot (T_1/B_1) \cdot 10^{-4}$
	C_y	$3{,}3 \cdot (1 - 1{,}56 \cdot \overline{p}) \cdot (T_1/B_1) \cdot 10^{-3}$
	C_z	$4{,}84 \cdot (1 + 5{,}2 \cdot \overline{p}) \cdot (T_1/B_1) \cdot 10^{-3}$

13. REQUIREMENTS FOR THE EQUIPMENT OF SHIPS TO PROVIDE DURABLE OPERATION AT LOW TEMPERATURES

13.1 GENERAL

13.1.1 Application.

13.1.1.1 Requirements for the equipment of ships to ensure long-term operation at low temperatures apply to ships designed for operation in cold climatic conditions (refer to **2.2.3.1.4** of Part I "Classification"), and are additional to the requirements of Part I "Classification", Part II "Hull", Part VII "Machinery installations", Part VIII "Systems and piping", Part IX "Machinery", part XI "Electrical equipment" and part XIII "Materials" of the Rules, part II "Life-saving appliances", Part III "Signal means ", Part I V "Radio equipment" and Part V "Navigation equipment" of the Rules for the equipment of sea-going ships, as well as the Rules for the cargo handling gear of sea-going ships.

13.1.1.2 Ships complying with the specified requirements and the requirements of this Chapter, at the request of the ship-owner, a distinguishing mark **WINTERIZATION (DAT)** may be added to the character of classification (refer to **2.2.30**, Part I "Classification").

13.1.2 Definitions, explanations and abbriviations.

For the purpose of the present Section the following definitions, explanations and abbriviations have been adopted.

Accommodation are spaces complying with the requirements of 1.5.2, Part VI "Fire protection".

Pollutant is any substance that is subject to restrictions on discharge into the sea in accordance with MARPOL 73/78.

Enclosed space is a space with access to an open deck and fitted with appropriate closure.

IBC Code is the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk.

LSA Code is the International Life-saving appliance Code.

MARPOL 73/78 is the International Convention for the Prevention of Pollution from Ships 1973 as amended by the Protocol 1978 .

Open space is a space with access to an open deck, which is not and fitted with closure or must be open for a long time under the operating conditions of the equipment installed in this space.

Design Ambient Temperature, DAT is an outdoor temperature in degrees Celsius, which is used as a criterion for the selection and testing of materials and equipment that are exposed to low temperatures.

Design Structural Temperature is a temperature in degrees Celsius, which is accepted for the choice of structural material. If there are no additional instructions in the Rules or in this section regarding the design temperature of the structure, the design ambient temperature is adopted.

Operating fluids are fuel and lubricating fluids and hydraulic oils, with the exception of marine fuels necessary for the normal operation of the ship and her equipment.

Harmful liquid substance (HLS) – any substance listed in the pollutant category column of Chapter 17 or 18 of the International Bulk Chemical or provisionally assessed in accordance with the provisions of Appendix **I** of Annex **II** to MARPOL 73/78 relating to Category X, Y or Z.

13.2 DESIGN AMBIENT TEMPERATURES

13.2.1 The design ambient temperature is set by the ship-owner based on the purpose of the ship and her operating conditions.

13.2.2 The following standard values for the design ambient temperature are provided in this section:

-30°C (distinguishing mark **WINTERIZATION(-30)**);

-40°C (distinguishing mark **WINTERIZATION(-40)**); and

-50°C (distinguishing mark **WINTERIZATION(-50)**).

The application of the requirements of this section for design ambient temperature above -30° C, as well as for intermediate values, is determined by the Register in agreement with the ship-owner.

13.2.3 Design ambient temperature cannot be accepted higher than specified in 1.2.3.3, Part II “Hull” for the corresponding ice class of the ship.

13.2.4 Design structural temperature shall be adopted in accordance with 1.2.3.4, Part II “Hull”. In this case, design ambient temperature should be taken as the T_A value.

13.2.5 For the equipment and machinery installed on open decks, as well as in open spaces, the design ambient temperature shall be taken as the design structural temperature . For the equipment and machinery installed in enclosed spaces that are not heated and bordering the external environment and adjacent enclosed unheated spaces the design ambient temperature shall be taken as the design structural temperature.

For the equipment and machinery installed in enclosed unheated rooms bordering the external environment and adjacent to enclosed heated spaces, the temperature 20° C higher than the design ambient temperature shall be taken as the design structural temperature.

13.3 GENERAL REQUIREMENTS

13.3.1 Cargo and slop tanks of tankers with a deadweight of less than 5000 tons over the entire length shall be protected by ballast tanks or compartments not intended for the transport of pollutants, located in accordance with the requirements of regulation **19.6.1** (from the bottom plating) and the requirements for distance w of regulation **19.6. 2** (from the shell plating) Annex I to MARPOL 73/78.

In ships other than tankers, all cargo tanks designed and intended to carry oil shall be located at a distance of at least 0.76 m from the shell plating.

On type 3 chemical carriers specified in 2.1.2 of the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code), or on bulk ships for the carriage of HLS cargo tanks shall be located at a distance of at least 0.76 m from the shell plating.

13.3.2 For ships with a total fuel tank capacity of less than 600m^3, all fuel tanks shall be located at a distance of at least 0.76m from the shell plating. This requirement does not apply to small fuel tanks, the capacity of which does not exceed 30m^3.

13.3.3 All tanks of oil residues (oil-containing sediments), tanks for the storage of operating fluids, as well as tanks of oil-containing bilge water shall be located at a distance of at least 0.76 m from the shell plating. This requirement does not apply to small fuel tanks, the capacity of which does not exceed 30m^3.

13.3.4 In addition to the requirements of MARPOL 73/78 Annex I, each ship shall be equipped with a collecting tank (s) for oil residues (sludge), as well as a collecting tank (s) for oil-containing bilge water of sufficient capacity, as agreed with the Register for the complete storage on board ship of accumulated oil residues (oily sediments) and oily bilge water during the voyage in polar waters and their discharge to reception facilities.

13.3.5 Navigating bridge wings shall be enclosed.

The viewing angles shall comply with the requirements of 3.2, Part V, "Navigation Equipment" of the Rules for the Equipment of Sea-Going Ships. The windows of the front, rear and side windows of the bridge (including wings) shall be tilted outwards from the vertical plane to an angle of not less than 10 ° and not more than 25 ° (except for the door glass)..

13.3.6 Exit from the accommodation corridors to the open deck shall be arranged through heated tambours.

13.3.7 A heated deck house shall be provided to cover the crew when performing such functions as monitoring the environment during the movement of the ship or guarding the gangway while in port.

13.4 EQUIPMENT, ARRANGEMENT AND OUTFIT

13.4.1 Anchor gear.

13.4.1.1 Anchor materials shall comply with the requirements of **8**, Part XIII "Materials".

13.4.1.2 Anchor chain cables materials shall comply with the requirements of **11**, Part XIII «Materials».

13.4.1.3 Casting materials for the manufacture of anchor fairleads shall comply with the requirements of **11**, Part XIII «Materials».

The Register documents that are issued for anchor fairleads, installed on ships with the distinguishing marks **WINTERIZATION (-40)** and **WINTERIZATION (-50)**, shall indicate the permissibility of their use at the corresponding design ambient temperature.

13.4.1.4 Anchor chain stoppers comply with the requirements of **3.6.1** of this Part.

The Register documents that are issued for anchor chain stoppers, installed on ships with the distinguishing marks **WINTERIZATION (-40)** and **WINTERIZATION (-50)**, shall indicate the permissibility of their use at the corresponding design ambient temperature.

13.4.2 Mooring gear.

13.4.2.1 Casting materials for the manufacture of bollards, roller chocks and other mooring equipment shall comply with the requirements of **11**, Part XIII «Materials».

The Register documents that are issued for mooring gear, installed on ships with the distinguishing marks **WINTERIZATION (-40)** and **WINTERIZATION (-50)**, shall indicate the permissibility of their use at the corresponding design ambient temperature.

13.4.2.2 Chain stoppers for single point mooring to offshore terminals shall meet the requirements **14.4.1.4**.

13.4.3 Towing gear.

13.4.3.1 Casting materials for the manufacture of bitts, bollards, roller chocks, towing roller fairlead and other towing equipment shall comply with the requirements of **11**, Part XIII «Materials».

The Register documents that are issued for towing gear, installed on ships with the distinguishing marks **WINTERIZATION (-40)** and **WINTERIZATION (-50)**, shall indicate the permissibility of their use at the corresponding design ambient temperature.

13.4.3.2 Emergency towing gear chains shall comply with the requirements of **11**, Part XIII «Materials».

13.4.4 Side scuttles.

13.4.4.1 The side scuttles of the wheelhouse and the cargo operations control station shall be heated in accordance with **10.3.5**.

13.4.4.2 In ships with the distinguishing marks **WINTERIZATION(-40)** and **WINTERIZATION(-50)** double-glazed side scuttles shall be installed in the accommodation.

13.4.4.3 If a view onto the cargo deck is provided through the side scuttles of the Master's cabin, at least one of these side scuttles shall be heated.

13.4.4.4 External access or other equivalent means for cleaning of the bridge and the cargo control station side scuttles shall be provided.

13.4.5 Cargo hatches, shell doors, cargo doors.

13.4.5.1 Materials for the manufacture of cargo holds hatches covers and bulk cargo compartments, shell and cargo doors, including packing, shall comply with the requirements of **11**, Part XIII «Materials».

13.4.5.2 Hydraulic fluids and lubricating oils shall be suitable for use at design ambient temperature.

13.4.5.3 The Register documents that are issued for hatch covers of cargo holds and bulk cargo compartments, shell and cargo doors, installed on ships with the distinguishing marks **WINTERIZATION (-40)** and **WINTERIZATION (-50)**, shall indicate the permissibility of their use at the corresponding design ambient temperature.

14. MANEUVERABILITY

14.1 GENERAL

14.1.1 This section of the Rules sets out the basic minimum requirements for the maneuverability of ships and convoys.

In cases where the convoy consists, for example, of several vessels or of a pusher with one or more barges, the maneuverability requirements apply to the convoy in general according to **2.1.1**.

14.1.2 Ships shall be able to maneuver, that is, be abile to change direction and speed quickly, ensuring the safety of navigation or solving operational tasks, both in inland waterways (not offshore) and in sea areas corresponding to the sign of the area restriction in the ship's character of class.

14.1.3 Ships longer than 100 m, and gas and chemical carriers, regardless of the length, shall be maneuverable, complying with the provisions of IMO Resolution MSC.137 (76) “Standards for ship manoeuviability”, taking into account MSC / Circ.1053 “Explanatory notes to the Standards for shipmanoeuvrability".

14.1.4 The main characteristics of the vessel affecting controllability, the characteristics of the steering gear and the steering nozzle are selected at the discretion of the designer and the shipowner, taking into account the need to ensure proper controllability of the vessel, corresponding to its purpose and operating conditions, the need to ensure compliance of the relative rudder areas or steering nozzles of the designed vessel and prototype vessel, provided, however, that the total efficiency of the selected rudders and (or) steering nozzles shall not be less than assigned in the applicable requirements of **2.10,** Part **III** « Equipment, Arrangements and Outfit» and **14,** Part **III** « Equipment, Arrangements and Outfit. Signal Means» of the Rules for the classification and construction of inland navigation ships.

15. EMERGENCY OUTFIT

15.1 GENERAL

15.1.1 The items listed in Tables 12.2.1, 12.2.2-1, 12.2.2-2 i 12.2.3, may be included into the emergency outfit, provided these items have corresponding markings and their permanent storage places are situated above the bulkhead deck.

15.2 EMERGENCY OUTFIT REQUIRED

15.2.1 All ships exept those specified in **15.2.4** and **15.2.6**, shall have emergency outfit in the scope not less than listed in Table 15.2.1.

For the unmanned non-self-propelled ships no emergency outfit is required. The manned non-selfpropelled ships shall be supplied with the emergency outfit in accordance with **15.2.10** like floating docks with no permanent direct communication with the shore.

Table 15.2.1

Nos.	Item, unit	Розмір	Quantity for ships of length *L*, in m				Quantity for tankers *
			150 and over	from 150 to 70 incl.	from 70 to 24 incl.	below 24	
1	2	3	4	5	6	7	8

1	Armoured collision mat, pc	4,5x4,5 m	1	–	–	–	–
2	Lightened collision mat, pc	3,0x3,0 m	–	1	–	–	1
3	Thrummed collision mat, pc	2,0x2,0 m	–	–	1	–	–
4	Thrummed pad, pc	0,4x0,5 m	4	3	2	1	2
5	Set of rigging tools.	as per Table 12.2.3	1	1	1	1	1
6	Set of fitter's tools	as per Table 12.2.3	1	1	1	1	1
7	Pine bar, pc	150x150x x4000 mm	8	6	–	–	–
8	Pine bar, pc	80x100x 2000mm	2	2	4	–	4
9	Pine plank, pc	50x200x 4000mm	8	6	2	–	–
10	Pine plank, pc	50x200x2000mm	4	2	2	–	2
11	Pine wedge, pc	30x200x 200mm	10	6	4	–	4
12	Birch wedge, pc	60x200x 400mm	8	6	4	–	4
13	Pine plugs, pc	10x30x150mm	10	6	4	2	4
14	Pine plugs for ships with side scuttles, pc	side scuttle diameter	6	4	2	2	4
15	Unbleached canvas, m^2	–	10	6	4	2	–
16	Coarse felt, m^2	s = 10mm	3	2	1	–	–
17	Rubber plate, ^{2}	s = 5mm	2	1	0,5	–	0,5
18	Tarred tow, kg	–	50	30	20	10	5
19	Wire (low-carbon steel pc 50 m each), pc	∅ 3mm	2	2	1	–	1
20	Construction shackles, pc	d = 12mm	12	8	4	–	4
21	Hexagon-head bolt, pc	M16x400mm	10	6	2	–	–
23	Hexagonal nut, pc	M16	16	10	6	4	–
24	Washer for bolt, pc	M16	32	20	12	8	–
25	Construction nails, kg	l = 70mm	4	3	2	1	1
26	Construction nails, kg	l = 150mm	6	4	2	1	1
27	Cement (quick setting), kg	–	400	300	100	100	100

End of Table 15.2.1

Nos	Item, unit	Розмір	Quantity for ships of length L, in m				Quantity for tankers *
			150 and over	from 150 to 70 incl.	from 70 to 24 incl.	below 24	
1	2	3	4	5	6	7	8
28	Sand, natural, kg	–	400	300	100	100	100
29	Accelerator for concrete setting, kg	–	20	15	5	5	5
30	Minium, kg	–	15	10	5	5	5
31	Technical fat, kg	–	15	10	5	–	5
32	Carpenter's axe, pc.	–	2	2	1	1	1
33	Saw, cross-cut, pc	l = 1200mm	1	1	1	–	–
34	Hack-saw, pc	l = 600mm	1	1	1	1	1
35	Shovel, pc	–	3	2	1	1	1
36	Bucket, pc	–	3	2	1	1	1
37	Sledge hammer, pc	5kg	1	1	1	–	–

38	Lantern of explosionproof type, pc	–	1	1	1	1	1
39	Stop of telescopic type, pc	–	3	2	1	1	1
40	Emergency screw clamp, pc	–	2	1	1	–	–
Note. *Whatever the ship length, ice class and navigation area are.							

15.2.2 Additional set of emergency outfit, above that listed in Table 15.2.1, shall be provided:

in accordance with Table 15.2.2-1 for passenger and special purpose ships, of 70 m in length and over, except for fiber-reinforced plastic ships;

in accordance with Table 15.2.2-2 for fiber-reinforced plastic ships.

Table 15.2.2-1

Nos	Item	Quantity
1	Portable autogenous cutting torch complete with set of fully charged gas cylinders	1
2	Hand jack, hydraulic	1
3	Blacksmith's sledge hammer	1
4	Forge chisel with haft	1
5	Crowbar	2
6	Jack 9,8 kN	1
7	Jack 19,6 kN	1

Table 15.2.2-2

Nos	Item	Quantity
1	Glass fabric	25m^2
2	Glass fabric	3kg
3	Resin binder with hardener	5kg

15.2.3 The sets of rigging and fitter's tools specified in Table 15.2.1, shall be completed according to Table 15.2.3.

Таблиця 15.2.3

Nos	Item	Size	Quantity per set	
			rigging	fitter's
1	Tape measure	l = 2000 mm	1	–
2	Bench hammer	0,5 kg	1	1
3	Sledge hammer	3,0 kg	–	1
4	Rigger's mallet	–	1	–
5	Puncher (dumb iron)	–	1	–
6	Chisel	b = 20 mm l = 200 mm	1	1
7	Marline spike	l = 300 mm	1	–
8	Carpenter's chisel	b = 20 mm	1	–
9	Screw auger	∅ 18 mm	1	–
10	Tongs	l = 200 mm	1	–
11	Hollow punch	∅ 18 mm	–	1
12	Hollow punch	∅ 25 mm	–	1
13	Triangular file	l =300 mm	–	1
14	Half-round file	l = 300 mm	–	1

Nos	Item	Size	Quantity per set	
			rigging	fitter's
15	Multi-purpose tongs	*l*= 200 mm	–	1
16	Screw driver	*b* = 10 mm	–	1
17	Adjustable wrench	Jaw width up to 36 mm	–	1
18	Wrench	Jaw width up to 24 mm	–	1
19	Rigger's knife	–	1	–
20	Hack-saw frame	–	–	1
21	Hack-saw blade	–	–	6
22	Kit-bag	–	1	1

15.2.4 For ships of restricted areas of navigation **R1**, **A-R1, A-R2**, **A-R2-RS**, **A-R2-S**, **R2, R2-S, R2-RS**, **R3-S**, **R3-RS**, **B-R3-S**, **B-R3-RS**, **C-R3-S**, except those specified in **15.2.5**, equipment with emergency outfit and materials may be laid down as for the nearest lower group of ship's division depending on their length according to Table 15.2.1.

The minimum amount of emergency outfit for ships of restricted areas of navigation **R3, R3-IN** and **D-R3-S, D-R3-RS** shall be determined by the shipowner.

15.2.5 For **Ice5** and **Ice6** ice class ships, Polar class **PC1** ÷ **PC6** and Baltic ice class **IA Super** equipment with emergency outfit and materials shall be established as for the nearest higher group of ship's division according to their length as per 15.2.1.

15.2.6 For glass-reinforced plastic ships provision of emergency outfit listed under items 6, 9, 17, 21–24, 26–29, 31, 35, 36, 39 i 40 of Table 15.2.1 is not required.

15.2.7 In ships intended to carry flammable and explosive cargoes tools of emergency outfit shall be made of nonsparking materials wherever practicable.

15.2.8 The tugs of restricted area of navigation **R3** and **R3-IN** need not be equipped with emergency outfit, except for the sets of rigging and fitter's tools required in accordance with Table 15.2.3.

15.2.9 For tugs of unrestricted service and restricted area of navigation **R1** with ice class **Ice5,** category equipment with emergency outfit and materials shall be established as for the nearest higher group according to Table 15.2.1.

15.2.10 The floating docks which are not in permanent direct communication with the shore shall have emergency outfit as indicated under items 5, 6, 19 - 26, 32 - 34 and 37 of Table 15.2.1, length of the floating dock *L* being taken in this case instead of the ship's length *L*.

The floating docks which are in permanent direct communication with the shore need not be provided with emergency outfit.

15.2.11 For berth-connected ships, the emergency outfit shall be chosen by the owner.

15.2.12 Ships having a distinguishing mark **FF1**, **FF1WS**, **FF2**, **FF2WS** and **FF3WS** in the class notation shall have two searchlights capable of providing an efficient horizontal and vertical range of illumination of a surface not less than 10 m in diameter at a distance up to 250 m at the minimum illumination intensity up to 50 lx at dark time and clear atmosphere.

15.3 STORAGE OF EMERGENCY OUTFIT

15.3.1 The emergency outfit indicated in **15.2** shall be stored at least in two emergency stations, one of which shall be situated in the machinery space.

Emergency stations may be special spaces, boxes or places allocated on the deck or in spaces.

In the emergency station of the machinery space the outfit necessary for carrying out the emergency operations inside the space shall be stored; the rest of the emergency outfit shall generally be stored in the emergency stations located above the bulkhead deck;

in ships of less than 45 m in length it is allowed to locate the emergency station below the bulkhead deck on condition that free access to this station is provided at all times.

In ships of 31 m in length and below it is allowed to store the emergency outfit only in one emergency station.

15.3.2 A free passage shall be provided in front of the emergency station; the passage width shall be selected depending on the overall dimensions of the outfit stored in the station but not less than 1,2 m. In ships of less than 70 m in length the passage width is allowed to be reduced to 0,8 m and in ships of 31 m in length and below to 0,6 m.

The passages to the emergency stations shall be as straight and short as practicable.

15.4 MARKING

15.4.1 Items of the emergency outfit and cases for their storage (apart from collision mats) shall be painted blue either entirely or in a stripe.

The cases for emergency equipment storage shall have the distinct inscription to indicate the name of the material, weight and warranted storage period.

15.4.2 The emergency stations shall be provided with distinct inscriptions "Emergency Station". Moreover, in the passages and on the decks notices shall be posted showing location of the emergency stations.

15.5 COLLISION MATS

15.5.1 Collision mats shall be made of water-resistant canvas or other equivalent fabric and be provided with either a soft or wire interlayer depending on the type of the collision mat. The collision mats shall be edged by a leech rope with four thimbles fitted into its corners. Moreover, cringles shall be provided according to the number of ropes specified in Table 15.5.1.

Basic data on the collision mats are given in Table 15.5.1 and Fig. 15.5.1.

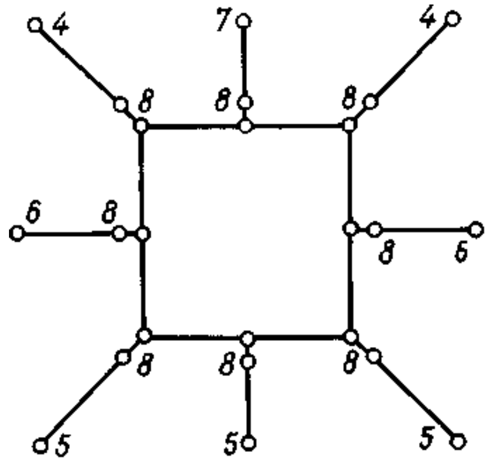


Fig.15.5.1

Table 15.5.1

Nos	Item	Quantity		
		Armoured collision mat, 4,564,5 m	Lightened collision mat, 3,063,0 m	Thrummed collision mat, 2,062,0 m
1	Canvas layers	4	2	2
2	Interlayer	wire net with leech rope	felt padding	1 pad
3	Fastening of stiffeners	–	In pockets (pieces of wire rope or pipes)	–
4	Sheets	2	2	2
5	Hogging lines	3	2	2
6	Guys	2	2	–
7	Control lanyard with marking	1	1	1
8	Shackles	12	9	6

Nos	Item	Quantity		
		Armoured collision mat, 4,564,5 m	Lightened collision mat, 3,063,0 m	Thrummed collision mat, 2,062,0 m
9	Tackles (safe working load)	4 (14,7 kN)	2 (9,8 kN)	2 (9,8 kN)
10	Snatch blocks (safe working load)	4 (14,7 kN)	2 (9,8 kN)	2 (9,8 kN)

15.5.2 The pads shall be made of natural fibre rope strands and be thrummed with natural fibre spun yarn. A canvas shall be sewn on the bottom side of the pad.

15.5.3 Sheets and guys of armoured collision mats shall be made of flexible steel wire ropes, control lanyards - of natural fibre ropes and hogging lines for all collision mats - of flexible steel wire ropes or chains having suitable diameter.

Wires of steel ropes shall have heavy zinc coating in accordance with the national standards.

The length of the sheets shall be chosen so that a hole may be shut up in any place of the shell plating and the ends of the ropes may be efficiently secured on the deck.

Breaking strength of the whole sheets shall exceed that of the leech ropes by not less than 25 %.

15.5.4 The blocks of emergency outfit may have hooks as hangers. The permissible load of the shackles joining the ropes shall not be less than 0,25 times the breaking load of the whole ropes referred to above.

APPENDIX 1

CALCULATION OF THE WIDTH OF STAIRWAYS SORMING MEANS OF ESCAPE ON PASSENGER SHIPS AND ON SPECIAL PURPOSE SHIPS CARRYING MORE THAN 60 PERSONS

1. The calculation method considers evacuation from enclosed spaces within each main vertical zone individually and takes into account all of the persons using the stairway enclosures in each zone, even if they **enter that stairway from another main vertical zone.**

2. For each main vertical zone the calculation shalld be completed for the night time (case 1) and day time (case 2) and the largest dimension from either case used for determining the stairway width for each deck under consideration.

3. For multi-deck ships, the total stairway width *W*, in mm, which allows for the timely flow of persons evacuating from adjacent decks is determined using the following calculation method:

when joining two decks:

$$W = (N_1 + N_2) \cdot 10; \quad (3\text{-}1)$$

when joining three decks

$$W = (N_1 + N_2 + 0{,}5N_3) \cdot 10; \quad (3\text{-}2)$$

when joining four decks

$$W = (N_1 + N_2 + 0{,}5N_3 + 0{,}25N_4) \cdot 10, \quad (3\text{-}3)$$

where: N_1 – the number of persons to be evacuated from deck with the largest number of persons using the stairway;

N_2 – the number of persons to be evacuated from the deck with the next largest number of persons directly entering the stairway etc., i.e. $N_1 > N_2 > N_3 > N_4$.

When joining five or more decks, the total stairway width shall be determined by Formula (3-3) with regard for the number of tiers and their capacity (refer to Fig. 3-1).

The calculated value of *W* may be reduced where available landing area is provided in stairways at the deck level (refer to Fig. 3-2).

The doors to the muster station shall have an aggregate width of at least

D = 900+9355 = 10255

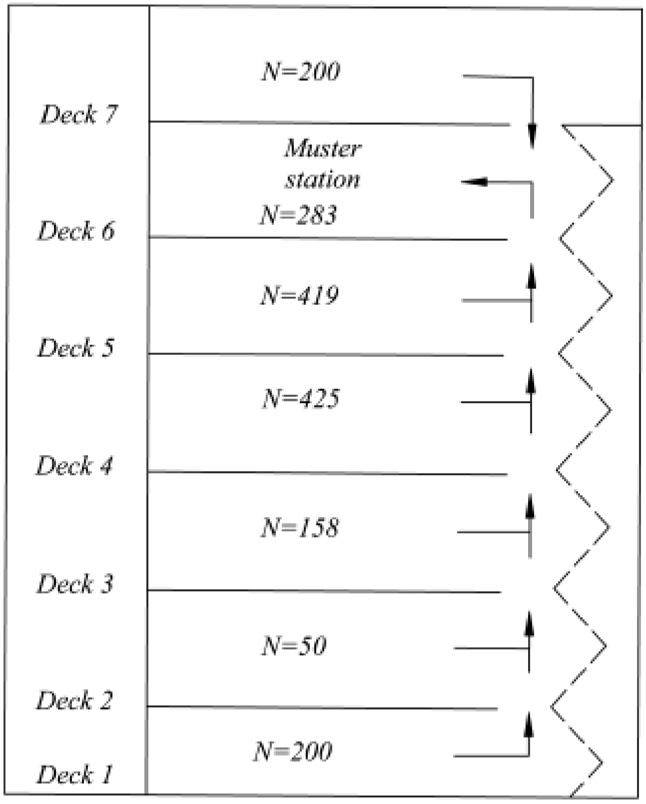


Fig.3-1 Minimum stairway width calculation example:

Deck 1:

$N_1 = 200$, $W = 200 \cdot 10 = 2000$;

Deck 2:

$N_1 = 200$, $N_2 = 50$,

$W = (200 + 50) \cdot 10 = 2500$;

Deck 3:

$N_1 = 200$, $N_2 = 158$, $N_3 = 50$,

$W = (200 + 158 + 0{,}5 \cdot 50) \cdot 10 = 3830$;

Deck 4:

$N_1 = 425$, $N_2 = 200$,

$N_3 = 158$, $N_4 = 50$,

$W = (425 + 200 + 0{,}5 \cdot 158 + +0{,}25 \cdot 50) \cdot 10 = 7165$;

Deck 5:

$N_1 = 425$, $N_2 = 419$, $N_3 = 158$, $N_4 = 50$,

$W = (425 + 419 + 0{,}5 \cdot 158 + 0{,}25 \cdot 50) \cdot 10 = 9355$;

Deck 7:

$N_1 = 200$, $W = 900$.

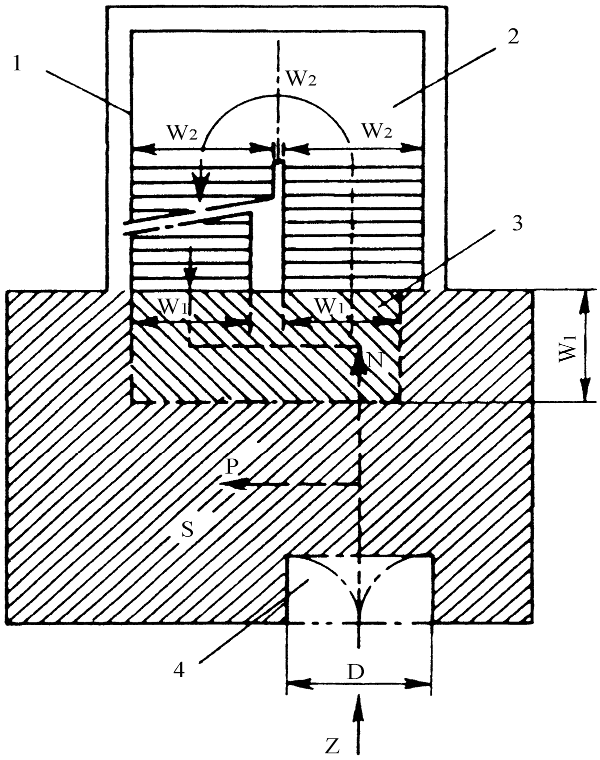


Fig.3-2 Landing calculation for stairway width reduction:

1 – handrail on both sides of the stairway;
2 – intermediate landing;
3 – necessary flow area for accessing the flow on the stairs;
4 – door area;
$P = S$ x 3 persons/m^2 – the number of persons taking refuge on the landing to a maximum value of $P_{max} = 0,25Z$;
$N = Z – P$ – the number of persons directly entering the stairway flow from a given deck;
Z – the number of persons to be evacuated from the deck considered;
S – available landing area, in m^2, after subtracting the surface area necessary for movement and subtracting the space taken by the door swing area;
D – width of exit doors to the stairway landing area, in mm.

4. The stairway shall not decrease in width in the direction of evacuation to the muster station, except in the case of several muster stations in one main vertical zone the stairway width shall not decrease in the direction of the evacuation to the most distant muster station.

5. Where the passengers and crew are held at a muster station which is not at the survival craft embarkation position the dimensions of stairway width and doors from the muster station to this position shall be based on the number of persons in the controlled groups. The width of these stairways and doors need not exceed 1500 mm unless larger dimensions are required for evacuation from these spaces under normal conditions.

6. The calculations of stairway width shall be based upon the crew and passenger load on each deck. For the purpose of the calculation the maximum capacity of a public space shall be defined by either of the following two values: the number of seats or similar arrangements, or the number obtained by assigning 2 m^2 of gross deck surface area to each person.

7. The dimensions of the means of escape shall be calculated on the basis of the total number of persons expected to escape by the stairway and through doorways, corridors and landing (refer to Fig. 7).

Calculations shall be made separately for the two cases of occupancy of the spaces specified below. For each component part of the escape route, the dimension taken shall not be less than the largest dimension determined for each case.

Case 1:

passengers in cabins with maximum berthing capacity fully occupied;

members of the crew in cabins occupied to 2/3 of maximum berthing capacity;

service spaces occupied by 1/3 of the crew.

Case 2:

passengers in public spaces occupied to 3/4 of maximum capacity;
members of the crew in public spaces occupied to 1/3 of maximum capacity;
service spaces occupied by 1/3 of the crew;
crew accommodation occupied by 1/3 of the crew.

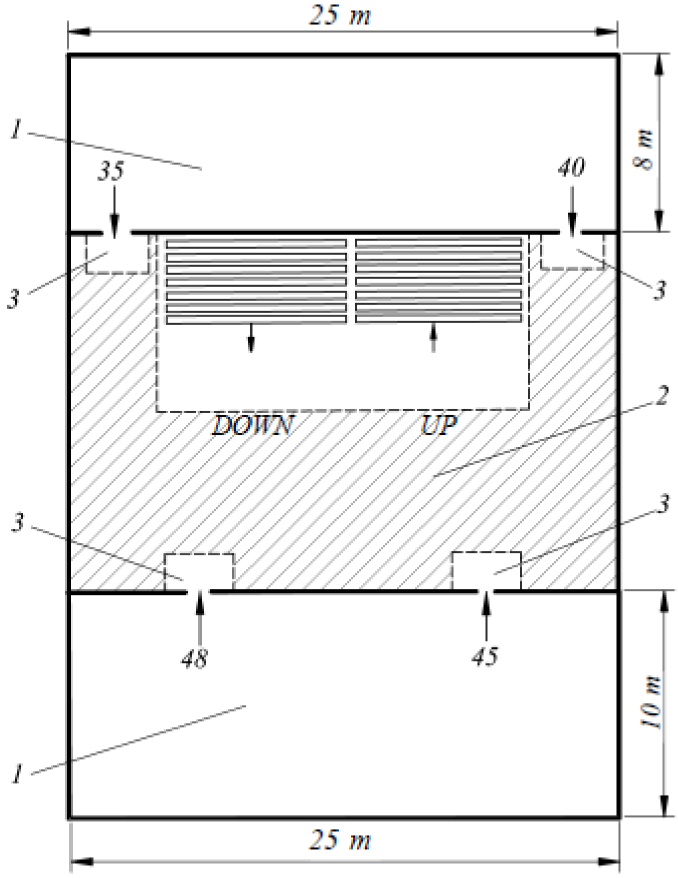


Fig.7 Occupant loading calculation example:
1 – public space;
2 – landing credit area;
3 – door area;
DOWN, UP – stairway flow path for upper space:

$$Z_{(pers.)} = \frac{25\ \text{m} \cdot 8\ \text{m}}{2\ \text{m}^2} = 100;\ N_{(pers.)} = 100 \cdot 0{,}75 = 75;$$

for lower space:

$$Z_{(pers.)} = \frac{25\ \text{m} \cdot 10\ \text{m}}{2\ \text{m}^2} = 125;\ N_{(pers.)} = 125 \cdot 0{,}75 = 93$$

8. The maximum number of persons contained in a vertical zone including persons entering stairways from another main vertical zone shall not be assumed to be higher than the maximum number of persons authorized to be carried on board for the calculation of the stairway width only.

ADDITIONAL REQUIREMENTS

1. The aggregate width of stairway exit doors to the muster station shall not be less than the aggregate width of stairways serving this deck.

2. Means of escape plans shall be provided indicating the following:

.1 the number of crew and passengers in all normally occupied spaces;

.2 the number of crew and passengers expected to escape by the stairway and through doorways, corridors and landing;

.3 muster stations and survival craft embarkation positions;

.4 primary and secondary means of escape;

.5 width of stairways, doors, corridors and landing areas.

3. Means of escape plans shall be accompanied by detailed calculations for determining the width of escape stairways, doors, corridors and landing areas.

APPENDIX 2

SAFE ENTERING INTO CARGO HOLDS, CARGO AND BALLAST TANKS AND OTHER SPACES

1. Safe access[1] to cargo holds, cargo and ballast tanks and other premises of the cargo area shall be directly from the open deck and shall be such as to ensure full inspection of these premises.

Safe access to the double bottom or forepeak is possible through the pump room, deep cofferdam, pipeline tunnel, cargo hold, double hull or similar compartment, which is not intended for the carriage of oil or hazardous goods.

2. Tanks and tank compartments of 35 m in length or more shall be equipped with at least two access hatches and access ladders, located as far as possible from each other.

Tanks less than 35m in length shall be equipped with at least one hatch and ladder for access.

If a tank is divided by one or more baffle bulkheads or similar obstacles that do not provide easy access to other parts of the tank, it shall be fitted with at least two access hatches and ladders.

3. Each cargo hold shall be equipped with at least two access means, as far as practicable, as far apart as possible.

As a rule, these means for access are located diagonally, for example, one in the nasal forward bulkhead from the port side, and the second in the aft bulkhead from the starboard side.

[1] Refer to IMO A.1050(27) – «Revised Recommendations for Entering Enclosed Spaces aboard Ships».

PART V. SUBDIVISION

1. GENERAL

1.1 APPLICATION

1.1.1 The requirements of the present Part cover the following types of ships:

.1 passenger ships;

.2 oil tankers;

.3 fishing vessels having the length $L_1 \geq 100$ m and having over 100 persons on board;

.4 type "A" ships and type "B" ships with reduced freeboard as mentioned under **4.1.2.1** and **4.1.3.3** of Load Line Rules for Sea-Going Ships;

.5 chemical tankers;

.6 gas carriers;

.7 special purpose ships;

.8 supply vessels;

.9 ships intended for the carriage of radioactive agents;

.10 cargo ships having the length $L_1 \geq 80$ m not mentioned above;

.11 dry cargo ships having the length $L_1 < 80$ m (refer to **1.4.9**);

.12 icebreakers having the length $L_1 \geq 50$ m;

.13 tugs having the length $L_1 \geq 40$ m;

.14 dredgers having the length $L_1 \geq 40$ m, hopper dredgers having the length $L_1 \geq 60$ m;

.15 drilling ships;

.16 lightships;

.17 **Ice4, Ice5** and **Ice6**, Baltic **IA Super** and **IA** and Polar Class ships;

.18 berth-connected ships used as floating hotels and/or having over 100 persons on board;

.19 bulk carriers, ore and combination carriers in service, which construction date is stated in Section **5**;

.20 cargo ships having the length $L_1 < 100$ m, other than bulk carriers, and a single cargo hold or cargo holds which are not separated by a bulkhead made watertight up to the freeboard deck (refer to **3.4.13**);

.21 ro-ro passenger ships – a passenger ship carrying more than 12 passengers and having closed or open ro-ro spaces or spaces of special category as defined in **1.5.4.3**, **1.5.4.4** and **1.5.9**, Part VI "Fire Protection", "Rules for the Classification and Construction of Sea-Going Ships".

Ferryboats that are via ferry crossing engaged on regular carriages of passengers and carriage of vehicles with oil in tanks on open and/or closed deck and/or railway rolling stock with horizontal loading and discharging shall be referred to as ro-ro passenger ships.

1.1.2 For ships to which the present Part is not applicable it is recommended that all measures allowed by the type and service conditions of the ship be taken to obtain the best subdivision characteristics possible.

However, if the shipowner wishes a subdivision distinguishing mark to be introduced in the class notation, the ship shall satisfy all the requirements contained in the present Part.

1.1.3 The requirements of Section **4** are applicable to type "A" ships and type "B" ships with reduced freeboard provided compliance with **4.1** of the Load Line Rules for Sea-Going Ships as regards the subdivision of those ships is confirmed. When making calculations required by Section **4**, calculations as required by Sections **2** and **3** may be considered.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 Definitions and explanations related to the general terminology of the Rules are given in General Regulations for Technical Supervision and Part I, "Classification", "Rules for the Classification and Construction of Sea-Going Ships"[1].

For the purpose of the present Part the following definitions and explanations have been adopted:

Damage waterline is the waterline of a damaged ship with one or more adjacent compartments flooded.

Subdivision loadline is the load line of an intact ship, which is used in determining the subdivision of

[1] Hereinafter – Part I «Classification».

the ship.

A compartment is an inner space limited by the ship bottom, sides, bulkhead deck and two adjacent transverse watertight bulkheads or a peak bulkhead and an extremity.

Equalization of a ship is the process of eliminating or reducing heel and/or trim.

D e p t h D is the least vertical distance measured from the top of the plate keel or from the line where the inner surface of shell plating abuts upon the bar keel, to the inner line of bulkhead deck abutting to the side.

In ships having rounded gunwales, this distance is measured to the point of intersection of the continued inner surfaces of bulkhead deck steel plating and the side shell plating at side, as though the gunwale were of angular design.

In non-metal ships the above said shall be referred to the outer surface of the deck and plating.

Moulded depth is measured in the same way as the depth D, but to the top of the freeboard beam.

Subdivision length L_s is the greatest projected moulded length of that part of the ship at or below deck or decks limiting the vertical extent of flooding with the ship at the deepest subdivision draught

Ship length L_{ice} is the ship length on the waterline corresponding to the draught dice.

Ship length L_1 is 96 per cent of the total length on a waterline at 85 per cent of the least moulded depth or the length from the fore side of the stem to the axis of rudder stock on that waterline if that be greater.

Trim is the difference between the draught forward and the draught aft, where the draughts are measured at the forward and aft terminals respectively, disregarding any rake of heel.

Permeability index of a space (permeability) μ is the proportion of the immersed volume of that space which can be occupied by water.

Aft terminal is the aft limit of the subdivision length.

Forward terminal is the forward limit of the subdivision length.

Keel line is a line parallel to the slope of the keel passing amidships through:

.1 the top of the keel at centreline or line of intersection of the inside of shell plating with the keel if a bar keel extends below that line on a ship with a metal shell;

.2 in wood and composite ships the distance is measured from the lower edge of the keel rabbet.

When the form at the lower part of the midship section is hollow, or where thick garboards are fitted, the distance is measured from the point where the line of the flat of the bottom continued inward intersects the centreline amidships.

Machinery spaces are spaces between the watertight boundaries of a space containing the main and auxiliary propulsion machinery, including boilers, generators and electric motors primarily intended for propulsion.

Amidships is at the middle of the length L_1.

Deepest subdivision loadline is the subdivision load line which corresponds to the deepest draught permitted by applicable subdivision requirements.

Light service draught d_l the service draught corresponding to the lightest anticipated loading and associated tankage, including, however, such ballast as may be necessary for stability and/or immersion.

Passenger ships shall include the full complement of passengers and crew on board.

Deepest subdivision *draught* d_s is the waterline corresponding to the summer load line draught of the ship.

Draught d is the vertical distance from the keel line at mid-length to the waterline in question.

Ship draught d_{ice} is the smallest draught out of a draught corresponding to the waterline serving as the upper boundary of the ice strengthening of the hull, or a draught at which the requirements for ice damage trim and stability are met as provided by **3.4.10**.

Bulkhead deck in a passenger ship means the uppermost deck at any point in the subdivision length L_s to which the main bulkheads and the ship's shell are carried watertight and the lowermost deck from which passenger and crew evacuation will not be impeded by water at any stage of flooding for damage cases defined in Section **2**.

The bulkhead deck may be a stepped deck.

In a cargo ship the freeboard deck may be taken as the bulkhead deck.

Mid-length is the mid-point of the subdivision length L_s of the ship.

Partial subdivision draught d_p is the light service draught plus 60 per cent of the difference between the light service draught and the deepest subdivision draught.

Breadth B is the greatest moulded breadth of the ship at or below the deepest subdivision draught.

1.2.2 In all calculated cases of flooding only one hole in the hull and only one free surface of sea water which penetrated after the accident is assumed. In this case the hole is considered to have the shape of a rectangular parallelepiped.

1.2.3 All linear dimensions used herein are taken in meters.

1.3 SCOPE OF SURVEY

1.3.1 The provisions pertaining to the procedure of classification, survey of ships under construction and classification surveys, as well as the requirements for the technical documentation to be submitted to the Register for review are contained in General Regulations for Technical Supervision and Part I, Classification (in particular in **4.2.8**).

1.3.2 For every ship meeting the requirements of this Part, the Register shall carry out the following:

.1 check for compliance of the structural measures taken to ensure subdivision of the ship with the requirements specified in **1.1**.6 and **2.7**, Part II "Hull", Section 7, Part III "Equipment, Arrangements and Outfit", Sections **2**, **4**, **5** and **7.1** to **7.11**, **10.1**, **10.2**, **10.4**, **12.1**, Part VIII "Systems and Pipelines";

.2 consideration and approval of the Information on Damage Trim and Stability, Flooding Detection System Manual provided by **3.4.11.4**, Damage Control Plan and consideration of the Information on the Effect of Flooding (to be duly noted) as defined in **1.4.9**;

.3 checking of correct assignment and marking of additional load lines corresponding to subdivision load lines;

.4 examination and approval of the computer installed onboard the ship and the relevant software where it is used for assessing damage trim and stability.

1.4 GENERAL TECHNICAL REQUIREMENTS

1.4.1 The ship subdivision shall be the most effective taking in account the service of the ship. The degree of subdivision shall vary proceeding from the area of navigation, ship length and number of persons on board so that the highest subdivision degree would be characteristic of ship of the greatest length mostly engaged in the carriage of passengers and of those navigating in the Arctic and the Antarctic.

1.4. In no case shall any subdivision load line be assigned above the deepest subdivision load line in seawater determined on the basis of the ship hull safety or in accordance with the Load Line Rules for Sea-Going Ships.

The subdivision load line assigned to the ship is marked on its sides and recorded in the documents of the Register as required by the Load Line Rules for SeaGoing Ships.

1.4.3 The volumes and areas shall, in all cases, be calculated to moulded lines. The volumes and free surfaces of water which penetrates the compartments of reinforced-concrete, plastic, wood and composite ships shall be calculated to inboard hull lines.

1.4.4 When determining the initial metacentric height of a damaged ship, corrections for the effect of free surfaces of liquid cargoes, ship stores and ballast water shall be taken into account in the same manner as in the case of calculating the intact stability of a ship as per **1.4.7**, Part IV "Stability".

When plotting static stability curves for a damaged ship, the enclosed superstructures, trunks, deckhouses, angles of flooding through openings in ship's sides, decks, hull and superstructure bulkheads considered open as well as corrections for free surfaces of liquid cargoes shall be taken into account in the same manner as in the case of plotting curves for intact ship as per **1.4.9**, Part IV "Stability".

Ventilation pipes openings, which, for operational reasons, must remain open for continuous supply of air to the engine room, emergency generator room or spaces for ro-ro vehicles (if the ventilation pipes are taken into account in buoyancy or safety calculations or protect the opening leading to the bottom) shall be considered as open.

Superstructures, trunks and deckhouses which sustain damage only may be taken into consideration with the permeability specified in **1.6**, or ignored. The openings in such structures leading to spaces, which are not flooded, are considered open at appropriate angles of heel only when regular weathertight means of closing are not fitted.

1.4.5 When calculating damage trim and stability, account shall be taken of changes in the initial ship loading (intact ship) due to liquid cargoes being replaced by sea water in damaged tanks considering that in the flooded tanks below the damage waterline the free surface of those cargoes disappears.

1.4.6 Ships to which this Part is applicable shall be provided with approved (by the Register) Information on Damage Trim and Stability with compartments flooded and with Damage Control Plan.

These documents are intended to provide ship's officers with clear information on ship's watertight subdivision and equipment related to maintaining the boundaries and effectiveness of the subdivision so that, in the event of damage to the ship causing flooding, proper precautions can be taken to prevent progressive flooding through openings therein and effective action can be taken quickly to mitigate and, where possible, recover the ship's loss of stability.

Damage Trim and Stability Booklet and Damage Control Plan shall be clear and easy to understand. They shall not include information which is not directly relevant to damage control, and shall be provided in the working language of the ship.

If the language used in Damage Trim and Stability Booklet with compartments flooded and with Damage Control Plan is not one of the official Administration languages, those documents shall be translated into English.

1.4.6.1 Damage Trim and Stability Booklet shall include the following:

.1 data on the ship, including its dimensions and permissible draughts on clear water and in ice conditions, its longitudinal section, deck and doublebottom plans, typical cross-sections with indication of all watertight bulkheads and enclosures with openings therein, means of their closure and drives, openings of air and ventilation pipes;

.2 information necessary to maintain the stability of an intact ship sufficient to withstand, in compliance with the requirements hereof, the most dangerous extent of damage; instructions on loading and ballasting the ship, including recommendations on distributing cargo in the holds, stores and ballast in a manner reasonable as regards the subdivision adopted and satisfying at the same time the requirements for the trim, stability and strength of the ship; brief list of requirements for damage trim and stability;

.3 curve of maximum permissible vertical position of centre of ship' gravity (limiting moments or minimum metacentric heights) plotting considering the requirements of this Part and Part IV "Stability".

For ships in relation to which the requirements of Section **2** apply, a curve of maximum permissible vertical positions of centre of gravity (or minimum metacentric heights) shall be determined considering the subdivision index as follows:

minimum metacentric heights (or maximum permissible vertical positions of centre of gravity) for the three draughts d_s , d_p and d_l are equal to metacentric heights (or vertical positions of centre of gravity) of corresponding loading cases used for calculation of factor s_i;

minimum metacentric heights vary linearly between d_s and d_p and between d_p and d_l respectively;

if the subdivision index is calculated for different trims, the curve of maximum permissible vertical positions of centre of gravity shall be established considering the above trims;

.4 list of results of symmetrical and unsymmetrical flooding calculations with data on initial and damage draught, heel, trim and metacentric height both before and after taking measures for the equalization of the ship or for improving its stability as well as measures recommended for these procedures and the period of time required. Parameters of static stability curves anticipated under the worst flooding conditions shall also be included.

Where necessary, for **Ice4** ÷ **Ice6**, Baltic ice classes **IA Super** and **IA** and Polar classes ships, the information on the characteristics of ice unsinkability, damage trim and stability shall be indicated when sustaining design ice damage;

.5 general instructions for controlling the effects of damage, such as:

immediate closing all watertight and weathertight closing appliances;

establishing the locations and safety of persons on board, sounding tanks and compartments to ascertain the extent of damage and repeated soundings to determine rates of flooding;

cautionary advice regarding the cause of any heel and liquid transfer operations to lessen heel and/or trim, and the resulting effects of creating additional free surfaces and of initiating pumping operations to control the ingress of seawater;

.6 details of the locations of flooding detection systems, sounding devices, tanks vents and overflows which do not extend above the weather deck, pump capacities, piping diagrams, instructions for operating cross-flooding systems, means of accessing and escaping from watertight compartments below the bulkhead deck for use by damage control parties, and alerting ship management and other organizations to stand by and to coordinate assistance, if required.

.7 locations of non-watertight openings with non-automatic closing devices through which progressive flooding might occur; as well as guidance on the possibility of non-structural bulkheads and doors or other obstructions retarding the flow of entering seawater to cause at least temporary conditions of unsymmetrical flooding.

1.4.6.2 Damage Control Plan shall be made on a scale acceptable for operation, but not less than 1:200.

For passenger ships, the Damage Control Plan shall be permanently exhibited or readily available on the navigation bridge, as well as in the ship's control station, safety centre or equivalent.

On cargo ships the Plan shall be permanently exhibited or be readily available on the navigation bridge, in the cargo control room, ship's control station etc.

The plan shall include inboard profile, plan views of each deck and double bottom, as well as transverse sections and show the following:

.1 watertight compartments and tanks boundaries;

.2 the locations and arrangements of cross-flooding systems, blow-out plugs and any mechanical means to correct heel due to flooding, together with the locations of all valves and remote controls, if any;

.3 the locations of all internal watertight closing appliances including, on ro-ro ships, internal ramps or doors acting as extension of the collision bulkhead and their controls and the locations of their local and remote controls, position indicators and alarms.

The locations of those watertight closing appliances, which are not allowed to be opened during the navigation, shall be clearly indicated on the plan;

.4 the locations of all doors in the shell of the ship, including position indicators, leakage detection and surveillance devices;

.5 the locations of all external watertight closing appliances in cargo ships, position indicators and alarms;

.6 the locations of all the weathertight closing appliances in local subdivision boundaries above the bulkhead deck and on the lowest exposed weather deck, together with locations of controls and position indicators, if applicable;

.7 the locations of all bilge and ballast pumps, their control positions and associated valves.

1.4.7 Damage Stability Booklet shall be compiled on the basis of the Stability Booklet.

The procedure of extending the validity of the Damage Stability Booklet from one ship to another is similar to that of extending the validity of Stability Booklet as specified in **1.4.11.2**, Part IV "Stability". Damage Stability Booklet may be incorporated in Information on Intact Stability as a separate section.

1.4.8 For estimation of the ship damage trim and stability it is recommended to use the onboard computer. The associated software shall have Type Approval Certificate issued by the Register.

A computer is not equivalent to Damage Stability Booklet. Damage Stability Booklet and Damage Control Plan shall be kept on board in printed form. Onboard damage stability software developed for the specific ship and approved by the Register may be used by properly trained ship's officers only as a rapid means to supplement Damage Stability Booklet and Damage Control Plan for effective damage control.

Where rapid access to shore-based computerized support organization, recognized by the Regidter, hich makes damage stability and residual strength assessments is provided on board, this may be used to supplement Damage Stability Booklet. In such a case the contact information for gaining rapid access to shore-based computerized support organization together with a list of information required for making damage stability and residual strength assessments shall be included in Damage Stability Booklet.

1.4.9 Dry cargo ships having the length L_1<80 m instead of Damage Stability Booklet shall be provided with Damage Control Plan and Information on the Effect of Flooding. This Information shall contain data and documentation listed in **1.4.6.1** and results of damage trim and stability calculations when engine room and every cargo space are flooded. The calculations shall be made for two draughts one of which shall be the summer load line draught. The maximum permissible position of ship's centre of gravity shall be taken according to Stability Booklet.

Permeabilities of cargo spaces shall be taken with regard to the cargoes intended to be carried and shall be within 0,60 to 0,90.

The Information shall contain a summary table of calculation results with indication of critical factors, as well as details given in **1.4.6.1.5**.

1.4.10 Every ship shall have draught scales prominently marked at bow and stern.

Where the draught scales are so placed that they are not clearly visible or where service conditions impede reading the indications of the scale the ship shall be provided with a reliable draught measurement system whereby the forward and aft draughts can be easily determined.

1.4.11 When performing damage stability calculations «REVISED EXPLANATORY NOTES TO THE SOLAS CHAPTER II-1 SUBDIVISION AND DAMAGE STABILITY REGULATIONS» adopted by

MSC.429(98) shall be used.

1.5 SATISFACTORY SUBDIVISION

1.5.1 The subdivision of a ship can be considered satisfactory as regards the present Part, if:

.1 the attained subdivision index *A*, determined as per 2.3, is not less than the required subdivision index R calculated in compliance with 2.2 and if, in addition, the partial indices A_s, A_p and A_l are not less than 0.9*R* for passenger ships and 0.5*R* for cargo ships;

.2 the requirements under **1.5.1.1** are not applicable to ships for which in Section **2** there are no instructions for determining the indices *A* and/or *R*;

.3 damage trim and stability are in accordance with Section **3**, considering **3.3.6**.

1.5.2 A subdivision distinguishing mark is introduced in the class notation of the ship as per **2.2.4**, Part I "Classification" provided under all design loading conditions corresponding to the type of ship concerned its subdivision is considered satisfactory according to **1.5.1**, damage trim and stability comply with the requirements of **3.3** when any single ship compartment or any adjacent ship compartments are flooded throughout the ship's length as per the introduced subdivision distinguishing mark, and the compliance of structural measures related to the subdivision of the ship with the requirements of **1.1.6** and **2.7**, Part II "Hull" and Section **7**, Part III "Equipment, Arrangements and Outfit" is ensured.

When, in compliance with **3.4** the number of floodable compartments is changed throughout the ship length, the lowest value shall be stated in the subdivision distinguishing mark.

1.5.3 Additional conditions under which a subdivision distinguishing mark shall be introduced in the class notation are specified in **3.4**.

1.6 PERMEABILITY INDEX

1.6.1 In the calculations of damage trim and stability the permeability index of flooded space shall be assumed equal to:

.1 0.85 for spaces occupied by machinery, electric generating sets and processing equipment on fishing vessels and factory ships;

.2 0.95 for accommodation spaces and empty spaces including empty tanks;

.3 0.60 for the spaces intended for dry stores.

1.6.2 Permeability of flooded tanks with liquid cargo or liquid stores or water ballast is determined based on the assumption that all the cargo is discharged from the tank and sea water is ingressed taking into consideration the permeability index being equal to 0.95.

1.6.3 The permeability index of the spaces intended for solid cargoes is given below in the appropriate paragraphs of Sections **2** ÷ **5**.

1.6.4 The permeability index of spaces may be assumed lower than specified above only in case a special calculation is performed which is approved by the Register.

When performing such special calculations for cargo spaces including refrigerating ones, the permeability index of net cargo shall be assumed equal to 0.6, and that of the cargo in containers, trailers, roll trailers and lorries shall be assumed equal to 0.71.

1.6.5 Where the arrangement of spaces or the service conditions of the ship are such that the necessity to apply other permeability indices is evident, the calculations shall be made considering those rigid permeability indices.

1.7 REQUIREMENTS FOR SUBDIVISION AND STABILITY OF PASSENGER SHIPS WITH DISTINGUISHING MARKS B-R3-S, B-R3- RS, C-R3-S, C-R3-RS B-R3-S, B-R3-RS, C-R3-S, C-R3-RS AND D-R3-S, D-R3-RS IN THE CLASS NOTATION.

1.7.1 Passenger ships with distinguishing marks **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS** i **D-R3-S, D-R3-RS** in the class notation may comply with the requirements of this subsection instead of the requirements given in **1.5** and **2.7**.

1.7.2 Subdivision.

1.7.2.1 Every ship shall be subdivided by bulkheads, which shall be watertight up to the bulkhead deck, into watertight compartments the maximum length of which shall be calculated according to the specific requirements given below.

Every other portion of the internal structure which affects the efficiency of the subdivision of the ship shall be watertight.

1.7.2.2 Floodable length.

.1 The floodable length at a given point is the maximum portion of the length of the ship, having its centre at the point in question, which can be flooded, under the assumption for permeability given in **1.7.2.4**, without the ship being submerged beyond the margin line.

.2 In case of a ship not having a continuous bulkhead deck, the floodable length at any point may be determined to an assumed continuous margin line which at no point is less than 76 mm below the top of the deck at side to which the bulkheads concerned and the shell are carried watertight.

.3 Where a portion of an assumed margin line is appreciably below the deck to which bulkheads are carried, the Register may permit a limited relaxation in the watertightness of those portions of the bulkheads which are above the margin line and immediately under the higher deck.

1.7.2.3 Permissible length of compartments.

The maximum permissible length of a compartment having its centre at any point in the ship's length is obtained from the floodable length by multiplying the latter by an appropriate factor called factor of subdivision.

1.7.2.4 Permeability

The definite assumptions referred to in **1.7.2.2** relate to the permeability of the spaces below the margin line.

In determining the floodable length, the assumed average permeability of the spaces below the margin line shall be as indicated in the Table 1.7.3.7.1.

1.7.2.5 Subdivision factor

The factor of subdivision shall be:

1.0 when the number of persons the ship is certified to carry is less than 400, and

0.5 when the number of persons the ship is certified to carry is 400 or more.

1.7.2.6 Special requirements concerning ship subdivision

.1 Where in a portion or portions of a ship the watertight bulkheads are carried to a higher deck in the remainder of the ship and it is desired to take advantage of this higher extension of the bulkheads in calculating the floodable length, separate margin line may be used for each such portion of a ship, provided that:

- - the sides of the ships are extended throughout the ship's length to the deck corresponding to the upper margin line and all openings in the shell plating below this deck throughout the length of the ship are treated as being below a margin line for the purposes of **7.2.1**, Part III "Equipment, Arrangements and Outfit", and

- the two compartments adjacent to the 'step' in the bulkhead deck are each within the permissible length corresponding to their respective margin lines, and, in addition, their combined length does not exceed twice the permissible length based on the lower margin line;

.2 A compartment may exceed the permissible length as provided by **1.7.2.3**, provided the combined length of each pair of adjacent compartments to which the compartment in question is common does not exceed either the floodable length or twice permissible length, whichever is the less;

.3 A main transverse bulkhead may be recessed, provided that all parts of the recess lie inboard of vertical surfaces on both sides of the ship, situated at a distance from the shell plating equal to one fifth of the breadth of the ship and measured at right angles to the centreline at the level of the deepest subdivision load line.

Any part of a recess which lies outside these limits shall be dealt with a step in accordance with **1.7.2.6.6**.

.4 Where a main transverse bulkhead is recessed or stepped, an equivalent plane bulkhead shall be used in determining the subdivision.

.5 Where a main transverse watertight compartment contains local subdivision and the Register is satisfied that, after any assumed side damage extending over a length of 3.0 m plus 3 per cent of the length of the ship, or 11 m, or 10 per cent of the length of the ship, whichever is the less, the whole volume of the main compartment will not be flooded, a proportionate allowance may be made in the permissible length otherwise required for such compartment without consideration of the additional subdivision.

In such a case the volume of the effective buoyancy assumed on the undamaged side shall not be greater than that assumed on the damaged side.

It can be provided subject to noncontradiction with the requirements of **1.7.3**.

.6 The main transverse bulkhead may be stepped provided that it meets one of the following conditions:

.6.1 combined length of the two compartments, separated by the bulkhead in question, does not exceed either 90 per cent of the floodable length or twice the permissible length, except that, in ships having a factor of subdivision equal to one, the combined length of the two compartments in question shall not exceed the permissible length;

.6.2 additional subdivision is provided in way of the step to maintain the same measure of safety as that secured by a plane bulkhead;

.6.3 the compartment over which the step extends does not exceed the permissible length corresponding to a margin line taken 76 mm below the step.

.7 In ships of 100 m in length and upwards, one of the main transverse bulkheads abaft the forepeak shall be fitted at a distance from the forward perpendicular which is not greater than the permissible length.

.8 If the distance between two adjacent main transverse bulkheads or their equivalent plane bulkheads or the distance between the transverse plane passing through the nearest stepped portions of the bulkheads, is less than 3.0 m plus 3 per cent of the length of the ship, or 11 m, or 10 per cent of ship's length (whichever is the less), only one of these bulkheads shall be regarded as forming part of the subdivision of the ship.

.9 Where the required factor of subdivision is equal to 0.5, the combined length of any two adjacent compartments shall not exceed the floodable length.

1.7.3 Damage stability of a passenger ship with distinguishing markB-R3-S, B-R3-RS, C-R3-S, C-R3-RS and D-R3-S, D-R3-RS in the class notation in damaged condition.

1.7.3.1 Sufficient intact stability shall be provided in all service conditions so as to enable the ship to withstand the final stage of flooding of any one main compartment which is required to be within the floodable length.

.1 Where two adjacent main compartments are separated by a bulkhead which is stepped under the conditions of **1.7.2.6.6.1**, the intact stability shall be adequate to withstand the flooding of those two adjacent main compartments.

.2 Where the factor of subdivision is equal to 0.50, the intact stability shall be adequate to withstand the flooding of any two adjacent main compartments.

1.7.3.2 The requirements of **1.7.3.1** shall be determined by calculations which are in accordance with paragraphs **1.7.3.7** and **1.7.3.9**, which take into consideration the proportions and design characteristics of the ship, and the arrangement and configuration of the damaged compartments.

In making these calculations the ship is to be assumed in the worst anticipated service conditions as regards stability.

Where it is proposed to fit decks, inner skins or longitudinal bulkheads of sufficient tightness to seriously restrict the flow of water, then, proper consideration is given to such restrictions in the calculations.

1.7.3.3 The stability required in the final condition after damage, and after equalization where provided, shall be determined as follows:

.1 The positive residual righting lever curve shall have a minimum range of 15° beyond the angle of equilibrium. This range may be reduced to a minimum 10°, in the case where the area under the righting lever curve is that specified in **1.7.3.3.2** increased by the ratio "15/range" where the range is expressed in degrees.

.2 The area under the righting lever curve shall be at least 0.015 m·rad measured from the angle of equilibrium to the lesser of:

.2.1 angle at which progressive flooding occurs; or

.2.2 22° (measured from the upright) in the case of one compartment flooding, or 27° (measured from the upright) in the case of the simultaneous flooding of two or more adjacent compartments.

.3 A residual righting lever is to be obtained within the range of positive stability, taking into account the greatest of the following heeling moments:

.3.1 the crowding of all passengers towards one side;

.3.2 the launching of all fully loaded davit-launched survival craft on one side;

.3.3 due to wind pressure as calculated by the formula:

GZ = (heeling moment / displacement) + 0.04 (m).

However, in no case is this righting lever to be less than 0.10 m.

.4 For the purposes of calculating the heeling moments in paragraph **1.7.3.3.3**, the following assumptions shall be made:

.4.1 moments due to crowding of passengers:

- four persons per m^2;
- a mass of 75 kg per each passenger;
- passengers are distributed on available deck areas towards one side of the ship on the decks where muster stations are located and in such a way that they produce the most adverse heeling moment.

.4.2 moments due to launching of all fully loaded davit-launched survival craft on one side of the ship:

.4.2.1 all lifeboats and rescue boats fitted on the side to which the ship has heeled after having sustained damage shall be assumed to be swung out fully loaded and ready for lowering;

.4.2.2 for lifeboats which are arranged to be launched fully loaded from the stowed position, the maximum heeling moment during launching shall be taken:

.4.2.3 a fully loaded davit-launched liferaft attached to each davit on the side to which the ship has heeled after having sustained damage shall be assumed to be swung out ready for lowering;

.4.2.4 persons not in the life-saving appliances which are swung out shall not provide either additional heeling or righting moment;

.4.2.5 lifesaving appliances on the side of the ship opposite to the side to which the ship has heeled shall be assumed to be in a stowed position.

.4.3 moments due to wind pressure:

- for the ship with distinguishing marks **B-R3-S, B-R3-RS**: a wind pressure of 120 Pa to be applied;
- for the ship with distinguishing marks **C-R3-S** and **C-R3-RS** and **D-R3-S** and **D-R3-RS**: the wind pressure of 80 Pa to be applied;
- the area applicable shall be projected lateral area of the ship above the waterline corresponding to the intact condition;
- moment arm shall be vertical distance from a point at one half of the mean draft corresponding to the intact condition to the centre of gravity of the lateral area.

1.7.3.4 When major progressive flooding occurs, that is when it causes a rapid reduction in the righting lever of 0.04 m or more, the righting lever curve is to be considered as terminated at the angle the progressive flooding occurs.

The range and area referred to in**1.7.3.3.1** and **1.7.3.3.2** shall be measured to that angle.

1.7.3.5 In case when progressive flooding is limited and not worsened and leads to slow change of the permissible righting lever curve less than 0.04 m, the part of the remaining curve shall be partially cut off in advance considering the progressive flooding.

1.7.3.6 In intermediate stages of flooding, the maximum righting lever shall be at least 0.05 m, and the range of positive righting levers shall be at least 7°.

In all cases, only one breach in the hull and only one free surface shall be assumed.

1.7.3.7 For the purpose of making damage stability calculations, the following shall be taken:

.1 the volume and surface permeabilities as per the Table 1.7.3.7.1.

Higher surface permeabilities are to assumed in respect of spaces which, in the vicinity of the damage waterline, contain no substantial quantity of accommodation or machinery and spaces which are not generally occupied by any substantial quantity of cargo or stores.

Table 1.7.3.7.1

Spaces	Permeability (%)
Cargo and stores	60
Accommodation	95
Machinery	85
liquids	0 or 95 (*)
(*)Whichever results in the more severe requirements	

.2 the following assumed extent of damages:

.2.1 longitudinal extent: 3.0 m plus 3 per cent of the length of the ship, or 11.0 m or 10 per cent of the length of the ship, whichever is the less;

.2.2 transverse extent (measured inboard from the ship's side, at right angles to the centreline at the level of the deepest subdivision load line): a distance of 1/5 of the ship's breadth; and

.2.3 vertical extent - from the base line upwards without limit;

.2.4 if any damage of lesser extent than indicated in **1.7.3.7.2** would result in a more severe condition regarding heel or loss of metacentric height, such damage shall be assumed in the calculations.

1.7.3.8 Unsymmetrical flooding is to be kept to a minimum consistent with efficient arrangements.

Where it is necessary to correct large angles of heel, the means adopted shall, where practicable, be self-acting, but in any case where controls to crossflooding fittings are provided they shall be operable from above the bulkhead deck.

For the ships with distinguishing marks B-R3-S, B-R3-RS, C-R3-S, C-R3-RS and **D-R3-S, D-R3-RS** in the class notation the maximum angle of heel after flooding but before equalization shall not exceed 15°.

Where cross flooding fittings are required, the time for equalization shall not exceed 15 minutes.

Suitable information concerning the use of cross flooding fittings shall be supplied to the master of the ship.

1.7.3.9 The final conditions of the ship after damage and, in the case of unsymmetrical flooding, after equalization measures have been taken shall be as follows:

.1 in the case of symmetrical flooding there shall be a positive residual metacentric height of at least 0.05 m as calculated by the constant displacement method;

.2 in case of unsymmetrical flooding, the angle of heel for onecompartment flooding shall not exceed:

7° − for ships with distinguishing marks **B-R3-S, B-R3-RS**; and

12° − for ships with distinguishing marks **C-R3-S, C-R3-RS** and **D-R3-S, D-R3-RS**.

In the case of simultaneous flooding of two adjacent compartments the angle of heel up to 12° can be allowed for the ships with distinguishing mark **B-R3-S**, **B-R3-RS** in the class notation provided that the factor of subdivision is not more than 0.5 in the flooded part of the ship;

.3 in no case shall the margin line be submerged at the final stage of flooding.

If it is considered that the margin line may become submerged at intermediate stage of flooding, the Register may require such investigations and arrangements as it considers necessary for the safety of the ship.

1.7.3.10 The ship's master shall be supplied with the data necessary to maintain sufficient intact stability under service conditions to enable the ship to withstand the critical damage.

In the case of ships having cross flooding fittings the master of the ship shall be informed on the conditions of stability on which the calculations of heel are based and be warned that excessive heeling might result should the ship sustain damage when in a less favourable condition.

The data to enable the master to maintain sufficient intact stability shall include information which indicates the maximum permissible height of the ship's centre of gravity above keel, or alternatively the minimum permissible metacentric height for a range of draughts or displacements sufficient to include all service conditions.

On completion of loading of the ship and prior to its departure, the master shall define the ship's trim and stability and also ascertain and record in the ship's log book that the ship is in compliance with stability criteria in the corresponding regulations.

The ship's stability shall be always determined via calculations.

It is permitted to use electronic loading and stability computer or equivalent means for this purpose.

1.7.3.11 No deviation from the requirements for damage stability may be considered by the Register, unless it is shown that the intact metacentric height in any service condition necessary to meet these rules is excessive for the service intended.

Deviation from the requirements for damage stability shall be permitted only in exceptional cases and provided that the Register is to be satisfied that the proportions, arrangements and other characteristics of the ship are the most favourable to stability after damage which can practically and reasonably be adopted in the particular circumstances.

1.7.4 Damage stability of a ro-ro passenger ship with the distinguishing mark B-R3-S, B-R3-RS, C-R3-S, C-R3-RS and D-R3-S, D-R3-RS in the class notation.

1.7.4.1 Stability of a ro-ro passenger ship with the distinguishing mark **B-R3-S, B-R3-RS, C-R3-S, C-R3-RS** and **D-R3-S, D-R3-RS** в символі класу судна, яка вимагається в кінцевому стані після пошкодження внаслідок зіткнення, та після випрямлення, повинна відповідати вимогам цього підрозділу in the class notation required at the final stage after the damage due to collision, and after equalization shall comply with the requirements of this Chapter.

1.7.4.2 Stability of a ro-ro passenger ship, including the ro-ro passenger ships certified to carry 400 persons or more with the distinguishing mark **B-R3-S, B-R3-RS, C-R3-S, C-R3-RS** and **D-R3-S, D-R3-RS**

in the class notation required at the final stage after the damage due to collision, and after equalization shall comply with the requirements of **3.4.14.2** ÷ **3.4.14.24**.

1.7.5 Special requirements for passenger ships with distinguishing mark B-R3-S, B-R3-RS, C-R3-S, C-R3-RS and D-R3-S, D-R3-RS, in the class notation certified to carry 400 persons or more other than ro-ro passenger ships.

Passenger ships with the distinguishing mark **B-R3-S, B-R3-RS, C-R3-S, C-R3-RS** and **D-R3-S, D-R3-RS** in the class notation certified to carry 400 persons or more other than ro-ro passenger ships shall comply with the requirements of **1.7.3.3** and **1.7.3.6** in case of assumed damage applied anywhere within the ship's length *L*;

1.7.6 Passenger ships with distinguishing mark **B-R3-S**, **B-R3-RS**, **C-R3-S**, **C-R3-RS** and **D-R3-S**, **D-R3-RS** in the class notation of the length less than 24 m may comply with the requirements of **1.7.3** or **1.5.**

2. PROBABILITY ESTIMATION OF SUBDIVISION

2.1 GENERAL

2.1.1 The requirements of the present Section apply to cargo ships having the length $L_1 \geq$ 80 m and to all passenger ships regardless of their length except those ships, whose types are specified in **1.1.1.2**, **1.1.1.3**, **1.1.1.5**, **1.1.1.6**, **1.1.1.8**, **1.1.1.9**, **1.1.1.18**, **1.1.1.19**, ships specified in **1.1.1.4**, if not intended for the carriage of deck cargo, as well as nuclear ships and nuclear floating facilities.

Ships as mentioned in **1.1.1.7** shall comply with the requirements of the Section as specified in **3.4.3**.

2.1.2 When checking the probabilistic requirements for such ships the IMO MSC.281(85) «REVISED EXPLANATORY NOTES TO THE SOLAS CHAPTER II-1 SUBDIVISION AND DAMAGE STABILITY REGULATIONS.».

2.2 REQUIRED SUBDIVISION INDEX *R*

2.2.1 The subdivision of a ship is considered sufficient if the attained subdivision index *A*, determined in accordance with 2.3, is not less than the required subdivision index *R* calculated in accordance with 2.2.2 and if, in addition, the partial indices A_s, A_p and A_l, are not less than 0,9*R* for passenger ships and 0,5*R* for cargo ships.

2.2.2 For all ships to which the damage stability requirements of this Chapter apply, the degree of subdivision to be provided shall be determined by the required subdivision index *R,* as follows:

.1 in the case of cargo ships having the length $L_s \geq 100$ m:

$$R = 1 - [128/(L_s + 152)];$$

.2 in the case of cargo ships having the length $L_1 \geq 80$ m, and $L_s \leq 100$ m:

$$R = 1 - \{1/[1 + (0{,}01 L_S \cdot R_o / (1 - R_o))]\},$$

where: R_o – value *R* as calculated in accordance with formula in **2.2.2.1**;

.3 in the case of passenger ships:

Persons on board	*R*
$N < 400$	$R = 0{,}722$
$400 \leq N \leq 1350$	$R = N/7580 + 0{,}66923$
$1350 \leq N \leq 6000$	$R = 0{,}0369 \cdot \ln(N + 89{,}049) + 0{,}579$
$N > 6000$	$R = 1 - (852{,}5 + 0{,}03875 \cdot N)/(N + 5000)$

where: *N* – total number of persons on board.

2.3 ATTAINED SUBDIVISION INDEX *A*

2.3.1 The attained subdivision index *A* is obtained by the summation of the partial indices A_s, A_p and A_l, calculated for the draughts d_s, d_p and d_l in accordance with the following formula:

$$A = 0{,}4A_s + 0{,}4A_P + 0{,}2A_l, \qquad (2.3.1\text{-}1)$$

Each partial index is a summation of contributions from all damage cases taken in consideration, using the following formula:

$$A = \sum p_i s_i, \qquad (2.3.1\text{-}2)$$

where: i - each compartment or group of compartments under consideration;

p_i - probability that only the compartment or group of compartments under consideration may be flooded, disregarding any horizontal subdivision, as defined in **2.4**;

s_i - probability of survival after flooding the compartment or group of compartments under consideration, and includes the effect of any horizontal subdivision, as defined in **2.5**.

2.3.2 As a minimum, the calculation of A shall be carried out at the level trim for the deepest subdivision draught and the partial subdivision draught. The estimated service trim may be used for the light service draught d_l.

If, in any anticipated service condition within the draught range from lightservice draught *dl* to deepest subdivision draught d_s, the trim variation in comparison with the calculated trims is greater than 0,5 % of L_s, one or more additional calculations of A shall be performed for the same draughts but including sufficient trims to ensure that, for all intended service conditions, the difference in trim in comparison with the reference trim used for one calculation will be not more than 0,5% of L_s. Each additional calculation of A shall comply with the requirement of **2.2.1**.

2.3.3 When determining the positive righting lever of the residual stability curve, the constant displacement method of calculation shall be used..

2.3.4 The summation indicated by the above formula shall be taken over the ship's subdivision length L_s for all cases of flooding in which a single compartment or two or more adjacent compartments are involved.

In the case of unsymmetrical arrangements, the calculated A value shall be the mean value obtained from calculations involving both sides.

Alternatively, it shall be taken as that corresponding to the side which evidently gives the least favourable result.

2.3.5 Wherever wing compartments are fitted, contribution to the summation indicated by Formula (2.3.1-2) shall be taken for all cases of flooding in which wing compartments are involved. Additionally, cases of simultaneous flooding of a wing compartment or group of compartments and the adjacent inboard compartment or group of compartments, but excluding damage of transverse extent greater than one half of the ship breadth B, may be added.

For the purpose of **2.3**, transverse extent is measured inboard from ship's side, at right angle to the centreline at the level of the deepest subdivision draught.

2.3.6 In the flooding calculations carried out according to the regulations, only one breach of the hull and only one free surface need to be assumed. The assumed vertical extent of damage shall extend from the baseline upwards to any watertight horizontal subdivision above the waterline or higher.

However, if a lesser extent of damage will give a more severe result, such extent shall be assumed.

2.3.7 If pipes, ducts or tunnels are situated within the assumed extent of damage, arrangements shall be made to ensure that progressive flooding cannot thereby extend to compartments other than those assumed flooded.

However, the Register may permit minor progressive flooding if it is demonstrated that its effects can be easily controlled and the safety of the ship is not impaired.

2.4 CALCULATION OF THE FACTOR p_i

2.4.1 The factor p_i for a compartment or group of compartments shall be calculated in accordance with **2.4.1.1.1** and **2.4.1.1.2** using the following symbols:

j- aftmost damage zone number involved in the damage starting with No. 1 at the stern;

n - number of adjacent damage zones involved in the damage;

k - number of a particular longitudinal bulkhead as barrier for transverse penetration in a damage zone counted from shell towards the centreline. The shell has $k = 0$;

xl - distance from the aft terminal of L_s to the aft end of the zone in question;

x2 - distance from the aft terminal of L_s to the forward end of the zone in question;

b - the mean transverse distance, in m, measured at right angles to the centreline at the deepest subdivision draught between the shell and an assumed vertical plane extended between the longitudinal limits used in calculating the factor p_i, and which is a tangent to, or common with, all or part of the outermost portion of the longitudinal bulkhead under consideration. This vertical plane shall be so orientated that the mean transverse distance to the shell is a maximum, but not more than twice the least distance between the plane and the shell.

If the upper part of a longitudinal bulkhead is below the deepest subdivision draught the vertical plane used for determination of b is assumed to extend upwards to the deepest subdivision waterline. In any case, b is shall not be taken greater than $B/2$.

If the damage involves a single zone only:

$$p_i = p(x1_j,x2_j)[r(x1_j,x2_j,b_k) - r(x1_j,x2_j,b_{k-1})].$$

If the damage involves two adjacent zones:

$$p_i = p(x1_j,x2_{j+1})[r(x1_j,x2_{j+1},b_k) - r(x1_j,x2_{j+1},b_{k-1})] - p(x1_j,x2_j)[r(x1_j,x2_j,b_k) - r(x1_j,x2_j,b_{k-1})] - p(x1_{j+1},x2_{j+1})[r(x1_{j+1},x2_{j+1},b_k) - r(x1_{j+1},x2_{j+1},b_{k-1})].$$

If the damage involves three or more adjacent zones:

$$p_i = p(x1_j,x2_{j+n-1})[r(x1_j,x2_{j+n-1},b_k) - r(x1_j,x2_{j+n-1},b_{k-1})] - p(x1_j,x2_{j+n-2})[r(x1_j,x2_{j+n-2},b_k) - r(x1_j,x2_{j+n-2},b_{k-1})] - p(x1_{j+1},x2_{j+n-1})[r(x1_{j+1},x2_{j+n-1},b_k) - r(x1_{j+1},x2_{j+n-1},b_{k-1})] + p(x1_{j+1},x2_{j+n-2})[r(x1_{j+1},x2_{j+n-2},b_k) - r(x1_{j+1},x2_{j+n-2},b_{k-1})],$$

where: $r(x1, x2, b_0) = 0$.

2.4.1.1 The factor $p(x1,x2)$ shall be calculated according to the following formulae:
overall normalized max damage length:

$J_{max} = 10/33$;

knuckle point in the distribution:

$J_{kn} = 5/33$;

cumulative probability at J_{kn}:

$p_k = 11/12$;

maximum absolute damage length: $l_{max} = 60$ m;

length where normalized distribution ends: $L^* = 260$ m;

probability density at $J = 0$:

$$b_0 = 2[(p_k/J_{kn}) - (1-p_k)/(J_{max} - J_{kn})].$$

When $L_s \le L^*$:

$$J_m = \min(J_{max}, l_{max}/L_s),$$

$$J_k = J_m/2 + \{1 - [1+(1-2p_k)b_0 J_m + 0,25 b_0^2 J_m^2]^{1/2}\}/b_0,$$

$$b_{12} = b_0.$$

When $L_s > L^*$:

$$J_m^* = \min(J_{max}, l_{max}/L^*),$$

$$J_k^* = J_m^*/2 + \{1 - [1+(1-2p_k)b_0 J_m^* + 0,25 b_0^2 J_m^{*2}]^{1/2}\}/b_0,$$

$J_m = J_m{*}\ L{*} / L_s$,

$J_k = J_k{*}\ L{*} / L_s$,

$b_{12} = 2[(p_k/J_k) - (1 - p_k)/(J_m - J_k)]$,

$b_{11} = \{4(1 - p_k)/[(J_m - J_k) J_k]\} - (2 p_k / J^2_k)$,

$b_{21} = -2(1 - p_k)/(J_m - J_k)^2$,

$b_{22} = - b_{21} J_m$.

the non-dimensional damage length:

$J = (x2 - x1)/L_s$.

the normalized length of a compartment or group of compartments:

J_n shall be taken as the lesser of J and J_m.

2.4.1.1.1 Where neither limits of the compartment or group of compartments under consideration coincides with the aft or forward terminals:

$J \leq J_k$:

$p(x1,x2) = p_1 = (1/6)J^2(b_{11}J + 3b_{12})$,

$J > J_k$:

$p(x1, x2) = p_2 = -(1/3)b_{11}J^3_k + 0{,}5(b_{11}J - b_{12})J^2_k + b_{12}JJ_k - (1/3)\ b_{21}(J^3_n - J^3_k) +$
$+\ 0{,}5(b_{12}J - b_{22})\ (J^2_n - J^2_k) + b_{22}\ J\ (J_n - J_k)$.

2.4.1.1.2 Where the aft limit of the compartment or group of compartments under consideration coincides with the aft terminal or the forward limit of the compartment or group of compartments under consideration coincides with the forward terminal:

$J \leq J_k$:

$p(x1,x2) = 0{,}5(p_1 + J)$,

$J > J_k$:

$p(x1,x2) = 0{,}5(p_2 + J)$.

2.4.1.1.3 Where the compartment or groups of compartments considered extends over the entire subdivision length L_s:

$p(x1,x2) = 1$.

2.4.1.2 The factor $r(x1,x2,b)$ shall be determined by the following formulae:

$r(x1,x2, b) = 1 - (1 - C)[1-(G/p(x1,x2)]$,

where: $C = 12\ J_b\ (-\ 45\ J_b + 4)$ i $J_b = b/(15B)$.

2.4.1.2.1 Where the compartment or groups of compartments considered extends over the entire subdivision length L_s:

$G = G_1 = 0,5 b_{11} J^2_b + b_{12} J_b$.

2.4.1.2.2 Where neither limits of the compartment or group of compartments under consideration coincides with the aft or forward terminals:

$G = G_2 = -(1/3) b_{11} J^3_0 + 0,5(b_{11} J - b_{12}) J^2_0 + b_{12} J J_0$,

where: $J_0 = \min(J, J_b)$.

2.4.1.2.3 Where the aft limit of the compartment or group of compartments under consideration coincides with the aft terminal or the forward limit of the compartment or group of compartments under consideration coincides with the forward terminal:

$G = 0,5(G_2 + G_1 J)$.

2.5 CALCULATION OF THE FACTOR s_i

2.5.1 The factor s_i shall be determined for each case of assumed flooding, involving a compartment or group of compartments, in accordance with the following notations and the provisions in this regulation.

θ_e - the equilibrium heel angle in any stage of flooding, in degrees;

θ_v - the angle, in any stage of flooding, where the righting lever becomes negative, or the angle at which an opening incapable of being closed weathertight becomes submerged;

GZ_{max} − the maximum positive righting lever, in m, up to the angle θ_v;

Range − is the range of positive righting levers, in deg., measured from the angle θ_e. The positive range shall be taken up to the angle θ_v;

Flooding stage − any discrete step during the flooding process, including the stage before equalization (if any) until final equilibrium has been reached.

2.5.1.1 The factor s_i for any damage case at any initial loading condition, d_i, shall be obtained from the formula:

$s_i = \min(s_{intermediate,.i}$, or $s_{final,i} \times s_{mom,i})$,

where: $s_{intermediate,.i}$ - probability to survive all intermediate flooding stages until the final equilibrium stage, and is calculated in accordance with **2.5.2**;

$s_{final,i}$ – probability to survive in the final equilibrium stage of flooding. It is calculated in accordance with **2.5.3**;

$s_{mom.i}$ – probability to survive heeling moments, and is calculated in accordance with **2.5.4.**

2.5.2 For passenger ships, and cargo ships fitted with cross-flooding devices, the factor $s_{intermediate,i}$ is taken as the least of the *s*-factors obtained from all flooding stages including the stage before equalization, if any, and shall be calculated as follows:

$s_{intermediate.i} = [(GZ_{max}/0,05) \times (Range/7)]^{1/4}$,

where: GZ_{max} shall not be taken as more than 0,05 m and *Range* as not more than 7º, $s_{intermediate.i} = 0$, if the intermediate heel angle exceeds 15° for passenger ships and 30° for cargo ships.

For cargo ships notfitted with cross-flooding devices the factor $s_{intermediate,i}$ is taken as unity, except for cases when the stability in intermediate stages of flooding may be insufficient, it should require further investigation thereof.

For passenger and cargo ships, where cross-flooding devices are fitted, the time for equalization shall not exceed 10 min.

2.5.3 The factor $s_{final,i}$ shall be obtained from the formula:

$s_{кін.i} = K\,[(GZ_{max}/\,TGZ_{max}) \times (Range/\,TRange)]^{1/4}$,

where: GZ_{max} shall not be taken as more than TGZ_{max};
Range shall not be taken as more than *TRange*;
TGZ_{max} = 0,20 m, for ro-ro passenger ships each damage case that involves a ro-ro space,
TGZ_{max} = 0,12 m, otherwise;
TRange = 20°, for ro-ro passenger ships each damage case that involves a ro-ro space;
TRange. = 16°, otherwise;
$K = 1$, if $\theta_e \le \theta_{min}$;
$K = 0$, if $\theta_e \ge \theta_{min}$;
$K = [(\theta_{max} - \theta_e)\times(\theta_{max} - \theta_{min})]^{1/2}$ - otherwise,
where: θ_{min} = 7° for passenger ships and θ_{min} = 25° for cargo ships; and
θ_{max} = 15° for passenger ships and θ_{max} = 30° for cargo ships.

2.5.4 The factor $s_{mom.i}$ is applicable only to passenger ships (for cargo ships $s_{mom,i}$ shall be taken as unity) and shall be calculated at the final equilibrium from the formula:

$$s_{mom,i} = (GZ_{max} - 0{,}04)\times(Displacement/\ M_{heel}),$$

where: *Displacement* – intact displacement at the respective draught;
M_{heel} – maximum assumed heeling moment as calculated in accordance with **2.5.4.1**;
$s_{mom,i} \le 1$.

2.5.4.1 The heeling moment M_{heel} shall be calculated as follows:

$$M_{heel} = \max(M_{passenger}, M_{wind}, M_{survivalcraft}).$$

2.5.4.1.1 $M_{passenger}$ is the maximum assumed heeling moment resulting from movement of passengers, and shall be obtained as follows:

$$M_{passenger} = (0{,}075N_p)0{,}45B,$$

where: N_p – maximum number of passengers permitted to be on board in the service condition corresponding to the deepest subdivision draught under consideration;

B– breadth of the ship, in m.

Alternatively, the heeling moment may be calculated assuming the passengers are distributed with 4 persons per m^2 on available deck areas towards one side of the ship on the decks where muster stations are located and in such a way that they produce the most adverse heeling moment.

In doing so, a weight of 75 kg per passenger shall be assumed.

2.5.4.1.2 M_{wind} is the maximum assumed wind force, in t·m, acting in a damage situation:

$$M_{wind} = (PAZ)/9806,$$

where: P = 120 N/m²;
A – projected lateral area above waterline;
Z – distance from centre of lateral projected area above waterline to *T*/2;
T – respective draught (d_S, d_p or d_l),
for d_S, d_p, d_l – refer to **1.2.1**.

2.5.4.1.3 $M_{survivalcraft}$ is the maximum assumed heeling moment due to the launching of all fully loaded davit-launched survival craft on one side of the ship. It shall be calculated using the following assumptions:

all lifeboats and rescue boats fitted on the side to which the ship has heeled after having sustained damage shall be assumed to be swung out fully loaded and ready for lowering;

for lifeboats which are arranged to be launched fully loaded from the stowed position, the maximum heeling moment during launching shall be taken;

a fully loaded davit-launched liferaft attached to each davit on the side to which the ship has heeled after having sustained damage shall be assumed to be swung out ready for lowering;

persons not in the life-saving appliances which are swung out shall not provide either additional heeling or righting moment;

life-saving appliances on the side of the ship opposite to the side to which the ship has heeled shall be assumed to be in a stowed position.

2.5.5 Unsymmetrical flooding shall be kept to a minimum consistent with the efficient arrangements.

Where it is necessary to correct large angles of heel, the means adopted shall, where practicable, be self-acting, but in any case where controls to equalization devices are provided they shall be operable from above the bulkhead deck of passenger ships and the freeboard deck of cargo ships.

These fittings together with their controls shall be approved by the Register[1].

Suitable information concerning the use of equalization devices shall be supplied to the master of the ship.

2.5.5.1 Tanks and compartments taking part in such equalization shall be fitted with air pipes or equivalent means of sufficient cross-section to ensure that the flow of water into the equalization compartments is not delayed.

2.5.5.2 In all cases, s_i shall be taken as zero in those cases where the final waterline, taking into account sinkage, heel and trim, immerses:

.1 the lower edge of openings through which progressive flooding may take place and such flooding is not accounted for in the calculation of factor s_i.

Such openings shall include air-pipes, ventilators and openings which are closed by means of weathertight doors or hatch covers; and

.2 any part of the bulkhead deck in passenger ships considered a horizontal evacuation route for compliance with Part VI "Fire Protection".

2.5.5.3 The factor s_i shall be taken as zero if, taking into account sinkage, heel and trim, any of the following occur in any intermediate stage or in the final stage of flooding:

.1 immersion of any vertical escape hatch in the bulkhead deck of passenger ships and freeboard deck of cargo ships intended for compliance with Part VI "Fire Protection";

.2 any controls intended for the operation of watertight doors, equalization devices, valves on piping or on ventilation ducts intended to maintain the integrity of watertight bulkheads from above the bulkhead deck of passenger ships and the freeboard deck of cargo ships become inaccessible or inoperable;

.3 immersion of any part of piping or ventilation ducts located within the assumed extent of damage and carried through a watertight boundary if this can lead to the progressive flooding of compartments not assumed as flooded.

2.5.5.4 However, where compartments assumed flooded due to progressive flooding are taken into account in the damage stability calculations multiple values of $s_{intermediate,i}$ may be calculated assuming equalization in additional flooding phases.

2.5.5.5 Except as provided in 2.5.5.3.1, openings closed by means of watertight manhole covers and flush scuttles, small watertight hatch covers, remotely operated sliding watertight doors, side scuttles of the non-opening type as well as watertight access doors and watertight hatch covers required to be kept closed at sea need not be considered.

2.5.6 Where horizontal watertight boundaries are fitted above the waterline under consideration the s-value calculated for the lower compartment or group of compartments shall be obtained by multiplying the value as determined in **2.5.1.1** by the reduction factor v_m according to **2.5.6.1**, which represents the probability that the spaces above the horizontal subdivision will not be flooded.

2.5.6.1 The factor v_m shall be obtained from the formula

$$v_m = v(H_{j,n,m},d) - v(H_{j,n,m-1},d),$$

where: $H_{j,n,m}$ — least height above the baseline, in m, within the longitudinal range of $xl_{(j)}...x2_{(j+n-1)}$ of the mth horizontal boundary which is assumed to limit the vertical extent of flooding for the damaged compartments under consideration;

$H_{j,n,m-1}$— least height above the baseline, in m, within the longitudinal range of $xl_{(j)}...x2_{(j+n-1)}$ of the (m–1)th horizontal boundary which is assumed to limit the vertical extent of flooding for the damaged compartments under consideration;

j — aft terminal of the damaged compartments under consideration;

m — each horizontal boundary counted upwards from the waterline under consideration;

[1] Refer to IMO resolution MSC.362(92)

d — draught in question as defined in **1.2**;
*x*1 and *x*2 — terminals of the compartment or group of compartments considered in regulation **2.4**.

The factors $v(H_{j,n,m},d)$ and $v(H_{j,n,m-1},d)$, shall be obtained from the formulae:

$v(H,d)$=0,8(H-d)/7,8, if (H_m - d) is less than, or equal to 7,8 m;

$v(H,d)$= 0,8 + 0,2[(H - d) - 7,8]/4,7 − in all other cases,

where: $v(H_{j,n,m},d)$ shall be taken as 1, if H_m coincides with the uppermost watertight boundary of the ship within the range $xl_{(j)}...x2_{(j+n+1)}$ and $v(H_{j,n,0}, d)$ shall be taken as 0.

In no case shall v_m be taken as less than zero or more than 1.

2.5.6.2 In general, each contribution *dA* to the index *A* in the case of horizontal subdivisions is obtained from the formula:

$$dA = p_i[v_1 s_{\min 1} + (v_2 - v_1) s_{\min 2} + ... + (1 - v_{m-1}) s_{\min m}],$$

where: v_m - the *v*-value calculated in accordance with**2.5.6.1**;
$s_{\min}$ - the least *s*-factor for all combinations of damages obtained when the assumed damage extends from the assumed damage height H_m downwards.

2.6 PERMEABILITY

2.6.1 For the purpose of the subdivision and damage stability calculations of the regulations, the permeability of each general compartment or part of a compartment shall be as per Table 2.6.1.

Table 2.6.1

Spaces	Permeability
Appropriated to stores	0,60
Occupied by accommodation	0,95
Occupied by machinery	0,85
Void spaces	0,95
Intended for liquids	0 or 0,95[1]
[1] Whichever results in the more severe requirement.	

2.6.2 For the purpose of the subdivision and damage stability calculations of the regulations, the permeability of each cargo compartment or part of a compartment shall be as per Table 2.6.2.

Table 2.6.2

Spaces	Permeability at draught		
	d_s	d_p	d_l
Dry cargo spaces	0,70	0,80	0,95
Container spaces	0,70	0,80	0,95
Ro-ro spaces	0,90	0,90	0,95
Cargo liquids	0,70	0,80	0,95

2.6.3 Other figures for permeability may be used if substantiated by calculations.

2.7 SPECIAL REQUIREMENTS CONCERNING PASSENGER SHIP STABILITY

2.7.1 A passenger ship intended to carry 400 or more persons shall have watertight subdivision abaft the collision bulkhead so that s_i = 1 for a damage involving all the compartments within 0,08L_1 measured from the forward perpendicular for the three loading conditions used to calculate the attained subdivision index *A*.

If the attained subdivision index *A* is calculated for different trims, this requirement shall be also satisfied for those loading conditions.

2.7.2 A passenger ship intended to carry 36 or more persons shall be capable of withstanding damage along the side shell to an extent specified in **2.7.3**. Compliance with this regulation shall be achieved by demonstrating that s_i, as defined in **2.5**, is not less than 0,9 for the three loading conditions used to calculate the attained subdivision index *A*.

If the attained subdivision index *A* is calculated for different trims, this requirement shall also be satisfied for those loading conditions.

2.7.3 The damage extent to be assumed when demonstrating compliance with 2.7.2, shall be depend on both N as defined in 2.2, and Ls, as defined in 1.2, such that:

.1 the vertical extent of damage shall extend from the ship's moulded baseline to a position up to 12.5 m above the position of the deepest subdivision draught as defined in **1.2**, unless a lesser vertical extent of damage were to give a lower value of si, in which case this reduced extent shall be used;

.2 where 400 or more persons shall be carried, a damage length of 0.03 L_s, but not less than 3 m shall be assumed at any position along the side shell, in conjunction with a penetration inboard of 0,1*B* but not less than 0.75 m measured inboard from the ship side, at right angle to the centerline at the level of the deepest subdivision draught;

.3 where less than 400 persons are carried, damage length shall be assumed at any position along the shell side between transverse watertight bulkheads provided that the distance between two adjacent transverse watertight bulkheads is not less than the assumed damage length. If the distance between two adjacent transverse watertight bulkheads is less than the assumed damage length, only one of these bulkheads shall be considered effective in compliance with **2.7.2**;

.4 where 36 persons are carried, a damage length of 0.015L_s, but not less than 3 m shall be assumed, in conjunction with a penetration inboard of 0.05*B* but not less than 0.75 m;

.5 where more than 36, but fewer than 400 persons are carried the values of damage length and penetration inboard, used in the determination of the assumed extent of damage, shall be obtained by linear interpolation between the values of damage length and penetration which apply for ships carrying 36 persons and 400 persons as specified in **2.7.3.2** and **2.7.3.4.**

2.7.4 Passenger ships carrying 36 or more persons shall be provided with flooding detection systems giving an audible and visual alarm for watertight spaces below the bulkhead deck.

Any watertight spaces that are separately equipped with a liquid level monitoring system (such as fresh water, ballast water, fuel, etc.), with an indicator panel or other means of monitoring at the navigation bridge (at the safety centre if located in a separate space from the navigation bridge), are excluded from these requirements.

2.7.4.1. A flooding detection system shall be fitted in all watertight spaces below the bulkhead deck of the passenger ship that have a volume, in m^3, that is more than the ship's moulded displacement per 1 cm immersion at deepest subdivision draught or have a volume more than 30 m^3, whichever is greater.

2.7.4.2 The number and location of flooding detection sensors shall be sufficient to ensure that any substantial water ingress is detected under reasonable angles of trim and heel. To accomplish this, flooding detection sensors shall generally be installed as indicated below:

.1 vertical location - sensors shall be installed as low as practical in the watertight space;

.2 longitudinal location - in watertight spaces located forward of the mid-length, sensors shall generally be installed at the forward end of the space; and

in watertight spaces located aft of the mid-length, sensors shall generally be installed at the aft end of the space.

For watertight spaces located in the vicinity of the midlength, consideration shall be given to the appropriate longitudinal location of the sensor.

In addition, any watertight space of more than L_s/5 in length or with arrangements that would seriously restrict the longitudinal flow of water shall be provided with sensors at both the forward and aft ends;

.3 transverse location - sensors shall generally be installed at the centreline of the space (or alternatively at both the port and starboard sides).

In addition, any watertight space that extends the full breadth of the ship or with arrangements that would seriously restrict the transverse flow of water shall be provided with sensors at both the port and starboard sides.

2.7.4.3 Where a watertight space extends in height over more than one deck, there shall be at least one flooding detection sensor at each deck level.

This provision is not applicable in cases where a continuous flood level monitoring system is installed.

2.7.4.4 For watertight spaces with unusual arrangements or in other cases where these guidelines would not achieve the intended purpose, the number and location of flooding detection sensors is subject to revision to achieve the intended purpose.

2.7.4.5 The sensors shall be installed where they are accessible for testing, maintenance and repair.

2.7.4.6 On ships the Flooding Detection System Manual shall be provided, which includes, as a minimum:

.1 the flooding detection system specification, including a list of procedures for checking the operability, as far as practicable, of each element at any stage of the ship service;

.2 the Type Approval Certificate issued for the flooding detection system;

.3 the single-line diagram of the flooding detection system with the location of equipment indicated in the ship's general arrangement plan;

.4 the instructions indicating the location, securing, protection and testing of the flooding detection system equipment;

.5 the procedures to be followed in case of failure of the flooding detection system;

.6 the maintenance requirements for the flooding detection system equipment.

The Manual shall be in the working language of the ship officers, as well as in English.

2.7.4.7 The flooding detection system shall comply with **7.10.3** and **7.10.4**, Part XI "Electrical Equipment".

2.7.5 Passenger ships having the length $L_1 \geq 120$ m or having three or more main vertical zones shall be provided with:

.1 onboard damage stability software approved by the Register (Recognized organization); or

.2 rapid access to shore-based computerized support organization, recognized by the Register, which makes damage stability and residual strength assessments, for the purpose of providing operational information to the master for safe return to port after flooding casualty, in accordance with IMO MSC.1/Circ.1532/Rev.

2.7.6 In case of flooding of any watertight compartment the requirements of **2.2.6.8**, Part VI "Fire Protection" shall be met.

2.8 TIMBER DECK CARGO IN THE CONTEXT OF DAMAGE STABILITY REQUIREMENTS

2.8.1 Timber deck cargo means the following cargo carried on an uncovered part of a freeboard or superstructure deck: sawn wood or lumber, cants, logs, poles, pulpwood and other types of timber in loose or packaged forms, except wood pulp or similar cargo.

2.8.2 Timber deck cargo shall be properly stowed and secured.

2.8.3 The height and extent of the timber deck cargo shall be at least stowed to the standard height of one superstructure.

2.8.4 The permeability of the timber deck cargo shall be not less than 25 % of the volume occupied by the cargo up to one standard superstructure.

2.8.5 The Stability Booklet and Damage Stability Booklet for ships with timber deck cargoes may be supplemented by additional curve of maximum permissible vertical positions of centre of gravity or minimum metacentric heights covering the timber draught range considering maximum permissible vertical position of centre of gravity or minimum metacentric height at the deepest timber subdivision draught and the partial timber subdivision draught.

The minimum metacentric heights shall be varied linearly between the deepest timber subdivision draught and the partial timber subdivision draught, and between the partial timber subdivision draught and the light service draught, respectively.

Where timber freeboards are not assigned the deepest and partial draughts shall relate to the summer load line.

This curve shall apply to ships carrying timber deck cargo only.

2.8.6 When considering the vertical extent of damage, the upper deck may be regarded as a horizontal subdivision. Thus when calculating damage cases are limited vertically to the upper deck with the corresponding v-factor, the timber deck cargo may be considered to remain buoyant with an assumed permeability of 0,25 at the deepest and partial draught.

For damage extending above the upper deck the timber deck cargo buoyancy in way of the damage zone shall be ignored.

2.9 BOTTOM DAMAGE

2.9.1 Any part of a cargo ship of $L_1 \geq 80$ m in length or a passenger ship that is not fitted with a double bottom, where it's omitted in accordance with **1.1.6.6.1**, **1.1.6.6.4**, Part II «Hull», shall be capable of withstanding bottom damages, as specified in **2.9.3**, in that part of the ship.

For cargo ships of less than 80 meters in length, such alternative arrangements shall provide a level of safety which satisfies the Register.

2.9.2 In the case of unusual bottom arrangements in a cargo ship of $L_1 \geq 80$ m or a passenger ship, it shall be demonstrated that the ship is capable of withstanding bottom damages as specified in **2.9.3.**

For cargo ships of less than 80 meters in length, such alternative arrangements shall provide a level of safety which satisfies the Register.

2.9.3 Compliance with **1.1.6.6.3** or **1.1.6.6.3.2**, Part II «Hull» and **2.9.1** or **2.9.2** shall be achieved by demonstrating that s_i, when calculated in accordance with **2.5**, is not less than 1 for all loading conditions when subject to a bottom damage assumed at any position along the ship's bottom and with an extent specified in **2.9.3.2** below for the affected part of the ship:

.1 flooding of such spaces shall not render emergency power and lighting, internal communication, signals or other emergency devices inoperable in other parts of the ship;

.2 assumed extent of damage is specified in Table 2.9.3.2;

Table 2.9.3.2

Estimated damage	For 0,3 L_1 from the forward perpendicular of the ship	Any other part of the ship
Longitudinal extent	$^1/_3\, L_1^{2/3}$ or 14,5 m, whichever is less	$^1/_3\, L_1^{2/3}$ or 14,5 m, whichever is less
Transverse extent	*B/6* or 10 m, whichever is less	*B/6* or 5 m, whichever is less
Vertical extent measured from the keel line	*B*/20, to be taken not less than 0,76 m and not more than 2 m	*B*/20, to be taken not less than 0,76 m and not more than 2 m

.3 if any damage of a lesser extent than the maximum damage specified in **2.9.3.2** would result in a more severe condition, such damage shall be considered.

2.9.4 In case of large lower holds in passenger ships, double bottom height shall be increased for not more than *B*/10 or 3 m, whichever is less, or bottom damages may be calculated for these areas, in accordance with **2.9.3**, but assuming an increased vertical extent.

3. DAMAGE TRIM AND STABILITY

3.1 GENERAL

3.1.1 Under all loading conditions to be encountered in service and which are in agreement with the purpose of the ship (icing disregarded), the trim and stability of an intact ship shall be sufficient for satisfying damage trim and stability requirements.

3.1.2 Requirements for the ship trim and stability shall be considered satisfied if, in case of damage mentioned in **3.2** and **3.4**, with the number of compartments flooded as mentioned in **3.4**, and the permeability determined in accordance with **1.6**, calculations made in conformity with **3.1.3** to **3.1.7** indicate that the requirements of **3.3** and **3.4** are satisfied.

3.1.3 Calculations for all cases of distribution and extent of damage specified in **3.2** and **3.4** to confirm compliance with the requirements of **3.3** and **3.4** as regards damage trim and stability shall be performed for such a number of loading conditions to be encountered in service and being the most unfavourable from the point of view of trim and stability (within the range of draughts up to the deepest subdivision load line and cargo distribution stipulated by the design), that, proceeding from those calculations, one could assure that in all other cases the damaged ship would be in a better condition as regards damage stability, the residual freeboard, distance from the damage waterline to openings through which the ship may be flooded and heeling angles.

Besides, the following shall be considered: the actual configuration of damaged compartments, their permeabilities, type of covers, whether intermediate decks, platforms, double sides, longitudinal and transverse bulkheads are provided sufficiently watertight as to render the flow of water through the ship completely or temporarily impossible.

3.1.4 Where the distance between two consecutive main transverse bulkheads is less than the longitudinal extent of design damage, the relevant compartment shall, at the discretion of the designer, be added to any of the adjacent compartments when checking damage stability. For non-passenger ships deviation from this provision may be granted where the arrangement of the bulkhead is in agreement with the condition $A \geq R$.

Forepeak and afterpeak are considered to be separate compartment regardless of the length.

3.1.5 Where two adjacent compartments are separated from each other by a stepped bulkhead, the bulkhead shall be held for damaged when the flooding of any of the two compartments is considered.

Where condition $A \geq R$ is observed or the length of the step does not exceed one frame or 0,8 m, whichever is less, or where the step is formed by floors of the double bottom, this requirement may be dispensed with in case of non-passenger ships.

3.1.6 If any damage of a lesser extent than stated in **3.2** and **3.4** might result in a more severe condition as regards damage trim and stability, such a damage shall be considered when making check calculations for damage trim and stability.

3.1.7 Where there are pipes, ducts or tunnels in the area of assumed damage, these shall be so designed that no water enters compartments which are considered not flooded.

3.1.8 The arrangements for righting the ship after damage shall be approved by the Register and shall be self-acting as far as practicable.

Where controllable cross-flooding arrangements are available, side-valve control stations shall be located above the bulkhead deck.

3.2 EXTENT OF DESIGN DAMAGE

3.2.1 Except cases specially provided for, including those stated in **3.1.6**, the following extent of side damage shall be assumed when making damage trim and stability calculations to confirm compliance with **3.3** and **3.4**:

.1 longitudinal extent – $^1/_3\, L_1^{2/3}$ or 14,5 m (whichever is less);

.2 transverse extent measured inboard of ship side at right angles to the centreline at the level of the deepest subdivision load line: $^1/_5$ of the ship breadth B or 11,5 m (whichever is the less);

.3 vertical extent: from the base line upwards without limit.

3.2.2 The requirements of **3.3** shall be complied with in case of simultaneous flooding of all compartments located forward of collision bulkhead.

3.3 REQUIREMENTS FOR DAMAGE TRIM AND STABILITY CHARACTERISTICS

3.3.1 In the final stage of flooding, the initial metacentric height of a ship in the upright condition determined by the constant displacement method, shall not be less than 0,05 m before appropriate measures to increase the metacentric height are taken.

For non-passenger ships, a positive metacentric height below 0,05 m may be permitted for the upright condition in the final stage of flooding.

3.3.2 For unsymmetric flooding the angle of heel shall not exceed:

20° before equalization measures and cross-flooding fittings being used;

12° after equalization measures and cross-flooding fittings being used.

3.3.3 The static stability curve of a damaged ship shall have a sufficient positive lever arm section. In the final stage of flooding, cross-flooding fittings disregarded, and after the equalization of the ship, a length of positive lever arm curve, flooding angle considered, shall be ensured not less than 20°. The angle of submersion of the openings specified in 1.4.5.3, Part IV "Stability", and openings, which are not equipped with watertight or weathertight covers through which water may spread to intact compartments may be taken as flooding angle.

The maximum lever arm shall be at least 0,1 m within this length, i.e. within the heel angle equal to the static one plus 20°.

The positive lever arm section within the said extent shall not be less than 0,0175 m·rad.

In the intermediate stages of flooding, the maximum lever arm of the static stability curve shall be at least 0,05 m, and the length of its positive section shall not be less than 7°.

3.3.4 Before, during and after equalization, the damage waterline shall be at least 0,3 m or $0{,}1 + (L_1 - 10)/150$ m (whichever is less) below the openings in the bulkheads, decks and sides through which progressive flooding could take place. Such openings include the outlets of air and vent pipes and those which are closed by means of weathertight doors and covers.

These do not necessarily include:

.1 non-opening side and deck scuttles;

.2 manholes having covers with closely space bolts;

.3 cargo tank hatchways in tankers;

.4 remotely controlled sliding doors, watertight doors with indication systems (except ships specified in **1.1.1.2**, **1.1.1.5**, **1.1.1.6** and **1.1.1.8**) and access hatches normally closed at sea;

.5 openings in subdivision bulkheads intended for the passage of vehicles during cargo handling operations which are permanently closed with strong watertight covers while at sea. Such openings are only permitted for ro-ro ships.

The position and arrangement of closures of openings shall meet the requirements of Section **7**, Part III "Equipment, Arrangement and Outfit".

The location of spaces for emergency sources of electrical power shall comply with the requirements of **9.2.1**, Part XI "Electrical Equipment"

3.3.5 For cargo ships, immersion of the bulkhead deck and, moreover, of the weather deck is permitted.

3.3.6 The requirements of **3.3.1** to **3.3.5** apply to ships specified in **3.4** considering the additional requirements for damage trim and stability specific for each ship type.

For ships not mentioned in **3.4** the requirements of **3.3.1** to **3.3.5** apply, if, at the shipowner's request, the ship's class notation provides for the subdivision distinguishing mark.

3.4 ADDITIONAL REQUIREMENTS FOR DAMAGE TRIM AND STABILITY

3.4.1 Roll-on/roll-off ships similar to passenger ships.

3.4.1.1 Where vehicles accompanied by personnel of more than 12 persons including passengers (if any) shall be carried by roll-on/roll-off ships, such ships, irrespective of their length, shall be considered equal to passenger ships in respect of all relevant requirements for subdivision bearing in mind the deviation stated in **3.3.4.5**, if applicable according to **7.12.1.1**, Part III "Equipment, Arrangements and Outfit".

3.4.2 Icebreakers and fishing vessels.

3.4.2.1 In Table 3.4.2.1 the number of compartments is indicated after the flooding of which the requirements of **3.3** for damage stability considering damage as defined in **3.2** shall be satisfied.

Table 3.4.2.1

Type of ship	Length L_1, in m	Number of floodable compartments
Icebreakers	50 and upwards	2
Fishing vessels having over 100 persons on board	100 and upwards	1

Ships of ice classes **Icebreaker1** or **Icebreaker2**, which perform icebreaking operations periodically, as defined in **2.2.3.2**, Part I "Classification" shall only comply with the requirements for damage stability specified in **3.4.2.2**, at damage extent and its position as defined in **3.4.2.3** and **3.4.2.4**.

Damage as defined in **3.2** is not considered for the above mentioned ships.

3.4.2.2 Damage stability of **Icebreaker1** ÷ **Icebreaker4** ice class ships shall be such that $s_i = 1$ for all loading conditions in case of ice damage specified in **3.4.2.3**, in positions as defined in **3.4.2.4**.

3.4.2.3 For the purpose of damage trim and stability calculations, the following extent of ice damage shall be assumed:

1. longitudinal extent $0{,}045L_{ice}$ if the centre of damage lies forward of the point of maximum beam on the waterline related to draught d_{ice}, and $0{,}015L_{ice}$ in other areas;

2. damage depth 0,76 m as measured along the normal to the shell at any point in the area of assumed damage;

3. vertical extent the lesser of $0{,}2d_{ice}$, or of longitudinal extent;

4. location of ice damage from the base line to the level of $1{,}2d_{ice}$ and within L_{ice}; and

5. the vertical extent of damage may be assumed from the base line to the level of $1{,}2d_{ice}$.

3.4.2.4 Damage as defined in **3.4.2.3** shall be assumed at any position along the side shell in the ice damage area.

3.4.3 Special purpose ships.

3.4.3.1 Special purpose ships shall comply with the requirements of Section 2 related to passenger ships, and special personnel shall be considered passengers. Where the ship is certified to carry less than 240 persons, the requirements of 2.7 are not applicable.

3.4.3.2 The required subdivision index *R* shall be calculated as follows:

.1 where the ship is certified to carry 240 persons or more, the *R*-value shall be assigned in compliance with **2.2.2.3**;

.2 where the ship is certified to carry not more than 60 persons, the *R*-value shall be assigned as 0,8*R* determined in compliance with **2.2.2.3**; and

.3 for more than 60 (but not more than 240) persons, the *R*-value shall be determined by linear interpolation between the *R*-values given in **3.4.3.2.1** and **3.4.3.2.2**.

3.4.3.3 Requirements for subdivision of special purpose ships also apply to standby vessels.

3.4.4 Tugs, dredgers and lightships.

3.4.4.1 If a single compartment is flooded, the requirements of **3.3** for damage trim and stability shall be satisfied for the following types of ships:

tugs having the length L1 ≥ 40 m;

dredgers having the length L1 ≥40 m;

lightships irrespective of length;

hopper dredgers having the length L1 ≥60 m.

3.4.4.2 Bucket dredgers shall comply with the requirements of 3.3 if a single compartment is flooded in way of the bucket opening. The depth of the damage is assumed equal to 0.76 m.

3.4.4.3 Where hopper dredgers and hopper barges are concerned, damage conditions may not be considered corresponding to ship condition after spoil discharge from one side.

3.4.5 Oil tankers and chemical tankers.

3.4.5.1 The damage trim and stability of oil tankers and chemical tankers shall satisfy the requirements of **3.3** both for the case of side and bottom damage.

3.4.5.2 Extent of bottom damage:

.1 the longitudinal extent shall be $^1/_3\,L_1^{2/3}$ or 14,5 m (whichever is less) within 0,3L_1 from the forward perpendicular (from the foremost point of the length L1) and $^1/_3\,L_1^{2/3}$ or 5 m (whichever is less) through the rest of the ship length;

.2 the transverse extent shall be B/6 or 10 m (whichever is less) within 0,3L_1 from the forward perpendicular and B/6 or 5 m (whichever is less) through the rest of the ship length;

.3 the vertical extent, measured from the moulded line of the shell at centreline, shall be B/15 or 6 m (whichever is less).

3.4.5.3 In addition to **3.4.5.2**, bottom shell damage shall be considered for oil tankers with a deadweight of 20 000 t and upwards, having touched the ground, the extent of damage being as follows:

.1 length of 0,6L_1 from the forward perpendicular for ships having a deadweight of 75 000 t and upwards, and 0,4L_1 from the forward perpendicular for ships having a deadweigth below 75 000 t;

.2 breadth B/3 anywhere in the bottom.

3.4.5.4 Damage trim and stability requirements shall be satisfied for the following locations of side and bottom damage:

.1 oil tankers:

where the length L_1 > 225 m - anywhere along the ship length;

where the length 225≥ L_1>150 m - anywhere in the ship length except for the engine room when this is located aft. In this case, the engine room shall be considered a separate floodable compartment;

where the length L_1≤150 m - anywhere in the ship length between consecutive transverse bulkheads except for the engine room;

where the substances of the Category C are carried under the provisions of Annex II to MARPOL 73/78, as for chemical tankers 3;

.2 chemical tankers:

chemical tanker 1 - anywhere along the ship length;

chemical tanker 2 having the length L_1 >150 m - anywhere along the ship length;

chemical tanker 2 having the length L_1 ≤150 m - anywhere in the ship length except for the engine room where this is located aft. In this case, the engine room shall be considered a separate floodable compartment;

chemical tanker 3 having the length L_1 >225 m - anywhere along the ship length;

chemical tanker 3 having the length 225≥ L_1 ≥125 m - anywhere in the ship length except for the engine room where this is located aft. In this case, the engine room shall be considered a separate floodable compartment;

chemical tanker 3 having the length L_1 <125 m - anywhere along the ship length except for the engine room where this is located aft. Nevertheless, damage trim and stability calculations for the conditions of the engine room flooded shall be submitted to the Register for review.

3.4.5.5 Ships which do not comply with the requirements for damage trim and stability when their engine room is flooded, as stipulated by **3.4.5.4.1** and **3.4.5.4.2**, are not assigned a subdivision distinguishing mark in their character of classification.

3.4.5.6 In the final stage of unsymmetric flooding before equalization measures and cross-flooding fittings being used, the angle of heel shall not exceed 25° (or 30° where the bulkhead deck is not immersed). After equalization measures, the heeling angle shall not exceed 17°.

3.4.6 Gas carriers.

For gas carriers, the requirements of **3.4.5** apply except for the following details:

.1 damage trim and stability requirements shall be satisfied when side and bottom damage is sustained as stated below:

gas carriers 1G - anywhere along the ship length;

gas carriers 2G having the length L_1 > 150 m - anywhere along the ship length;

gas carriers 2G having the length L_1 ≤ 150 m or below - anywhere along the ship length except the engine room where this is located aft. In this case the engine room shall be considered a separate floodable compartment;

gas carriers 2PG - anywhere in the ship length between subdivision bulkheads;

gas carriers 3G having the length L_1 ≥ 80 m - anywhere in the ship length between subdivision bulkheads;

gas carriers 3G having the length L_1 ≥ 80 m - anywhere in the ship length between subdivision bulkheads except the engine room where this is located aft. However, damage trim and stability calculations for the case of the engine room being flooded shall be submitted for the consideration of the Register. No subdivision distinguishing mark shall be introduced in the character of classification if damage trim and stability requirements are not met;

.2 the longitudinal extent of bottom damage shall be assumed equal to $1/3L_1^{2/3}$ or 14,5 m, whichever is less, over the full ship length;

.3 the vertical extent of a bottom damage shall be assumed equal to B/15 or 2 m, whichever is less;

.4 requirements of **3.3** shall be met for local damage anywhere in the cargo area. The depth of damage shall be taken not less than the distance d, which is determined as follows:

.1 for $V_c \le 1000$м^3: $d = 0{,}8$м;

.2 for 1000м^3 < $V_c < 5000$ m^3: $d = 0{,}75 + V_c \cdot 0{,}2/4000$, m;

.3 for 5000м^3 ≤ $V_c < 30000$м m^3: $d = 0{,}8 + V_c/25000$, m; and

.4 for $V_c \ge 30000$ m^3: $d = 2{,}0$ m,

where: V_c - corresponds to 100% of the estimated gross volume of a single cargo tank at 20°C, including domes and protruding parts;

d - measured in any cross-section at right angles to the theoretical line of the ship's hull shell plating.

3.4.7 Drilling ships.

With any single compartment flooded, drilling ships shall comply with the requirements of **3.3**, unless more stringent requirements are put forward by the shipowner.

Drilling ships shall have sufficient reserve of damage stability to withstand the wind heeling moment produced by wind with a speed of 25,8 m/s (50 knots) acting from any direction.

Under these conditions the final waterline after flooding shall be located below the lower edge of any opening through which the intact compartments may be flooded by the sea.

3.4.8 Ships intended for the carriage of radioactive agents.

The requirements for damage trim and stability of the ships carrying packaged irradiated nuclear fuel or high-level radioactive wastes with the total radioactivity above $2 \cdot 10^6$ TBq or plutonium with the total radioactivity $2 \cdot 10^5$ TBq and above shall be met in the case of the calculated damage anywhere along the ship length.

The possible probability estimation of the ship subdivision may be considered being an alternative to the requirements indicated.

For ships carrying radioactive agents the required subdivision index *R* shall be determined in compliance with **2.2**.

Thus, for cargo ships less than 80 m in length the value of the required subdivision index *R* shall be determined as for a ship of 80 m in length. In any case, for ships carrying radioactive agents with the total radioactivity above $2 \cdot 10^6$ TBq or plutonium with the total radioactivity above $2 \cdot 10^5$ TBq, the required subdivision index shall be equal to R+0,2(17R), but not less than 0,6, where *R* is determined in compliance with **2.2.2.1** and **2.2.2.2**.

For ships less than 80 m in length, the value of required subdivision index *R* shall be determined by the formula:

$$R = R_0 + 0,2 \cdot (1 - R_0), \text{ but not less than } 0,6,$$

where: R_0 - the value of *R*, calculated in compliance with **2.2.2.1** and **2.2.2.2.**

For ships having length L_S < 80 m, the value of required subdivision index *R* is detrmined by the formula:

$$R=1-[1/(1+0,8 \cdot R_0 /(1- R_0)], \quad (3.4.8)$$

where: R_0 - the value of *R*, calculated in compliance with **2.2.2.1**.

3.4.9 Supply vessels.

3.4.9.1 The extent of damage:

.1 longitudinal extent shall be $1/3L_1^{2/3}$, for ships with length $L_1 \geq 80$ m, 3 m plus 3 % of the ship's length for ships with the length (L_1) greater than 43 m. For those with length (L_1) not greater than 43 m, 10 % of the ship's length;

.2 transverse extent of damage shall be assumed as 0,76 m and *B*/20 (but not less than 0,76 m) with length $L_1 \geq 80$ m, measured inboard from the side of the ship perpendicularly to the centerline at the level of the summer load waterline;

.3 vertical extent: from the underside of the cargo deck, or the continuation thereof, for the full depth of the ship.

3.4.9.2 A transverse watertight bulkhead extending from the ship's side to a distance inboard as specified in **3.4.9.1.2** or more measured perpendicularly to the centerline at the level of the summer load line joining longitudinal watertight bulkheads may be considered as a transverse watertight bulkhead for the purpose of the damage trim and stability calculations.

3.4.9.3 Where a transverse watertight bulkhead is located within the transverse extent of assumed damage and is stepped in way of a double bottom or side tank by more than 3,0 m, the double bottom or side tanks adjacent to the stepped portion of the transverse watertight bulkhead shall be considered as damaged.

3.4.9.4 In the final stage of unsymmetrical flooding the angle of heel shall not exceed 15° before equalization measures are taken and cross-flooding fittings are used. This angle may be increased up to 17° if no deck immersion occurs.

3.4.9.5 Number of floodable compartments.

The damage stability requirements of **3.3** shall be met in the case of single compartment flooding proceeding from the extent of damage stated under **3.2.1.1**, **3.2.1.3** and **3.4.9.1**.

3.4.9.6 Ships complying with the requirements of **3.4.9.3** only will receive no subdivision distinguishing mark in the character of classification.

3.4.9.7 If preferred by the shipowner, a supply vessel may receive a subdivision distinguishing mark with the number of floodable compartments indicated in the class notation. In this case, the transverse extent of damage shall be assumed in accordance with **3.2.1.2**. The number of compartments at the flooding of which the damage trim and stability requirements shall be met shall be determined by the shipowner.

3.4.10 Polar Class, Baltic Ice Classes IA, IA Super and Ice4, Ice5 i Ice6 ice class ships.

3.4.10.1 The requirements of this paragraph apply to all Polar classes **PC1** ÷ **PC7**, Baltic ice classes **IA** and **IA Super Ice4** and **Ice5, Ice6** ice class ships

The damage trim and stability requirements shall be met as far as the draught d_{ice} is concerned except for the

requirement of **3.4.10.2**.

3.4.10.2 Where the extent of damage is in accordance with 3.2, within range of the summer load line draught assigned to the ship the damage trim and stability requirements of 3.3 shall be met if a single compartment is flooded in the following ice class ships:

Polar classes **PC1** ÷ **PC4** – irrespective of the ship's length;

Polar classes **PC5, PC6** i **PC7,** Baltic ice classes **IA** and **IA Super, Ice 6**, **Ice5** and **Ice4** ice class ships – with the ship length $L_1 \geq 120$ m.

The subdivision distinguishing mark **1** shall be introduced in the character of classification of such ships.

3.4.10.3 Polar classes **PC1** ÷ **PC7**, Baltic ice classes **IA** and **IA Super**, **Ice4** ÷ **Ice6** ice class ships (irrespective of the ship's length), shall comply with the requirements of **3.3** with relevant ice damage stated in **3.4.10.4** and the number of floodable compartments given in **3.4.10.5**.

Where compliance with the requirements of other Sections of this Part also testifies to **3.4.10** being complied with, no additional damage trim and stability calculations need be made for damage conditions mentioned under **3.4.10.4** and **3.4.10.5**.

3.4.10.4 For the purpose of damage trim and stability calculations, the following extent of ice damage shall be assumed:

.1 longitudinal extent 0,045Lice, if the centre of damage lies within $0{,}4L_{ice}$ from the forward perpendicular and for Polar class ships, if the centre of damage lies forward from the point of maximum breadth of the upper ice waterline and $0{,}015L_{ice}$ – in other areas, where L_{ice} – the length of the upper ice waterline;

.2 damage depth 0,76 m as measured along the normal to the shell at any point in the area of assumed damage;

.3 vertical extent $0{,}2d_{ice}$;

.4 location of damage from the base line to the level of $1{,}2d_{ice}$ within L_{ice}.

3.4.10.5 When performing damage trim and stability calculations, the number of floodable compartments shall be determined proceeding from the location of the assumed ice damage listed in Table 3.4.10.5.

3.4.10.6 In all cases, irrespective of the requirements stated in items 11 and 12 of Table 3.4.10.5, the calculations of damage trim and stability for the case of the engine room being flooded shall be submitted for the consideration of the Register.

3.4.10.7 Ships conforming with the requirements of **3.4.10.3** ÷ **3.4.10.6**, only will receive no subdivision distinguishing mark in the character of classification.

Table 3.4.10.5 **Location of ice damage depending on purpose and ice class**

№	Ship types and/or their ice classes	Location of ice damage mentioned under **3.4.10.4**
1	2	3
1	Polar classe PC1 ÷ PC7	Anywhere in the ice damage area
2	Passenger ships allowed to carry over 400 passengers including the crew	Ditto
3	Special purpose ships allowed to carry over 400 passengers including the crew	Ditto
4	Ships intended for the carriage of radioactive agents	Ditto
5	Chemical tankers	Ditto
6	Oil tankers	Ditto
7	Gas carriers	Ditto
8	Drilling ships	Ditto
9	Salvage ships of ice classes **Ice5, Ice6, IA Super**	Ditto

End of Table 3.4.10.5

№	Ship types and/or their ice classes	Location of ice damage mentioned under **3.4.10.4**
1	2	3
10	**Ice5, Ice6, IA Super** ice class ships not mentioned in 1 ÷ 9	Between watertight bulkheads, platforms, decks and plating1. With the hull length L_I<100 m it is permitted not to comply with the requirements for damage trim and stability where engine room located aft is flooded in case of ice damage. The same refers to the flooding of engine rooms of tugs less than 40 m in length irrespective of the engine room location
11	**Ice4 та IA** ice class ships not mentioned in 1 ÷ 9	Between watertight bulkheads, platforms, decks and plating[1]. With the hull length L_I<125 m it is permitted not to comply with the requirements for damage trim and stability where engine room located aft is flooded in case of ice damage. The same refers to the flooding of engine rooms of tugs less than 40 m in length irrespective of the engine room location
[1] Where the distance between two consecutive watertight structures is less than the extent of damage, relative adjacent compartments shall be considered a single floodable compartment when checking damage trim and stability		

3.4.11 Bulk carriers, ore carriers and combination carriers.

3.4.11.1 Bulk carriers having the length L1 of 150 m and upwards, which carry solid bulk cargoes with density of 1000 kg/m3 and above, shall meet the requirements of **4.4** at flooding of any cargo hold bounded by the side shell only or being double side skin construction with the width less than *B*/5 or 11,5 m (whichever is the less) in all load cases up to the summer load line.

3.4.11.2 When calculating damage stability the following permeabilities shall be taken:

0,90 for loaded holds;

0,95 for empty holds.

Ships assigned with the reduced freeboard in accordance with Section **4** are regarded of satisfying the requirements of **3.4.11.1**.

Information on compliance with these requirements shall be included in the Booklet as required by 1.4.9.7, Part II "Hull".

3.4.11.3 Ships are fitted with flooding detection sensors:

.1 in each cargo hold, giving audible and visual alarms, one when the water level above the inner bottom in the hold reaches a height of 0,5 m high, and another at a height not less than 15 % of the cargo hold depth but not more than 2,0 m; it is allowed to use one detector instead of two provided its design allows to give alarm at both levels of hold flooding. The detectors are fitted in the aft end of the cargo hold as close to the centerline, as practicable, or above its lowest part where the inner bottom is not parallel to the designed waterline.

If detectors cannot be placed within a distance equal to one corrugation space or one bulkhead vertical stiffener space from the centerline, they shall be located at both the port and starboard sides of the cargo hold;

.2 in any ballast tank forward of the collision bulk-head required in **1.1.6**, Part II "Hull" giving an audible and visual alarm when the liquid in the tank reaches a level not exceeding 10 % of tank capacity;

.3 in any dry or void space other than a chain cable locker, any part of which extends forward of the foremost cargo hold, giving an audible and visual alarm at a water level of 0,1 m above the deck.

Such alarms need not be provided in enclosed spaces, the volume of which does not exceed 0,1 % of the ship's maximum displacement volume.

Detectors in cargo holds shall be protected by a robust construction from damage by cargoes or mechanical handling equipment associated with bulk carrier operations.

3.4.11.4 On ships the Flooding Detection System Manual shall be provided, which includes, as aminimum:

.1 the flooding detection system specification, including a list of procedures for checking the operability, as far as practicable, of each element at any stage of the ship service;

.2 the Type Approval Certificate issued for the flooding detection system;

.3 the single-line diagram of the flooding detection system with the location of equipment indicated in the ship's general arrangement plan;

.4 the instructions indicating the location, securing, protection and testing of the flooding detection system equipment;

.5 list of cargoes in which 50 % mixture with seawater detectors protected by guard remain operable;

.6 the procedures to be followed in case of failure of the flooding detection system;

.7 the maintenance requirements for the flooding detection system equipment.

The Manual shall be in the working language of the ship officers, as well as in English.

3.4.11.5 The flooding detection system shall meet the requirements of **7.10**, Part XI "Electrical Equipment".

3.4.12 Berth-connected ships.

3.4.12.1 Damage stability requirements stated in **3.3** shall be complied with in the case of any single flooded compartment lying along the ship periphery and having the length not less than the length of damage given in **3.4.12.2.2**.

3.4.12.2 For the purpose of damage trim and stability calculations, the following extent of damage shall be assumed:

.1 transverse extent measured from the inner skin at right angles to the centreline on the level of the deepest waterline permitted by the load line – 0,76 m;

.2 longitudinal extent– $1/6L_1^{2/3}$ or 7,2 m (whichever is less);

.3 vertical extent in accordance with **3.2.1.3**.

3.4.12.3 No subdivision distinguishing mark will be introduced in the character of classification of berth-connected ships which comply solely with the requirements of **3.4.12** and for which regard to **3.4.12.2** shall be taken.

3.4.13.4 If the depth of waters on which the berth-connected ship floats is such that the lowermost deck accessible to passengers cannot be immersed not to mention capsizing of the ship, the requirements of this Section may be waived.

3.4.13 Cargo ships having the length L_1 < 100 m other than bulk carriers.

3.4.13.1 Single hold cargo ships other than bulk carriers constructed before 1 January 2007 shall omply with these requirements not later than 31 December 2009.

3.4.13.2 Ships having the length L_1<80 m, or L_1<100 m if constructed before 1998, and a single carg ohold below the freeboard deck or cargo holds below the freeboard deck which are not separated by at least one bulkhead made watertight up to that deck, shall be fitted in such space or spaces with flooding detection sensors, which give an audible and visual alarm at the navigation bridge when the water level above the inner bottom in the cargo hold reaches a height of not less than 0,3 m, and another when such level reaches not more than 15 % of the mean depth of the cargo hold.

3.4.13.3 Flooding detection sensors shall be fitted at the aft end of the hold, or above its lowest part where the inner bottom is not parallel to the designed waterline. If sensors cannot be placed within a distance equal to one corrugation space or one bulkhead vertical stiffener space from the centerline, they shall be located at both sides of the cargo hold. Where webs or partial watertight bulkheads are fitted above the inner bottom, the fitting of additional sensors may be required. It is allowed to use one sensor vertically instead of two provided its design allows giving alarm at both levels of hold flooding.

3.4.13.4 The flooding detection sensors need not be fitted in ships complying with the requirements of **3.4.11.3**, or in ships having watertight side compartments each side of the cargo hold length extending vertically at least from inner bottom to freeboard deck.

3.4.13.5 The flooding detection system shall comply with the requirements of **7.10**, Part XI "Electrical Equipment".

3.4.13.6 Flooding Detection System Manual shall be provided on board the ship, which shall be developed in compliance with the requirements of **3.4.11.4**.

3.4.14 Ro-ro passenger ships.

3.4.14.1 Ro-ro passenger ship stability required at the final stage after the damage caused by collision and after equalization shall comply with the requirements of this paragraph in addition to **3.4.1**.

3.4.14.2 The existing ro-ro passenger ships shall comply with the requirements of this paragraph within the terms as provided by Article 7 of the Directive 2003/25/EC of the European Parliament and of the Council of 14 April 2003 considering amendments and additions as per the Commission Directive 2005/12/EC of 18 February 2005 of the European Parliament and of the Council on specific stability requirements for ro-ro passenger ships.

3.4.14.3 In addition to 1.2.1 the following definitions and explanations have been adopted in this paragraph:

Drainage system means a system providing removal of seawater from the ro-ro deck that comes due to the stormy conditions or damage to a ship.

Residual freeboard (f_r) is the minimum distance between the damaged roro deck and the final waterline (after equalisation measures if any have been taken) in way of the assumed damage after examining all possible damage scenarios in determining, without taking into account the additional effect of the sea water accumulated on the damaged ro-ro deck.

Significant wave height (h_S) is the average height of the highest wave heights measured between the wave hollow and wave top. The figures of significant wave heights shall be those which are not exceeded by a probability of more than 10 % on a yearly basis.

Significant wave height (h_S) shall be used in determining the height of water on ro-ro deck (h_w) when applying the specific stability requirements*.

Ro-ro deck means a deck in closed or open ro-ro cargo spaces or special roro spaces as defined in **1.5.4.3 ÷ 1.5.4.4** and **1.5.9**, Part VI "Fire Protection" of the Rules.

Ro-ro passenger ship means a ship carrying more than 12 passengers, having closed or open ro-ro cargo spaces or special category spaces as defined in **1.5.4.3 ÷ 1.5.4.4** and **1.5.9**, Part VI "Fire Protection" of the Rules.

Ferryboats that are via ferry crossing engaged on regular carriages of passengers and carriage of vehicles with oil in tanks on open and/or closed deck and/or railway rolling stock with horizontal loading and discharging shall be also referred to ro-ro passenger ships.

Regular service means a series of ro-ro passenger ship crossings serving traffic between the same two or more ports, which is operated either

according to a published timetable; or

with crossings so regular or frequent that they constitute a recognisable systematic series.

Specific stability requirements means the requirements based on the method**, calculating the height of water on the ro-ro deck after the damage under the two basic parameters: residual freeboard (fr) and significant wave height on the territory of the ship (h_S).

SOLAS Stability Standard means the requirements providing a level of safety equivalent to the specific stability requirements established for ships operating in sea areas where the significant wave height (h_S) is equal to or less than 1.5 m.

Stability standard for ro-ro passenger ships in damaged condition means the requirements to take into account the effect of water accumulation on the ro-ro deck and to enable the ship to survive in more severe states than the SOLAS standard, up to 4 m significant wave heights.

Stockholm Agreement means the Agreement concluded at Stockholm on 28 February 1996 in pursuance of SOLAS 95 Conference Resolution 14 "Regional agreements on specific stability requirements for ro-ro passenger ships", adopted on 29 November 1995.

Freeing ports means scuppers providing to free the water accumulated due to stormy conditions or damage of the ship from the ro-ro deck directly overboard.

* When determining significant wave height (hS), the wave heights given on the maps or list of sea areas are to be used.

In compliance with clause 21, Articles 4 and 5 of the Directive 2003/25/EC of the European Parliament and of the Council of 14 April 2003 considering amendments and additions as per the Commission Directive 2005/12/EC of 18 February 2005 of the European Parliament and of the Council, each Member State should determine and update, if necessary, the sea areas under their jurisdiction, of the significant wave height (h_S), delimiting the zones for the all-yearround and, where appropriate, restricted periodical operation of ro-ro passenger ships.

Significant wave heights (h_S) for seasonal operation shall be determined by the host State Administration in agreement with the other country whose port is included in the ship's route.

** Refer to Annexes to the Stockholm Agreement and Directive 2003/25/EC of the European Parliament and of the Council.

3.4.14.4 Ro-ro passenger ship's stability in the final condition after damage due to collision and after equalization shall be determined considering the effect of water that may be accumulated on the first ro-ro deck or special cargo space above the waterline and to enable the ship to survive in more severe states than the SOLAS standard, up to 4 m significant wave heights.

3.4.14.5 The stability required in the final condition after damage, and after equalization shall be determined as follows as per the SOLAS stability standard:

.1 The positive residual righting lever curve shall have a minimum range of 15° beyond the angle of equilibrium. This range may be reduced to a minimum of 10°, in the case where the area under the righting lever curve is that specified in **3.4.14.5.2**, multiplied by the ratio "15/range", where the range is expressed in degrees.

.2 The area under the righting lever curve shall be at least 0.015 m·rad, measured from the angle of equilibrium to the lesser of:

.2.1 the angle at which progressive flooding occurs; or

.2.2 22° (measured from the upright) in the case of one-compartment flooding, or 27° (measured from the upright) in the case of the simultaneous flooding of two adjacent compartments. .3 A residual righting lever GZ, in m, is to be calculated by the formula:

GZ = (heeling moment/displacement) + 0.04 (3.4.14.5.3),

shall be within the range of positive stability, taking into account the greatest of the following heeling moments:

.3.1 the crowding of all passengers towards one side;

.3.2 the launching of all fully loaded davit-launched survival craft on one side;

.3.3 due to wind pressure. However, in no case is this righting lever to be less than 0.10 m;

.4 For the purpose of calculating the heeling moments given in paragraph **3.4.14.5.3**, the following assumptions shall be made:

.4.1 moments due to crowding of passengers:

- four persons per m^2;
- a mass of 75 kg per each passenger;
- passengers are distributed on available deck areas towards one side of the ship on the decks where muster stations are located and in such a way that they produce the most adverse heeling moment.

.4.2 moments due to launching of all fully loaded davit-launched survival craft on one side of the ship:

.4.2.1 all lifeboats and rescue boats fitted on the side to which the ship has heeled after having sustained damage shall be assumed to be swung out fully loaded and ready for lowering.

.4.2.2 for lifeboats which are arranged to be launched fully loaded from the stowed position, the maximum heeling moment during launching shall be taken:

.4.2.3 a fully loaded davit-launched liferaft attached to each davit on the side to which the ship has heeled after having sustained damage shall be assumed to be swung out ready for launching.

.4.2.4 persons not in the life-saving appliances which are swung out shall not provide either additional heeling or righting moment.

.4.2.5 lifesaving appliances on the side of the ship opposite to the side to which the ship has heeled shall be assumed to be in a stowed position.

.4.3 moments due to wind pressure:

a wind pressure of 120 Pa (120 N/m2), to be applied,

where:

- the area applicable shall be the projected lateral area of the ship above the waterline corresponding to the intact condition;
- the moment arm shall be the vertical distance from a point at one half of the mean draught corresponding to the intact condition to the centre gravity of the lateral area.

3.4.14.6 The conditions for stability required by SOLAS stability standard, refer to paragraph **3.4.14.5**, are to be complied with considering the effect of sea water that may be accumulated on the first ro-ro deck or special cargo space (hereinafter referred to "damaged ro-ro deck") above the deepest subdivision load line in a way of damage.

3.4.14.7 The accumulated water is added as a liquid load with one common surface inside all compartments which are assumed flooded on the damaged ro-ro deck.

The height of water (h_w) on deck is dependent on the residual freeboard (f_r) after damage, and is measured in way of the damage (refer to Fig. 3.4.14.7-1).

No account should be taken of the effect of the hypothetical volume of water assumed to have accumulated on the damaged ro-ro deck when calculating the residual freeboard (f_r).

The amount of assumed accumulated sea water shall be calculated on the basis of a water surface having a fixed height above:

the lowest point of the ro-ro deck edge of the damaged compartment, if the edge of the damaged ro-ro deck is not submerged (refer to Fig. 3.4.14.7-2 a)); or

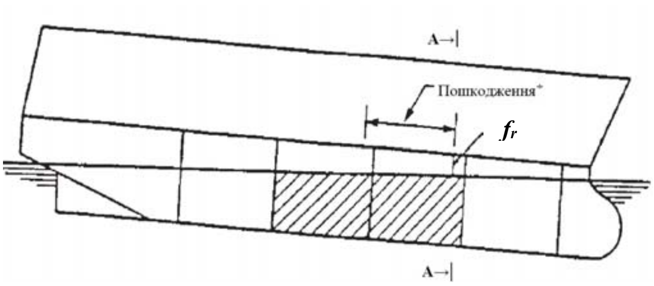
if the ro-ro deck edge of the damaged compartment is submerged, then the calculation is based on a fixed height above the still water surface at all heel and/or trim angles (refer to Fig 3.4.14.7-2 b)).

If $f_r \geq 2.0$ m, no water is assumed on the damaged ro-ro deck.

If $f_r \leq 0.3$ m, the height h_w on the damaged ro-ro deck is assumed to be 0.5 m. If 0.3 m $\leq f_r <$ 2.0 m, the height hw on the damaged ro-ro deck shall be obtained by linear interpolation.

3.4.14.8 When a high efficiency drainage system is installed, the reduce of the permissible height (h_w) of water surface may be allowed.

Note. Means for drainage of water can only be considered as effective if these means are of a capacity to prevent large amounts of water from accumulating on the damaged ro-ro deck i.e. many thousands of tonnes per hour.



* Damage provided by SOLAS Stability Standard.

A-A (Scheme determining the size of a freeboard)

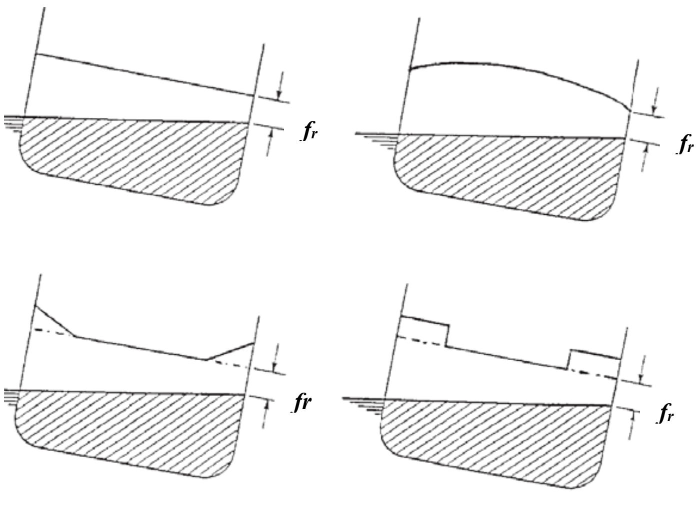
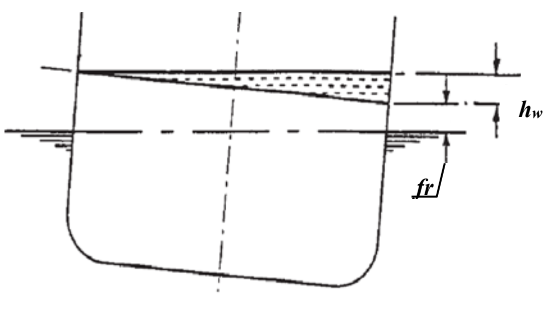
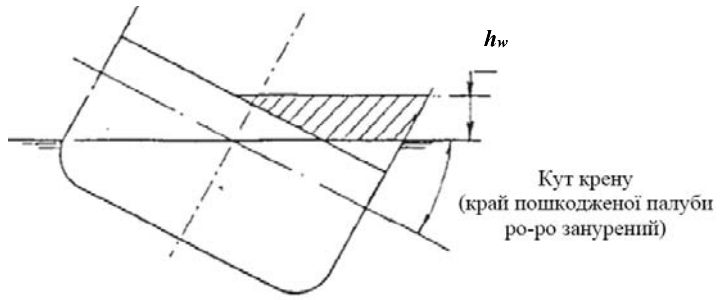


Fig. 3.4.14.7-1



a)



b)
Fig. 3.4.14.7-2

3.4.14.9 The height of accumulated water (hw), permitted on the damaged roro deck as per **3.4.14.6** ÷ **3.4.14.7**, may be reduced for ships in geographically defined restricted areas of operation with the significant wave height (h_S) by substituting such height (h_w) of accumulated water on the damaged ro-ro deck by the following:

if the significant wave height (h_S), in the area concerned, is 1.5 m or less, then no additional water is assumed to accumulate on the damaged ro-ro deck, that is $h_w = 0.0$ m;

if the significant wave height (h_S) in the area concerned is 4.0 m or more, then the height of the assumed accumulated water on the damaged ro-ro deck (hw) shall be the value calculated in accordance with paragraph **3.4.14.7**;

if 1.5 m $\leq h_S <$ 4.0 m, the intermediate water height permitted on the damaged ro-ro deck (h_w) shall be determined by linear interpolation,

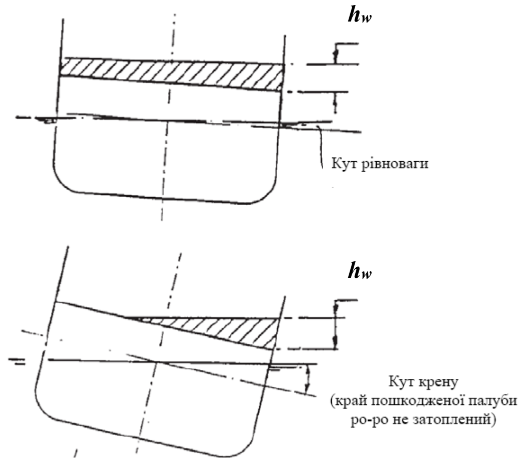
subject to the following:

the area of operation and rate of the significant wave height (h_S) comply with the requirements of the State Administration;

the areas of operation and part of the year for which a certain value of the significant wave height (h_S) has been established are entered into ship's certificate.

3.4.14.10 In calculations the following shall be considered:

- the height of the accumulated water (h_w), permitted on the damaged ro-ro deck, is kept constant, therefore the amount of added water is variable as it is dependent upon the heeling angle and whether at any particular heeling angle the deck edge is immersed or not (refer to Fig 3.4.14.10);
- the assumed permeability of the damaged deck spaces is to be taken as 0.90 (refer to MSC/Circ.649), whereas other assumed flooded spaces permeabilities are to be those prescribed in **2.6**.



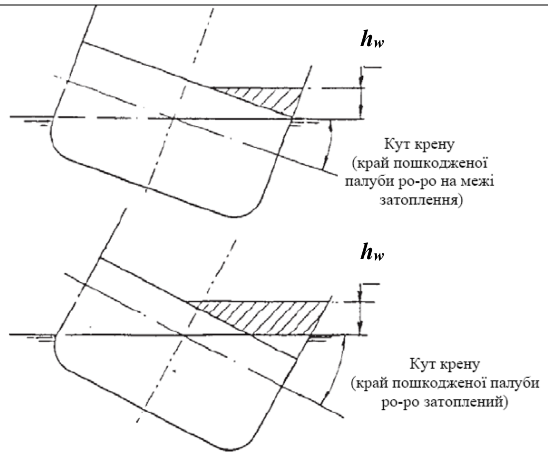


Fig. 3.4.14.10

3.4.14.11 If the calculations to demonstrate compliance with the *Stability standard for ro-ro passenger ships in damaged condition* relate to a significant wave height less than 4.0 m (h_S < 4.0 m) that restricting significant wave height must be recorded in the vessel's passenger ship safety certificate.

3.4.14.12 As an alternative to comply with the stability requirements as per **3.4.14.6 ÷ 3.4.14.7** or **3.4.14.9 ÷ 3.4.14.10** the *specific stability requirements* can be accepted by model tests carried out for an individual ship that will certify that ro-ro passenger ship will not capsize under particular circumstances.

The model test requirements are detailed in the Directive 2003/25/EC of the European Parliament and of the Council.

The model test as for compliance with specific stability requirements for ro-ro passenger ships shall be according to the test programme and method to be in accordance with the provisions of the Directive 2005/12/EC of 18 February 2005 of the European Parliament and of the Council approved by the Register in the presence of a representative of the Register.

Reference to acceptance of the results of the model test as an equivalence to compliance with the requirements of **3.4.14.6 ÷ 3.4.14.7** or **3.4.14.9 ÷ 3.4.14.10** by calculations as for specific stability requirements of ro-ro passenger ships, and the significant wave height (h_S) used in model tests shall be entered on the ship's certificate.

3.4.14.13 *SOLAS stability standard* (refer to **3.4.14.3)** limiting operational curve(s) KG or GM, may not remain applicable in cases where "water on deck" is assumed under the terms of this paragraph and it may be necessary to determine revised limiting curve(s) which take into account the effects of this added water.

Sfficient calculations corresponding to an adequate number of operational draughts and trims shall be carried out.

Note. Corrected limiting operational KG/GM curves may be derived by iteration, whereby the minimum excess GM resulting from damage stability calculations with water on deck is added to the input KG (or deducted from the GM) used to determine the damaged freeboards (f_r), upon which the quantities of water on deck are based, this process being repeated until the excess GM becomes negligible.

Such an iteration with a maximum of KG / minimum of GM, and work on the placement of the bulkhead (dock) on the ro-ro deck shall be performed in such a way that the excess GM in the stability calculations after damage on the deck with water has been minimized.

3.4.14.14 For assessing the effect of the volume of the assumed accumulated sea water on the damaged ro-ro deck as per **3.4.14.6 ÷ 3.4.14.7** or **3.4.14.9 ÷ 3.4.14.10** the following conditions shall be considered:

- a transverse or longitudinal bulkhead shall be considered intact in the event of side collision damage if all parts of it lie inboard of vertical surfaces on both sides of the ship, which are situated at a distance from the shell plating equal to 1/5*B* and measured at right angles to the centreline at the level of the deepest subdivision load line;

- in cases where the ship's hull is structurally partly widened for compliance with the stability requirements, the resulting increase of the value 1/5*B* shall not cause the relocation of any existing structural parts or any existing penetrations of the main transverse watertight bulkheads below the bulkhead ro-ro deck, piping systems, etc., which were acceptable prior to widening.

3.4.14.15. The tightness of transverse or longitudinal bulkheads which are taken into account as effective to confine the assumed accumulated sea water in the compartment(s) concerned in the damaged ro-ro deck, shall be commensurate with drainage system, and shall withstand hydrostatic pressure in accordance with the results of the damage calculation.

Such bulkheads/barriers shall be not less than 4 meters, if the water height on the damaged ro-ro deck is $h_w > 0{,}5$ m.

In other cases, the height of a bulkhead/barrier shall be calculated by the following formula:

$$B_h = 8 \times h_w , \qquad (3.4.14.15)$$

where:
B_h – height of a bulkhead/barrier, in m;
h_w – water height, in m.

The height of bulkhead/barrier shall not be less than 2,2м.

However, in case of a ship with suspended car decks, the minimum height of the bulkhead/barrier shall be not less than the height to the underside of the hanging deck when it its lowered position. It should be noted that any gaps between the top edge of the bulkhead/barrier and the underside of the plating must be "plated-in" in the transverse or longitudinal direction as appropriate.

In this case, the underside of the suspended deck and the top of the bulkhead/barrier shall be sewn.

Bulkheads/barriers with a height less than that specified above, and special arrangements, such as full-width hanging decks and wide side casings, may be accepted if model tests are carried out in accordance with **3.4.14.12**, to confirm that the alternative design ensures to prevent progressive flooding within the required stability range (refer to **3.4.14.4.5**).

Note. This range may be reduced to 10° provided the corresponding area under the righting lever curve complies with the requirements of **3.4.14.4.5**.

3.4.14.16 Transverse or longitudinal bulkheads/barriers in the lower part up to the level provided for h_w, which are fitted and taken into account to confine the movement of assumed accumulated water on the damaged ro-ro deck need not be strictly "watertight" subject to the drainage provisions being capable of preventing an accumulation of water on the "other side" of the bulkhead/barrier.

In such cases where scuppers become inoperative as a result of a loss of positive difference of water levels other means of passive drainage shall be provided.

3.4.14.17 The effect of seawater accumulation may not be taken into account for any compartment of the damaged ro-ro deck, if such compartment is fitted with freeing ports on each side of the deck, evenly spaced along the compartment in accordance with the following formula:

$$A \geq 0{,}3 \cdot l , \qquad (3.4.14.17)$$

where:
A – total area of freeing ports on each side of the ro-ro deck of the ship's compartment, m^2;
l – length of the compartment, in m.

If freeing ports are provided for ships requiring buoyancy of all or part of the ro-ro deck structure arrangement, freeing ports shall be fitted with non-return valves (flaps) to prevent ingress of water, but providing drainage.

Such non-return valves (flaps) shall be automatic and shall not restrict water outlet to a certain level.

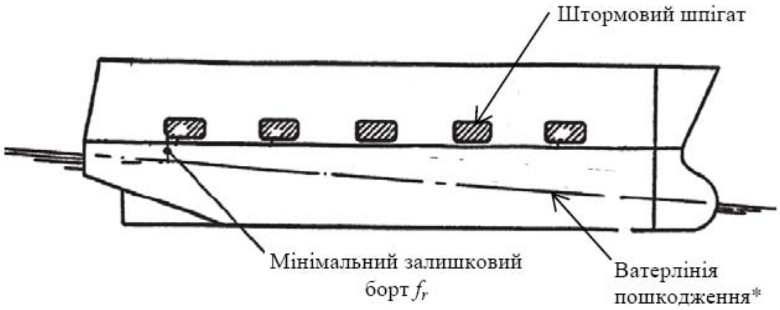
Any efficiency reduction shall be compensated by fitting of additional scuppers to maintain the required area.

Where scuppers become inoperative as a result of the loss of a positive difference in water levels in the compartment and outboard, other means of passive drainage shall be provided.

3.4.14.18 The ship shall maintain a residual freeboard of at least 1.0 m in the worst damage condition without taking into account the effect of the assumed volume of water on the damaged ro-ro deck.

To provide the efficiency of freein ports the minimum distance from the lower edge of the freeing port to the damaged waterline shall be at least 1.0 m (refer to Fig. 3 3.4.14.18).

The calculation of the minimum distance shall not take into account the effect of water accumulation on deck.



* Damage waterline – waterline in the final condition after damage and equalization of the ship

Fig. 3.4.14.18

3.4.14.19 Freeing ports shall be fitted in the bulwark or shell plating as low as possible.

The lower edge of the freeing port shall not be heigher than 2 cm abjve the ro-ro deck, and the upper edge no higher than 0.6 m.

Such freeing ports, if required, shall comply with the requirements of **3.4.14.17**.

Note. Spaces fitted with freeing ports or similar openings, shall not be included as intact spaces in determining of the intact and damage stability curves.

3.4.14.20 The estrimated damage level under the SOLAS stability standard shall apply to the entire length of the ship.

In accordance with **1.2.2**, in all estimated cases of flooding only one hole in the hull that may not affect any bulkhead or may only affect a bulkhead below the bulkhead deck or only bulkhead above the bulkhead deck or various combinations and only one free surface of sea water which penetrated after the accident is assumed.

In this case the hole is considered to have the shape of a rectangular parallelepiped.

The assumed extent of damage shall be considered as per Table 3.4.14.20.

Table 3.4.14.20

№ з/п	Estimated damage	Extent of damage
1	Longitudinal extent	3,0 м плюс 0,03 L_1 або 11,0 м (залежно від того, що менше)[1]
2	Transverse extent [2]	$^1/_5 B$
3	Vertical extent	From the centre plane unlimited upwards
4	Any damage	Any damage of lesser extent than indicated in No.1, No.2 and No.3, that would result in a more severe condition regarding heel or loss of metacentric height shall be assumed in the calculations

[1] If the required subdivision factor is equal or less than 0.33, the assumed longitudinal extent of damage shall be increased in such a way, if necessary, to enable the damage to cover any two consecutive main transverse watertight bulkheads.

[2] Measured at right angle to the centreline at the level of the deepest subdivision load line.

3.4.14.21 When a bulkhead above the ro-ro deck is assumed damaged, both compartments bordering the bulkhead shall be assumed flooded to the same height of water surface as calculated in **3.4.14.6 ÷ 3.4.14.7** or **3.4.14.9 ÷ 3.4.14.10**.

3.4.14.22 All transverse and longitudinal bulkheads/barriers which constrain the assumed accumulated amount of water must be in place and secured at all times when the ship is at sea.

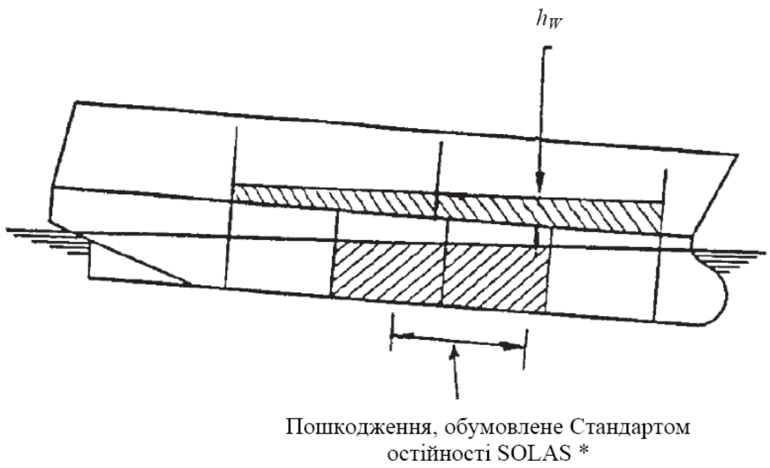
3.4.14.23 Where the transverse bulkhead/barrier is damaged the accumulated water on deck shall have a common surface level on both sides of the damaged bulkhead/barrier at the height h_w (refer to Fig. 3.4.14.23).

3.4.14.24 The ship's master shall be supplied with the data necessary to maintain sufficient intact stability under service conditions to enable the ship to withstand the assumed damage.

On ships fitted with overflow arrangements, the master shall be informed about the stability conditions of the vessel, on the basis of which the heel angles were calculated, and warned that in case of damage to the vessel under less favorable conditions, heel angles may exceed the calculated values.

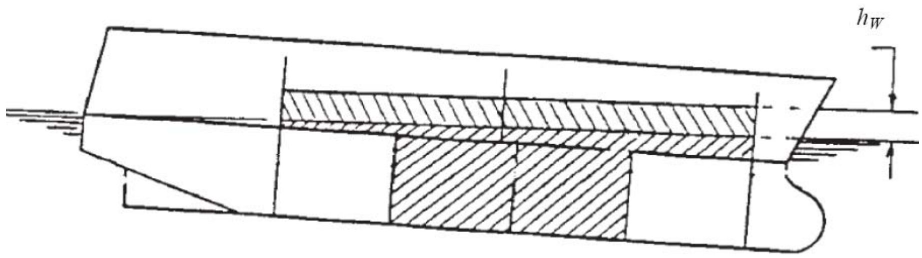
The data to enable the master to maintain sufficient intact stability shall include information which indicates the maximum permissible height of the ship's centre of gravity above keel (KG), or alternatively the minimum permissible metacentric height (GM) for a range of draughts or displacements sufficient to include all service conditions.

This information shall show the influence of different trims taking into account the operation limitations



*Refer to 3.4.14.7.

a) the edge of a ro-ro deck is not submerged



б) the edge of a ro-ro deck is submerged (damage as per a))

Рис 3.4.14.23

3.4.15 Anchor handling vessels.

Ships engaged in the operation of setting, lifting or moving the anchors of offshore installations or other ships with distinguishing mark **Anchor handling vessel** shall comply with the requirements of **3.4.9**, and ships with distinguishing mark **Anchor handling vessel, Tug** (which, in addition to the anchor operations, perform towing of floating objects), in addition to the requirements of **3.4.9**, shall comply with the requirements **3.4.4**.

4. SPECIAL REQUIREMENTS FOR TYPE B SHIPS WITH REDUCED FREEBOARD AND FOR TYPE A SHIPS

4.1 GENERAL

4.1.1 This Section applies to type A and type B ships specified in **1.1.3**.

The requirements of the Section shall be fulfilled irrespective of meeting requirements of other Sections by these ships.

4.1.2 The requirements are considered fulfilled where it is demonstrated by calculations that a ship being in assumed loading condition specified in **4.2** after the flooding of the number of compartments required by **4.1.3**, **4.1.4** or **4.1.5**, caused by damages stipulated by **4.3** remains afloat and in a condition of equilibrium it meets the requirements of **4.4**.

4.1.3 For type *A* ships having the length L_1 more than 150 m, when they are assigned a freeboard less than that of the appropriate ships of type *B* the requirements of this Chapter shall be complied with in the case of any single compartment being flooded.

4.1.4 For type *B* ships having the length L_1 more than 100 m for which the permitted reduction of tabular freeboard does not exceed 60 per cent of the difference between its values as per Tables 4.1.3.2 and 4.1.2.3 of the Load Line Rules for Sea-Going Ships, the following cases of flooding shall be considered:

.1 any single compartment with the exception of the engine room;

.2 any single compartment including the engine room where the ship length is more than 150 m.

4.1.5 Type *B* ships having the length L_1 more than 100 m for which the permitted reduction in the tabular freeboard exceeds 60 per cent of the difference between its values as per Tables 4.1.3.2 and 4.1.2.3 of the Load Line Rules for Sea-Going Ships shall be considered for the following cases of flooding:

.1 any two adjacent compartments, except for the engine room;

.2 any two compartments and the engine room considered separately in ships having the length more than 150 m.

4.1.6 The following permeabilities shall be assumed in calculations required by **4.1.2**:

0.95 for any floodable compartments and spaces except for the engine room;

0.85 for floodable engine room.

The permeability value of 0.95 is applicable to cargo spaces and tanks as well which shall be considered full when determining the height of the ship centre of gravity in conformity with **4.2.3**.

4.1.7 In addition to the requirements of **4.1.4** and **4.1.5**, ships intended for carriage of deck cargo shall comply with the requirements of Section **2**.

Height of the centre of gravity used for demonstration of compliance with the requirements of **4.4** during the deterministic analysis of damage stability shall be equal to the height of the centre of gravity used for calculation of damage stability at probabilistic assessment at assumption of the highest load line.

The diagram of ultimate elevation of the ship centre of gravity (limiting moments or minimum metacentric heights) with deck cargo drawn taking into consideration the fulfillment of the requirements of Section **2** shall be included into the Information on Stability and Information on Damage Trim and Stability.

4.2 TRIM AND LOADING CONDITION OF THE SHIP PRIOR TO DAMAGE

4.2.1 All cases of flooding shall be analyzed under one assumed initial loading condition of the ship as specified in **4.2.2** ÷ **4.2.4**.

4.2.2 The ship is considered to be loaded by homogeneous cargo without trim and to its summer load line draught in sea water.

4.2.3 The height of the centre of gravity of the ship shall be calculated for the following assumed loading condition:

.1 all cargo spaces, except for those under **4.2.3.2**, including the anticipated service, partly filled spaces are considered to be fully loaded with dry cargo and to be 98 per cent loaded with liquid cargo;

.2 where the ships when loaded to the summer load line is to operate with some spaces not loaded or filled with liquid cargo, such spaces shall be assumed empty provided that the height of the centre of gravity of the ship calculated with regard to empty compartments is not less than that calculated on the assumption that all the spaces are loaded with cargo;

.3 the amount of every type of the ship's stores and consumable liquids is taken to be equal to 50 per cent of the full capacity. Tanks, except for those under **4.2.4.2**, are assumed to be empty or completely filled, and the distribution of the stores in the tanks resulting in the highest position of the centre of gravity of the ship. The centres of gravity of the contents of the tanks mentioned in **4.2.4.2** are taken to be in the centres of gravity of their volumes;

.4 ballast water tanks shall normally be considered to be empty and no free surface correction shall be made for them (refer to the IMO Resolution MSC.345(91);

.5 loading of the ship as regards consumable liquids and ballast water shall be estimated on the basis of the following values of their density, in t/m ^{3}:

Sea water	1,025
Fresh water	1,000
Fuel oil	0,950
Diesel oil	0,900
Lubricating oil	0,900

4.2.4 In estimating the height of the centre of gravity of the ship account shall be taken of the effect of free surfaces of liquids:

.1 for liquid cargo proceeding from loading specified in **4.2.3.1**;

.2 for consumable liquids proceeding from the assumption that for every type of liquid at least one centreline tank or one transverse pair of tanks have free surfaces. The tanks or combination of tanks where the effect of free surfaces is the greatest shall be taken into account.

It is recommended that the correction for free surfaces effect be taken into consideration as per **1.4.7**, Part IV "Stability".

4.3 EXTENT OF DAMAGE

4.3.1 The vertical extent of damage shall be assumed from the base line upwards without limit.

4.3.2 The transverse extent of dam-age measured inboard from the ship's side at a right angle to the centreline at the level of the summer load waterline shall be assumed equal to $^1/_5$ of the breadth of the ship, or 11.5 m, whichever is the less.

4.3.3 If any damage of lesser extent than indicated in **4.3.1** and **4.3.2** would result in a more severe condition, such damage shall be assumed in the calculations.

4.3.4 Transverse bulkheads are considered effective if the distance between them or between the transverse planes passing through the nearest portions of the stepped bulkheads is at least $^1/_3\, L_1^{2/3}$ or 14.5 m, whichever is the less.

In case of lesser distance, one or more of these bulkheads shall be assumed as non-existent.

4.3.5 When one compartment is flooded, with due regard for provisions of **4.3.4**, main transverse bulkheads are considered not to be damaged if they have no steps more than 3 m in length.

In case these bulkheads are provided with steps more than 3 m in length, the two compartments adjacent to such bulkheads shall be considered as flooded.

The extent of damage may be limited by transverse bulkheads of a side tank in case its longitudinal bulkhead is beyond the transverse extent of damage.

Where a side tank or a double bottom tank is divided by a transverse bulkhead located more than 3 m from a main transverse bulkhead, both tanks divided by such bulkhead shall be considered as flooded.

The following compartments shall be considered as flooded:

A+D, B+E, C+E+F (refer to Fig. 4.3.5-1);
A+D+E, B+E, C+F (refer to Fig. 4.3.5-2);
A+D, B+D+E, C+F (refer to Fig. 4.3.5-3);
A+B+D, B+D+E, C+F (refer to Fig. 4.3.5-4).

Where the forecastle is arranged above the fore cargo hold, subject to the condition that the forecastle bulkhead is located not more than 3 m aft from the forward bulkhead of the hold and watertightness of the stepped deck structure is ensured the bulkhead shall be considered to be continuous and not to be damaged.

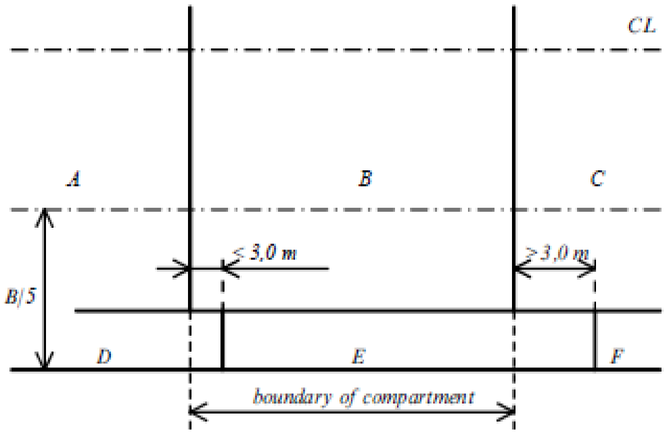


Fig. 4.3.5-1

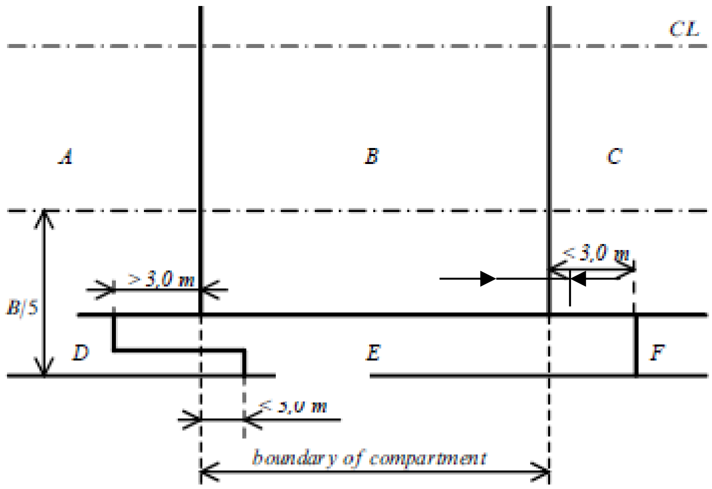


Fig. 4.3.5-2

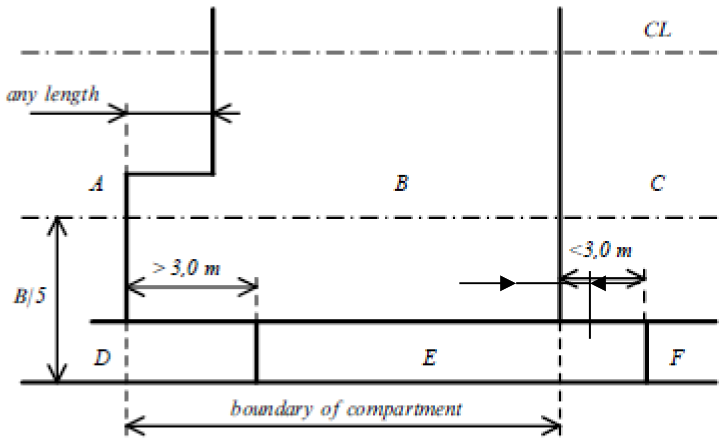


Fig. 4.3.5-3

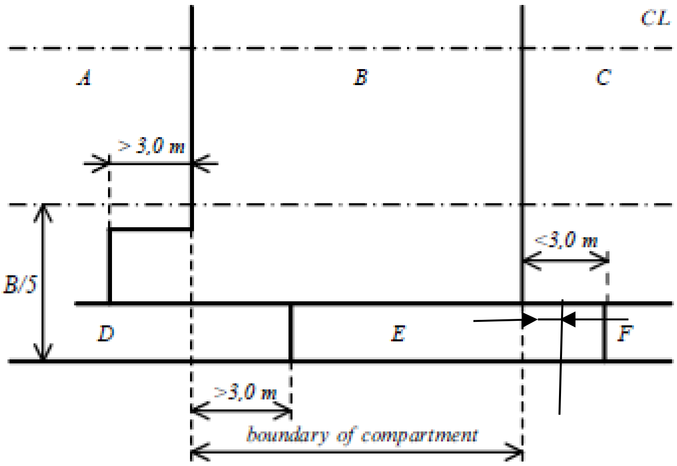


Fig. 4.3.5-4

4.3.6 Where a side tank has openings into a hold, it shall be considered as communicating with the hold even where such openings are fitted with closing appliances. This provision is applicable to ships carrying liquid cargoes, except in case of sluice valves fitted in watertight bulkheads between tanks and where the valves are controlled from above the bulkhead deck.

4.3.7 Where pipes, ducts or tunnels are located within the assumed extent of damage, satisfactory arrangements shall be provided to preclude the possibility of progressive flooding through them to other spaces beyond the limits assumed for the calculations of the damage stability of the ship.

4.3.8 In case of two-compartment flooding the requirements of **4.3.1÷4.3.4**, **4.3.6** and **4.3.7** shall be met.

4.4 DAMAGE TRIM AND STABILITY

4.4.1 The metacentric height of the damaged ship prior to taking measures for the increase thereof shall be positive.

4.4.2 The angle of heel due to unsymmetrical flooding prior to the beginning of the ship's equalization shall not exceed 15°. If no part of the bulkhead deck immerses, the increase of heel up to 17° may be allowed.

4.4.3 The final damage waterline having regard to heel and trim prior to the beginning of the ship's equalization shall not be above the lower edge of openings indicated in **3.3.4**, through which progressive flooding may take place.

4.4.4 When any part of the bulkhead deck beyond the limits of the flooded compartments immerses, or margin of damage stability is doubtful, damage stability at large angles of heel shall be investigated. It shall be shown that the value of a maximum arm of the righting lever curve of a damaged ship is not less than 0.1 m within the rated extent (20°) in association with a range of the curve with positive arms of at least 20°, the area of the positive portion of the curve being not less than 0.0175 m·rad.

5. REQUIREMENTS FOR SHIPS IN SERVICE

5.1 BULK CARRIERS, ORE CARRIERS AND COMBINATION CARRIERS

5.1.1 Bulk carriers with single side shell the design of which complies with the requirements of **3.3.1.6.1**, Part II "Hull", having the length L_1 150 m and above, carrying solid bulk cargoes with a density of 1000 kg/m3 and above, constructed on 1 July 1999 or later that date, shall comply with the requirements of **4.4** at flooding of any forward cargo hold under all loading cases up to the summer load line.

The bulk carrier which forward cargo hold is confined by the outer plating or double side skin construction with a width less than 760 mm with a length L_1 150 m and above, built before 1 July 1999 carrying solid bulk cargoes with density of 1780 kg/m^3 and above, shall comply with the requirements of **4.4** while flooding the fore cargo hold in all cases of loading up to the summer load line not later than the date of survey assigned in relation to the ship's age:

.1 for ships which age at 1 July 1998 is 20 years and more, the date of the first intermediate (the second or the third annual survey) or the first special survey, which shall be carried out after 1 July 1998 is accepted, whichever is earli-er;

.2 for ships which age at 1 July 1998 is 15 years and more, but less than 20 years, the date of the first special survey which shall be carried out after 1 July 1998, but not later than 1 July 2002 is accepted;

.3 for ships which age at 1 July 1998 is less than 15 years, the date of the third special survey or the date when the ship's age becomes equal to 15 years is accept-ed, whichever is later.

5.1.2 The following values of permeabilities shall be taken for the damage stability calculations:

0,90 for loaded holds;

0,95 for empty holds.

5.1.3 The ships which do not comply with the requirements of 5.1.1 may be acquitted from this requirement provided the following conditions are met:

.1 the programme of the fore hold annual survey is replaced by the programme approved at the full scale intermediate survey as per Section **5** "Additional Surveys of Ships in Relation to their Purpose, Cargo Transported and Hull Material" of the Rules for the Classification Surveys of Ships in Service";

.2 the visual and audible alarm shall be fitted in the wheelhouse for signalling in case of:

flooding over two metres above the double bottom in the stern part of each cargo hold;

filling of bilge well of each hold up to the upper level.

Such signalling system shall meet the requirements of Part XI "Electrical Equipment";

.3 the ship shall be supplied with detailed information on the effect of the phased flooding of cargo hold and detailed instructions as per Section 8 of the International Safety Management Code (ISM Code).[1]

Information shall include the data and documents specified in **1.4.6.1** and the results of damage trim and stability calculations at stage-by-stage compartment flooding under all conditions of loading to the summer load line on an even keel. When the ship meets the requirements of **4.4** at a lesser draught, the document shall contain a diagram of maximum heights of the centre of gravity of the ship (limiting moments or min-imum metacentric heights) plotted with due regard to the trim and ship load. The strength of the bulkhead shall be taken into consideration.

The information shall contain a summary table of calculation results with indication of critical factors and the data given in **1.4.6.1.5**.

5.1.4 The ships which are assigned with the reduced freeboard as per Section **4** are considered compliant with the requirements of **5.1.1**.

5.1.5 Information on compliance with the requirements of **5.1.1** ÷ **5.1.3** shall be included in the Booklet required by **1.4.9.7**, Part II "Hull".

5.1.6 Ships built before 1 July 2004 shall meet the requirements of **3.4.11.3** ÷ **3.4.11.5** not later than the date of the first periodical survey of a ship conducted after 1 July 2004.

5.1.6.1 If flooding detection sensors cannot be placed in the aft end of the cargo hold within a distance less than or equal to $B/6$ from the centerline, they shall be located at both the port and starboard sides of the cargo hold.

5.1.6.2 The upper sensor only may be fitted in cargo holds of the ships being subject to the requirement of **5.1.3**; the ships not complying with the requirements of **5.1.3.2** on 1 January 2004 shall be fitted with flooding detection sensors in cargo holds as per **3.4.12.3.1** (considering **5.1.6.1**).

[1]Refer to IMO Resolution A.741(18) as amended

APPENDIX 1

GUIDELINES FOR THE PREPARATION OF SUBDIVISION AND DAMAGE STABILITY CALCULATIONS

1 GENERAL

1.1 Purpose of the Guidelines.

1.1.1 These guidelines serve the purpose of simplifying the process of the damage stability analysis, as experience has shown that a systematic and complete presentation of the particulars results in considerable saving of time during the approval process.

1.1.2 A damage stability analysis serves the purpose to provide proof of the damage stability standard required for the respective type of a ship. At present, two different calculation methods, the deterministic concept and the probabilistic concept are applied.

1.2 Scope of analysis and documentation on board

1.2.1 The scope of subdivision and damage stability analysis is determined by the required damage stability standard and aims at providing the ship's master with clear intact stability requirements.

In general, this is achieved by determining *KG*-respective *GM*-limit curves (minimum operational metacentric height), containing the admissible stability values for the draught range to be covered.

1.2.2 Within the scope of analysis thus defined, all the possible or required damage conditions depending on the damage stability criteria to get the required stability standard will be determined. Depending on the type and size of a ship, this may involve a considerable amount of analysis.

1.2.3 The necessity to provide the crew with the relevant information regarding the subdivision of the ship is expressed. Therefore, the Damage Control Plan (refer to **1.4.6.2** hereof) shall be permanently exhibited for the guidance of the duty officer of the crew. In addition, Information on Damage Trim and Stability shall be always available on board (refer to **1.4.6.1** hereof).

2 DOCUMENTS FOR SUBMISSION

2.1 General details to be included in the documentation on board.

2.1.1 The documents shall include, as a minimum, the following details: principal dimensions, ship type, designation of intact conditions, designation of damage conditions and *KG*-respective *GM*-limit curve.

2.2 General documents.

2.2.1 For the checking of the input data, the following shall be submitted:

.1 main dimensions;

.2 lines plan, plotted or numerically;

.3 hydrostatic data and righting lever curves, including cross curves of stability (as well as drawing of buoyant hull included into righting lever calculations);

.4 definition of ships spaces and compartments with moulded volumes, centres of gravity and permeability;

.5 layout plan for all watertight structures and bulkheads with all internal and external opening points including their connected spaces, and reference to the source materials used in measuring the spaces, such as general arrangement plan and subdivision plan.

The subdivision limits, longitudinal, transverse and vertical, shall be included;

.6 light service condition;

.7 load line draught;

.8 coordinates of opening points with their level of tightness (e.g., weathertight or unprotected);

.9 watertight door location coordinates with pressure calculation;

.10 side contour and wind profile;

.11 cross and down flooding devices and the calculations thereof accord-ing to IM Resolution MSC.362(92) with information about diameter, valves, pipe lengths and coordinates of inlet/outlet;

.12 pipes in damaged area when the destruction of these pipes results in progressive flooding;

.13 damage extensions and definition of damage cases.

2.3 Special documents.

To confirm damage stability calculation results the following documentation shall be submitted.

2.3.1 Documentation.

2.3.1.1 Initial data:

.1 subdivision length;

.2 initial draughts and the corresponding *GM*-values;

.3 required subdivision index *R*; and

.4 attained subdivision index *A* with a summary table of all contributions for all damaged zones.

2.3.1.2 Results for each damage case, which contributes to the index *A*:

.1 draught, trim, heel, *GM* in damaged condition;

.2 extent of the damage with probabilistic values *p*, *v* and *r*;

.3 righting lever curve (including GZ_{max} and range) with factor of survivability and buoyancy *s*;

.4 list of critical weathertight and unprotected openings with their angle of immersion; and

.5 details of the ship spaces and compartments with amount of inflooded water, lost buoyancy with their centres of gravity.

2.3.1.3 In addition to the requirements of **2.3.1.2**, particulars of non-contributing damages to index *A* (s_i = 0 and p_i, > 0,00) shall be submitted for passenger ships and ro-ro ships fitted with long lower holds including full details of the calculated subdivision factors.

2.3.2 Special consideration.

2.3.2.1 For intermediate conditions, as stages before cross-flooding or before progressive flooding, additional damage trim and stability calculations shall be submitted in the scope covering the aforementioned items.

APPENDIX 2

DETERMINATION OF THE MOULDED PENETRATION DEPTH

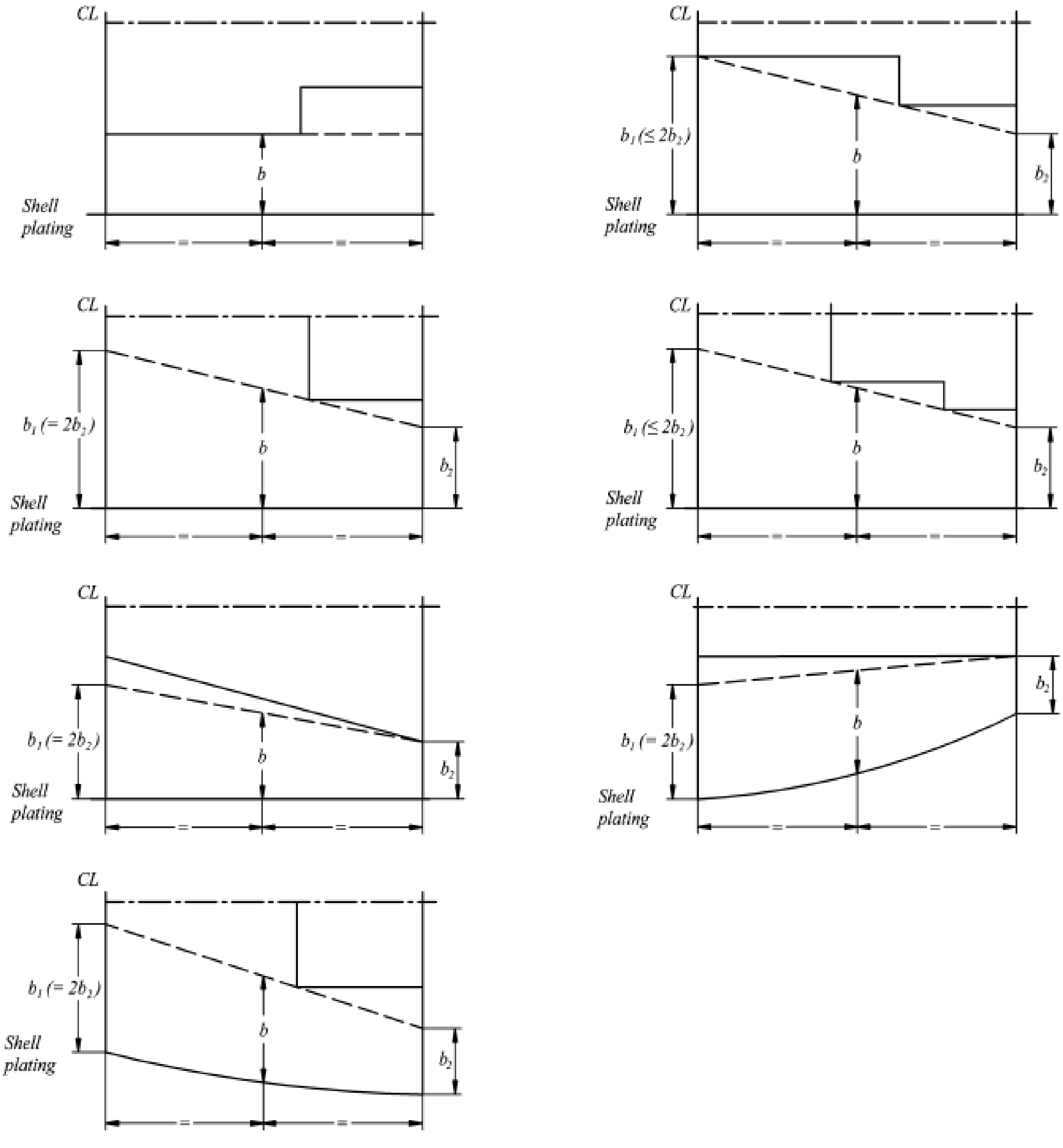


Fig. 2.1

Notes to Fig. 2.1:

1. Each drawing given in Fig. 2.1 represents an area of a single damage at the waterline d_s, the longitudinal bulkhead is a location of the outer bulkhead below the level d_s +12,5 m.

2. The penetration depth b is measured at even keel under the deepest subdivision load line d_s as a transverse distance from the side to the centreline at right angle at the level of longitudinal limiting construction (watertight bulkhead).

3. If the watertight bulkhead does not provide an area parallel to the plating, the size b shall be de-termined via the assumed line dividing the area up to the shell under the ratio b_1 / b_2, as $½ \le b_1 / b_2 \le 2$.

PART XVI. STRUCTURE AND STRENGTH OF FIBER-REINFORCED PLASTIC SHIPS

1. GENERAL

1.1 APPLICATION

1.1.1 The requirements of this Part of the Rules are applicable to hulls and superstructures manufactured of fiber-reinforced plastic (FRP) for the following ships, covered by these Rules in accordance with **1.3.1.1** Part I «Classification» of the Rules for the Classification and Construction of ships[1], namely:

.1 displacement ships of 15 – 70 m in length, inclusive;

.2 high-speed displacement craft with a Froude number within the range of $Fr_v \approx 1{,}0 - 2{,}5$;

.3 life-boats and motorboats of 4,5 – 15 m in length with a Froude number $Fr_v < 2{,}5$.

1.1.2 Hulls and superstructures manufactured of FRPs for ships and boats designed to the Register class but not specified in **1.1.1** and not regulated by other Register Rules, shall be reviewed by the Register together with technical background such as normative documents, calculation and test results. Technical background shall confirm the safety level of a structure or a product to be not lower than the one required by the relevant Register rules. In such case, the provisions of this Section and Section **2** shall be applied.

1.1.3 The requirements of this Part of the Rules may apply to boats and votorboats manufactured of FRPs of 4,5 – 15 m in length with a Froude number $Fr_v < 2{,}5$ upon their voluntary certification by the Register (refer to Section 4).

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 Definitions and explanations relating to the general terminology of the Rules are given in **1.1** of Part I "Classification".

The definitions of ship dimensions comply with the provisions of Part II "Hull".

1.2.2 For the purpose of this Part the following definitions have been adopted:

Adhesive means glue/filler, which is an organic matter intended for jointing structural members manufactured of FRP and filling clearances between them, compatible with a polymer matrix.

Fiber means glass, carbon or aramid type reinforcement element used in the form of the following: rovings (woven rovings);

tapes;

woven fabrics;

multiaxial (non-crimp) fabrics.

Hybrid FRP means material made up with layers based on reinforcement elements of different chemical nature, or with individual layers, each made of reinforcement elements of the same chemical nature.

Roving (woven roving) means numerous fibers connected to each other;

Mat means FRP consisting of chops 3-20 mm long randomly arranged on the plane, on the basis of the polymer matrix, where microspheres may be added.

Contact moulding technique means a method including laying the reinforcement materia (fabric, mat) soaked on binder into a matrix or on a punch, followed by its compaction and removal of air bubbles.

Spraying technique means a version of the contact moulding technique when moulding is performed by laying-up of chopped fibers with binder on the matrix or punch surface, followed by plydown and compaction of material.

Closed moulding techniques means a common name for the techniques of impregnation of the dry reinforcement material in a closed plane with a liquid binder moving through this material.

Infusion technique means one of the closed moulding techniques, when the reinforcement material is soaked in binder due to the vacuum created in a pressure-tight plane formed with a matrix where the dry reinforcement material is laid and with a leak-tight film adjacent tightly to the matrix.

RTM (Resin Transfer Moulding) technique means closed moulding techniques differing from the infusion technique by the fact that a pressure-tight plane is formed between a rigid matrix where the dry reinforcement material is laid and with a rigid punch adjacent tightly to it. The binder is forced to move over the reinforcement material by the pressure created therein, or due to simultaneous vacuum and pressure in the binder.

Non-homogeneous FRP means material made up with layers of reinforcement elements of different types but the same chemical nature.

Homogeneous FRP means material made up with layers of reinforcement elements of the same

[1] Hereinafter - Part I "Classification".

type and the same chemical nature, with the same reinforcement scheme.

F o a m p l a s t i c means material with the lower density than that of water, having a porous structure, mainly close-cellular one, compatible with a polymer matrix of load-bearing layers.

FRP means material with heterogeneous nature and consisting of reinforcement elements and polymer matrix.

Particles and fibers are applied as reinforcement elements. Using FRP with reinforcement elements not mentioned in this Part of the Rules is allowed provided that the relevant technical justification including strength tests and calculations of hull structures made of FRP is provided.

P o l y m e r m a t r i x means a binder in cured state, on the basis of thermoset organic resin (polyester, vinylester, epoxy, etc.) with a curing system and various additives (a catalyst, an accelerant, thixotropic agent and colour pigment).

P r e p r e g means reinforcement elements such as tapes, woven fabrics or multiaxial (non-crimp) fabrics pre-soaked in thermosetting binder, which cures under certain conditions (temperature and/or pressure).

T a p e means numerous rovings transversally interconnected to each other;

S p h e r o p l a s t i c means FRP consisting of microspheres and polymer matrix.

M u l t i a x i a l (n o n - c r i m p) f a b r i c means material made up with layers of tapes with onedirectional reinforcement, superimposed on each other at specified angles, and interconnected with each other.

Depending on the number of reinforcement directions, multiaxial (non-crimp) fabrics are classified into the following types:

biaxial fabrics with two reinforcement directions, generally 0° and 90° or + 45° and – 45°;

triaxial fabrics with three reinforcement directions, mainly 0°, + 45° and – 45°;

quadriaxial fabrics with four reinforcement directions, usually 0°, + 45°, – 45° and 90°.

Wo v e n f a b r i c means material made by weaving twisted fibers or rovings according to a weaving technique used in the textile industry with different weave types (satin, plain, twill, etc.);

S a n d w i c h c o n s t r u c t i o n means a structure consisting of outer load-bearing layers manufactured of FRP and a core, where foam plastics, spheroplastics, mats, and such structural members as honeycombs, ribs, corrugations of various configurations may be applied. The latter may be used separately or in combination with foam plastics and spheroplastics filling the free space between these members.

P a r t i c l e means reinforcement element as a glass or polyester microsphere used in shipbuilding structures, in such materials as spheroplastic and mat.

1.3 GENERAL

1.3.1 When designing FRP structures physical and mechanical properties of the material shall be taken into account, including the main ones:

elastic and strength anisotropy of material properties;

its dependence on properties of basic components (reinforcement elements, cores and binders), their quantitative ratio, as well as on laying directions of these elements (reinforcement scheme);

comparatively low interlaminar shear strength and transverse tension;

lower Young's moduli than those of typical shipbuilding materials such as steel, titanium and aluminum alloys;

nearly absence of plastic deformations.

1.3.2 Design of a ship hull manufactured of the FRPs and its basic members shall be accompanied by development of their manufacturing techniques, requirements for quality control and performance standards, with due regard of the shipyard production facilities, availability of proved moulding and assembly processes, and quality control procedures.

1.3.3 Closed moulding techniques are preferred in development of structures manufacturing procedures, such as infusion and RTM techniques (refer to **1.2.7**).

Application of the contact moulding technique shall be limited and is allowed in structures where it is technically feasible and when other moulding techniques cannot be applied.

In all cases, the procedure of FRP structures manufacture shall be agreed with the Register.

1.3.4 When selecting the hull framing system, it is recommended to minimize the number of frames that support the hull shell (deck plating, bulkhead plating) and reduce the number of joint intersections of frames in different directions, thus contributing to the structural strength.

1.3.5 Primary members (stringers, deck girders or web frames (frames changing to floors and beams)) shall be made continuous. To comply with this requirement, members of inter- perpendicular directions shall have different depths at intersections.

Application of intercostal framing members is allowed provided their ends are durably fastened.

1.3.6 Composition and structure of the hull shell plating and upper deck plating shall be selected subject to condition of maximum bending stiffness in main directions, with required strength characteristics ensured.

To satisfy this requirement, the hybrid reinforcement using reinforcement materials different in type, stiffness and density, and cores, shall be applied.

1.3.7 Hull shell plating and plating of decks shall be made with variable thickness of members in accordance with their stress-strain behavior.

Thickness variation shall be smooth due to adding (removing) partial layers of the reinforcement material between its continuous layers.

1.3.8 Local reinforcement of members is allowed to be manufactured by additional moulding to increase the basic thickness only when vacuum injection techniques are applied for their manufacture.

Additional moulding on the basic thickness by the contact moulding technique is only allowed where outfittings, individual elements of the equipment and systems are fastened, and in special cases stated in the relevant sections of this Part of the Rules.

1.3.9 All local thicknesses and connecting elements (moulding-on straps, sheathings, moulding-in angles, etc.) shall have variable thickness with smooth reduction towards edges. In such case, each layer of fabric shall overlap the preceding one in accordance with the requirements specified in **3.2.1** and **3.2.2**.

1.3.10 Any design and technology solutions other than those stated in this Part of the Rules shall be agreed with the Register.

1.4 TECHNICAL DOCUMENTATION

1.4.1 Prior to manufacture of the ship's hull and superstructures, including the following:

decks, platforms and their individual sections;

bulkheads;

tanks;

seatings for main engines and other machinery and arrangements subject to survey by the Register, technical documentation of the hull in the scope specified in **4.2.3** of Part I "Classification" shall be submitted to the Register for review and approval.

1.4.2 The technical documentation of the hull shall be supplemented by technical specifications on

FRPs and reference guidelines on the manufacturing procedure (technological instruction). The abovementioned documents shall contain the following:

complete list of basic components (reinforcement materials, resins, curing agents, glues, etc.) used in manufacture of FRP structural members, as well production and auxiliary materials;

composition of FRPs, physical and mechanical characteristics, chemical formulation of a binder;

information on the Register type approval (Type Approval Certificate (CTO)) for basic materials, cores (if any);

requirements for the equipment to be used in moulding hull structures and construction documentation on its manufacture;

list of measures to be taken for manufacture preparation of hull structures, including the list of the process equipment required for production;

technological instructions for moulding of hull structures, their individual members and elements, as well as assembly instructions;

requirements for structures cure conditions;

requirements for quality control, including allowances for maximum permissible defects;

technological instructions for repair of impermissible defects.

1.4.3 The construction documentation for FRP structures, in addition to conventional designations of scantlings and thicknesses, shall specify the material brand and composition (reinforcement material and binder brands), reinforcement scheme layer by layer, density of laying up (surface density), number of reinforcement material layers.

1.5 SCOPE OF SURVEYS

1.5.1 After review and approval of the technical design of a ship, including the list of technical documentation specified **1.4**, the following items shall be subject to the Register survey for compliance with the requirements of **1.4.2**:

basic components of FRPs (reinforcement materials, resins, curing agents, cores, etc.), which shall be approved by the Register (refer to Section **2**), have technical specifications and be supplied together with Manufacturer's Certificate of Quality per batch, to confirm compliance of their characteristics to those stated;

storage conditions and incoming inspection results of FRP basic components;

condition of production spaces and equipment for moulding of hull structures in accordance with the requirements of the technique selected;

microclimate in production spaces and means to maintain the spaces within specified limits as required by technological intructions;

equipment to be used in moulding hull structures, production facilities and measurement means;

moulding of hull structures, their members and elements, as well as assembly processes in accordance with technological instructions;

heat treatment conditions of hull structures, their members and elements;

quality performance control of completed hull structures, their members and elements.

1.5.2 Tests of completed structures and their individual members shall be carried out when new engineering solutions and/or manufacturing procedures that are not regulated by these Rules are applied in construction of hulls and superstructures using FRPs. Test schedules and procedures shall be developed by the firm (manufacturer) and approved by the Register.

1.5.3 Tests of specimens cut out from allowances and cutouts shall be carried out during quality performance control of hull structures and their individual members for the hull of a prototype ship of a series, and in case of any changes in the composition of FRP. Test schedules and procedures shall be developed by the firm (manufacturer) and approved by the Register.

2 MATERIALS

2.1 GENERAL

2.1.1 These requirements apply to structural FRP based on reinforcement cores manufactured of glass and/or carbon fibers, as well as aramid fibers, thermosetting polymer binders: polyester, vinylester and epoxy ones, which are applied for manufacture of hulls and superstructures of various displacement, including motorboats and boats.

2.1.2 General requirements:

manufacture procedure of structures shall ensure sustained quality and possibility of application of high-efficiency moulding techniques and mechanical aids;

hull structures shall maintain their qualities primarily operability and reliability, during operation under sea conditions within specified temperature ranges (from – 40° C to + 60°C) for a long period of time, at least 20 years;

materials, procedures and construction solutions applied shall ensure maintainability of structures both at the manufacturer and when at sea.

2.1.3 Structural FRPs and cores approved by the Register (CTO) delivered in accordance with standards and provided with technical specifications for industrial supply, as well as a Manufacturer's Certificates of Quality per batch (refer to **2.2**) shall be used for ship structures.

2.1.4 FRP applied in ship structures shall comply with the requirements of this Part containing omplete list of type tests and checks every material shall be subject to.

2.1.5 Tests to be carried out for new FRP not specified in this Part of the Rules are listed in type test program specified in Appendix **2**.

2.2 SCOPE OF TECHNICAL SUPERVISION

2.2.1 Binders for manufacture of FRPs and cores shall be provided with Type Approval Certificate (CTO) or Register Certificate per batch to allow their application in ship structures. Application of FRP binders for boats is allowed based on the report documents of firms (manufacturers) or laboratories recognized by the Register.

Type Approval Certificates (CTO) for reinforcement materials applied for FRP manufacture are recommended (refer to **2.3.1.6**).

2.2.2 Type Approval Certificates (CTO) are issued to a material firm (manufacturer) based on the approved documentation, results of materials tests for verification of compliance for the requirements of these Rules (refer to **2.3.1 ÷ 2.3.3, 2.3.5**), direct survey of production and check test of serial products.

Tests shall be performed by a firm's (manufacturer's) laboratory or another laboratory recognized by the Register.

Where the production is transferred to another firm (manufacturer), the Type Approval Certificate (CTO) shall be issued based on the results of technical supervision and check tests.

The check test program shall be developed by the firm (manufacturer) taking into account the standards of quality performance control and approved by the Register.

2.2.3 Technical supervision for manufacture at the firm (manufacturer) includes the following:

review and analysis of documents submitted by the firm (manufacturer) (refer to **2.2.4**) confirming the capability of firm (manufacturer) to manufacture products of sustained quality in required amounts;

survey of the firm (manufacturer), including assessment of the product manufacture quality system and carrying out of check tests required (refer to **2.2.2);**

drawing up of the Type Approval Certificate (CTO) for products manufactured (refer to **2.2.5**).

2.2.4 The firm (manufacturer) shall submit the following information to the Register for review:

outline of firm (manufacturer), containing the information on its organization structure, production and management structure, affiliation or form of ownership;

list of materials produced, their characteristics, delivery specifications and other technical documentation confirming the stated characteristics of materials;

technological instructions on materials/structures manufacture using FRPs (as applicable) and the quality performance control standards;

instructions on stacking and storage of basic components for manufacture of materials, and their incoming inspection;

report containing the information on the equipment and quality control instruments used during manufacture of materials, and qualification level of laboratory personnel involved in quality performance control product;

Manufacturer's Certificates of Quality confirming availability of an implemented Quality Management System at the firm (manufacturer);

check test program for product specimens;

results of material tests for compliance with the requirements of these Rules, and check tests of material specimens to confirm characteristics stated and ability of using materials as intended.

2.2.5 Upon satisfactory results of the technical documentation review specified in **2.2.4**, the firm (manufacturer) shall be subject to survey to verify the organization condition and product quality control system management, and availability of conditions for manufacture of required volume of products in accordance with the requirements of Section **7**, Part I "General Regulations for Technical Supervision" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

2.2.6 Upon satisfactory survey results of the firm (manufacturer) considering the requirements of Section **6**, Part I "General Regulations for Technical Supervision" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships, the Register shall draw up the Type Approval Certificate (CTO) for materials produced.

2.2.7 Technical supervision during manufacture of hull/structures using FRP.

Prior to manufacture, the manufacture (a shipyard) shall submit the following:

approved technical documentation in the scope specified in **1.4.2** (technical specifications on FRPs, technological instriction);

reports on fire safety test results of FRPs carried out in laboratories recognized by the Register, with a conclusion on compliance of the fire protection with the requirements of these Rules according to which the ship design is approved;

where FRPs other than those stated in this Part of the Rules is used, reports on FRP test results in accordance with the approved test program (refer to Appendix **2**).

Technical supervision shall include the following:

review of documents submitted by the firm (manufacturer) in a scope specified in **2.2.4** to confirm its capability of manufacturing FRP products of stable quality in required volumes;

survey of the firm (manufacturer) to assess its capability of manufacturing FRP hulls/structures and quality control systems;

technical supervision during manufacture in a scope specified in**1.5.1**;

technical supervision during tests of FRP specimens cut out from manufacturing allowances or witness sample (as applicable), complying with the technical documentation on the product manufactured;

technical supervision of hull defects detection and repair.

Upon results of technical supervision of FRP hull/structures, the Register shall draw up the Report on Survey (form 1.9.2).

2.2.8 In case of serial production of FRP hulls/structures (two and more), the Report on Survey (refer to **2.2.7**) may be substituted with the Type Approval Certificate (СТО) for FRP hull/structures taking into account the compliance with the requirements of Sections **6** and **7**, Part I "General Regulations for Technical Supervision" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

In such case, the manufacturer's report on FRP hull/structures (passport, Manufacturer's Certificate of Quality, etc.) shall be submitted.

2.3 REQUIREMENTSFOR FRP CHARACTERISTICS AND THEIR BASIC COMPONENTS

2.3.1 Reinforcement materials.

2.3.1.1 Reinforcement materials in FRPs shall ensure specified stiffness and strength characteristics, including the material exposed to various operational factors (external forces, temperature, humidity, etc.).

2.3.1.2 To ensure the adhesion strength between fibers and polymer matrix, a hydrophobic-adhesive (coupling agent) shall be applied on the fiber surface, the adhesive being compatible with the binder type - polyester, vinylester or epoxy one.

A procedure of applying a hydrophobic-adhesive (coupling agent) shall ensure coating resistance to mechanical impacts.

2.3.1.3 Glass reinforcement materials (fabrics, tapes, mats) for constructional fiber glass plastics shall be manufactured from fibers of standard non-alkaline aluminoborosilicate glass, grade E, or high-modulus magnesium aluminosilicate glass, grade S. Characteristics of the specified glass fibers used in reinforcement materials shall be not lower than the values provided in Table 2.3.1.3.

Table 2.3.1.3 **Physical and mechanical characteristics of basic fiber types used in ship structures**

Characteristic	Glass fiber		Carbon fibers	Aramid fibres
	Glass, grade E	Glass, grade S		
Density, in kg/m^3	2500-2550	2550-2580	1800	1420
Young's modulus of elongation, in GPa	at least 70	at least 90	at least 250	at least 120
Ultimate tensile strength, in GPa	at least 3,0	at least 4,0	at least 4,5	at least 3,0
Ultimate tensile elongation, in %	4,5	4,5	at least 1,6	2,5-3,5

2.3.1.4 Carbon reinforcement materials (fabrics, tapes) for constructional carbon fiber-reinforced plastics shall be manufactured from high-strength 3K, 6K, 12K (K=1000 fibers) fibers with characteristics in accordance with Table 2.3.1.3.

Application of high-modulus fibers with a Young's modulus of more than 350 GPa and ultimate elongation less than 1,1 % is allowed in members subjected mainly to compression loads.

2.3.1.5 Characteristics of aramid fibers as part of tapes and fibers (refer to Table 2.3.1.3) shall ensure efficient application thereof as part of ship structures exposed mainly to significant impact and vibration loads.

Considering their increased water absorption, reinforcement materials manufactured of these fibers are recommended for application inside a laminated package between monolayers based on glass and/or carbon materials to prevent aramid fibers from water contact.

2.3.1.6 Fibres and reinforcement materials on their basis shall be tested for compliance of their mechanical properties with stated ones. The testing shall be carried out according to the methods of international and/or national standards, or other documents agreed with the Register.

The list of parameters to be tested is determined by technological instructions and quality control standards. If Type Approval Certificate (CTO) is available, the testing shall be carried out by the firm (manufacturer) of fibres and reinforcement materials, and the results shall be recorded in the Manufacturer's Certificate of Quality of each product batch produced (refer to **2.2.1**). The testing may be also carried out by the shipyard or firm (manufacturer) of FRP products and structures, or other laboratories recognized by the Register. Test reports shall be submitted to the Register.

2.3.1.7 Reinforcement materials applied in FRPs shall have certain wettability and drapability properties to be combined with a selected type of thermoset binder when moulding irregular-shaped structures.

When closed moulding techniques are applied for reinforcement materials, permeability factor shall be estimated to determine process parameters in selection of a binder injection strategy.

2.3.1.8 Manufacturer's Certificate of Quality drawn up for each fiber (reinforcement material) batch shall contain the following information:

firm's (manufacturer's) data;

fiber (material) brand mark;

reinforcement type and scheme (for reinforcement material);

weight per unit length or area;

acceptance test results (refer to **2.3.1.6**).

2.3.1.9 The firm (manufacturer) of reinforcement materials or FRP structures (refer to **2.2.1**) shall verify laminating properties of these materials by manufacturing laminates of them, using contact moulding and infusion techniques based on selected polyester and vinylester binders.

Specimens shall be cut out from these laminates in main directions of reinforcement and tested according to the methods of international and/or national standards, or other methods agreed with the Register, to determine the following:

ultimate strength and Young's modulus of elongation;

ultimate bending strength;

ultimate interlaminar shear strength.

Standards and methods to be used in determining of the specified characteristics are listed in the type test program (refer to Appendix **2**).

2.3.1.10 When used in structures, reinforcement materials may be applied in the form of woven fabric, multiaxial (non-crimp) fabrics, tapes and mats.

Selection of the reinforcement material type, combination thereof and reinforcement scheme depends on the requirements for the FRP, conditions of its operation as part of a structure and its function. In this case, scantlings of the structure and its primary members, their shape and manufacture procedure shall be taken into account (refer to **2.4**).

2.3.2 Binders.

2.3.2.1 The following parameters shall be determined for thermosetting binders used in FRP (refer to **2.1.1**):

mechanical properties that ensure proper strength and rigidity characteristics in FRPs;

adhesion to fibers of reinforcement materials under all exposures of FRPs during operation;

water absorption and resistance when subjected to long-term exposure to sea water;

heat resistance within the temperature range of -40ºC to +60ºC;

resistance to oil and petroleum products.

2.3.2.2 Physical and mechanical properties of polyester and vinylester binders as cured shall comply with the requirements specified in Table 2.3.2.2.

Table 2.3.2.2 **Physical and mechanical characteristics of main binder types used in ship structures**

Characteristic	Polyester binder	Vinylester binder	Epoxy binder
Density, in kg/m^3	1100-1300	1130-1180	1150-1280
Tensile strength, in MPa	at least 65	at least 75	at least 100
Young's modulus of elongation, in GPa	at least 3,0	at least 3,3	at least 3,5
Bending strength, in MPa	at least 90	at least 135	at least 150
Tensile elongation, in %	2 - 3	4 - 5	3 - 6
Water absorption at a normal pressure within 24 h, in %	not more than 0,1	not more than 0,1	not more than 0,08

2.3.2.3 Epoxy binders used in moulding individual structural elements and members, and as prepreg components, shall have characteristics not lower than those specified in Table 2.3.2.2. as cured. In such case, curing shall be carried out at shipbuilding facility.

Taking into account that epoxy binders are mostly related to hot-curing resins, their application in manufacture for ship structures shall be justified by production processes.

2.3.2.4 Binders shall be adaptable and have viscosity and wettability that ensure proper impregnation of reinforcement materials, and allow closed moulding techniques for structures manufacture and mechanization of their manufacture process.

Binder pot life shall ensure manufacture of large-sized irregular-shaped structures with relatively thick members.

2.3.2.5 All components (catalysts, accelerants, thixotropic agents, colour pigments) constituting the thermosetting binder shall be compatible with resin, ensure complete curing of the binder without deterioration of its properties when cured.

2.3.2.6 Colour pigments shall be resistant to climatic factors. Pigment amount added to the binder shall not exceed the standard established by the resin manufacturer.

2.3.2.7 Binders applied in closed moulding techniques shall have the following characteristics:

dynamic Brookfield viscosity at a temperature of 25°C - 150 - 400 mPa·s;

gel time at a temperature of 18 - 22°C, variable within the range of 0,5 - 6 h, with physical and mechanical properties remaining unchanged;

temperature of exothermic reaction with binder polymerization - not more than 200°C;

heat treatment temperature - not more than 80°C;

glass transition temperature of binder as cured - not less than 110°C.

2.3.2.8 Firms (manufacturers) of thermosetting binders shall confirm their characteristics by estimation of properties in the course of and after curing. The list of properties to be estimated shall be determined by the documentation on production process and quality performance control requirement and agreed with the Register.

Tests to determine binder characteristics shall be carried out by the firm (manufacturer) according to the international and/or national standards, or other documents agreed with the Register.

Testing may be also carried out by a laboratory recognized by the Register.

2.3.2.9 Each binder batch shall be provided with a Manufacturer's Certificate of Quality containing the following information:

firm's (manufacturer's) data;

binder type;

binder brand mark;

acceptance test results.

Instructions on binder use and storage conditions shall be enclosed with the Manufacturer's Certificate of Quality.

2.3.3 Cores.

2.3.3.1 Materials used as cores in sandwich (multi-layered) constructions of a ship, and in cores of closed box stiffeners shall have relevant strength and stiffness at minimum density to ensure combined operation of load-bearing layers in these structures and stiffener sheathings under all impacts during operation.

2.3.3.2 Core materials shall be compatible with materials of load-bearing layers and sheathings. The binder of load-bearing layers shall not change the structure and impair characteristics of the core material whereas the latter shall not change curing properties of the binder.

Where adhesive is used for jointing FRP and core layers, it shall ensure their formation in a single structure under all operational impacts, and be compatible with the binder and core.

2.3.3.3 When selecting core materials used in external structural members (hull shell, superstructure sides, etc.), it is recommended to use cores with low water absorption, resistance to ageing due to temperature differential and exposure to ultraviolet irradiation, and, when possible, proper thermal insulation.

2.3.3.4 The following materials may be used as a core of external members in sandwich (multilayered) constructions:

polyvinyl chloride (PVC) foams of the rigid close-cell type;

polyurethane (PUR) foam;

balsa wood;

lightweight mats with microspheres (refer to**1.2**).

To increase rigidity and strength of PVC foams, PUR foams and lightweight mats, especially to lateral shear strength, additional reinforcement may be introduced, such as layers of reinforcement material, corrugations**, ribs, etc. Use of additional reinforcement shall be substantiated.**

2.3.3.5 Constructional discrete types of cores such as honeycombs, corrugations, ribs (without using of expanded-type core, e.g. foam plastic) may be used in inner members of hulls and superstructures, except those specified in **2.3.3.4**.

2.3.3.6 Polyvinyl chloride (PVC) foams shall be used in closed box stiffeners of framing.

2.3.3.7 Use of other core types in sandwich (multi-layered) constructions and closed box stiffeners shall be substantiated based on calculation and test results and agreed with the Register.

2.3.3.8 Physical and mechanical properties of PVC foams and PUR foam specified for the relevant typical density values shall comply with the requirements in Table 2.3.3.8. Their properties related to intermediate density values shall be determined by extrapolation.

2.3.3.9 Firms (manufacturers) of PVC foams, PUR foam, honeycombs and other core types shall confirm their characteristics by carrying out testing of material specimens.

Procedure of specimen selection, a list of properties to be determined, and test procedures shall be established by firms (manufacturers) in the production documentation and quality performance control requirements, and agreed with the Register.

2.3.3.10 Prior to moulding of sandwich (multi-layered) constructions and closed box stiffeners of framing with application of foam plastic as a core, the latter shall be machined to remove surface layers (slags) formed during manufacture.

Where closed moulding techniques are applied, the foam plastic shall be prepared by making channels for the binder to flow.

2.3.3.11 Thermal treatment of structures with a core of foam plastic type shall be carried out at a temperature that does not cause any irreversible changes in the foam plastic resulting in deterioration of its strength and elasticity properties and in its shrinkage and shape deformation.

Table 2.3.3.8 **Physical and mechanical properties of PVC foams and PUR foam**

Characteristic	Foam plastic					
	PVC foam			PUR foam		
Density, in kg/m^3	40	100	200	35 - 55	100 - 120	200 - 220
Compression strength (at 10 % deformation), in MPa	at least 0,4	at least 1,5	at least 4,0	at least 0,2	at least 0,9	at least 2,5
Young's compression modulus, in MPa	30	100	250	7,5 - 10	25 - 35	100 - 120
Tensile strength, in MPa	at least 0,7	at least 2,5	at least 6,0	at least 0,16	at least 0,8	at least 2,0
Young's elongation modulus, in MPa	25	80	180	-	-	-
Shear strength, in MPa	at least 0,4	at least 1,5	at least 3,5	at least 0,1	at least 0,5	at least 1,0
Shear modulus in laminate plane, in MPa	10	35	30	-	-	-
Ultimate shear strain, in %	8	25	75	-	-	-

2.3.4 Adhesives.

2.3.4.1 Adhesives such as glues and fillers shall be used for jointing structural elements manufactured of FRPs. The latter may be filled with microspheres or chops and used for filling production spaces when jointing structural elements.

Glues and fillers shall be compatible with materials of elements jointed, ensure high strength of joint with due regard of the specified operating temperature range, resist to ageing, moisture and oil and petroleum products.

2.3.4.2 Where possible, adhesives shall two-component, cured under standard conditions within approximately 20 - 60 min to allow elements of large-sized hull structures to be jointed under production conditions of shipyard.

2.3.4.3 Adhesive shall provide the data on static shear strength and strength of the adhesive bondage when in initial state and after being moistened at the standard and increased temperature, as well as on determining fatigue and long-term stress-rupture strengths for these deformation types, for each pair of materials being jointed.

2.3.4.4 When adhesives are used for jointing structural elements, preparation of their surfaces and procedure of adhesive application shall correspond to the recommendations of the firm (manufacturer).

The adhesive thickness between structural elements being jointed shall not exceed the value specified by the manufacturer; air ingress therein is not allowed.

2.3.4.5 When a structure containing adhesives is subjected to heat treatment under increased temperature, its value shall not exceed the curing temperature specified for the adhesive.

2.3.4.6 Adhesive shall be delivered with a Manufacturer's Certificate of Quality containing the following information:

firm's (manufacturer's) data;

adhesive brand mark;

acceptance parameters and their numerical values, which shall be specified in the production documentation of the firm (manufacturer);

strength test results for selected pairs of materials being jointed.

2.3.5 FRPs.

2.3.5.1 FRPs used in hull structures shall comply with the following basic requirements:

have elasticity and strength characteristics required for making an effective hull structure, and operability under repeated static, permanent, vibration and impact loads;

maintain their elasticity and strength characteristics, as well as operability within specified limits in the course of long-term operation in water and in different climate conditions for at least 20 years;

have low water absorption and high water resistance in sea water;

be resistant to oil and petroleum products as well as marine organisms;

be non-combustible and not generating excessive quantities of smoke and toxic products.

The requirements for hazardous properties shall be determined depending on the ship type and provisions of the Register rules according to which the ship design was approved.

2.3.5.2 The techniques of FRP processing to hull structures, their members and elements shall ensure the following:

manufacturing of the material as part of a structure with properties required;

reproduction of these properties when duplicating structures;

high manufacture quality without impermissible defects (delamination, pits, loose laying-up, etc.);

possibility of closed moulding techniques application (infusion, RTM techniques, etc.) and mechanization aids.

2.3.5.3 The following techniques are allowed for manufacture of FRP structures:

contact moulding;

closed (vacuum) moulding, including infusion and RTM techniques;

spraying;

moulding with the use of prepregs.

2.3.5.4 When selecting technique for manufacture of structures, the maturity of this technique at the firm (manufacturer), availability of qualified personnel and required equipment shall be considered.

2.3.5.5 To manufacture ship hull structures and their members, it is recommended to use mostly infusion technique.

To manufacture individual structural elements, RTM techniques are allowed.

2.3.5.6 The contact moulding technique shall be applied in the areas of a structure where the infusion technique is impossible or inappropriate, e.g. in intersections or in strengthening areas.

2.3.5.7 The spraying technique is allowed for manufacture of hull structures and their individual members to which the strength and rigidity requirements are not applied (not considered in strength calculations).

The spraying process shall be performed in accordance with the technological instruction, with the chops length within the range of 10 – 30 mm. It is recommended to apply spraying technique in layers.

Rolling procedure to remove air and compact the material shall be carried out after each layer spraying.

2.3.5.8 Moulding with the use of prepregs is allowed for ship hulls of up to 15 m in length, and for structural elements and members agreed with the Register. Prepreg properties shall comply with the requirements for their components – reinforcement material and binder.

2.3.5.9 Moulding techniques shall ensure optimal ratio between the reinforcement material and binder to achieve the most balanced properties of the material. Percentage content of reinforcement materials with glass and carbon fibers as reinforcement by mass depending on their type and moulding technique are specified in Table 2.3.5.9.

Table 2.3.5.9 **Percentage content of reinforcement materials with glass and carbon fibers as reinforcement by mass in FRPs**

Moulding technique	Type of reinforcement material			
	Glass mats	Fiber glass	Carbon fibers	Glass roving
Contact moulding	at least 0,3	at least 0,5	at least 0,35	-
Closed (vacuum) moulding	-	0,65 – 0,7	0,4 – 0,6	-
Spraying technique	-	-	-	at least 0,35
Using prepregs	-	at least 0,7	at least 0,45	-

2.3.5.10 Curing mode at higher temperatures shall not cause considerable residual deformations and impair the structural integrity. In case of sandwich (multi-layered) construction, a core of foam plastic type shall not experience irreversible changes that deteriorate its strength and elasticity properties (refer to **2.3.3.11**).

2.3.5.11 Basic characteristics of FRPs based on one-directional tapes (08) and balanced scheme reinforced (0°/90°) and (+45°/-45°) with glass fiber, carbon fiber, and polyester (vinylester) binder shall be not lower than those specified in Table 2.3.5.11.

Table 2.3.5.11 **Basic characteristics of glass, carbon fiber-reinforced plastics**

FRP type	Reinforcement fiber							
	Carbon fiber				Glass fiber			
	Tape		Fabric		Tape		Fabric	
Percentage content of reinforcement material by mass	0,4	0,6	0,35	0,6	0,5	0,7	0,5	0,7
Values of physical and mechanical properties, at least								
Young's modulus, in GPa	65	95	35	55	30	45	16	24
Shear modulus in the reinforcement plane, in GPa	2.0	3,5	5,5	6,5	2,0	2.5	3.0	4,5
Tensile strength, in MPa	850	1200	500	800	550	700	250	400
Compression strength, in MPa	400	500	350	400	300	400	200	300

2.3.5.12 Deterioration of elasticity and strength properties of FRPs after long-term exposure to operational factors for 20 years shall be equal to:

for Young's modulus and shear modulus in laminate plane – less than 10 %;

for strength properties – less than 20 %..

2.3.5.13 Water absorption by the FRP when exposed to sea water for a long period at normal pressure shall have the following values:

not more than 0,15 % of the material weight for 24 h of exposure to sea water;

not more than 3,0 % of the material weight after being exposed to sea water for 30 days.

2.3.5.14 Strength and elasticity properties of FRP when exposed to various force impacts (short-term, repeated static, long-term, etc.), and after being moistened and impacted with increased temperatures, shall be determined by test procedures specified in type test program (refer to Appendix **2**).

2.3.5.15 Manufacture of FRP structures shall be performed simultaneously with quality performance control at all production stages in accordance with the applicable reference documents.

The quality performance control methods applied shall detect impermissible deviations from the production process, including various defect types that may deteriorate strength and operability of a structure.

2.3.5.16 The Register may carry out quality performance control of random FRP structures and products, upon which a decision on material approval shall be made.

3 HULL AND SUPERSTRUCTURES OF SHIPS

3.1 HULL STRUCTURAL TYPES AND FRAMING SYSTEMS

3.1.1 The following hull shell structural types (deck plating and bulkhead plating) are recommended (refer to Fig. 3.1.1):

.1 single-skin construction shell:

homogeneous FRP based on the same reinforcement material type;

non-homogeneous FRP based on two (less frequent – three) different types of material, e.g. manufactured of glass fabric with different weaving and reinforcement schemes;

hybrid FRP based on reinforcement materials of different chemical nature, e.g. glass fabric and carbon fiber (refer to **1.2.2**);

.2 sandwich construction shell with load-bearing layers manufactured of homogenous, nonhomogeneous and hybrid FRP and expanded-type core, for which PVC and PUR foams are recommended.

.3 sandwich construction shell with a core reinforced with reinforcement material layers. In such case, a lightweight mat is recommended as a core (refer to **2.3.3.4**).

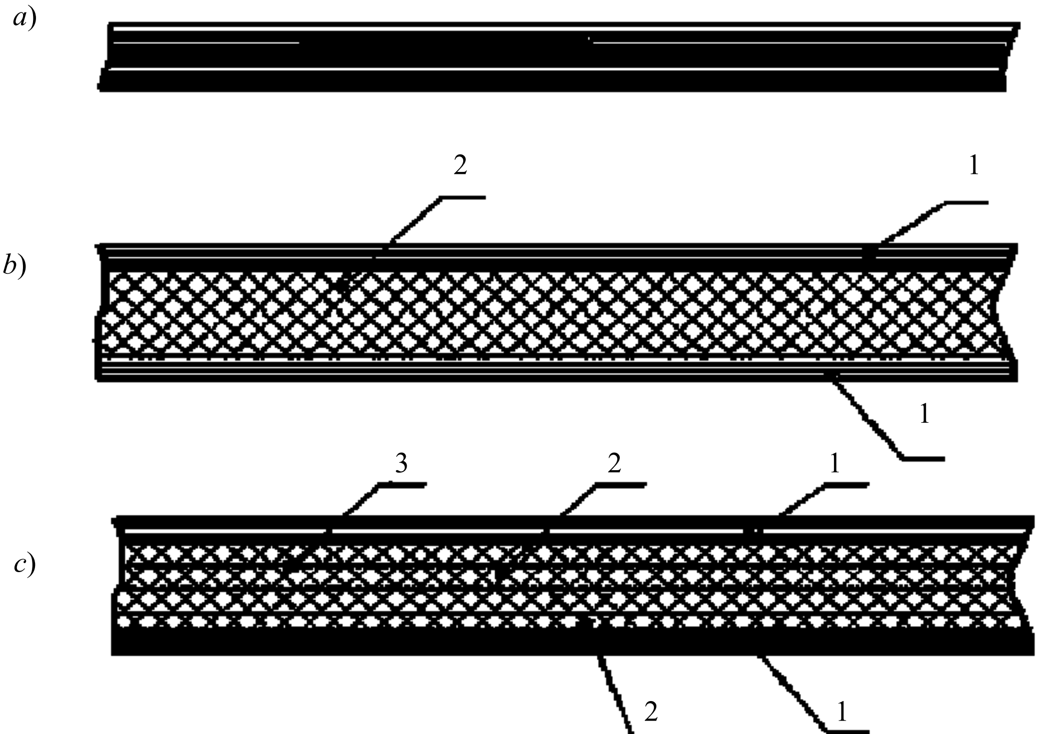


Fig. 3.1.1 Structural schemes of the hull shell (decks plating and bulkhead plating) manufactured of FRPs: *a)* single-skin construction shell; *b)* sandwich construction shell with expanded-type core; *c)* sandwich construction shell with a core reinforced layer by layer
1 – load-bearing layers; *2* – core; *3* – reinforcement layers

3.1.2 Application of sandwich construction for the hull shell may be permitted by the Register in case the mature manufacture procedure and proven quality performance control methods to ensure firm joint of all layers to form integral structure are available at the firm (manufacturer).

3.1.3 The hull shell shall be stiffened, with the following framing systems used depending on mutual arrangement of members (refer to Fig. 3.1.3):

transverse framing system when all framing members are fitted in line with every frame, except for a centre girder (refer to Fig. 3.1.3, *a*);

mixed framing system – transverse on sides and in way of bottom (upper deck) as follows:

with framing members fitted along the hull (refer to Fig. 3.1.3, *b*);

mixed framing system with continuous or intercostal transverse members (refer to **1.3.5**, Fig. 3.1.3, *c*);

mixed framing system with transverse deep members (refer to Fig. 3.1.3, *d*).

In case of mixed framing system, transverse members in way of bottom shall be arranged in line with every frame.

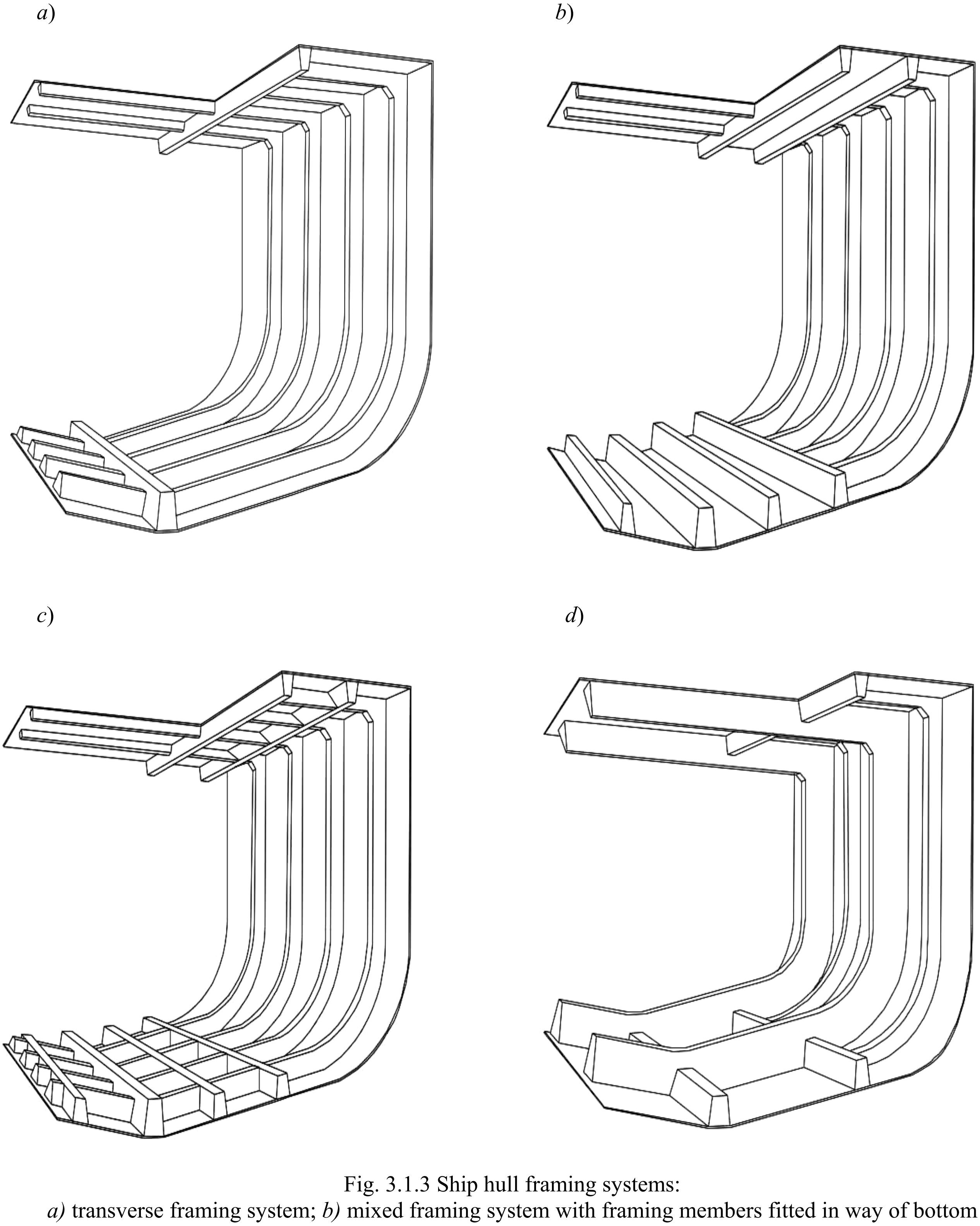


Fig. 3.1.3 Ship hull framing systems:
a) transverse framing system; *b)* mixed framing system with framing members fitted in way of bottom and upper deck along the hull; *c)* mixed framing system with continuous or intercostal transverse members in way of bottom and upper deck; *d)* mixed framing system with transverse deep members.

3.1.4 When selecting hull structural type of a ship, including its framing system, the following shall be considered:

purpose and size of a ship;

operating conditions;

requirements for the hull weight and necessity of ensuring its longitudinal and local strength and stiffness;

labour input in ship hull construction;

number of ships in a series, etc.

3.1.5 For ships of 15 – 70 m in length, minimum spacing of a transverse framing considering the requirements of **1.3.4** shall be equal to:

for hulls with a single-skin shell – 500 mm;

for hulls with a sandwich shell – 1000 mm.

Transverse framing system shall be applied in the forepeak, and the above spacing shall be decreased to the following values:

for hulls with a single-skin shell – 400 mm;

for hulls with a sandwich shell – 800 mm.

3.1.6 Selection of hull framing system and spacing values shall be substantiated by the designer based on longitudinal and local strength calculations taking into account the factors specified in **3.1.4.** In such case, the recommendations mentioned below shall be considered.

Transverse framing system is recommended to apply with the following:

single-skin shell for ships of $L \leq 20$ m in length;

sandwich shell for ships of $L \leq 30$ m in length.

Mixed framing system with a single-skin or sandwich construction shell is recommended for ships of $L \leq 30$ m in length. When selecting a shell structure, it shall be considered that sandwich construction shell as compared to a single-skin allows reducing the number of framing members and their intersections accordingly (refer to **1.3.4**), as well as reducing weight of a structure considering the conditions enabling the implementation of the structure (refer to **3.1.2**).

Mixed framing system with longitudinal arrangement of members in way of bottom with both single-skin and sandwich construction shell is recommended for ships, including high-speed craft of$L$ = 15÷20 m in length. In the latter case, redans may be used as framing members.

3.1.7 Closed box section or its variety, trapezoidal section, shall be mainly for framing members. These sections consist of a core and its sheathing that forms a face plate and framing member webs that shall be tapered into flanges jointing the framing member to the hull shell (deck plating, bulkhead plating) (refer to Fig. 3.1.7 *a*, *b*).

The above-mentioned sections may not have a core, and their webs and face plate shall be performed over a former with flanges, or the latter may be made as a separate blank which is connected to the hull shell (deck plating, bulkhead plating) by means of moulding-in angles.

3.1.8 Application of T-shaped and L-shaped sections is allowed when they are able to function as seating girders at the same time (refer to Fig. 3.1.7 *c*, *d*).

The stiffeners of these sections shall be connected to the hull shell (deck plating, bulkhead plating) by means of moulding-in angles.

3.1.9 Recommendations on shell structures (deck plating, bulkhead plating) and the stiffeners of the sections specified, including reinforcement components and schemes of these elements are provided in **3.2.1** ÷ **3.2.3**.

3.2 HULL STRUCTURE

3.2.1 Shell plating.

3.2.1.1 Single-skin shell.

.1 woven roving and multiaxial fabrics shall be used for single-skin hull shell for ships of 15 ÷ 70 m in length. When selecting type and grade of reinforcement material, the laying-up procedure of material and shell moulding technique using either contact or vacuum moulding techniques;

.2 for ships of 15 ÷ 20 m in length, fabric may be laid both along and across the hull. Parallel shell reinforcement scheme [$(0^{\circ}/90^{\circ})$] shall be used, with 0º direction (warp) positioned along the shell generatrix, or along its directrix. In the latter case, the breaking strength in 90° direction (weft) shall be not lower than the breaking strength in 0° direction (warp), in fabrics with $(0^{\circ}/90^{\circ})$ reinforcement;

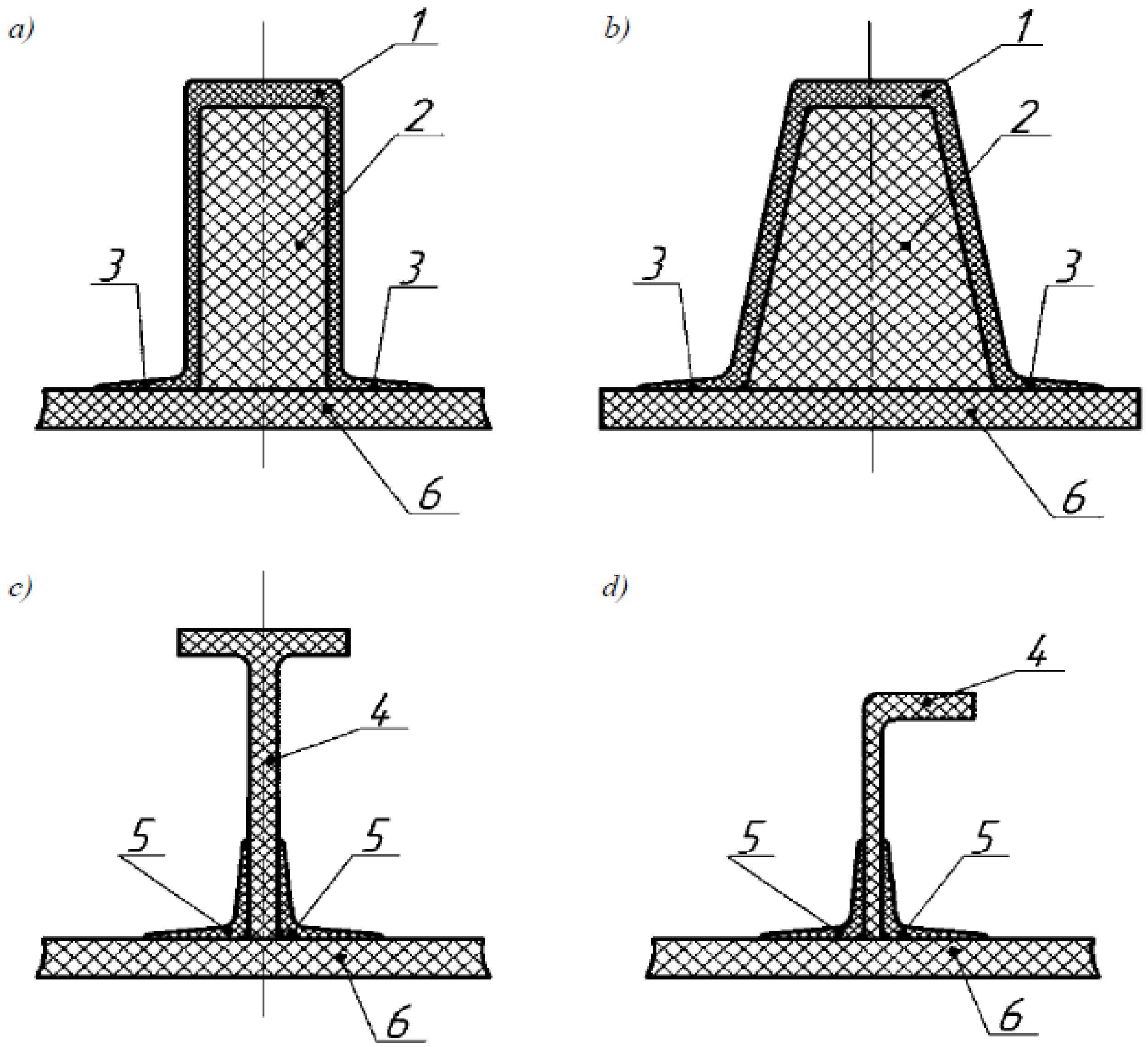


Fig. 3.1.**7** Structural types of framing members:

a) closed box section; *b)* closed box section variety – trapezoidal section; *c)* T-shaped stiffener; *d)* L-section stiffener *1* – section sheathing; *2* – core; *3* – flanges; *4* – framing member; *5* – moulding-in angles; *6* – shell (deck plating, bulkhead plating)

.3 for ships of 20 m in length, it is recommended to lay fabric blankets across the hull. In such case, parallel and diagonal reinforcement scheme [(0°⁄+ 45°⁄ 90°⁄–45°)] shall be applied. It may be implemented by using two types of fabric _ biaxial with reinforcement (0°⁄ 90°) and diagonal with reinforcement (+ 45°⁄– 45°), or based on quadriaxial fabric with 4 reinforcement directions (0°⁄+ 45°⁄ 90°⁄–45°);

.4 when two types of fabric with reinforcement (0°⁄90°) and (+45°⁄–45°) and similar surface density are used, the number of layers in the second fabric shall be determined based on the condition that the total thickness of its layers soaked in binder shall be equal to (0,4–0,45) of the shell thickness. In such case, two alternatives of layer arrangement over the thickness are available for these fabrics:

uniform arrangement, when fabric layers (0°⁄ 90°) are uniformly alternated with diagonal fabric layers (+45°⁄–45°), with 2 – 4 layers of the first fabric (depending on the shell thickness) shall be laid on outer surfaces of the shell;

packet arrangement, when fabric layers (0°⁄ 90°) are assembled in packets arranged on outer surfaces of the shell, with fabric layers (+ 45°⁄–45°) between them;

.5 when quadriaxial fabrics with reinforcement (0º/+45º/90º/-45º) are used, the total surface density of the roving in reinforcement directions (0º/90º) shall be approximately equal (up to 15 % difference) to that in directions (+45º/-45º);

.6 when moulding the shell, the first and last 2 – 4 fabric layers (depending on the shell thickness) arranged on its outer surfaces shall be laid up along butts (in warp) with at least 50 mm overlap, and along seams (in weft) – without overlapping. The overlap shall be performed from bow to aft. Other layers shall be laid up along butts and seams without overlapping (refer to Fig. 3.2.1-1).

Fabric butts and seams shall be spaced not closer than 100 mm apart from adjacent layers. Butts and seams are permitted to be coincident in one section after 5 layers at least;

.7 shell thickness s in the midship body shall be determined as the maximum of the two values $s = \max(s_d, s_s)$, where s_d, s_s - shell thickness determined according to the diagrams in Fig. 3.2.1-2, based on the specified requirements for stiffness and strength accordingly.

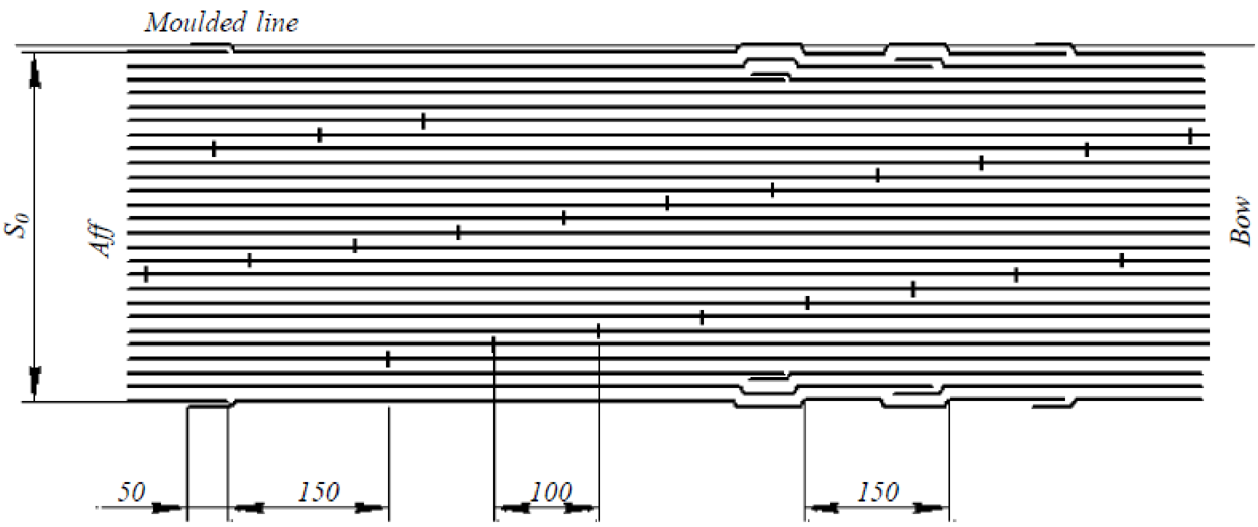


Fig. 3.2.1-1 Scheme of a ship hull single-skin shell

Minimum thickness *s* of the hull shell in bottoms and sides in the midship body shall not be lower than the values determined according to the diagrams in Fig. 3.2.1-4 depending on the ship length between perpendiculars *L*.

In the fore and after ends these thicknesses shall be increased by at least 20 %, and for high-speed craft subject to high loads due to slamming, the shell thickness in the fore end shall be increased by at least 40 %.

Selected thicknesses of the hull shell shall be confirmed by the designer based on longitudinal and local hull strength calculations;

.8 shell thickness shall be increased gradually by adding fiber layers inside the packet of basic continuous layers, whereas reduction of the thickness requires removal of some layers inside the packet.

It is recommended to alternate layers that are removed or added with continuous layers.Cross sections where fabric layers start or terminate shall be spaced from each other to at least 50 mm.

In this case, length Δ, within which the shell thickness changes gradually, shall comply with the following condition:

$\Delta \geq 15 \times (S_1 - S_0)$,

where $(S_1 - S_0)$ - difference in shell thicknesses (refer to Fig. 3.2.1-5);

.9 the plate keel and sheerstrake shall be moulded by adding a packet of additional fabric layersbetween basic layers after 75 % of the shell thickness around these members is ensured. It is allowed to frame a keel plate and a sheerstrake by laying-up fabric layers on the basic shell if the shell is made by infusion.

Each subsequent fabric layer forming the plate keel and a sheerstrake shall overlap the preceding one over at least 5 mm of this thickness. Seams and butts of additional layers shall be spaced from each other and from seams and butts of basic layers to at least 50 mm. Butts and seams are permitted to be coincident in one section after 5 layers at least;

.10 woven roving or biaxial fabrics with reinforcement (0°/90°) and increased strength in 0° direction are recommended as a reinforcement material when moulding the plate keel and sheerstrake.

Fabric layers in the plate keel and sheerstrake shall be laid in 0° direction along the hull;

.11 the plate keel thickness shall be assumed at least 50 % greater than the bottom shell thickness, and width shall be at least its 40 thicknesses, considering both sides. In such case, the width of the plate keep is specified at the level of its full thickness. The following scheme is recommended for the thickness tapering – the 5 mm change of thickness shall take at least 50 mm of width (on one side) provided that the requirements for overlapping are complied with (refer to **3.2.1.1.9**).

.12 the sheerstrake thickness shall be assumed 40 % greater than the side thickness, and its width – at least its 40 thicknesses. Thickness tapering is recommended to be carried out in the same manner as at the plate keel.

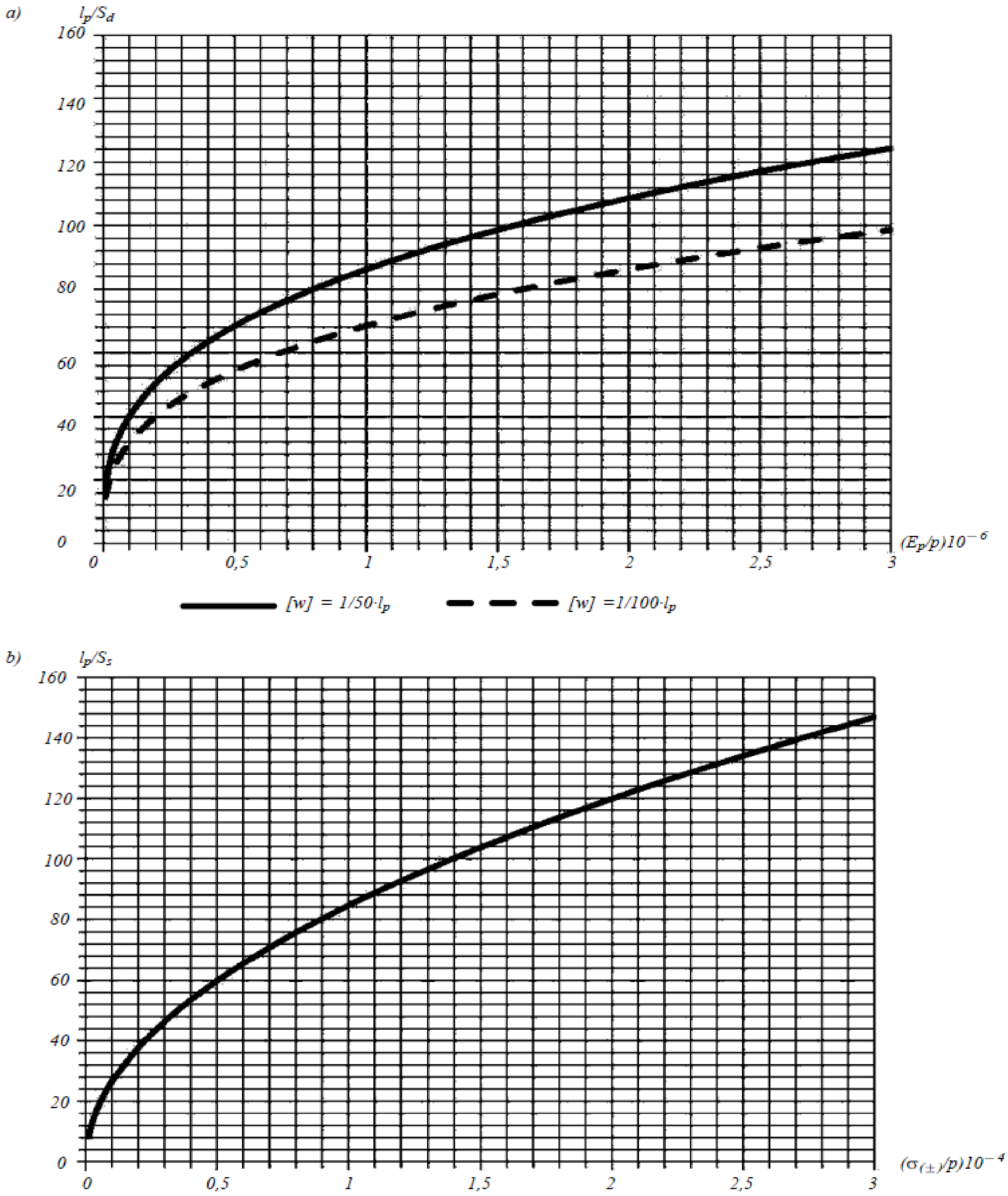


Fig. 3.2.1-2 Dependency diagrams of the maximum supporting contour length l_p, in m, of the laminate ratio to its thickness s_d, (s_s), in m, and the ratio of laminate material properties E_p, $\sigma_{(\pm)}$, in MPa, to design pressure p:

E_p - design Young's modulus of shell material, in MPa;

$\sigma_{(\pm)}$ - minimum ultimate strength of shell material, in MPa;

l_p - supporting contour length of a laminate determined in accordance with Fig. 3.2.1-3.

a - requirements for permissible deflections $[w] = 1/50 \cdot lp$, $[w] = 1/100 \cdot lp$;

b – requirements for permissible stresses [s] = 0,36$\sigma_{(\pm)}$

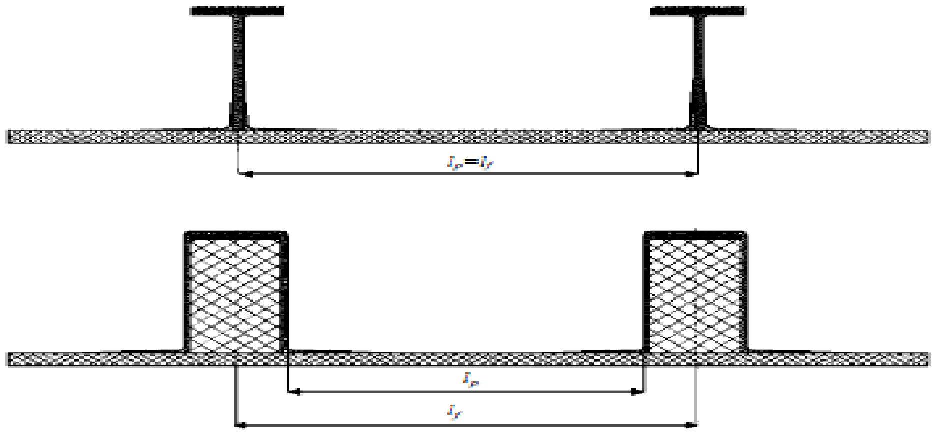


Fig. 3.2.1-3 Determination of the supporting contour length with framing members of different sections: l_f – spacing

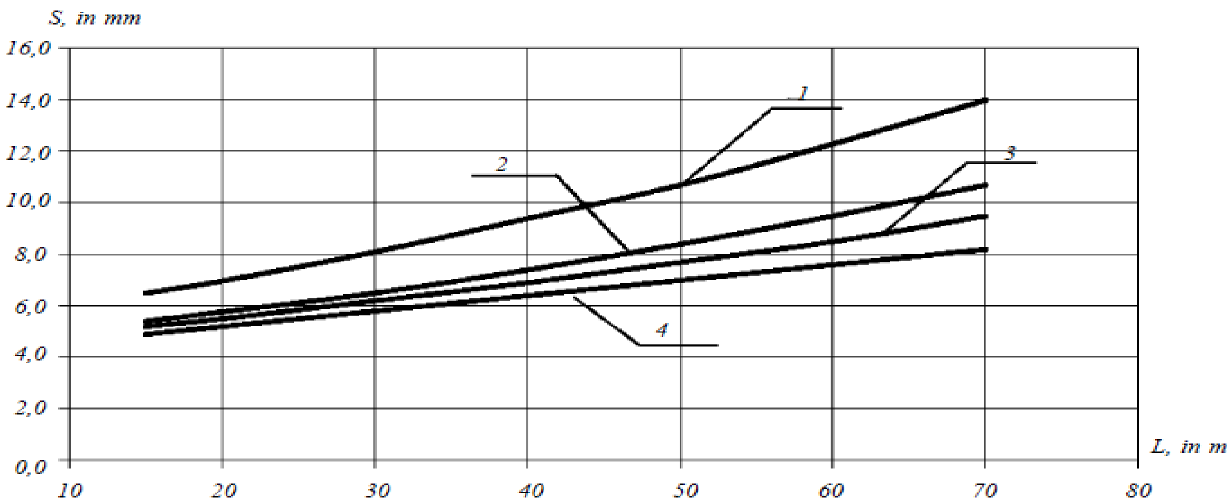


Fig. 3.2.1-4 Dependence of the minimum thickness of single-skin structures of the hull shell, deck and bulkhead plating manufactured of glass-reinforced plastic on the ship length (*L* = length between perpendiculars):

1 – bottom shell plating; *2* – side shell plating; *3* – upper deck; *4* – bulkheads

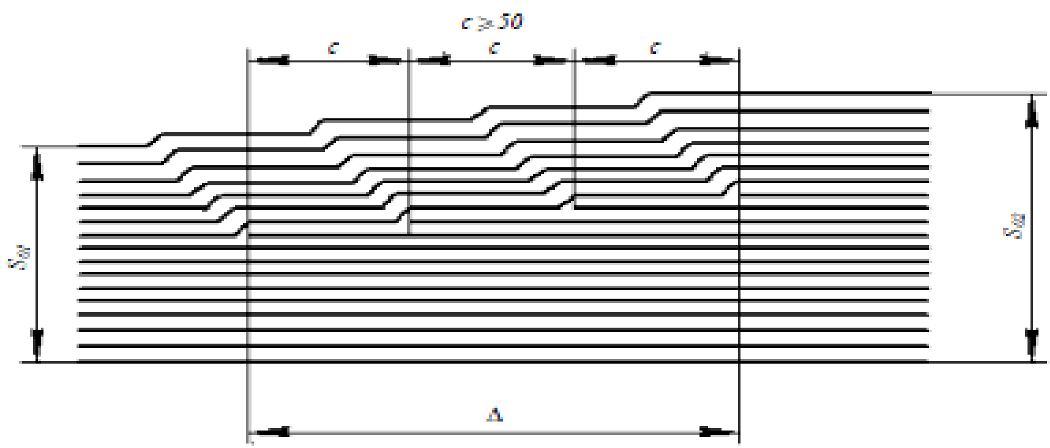
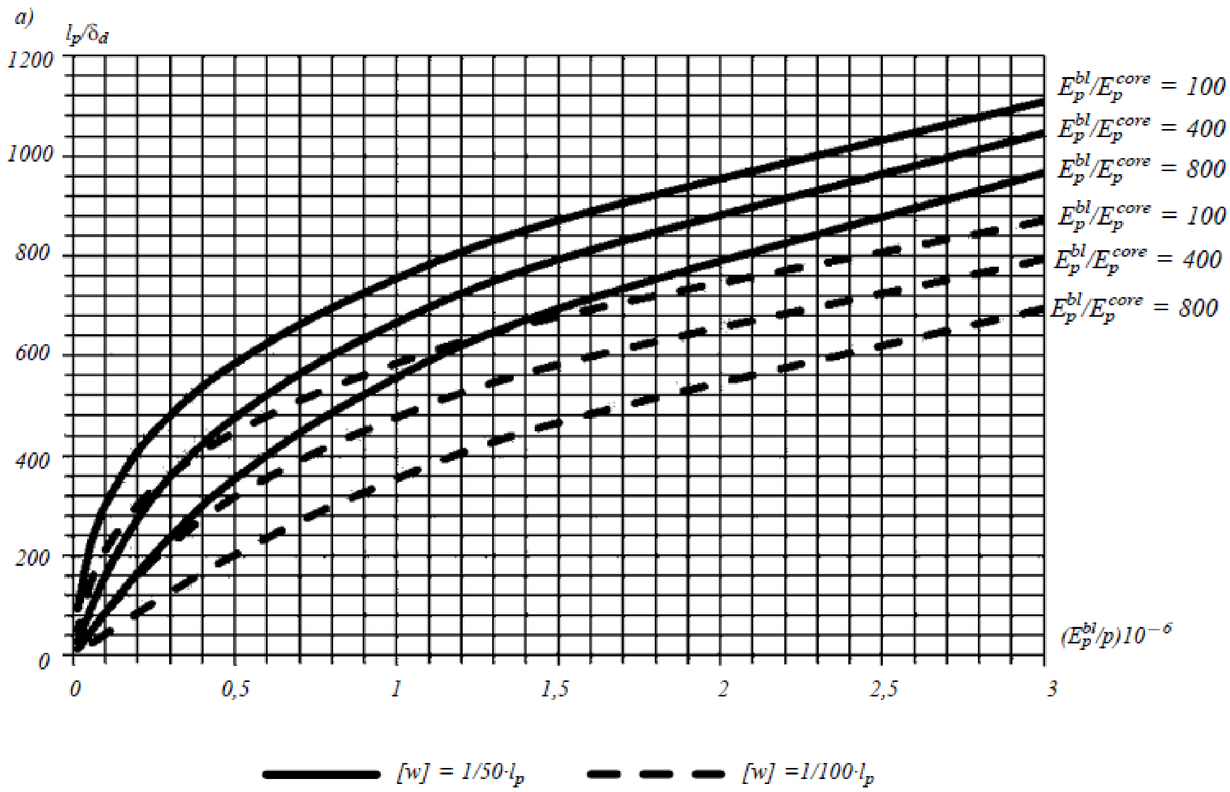


Fig. 3.2.1-5 Structure of a ship hull single-skin shell where its thickness varies



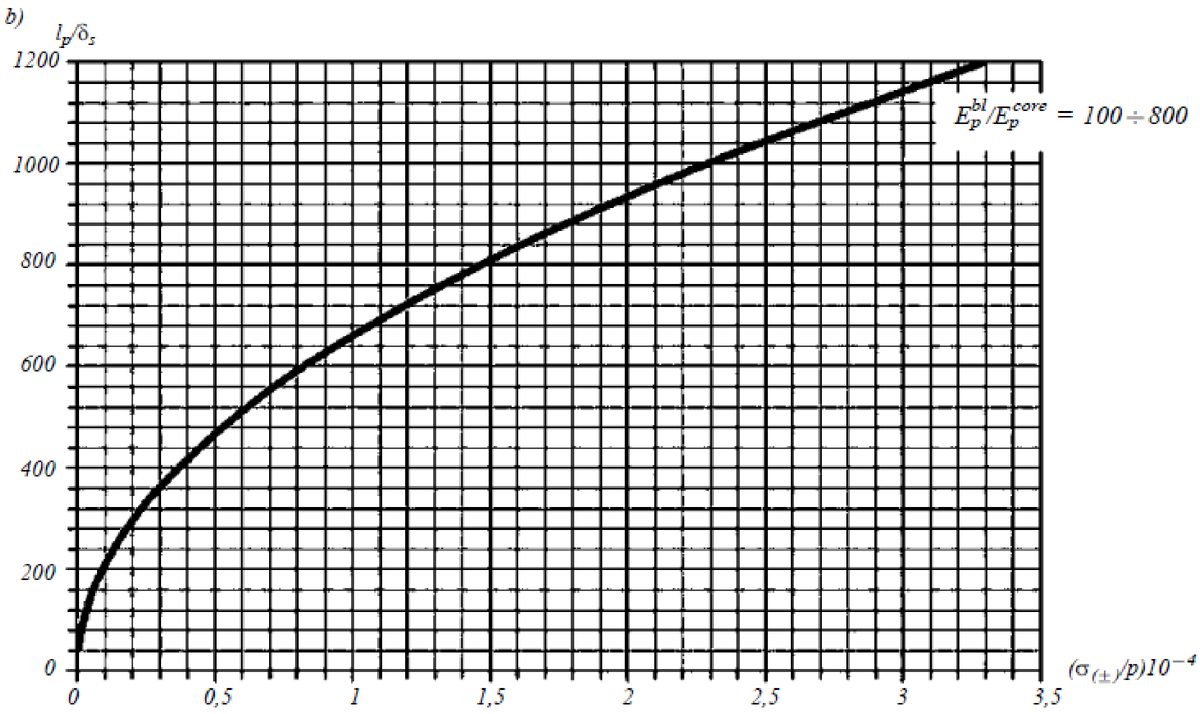


Fig. 3.2.1-6 Dependency diagrams of the maximum supporting contour length l_p, in m, of the sandwich laminate ratio to thickness of its load-bearing layers δ_d, (δ_s), in m, and the ratio of laminate load-bearing layers' material Properties E_p^{bl}, $\sigma_{(\pm)}^{bl}$, in MPa, to design pressure p (at $2h = 10\delta$):

E_p^{bl} - design Young's modulus of load-bearing layer material of sandwich laminate;

E_p^{core} - design Young's modulus of the sandwich laminate's core material, in MPa;

$\sigma_{(\pm)}^{bl}$ - minimum ultimate strength of load-bearing layer material, in MPa.

a – requirements for permissible deflections $[w] = 1/50 \cdot lp$, $[w] = 1/100 \cdot lp$;

b – requirements for permissible stresses $[\sigma] = 0{,}36\sigma_{(\pm)}$.

3.2.1.2 Sandwich platings.

.1 for load-bearing layers of the deck and platform sandwich plates , it is recommended to apply the same reinforcement materials and reinforcement schemes as for single-skin platings (refer to **3.2.1.1.1** ÷ **3.2.1.1.5**);

.2 PVC foams, PUR foams or mats may be used as a core in deck and platform sandwich plates (refer to **2.3.3.4**). When higher strength and thickness are required, they may be reinforced with fabric, preferably of woven roving type (refer to Fig. 3.1.1 *b*, *c*);

.3 in case of an expanded-type foam, the following foam plastic densities are recommended for the hull and upper deck shell:

for ships of more than 20 m in length – 60 – 80 kg/m^3;

for ships of 20 – 40 m in length – 80 – 120 kg/m^3;

for ships over 40 m in length – 120 – 200 kg/m^3.

The specified recommendations are applicable to the listed structural members beyond reinforcement and joint areas (plate keel, sheerstrake, joint of the side to the deck etc.).

Recommendations for selection of expanded-type foam densities for these areas are specified below;

.4 thickness of load-bearing layers of the bottom and side sandwich shells δ shall be determined according to the diagrams specified in Fig. 3.2.1-6, as the maximum value of δ_d, δ_s, determined in accordance with the conditions for compliance with the requirements for stiffness and strength accordingly. In this case, core thickness $2h$ is recommended to be assumed at least 10 thicknesses of the load-bearing layer ($2h \geq 10\delta$) in the first approximation.

The thickness of the core manufactured of the fabric-reinforced lightweight mat is assumed equal to $2h \geq 6\delta$.

In such case, the minimum thickness of load-bearing layers of the shell shall not be less than that specified in diagrams specified in Fig. 3.2.1-7, depending on the hull length between perpendiculars *L*.

In the fore and after ends the thickness of load-bearing layers determined according to these diagrams shall be increased by at least 30 %. If the hull weight is restricted, it is allowed to increase the thickness of the outer load-bearing layer only;

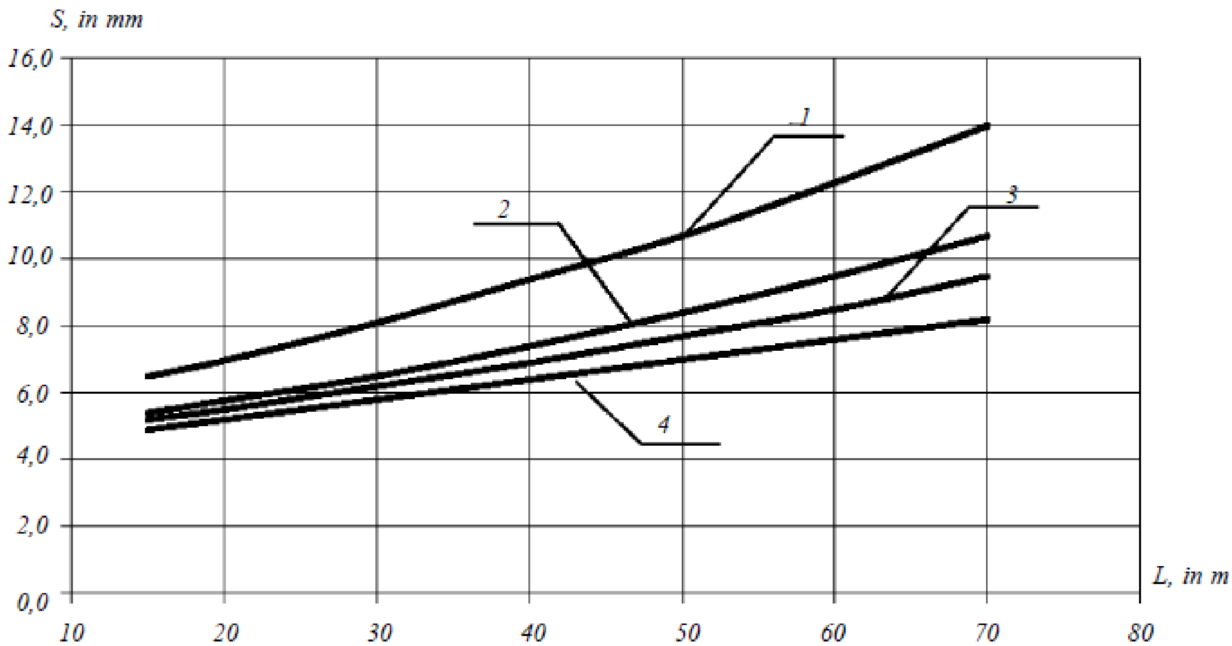


Fig. 3.2.1-7 Dependence of the minimum thickness of single-skin structures of the hull shell, deck and bulkhead plating manufactured of glass-reinforced plastic on the ship length (*L* = length between perpendiculars):

1 – bottom shell plating; *2* – side shell plating; *3* – upper deck; *4* – bulkheads

.5 the plate keel in a sandwich shell shall be moulded by thickening of the inner load-bearing layer and/ or by filling the core with an aggregate of the higher density as compared to that of the basic shell (refer to Fig. 3.2.1-8).

The inner load-bearing layer thickening is performed by moulding of additional fabric layers or by adding these layers between basic fabric layers forming this layer.

Application of thickening technique, type of fabrics used for this purpose, and the requirements for overlapping of additional fabric layers and mutual arrangement of their butts and seams shall be determined in accordance with the provisions of **3.2.1.1.9 ÷ 3.2.1.1.11**;

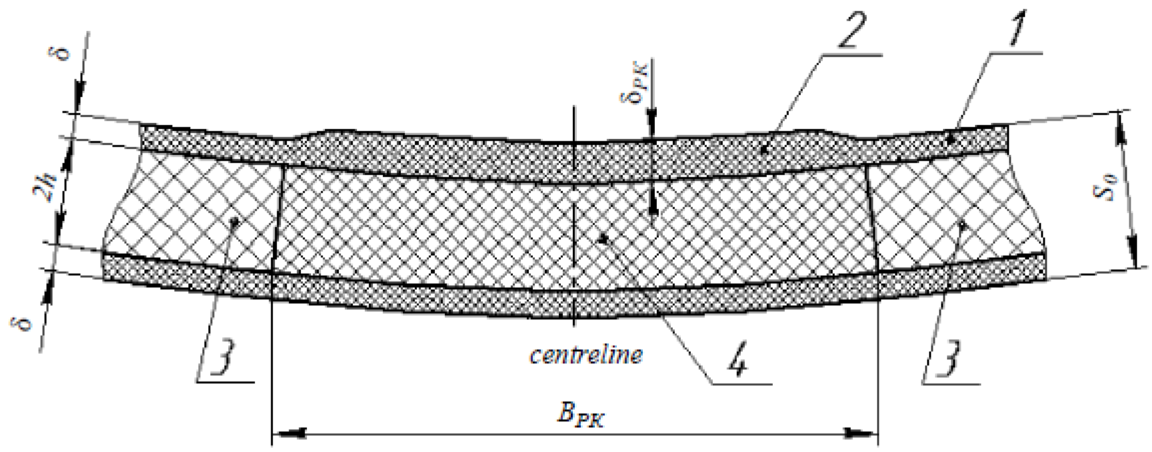


Fig. 3.2.1-8 Sandwich shell structure at the plate keel area
1 - load-bearing layers; *2* - thickening of the inner load-bearing layer;
3 - core (foam plastic); *4* - core (foam plastic of increased density)

.6 inner load-bearing layer thickness δ_2 at the plate keel area is assumed equal to δ_{PK} = 1,5 δ_2, whereas its width - B_{PK} = 5*s*, where *s* - is a total sum of the sandwich shell beyond the thickened area (refer to **3.2.1.2.4**). The specified geometric parameters may be corrected based on the results of strength calculations that may also require increasing the outer load-bearing layer thickness d_1;

.7 sheerstrake in the sandwich shell is recommended to be moulded using the same procedure as for the plate keel - by thickening the inner load-bearing layer and/or adding filler of higher density to the core.

Reinforcement scantlings for the sheerstrake plating are selected according to the recommendations for the plate keel specified in **3.2.1.2.6**.

3.2.2 Plating of decks and platforms.

3.2.2.1 Single-skin platings

.1 single-skin platings are recommended for decks and platforms with heavy equipment fitted and that requires to be fastened to the shell and its supporting members. Such decks include cargo decks that accommodate the crane equipment and cargoes;

.2 for single-skin platings, multiaxial fabrics and infusion moulding technique are recommended.

For deck and platform platings of ships of up to 20 m in length it is allowed to apply biaxial fabrics with reinforcement (0º/90º), and combination products based on these fabrics laid either along or across the hull, depending on the reinforcement direction considered to be stronger.

For ships of more than 20 m in length, single-skin platings shall be based on quadriaxial fabrics with reinforcement (0°/+45°/90°/-45°), or from a combination of two fabrics (0°/90°) and (+45°/-45°) considering the requirements of **3.2.1.1.4**. When moulding laminate, these fabrics (in 0° direction) may be laid both along and across the hull.

For inner (intermediate) decks and platforms, it is allowed to apply biaxial fabrics, as well as combination products on their basis;

.3 upper deck plating thickness and its minimum permissible value shall be determined according to **3.2.1.1.7**.

The plating thickness of inner (intermediate) decks and platforms may be reduced by 10-20 % relative to that of the upper deck determined in accordance with the diagram provided, for specified length *L*.

.4 when moulding the upper deck platings, the first and last two fabric layers arranged on its outer surfaces shall be laid up along butts with at least 50 mm overlap, and along seams - without overlapping.

Fabric butts and seams shall be spaced not closer than 100 mm apart from adjacent layers. Butts and seams are permitted to be coincident in one section after 5 layers at least.

In laminates of inner (intermediate) decks and platforms, it is allowed to lay fabric layers along butts and seams without overlapping;

.5 deck stringer and other reinforcements in deck and platform plates may be moulded by adding fabric layers on the packet of basic layers forming the laminate during its manufacture by means of infusion technique. In this case, the recommendations considering the overlapping of additional layers and thickness tapering specified in **3.2.1.1.8** and **3.2.1.1.9**;

.6 thickness and width of a deck stringer, as well as its thickness tapering, are recommended to be assumed the same as for the sheerstrake (refer to **3.2.1.1.12**).

Woven roving or biaxial fabrics with reinforcement (0°⁄ 90°) and increased strength in 0° direction are recommended as a reinforcement material when moulding a deck stringer;

.7 deck and platform platings subject to intense wear shall be increased in thickness by straps of 2 mm, or protection coating shall be applied;

.8 accepted thicknesses of deck and platform plates, and that of the deck stringer plate shall be specified based on the calculation results of strength and buckling strength of hull's structural members.

3.2.2.2 Sandwich platings.

.1 for load-bearing layers of the deck and platform sandwich plates , it is recommended to apply the same reinforcement materials and reinforcement schemes as for single-skin platings (refer to **3.2.2.1.2**).

An infusion technique is recommended for manufacturing these structures;

.2 PVC foams, PUR foams or mats may be used as a core in deck and platform sandwich plates (refer to **2.3.3.4).** When higher strength and thickness are required, they may be reinforced with fabric, preferably of woven roving type (refer to Fig. 3.1.1, *c*);

.3 plate thickness of upper deck load-bearing layers and its minimum permissible value shall be determined according to **3.2.1.2.4**.

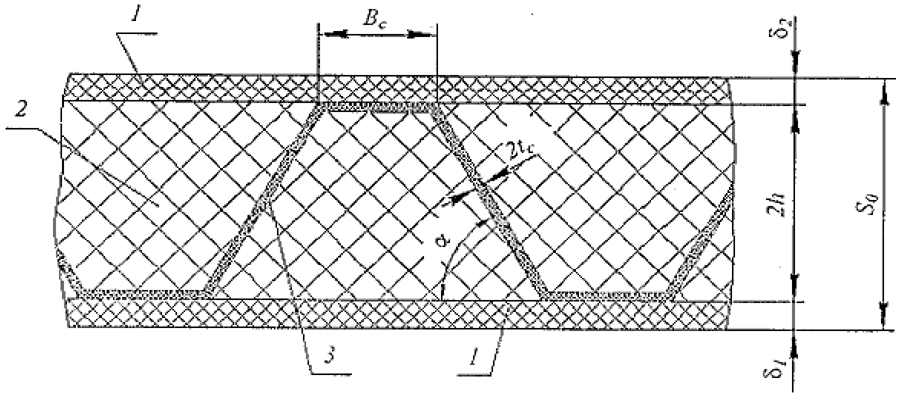
It is recommended to assume the thickness of a core filled with foam plastic to be at least 10 thicknesses of the load-bearing layer at the first approximation, while for the fiberglass-reinforced mat core - at least its 5 thicknesses;

.4 recommendations on selecting the foam plastic density for the upper deck with an expanded core are specified in **3.2.1.2.3**.

For inner (intermediate) decks and platforms, the foam plastic density in the core may be reduced by 10 - 20 kg⁄m^3 compared to the foam plastic selected for the hull shell but it shall be at least 40 kg⁄m^3.

In such case, it shall be taken into account that in places of joint to other structures (sides, bulkheads, superstructure sides and ends, etc.) and in places of equipment fastening, the expanded foam density shall be increased to bear transverse local forces. Recommendations on selection of the foam plastic density for a core in deck and platform sandwich plates in such places are specified in **3.2.4 ÷ 3.2.7**;

.5 structural orthotropic filler consisting of PVC foam or PUR foam with density of at least 35 - 50 kg/m^3 reinforced with a corrugated element may be applied as a core in deck sandwich plates (refer to Fig. 3.2.2-1);



Ашп. 3.2.2-1 Scheme of a deck sandwich laminate (bulkhead plating) with a corrugated element and foam plastic in a core:
1 - load-bearing layers; *2* - foam plastic; *3* - corrugated element

.6 parameters of a corrugated element at the first approximation shall be assumed equal to:
inclination angle of a corrugated element web $\alpha = 45^\circ \div 55^\circ$;
corrugated element thickness $2t_c = (0{,}1 \div 0{,}3)\delta$, but at least 0,2 mm;
flange width $B_c = (2 \div 4)\delta$;
core width $2h \geq 10\delta$.

In such case, the corrugated element generatrix shall be directed along the ship hull, except when the transverse stiffness of the deck skin requires increasing;

.7 deck stringer and other reinforcements in deck and platform sandwich plating shall be formed by increasing the thickness of load-bearing layers and/or increasing the foam plastic density in the core (refer to **3.2.1.2.5**). The load-bearing layers are thickened by laying additional fabric layers on basic layers forming load-bearing layers of a plate;

.8 width and thickness of the inner load-bearing layer of the deck stringer, as well as the core density are recommended to be the same as that of the sheerstrake in the hull sandwich shell (refer to **3.2.1.2.7**). If necessary, the thickness of the outer layer of the upper deck at the deck stringer area may be also increased;

.9 where sandwich to single-skin transition is required in the deck, it shall be gradual as possible (refer to Fig. 3.2.2-2). The tapering length shall be selected based on condition $l_{tap} \geq 5(s_s^2 - s_s^1)$, where s_s^2 and s_s^1 is the thickness of sandwich and single-skin areas of the deck laminate accordingly. Where $s_s^1 > 2\delta$, the lacking thickness shall be is made up by laying additional fiber layers to load-bearing layers, with their thickness gradually increased and selected reinforcement scheme maintained;

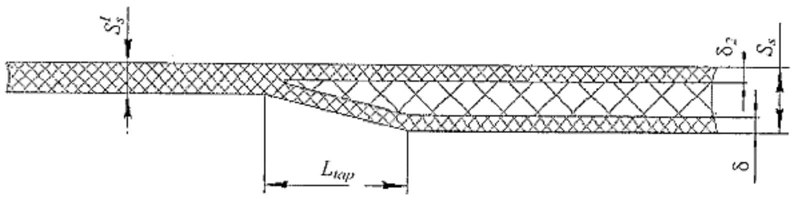


Fig. 3.2.2-2 Single-skin to sandwich transition of the deck plating

.10 deck parts subject to intense wear shall be protected according to the requirements of **3.2.2.1.7**.

3.2.3 Bulkhead platings.

3.2.3.1 Single-skin plating.

.1 plating of watertight bulkheads shall be single-skin where they carry heavy mechanisms and equipment that require secure and reliable fastening to the plating and bulkhead stiffeners.

.2 reinforcement materials, reinforcement composition and schemes for single-skin platings are recommended to be assumed the same as for single-skin deck platings (refer to **3.2.2.1.2** and **3.2.2.1.4**). Fabrics (0° direction) shall be laid vertically (relative to 0° direction). It is allowed to lay fabrics along butts and seams without overlapping;

.3 minimum thickness of bulkhead platings is determined from the diagram in Fig. 3.2.1-4, depending on ship length between perpendiculars *L*.

Accepted thickness of bulkhead platings shall be specified based on the results of strength and bucking strength calculations;

.4 procedure of bulkhead plating thickening shall be the same as for deck plating - by adding fabric layers on the packet of basic layers forming the plating when it is manufactured using the infusion technique, according to the provisions specified in **3.2.2.1.5**.

3.2.3.2 Sandwich plating.

.1 recommendations for selection of fabrics and reinforcement schemes for load-bearing layers of watertight bulkhead platings of sandwich construction are similar to those specified in **3.2.3.1.2**;

.2 core in sandwich bulkhead platings may be formed as in sandwich deck laminates, using foam plastic or mat reinforced with fiber layers, or consist of a corrugated element with foam plastic in a space between corrugations (refer to. **3.2.2.2.2** and **3.2.2.2.5**);

.3 minimum thickness of bulkhead plating load-bearing layers is determined from the diagram in Fig. 3.2.1-7, depending on ship length between perpendiculars *L*.

It is recommended to assume the thickness of a core filled with foam plastic to be at least 10 thicknesses of the load-bearing layer at the first approximation, while for the fiber-reinforced mat core - at least its 5 thicknesses;

.4 in case of the expanded-type foam, the foam plastic density in the core may be reduced by 10 - 20 kg/m^3 compared to the foam plastic selected for the upper deck (refer to **3.2.1.2.3**) but it shall be at least 40 kg/m^3;

.5 for structural orthotropic filler, the foam plastic density and corrugated element parameters shall be determined as the first approximation in accordance with the provisions of **3.2.2.2.5** and **3.2.2.2.6**. In such case, generatrix of a corrugated element shall be vertically directed;

.6 reinforcements in sandwich bulkhead platings shall be formed in deck plating, according to the provisions of **3.2.2.2.7**.

3.2.4 Framing members.

3.2.4.1 The stiffening framing members of the hull shell, deck (platform) plating, as well as bulkhead platings shall be generally moulded in accordance with **3.1.7**, using a closed box section.

3.2.4.2 The following alternatives of the section sheathing are possible:

.1 reinforcing fabric layers are laid on the surface of a core fitted on the shell (deck plating and bulkhead plating), continuously along the section profile simultaneously forming flanges that connect a framing member to the shell (plating) (refer to Fig. 3.2.4-1, *a*).

A face plate shall be reinforced by adding fabric or tape layers (laid along the framing member) between basic sheathing layers, or by assembling additional layers into a packet which is placed on a core followed by sheathing with basic layers;

.2 basic fabric layers forming the core sheathing are cut and laid when forming a face plate with an overlap, to alternate with each other successively while being laid from one and other section sides. In this case, a face plate contains twice as many fiber layers as compared to webs (refer to Fig. 3.2.4-1, *b*). A face plate may be also reinforced by adding fabric layers;

.3 A stiffener is moulded from premanufactured core with webs matted on both webs. Such premoulded stiffener is fitted on the shell (deck plating and bulkhead plating) and connected to by means of moulding-in angles.

A face plate is moulded as a strap, with its layers matted on the pre-moulded stiffener side and bent around the section web, each next layer overlapping a preceding one (refer to Fig. 3.2.4-2). A face plate may be also reinforced additionally with fabric or tape layers.

3.2.4.3 In all cases, a core is placed on the shell (deck plating and bulkhead plating) via adhesive. To form rounded flanges in section angles or moulding-in angles of the relevant radius, adhesive is also used, which may be filled with microspheres or chops to increase its viscosity, or special pastes.

3.2.4.4 For a filler (core) of a closed box section, it is recommended to use foam plastics of PVC type (refer to **2.3.3.6** and **2.3.3.8**), of the density not lower than the one recommended for the hull shell of a ship with the specified length (refer to **3.2.1.2.3**).

3.2.4.5 The sheathing of a closed box section shall be based on woven roving and multiaxial fabrics.

Additional layers between basic fabrics of the sheathing or a packet to reinforce a face plate of the framing member (refer to **3.2.4.2**) shall be also made of woven roving or multiaxial fabrics with reinforcement (0°/90°) of increased strength in 0° direction positioned along the framing member, or of one-directional tapes with reinforcement (0°).

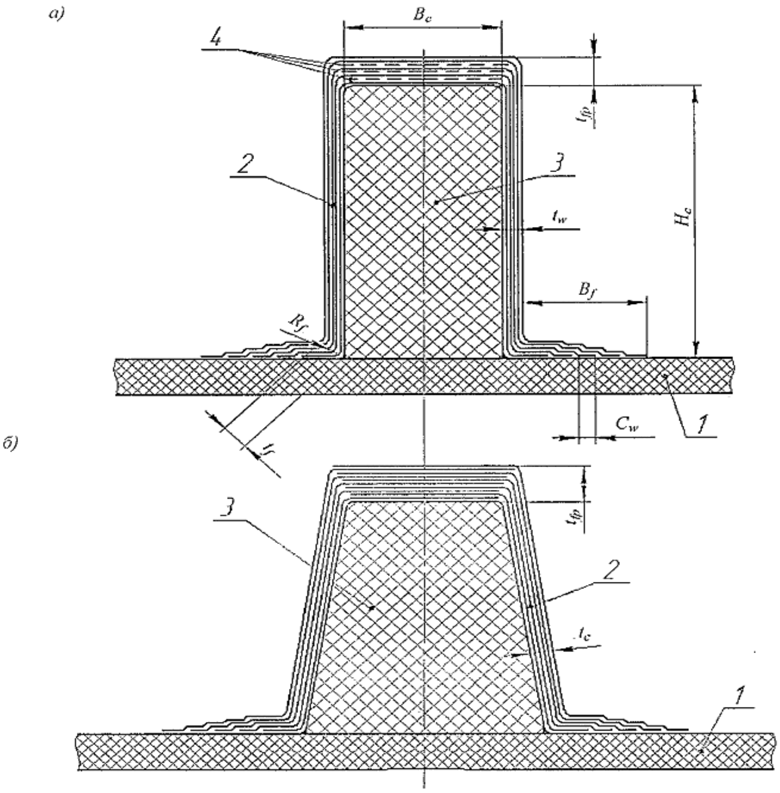


Fig. 3.2.4-1 Design of a closed box framing section with continuous sheathing along the stiffener contour (*a*) and with sheathing layers cut and overlapped on a face plate (*b*):
1 - shell (deck plating and bulkhead plating); *2* - stiffener sheathing; *3* - core;
4 - additional reinforcement of a face plate

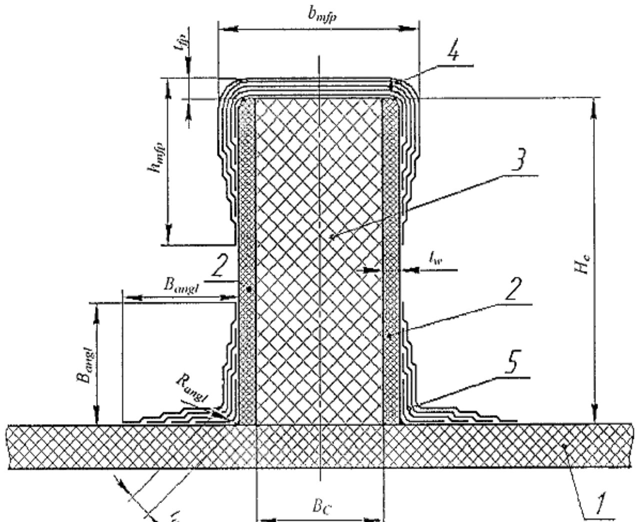


Fig. 3.2.4-2 Design of a closed box section of framing member with a face plate as a matted-on strap bent around section webs:
1 - shell (deck plating and bulkhead plating); *2* - section webs; *3* - filler (core);
4 - strap (face plate); *5* - matted-in angles

3.2.4.6 If relative depth of the framing member $H_c/l_p < 1/10$, where H_c is the section core depth, l_p - is the design length of the framing member span, then fabrics with reinforcement (0°/90°) with 0° direction laidalong the framing member, shall be used in the sheathing. In such case, fabric strength in this direction shall be at least not lower than in 90° direction.

For the relative depth of the framing member$H_c/l_p \geq 1/10$, the reinforcement scheme of the closed box section sheathing shall be parallel and diagonal that requires quadriaxial fabrics with reinforcement (0°/+45°/90°/-45°) or a mix of fabric (0°/90°) and diagonal fabric (+45°/-45°) in parts of equal thickness, with 0° direction laid along the member, to be applied. In the first and last 1 - 2 sheathing layers, fabric (0°/90°), shall be used, other layers shall consist of uniformly alternating layers of the first and diagonal fabrics (+45°/-45°).

Seams of fabric platings in the sheathing and cuts on section webs, that are performed in curvilinear framing members where necessary, shall be spaced not closer than 80 mm apart. Seams and cuts are permitted to be coincident in one section after 3 layers at least.

3.2.4.7 Scantlings of closed box section elements of framing members shall be selected at the first approximation from the following:

$$B_c/H_c = 0,35 \div 0,5;\ t_w/H_c = 0,03 \div 0,05;\ t_{fp}/t_w = 1,8 \div 2,2;$$

$$1,2B_c \geq b_f \geq 10t_w \geq 30 \text{ mm};\ t_f = t_w,$$

where: B_c, H_c - width and depth of the section core, accordingly;
t_{fp}, t_w - thicknesses of the face plate and webs accordingly;
b_f - width of flanges;
t_f - flange thickness in transition radius R_f to webs (refer to Fig. 3.2.4-1, *a*).

The value B_c for the trapezoidal section corresponds to the length of the trapezoid median, and it may be assumed equal to $B_c/H_c = 0,7 \div 1,0$, when the ratio of the shorter and longer base shall be approximately 0,6 ÷ 0,7.

3.2.4.8 For the closed box section of framing members (refer to Fig. 3.2.2-2) parameters of moulding-in angles shall be selected based on the following:

$$t_{angl} \geq 0,5s_p;\ b_{angl} \geq 15t_{angl};\ R_{angl} = (1,0 \div 1,2)t_{angl},$$

where: $s_p = (t_w + s_{shell}/2)/2$,
s_{shell} - thickness of the single-skin shell (deck and bulkhead plating);
$s_{shell} = 4\delta$ - for the sandwich shell (deck and bulkhead plating);
δ - average thickness of load-bearing layers.

The amount of the strap bending that forms a face plate around section webs is recommended to be assumed equal to $H_c - b_{angl} > h_{mfp} \geq 5t_s$, where $b_{mfp} = B_c + 2(t_c + t_s)$ (refer to Fig. 3.2.4-2).

3.2.4.9 T-shaped and L-shaped sections, the installation of which are appropriate in the areas with the heavy equipment (refer to **3.1.8**), are formed by bending the half of web thickness from each side around the face plate. The framing member shall be connected to the shell (deck plating, bulkhead plating) by means of with moulding-in angles (refer to Fig. 3.2.4-3).

3.2.4.10 T-shaped sections shall be made of woven roving and multiaxial fabrics, with one-directional bands used for the face plate reinforcement.

3.2.4.11 Depending on the relative depth of the T-shaped section web H_c/l_p the web reinforcement scheme may be (0°/90°) or (0°/+45°/90°/-45°) (refer to **3.2.4.6**). The portion of the face plate thickness which is matted on bent parts of the wed is made of fabrics with reinforcement (0°/90°) with increased strength in 0° direction and/or one-directional tapes (0°).

3.2.4.12 Scantlings of T-section elements of framing members shall be selected at the first approximation based on the following (refer to Fig. 3.2.4-3):

$$B_{fp}/H_w = 0,35 \div 0,5;\ t_w/H_w = 0,04 \div 0,08;\ t_{fp}/t_w = 2,0 \div 2,5.$$

Parameters of moulding-in angles shall be selected in accordance with the requirements of **3.2.4.8**.

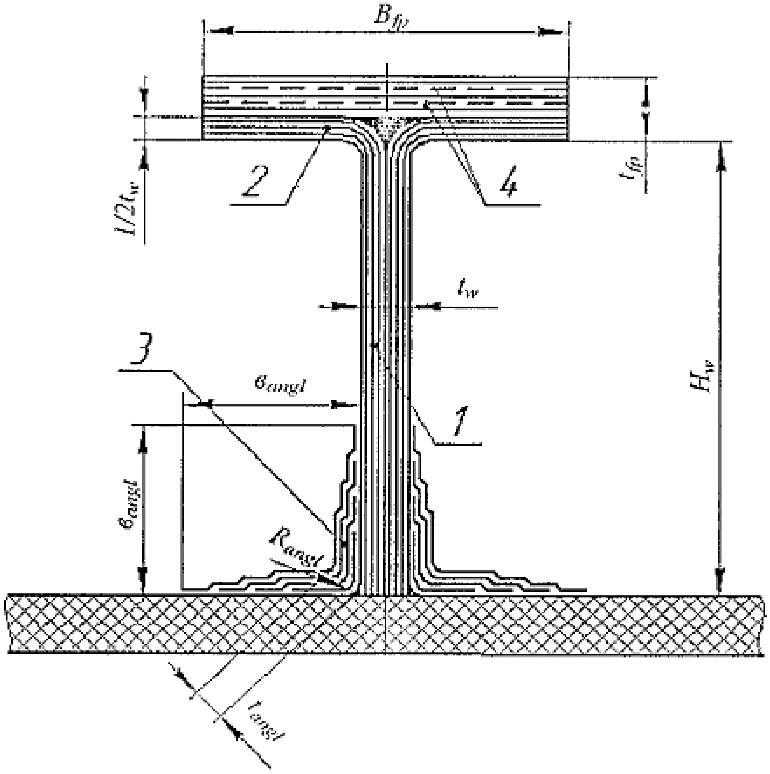


Fig. 3.2.4-3 Design of T-shaped section of framing members
1 - section web; *2* - face plate; *3* - moulding-in angles; *4* - additional reinforcement of a face plate

3.2.4.13 Scantlings of framing member elements shall be determined from the required bending stiffness using the following formula:

$$D_{11} = \sum_{i=1}^{n}(E_1^{(i)} F_i z_i^2 + I_i) - e^2 \sum_{i=1}^{n} E_1^{(i)} F_i z_i^2;\ e = \left(\sum_{i=1}^{n} E_1^{(i)} F_i z_i\right) / \left(\sum_{i=1}^{n} E_1^{(i)} F_i\right),$$

where: $E_1^{(i)}$ - Young's modulus of material of the *i*-th member section element along the framing member longitudinal axis;

F_i - cross-sectional area of the *i*-th element;

z_i - distance of the *i*-th element's center of gravity from the reference axis.

For members with the relative depth of the section H_c/l_p < 1/10 the bending stiffness D_{11} is determined as the maximum of the values:

$$D_{11} = \max(D_{11}^l, D_{11}^s);$$

$$D_{11}^l = \mu \frac{M_p l_p}{k_w};\ D_{11}^s = E_1^{(i)} \frac{M_p z_i}{k_\sigma \sigma_{11}^{(i)}},$$

where: M_p - design bending moment;

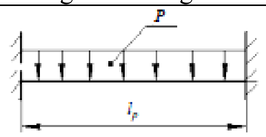
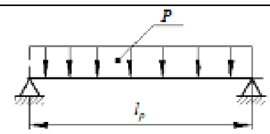
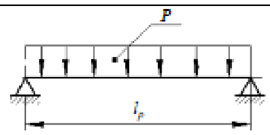
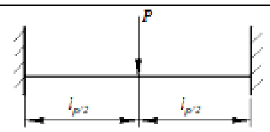
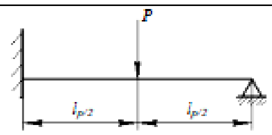
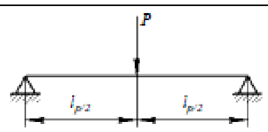
$\sigma_{11}^{(i)}$ - minimum ultimate strength of material of the *i*-th element (tensile strength or compression strength along the framing member);

μ - numerical factor depending on type of load and fastening of framing member support sections (refer to Table3.2.4.13);

k_w, $k_\sigma = k$, k_n - factors in accordance with **5.3.4** and **5.3.7**.

The formulae to determine the stress-strain behavior and shear capacity of framing members are specified in Appendix **1**.

Table 3.2.4.13 **Value of numerical factor μ**

№	Type of load and fastening of framing member support sections	$\mu \cdot 10^2$
1		3,125
2		7,688
3		10,417
4		4,167
5		3,646
6		8,333

3.2.4.14 Longitudinals (centre girder, stringers, deck girders) shall be continuous over the part of the ship length, which shall be at least 0,6*L*. In this case, longitudinals shall be continuous through transverse bulkheads and transverse deep members (floors and beams) (refer to Fig. 3.1.3, *d*).

3.2.4.15 Where the longitudinal framing member passes through the bulkhead, an opening therein shall exceed the section scantlings by 4 - 5 mm.

Where the bulkhead shall be watertight, gaps between the framing member and an opening shall be filled in with filler or paste based on chopped fibers and binder. After gaps are filled in, angle straps shall be matted on to connect the framing member to the bulkhead, and then straps to connect its face plate to the web and to overlap the first straps (refer to Fig. 3.2.4-4).

3.2.4.16 A passage assembly of longitudinals with the section core depth H_c^{prim} through transverses with the section core depth H_c^{tran} is prepared by matting on angle straps so that $H_c^{prim} < 0,7\ H_c^{tran}$.

The core of the transverse framing member during its installation is connected to longitudinal webs and face plate by means of compound or paste based on chopped fibers and binder, while transverse webs shall be thickened by 30 - 40 % by adding fabric layers to compensate for a opening passing the longitudinal (refer to Fig. 3.2.4-5).

3.2.4.17 Longitudinals (stringers, deck girders) shall terminate either behind the bulkhead while decreasing gradually in depth (refer to Fig. 3.2.4-6, *a*), or on the bulkhead connecting to it by means of moulding-in angles and a closed box section bracket (refer to Fig. 3.2.4-6, *b*). In the latter case the bracket core shall be manufactured from the same foam plastic as the framing member core and connected to the framing member face plate and bulkhead with adhesive or paste.

3.2.4.18 Transverse members (floors, frames and beams) shall be aligned.

Depending on the depth of longitudinals and transverses, the latter may pass through longitudinals with a passage assembly in accordance with Fig. 3.2.4-5.

Where the passage assembly can not be carried out in accordance with Fig. 3.2.4-5 (values of framing member depths are the same or approximately the same) shall be intercostal provided that longitudinals are continuous. In this case, a reliable connection shall be provided between framing member elements at their intersections, by means of adhesives and matted-on sheathings (refer to Fig. 3.2.4-7).

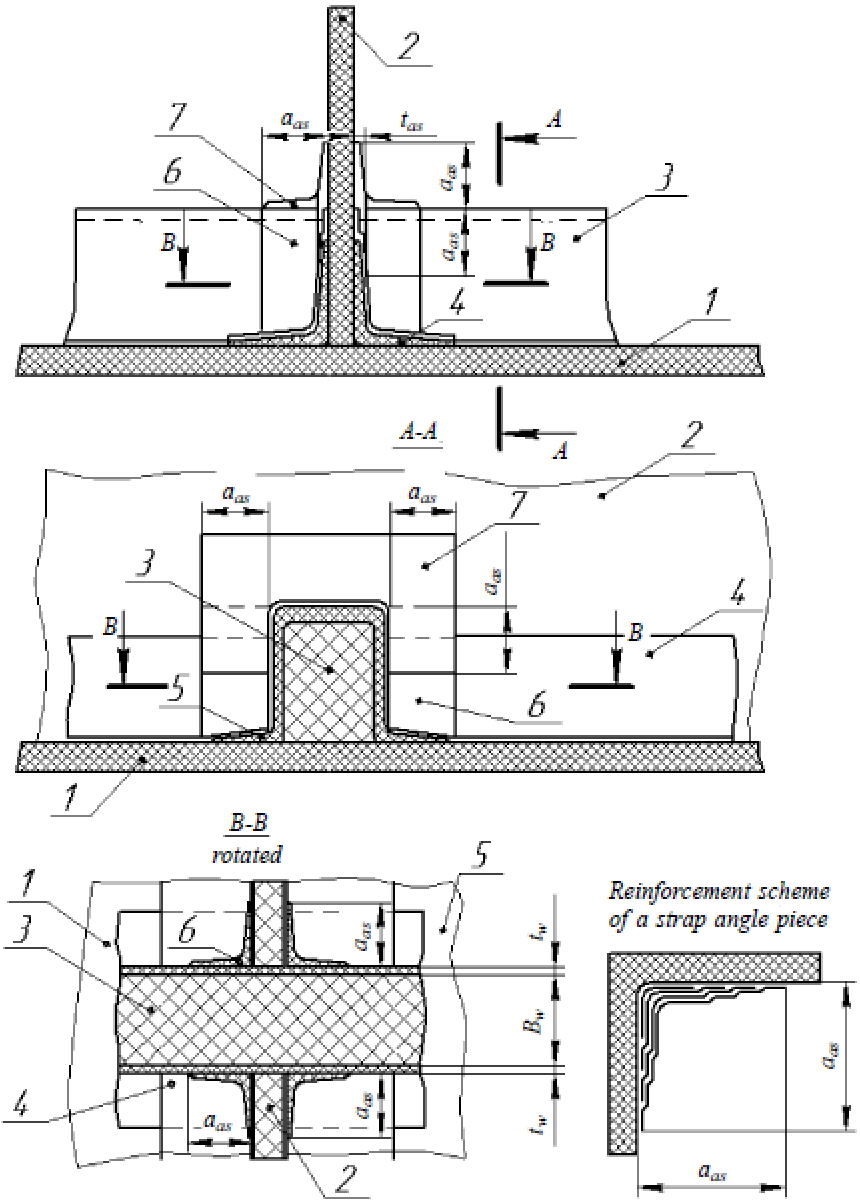


Fig. 3.2.4-4 Passage assembly for a closed box section framing member running through the watertight transverse bulkhead:
1 - shell (deck plating); *2* - bulkhead; *3* - framing member; *4* - bulkhead moulding-in angles;
5 - framing member flanges; *6* - angle straps connecting framing member webs to the bulkhead;
7 - angle strap connecting its face plate to the bulkhead: ($t_{as} \approx (0{,}5 - 0{,}7)\ t_w$, $a_{as} \approx 10t_{as}$)

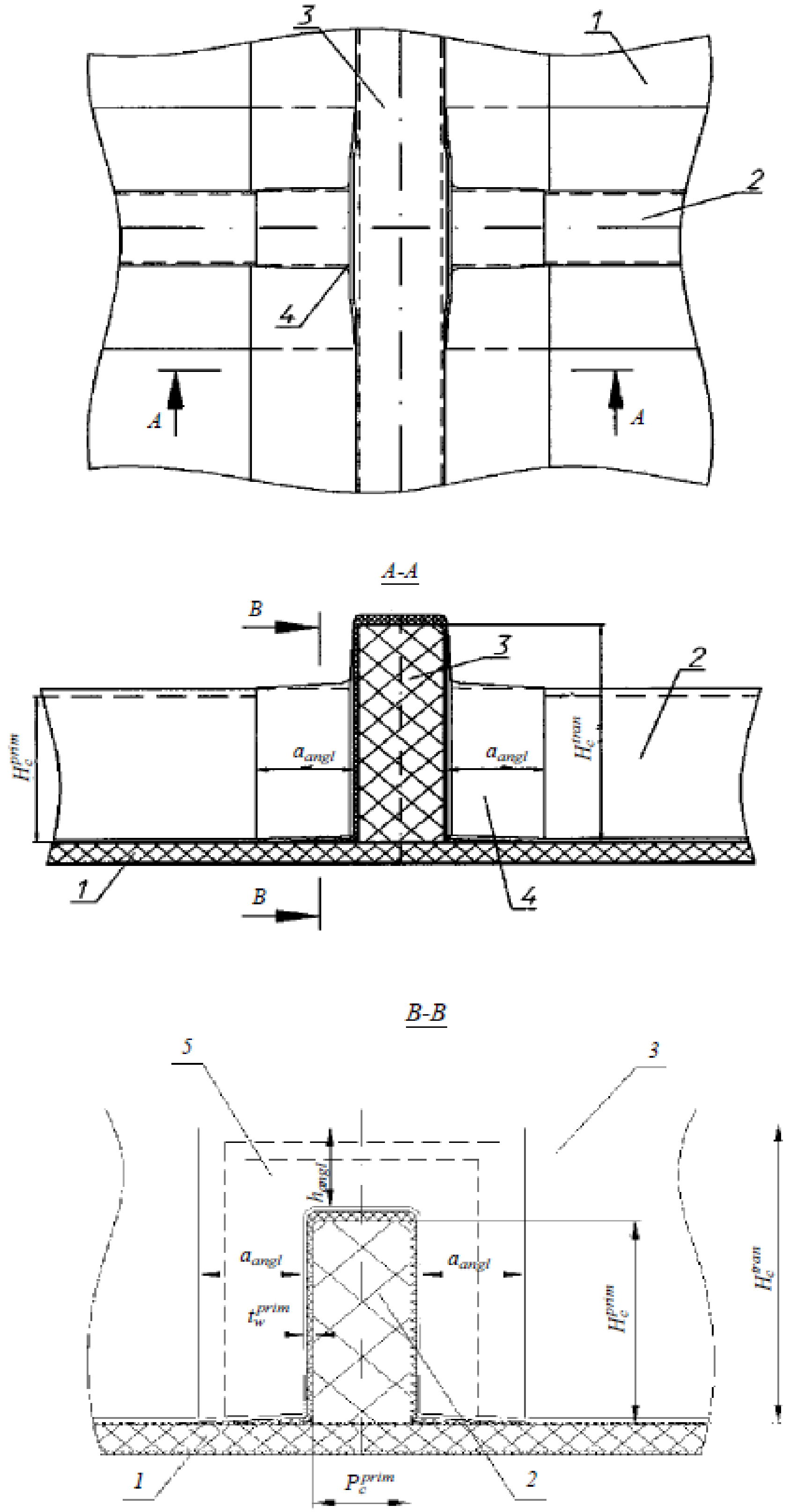


Fig. 3.2.4-5 Intersection of closed box sections of different depths:
1 - shell (deck); *2* - longitudinal; *3* - transverse; *4* - angle straps; *5* - thickening of transverse webs:
$a_{angl} \geq B_c^{prim}$; $t_{angl} = 0,8t_w^{prim}$; $h_{angl} \cong (H_c^{tran} - H_c^{prim}) \leq a_{angl}$)

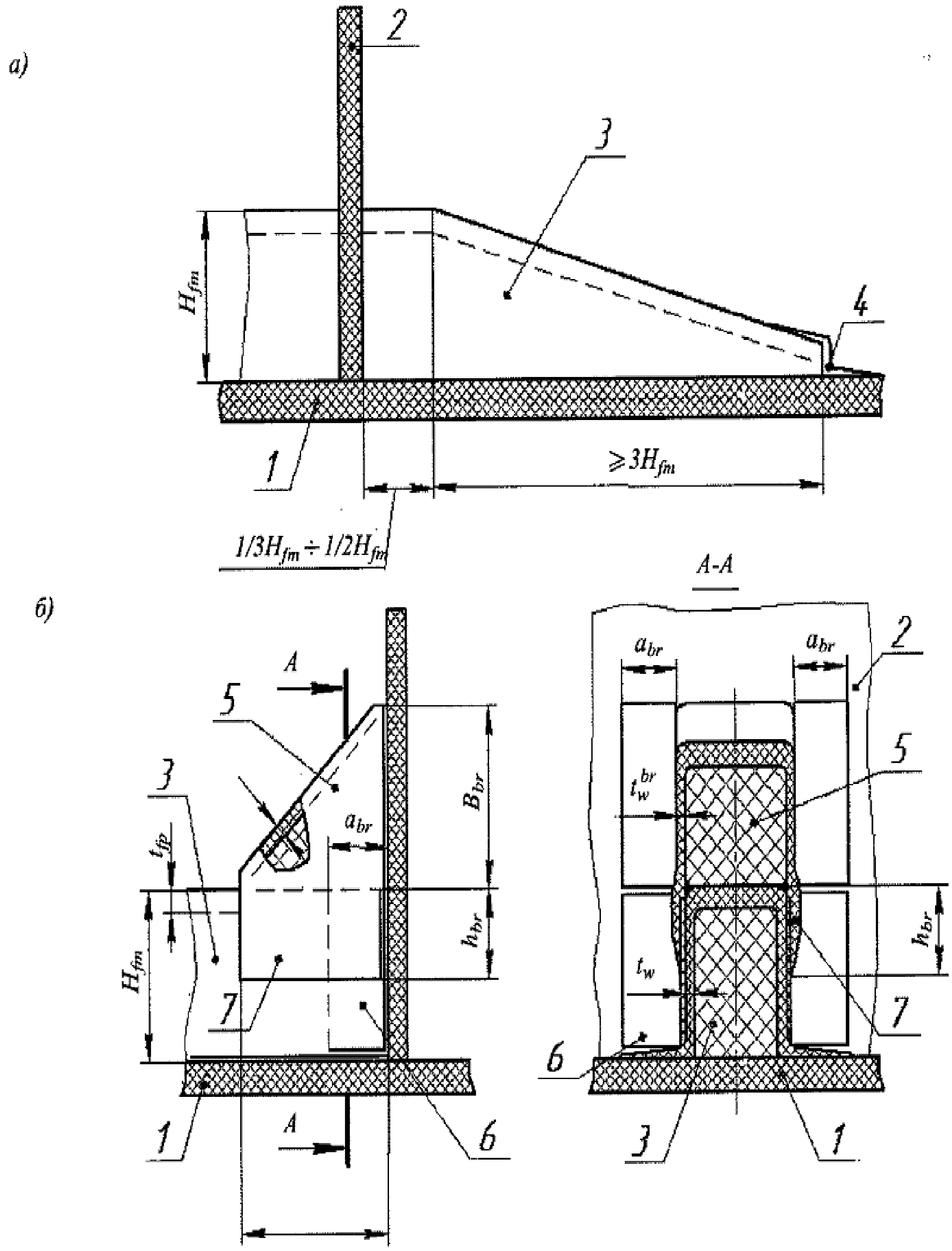


Fig. 3.2.4-Terminations of closed box section longitudinals:

a) _ bevel behind the bulkhead (design of the framing member passage through the bulkhead - refer to Fig. 3.2.4-5);

б - on the bulkhead with a closed box section bracket installed;

1 - shell (plating); *2* - bulkhead; *3* - framing member; *4* - moulding of the framing member end;

5 - bracket; *6* - angle strap connecting framing member webs to the bulkhead;

7 - bracket sheathing continued on framing member webs:

$B_{br} \cong H_{fm}$, $t_{fp}^{br} \geqslant 0{,}8 t_{fp}$, $t_w^{br} \cong t_w$, $t_{angl} \cong t_w$; $a_{br} \geqslant 12 t_w$; $1/2 H_{fm}) > h_{br} \geqslant 10 t_w^{br}$

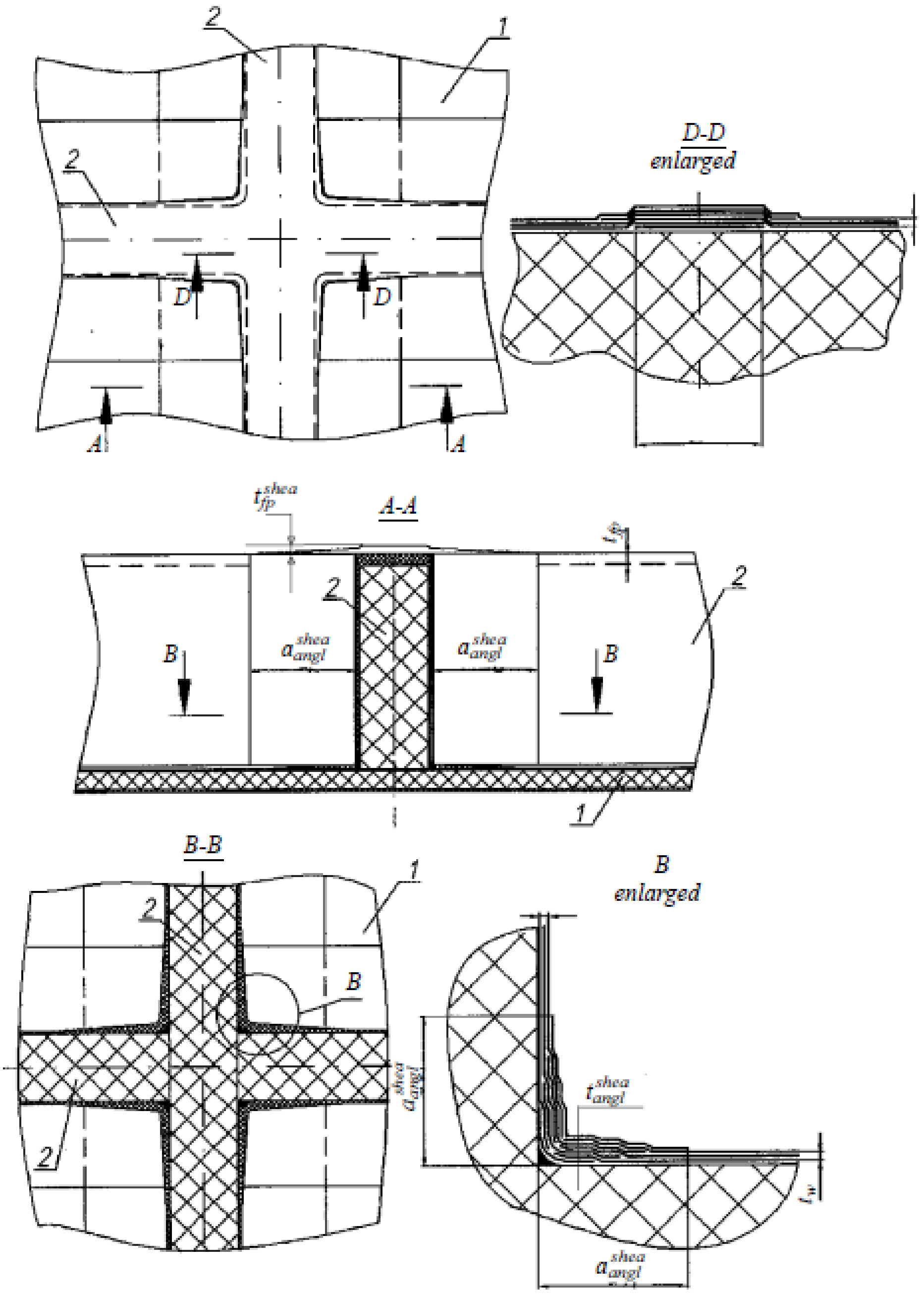


Fig. 3.2.4-7 Intersection of the longitudinal and intercostal transverse framing members of similar depths, with continuous face plates:

1 - shell (deck); *2* - framing members (scantlings of matted-on sheathings shall be determined according:

$$t_{fp}^{shea} \cong t_{fp};\ t_{angl}^{shea} \cong t_w;\ a_{angl}^{shea} \geq 12 t_{angl}^{shea}$$

3.2.4.19 Where the transverse frame member (frame) terminates on the longitudinal (stringer, deck girder), attachment of the first member end shall be ensured.

The intersection shall be performed by connecting the transverse frame core to longitudinal webs by means of adhesive, followed by moulding-in angles and the strap (refer to Fig. 3.2.4-8).

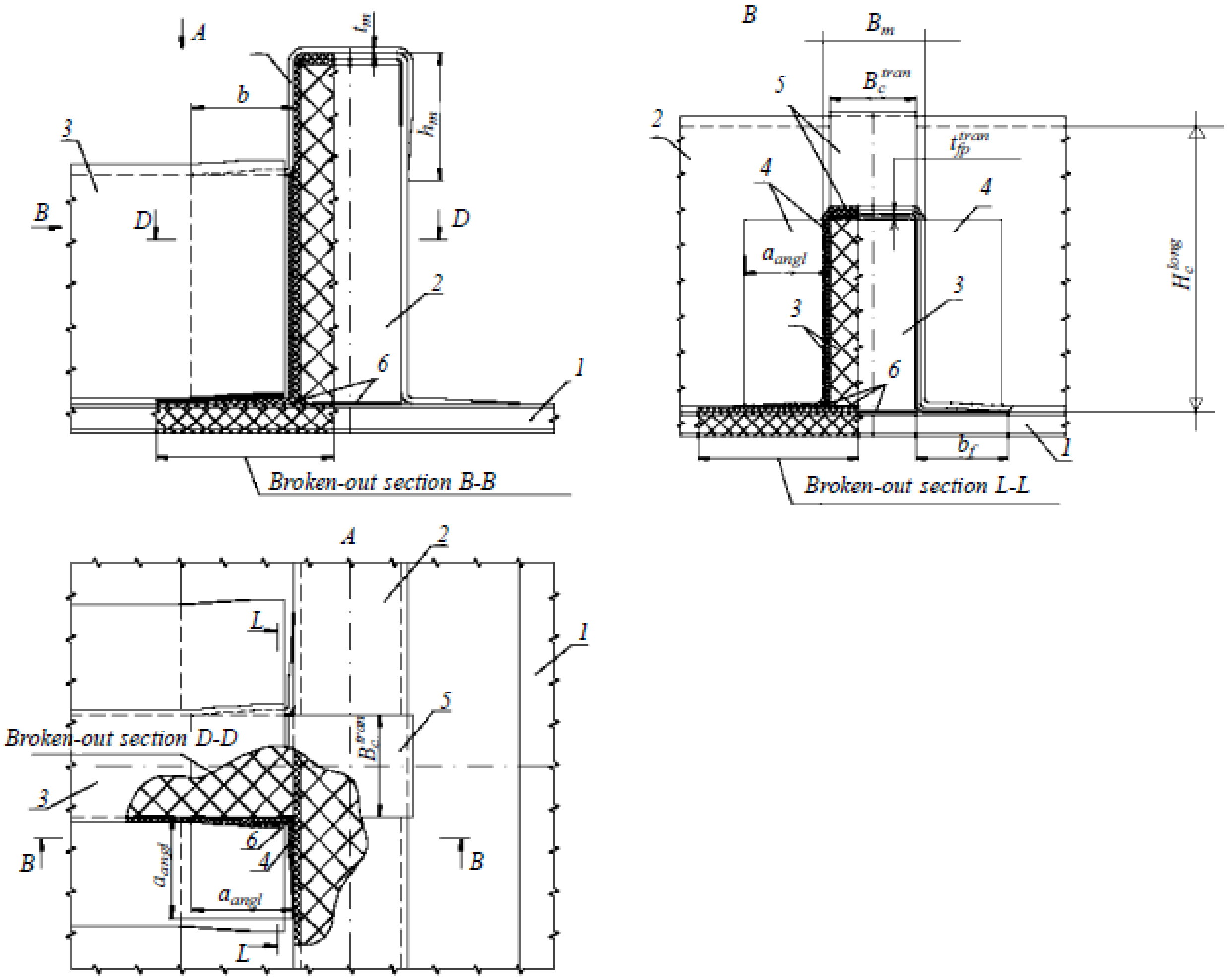


Fig. 3.2.4-8 Termination and joint of the transverse to the longitudinal:
1 - shell (plating); *2* - longitudinal; *3* - transverse; *4* - moulding-in angles ; *5* - strap; *6* - glue

$t_{angl} \cong t_w^{tran}$; $a_{angl} \geqslant 12t_w^{tran}$; $B_m = B_c^{tran} + 2t_w^{tran}$; $t_m \geqslant 0{,}8t_{fp}^{tran}$; $1/(2H_c^{long}) > h_m \geqslant 10t_m$

3.2.4.20 Reinforced floor and beam shall be in line with the web frame to form a ring structure.

Web frame scantlings shall be selected so that the value of its bending stiffness shall be at least 4 times that of the main frame.

The depth of reinforced floors shall be equal to at least the depth of the centre girder or side girders, whichever is greater. The depth of the reinforced beam shall be equal to at least 0,8 of the web frame depth.

3.2.4.21 The web frame is connected to the upper deck beam with a closed box section bracket, which core shall be manufactured from the foam plastic used in framing members being connected. In such case, it is recommended that the deck beam and frame section widths shall be equal to each other where a bracket is fitted, while the width of one framing member (beam, in general) gradually increases to the width of another member (frame).

The bracket core sheathing overlaps member webs, with its thickness gradually decreasing. The bracket face plate shall be thickened as compared to the webs by adding reinforcing fabric layers (refer to Fig. 3.2.4-9).

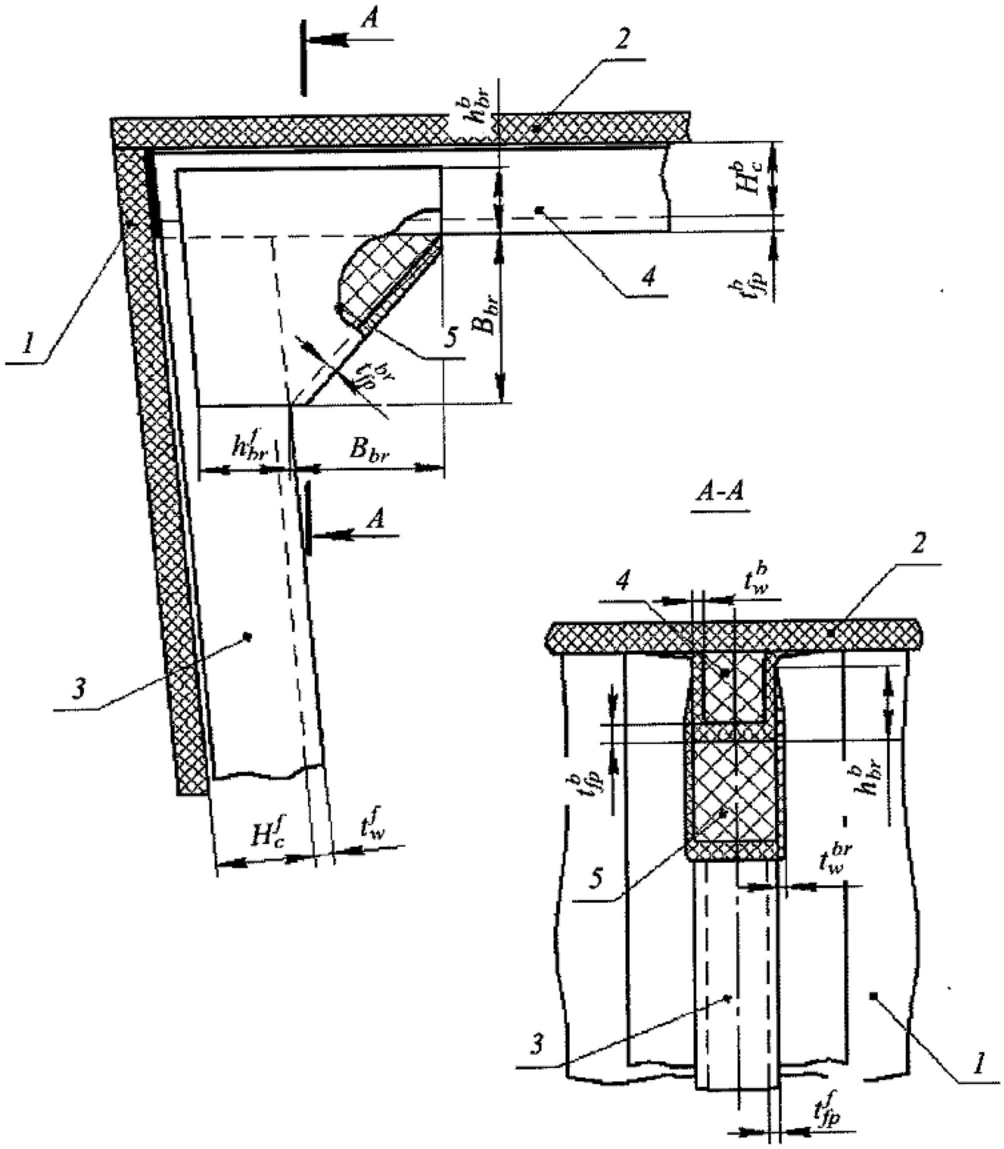


Fig. 3.2.4-9 Joint of the frame and upper beams:
1 - side plating; *2* - upper deck plating; *3* - frame; *4* - beam; *5* - bracket
$B_{br} \geq 0,8(H_c^b+H_c^f)$; $t_{fp}^{br}=1/2(t_{fp}^b+t_w^f)$; $t_w^{br}=1/2(t_w^b+t_{fp}^f)$; $h_{br}^{b(f)}=0,8H_c^{b(f)}$

3.2.4.22 The frame shall be continuous through the intermediate deck (platform) laminates. If necessary, its section depth may decrease gradually when passing through the deck laminates from the bottom tier to the upper one. The frame is connected to the intermediate deck (platform) beam with a bracket, which geometric parameters shall be selected in accordance with Fig. 3.2.4-10.

For the frame to pass through the deck laminate, an opening in the laminate shall exceed the frame section depth and width by 4 - 5 mm.

3.2.4.23 Vertical stiffeners of transverse bulkheads shall be in line with stringers and deck girder and continuous through intermediate decks (platforms).

They shall be connected to longitudinals (stringers, deck girders) by means of a closed box section bracket consisting of a core made of the same foam plastic as in the stiffener and in the sheathing (refer to Fig. 3.2.4-11).

3.2.4.24 Brackets in connections of framing members may be made as an individual closed box section element, which is then mounted on face plates of connected members by means of adhesive or paste, and straps are matted on webs of the bracket and members (refer to Fig. 3.2.4-12).

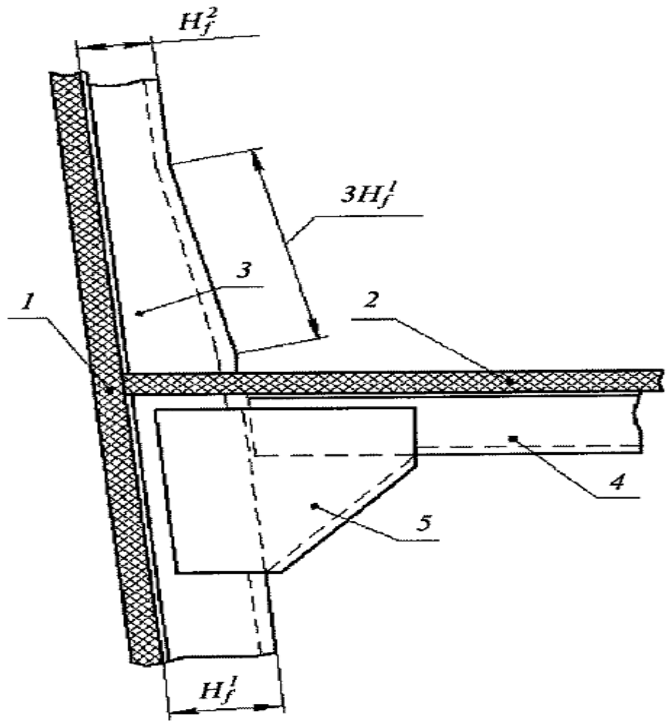


Fig. 3.2.4-10 Joint of the frame and intermediate deck (platform) beam:

1 - side plating; *2* - intermediate deck (platform) plating; *3* - frame; *4* - beam; *5* - bracket

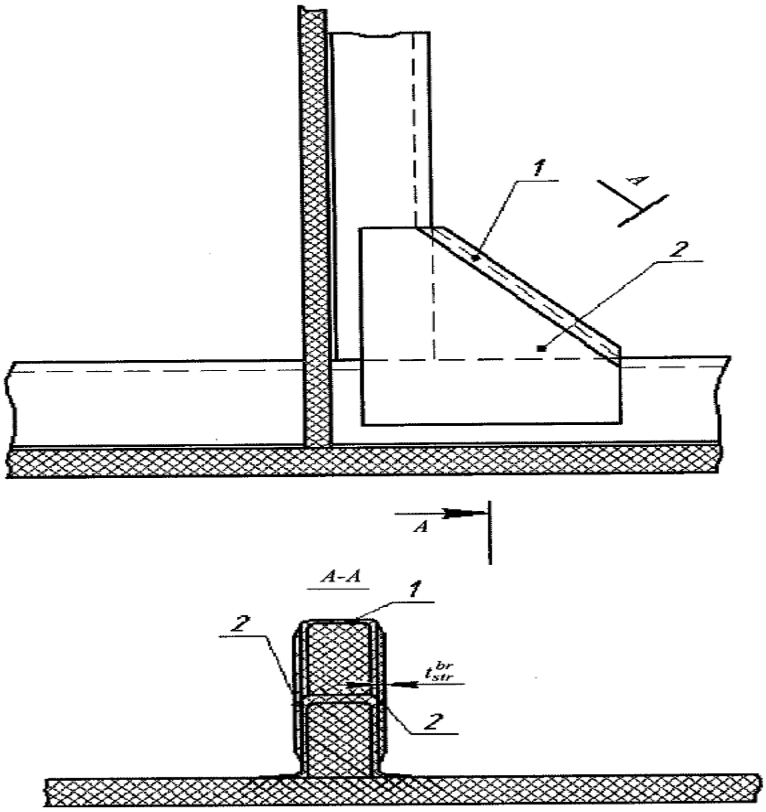


Fig. 3.2.4-12 Joint of the bracket and framing members by means of straps:
1 - bracket; *2* - straps $(t_{str}^{br} \cong t_{w}^{br})$

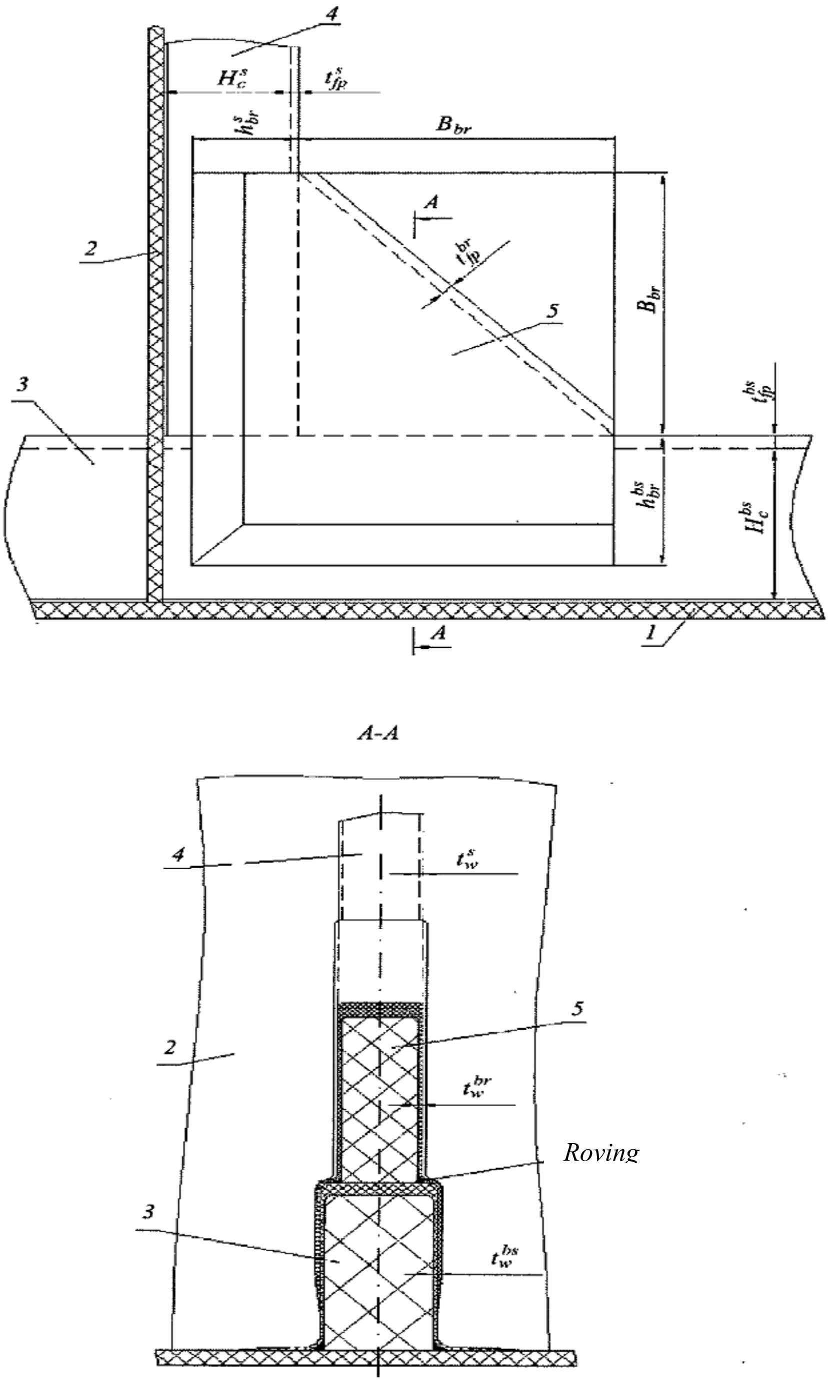


Fig. 3.2.4-11 Joint of the bulkhead stiffener and longitudinal (stringer, deck girder):
1 - bottom plating (deck plating); *2* - bulkhead plating; *3* - longitudinal bulkhead; *4* - stiffener; *5* – bracket
$B_{br} \geqslant 1{,}5H_c^s$; $t_{fp}^{br} = 1/2(t_{fp}^s + t_{fp}^{bs})$; $t_w^{br} = 1/2(t_w^s + t_w^{bs})$; $h_{br}^{bs(s)} = 0{,}7H_c^{bs(s)}$

3.2.4.25 Intermediate stiffeners that are fitted to stiffen the bulkhead plating between main stiffeners may be sniped at their ends (near the bottom and upper deck) (refer to Fig. 3.2.4-13). Intermediate stiffeners may be cut on intermediate decks and platforms.

Main stiffeners may be sniped based on the strength calculations and the Register approval.

3.2.4.26 Scantlings of closed box section stiffeners shall be determined according to the requirement of **3.2.4.7** and confirmed by the results of buckling strength calculations (refer to Appendix **1**).

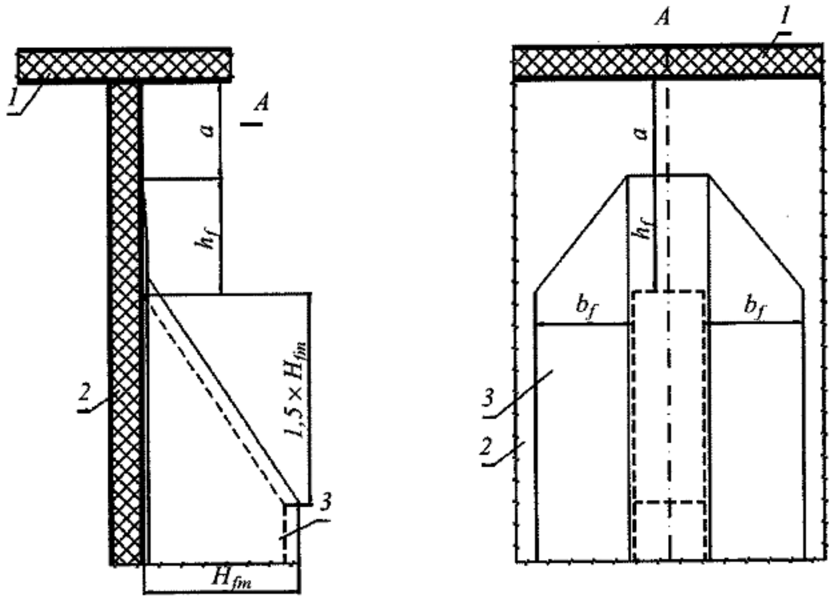


Fig. 3.2.4-13 Beveled termination of the bulkhead stiffener:
1 - bottom plating (deck plating); *2* - bulkhead plating; *3* - closed box section member

3.2.4.27 All connecting elements in connections of framing members to each other and to other hull members shall have a parallel reinforcement scheme and based on woven roving and biaxial fabrics with reinforcement (0º/90º).

Sheathings of brackets shall be of parallel and diagonal reinforcement scheme with the use of quadriaxial fabrics with reinforcement (0º/+45º/90º/-45º) or a mix of fabrics with reinforcement (0º/90º) and (+45º/-45º).

3.2.4.28 Openings in face plates of framing members are not allowed.

Openings in the framing member webs for the passage of passing pipes, cables, etc., are allowed with a maximum linear dimension not exceeding 1/3 of the member section (core) depth. Webs shall have parallel and diagonal reinforcement scheme (0º/+45º/90º/-45º).

Openings with diameter less than 1/5 of the member section depth are allowed not to be reinforced. Openings with diameter more than 1/3 of the member section depth shall be reinforced. Reinforcement shall performed by matting-on a strap along the section perimeter, with member webs and a face plate (refer to Fig. 3.2.4-14).

Strap material shall correspond to that of the framing member sheathing where an opening is located. Parallel and diagonal reinforcement scheme of the strap (0º/+45º/90º/-45º) shall be used.

3.2.4.29 The framing members shall be provided with water courses (scuppers to drain water and other liquids).

Openings for scuppers in framing webs of closed box sections shall be reinforced by placing a thinwalledformer manufactured of fiber-reinforced plastic using paste. Scupper opening depth shall be equal to 5 - 50 mm (refer to Fig. 3.2.4-14).

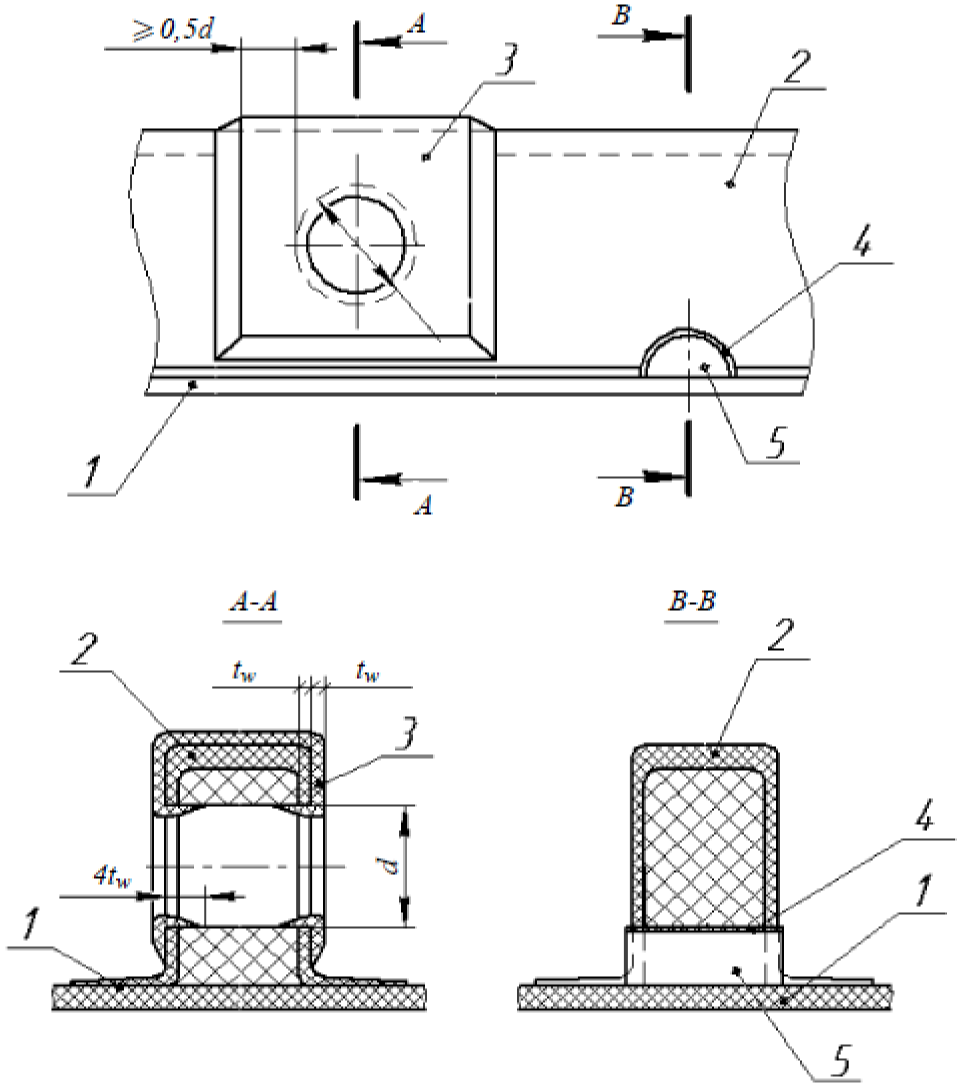


Fig. 3.2.4-14 Reinforcement of openings in closed box sections of the framing members
1 - shell plating (deck plating, platform); *2* - member; *3* - strap; *4* - opening former;
5 - water course (scupper)

3.2.5 Openings.

3.2.5.1 All openings in the side, deck, and bulkhead platings shall be reinforced where their minimum linear dimension exceeds the following values (whichever is less):

15 thicknesses for single-skin structures, or 150 mm;

5 thicknesses for sandwich structures, or 250 mm.

3.2.5.2 Openings in single-skin structures are reinforced by local thickening of the shell (deck laminate, plating) around the opening on the area with dimensions determined in accordance with Fig. 3.2.5-1, *a* and 3.2.5-2.

It is allowed to increase thickness by means of straps where infusion technique is applied for the structure manufacture, or where an opening location has not been determined earlier and its minimum dimension does not exceed 30 thicknesses of the shell (deck laminate, plating). Otherwise, the thickness shall be increased in advance by moulding additional fabric layers between basic ones.

3.2.5.3 To reinforce openings in the shell, deck and bulkhead plating of the sandwich structure, the following techniques are recommended to be applied:

local thickening of load-bearing layers over the specified area around the opening;

replacement with a foam plastic with higher density over the thickness at least 3*h* where *h* is 1/2 of the core thickness from the edge of an foam plastic opening, along the opening contour (refer to Fig. 3.2.5-1, *b* and 3.2.5-3).

Load-bearing layers shall be thickened with straps by matting on additional fiber layers simultaneously with moulding of the structure edge along the opening contour.

Density of the foam plastic added in the core along the opening contour shall be 30 - 40 kg/m^3 higher than that of the entire core in the structure, but not more than 200 kg/m^3. In this case, where the core is made of the lightweight mat reinforced with fabric (refer to Fig. 3.1.1, *c*), its reinforcement along the opening contour is not required.

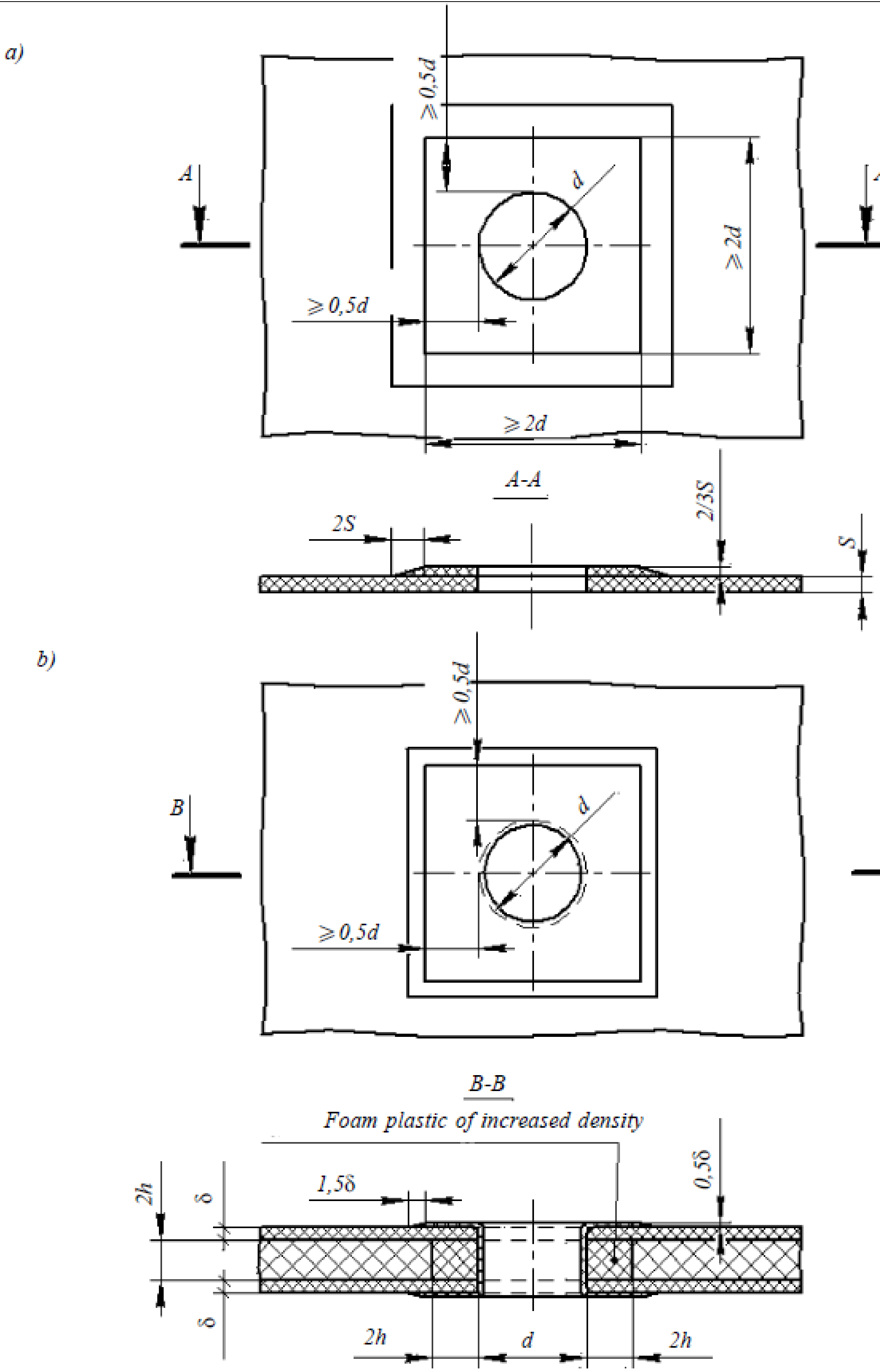


Fig. 3.2.5-1 Reinforcement of a round opening in single-skin (*a*) and sandwich (*b*) structures

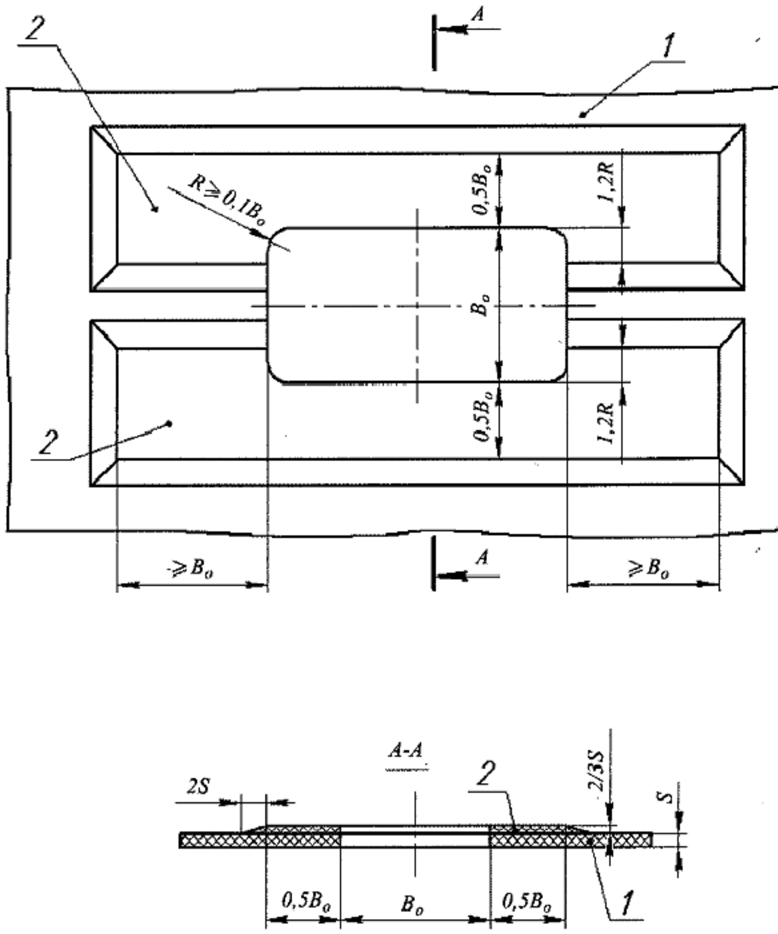


Fig. 3.2.5-2 Reinforcement of a rectangular opening in a single-skin structure:
1 - deck (platform) plating; *2* - thickenning

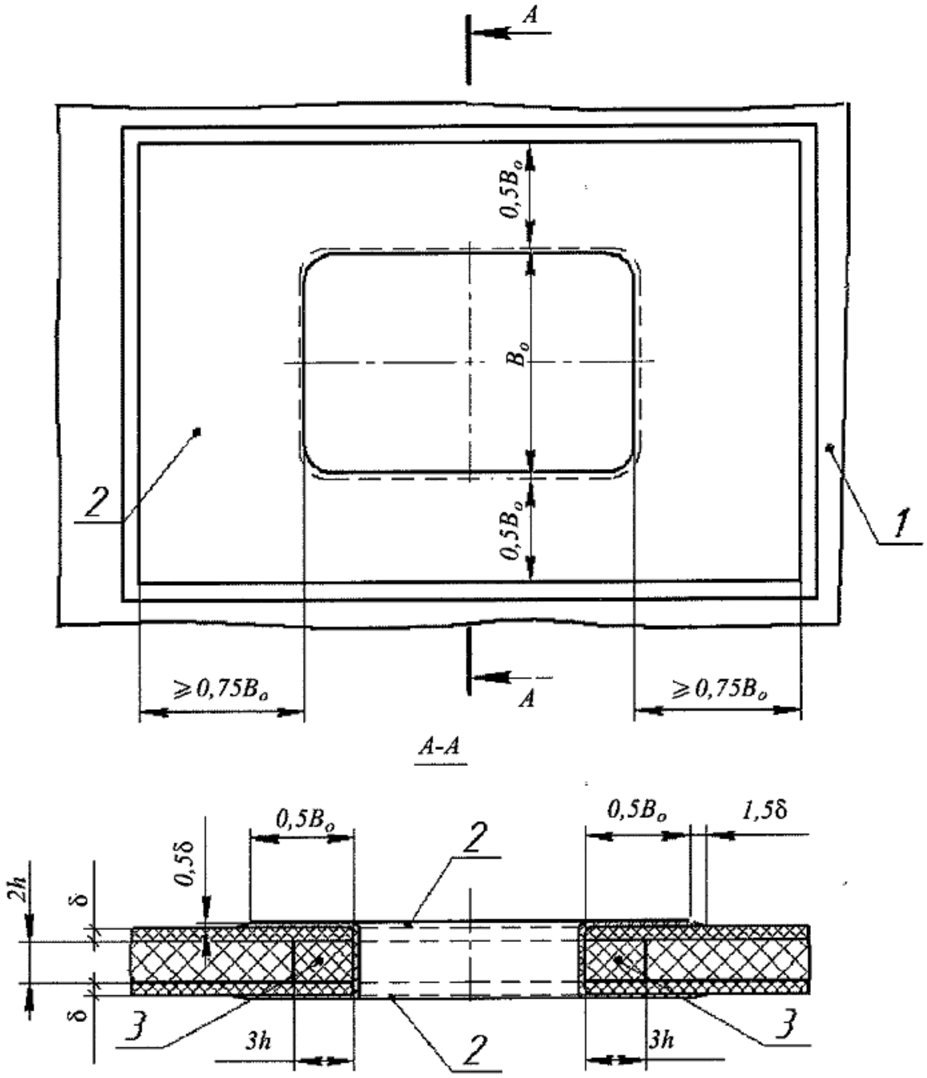


Fig. 3.2.5-3 Reinforcement of a rectangular opening in a sandwich structure:
1 - deck (platform) plating; *2* - thickening of load-bearing layers; *3* - foam plastic of increased density

3.2.5.4 The structure around the opening shall be thickened using the same fabrics as for the structure manufacture.

Round openings may be reinforced with woven roving and biaxial fabrics with reinforcement (0°/90°), (+45°/-45°) or with a combination thereof.

The reinforcement scheme of the thickened area around a rectangular opening shall, as far as possible, be the same as where this opening is located.

Thickening tapering shall be gradual, with each fabric layer overlapped over 30 - 50 mm with the subsequent layer.

3.2.5.5 Comparatively large openings in the deck, which width exceeding 1/4 ÷ 1/3 of the deck width, shall be reinforced with coamings.

Coamings may be manufactured from the same materials as the deck and have either closed box or *L*-shaped cross section. They may be also made of metal, e.g. standard coamings of hatchway covers.

Openings may not be provided with coamings. In this case, they shall be confined with deck girders and beams that shall be placed as close as possible to the opening edge, equal to the framing member flange width. Where this is not possible, additional members shall be provided, their terminations considering the provisions of **3.2.4.17**.

3.2.5.6 In exceptional cases, two or more deck openings spaced from each other to a distance measured between their edges and equal to less than 1,5 of the smallest opening width are allowed. Such openings shall be reinforced by increasing the plating thickness on the entire deck area where such group of openings is located.

Where the deck has a sandwich structure with the foam plastic in a core, in addition to thickening of load-bearing layers, the foam plastic of increased density shall be added along opening contours, according to the provisions of **3.2.5.3**.

3.2.5.7 Where the distance between openings is longer than that specified in **3.2.5.6**, a decision to increase the thickness of the laminate or load-bearing layers on the entire deck area where openings are located, or around each opening individually, or around separate openings, shall be taken on the basis of structural particulars and approved by the Register.

3.2.5.8 Openings around a deck stringer are not allowed. In exceptional cases, round holes of not more than 150 mm in diameter are allowed in a deck stringer. Opening edges shall be reinforced according to **3.2.5.2** and **3.2.5.3**.

3.2.6 Joints.

3.2.6.1 General.

.1 these requirements are applied to moulded butt (seam) and fillet joints of hull structural members, which are made with the use of adhesives and butt straps moulded layer by layer and moulding-in angles;

.2 butt straps and moulding-in angles shall be made of the same materials and have the same reinforcement scheme as the members being jointed;

.3 butt and angle joints between contact surfaces of the members being jointed shall be provided with adhesives, the properties of which shall ensure the specified strength of the joint and enable using it under production conditions of the shipyard, considering the requirements of **2.3.4;**

.4 butt straps and moulding-in angles shall be moulded by either infusion or contact moulding techniques while complying with the requirements for quality of preparation of surfaces being jointed and relative content of binder during moulding of straps and angles in accordance with the process regulations;

.5 selected parameters of joints, considering the requirements of **3.2.6.2** and **3.2.6.3,** shall be specified based on the results of strength calculations.

3.2.6.2 Moulded butt joints.

.1 material and reinforcement scheme of straps in moulded butt joints shall match the members being jointed (refer to **3.2.6.1.2**). Fabrics with reinforcement (0º/90º) may be laid with 0º direction along the butt, however in this case the breaking load in 90º direction shall not be lower than that in 0º direction;

.2 where the thickness of single-skin members being jointed does not exceed 10 mm, edge preparation may be omitted (refer to Fig. 3.2.6-1).

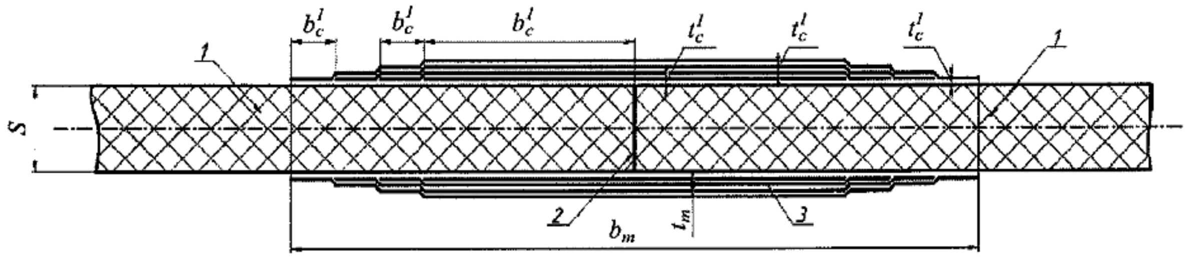


Fig. 3.2.6-1 Structural scheme of a moulded butt (seam) joint of single-skin members without edge preparation:
1 - members being jointed; *2* - butt; *3* - straps

For this type of joint, strap parameters shall be selected from the following:

$b_m \geq 180 + 15s$, in mm;

$b_c = 30 \div 50$, in mm;

$t_m \geq 0,5s$, in mm - for butt straps with parallel reinforcement scheme (0º/90º);

$t_m \geq 0,8s$, in mm - for butt straps with parallel and diagonal reinforcement scheme (0º/90º)(+45º/-45º).

.3 where the thickness of single-skin members exceeds 10 mm, butt joints shall be made with stepped edge preparation and beveling. These types of joints shall be used for connection of sandwich members;

.4 butt joint with stepped edge preparation is made by sequential removal of reinforcing material layers in members being connected around the butt (refer to Fig. 3.2.6-2).

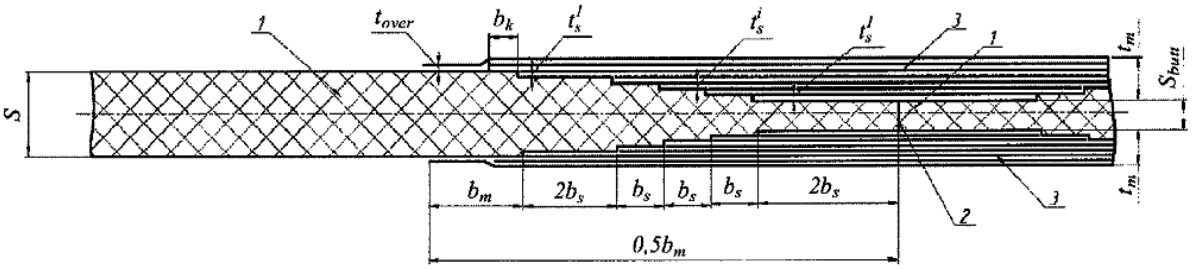


Fig. 3.2.6-2 Structural scheme of a moulded butt (seam) joint of single-skin members with double side stepped edge preparation:
1 - members being jointed; *2* - butt; *3* - straps

Joint parameters for single-skin members shall be selected from the following:

$s'_{butt} = 0{,}25s \geq 2$, in mm;

$m_1 = s'_{butt}/t_d$ (where m_1 is a fractional number, it is rounded to the smallest integral value);

$n_1 = (m - m_1)/2$,

where n_1 is an integral number $m_{butt} = m_1$;

where n_1 is a fractional number $m_{butt} = m_1 + 1$, and n_1 is rounded to the smallest integral value;

$s_{butt} = t_d\ m_{butt} \geq 2$, in mm;

$n_2 = (n_1 - 6)/3$ (where n_2 is a fractional number, it is rounded to the smallest integral value);

$n = 4 + n_2 + k$; $b_m \geq 2[(n + 2) \cdot b_s + b_n]$, in mm;

$b_n = 2b_s \geq 40$, in mm; at $b_s = 20 \div 30$, in mm;

$b_k = b_s$;

$t_m > 0{,}5(s - s_{butt}) + t_{over}$, in mm;

where: n - number of preparation steps;

m - number of fiber layers in a panel;

m_{butt} - number of fiber layers in the butt of panels s_{butt};

s'_{butt} - initial butt thickness;

s_{butt} - end butt thickness;

m_1 - number of fiber layers in the butt of panels of s'_{butt} in thickness;

t_d - thickness of one fabric or packet layer;

t_m - strap thickness;

k – factor equal to 0, if n_2 is an integral value, and equal to 1, if n_2 is a fractional number;

Steps shall be of the following depths t_s^i:

the first t_s^1 and the last step t_s^n - 1 fiber layer;

the second step t_s^2 - 2 fiber layers;

the third t_s^3 and subsequent steps – 2 ÷ 3 fiber layers, the following shall be taken into account:

where n_2 is an integral value, all the steps from the third one to the last but one shall have the thickness equal to 3 fabric layers;

where n_2 is a fractional number, and a figure after the decimal point is equal to 3, then (n_2-1) step shall have the thickness equal to 3 fabric layers and 2 steps with the thickness equal to 2 fabric layers;

where n_2 is a fractional number, and a figure after the decimal point is equal to 6, then n_2 steps shall have the thickness equal to 3 fabric layers and 1 step with the thickness equal to 2 fabric layers $t_s^{(n-1)}$ - 2 fiber layers.

For other symbols, refer to Fig. 3.2.6-2.

The number of external straps with thicknesses $t_{over} \approx t_d$ is equal to 2.

Butt joint parameters of sandwich members are determined from the following correlations:

$S_{fl} = m'''_{butt} \cdot t_d$, in mm;

$S_{butt} = 2S_{fl}$, in mm;

$n_1 = m''' - m'''_{butt}$;

where: S_{fl} - thickness of 1 fabric load-bearing layer in butt;

m''' - number of fabric layers in load-bearing layer;

m'''_{butt} - number of fabric layers in the butt of load-bearing layer;

$n_2 = (n_1 - 6)/3$ (where n_2 is a fractional number, it is rounded to the smallest integral value);

$t_m > \delta_{imax}$, in mm,

where: δ_{imax} ($i = 1,2$) - maximum thickness of one of two load-bearing layers;

s_{butt} - thickness of load-bearing layers in the butt.

Other strap parameters, number of steps and their depth shall be determined from the above correlations for the stepped joint of single-skin members;

.5 structural scheme of the butt joint with beveling for single-skin members is specified in Fig. 3.2.6-3.

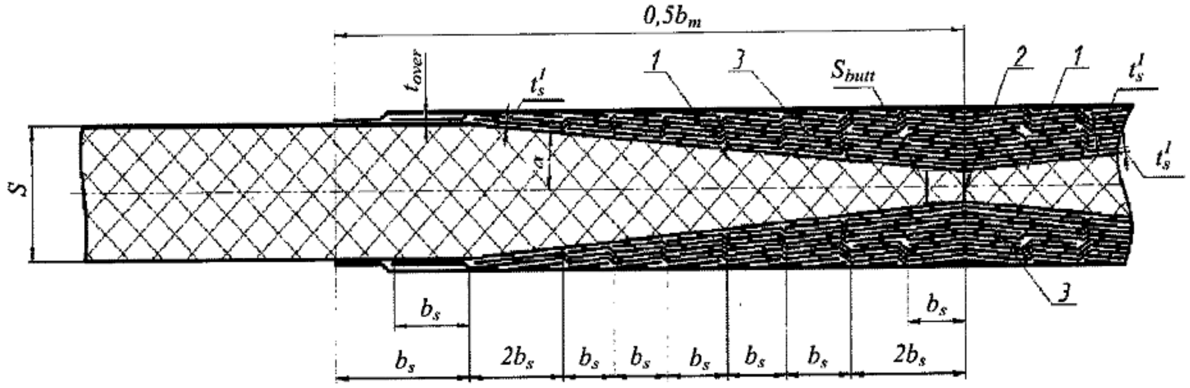


Fig. 3.2.6-3 Structural scheme of a moulded butt (seam) joint of single-skin members with double stepped beveling:
1 - members being connected; *2* - butt; *3* - straps

Parameters of butt joint with beveling for single-skin members shall be selected from the following:

$\alpha \leq 4^{o}$;

$s'_{butt} = 0{,}125s \geq 2$, in mm;

$n = ((s - s_{butt})/(2\alpha b_s)) - 2$ (where n is a fractional number, it is rounded to the smallest integral value);

$b_c = 15 \div 20$, in mm; $b_n = 2b_s \geq 30$, in mm;

$\cos(\alpha)/n(0{,}6(s - s_{butt}) + 0{,}2t_{over}n_{over}) \geq t'_n \geq n_1/n\ t_d \cdot \cos\alpha$, in mm (angle α, in deg.),

where t'_n - strap thickness in butt area.

Other joint parameters are determined from formulas for the stepped joint of single-skin members (refer to **3.2.6.2.4**).

Parameters of butt joint with beveling for sandwich members are determined according to the formulae for single-skin member parameters and according to the following formulae:

$\alpha \leq 2^{o}$; s_{butt} = thickness of 1 fabric layer;

$n = (\delta_{imax} - s_{butt})/(\alpha \cdot b_s) - 2$ (where n is a fractional number, it is rounded to the smallest integral value);

$(\cos(\alpha))/n \cdot (1{,}2(\delta_{imax} - s_{butt}) + 0{,}2t_{over}n_{over}) \geq t'_n \geq (\delta_{imax} - s_{butt})/n \cdot \cos(\alpha)$, in mm (angle α, in deg.);

.6 to connect members of hull structures, it is allowed to use joints of non-symmetrical thickness with and without edge preparation, e.g. to ensure a smooth outer surface of the deck (platform), beveling is performed on this surface, whereas on the opposite surface a strap is matted on the butt without edge preparation.

Straps with and without edge preparation shall be selected considering the requirements of **3.2.6.2.2, 3.2.6.2.4** and **3.2.6.2.5**;

.7 application of other butt (seam) joints for single and sandwich members of hull structures shall be substantiated based on the calculation and experimental results and agreed with the Register.

3.2.6.3 Moulded fillet joints.

.1 in moulded fillet joint that are not subject to significant shear in member reinforcement planes, the reinforcement scheme of moulding-in angles shall be (0°/90°) with 0° direction along the joint. In this case, the breaking load in 90° direction shall be not lower than that in 0° direction.

Where the members being jointed are exposed to higher shear strains, the reinforcement scheme of moulding-in angle shall be parallel and diagonal (0°/+45°/90°/-45°), for which purpose it is recommended to use combination of two fabrics (0°/90°) and (+45°/-45°) each of not more than 0,5 mm in thickness, to ensure their fitting to connection angles;

.2 when moulding-in angles in fillet joints, their thickness shall taper from the root towards leg terminations by each next fabric layer overlapping the preceding one over value ay, which is assumed equal to $a_{angl} = 10 - 15$ in mm (refer to Fig. 3.2.6-4).

Basic parameters of moulding-in angles in single-skin member joint shall be selected from the following:

$t_{angl} \geq 0{,}8s$, $b_{angl} \geq 15t_{angl}$ або $b_{angl} \geq 100 + 5s$ (whichever is greater),

where s - thickness of a horizontal member;

$R_{angl} \geq 1{,}5t_{angl}$;

.3 contact surface of vertical and horizontal members and angles, shall be coated with adhesion that serves for joint of members and rounding of angles prior to moulding of moulding-in angles (refer to Fig. 3.2.6-4);

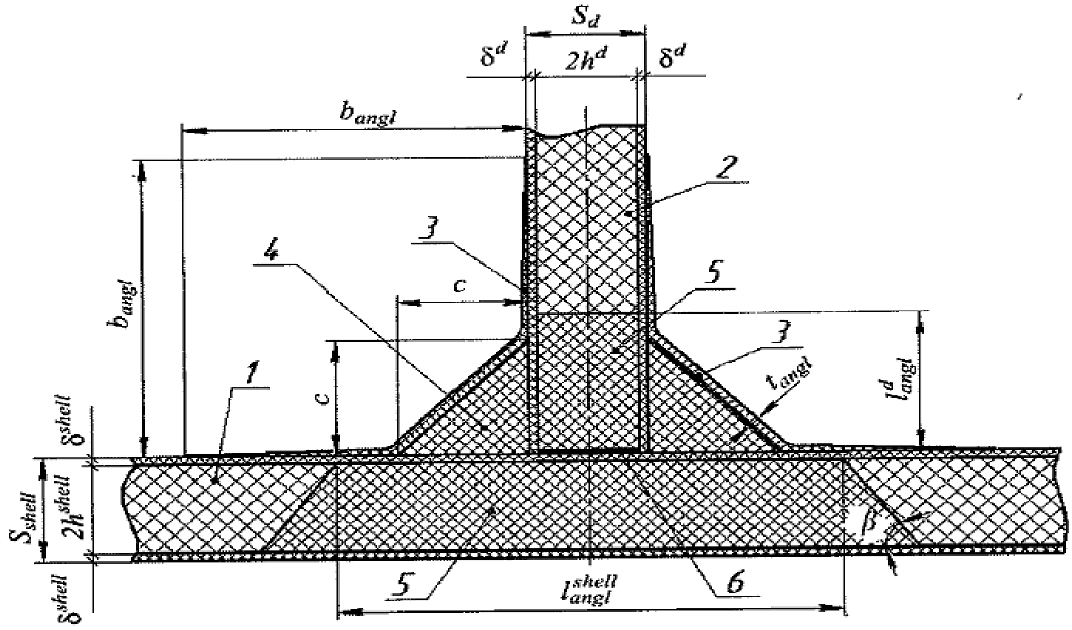


Fig. 3.2.6-4 Structural scheme of a moulded fillet joint:
1 - members being jointed; *2* - moulding-in angles; *3* - contact surface

.4 for a stressed fillet joint, a horizontal single-skin member may be thickened under a vertical member, which may be both single-skin and sandwich, e.g. joint of a single-skin hull shell with a sandwich bulkhead (refer to Fig. 3.2.6-5).

The shell is thickened by adding fiber layers (woven roving or biaxial fabric with (0°/90°) reinforcement) between basic layers along the vertical member (across the hull). Thickness of the thickened area shall taper towards edges, with each next fabric layer overlapping the preceding one with 20 ÷ 25 mm increment.

Thickened area scantlings shall be determined from the following:

$t_{th} = (0{,}2 \div 0{,}3)s$;

$B_{th} \geq 2(b_{th} + 6t_{th}) + S_{bulk}$, $b_{th} = b_{angl} + 5$ in mm;

$b_{angl} \geq 16t_{angl}$, $t_{angl} \geq 0{,}6s_p$,

where $s_p = \max(S_{shell}, S_{bulk})$, $R_{angl} = 2t_{angl}$;

.5 where both members, e.g. a bulkhead and a shell, are of sandwich construction and stressed, their fillet joint shall be made with triangular support elements made of foam plastic of 150 ÷ 200 kg/m^3, density, which shall be mounted on the shell from both sides of a transverse bulkhead via adhesive which is applied on the contact surface of the bulkhead to shell joint. The edge of a vertical member (bulkhead) shall be sheathed with 2 - 3 layers of woven roving passing over onto outer surfaces to the depth equal to at least the value of its thickness.

The foam plastic in cores of the bulkhead and shell shall be replaced by that of the density increased by 30 ÷ 40 kg/m^3 in the form of embedded elements of certain scantlings in the joint area (refer to Fig. 3.2.6-6).

Basic parameters of these joints shall be selected from the following:

$c \geqslant 0{,}6(s_{shell} + s_d)$; $l^d_{angl} = 1{,}2s_d$; $l^{shell}_{angl} = 2(1{,}1c + s_{shell}) + s_d$;

$t_{angl} = 1{,}2\max(\delta^d, \delta^{shell})$;

$b_{angl} = 16t_{angl} + c \geq 2s_{shell}$; $R_{angl} \geq 2t_{angl}$; $\beta = 45°$;

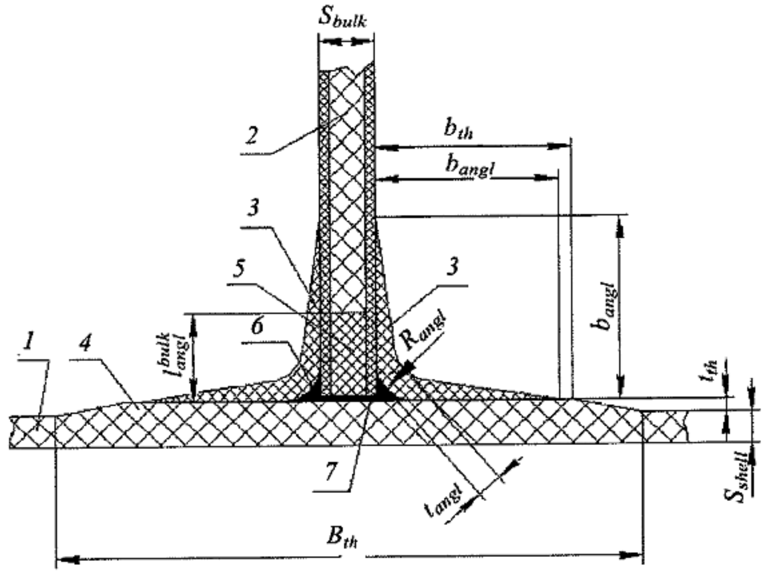


Fig. 3.2.6-5 Joint of a sandwich bulkhead with a single-skin hull shell with reinforcement under the bulkhead:
1 - shell; *2* - bulkhead; *3* - moulding-in angles; *4* - thickening;
5 - foam plastic of increased density; *6*, *7* - adhesive

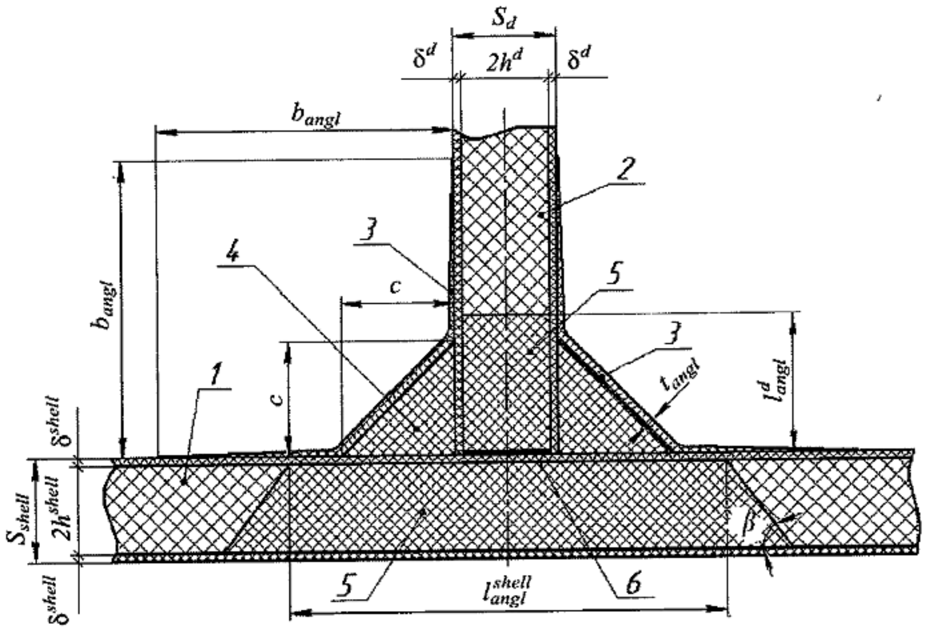


Fig. 3.2.6-6 Joint of the hull shell and sandwich bulkhead:
1 - shell; *2* - bulkhead; *3* - matted-in angles; *4* - support elements; *5* - embedded parts; *6* - adhesive

.6 fillet joint of the side and upper deck of single-skin construction may be made by means of mattedin angles provided that the maximum side thickness does not exceed 14 mm.

In this case, the leg size b_{angl} of moulding-in angles, their thickness at the root t_{angl} and inner radius R_{angl} of side to deck transition shall be determined from the following correlations:

$b_{angl} \geq 100 + 8S_s$, $t_{angl} \geq 0{,}8S_s$, $R_{angl} \geq 2S_s$,

where S_s - side (sheerstrake) thickness where it connects to the upper deck;

.7 where single-skin side and deck have comparatively greater thicknesses (over 15 – 20 mm), their angle joint shall be made by thinning the side and deck platings where they connect to each other and by installation of a triangular support element made of the foam plastic of increased density 150–200 kg/m^3 (refer to Fig. 3.2.6-7).

Basic parameters of this joint shall be assumed as follows:

$c \geq 2\max(S_s, S_d)$;

$h_d \geq 0{,}5S_d$; $h_s \geq 0{,}5S_s$;

$t_{angl}^{out} \geqslant 0{,}6S_s$, $b_{angl}^{out} \geqslant 20t_{angl}^{out}$;

$t_{angl}^{in} \geqslant 0{,}4S_s$, $b_{angl}^{in} \geqslant 16t_{angl}^{in} + c$;

$l_d = b_{angl}^{out} - s_d$; $l_s = b_{angl}^{out} - S_s$.

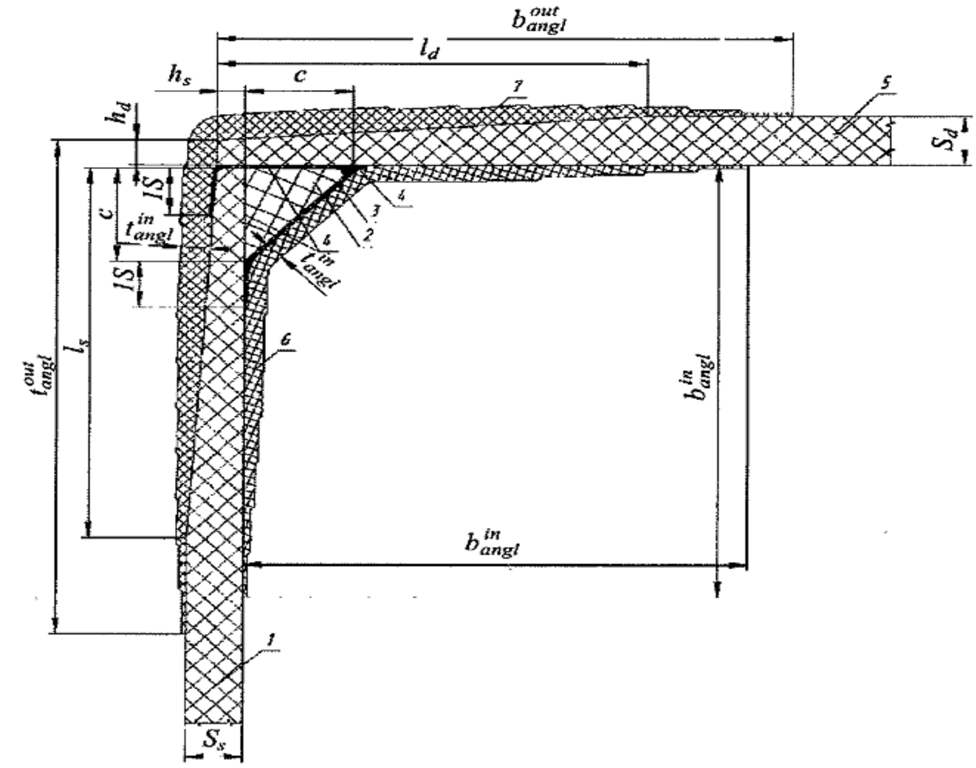


Fig. 3.2.6-7 joint of side and upper deck single-skin constructions of variable thickness, with a support element installed:
1 - side; *2* - support element; *3* - support element sheathing; *4* - adhesive; *5* - upper deck plating;
6 - inner moulding-in angle; *7* - outer moulding-in angle

.8 where the upper deck and side platings are of sandwich constructions, the following design joint types may be allowed:

Type A. The deck laminate is connected to the side laminate with adhesive and moulding-in angles, with the use of a support element made of the foam plastic of increased density 150 - 200 kg/m^3. In the place of joint, the upper deck laminate / edge is sheathed with 2 - 3 layers of woven roving with (0°/ 90°) reinforcement (refer to Fig. 3.2.6-8).

Basic parameters of this joint shall be selected from the following:

$c \geqslant 1{,}2\max(s_s, s_d)$; $t_{angl}^{out} = 2\max(\delta^d, \delta^s)$; $b_{angl}^{out} \geqslant 18t_{angl}^{out} \geqslant 3{,}5s_s$;

$t_{angl}^{in} = 1{,}2\delta^s$; $b_{angl}^{in} \geqslant 15t_{angl}^{in} + c \geqslant 2s_s$; $\beta = 45°$; $l_d = b_{angl}^{in} + s_s + s_d$; $l_s = b_{angl}^{in} + s_s$.

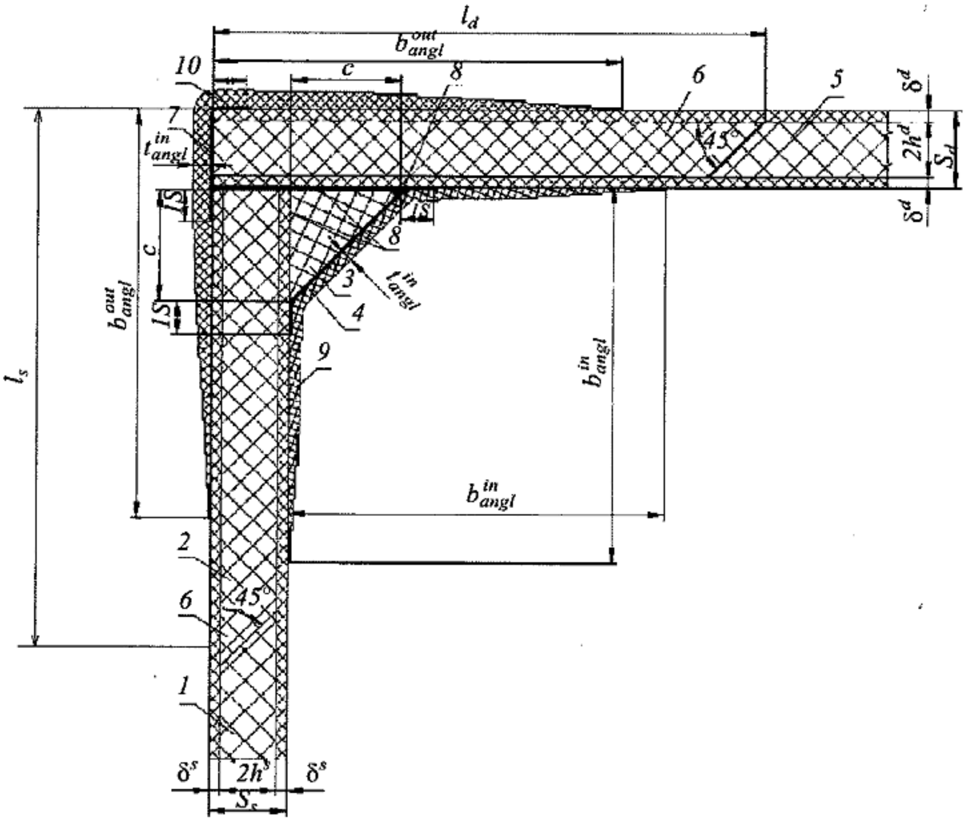


Fig. 3.2.6-8 Joint of the upper deck plating and side plating of sandwich construction (Type A):
1 - side laminate; *2* - reinforcement of the foam plastic of increased density; *3* - support element;
4 - heathing; *5* - deck laminate; *6* - reinforcement of the foam plastic of increased density; *7* - sheathing;
8 - adhesive; *9* - inner moulding-in angle; *10* - outer moulding-in angle

Type B. Sandwich deck laminate and side laminate transit to single-skin structures smoothly by bringing load-bearing layers together. Using adhesive, a triangular support element made of the foam plastic of 150 - 200 kg/m^3 in density is installed, and inner and outer moulding-in angles are laid (refer to Fig. 3.2.6-9).

Basic parameters of this joint are recommended to be selected from the following:

$$t^{out}_{angl} = 2\max(\delta^d,\ \delta^s);\ b^{out}_{angl} \geqslant 20t^{out}_{angl};\ t^{in}_{angl} = 1{,}2\max(\delta^d, \delta^s);\ b^{in}_{angl} \geqslant 18t^{in}_{angl};$$

For both joint types, where the deck and side are provided with a deck stringer and a sheerstrake accordingly, the values of δ^d, δ^s specified in the above-mentioned correlations shall be assumed equal to the thicknesses of load-bearing layers of these members;

.9 inner decks (platforms) are connected to the side plating by means of moulding-in angles and triangular support element made of the foam plastic of increased density of 150 - 200 kg/m^3.

For examples of joints of the single-skin deck (platform) with the single-skin and sandwich side platings, refer to Fig. 3.2.6-10 and Fig. 3.2.6-11.

Basic parameters of these joints shall be selected from the following:

$c \geq 1{,}2\max\ (s_s,\ s_d)$; $t_{angl} \geq 0{,}4s_s$ або $t_{angl} \geq 2d_s$ (for the sandwich shell);

$b_{angl} \geq 15t_{angl} + c \geq 2s_s$.

Where the inner deck (platform) has a sandwich construction, the joint is made using the same technique.

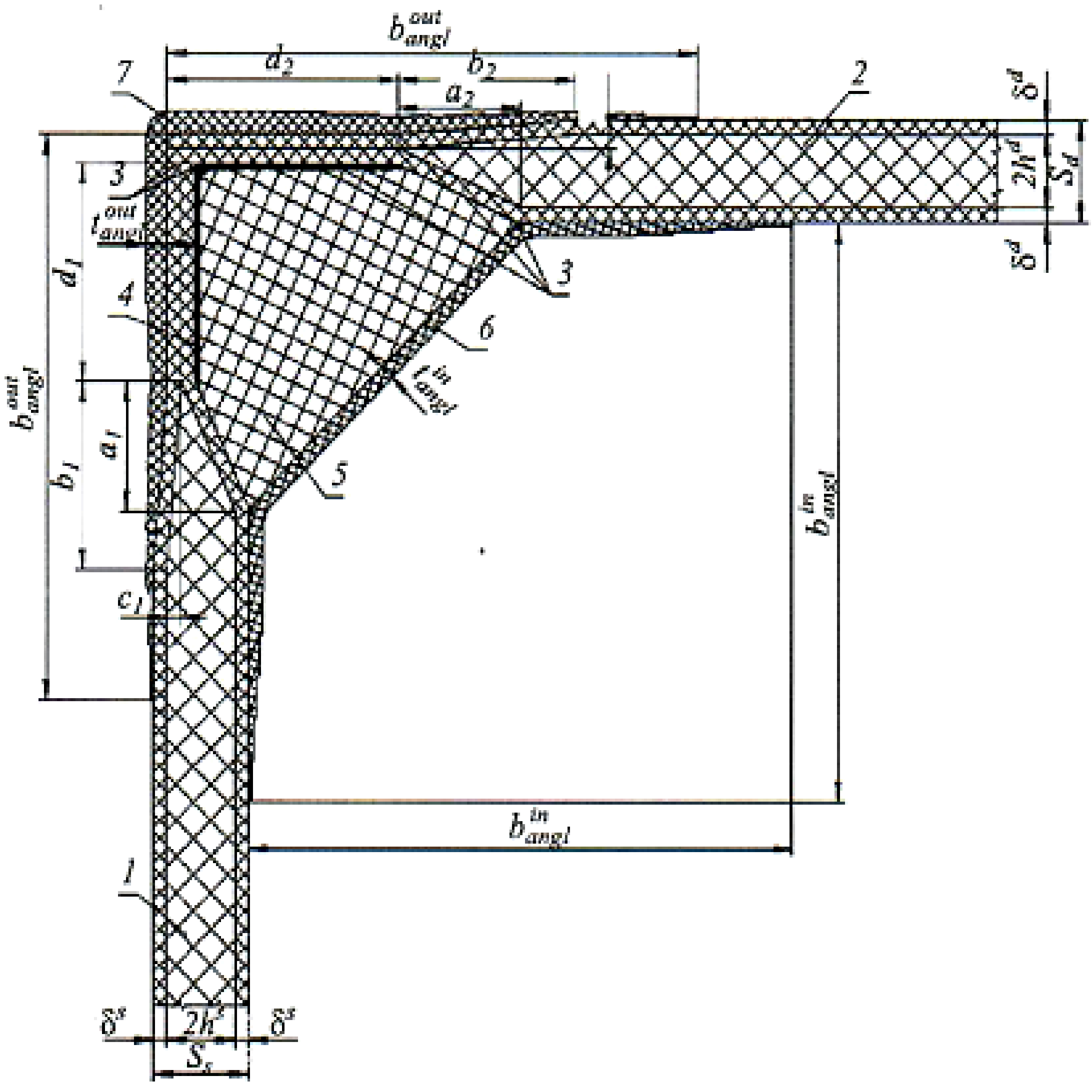


Fig. 3.2.6-9 Joint of the upper deck plating and side plating of sandwich construction (Type B):
1 - side laminate; *2* - deck laminate; *3* - adhesive; *4* - sheathing; *5* - support element;
6 - inner moulding-in angle; *7* - outer moulding-in angle.

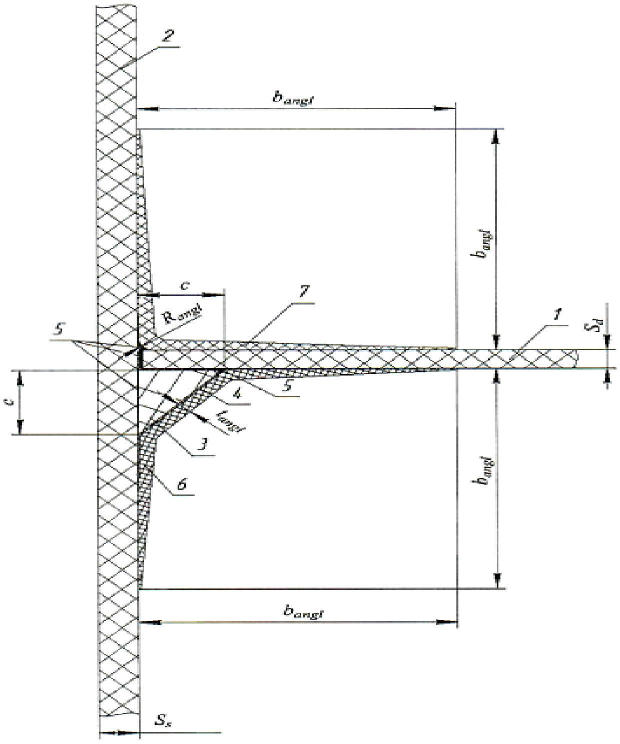


Fig. 3.2.6-10 Joint of the inner deck (platform) with a single-skin side plating:
1 - inner deck (platform) laminate; *2* - side laminate; *3* - support element; *4* - sheathing; *5* - adhesive;
6 - lower moulding-in angle; *7* - upper moulding-in angle

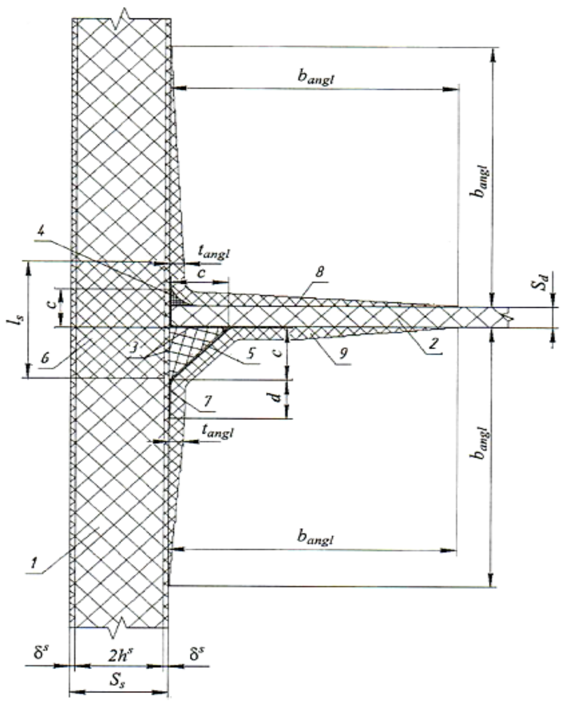


Fig. 3.2.6-11 Joint of the single-skin inner deck (platform) with a sandwich side plating:
1 - side laminate; *2* - inner deck (platform) laminate; *3*, *4* - adhesive;
5 - support element; *6* - reinforcement made of the foam plastic of increased density;
7 - sheathing; *8* - upper moulding-in angle; *9* - lower moulding-in angle

3.2.7 Engine seatings.

3.2.7.1 Two design types of engine seatings of machinery, equipment and various arrangements installed in the hull may be applied:

.1 composite - using the materials for hull construction;

.2 metal - metal elements of the engine seating are connected to composite elements and structural members with fasteners.

3.2.7.2 The engine seating construction is mainly determined by the characteristics specified for the equipment, machinery and arrangements (weight, operating loads, vibration loads, etc.). In this case, the following shall be taken into account:

members of the FRP engine seatings shall be of solid construction while the number of moulding-in angles and other connecting elements shall be reduced to minimum;

in FRP seatings of heavy machinery and equipment, where bolts pass through the material, metal bushes shall be provided to secure them;

in case of contact forces from the equipment and machinery that may cause the FRP crumpling, provision shall be made for metal straps on the contact surface of the engine seating members and their supports;

when a metal engine seating is designed, a structure of its fastening to hull members shall be considered, which will require fitting metal counterparts and, if necessary, reinforcement of these members.

3.2.7.3 Seatings of main engines and other heavy equipment shall be connected to framing members,e.g. side girders and bulkhead stiffeners, or framing members shall be used for seatings.

Where framing members cannot be used, additional members shall be fitted and connected to main members and terminated considering the requirements of **3.2.4.17**.

3.2.7. Longitudinals of engine seatings shall be connected with main framing members (stringers) by means of brackets and knees fitted at every frame.

3.2.7.5 T-shaped section is recommended for girders supporting the foundations of engines and equipment (refer to **3.1.8**).

In this case, girders support elements shall be connected with bolts that attach these elements to a face plate of the member, using metal L-shaped counterparts or moulded metal bushes (refer to Fig. 3.2.7-1).

3.2.7.6 Where seating girders are of closed box section, the foam plastic of increased density (180 - 250 kg/m^3) shall be added to the core, and an additional member as a vertical web made of the same material as the girder sheathing.

These support elements are connected to the girder with metal fasteners and parts. Seating design types with a closed box section girder are shown in Figs. 3.2.7-2 - 3.2.7-4.

3.2.7.7 To fasten main engines, equipment and various machinery to the hull structures, other design types are allowed based on technical background and agreed with the Register.

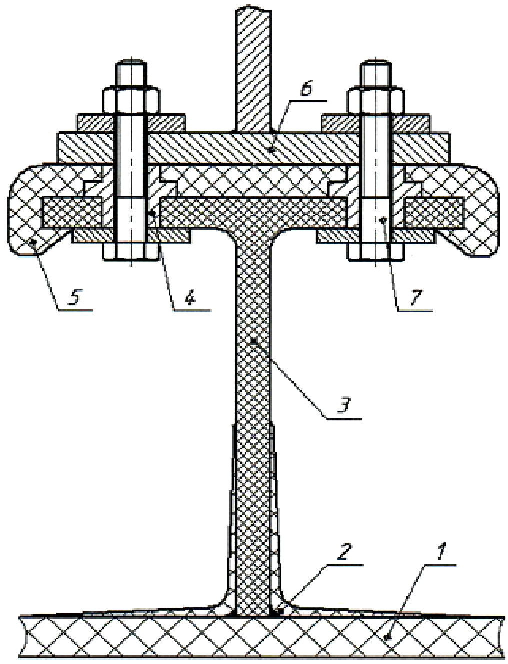


Fig. 3.2.7-1 Joint of a support element of an engine (equipment) to the seating T-shaped section with moulded bushes:
1 - shell; *2* - moulding-in angles; *3* - seating girder; *4* - moulded bush;
5 - mould welding; *6* - support element ; *7* - bolt

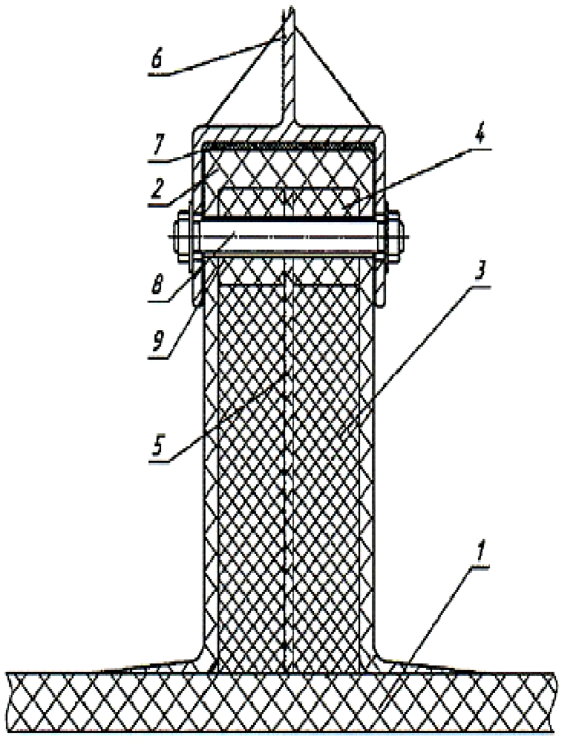


Fig. 3.2.7-2 Joint of a support element of an engine (equipment) to the seating closed box section with the use of bolts:
1 - shell; *2* - section sheathing; *3* - core; *4* - foam plastic of increased density; *5* - additional web;
6 - support element ; *7* - adhesive; *8* - bolt; *9* - bush

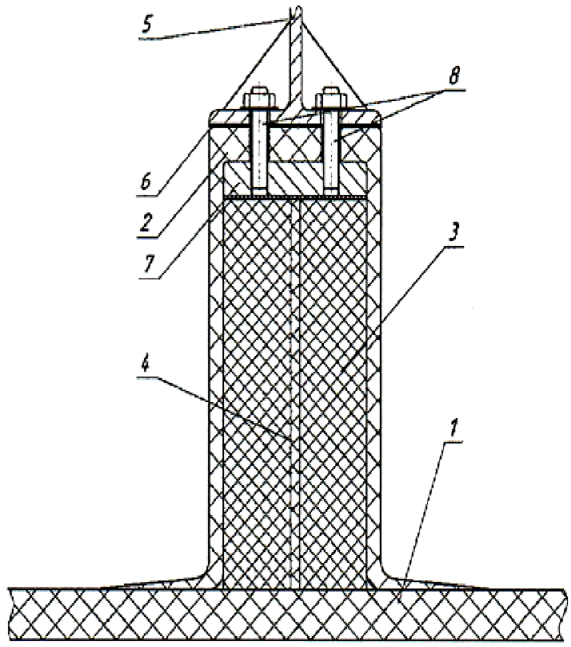


Fig. 3.2.7-3 Joint of a support element of an engine (equipment) to the seating closed box section with the use of studs and metal embedded parts:
1 - shell; *2* - section sheathing; *3* - core; *4* - additional web; *5* - support element;
6 - adhesive; *7* - metal embedded part; *8* - studs

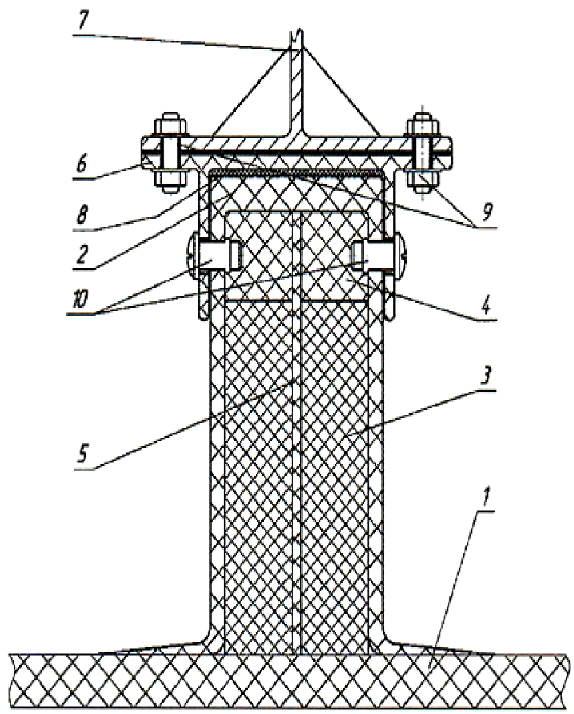


Fig. 3.2.7-4 Joint of a support element of an engine (equipment) to the seating closed box section with the use of a closed box flanged element made of FRP, bolts and rivet nuts:
1 - shell; *2* - section sheathing; *3* - core; *4* - foam plastic of increased density; *5* - additional web;
6 - closed box flanged element; *7* - support element; *8* - adhesive; *9* - bolts; *10* - rivet nuts

3.2.8 Tanks.

3.2.8.1 It is recomended, independent tanks that may be made of FRP or aluminium alloys shall be installed in FRP hulls.

3.2.8.2 In case of hull interior deficiency, it is allowed to install FRP integral tanks with either singleskin or sandwich sides stiffened by framing, where necessary.

Reinforcement scheme, material and structure of the tank shell is determined according to its intended purpose and operation conditions.

3.2.8.3 As the material for the shell and framing members of integrated tanks, it is allowed to use glass-reinforced plastic based on woven roving or biaxial fiber with reinforcement (0º/90º). As a core of the sandwich shell, either PVC foams, PUR foams or lightweight mats may be applied.

3.2.8.4 Tank shell thickness shall be determined according to the diagrams specified in Figs. 3.2.1-2 and 3.2.1-6, and scantlings of framing members - in accordance with **3.2.4.13**.

3.2.8.5 The tank framing and shell shall be manufactured simultaneously within one production process and, where possible, installed outside tanks to prevent it from being separated from the shell.

Hull framing members shall not cross the tank shell, if possible.

3.2.8.6 The inner surface of tank shell shall have 2 - 3 layers of fabric mesh with increased binder content and properly sealed to avoid leakages.

3.2.8.7 The construction of tank manholes and covers shall ensure watertightness and strength throughout the ship's service life (refer to Figs. 3.2.8-1 - 3.2.8-3).

These requirements are applied to assemblies of fittings in tank sides (refer to Fig. 3.2.8-4).

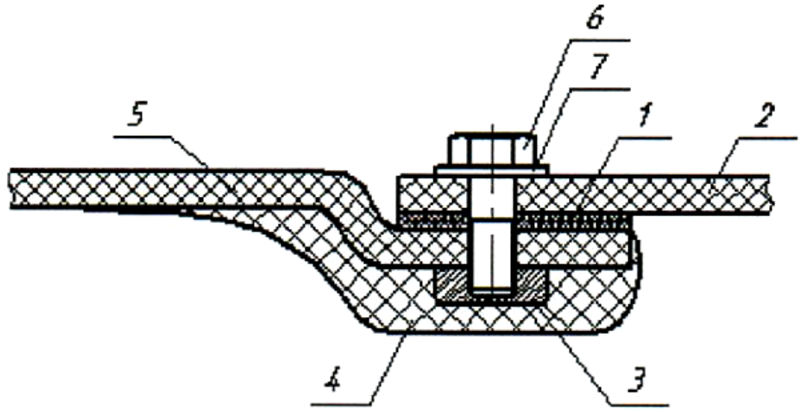


Fig. 3.2.8-1 Tank manhole assembled with a cover flush with the shell:
1 - gasket; *2* - cover; *3* - embedded plate; *4* - sheathing; *5* - tank shell; *6* - screw; *7* - washer

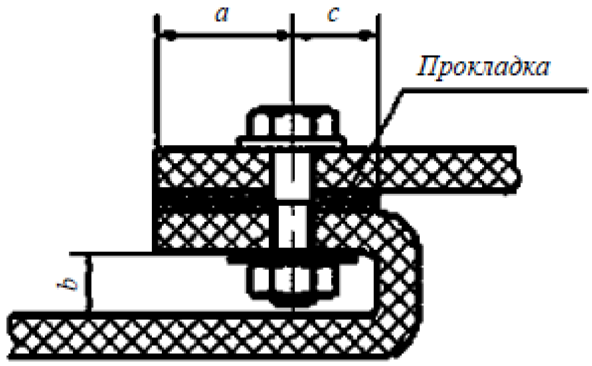


Fig. 3.2.8-2 Tank manhole assembly with the flanged shell
$a \geq 3d$, $c \geq 3d$, where d - bolt diameter; b = 30 – 40 mm

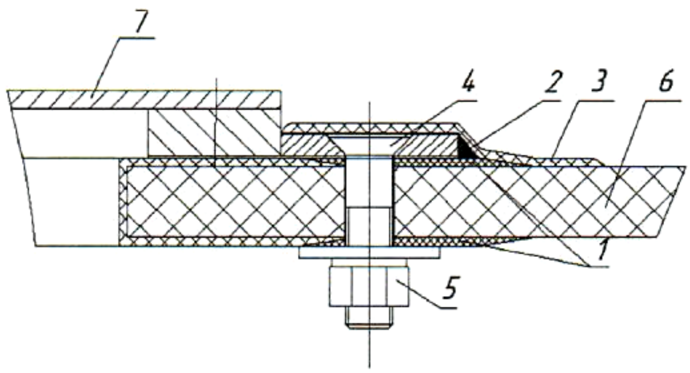


Fig. 3.2.8-3 Tank manhole assembly with metal cover:
1 - hole edge sheathing; *2* - adhesive; *3* - matting-in joint; *4* - screw; *5* - nut; *6* - tank shell; *7* - metal cover

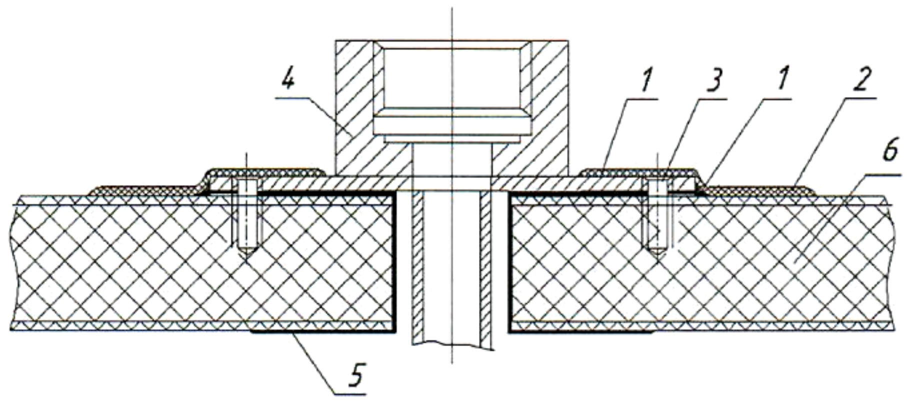


Fig. 3.2.8-4 Mounting assembly of the pipeline nipple in the tank shell
1 - adhesive; *2* - matting-in joint; *3* - screw; *4* - nipple; *5* - hole edge sheathing; *6* - tank shell

3.2.8.8 Fuel oil tanks made of plastic shall be provided with earthing arrangements for discharging static electricity or electrically-insulating coatings in accordance with the requirements of the relevant international or national standards.

3.3 STRUCTURE OF SUPERSTRUCTURES AND DECKHOUSES

3.3.1 General.

3.3.1.1 Superstructures contributing to the longitudinal bending of the ship's hull are referred to superstructures of category I that shall withstand joint effect of loads due to the hull hog and local stresses due to wave impact, motions, equipment weight, etc.

Superstructures of category I are considered to be strong in case the following conditions are simultaneously met:

longitudinal (side) ends and sides of a superstructure shall be jointed to the hull sides or longitudinal bulkheads;

superstructure shall be supported with at least 3 transverse hull rigid members (transverse bulkheads and deck transverses);

superstructure length shall be at least 4 times as much as its depth.

3.3.1.2 Where the above conditions are not met, a superstructure does not contribute to the longitudinal bending of the ship's hull, is referred to superstructures of category II, which are designed to withstand local loads only as well as deckhouses.

3.3.1.3 The structure requirements for strong superstructures are the same as for the ship hull.

Therefore, structures of main members and assemblies of the hull (refer to Section **3.2**) may be applied to strong superstructures.

Requirements for construction of superstructures, their members and assemblies are specified in **3.3.2**.

3.3.1.4 When designing FRP superstructures of ships with metal hulls, particular attention shall be paid to joint of superstructure ends and sides and bulkheads with the hull, which shall ensure strong and reliable joint between the hull and superstructure in all operation modes specified for the ship.

Designs and requirements for these assemblies are specified in **3.3.2**.

3.3.2 Ends and sides, decks, bulkheads and framing.

3.3.2.1 It is recommended that end and side plating, decks and bulkhead platings of superstructures and deckhouses shall have a sandwich construction with FRP load-bearing layers and a core, which reduces the number of framing members, ensures thermal insulation of internal spaces and increases their efficient volume due to absence of necessity for sealing and insulation.

3.3.2.2 The same reinforcing materials as those allowed for ship hulls (refer to **3.2.1.1 - 3.2.1.2**) shall be applied for load-bearing layers of superstructures' sandwich members.

The reinforcement scheme of sides and ends shall have a parallel and diagonal structure (0º/+45º/90º/-45º) by means of several techniques in accordance with **3.2.1.1.3** and **3.2.1.1.4**.

The reinforcement scheme of sides and ends for superstructures of category II and deckhouses is allowed to be parallel (0º/90º) based on woven roving and biaxial fabrics as well as combination products.

The bulkhead reinforcement scheme may be both parallel and parallel and diagonal, depending on the nature of the acting stresses.

Bulkheads of superstructures of category II and deckhouses may be single-skin with a smooth or corrugated plating.

3.3.2.3 PVC foams or PUR foams and balsa, as well as a structural orthotropic filler with a corrugated element and foam plastic in a space between corrugations are allowed as cores for superstructures of category I (refer to Fig. 3.2.2-1). Characteristics of this filler shall be selected according to **3.2.2.2.5** and **3.2.2.2.6**.

Foam plastic density in the core of sides and ends shall not be less than 100 kg/m3,but not more than 200 kg/m^3. If there is a corrugated element in the core, foam plastic of minimum density of 40-50 kg/m^3 is allowed.

For lightweight superstructures and deckhouses, foam plastic of the density not less than 60 kg/m^3, but not more than 100 kg/m^3, and honeycombs are allowed.

3.3.2.4 The thickness of load-bearing layers of superstructure sides and ends, decks and bulkheads shall be determined according to **3.2.1.2.4** from the diagrams shown in Fig. 3.2.1-6. In this case, minimum thickness of load-bearing layers of sides and aft walls of strong superstructures shall not be less than 0,8 of the thickness of load-bearing layers of side plating as is shown in Fig. 3.2.1-7, while the thickness of the fore wall load-bearing layers shall not be less than this thickness. In any case, the thickness of load-bearing layers of superstructure ends and sides shall not be less than 1,8 mm.

3.3.2.5 For ships with metal hulls, the thickness of load-bearing layers of ends and sides of strong superstructures shall be determined in accordance with **3.3.2.4**. Where the ship length L exceeds 70 m, the thickness of load-bearing layers of the superstructure sides shall not be less than 4 mm.

3.3.2.6 The core thickness of ends and sides of the sandwich construction and of the superstructure top shall be determined subject to compliance with the requirements for heat insulation of internal spaces while structural strength and stiffness are maintained.

Based on this condition, the core thickness shall be not less than 60 – 70 mm.

3.3.2.7 To reduce the concentration in the structure near the rugged superstructure termination, its sides shall extend beyond ends (front and back), gradually reducing to zero within the length equaling to the superstructure's first tier height.

The bottom strake of superstructure sides near ends shall have layer thicknesses equal to those of the fore web. End parts of sides shall be reliably connected to the hull, using butt straps and moulding-in angles, while fillet edges of free end parts of these sides shall be sheathed to make thickened areas.

Thickness increase and reduction of load-bearing layers of the sides' bottom layer shall be performed in accordance with para **3.2.1.1.8**.

3.3.2.8 Superstructure ends and sides, decks and bulkheads shall be stiffened with the use of closed box section designed as specified in Fig. 3.2.4-1.

Member reinforcement materials and schemes, as well as their scantlings shall be selected according to the requirements of **3.2.4.2 - 3.2.4.7** and **3.2.4.13**.

3.3.2.9 Transverse members (frames, beams, transverse bulkheads) of the strong superstructure shall be arranged in the same plane that coincides with the plane where frames are fitted in the hull.

It is recommended to arrange longitudinal members (stiffeners of the front and back sides, deck girders, longitudinal bulkheads) in the same plane, where deck girders of the ship hull upper deck are arranged.

3.3.2.10 Where a beam (deck girder) passes through the longitudinal (transverse) bulkhead, the latter shall be strengthened with a stiffener, which may be sniped (refer to Fig. 3.2.4-13).

3.3.2.11 Joints of stiffeners to beams and deck girders, and intersections of framing members shall be made taking into account the requirements of **3.2.4.16 - 3.2.4.18** and **3.2.4.21 ÷ 3.2.4.23**.

3.3.2.12 To enhance stiffness of deck grillages, where the equipment is installed, they shall be stiffened with pillars. Tubular pillars are made of aluminium alloys (AMg) or FRP, which is used for sheathing framing members.

Pillars are fitted on framing members, mainly at their intersections, and secured with metal support elements and bolts, or by means of matted-in angles (refer to Fig. 3.3.2-1 and Fig. 3.3.2-2).

Where a pillar is fitted, the foam plastic core in closed box section members shall be substituted with the foam plastic with density not lower than 200 kg/m3, or made with a glued laminated hardwoods (oak, birch, etc.).

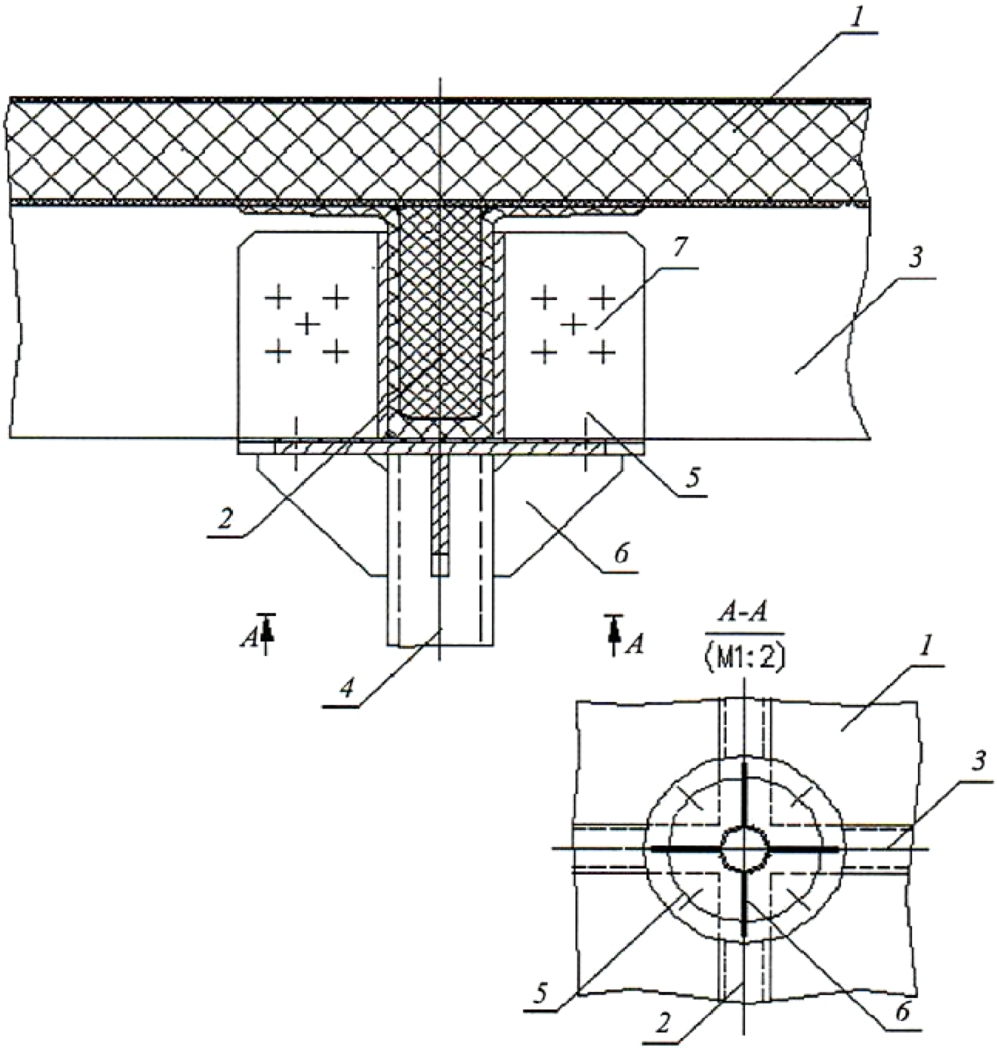


Fig. 3.3.2-1 Attachment of the upper end of an aluminum alloy pillar at the intersection of the superstructure beam and deck girder:
1 - deck; *2* - deck girder; *3* - beam; *4* - pillar; *5* - metal casing; *6* - bracket; *7* - bolts

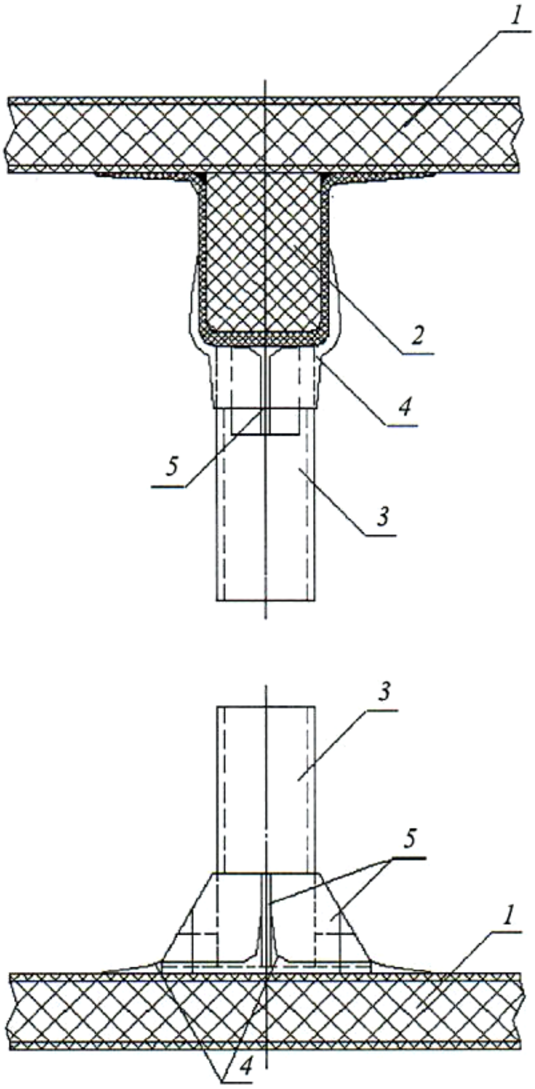


Fig. 3.3.2-2 Attachment of the FRP upper and lower ends to superstructure decks:
1 - decks; *2* - framing member; *3* - pillar; *4* - matting-in joint; *5* - bracket

3.3.3 Joint of superstructure members to the metal hull.

3.3.3.1 Joint of FRP sides, ends and bulkheads of superstructure with metal hull shall ensure strong and reliable joint between the hull and superstructure, as well as tightness of its internal spaces in all operation conditions of the ship (refer to **3.3.1.4**).

3.3.3.2 Superstructure sides and ends shall be connected with bonded and bolted joints consisting of a metal coaming with thickness equal to the shell thickness of hull side, a metal attached strip and bolts arranged chequerwise in two rows (refer to Fig. 3.3.3-1).

An attached strip shall have thickness of not less than 3 mm, while bolt diameter d shall be not less than M12. In this case, bolts shall be arranged according to the following ratios:

$w \geq 2{,}5d$;

$w_1 \geq 3{,}5d$;

$c \geq 3d$.

Bolt spacing in a row shall be assumed $t_d \geq 3d$ (refer to Fig. 3.3.3-1).

A metal coaming, plate and brackets shall be made of the hull metal.

3.3.3.3 Joint of longitudinal and transverse bulkheads with the hull may be made with a single-row bonded and bolted joint, which consists of a metal coaming, metal attached strip and bolts (refer to Fig. 3.3.3-2), or two metal coamings, with a bulkhead clamped in between with bolts (refer to Fig. 3.3.3-3).

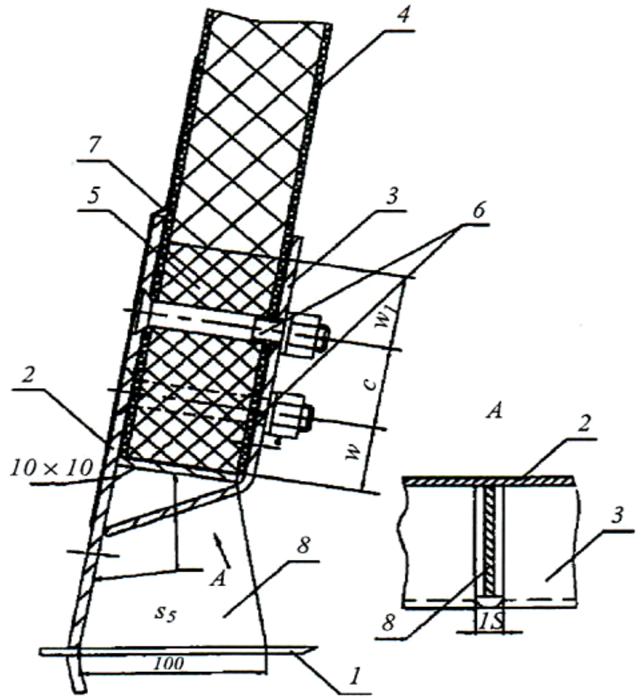


Fig. 3.3.3-1 Bonded and bolted joint of superstructure's side panels to the metal hull:
1 - hull deck; *2* - coaming; *3* - butt plate; *4* - side panel;
5 - foam plastic of increased density; *6* - bolts; *7* - sheathing; *8* - bracket

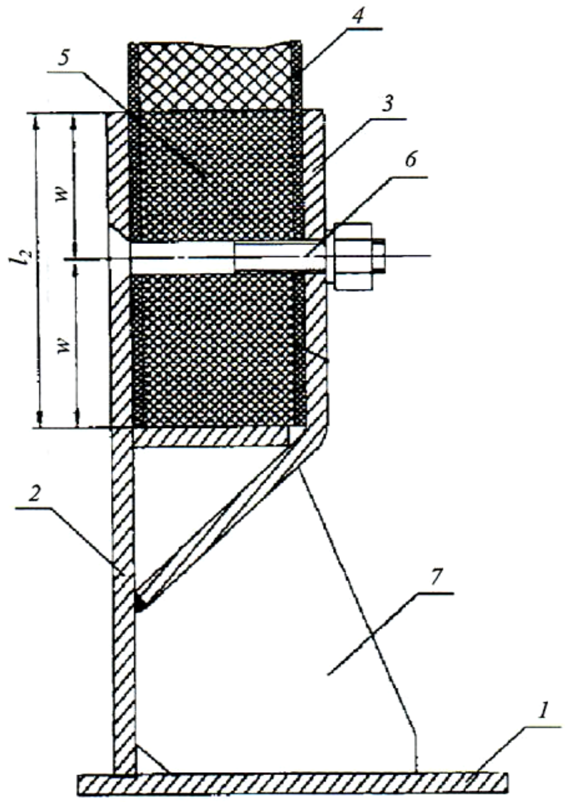


Fig. 3.3.3-2 Bonded and bolted joint of the bulkhead to the metal hull (with one metal coaming):
1 - hull deck; *2* - coaming; *3* - butt plate; *4* - bulkhead;
5 - foam plastic of increased density; *6* - bolt; *7* - bracket

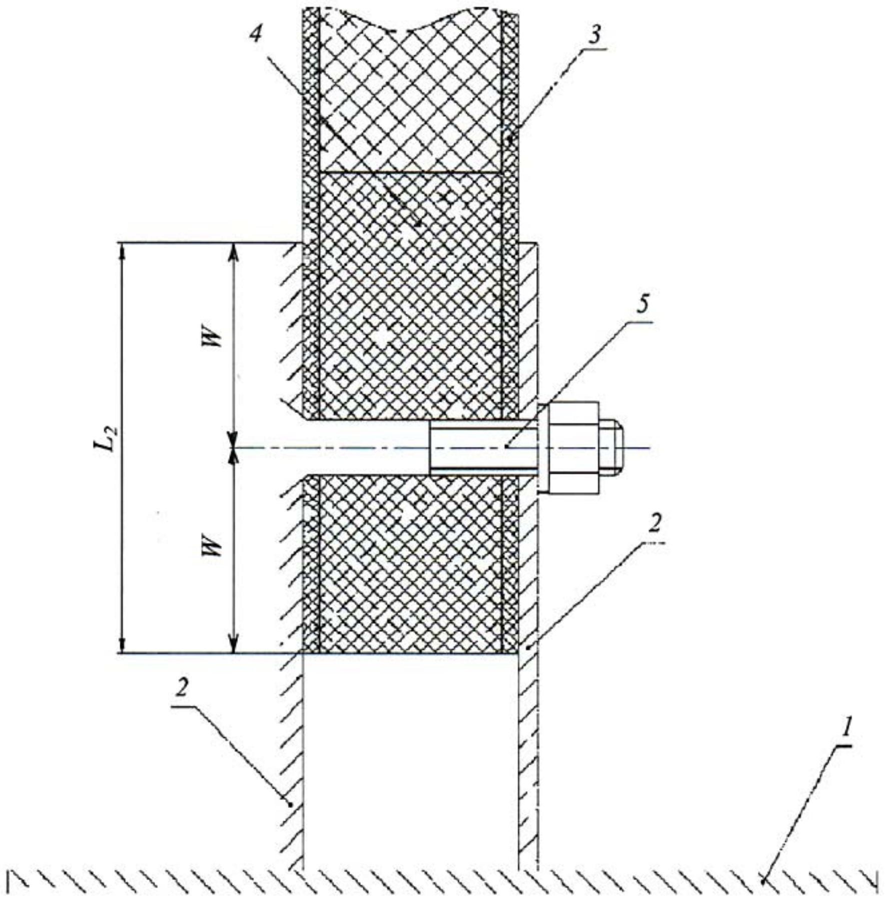


Fig. 3.3.3-3 Bonded and bolted joint of the bulkhead to the metal hull (with two metal coamings):
1 - hull deck; *2* - coamings; *3* - bulkhead; *4* - foam plastic of increased density; *5* - bolt

In the first case, the coaming and plate thickness shall be not less than 3 mm, while bolt diameter - not less than M10. In this case, joint parameters shall be as follows:

$w \geq 4d$;

$l_2 \geq 2w$.

In the second case, the coaming thickness shall be not less than 2 mm.

3.3.3.4 In these types of joints in the section of sandwich panels of the members arranged between metal elements, the core shall be made of the foam plastic of increased density of 200 kg/m^3. Metal elements (coamings, plates) are fitted on load-bearing layers of sandwich panels using adhesive and after drilling are screwed up with bolts and then welded to the hull.

3.3.3.5 In the joint of superstructure sides and ends to the hull a free space between the coaming and attached strip shall be filled with sealant, while the outer surface of web panels in the coaming location and the coaming itself shall be moulded with 2 - 3 layers of the reinforcing material (refer to Fig. 3.3.3-2).

4 HULLS OF BOATS AND MOTORBOATS

4.1 GENERAL

4.1.1 These requirements apply to FRP boats and motorboats of 4,5-15 m in length, with the Froude Number Fr_v < 2,5(refer to **1.1.3**) .

4.1.2 Where the requirements for scantlings, structures and materials of members and assemblies are not provided in this Section, they shall be determined according to the requirements specified in Sections **2** and **3**.

4.2 FRAMING SYSTEMS AND SHELL PLATING

4.2.1 For hulls of boats up to 10 m and motorboats up to 6 m in length, a transverse framing system is allowed with a centre girder (refer to Fig. 3.1.3, *a*) or a centre line box keel fitted.

For hulls of longer boats and motorboats, but not longer than 15 m, mixed longitudinal framing system shall be provided, with framing members arranged longitudinally on the bottom and with frames arranged along sides (refer to Fig. 3.1.3, *b*) or with transverse deep members fitted (refer to Fig. 3.1.3, *d*) and **4.1**).

For hulls of motorboats, transverse redans may be used as longitudinal framing.

4.2.2 Shell plating of boat and motorboat hulls may be either single-skin or sandwich.

In case of a sandwich shell, hulls of up to 8 m in length may be made without framing.

4.2.3 FRPs based on woven roving and multiaxial fabrics, polyester and vinylester binders shall be used as materials for a single-skin hull shell and load-bearing layers of sandwich shell.

For hulls of up to 8 m in length, either combination products or a mat are allowed. In the latter case, the outer skin surface shall have 2 or 3 woven fabric layers.

4.2.4 As a core in a sandwich shell, it is allowed to use PVC foams and PUR foams of 60-100 kg/m^3 in density or lightweight mats that may be reinforced with fabric layers.

4.2.5 Reinforcement of the single-skin shell and sandwich shell's load-bearing layers made using woven roving and biaxial fabrics shall have the scheme (0º/90º) with 0º direction (warp) positioned along the shell generatrix, or along its directrix. In the latter case, the breaking strength in 90° direction (weft) shall be not lower than the breaking strength in 08 direction (warp), in fabrics with (0°/90°) reinforcement.

4.2.6 Requirements for butts (seams) and overlaps of reinforcing material layers during moulding of the hull shell correspond to those specified in **3.2.1.1.6**.

Increase (reduction) of thickness of the shell (load-bearing layers) shall be performed in accordance with the requirements of **3.2.1.1.8**.

4.2.7 The thickness of the single-skin shell shall be determined according to the diagrams specified in **3.2.1.1.7**. In such case, the minimum thickness shall be equal to 3,5 mm.

The thickness of sandwich shell's load-bearing layers shall be determined according to the diagrams specified in **3.2.1.2.4**. The minimum thickness of the outer load-bearing layer shall be equal to 2,5 mm,and the inner layer - 2 mm.

4.2.8 The minimum thickness of air cases shell shall be assumed equal to 2 mm. For air cases serving at the same time as seats, the shell thickness shall be increased by 1 mm (refer to Fig. 4.2).

4.2.9 To increase resistance to sea water exposure and hull finishing the outer hull surface shall have 2 or 3 layers of a net, which ensures high content of binder, and to be gel-coated.

4.2.10 The side plating shall be connected to the deck or gunwale with bolts or moulding-in angles, according to **3.2.6.3**.

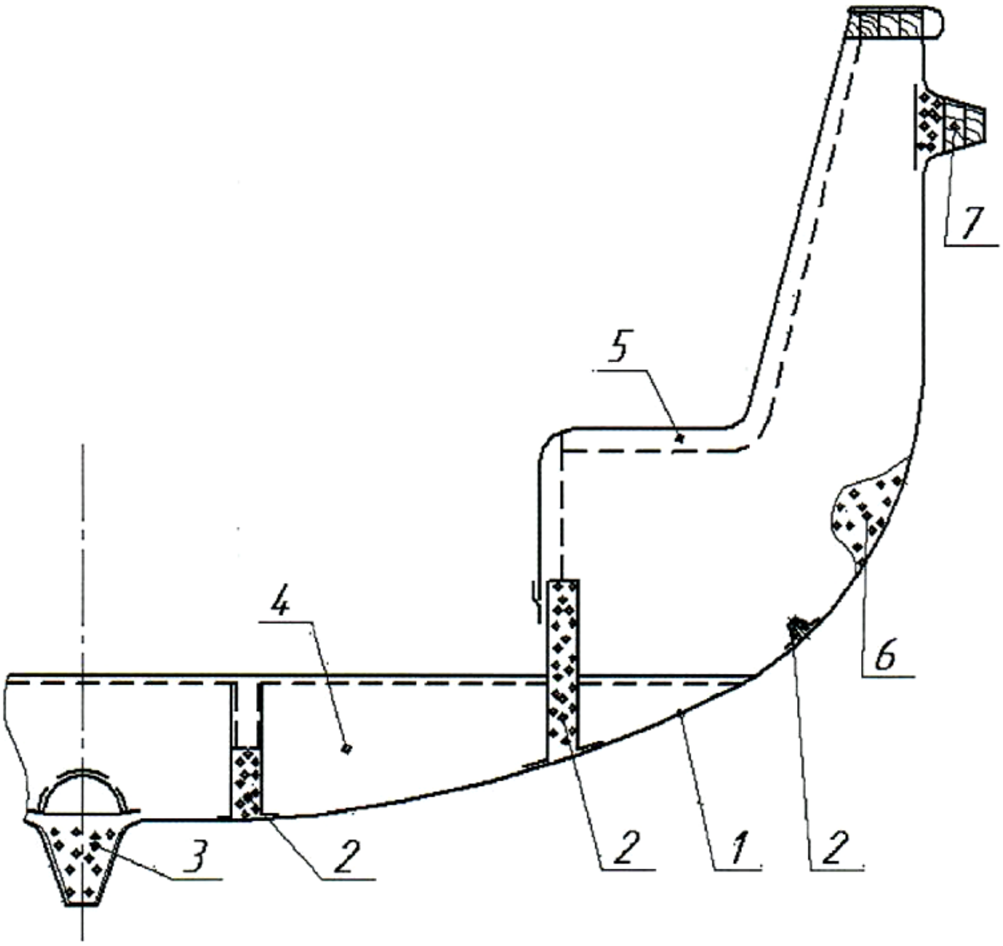


Fig. 4.2 Cross-section (midship frame) of the boat hull:
1 - shell; *2* - stringers; *3* - centre line box keel; *4* - floor; *5* - cladding of air cases;
6 - core of air cases (foam plastic); *7* - fender

4.3. FRAMING MEMBERS

4.3.1 Framing members shall have a closed box (trapezoidal) section with a core of PVC foam of the density not lower than that in the core of the sandwich shell (refer to **4.2.5**).

Where framing members serve as seating members for attachment of engines and equipment, they may have either T-shaped or L-shaped section (refer to **3.1.7** and **3.1.8**).

For boat hulls up to 8 m, air cases may serve as framing.

4.3.2 Selection of materials for manufacture of members, reinforcement schemes of their elements, scantlings and forming their connections to the shell and other hull members shall be performed according to the requirements of **3.2.4.**

4.3.3 Spacing shall be determined based on condition of ensuring strength considering the necessity to reduce the number of framing members and their intersections.

The minimum spacing shall be 400 mm for a single-skin shell and 800 mm for a sandwich shell.

4.4 ATTACHMENT OF LIFTING GEAR

4.4.1 Attachment of the boat hull to lifting gear parts shall ensure launching of a laden boat taking into account the dynamic forces caused due to irregular running of a launching and recovery arrangements, ship motions, wave, etc.

4.4.2 Attachment shall ensure load transfer to reinforced hull structural members (centre line box keel, web frames, stem, transom) and shall be subject to shear without hull members to be separated from the shell.

4.4.3 Metal parts of a lifting gear shall be mounted to the hull with bonded and bolted joints. Where they are installed, members shall be additionally reinforced with straps and moulding-in angles.

5 HULL STRENGTH AND SUPERSTRUCTURES

5.1 GENERAL

5.1.1 Strength calculations of FRP hull structures shall verify set external loads, materials and scantlings of elements and members of these structures, and confirm availability of required strength and buckling strength margins. Such calculations shall be carried out in the following scope:

.1 determination of values and external load types acting on the hull and their design values;

.2 standard setting of extreme and permissible stresses (refer to **5.3**) and deformations as well as determination strength and buckling strength margins required for hull members and structures;

.3 determination of hull member stresses and their deformations;

.4 verification of strength, stiffness and buckling strength conditions of hull members.

5.1.2 Strength calculations shall be carried out for the most severe operating conditions when the highest stress level develops in hull members.

5.1.3 Procedure of strength calculation for the element selection of hull girder shall be as follows:

determination of the design bending moment and, on its basis, hull girder section modulus;

after longitudinal member sections included in the hull girder are selected, determination of stress values developing due to bending moment, at the first approximation;

determination of reduction factors of plates and the section modulus of the hull girder, at the second approximation;

determination of stress values in hull members due to the bending moment from the section modulus of the hull girder at the second approximation, and verification whether strength conditions for stresses acting in these members are met.

Where the specified conditions are not met, correction of cross sections of the hull girder longitudinal members shall be carried out followed by recalculation.

5.1.4 When carrying out strength and buckling strength calculations of hull members and individual FRP structures the following shall be taken into account:

difference in properties of constituent elements of these members due to application of different materials, their different reinforcement schemes, and different influence of operation conditions;

shear strains, including both in the reinforcement plane, e.g. in bulkheads, framing webs, etc., and those between layers, especially in sandwich (multi-layered) members;

breaking stress acting in transverse direction in butt, and especially in angle moulded connections of hull members.

5.2 DESIGN LOADS

5.2.1 Values of design loads acting on the hull and its individual structures shall be determined regardless of the hull material, according to the Register rules according to which the ship design was approved considering the ship class and operation conditions.

5.2.2 When determine design loads and strength and stiffness specifications of hull structures, it is necessary to consider the nature and duration of these loads, with regard to FRP physical properties and operation of structures made thereof when exposed to the specified operation conditions.

5.2.3 According to the approach provided, external loads are divided as follows:

constant loads, the value and direction of which do not vary or vary slightly over the time;

variable loads, the amount and/or direction of which vary over the time.

Constant loads, in their turn, are divided into short-term distributed and long-term distributed, which duration is approximately equal to a ship voyage.

Variable loads are divided as follows:

static variable loads, the whole variation time of which, determined by increase and reduction periods, is three and more times longer than the first mode of structure's natural oscillations;

cyclic static variable loads, which vary repeatedly according to a periodic law;

dynamic loads, the variation time of which is comparable or shorter than the first mode of natural oscillations.

5.3 STANDARD EXTREME AND PERMISSIBLE STRESSES AND DEFORMATIONS

5.3.1 An extreme state of a structure when determine its strength is the state when design deformations and/or stresses in structural members, in their elements, and in layers, if it is a sandwich (multi-layered) structure, achieve critical values when damage may occur and develop further, and the structure may be destroyed, or characteristics of this structure may become non-compliant with performance requirements fully or partially.

5.3.2 Extreme strength limits (tension, compression, interlaminar shear, etc.) of FRPs, values of which are lower than the expected influence of operation factors (dampening, solar radiation, etc.) throughout the ship service life, and manufacturing technique, are assumed to be extreme stresses.

For members that may lose stability, ultimate Euler stresses are assumed to be extreme stresses. These stresses are determined with account of elastic behaviour anisotropy, the design value of which is also lower than initial values, basing on possible influence of the above factors (refer to **5.3.5**).

5.3.3 To assign extreme stresses and design values of elastic behaviour, the most unfavorable conditions that may occur during ship operation throughout its service life shall be considered.

5.3.4 Extreme stresses for members that do not loose stability and exposed to static and static variable loads shall be determined from the following correlations:

$\sigma_{ij}^{u} = k\sigma_{ij(\pm)}$,

where: σ_{ij}^{u} - extreme stresses;

$\sigma_{ij(\pm)}$ - initial ultimate tensile (+),compression (-), and shear stresses of the material (i, j = 1, 2, 3).

Values of the factor k considering strength variation of FRPs as a result of moistening, heating, aging influence, and manufacture technique are specified in Table 5.3.4 for various hull members.

5.3.5 Design values of elastic behaviour are determined from the following ratios:

$E_{pi} = nE_i$, $G_{pij} = nG_{ij}$,

where: E_{pi}, G_{pij} - design Young's and shear moduli;

E_i, G_{ij} - design Young's and shear moduli of the material in initial condition (i, j = 1, 2, 3).

Values of the factor n are specified in Table5.3.4.

***Table 5.3.4* Values of factors *k* and *n* used to determine ultimate stresses and design values of elastic behaviour**

Hull member	***k***	***n***
Upper deck plating (exposed) Deck stringer plate	0,55	0,80
Deck framing	0,70	0,90
Intermediate decks, platforms	0,70	0,90
Transverse watertight bulkheads	0,70	0,90
Bulkhead stiffeners	0,70	0,90
Side plating above waterline Sheerstrake	0,65	0,85
Side plating below waterline Bottom plating plate keel	0,60	0,80
Side and bottom framing	0,65	0,85

5.3.6 The values of factors k and n in Table 5.1 are applied to single-skin structures and load-bearing layers of sandwich structures, as well as to framing members made of FRPs with the use of closed moulding techniques. When applied to a core of sandwich structures and closed box sections, values of factors k and n shall be reduced by 0,05.

When a contact moulding technique is used for manufacture of hull structures and their individual elements, factor k shall be reduced by 0,1, and factor n - by 0,05.

5.3.7 Values of permissible stresses are assigned as portion of extreme stresses, which is determined from required strength margins:

for normal stresses $\sigma_{ii} = k_n\sigma_{ii}^{u}$ (i = 1, 2);

for shear stresses $\sigma_{ij} = k_c\sigma_{ij}^{u}$ ($i, j = 1, 2, 3, i \neq j$).

Values of factors k_n, k_c are specified in Table 5.3.7 depending on the nature of external loads acting on the hull.

***Table 5.3.7* Values of factors k_n and k_c used to determine permissible stresses**

External loads	k_n	k_c
Continuous, static variable loads	0,6	0,5
Accidental, emergency loads	0,8	0,7
Loads due to equipment weight	0,6	0,6

5.3.8 Deformations are rated depending on the condition that limits work of the member in the linear range, and based on its strength requirements due to performance reliability of ship equipment and systems.

When being calculated, member strains are included in the calculation together with their design elastic parameters determined according to **5.3.5**. A component associated with transverse shear shall be considered (refer to. **5.1.4**).

5.3.9 Permissible deflections of hull structural members are determined by the formula

$[w] = k_w^{-1} l_p$,

where l_p - design member span (the smallest side of the plating support contour, ship hull length between perpendiculars).

Values of the factor k_w are taken as follows:

for hull shell plating (deck plating) - $k_w = 80$;

for longitudinal framing members (stringers, deck girders) - $k_w = 100$;

for transverses (floors, frames, beams) - $k_w = 80$;

for the ship hull as a whole - $k_w = 300$.

For structural members exposed to emergency loads, the following standard deflections are specified:

for hull shell plating (bulkhead panels) $k_w = 50$;

for framing bulkheads, including bulkhead stiffeners $k_w = 80$;

for the ship hull as a whole $k_w = 250$.

5.3.10 When calculating structural members for buckling strength, the margin is assigned relative to ultimate Euler forces or stresses. In all cases, the stability margin shall be not less than 1,5.

Recommendations for assignment of buckling strength margins for individual members are specified below.

5.4 LONGITUDINAL HULL STRENGTH

5.4.1 Longitudinal hull strength calculation shall include verification using the following:

permissible normal and shear stresses;

permissible deflections of longitudinal members and hull as a whole;

relevant buckling strength margins for longitudinal members.

5.4.2 Design values of sagging and hogging bending moments and shear forces are determined for the specified operational conditions, and for the least favourable loading conditions.

Design values of sagging and hogging bending moments and shear forces are determined as a sum of still water hull bending component M_{sw}, N_{sw} and a wave component M_w, N_w:

$M_T = M_{sw} + M_w$;

$N_T = N_{sw} + N_w$.

For high-speed craft, dynamic component M_d, N_d, due to hydrodynamic pressure caused by wave impact shall be determined in addition to the design values specified.

Values M_{sw}, M_w, N_{sw}, N_w, as well as M_d and N_d, are determined in accordance with the Part II Rules and Part II "Hull Structure and Strength" of the Rules for the Classification and Construction of High-Speed Craft.

5.4.3 Longitudinal hull strength shall be checked for transverse sections exposed to the most unfavorable factors such as maximum permissible loads, location in the areas of abrupt change of stiffness, i.e. locations of large openings, etc.

Longitudinal hull strength calculations are performed for the midship and sections with maximum shear forces, as well as in locations of openings in the upper strength deck, of the width $B_o \geq 0{,}2B$, where B - deck width in the section under consideration, and in the section where a forecastle terminates.

5.4.4 When determine the hull girder characteristics, reduction factors for hull members shall be calculated to considering the difference in their design elastic response (refer to **5.1.4**), and structural features of these members.

For an n-th member, the reduction factor value is determined from the following formula:

$\Psi_n = (E_{1p})n/(E_{1p})_0$,

where: $(E_{1p})n$ - Young's modulus of the n-th member along the hull (direction of axis 1);

$(E_{1p})_0$ - Young's modulus of the n-th member along the hull assumed to be the main one, relative to one the n-th member geometry is reduced, e.g. Young's modulus of the bottom plating.

5.4.5 When determine hull girder, longitudinals (stringers, deck girders, and continuous side coamings) are calculated if the following conditions are met:

longitudinal length exceeds the midship side depth;

longitudinal ends are fitted at least two spacings from the hull cross-section calculated.

5.4.6 When determine hull girder elements, the cross-sectional area of the deck in the section where the opening of the width $B_o \geq 0,2B$ is located (refer to **5.4.3**), shall be decreased by the cross-sectional area of the deck in the opening. The openings located in the same section and spaced from each other to the distance (as measured between their edges) less than 1,5 of the smallest opening width is considered to be one opening of the width equal to the sum of widths of all openings located in the section under consideration.

In this case, mean values of design stresses in the deck around the opening are determined from the formula:

$$(\sigma_{11})_{deck} = \frac{M}{10(W_o)_{deck}} \psi_{deck},$$

where: M - value of the bending moment acting in the design section, in kNm;

$(W_o)_{deck}$ - section modulus of the deck, calculated with account of an opening, in cm^2m;

Ψ_{deck} - reduction factor of the deck determined according to **5.4.4**.

Where the deck (or another member) has a sandwich construction with load-bearing layers of thickness δ_i (i = 1, 2) and core of thickness $2h$, its reduction factor Ψ_{deck} is determined by the formula:

$\Psi_{deck} = (\Psi_{ll} + \gamma\Psi_{core})/(1+\gamma)$,

where: $\gamma = 2h/(\delta_1 + \delta_2)$;

Ψ_{ll}, Ψ_{core} reduction factors determined according to **5.4.4**, for load-bearing layers and cores accordingly.

5.4.7 When determine hull girder elements in the deck with the opening of width $0,2B$, a deck part beyond the opening shall be excluded from its cross-sectional area (refer to Fig. 5.4-1).

5.4.8 Where the opening is stiffened by thickening the deck plating (load-bearing layers) or by fitting of the coaming according to **3.2.5,** the remaining cross-sectional area of the deck (refer to **5.4.6**) shall be enlarged by the cross-sectional area of the members stiffening the opening.

5.4.9 Where $B_o < 0,2B$, in the deck section under consideration, the opening may not be considered when determine hull girder elements.

In this case, mean values of design stresses in the deck around the opening shall be determined by the formula

$$(\sigma_{11})_{deck} = \frac{M}{10W_{deck}} \frac{F_{deck}}{(F_o)_{deck}} \psi_{deck},$$

where: W_{deck} - section modulus of the deck in the section under consideration, opening not considered, in cm^2m;

F_{deck} - cross-sectional area of the deck, opening not considered, in cm^2;

$(F_o)_{deck}$ - cross-sectional area of the deck, opening not considered, in cm^2.

5.4.10 The superstructure is considered when determine hull girder elements if its length exceeds the depth of hull girder elements by 4 times and more, and/or hull girder elements are supported by at least three transverse bulkheads. In such case, in superstructure termination areas its longitudinal members shall be determined according to Fig. 5.4-2.

Deckhouses shall not be considered when determine hull girder elements.

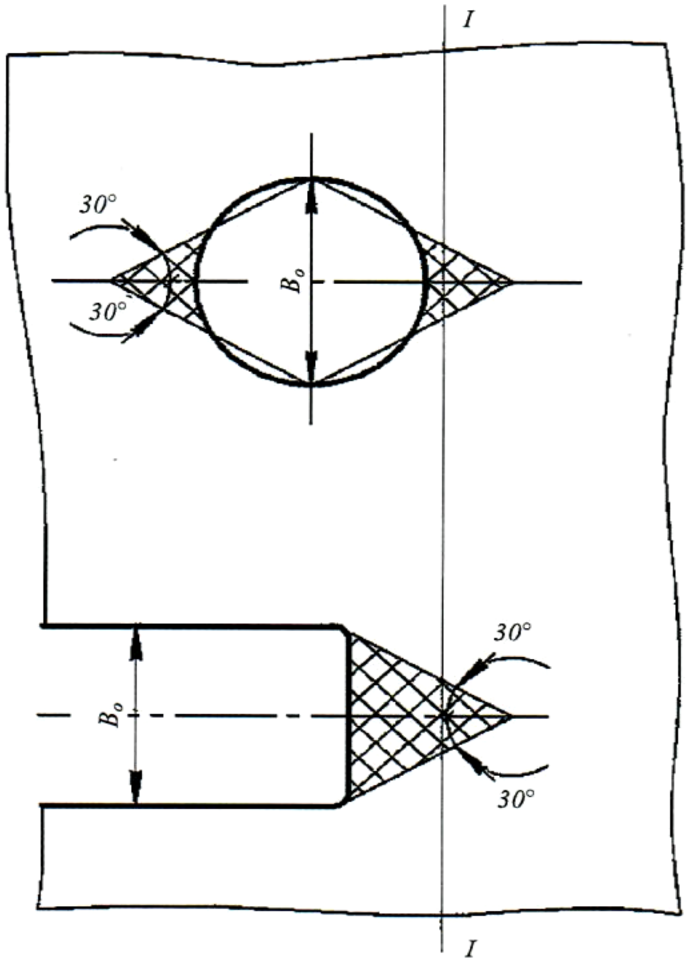


Fig. 5.4-1 Deck areas (hatched) not considered
in the design cross-section (*I* - *I*) when determine hull girder elements

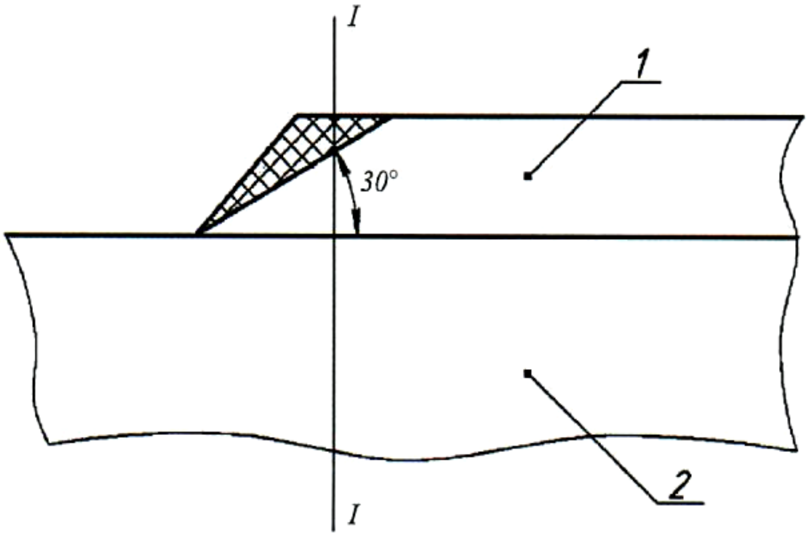


Fig. 5.4-2 Superstructure area (hatched) not considered
in design cross-section (*I* - *I*) when determine hull girder elements:
1 - superstructure; *2* - hull

5.4.11 All members ensuring longitudinal strength of the ship's hull and exposed to the local load shall be verified using combined normal stresses.

These members primarily include bottom members, for which the local load is water pressure p determined by the following formulae:

$p = \rho g H \cdot 10^{-3}$,

where: p - water pressure, in MPa;

ρ = 1,025 t/m3 - sea water density;

g = 9,81 m/s2 - gravity acceleration;

H = height of water column determined from the formula

$H = T + h/2 - z$, in m

where T - midship draft, m;

h - design wave height, in m, (refer to **4.2);**

z - distance of the member under consideration from the main surface, in m.

5.4.12 The hull strength for shear stresses shall be verified for the side plating and plating of longitudinal bulkheads by the following formula:

$$\sigma_{12} = \frac{N_p S}{J s_\Sigma} \leqslant [\sigma_{12}] = 0{,}8\sigma^o_{12},$$

where: N_p – refer to **5.4.2**;

$s_\Sigma = 2\sum_{n=1}^{m} s_n$ - total thickness of the side plating and plating of longitudinal bulkheads arranged on the same side from a centerline (if they are arranged symmetrically);

S - actual statical moment, about the neutral axis, of the hull's cross-sectional area part located above (or below) the horizontal plane, where shear stresses are determined;

J - moment of inertia of the hull cross-section calculated relative to the neutral axis.

When determine s_Σ thicknesses of members and their layers are calculated considering reduction factors (refer to **5.4.4**). In such case, Young's moduli E_{1p} shall be substituted with shear moduli G_{p12}; σ_{12} shall be assumed as the stress value in the member (or a load-bearing layer), relative to which the reduction is made.

5.4.13 When determine the longitudinal strength of the hull, its maximum deflection under design forces shall be determined (refer to **5.4.2**). The maximum deflection determined with consideration of shear shall not exceed the permissible level specified in **5.3.8**.

5.4.14 When the longitudinal strength is verified for buckling strength of longitudinal members shall meet the following conditions:

centre girder, stringer, deck girders, deck stringer plate and sheerstrake shall not lose buckling strength until the stresses are equal to three-fold design ones (considering combined stresses) or to extreme ones, whichever is lower;

plates of the bottom skin or upper (strength) deck shall not lose buckling strength until the stresses are equal to two-fold design ones (considering combined stresses) or to extreme ones, whichever is lower;

side plates under shear shall not lose buckling strength until the stresses are equal to two-fold design ones.

5.5 LOCAL HULL STRENGTH

5.5.1 Main hull structures (bottom, sides, decks, bulkheads, superstructure) shall be designed to withstand all the loads occurring under operational and emergency conditions.

Design loads shall be determined in accordance with the relevant Sections of the Register rules that regulates the hull strength and according to which the ship design was approved.

5.5.2 When determine grillages, frames, continuous members the following shall be taken into account:

design span length l_p, of the member as part of the grillage or frame is assumed equal to the distance between intersections with neutral exes of adjacent members of the same direction or members of the opposite directions, if they may be considered as supports, or equal to the distance between bulkheads, decks, etc.;

when statically indeterminate continuous members are calculated, brackets in bearing sections are not considered;

member of a variable cross-section shall be calculated as the first approximation, with the depth and area equal to minimum values of these parameters for the first member; if strength and stiffness requirements are not satisfied upon this calculation, the member shall be calculated at the second approximation, with actual variation of its cross-section taken into account;

5.5.3 When calculating grillage members, the width of the attached plate $\bar{b}_{ap}$ the hull and deck plating adjoining the members shall be determined from the following ratio:

for longitudinals (stringers, deck girders):

$$\frac{1}{6}L_p \geqslant \bar{b}_{ap} = B_b + \frac{1}{2}(b_f^r + b_f^l)\,\frac{(E_{p1})_{fp}}{(E_{1p})_{ffp}};$$

for transverses (floors, beams):

$$\frac{1}{6}L_p \geqslant \bar{b}_{ap} = B_b + l_f\,\frac{(E_{p2})_{fp}}{(E_{2p})_{ffp}},$$

where: L_p - design span length of the member determined for members according to **5.5.2**;

$b^r{}_f$, $b^l{}_f$ - distance between longitudinals (transverse spacing) to the right and to the left from the member calculated;

l_f – distance between transverses (longitudinal spacing);

B_b - width of the closed box stiffener section in the foundation; if the member has a T-shaped section, then $B_b = 0$;

$(E_{pj})_{fp}$ - design Young's modulus (refer to **5.3.5**) of the attached plate of the hull shell (deck) along (j = 1) and across (j = 2) the hull;

$(E_{pj})_{ffp}$ - design Young's modulus of the attached plate of the member calculated.

When determine the centre girder strength, the width of the attached plate is assumed equal to the full width of a plate keel multiplied by the reduction factor

$$\psi = \frac{(E_{p1})_{fp}}{(E_{1p})_{ffp}}.$$

5.5.4 When determine the members strength weakening of their webs with openings for members of different direction shall be taken into account (refer to **3.2.4**).

5.5.5 The hull shell strength shall be calculated for the water hydrostatic pressure impact, the value of which is determined in accordance with the Register rules according to which the ship design was approved

The design load on shell plating is considered to be uniformly distributed. Bottom platings supported with the support contour formed with stringers (centre girder and stringer) and floors are considered to be fixed.

For side plates, the support contour of which is formed with frames, decks and a bilge plate, fixing along vertical plates edges and free support of its horizontal edges are used. The values of the uniformly distributed load acting on the side plate is assumed equal to the mean value of intensity of the loads acting at the levels of its lower and upper horizontal edges.

5.5.6 Hull plating at the fore end shall be verified for the hydrodynamic pressure under the wave impact

upon the bottom of the fore end, the value of which shall be determined according to **2.8.3.2,** Part II "Hull".

5.5.7 Longitudinal strength and buckling strength of bottom grillage shall be determined upon uniformly distributed transverse load equal to the hydrostatic pressure value, and the forces acting in the grillage plane due to longitudinal bending from side grillages loaded with the water pressure.

When determine longitudinal strength, floors are considered to be freely supported, stringers and centre girder fixed on transverse bulkheads. When lengths of adjacent compartments or values of the loads they are exposed to are considerably different from each other, the factor of matched supporting longitudinals on bulkheads is determined by the following formula:

$$æ = \frac{1 + \frac{1}{2}\frac{\bar{p}}{p}\left(\frac{\bar{L}_p}{L_p}\right)^3}{1 + \frac{1}{2}\frac{\bar{L}_p}{L_p}},$$

where: $\bar{p}$ - average/mean intensity of the transverse load in two compartments adjacent with the grillage calculated;

p - intensity of the transverse load acting on this grillage with the design length L_p;

$\bar{L}_p$ - average design length of two adjacent compartments.

5.5.8 The bottom grillage supporting the side grillages and bulkheads shall be verified using maximum loads transferred from the structures specified. In this case, the following buckling strength margins k_y relative to acting stresses or forces shall be ensured:

for longitudinals - k_y = 2,0;

for transverses - k_y = 1,5;

When determine buckling strength at the first approximation, frame grillages may be considered as isolated with attached plate calculated according to **5.5.3**.

Where the above-mentioned buckling strength requirements are not complied with, the entire grillage shall be calculated.

5.5.9 The buckling strength check of bottom grillage members shall be mandatorily included in the buckling strength check in simple bending for T-shaped section webs and local buckling strength for closed-box section webs. In both cases, the buckling strength margin shall be $k_y \geq 1{,}5$.

5.5.10 The side grillage strength shall be calculated for the action of the hydrostatic pressure over the side depth according to the trapezoidal rule.

Frames are considered as continuous members freely supported on the upper deck and bilge plate. The design length of frames shall be determined according to **5.5.2**.

Where this requirement for permissible stresses is not complied with upon calculation of frames as continuous members, a transverse frame ring shall be calculated, including the bottom floor, upper and intermediate deck beams and frames.

5.5.11 The side grillage buckling strength shall be calculated for compression and shear. In this case, the buckling strength margin shall be $k_y \geq 1{,}5$ relative to maximum forces transferred to the grillage calculated from the side of supporting decks, platforms, transverse bulkheads and bottom grillage.

5.5.12 Frames and bottom framing at the fore end shall be designed to withstand hydrodynamic under the wave impact upon the bottom of the fore end.

Pressure shall be determined in accordance with the relevant Sections of the Register rules that regulates the hull strength and according to which the ship design was approved.

5.5.13 The strength of the upper deck, as well as intermediate decks and platforms shall be verified for service loads:

pressure due to wave impact on the upper deck;

weight of the cargo accommodated on decks and platforms, including inertial forces under conditions of the ship motions;

The load due to wave impact and design values of the inertial component based on amplitudes and periods of rolling and pitching as specified in the design documentation shall be determined in accordance with the relevant Sections of the Register rules that regulates the hull strength and according to which the ship design was approved.

5.5.14 Buckling strength of decks and platforms shall be checked under maximum forces due to longitudinal bending and those transferred from side supporting grillages and bulkheads.

The buckling strength margin is assumed equal to:

$k_y = 2{,}0$ - for deck girders;

$k_y = 1{,}5$ - for beams.

Framing members of decks and platforms shall be mandatorily checked for buckling strength in simple bending and local buckling strength of closed box section webs (refer to **5.5.9**).

5.5.15 Watertight bulkheads shall be checked for strength when exposed to flooding head, which value shall be determined in accordance with the relevant Sections of the Register rules that regulates the hull strength and according to which the ship design was approved.

The strength of decks and platforms shall be checked for the same load if they ensure water-tightness of ship compartments in case of their emergency flooding.

5.5.16 All bulkheads, which serve as supports for deck, side and bottom grillages shall be verified by calculation using maximum loads due to bidirectional compression and shear in the bulkhead plane. In this case, the buckling strength margin not less than $k_y = 1{,}5$ shall be ensured.

5.5.17 The local vibration and strength of the after end exposed to vibration loads shall be checked separately.

5.6 STRUCTURAL STRENGTH OF SUPERSTRUCTURE

5.6.1 Where the superstructure contributes to the longitudinal bending of the hull, its longitudinal members (sides, decks, longitudinal bulkheads) shall be calculated using forces under the hull longitudinal bending, and local loads due to wave impact and the equipment, machinery and other cargoes in the superstructure, including the crew.

5.6.2 Forces acting in longitudinal members of the superstructure contributing to longitudinal bending may be determined by the following formulae:

for sides and longitudinal bulkheads

$T_{in} \approx \frac{\sigma_{ok}}{E_{ok}} A_{ii}$;

for deck girders

$T_k \approx \frac{\sigma_{ok}}{E_{ok}} A_k$,

where: σ_{ok} - stress in the main hull on the upper deck level;

E_{ok} - stress in the main hull on the upper deck level;

A_{ii} - reduced axial stiffness of the of the plate specified members in the longitudinal direction;

$A_k = \Sigma A_j$ - reduced axial stiffness of the deck girder with an attached plate (refer to **5.5.3**).

5.6.3 The value of the load acting on superstructure sides shall be determined according to the requirements of the Register rules to which the ship design was approved.

Sides of the second tier superstructures shall be checked using loads equal to 50 % of the loads acting on relevant sides of the first tier.

5.6.4 Where the superstructure members (deck, bulkhead, etc.) accommodate the equipment, these members shall be additionally determined using local or concentrated loads according to the formula

$P_p^M = k_d^M M$,

where: M - weight of the equipment installed;

k_d^M - dynamic factor that shall be not less than $k_d^M \geq 2$ and is specified in the ship's project documentation.

5.6.5 When calculating the strength of superstructure (deckhouse) members for plates and framing members, factors k_n, k_c to determine permissible stresses (refer to **5.3.7**) are assumed equal to k_n = 0,7, k_c = 0,8 regardless of the acting load.

In superstructure members contributing to the longitudinal bending stresses due to longitudinal hull bending and local load impacts shall be summarized.

5.6.6 The check of superstructure (deckhouse) members for buckling strength shall ensure the buckling strength margin not less than $k_y \geq 1,5$.

5.6.7 The joint strength of the superstructure sides and the hull at superstructure ends shall be checked separately for shear and tear stresses. In this case, factorsk_n, k_c shall be assumed $k_n = k_c = 0,6$.

5.6.8 Plates of sides, decks and superstructure bulkheads shall be calculated as freely supported and/or fixed to the support contour. The support contour for plates of sides, fore and back ends are formed with horizontal members, which include the upper deck of the hull, intermediate decks of the superstructure and its top, and with vertical members, including bulkheads and frames (stiffeners). Support members for deck plates are ends and sides, bulkheads, beams and deck girders.

Plates of sides, fore and back ends and those of decks and top are considered to be fixed along all four edges, excluding side and top plates attached to each other along one of the edges. In these plates, edges supporting each other are considered to be freely supported, and other edges to be fixed.

5.6.9 Where the equipment is installed on the deck, the deck plate is calculated as freely supported on all four edges under local or concentrated load determined according to **5.6.4**. Determined stresses in plate elements are summarized with those in the same elements exposed to the uniform load.

5.6.10 The strength and stiffness of framing members (frames, beams, deck girders and stiffeners) shall be determined when exposed to the loads specified in **5.6.3** and **5.6.4**.

If frames and beams are aligned and form a frame or semi-frame, these frames and beams shall be determined as elements of the frame with fixed and/or flexible joints.

Otherwise, frames and beams, as well as deck girders and stiffeners, shall be considered as single-span (or multi-span) beams with fixed or freely supported ends. In the latter case, a frame terminates without changing in its plane to another member, e.g. a bulkhead.

The supports are:

for frames and stiffeners of the fore and back webs - decks and top;

for beams - sides, longitudinal bulkheads, pillars;

for deck girders - fore and back ends, transverse bulkheads, pillars.

5.6.11 When determine the geometric and stiffness characteristics of the framing member, the width of the attached plate of a plate is assumed (whichever is less) equal to $1/6l_d$ or $7H$, in case of a laminate of sandwich construction (where l_d - is design span length, H is total thickness of a sandwich laminate).

Design span length l_d is assumed equal to the distance between intersections of the neutral axis of the member calculated and planes passing through neutral axes of the members, or middle surfaces of member (side, bulkhead, etc.) plates it crosses.

5.6.12 When determine framing members, cross-section variability around support attachments due to brackets installed or section depth variability where the member is jointed to the crossing member, shall not be considered. The frame curvature shall not be considered either, unless it exceeds 20 %.

5.6.13 Sandwich laminates of sides and ends, decks, bulkheads, etc., and their framing shall be verified for longitudinal and local buckling strength when exposed to the most unfavorable load combination. In such case, the local buckling failure means:

in sandwich laminates - bucking failure of load-bearing layers;

in members - buckling failure of sides and ends for closed box section (simple bending for T-shaped sections).

The local buckling strength margin shall be not less than $k_y \geq 1{,}5$ relative to design stresses acting in load-bearing layers and webs of the closed box section accordingly.

5.6.14 Plates of superstructure's side webs, and of longitudinal bulkheads, shall be verified for buckling strength when exposed to joint action of the highest loads due to longitudinal bending and forces from the loads acting on the above structures, their weight, and weight of the equipment installed thereon.

The longitudinal buckling strength margin shall be $k_y \geq 1{,}7$.

5.6.15 Frames and stiffeners of the fore and stern ends are verified for buckling strength when exposed to forces specified in **5.6.14**. The longitudinal buckling strength margin of frames and stiffeners shall be not less than $k_y \geq 2{,}0$.

5.6.16 Deck plates shall be verified for buckling strength when exposed to joint action of the highest stresses due to longitudinal bending (refer to **5.6.1** and **5.6.2**), and stresses caused by grillages of sides supporting on them. The longitudinal buckling strength margin of deck and top plates shall be not less than $k_y \geq 1{,}5$.

5.6.17 Deck and top beams shall be verified for buckling strength when exposed to the highest forces transferred from sides supported by them, whereas deck girders - when exposed to stresses due to longitudinal bending. The longitudinal buckling strength margin overall stability safety margin of decks and top framing members shall be not less than $k_y \geq 1{,}7$.

5.6.18 Buckling strength of transverse bulkheads and fore and stern webs shall be verified when exposed to the highest forces transferred from grillages of sides supported by them and above structures. The longitudinal buckling strength margin shall be not less than $k_y \geq 2{,}0$.

5.6.19 The longitudinal strength and buckling strength of pillars shall be verified when exposed to the highest forces transferred from the above structures. The longitudinal buckling strength margin shall be not less than $k_y \geq 2{,}0$.

APPENDIX 1

LONGITUDINAL AND BUCKLING STRENGTH OF HULL STRUCTURAL MEMBERS AND PLATES

(Recommendations on calculation)

1 STRESS-STRAIN BEHAVIOR OF FRAMING MEMBERS

1.1 Stiffness characteristics are determined for the framing members of the section specified in Fig. 1. Recommended attached plate of the hull shell (deck plating and bulkhead plating) is generally of a sandwich scheme with a solid or structural orthotropic core with reduced elastic response. The core of the attached plate of sandwich construction under the member is reinforced with a core of the increased density.

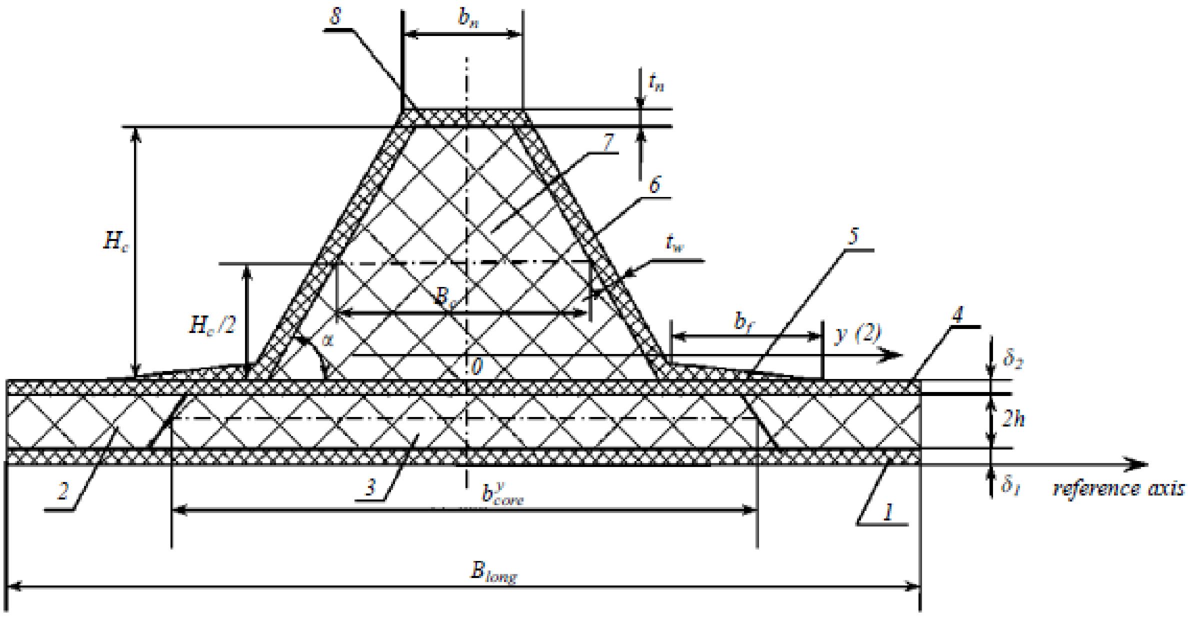


Fig. 1.1 Calculation method for the closed box (trapezoidal) member:
1, *4* - load-bearing layers; *2* - core; *3* - reinforcement with a core of increased density;
5 - flange; *6* - member web; *7* - core of a member; *8* - attached plate

The reduced geometric parameters of the cross-section, such as statical moment and inertia moment, relative to the reference axis shall be determined according to the formulae provided in Table 1.1.

Table 1.1 **Determination of the reduced geometric parameters of the cross-section**

i-th element (refer to Fig. 1.1)	Crosssectional area of the element F_i	Young's modulus of the element E_i	Distance of the element's gravity centre from the reference axis z_i	Reduced c rosssectional area of the element E_iF_i	Reduced statical moment of the element $E_iF_iz_i$	Reduced inertia moment	
						transferred $E_iF_iz_i^2$	intrinsic i_i
1	$\delta_1 B_{long}$	$E_{ll}^{(1)}$	$\delta_1/2$	$\delta_1 B_{long} E_{ll}^{(1)}$	$\frac{1}{2}\delta_1^2 B_{long} E_{ll}^{(1)}$	$\frac{1}{4}\delta_1^3 B_{long} E_{ll}^{(1)}$	-
2	$2h(B_{long}-b^y{}_{core})$	E_{core}	δ_1+h	$2h(B_{long}-b^y{}_{core}) E_{core}$	$2h(B_{long}-b^y{}_{core}) E_{core}(\delta_1+h)$	$2h(B_{long}-b^y{}_{core}) E_{core}(\delta_1+h)^2$	-
3	$2h \cdot b^y{}_{core}$	$E^y{}_{core}$	δ_1+h	$2h/b^y{}_{core}E^y{}_{core}$	$2h/b^y{}_{core}E_{core}$ $(\delta_1 + h)$	$2h/b^y{}_{core}E_{core}\times$ $\times(\delta_1 + h)^2$	-
4	$\delta_2 B_{long}$	$E_{ll}^{(2)}$	$\delta_1+2h+\delta_2/2$	$E_{ll}^{(2)}\delta_2 B_{long}$	$E_{ll}^{(2)}\delta_2 B_{long}\times$ $\times(\delta_1+2h+\delta_2/2)$	$E_{ll}^{(2)}\delta_2 B_{long}\times$ $\times(\delta_1+2h+\delta_2/2)^2$	-
5	$t_w b_f$	E_w	$\delta_1+2h+\delta_2+t_w/3$	$E_w t_w b_f$	$E_w t_w b_f(\boldsymbol{\delta}_1+2h++\boldsymbol{\delta}_2+ t_w/3)$	$E_w t_w b_f(\boldsymbol{\delta}_1+2h+\boldsymbol{\delta}_2+ t_w/3)^2$	
6	$2t_w \frac{H_c}{\sin\alpha}$	E_w	$\delta_1+2h+\delta_2+H_c/2$	$2E_w t_w \frac{H_c}{\sin\alpha}$	$2E_w t_w \frac{H_c}{\sin\alpha}\times$ $\times(\delta_1+2h+\delta_2+H_c/2)$	$2E_w t_w \frac{H_c}{\sin\alpha}\times(\delta_1 +$ $+2h+\delta_2+H_c/2)^2$	$\frac{E_w t_w H_c^3}{6}$

7	B_cH_c	E_c	$\delta_1+2h+\delta_2+H_c/2$	$E_cB_cH_c$	$E_cB_cH_c\times(\delta_1+2h+\delta_2+H_c/2)$	$E_cB_cH_c\times(\delta_1+2h+\delta_2+H_c/2)^2$	$\frac{E_cB_cH_c^3}{12}$
8	b_nt_n	E_n	$\delta_1+2h+\delta_2+H_c++t_n/2$	$E_nb_nt_n$	$E_nb_nt_n(\delta_1+2h+\delta_2++H_c+t_n/2)$	$E_nb_nt_n(\delta_1+2h+\delta_2++H_c+t_n/2)^2$	
				$\sum_{i=1}^{8} E_iF_i$	$\sum_{i=1}^{8} E_iF_iz_i$	$\sum_{i=1}^{8}(E_iF_iz_i^2+i_i)$	

The bending stiffness of the closed box stiffener relative to figure axis O_y is determined by the following formula

$$D_{11}=\sum_{i=1}^{8}(E_iF_iz_i^2+i_i)-e^2\sum_{i=1}^{8}E_iF_i,$$

where: e – distance between the reference axis and axis y is determined by the formula

$$e=\frac{\sum_{i=1}^{8}E_iF_iz_i}{\sum_{i=1}^{8}E_iF_i};$$

E_i, F_i, z_i – refer to Table 1.1.

Axial stiffness of the member shall be determined by the formula

$$B_{11}=\sum_{i=1}^{8}E_iF_i\,.$$

1.2 Normal stresses in member elements exposed to the bending moment M_1 and axial force T_1 are determined by the formula

$$\sigma_{11}^{(i)}=E_i\left(\frac{M_1z_i}{D_{11}}+\frac{T_1}{B_{11}}\right). \qquad (1.2)$$

For the most typical elements of the member section, these stresses determined by Formula (1.2) shall be equal to the following:

in the face plate of the member

$$\sigma_{11}^{(8)}=\max\sigma_{11}^{(8)}=E_n\left[\frac{M_1}{D_{11}}(z_8+t_n/2-e)+\frac{T_1}{B_{11}}\right];$$

in the section core

$$\sigma_{11}^{(7)}=\max\sigma_{11}^{(7)}=E_c\left[\frac{M_1}{D_{11}}(z_7+H_c/2-e)+\frac{T_1}{B_{11}}\right];$$

in the bottom load-bearing layer of the member attached plate

$$\sigma_{11}^{(1)}=\max\sigma_{11}^{(1)}=E_{II}^{(1)}\left(-\frac{M_1e}{D_{11}}+\frac{T_1}{B_{11}}\right);$$

where z_7, z_8 - refer to Table 1.1.

1.3 Shear stresses in member elements exposed to the shear force N_1 are determined in two design sections:

in the middepth of the section

$z=z^c$;

at the connection of the member to the attached plate (refer to Fig. 1.3)

$z=z^f$.

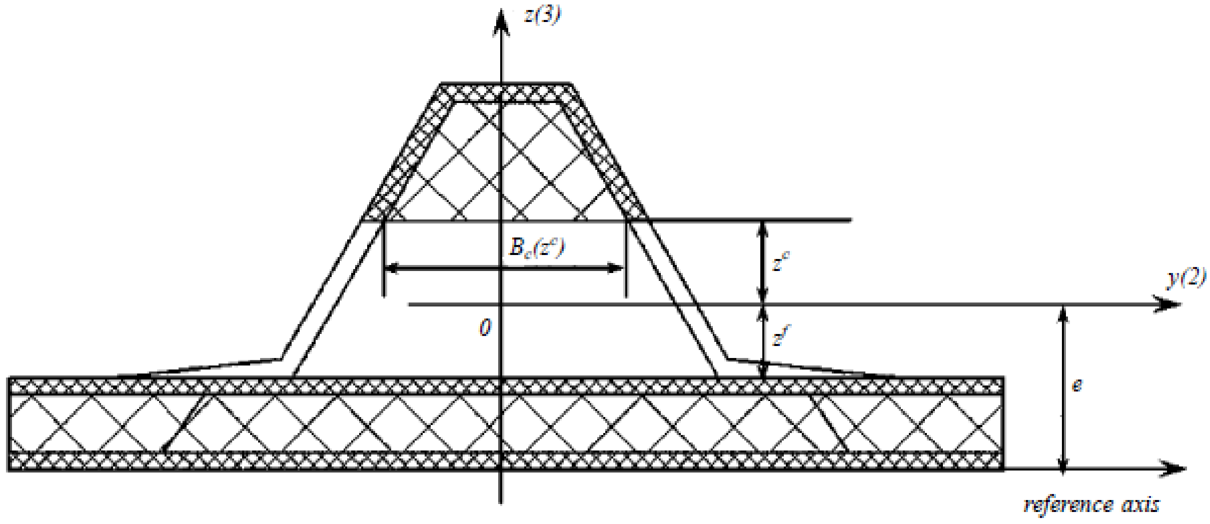


Fig. 1.3 Calculation method for determination of shear stresses

Shear stresses in section $z = z^c$ are determined by the following formulae:
in the core

$$\sigma_{13}^{(c)} = \frac{Q}{2t_w G_{13}^{w}/G^c + B_c(z^c)};$$

in webs of the member section sheathing

$$\sigma_{13}^{(w)} = \frac{Q}{2t_w G^c/G_{13}^{w} + B_c(z^c)},$$

where: G^c – shear modulus of the core material;
$G^w{}_{13}$ – shear modulus of the web material in the reinforcement plane

$$B_c(z^c) = B_c + 2(z_7 - e - z^c)\frac{\cos\alpha}{\sin\alpha};$$

$$Q = \frac{N_1}{D_{11}} \sum_{j=1}^{k} E_j \overline{F}_j \overline{z}_j \ . \tag{1.3}$$

The statical moment of the member cross-section part located above $z = z^c$ (refer to Fig. 1.3) shall be determined by the formula

$$\sum_{j=1}^{k} E_j \overline{F}_j \overline{z}_j = E_n \overline{F}_n \overline{z}_n = E_w \overline{F}_w \overline{z}_w + E_c \overline{F}_c \overline{z}_c ,$$

where: $\overline{F}_n \overline{z}_n = b_n t_n (z_8 - e);$

$$\overline{F}_w \overline{z}_w = \frac{t_w}{\sin\alpha}\left[(z_7 + H_c/2 - e)^2 - (z^c)^2\right];$$

$$\overline{F}_c \overline{z}_c = \frac{1}{2}\left[B_c + 2\left(z_4 + \frac{1}{2}\delta_2 - z - e\right)\frac{\cos\alpha}{\sin\alpha}\right]\cdot\left[\left(z_7 + \frac{1}{2}H_c - e\right)^2 - (z^c)^2\right].$$

Shear stresses in section $z = z^f$ (refer to Fig. 1.3) are by the formulas:
in the core

$$\sigma_{13}^{c} = \frac{Q}{2(t_w G_{13}^{w}/G^c + b_f G_{13}^{f}/G^c + B_c(z^f))};$$

along the contact line of the load-bearing layer and member flanges

$$\sigma_{13}^{f} = \frac{Q}{2(t_w + b_f) + B_c(z^f)\, G^c/G_{13}^{f}} ,$$

where: $C^f{}_{13}$ – interlaminar shear modulus of the flange equal to that of the web material;

$$B_c(z^f) = B_c + H_c)\frac{\cos\alpha}{\sin\alpha};$$

Q - determined by Formula (1.3), whereas:

$$\sum_{j=1}^{k} E_j \overline{F}_j \overline{z}_j = E_{ll}^{(1)} \overline{F}_{ll}^{(1)} \overline{z}_{ll}^{(1)} + E_{core} \overline{F}_{core} \overline{z}_{core} + E_{core}^{y} \overline{F}_{core}^{y} \overline{z}_{core}^{y} + E_{ll}^{(2)} \overline{F}_{ll}^{(2)} \overline{z}_{ll}^{(2)};$$

$$E_{ll}^{(1)} \overline{F}_{ll}^{(1)} \overline{z}_{ll}^{(1)} = E_{ll}^{(1)} B_{long} \delta_1 (e - \delta_1/2);$$

$$E_{core} \overline{F}_{core} \overline{z}_{core} = 2E_{core}(B_{long} - b_{core}^{y}) h (e - z_2);$$

$$E_{core}^{y} \overline{F}_{core}^{y} \overline{z}_{core}^{y} = 2E_{core}^{y} b_{core}^{y} h (e - z_3);$$

$$E_{ll}^{(2)} \overline{F}_{ll}^{(2)} \overline{z}_{ll}^{(2)} = E_{ll}^{(2)} B_{long} \delta_2 (e - z_4);$$

1.4 Member deflections w, bending moment M_1 and shear force N_1 are determined depending on its conditions of loading and attachment in supporting sections. Formulae to determine the parameters for the most typical cases when calculating FRP hull structures shall be determined based on General engineering approaches to the structural theory of the ship.

2 BUCKLING STRENGTH OF FRAMING MEMBERS

2.1 When the member is exposed to longitudinal (axial) compressive stresses T_1 ($T_1 < 0$), which may lead to its buckling failure, the buckling load is determined by the following formula

$$T_{1buck} = \frac{T_{1eu}}{1 + T_{1eu}/K_{11}},$$

where: T_{1eu} – theoretical Euler stress;
K_{11} – shear stiffness (refer to **1.3**)

$$K_{11} = 2G_{13}^{w} t_w + G^{c} B_c)H.$$

2.2 The theoretical Euler stress of buckling failure is determined by the following formulae:

for freely supported members

$$T_{1eu} = \frac{\pi^2 D_{11}}{l^2};$$

for fixed members

$$T_{1eu} = \frac{4\pi^4 D_{11}}{l^2};$$

for members fixed at one end and hinge-supported at the other

$$T_{1eu} = \frac{2\pi^4 D_{11}}{l^2},$$

where D_{11} –refer to **1.1**.

3 SHEAR STRESS-STRAIN BEHAVIOR OF SINGLE-SKIN PLATES

Shear strain-stress behavior of single-skin plates shall be determined by the following formulae:

$$w = k_1 \frac{pb^4}{E_1 t^3};$$

$$M_1 = k_2 pb^2;$$

$$M_2 = k_3 pb^2;$$

$$M_2' = k_5 pb^2,$$

where: p - design load intensity;

M_1 - bending moment at the plate center in the section parallel to axis y;

M_2 – bending moment at the laminate center in the section parallel to axis x;

M'_2 - bending moment in the middle of the longer side of the supporting contour in the section parallel to axis x;

E_1 and E_2 - Young's moduli in the core direction (08 direction) and weft direction (90° direction);

t - plate thickness.

Values of factors k_i for isotropic and orthotropic plates, with the Young's moduli ratio along the shorter and longer sides of the plate equal to 1,0 and 1,5 are specified in Table 3-1 and 3-2 for fixed bearing edges, and for plates with freely supported edges.

Where hull or deck platings are made with parallel and diagonal reinforcement schemes [(0º/90º)/(+45º/-45º)/(0º/90º)/... /(+45º/-45º)/(0º/90º)], plates shall be considered as isotropic ones with average values equal to a half-sum of the relevant characteristics in warp and weft directions of parallel layers:

$$E_{av} = \frac{E_1 + E_2}{2};$$

$$\nu_{av} = \frac{\nu_1 + \nu_2}{2}.$$

The values specified for orthotropic plates refer to FRPs with parallel reinforcement schemes [(0º/90º)] (E_1/E_2=1,0; E_1/G=5) i (E_1/E_2=1,5; E_1/G=6), positioned with 1 - (0º) direction along the shorter side.

Maximum normal stresses in the plate are determined by the formula

$\sigma_{ii} = \pm 6M_i/t_2$.

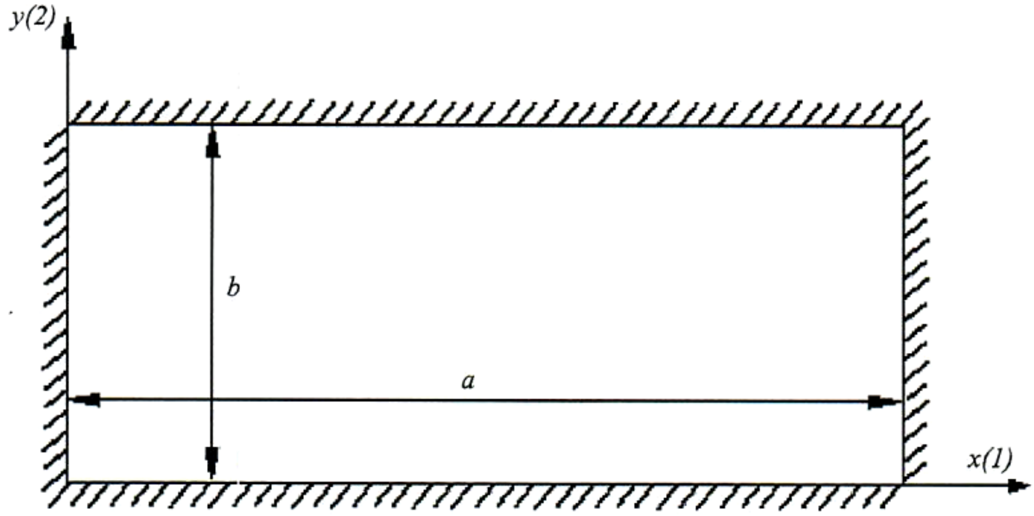


Fig. 3 Calculation method of single-skin plates

Table 3.1 **Values of factors k_i for plates with fixed edges**

k_i	Plate	*a/b*							
		1,0	1.25	1,5	1,75	2,0	2,5	3,0	∞
k_1	Isotropic	0,0138	0,02	0,0241	0,0263	0,0276	0,0278	0,0279	0,0284
	Orthotropic,, E_1/E_2=1,0	0,0153	0,021	0,0255	0,0275	0,029	0,0307	0,0312	0,032
	Orthotropic, E_1/E_2=1,5	0,0168	0,0227	0,0266	0,0283	0,0299	0,0299	0,0309	0,032
k_2	Isotropic	0,0229	0,0228	0,0201	-	-	-	-	-
	Orthotropic, E_1/E_2=1,0	0,024	0,0235	0,021	-	-	-	-	-
	Orthotropic, E_1/E_2=1,5	0,0213	0,0196	0,0174	-	-	-	-	-
k_3	Isotropic	0,0229	0,0315	0,0368	0,0383	0,0399	0,0404	0,0405	0,0417
	Orthotropic, E_1/E_2=1,0	0,024	0,033	0,0375	0,0395	0,0408	0,0415	0,0418	0,0425
	Orthotropic, E_1/E_2=1,5	0,0259	0,0344	0,0384	0,04	0,041	0,0415	0,0419	0,0425
k_5	Isotropic	0,0517	0,064	0,0753	0,0814	0,0829	0,083	0,0832	0,0833
	Orthotropic, E_1/E_2=1,0	0,054	0,067	0,0783	0,082	0,083	0,0833	0,0838	0,085
	Orthotropic, E_1/E_2=1,5	0,058	0,0698	0,0794	0,0825	0,0832	0,0835	0,084	0,085

Table 3.2 **Values of factors k_i for plates with freely supported edges**

k_i	Plate	*a/b*							
		1,0	1.25	1,5	1,75	2,0	2,5	3,0	∞
k_1	Isotropic	0,0443	0,0656	0,0843	0,099	0,1106	0,1221	0,1336	0,1422
	Orthotropic, E_1/E_2=1,5	0,0762	0,1062	0,1225	0,1381	0,1469	0,1542	0,1562	0,1563
k_2	Isotropic	0,0479	0,0503	0,05	0,0482	0,0464	0,434	0,0404	0,0375
	Orthotropic, E_1/E_2=1,5	0,0493	0,0444	0,0414	0,0292	0,0246	0,0188	0,0134	0,0125
k_3	Isotropic	0,0479	0,0659	0,0812	0,0928	0,1017	0,1101	0,1185	0,125
	Orthotropic, E_1/E_2=1,5	0,0661	0,0876	0,1069	0,1135	0,1201	0,126	0,13	0,133

4 BUCKLING STRENGTH OF SINGLE-SKIN PLATES IN COMPRESSION

4.1 Critical stresses of FRPs with parallel reinforcement scheme [(0º/90º)] is determined by the formula

$\sigma_{buck} = E_1 B(t/b)^2$,

where: E_1 - Young's compression modulus;

B - factor depending on the aspect ratio of plate sides:

$$B = \frac{(m/\gamma)^2 + 2[\nu_2 + 2\frac{G_1}{E_1}(1-\nu_1\nu_2)] + \frac{E_2}{E_1}(\gamma/m)^2}{12(1-\nu_1\nu_2)}\pi^2,$$

where: $\gamma = a/b$ - aspect ratio of plate sides;

m - number of half waves at buckling failure;

t - plate thickness.

4.2 FRPs with parallel and diagonal reinforcement schemes [(0º/90º)/(+45º/-45º)/(0º/90º)/..../(+45º/-45º)/(0º/90º)].

When determine finite stiffness FRP plates with parallel and diagonal reinforcement scheme, the calculation method for relevant isotropic plates may be used. In such case, the average values of Young's modulus and Poisson's ratio shall be determined by the following formulae:

$$E_{av} = \frac{E_1 + E_2}{2};$$

$$\nu_{av} = \frac{\nu_1 + \nu_2}{2}.$$

where: E_1 i E^2 - Young's moduli in the warp direction (08 direction) and weft direction (90° direction);

ν_1 i ν_2 - Poisson's ratios in the warp direction (0° direction) and weft direction (90° direction);

$\sigma_{buck} = E_{av} B(t/b)^2$

Values of factor B for $0,4 \le \gamma \le 3,0$ are specified in Table 4.2 and in Figs. 4.1 – 4.3.

Table 4.2 **Values of factor *B* depending on the aspect ratio of plate sides**

E_p^{bl}	m	1	1	1	1	1	1	2	2	2	2	2	3	3	3
	γ / G^{bl}_{12}	0,4	0,6	0,8	1	1,2	1,4	1,6	1.8	2	2,2	2,4	2,6	2,8	3
	5	6,57	3,99	3,44	3,57	4,06	4,78	3,44	3,45	3,57	3,78	4,06	3,43	3,48	3,57
15	8,5	6,96	4,38	3,82	3,96	4,44	5,16	3,82	3,83	3,96	4,16	4,44	3,82	3,86	3,96
	12	7,34	4,76	4,21	4,34	4,82	5,54	4,21	4,22	4,34	4,55	4,82	4,20	4,25	4,34
	5	6,44	3,86	3,30	3,44	3,92	4,64	3,30	3,31	3,44	3,64	3,92	3,30	3,34	3,44
20	8,5	6,73	4,14	3,59	3,72	4,21	4,93	3,59	3,60	3,72	3,93	4,21	3,58	3,63	3,72
	12	7,01	4,43	3,88	4,01	4,49	5,21	3,88	3,89	4,01	4,22	4,49	3,87	3,92	4,01
	5	6,36	3,77	3,22	3,35	3,84	4,56	3,22	3,23	3,35	3,56	3,84	3,21	3,26	3,35
25	8,5	6,59	4,00	3,45	3,58	4,07	4,79	3,45	3,46	3,58	3,79	4,07	3,44	3,49	3,58
	12	6,82	4,23	3,68	3,81	4,30	5,02	3,68	3,69	3,81	4,02	4,30	3,67	3,72	3,81
	5	6,30	3,72	3,17	3,30	3,78	4,50	3,17	3,18	3,30	3,51	3,78	3,16	3,21	3,30
30	8,5	6,49	3,91	3,36	3,49	3,97	4,69	3,36	3,37	3,49	3,70	3,97	3,35	3,40	3,49
	12	6,68	4,10	3,55	3,68	4,17	4,89	3,55	3,56	3,68	3,89	4,17	3,54	3,59	3,68
	5	6,26	3,68	3,13	3,26	3,74	4,46	3,13	3,14	3,26	3,47	3,74	3,12	3,17	3,26
35	8,5	6,43	3,84	3,29	3,43	3,91	4,63	3,29	3,30	3,43	3,63	3,91	3,29	3,33	3,43
	12	6,59	4,01	3,46	3,59	4,07	4,79	3,46	3,47	3,59	3,80	4,07	3,45	3,50	3,59
	5	6,23	3,65	3,10	3,23	3,71	4,43	3,10	3,11	3,23	3,44	3,71	3,09	3,14	3,23
40	8,5	6,38	3,79	3,24	3,38	3,86	4,58	3,24	3,25	3,38	3,58	3,86	3,24	3,28	3,38
	12	6,52	3,94	3,39	3,52	4,00	4,72	3,39	3,40	3,52	3,73	4,00	3,38	3,43	3,52
	5	6,19	3,61	3,06	3,19	3,67	4,39	3,06	3,07	3,19	3,40	3,67	3,05	3,10	3,19
50	8,5	6,31	3,72	3,17	3,31	3,79	4,51	3,17	3,18	3,31	3,51	3,79	3,17	3,21	3,31
	12	6,42	3,84	3,29	3,42	3,90	4,62	3,29	3,30	3,42	3,63	3,90	3,28	3,33	3,42
	5	6,16	3,58	3,03	3,16	3,65	4,37	3,03	3,04	3,16	3,37	3,65	3,02	3,07	3,16
60	8,5	6,26	3,68	3,13	3,26	3,74	4,46	3,13	3,14	3,26	3,47	3,74	3,12	3,17	3,26
	12	6,36	3,77	3,22	3,35	3,84	4,56	3,22	3,23	3,35	3,56	3,84	3,21	3,26	3,35

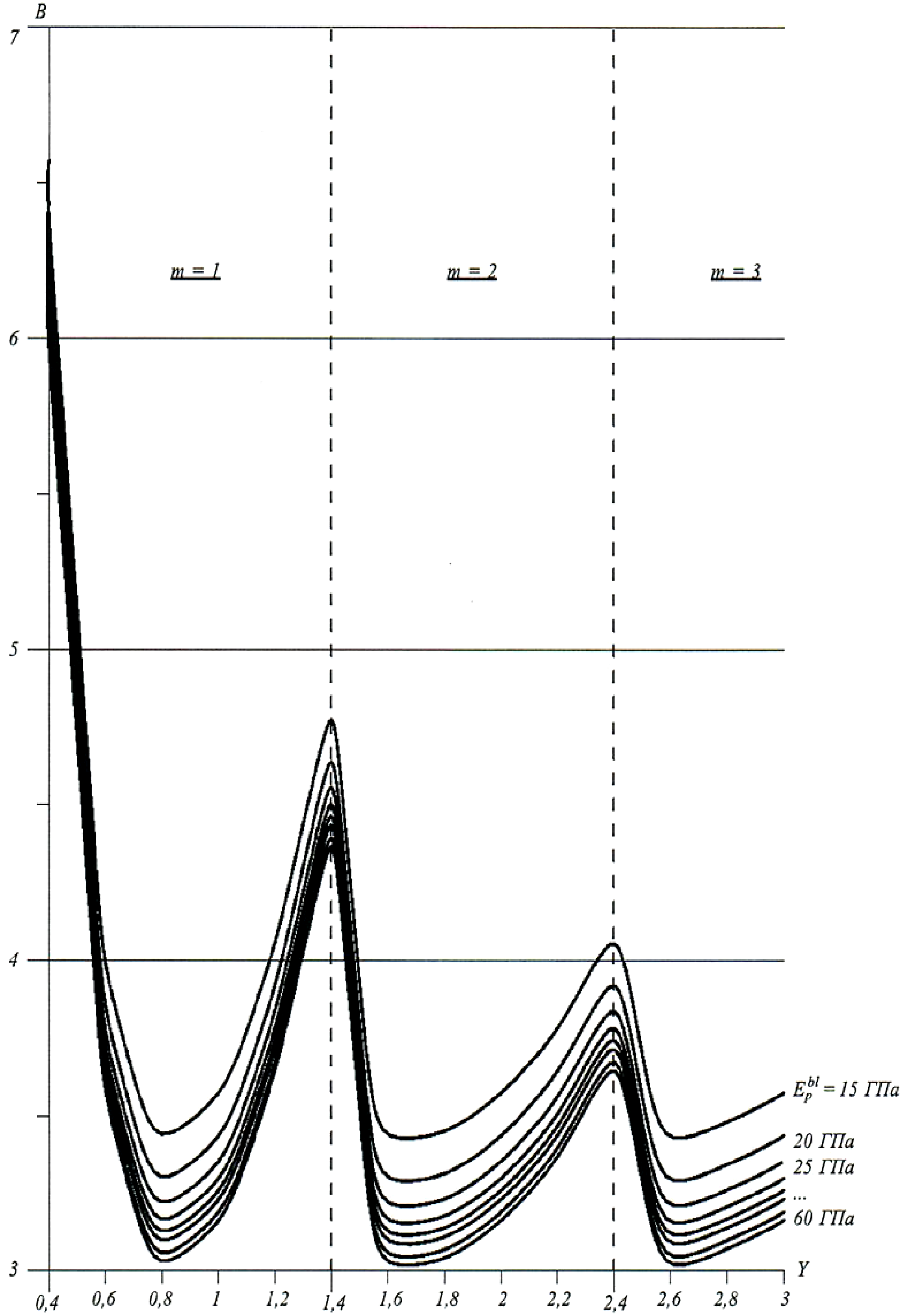


Fig. 4.1 Values of factor *B* at G^{bl}_{12} = 5 GPa

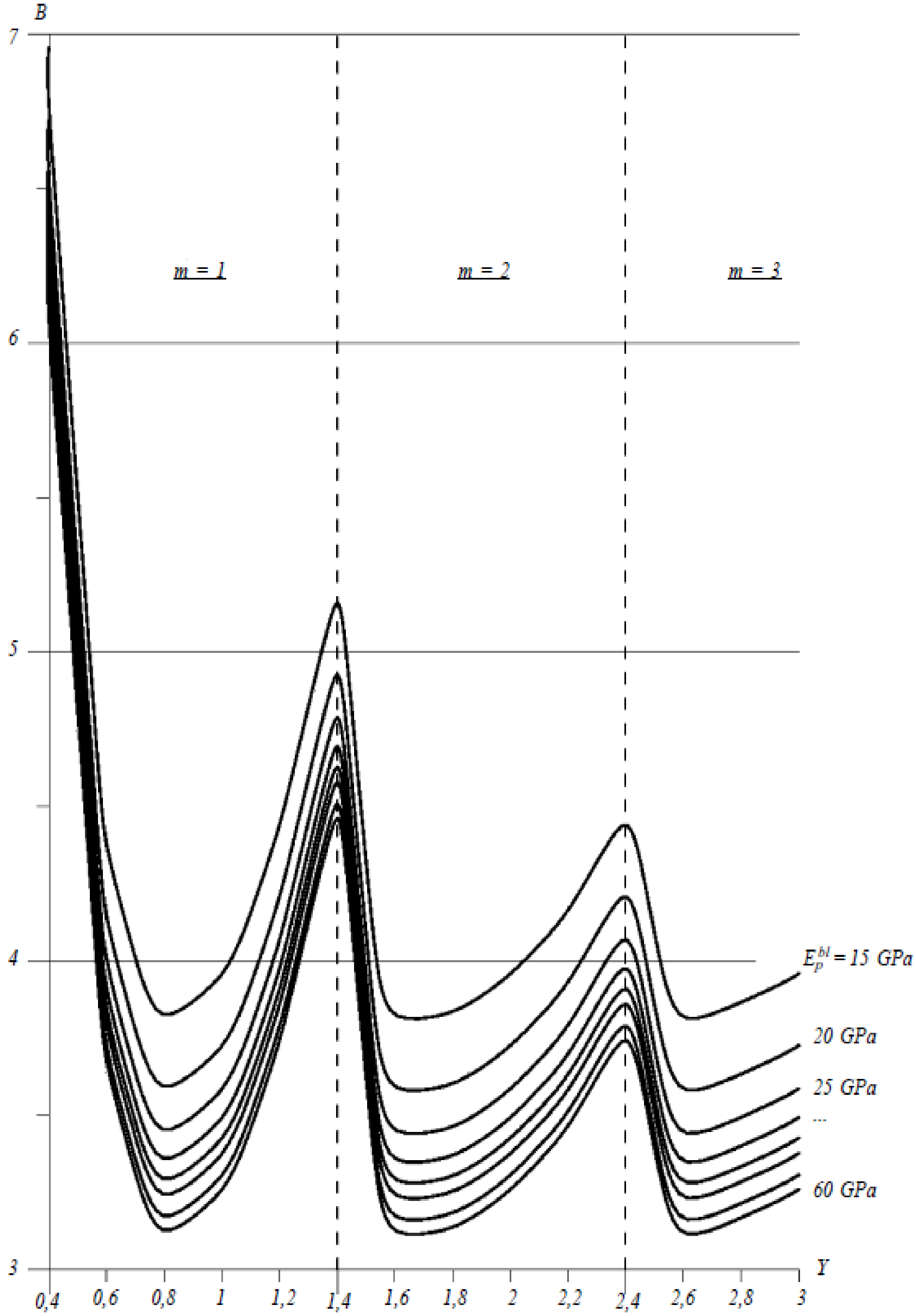


Fig. 4.2 Values of factor B at G^{bl}_{12} = 8,5 GPa

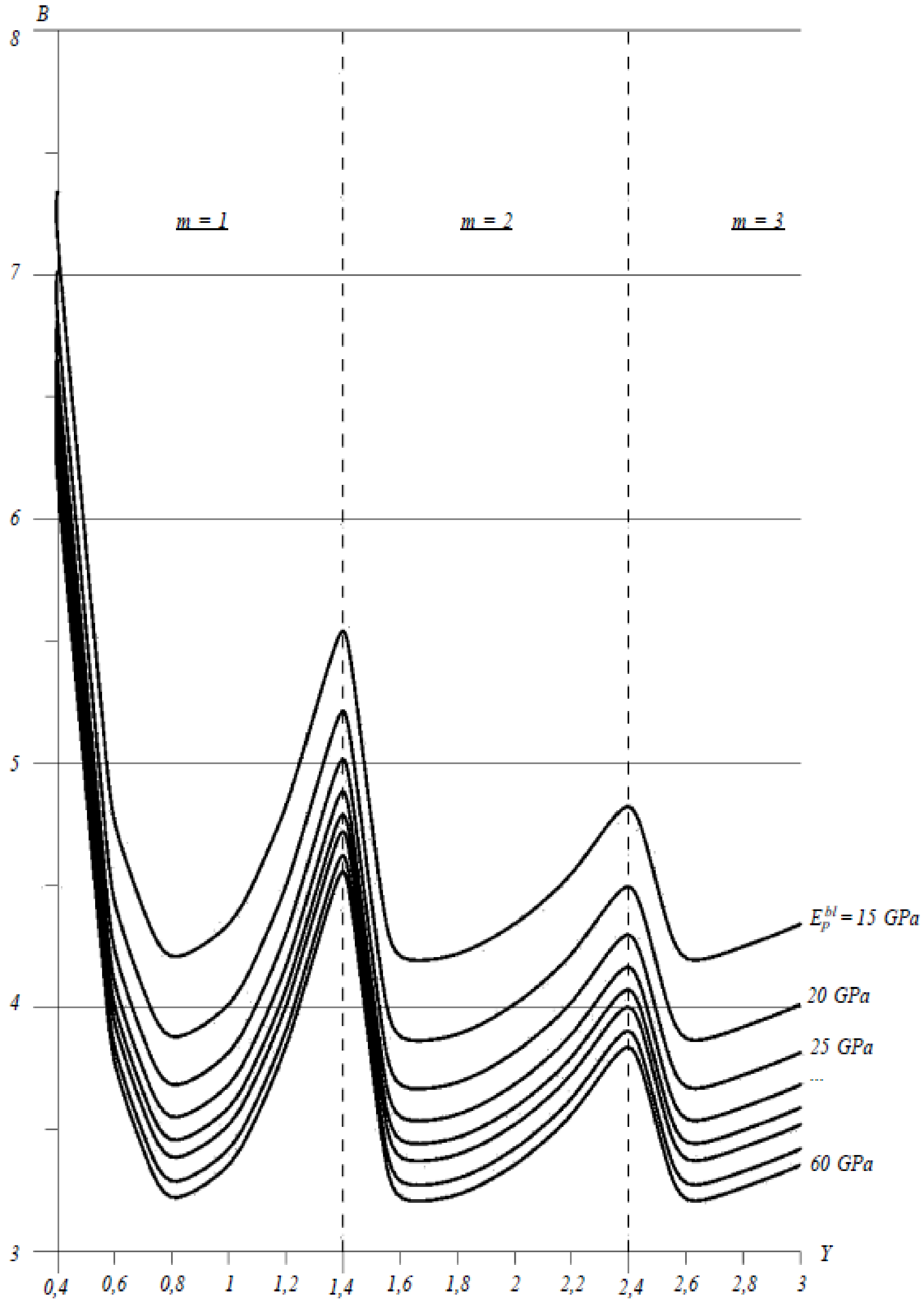


Fig. 4.3 Values of factor *B* at G^{bl}_{12} = 12 GPa

5 SHEAR BUCKLING STRENGTH OF SINGLE-SKIN PLATES

5.1 Shear critical stress of FRPs with parallel reinforcement scheme [(0°/90°)] is determined by formula **.1** at $\gamma \geq 1$:

$$\tau_{buck} = (E_1/\gamma^4 + 2E_3/\gamma^4 + E_2)B(t/b)^2,$$

where: $E_3 = E_1\nu_2 + 2(1-\nu_1\nu_2)G$;

$$B = \frac{\pi^4\gamma}{384(1-\nu_1\nu_2)}\sqrt{\frac{100}{1{,}395+4(k_1+k_2)}},$$

$$k_1 = \frac{1+2\gamma^2A+\gamma^4 l}{81+18\gamma^2A+\gamma^4 l};\quad k_2 = \frac{1+2\gamma^2A+\gamma^4 l}{1+18\gamma^2A+81\gamma^4 l};$$

where:

$$A = \nu_2 + 2\frac{G}{E_1}(1-\nu_1\nu_2);\ \gamma = a/b;\ l = \frac{E_2}{E_1}.$$

Note. Reinforcement direction (0°) - along side of length *a*.

Values of factor *B* for $\gamma \geq 1$ are specified in Table 5.1.1 and in Fig. 5.1-1;

Table 5.1.1 **Values of factor *B* depending on the aspect ratio of plate sides at $\gamma \geq 1$**

E_p^{bl}, GPa	G^{bl}_{12},GPa \ γ	1	1,2	1,4	1,6	1.8	2	2,2	2,4	2,6	2,8	3
	5	1,99	2,39	2,79	3,18	3,58	3,98	4,38	4,78	5,17	5,57	5,97
15	8,5	1,96	2,36	2,75	3,14	3,53	3,93	4,32	4,71	5,10	5,50	5,89
	12	1,94	2,33	2,72	3,11	3,49	3,88	4,27	4,66	5,05	5,44	5,82
	5	2,00	2,40	2,80	3,20	3,60	4,00	4,40	4,80	5,20	5,60	6,00
20	8,5	1,98	2,37	2,77	3,17	3,56	3,96	4,35	4,75	5,14	5,54	5,94
	12	1,96	2,35	2,74	3,14	3,53	3,92	4,31	4,70	5,10	5,49	5,88
	5	2,01	2,41	2,81	3,21	3,61	4,02	4,42	4,82	5,22	5,62	6,02
25	8,5	1,99	2,39	2,78	3,18	3,58	3,98	4,38	4,77	5,17	5,57	5,97
	12	1,97	2,37	2,76	3,16	3,55	3,94	4,34	4,73	5,13	5,52	5,92
	5	2,01	2,42	2,82	3,22	3,62	4,03	4,43	4,83	5,23	5,64	6,04
30	8,5	2,00	2,40	2,79	3,19	3,59	3,99	4,39	4,79	5,19	5,59	5,99
	12	1,98	2,38	2,77	3,17	3,57	3,96	4,36	4,76	5,15	5,55	5,95
	5	2,02	2,42	2,82	3,23	3,63	4,03	4,44	4,84	5,24	5,65	6,05
35	8,5	2,00	2,40	2,80	3,20	3,60	4,00	4,40	4,80	5,20	5,61	6,01
	12	1,99	2,39	2,78	3,18	3,58	3,98	4,38	4,77	5,17	5,57	5,97
	5	2,02	2,42	2,83	3,23	3,63	4,04	4,44	4,85	5,25	5,65	6,06
40	8,5	2,01	2,41	2,81	3,21	3,61	4,01	4,41	4,81	5,22	5,62	6,02
	12	1,99	2,39	2,79	3,19	3,59	3,99	4,39	4,79	5,18	5,58	5,98
	5	2,02	2,43	2,83	3,24	3,64	4,05	4,45	4,85	5,26	5,66	6,07
50	8,5	2,01	2,41	2,82	3,22	3,62	4,02	4,43	4,83	5,23	5,63	6,04
	12	2,00	2,40	2,80	3,20	3,60	4,00	4,40	4,81	5,21	5,61	6,01
	5	2,03	2,43	2,84	3,24	3,65	4,05	4,46	4,86	5,27	5,67	6,08
60	8,5	2,02	2,42	2,82	3,23	3,63	4,03	4,44	4,84	5,24	5,65	6,05
	12	2,01	2,41	2,81	3,21	3,61	4,02	4,42	4,82	5,22	5,62	6,02

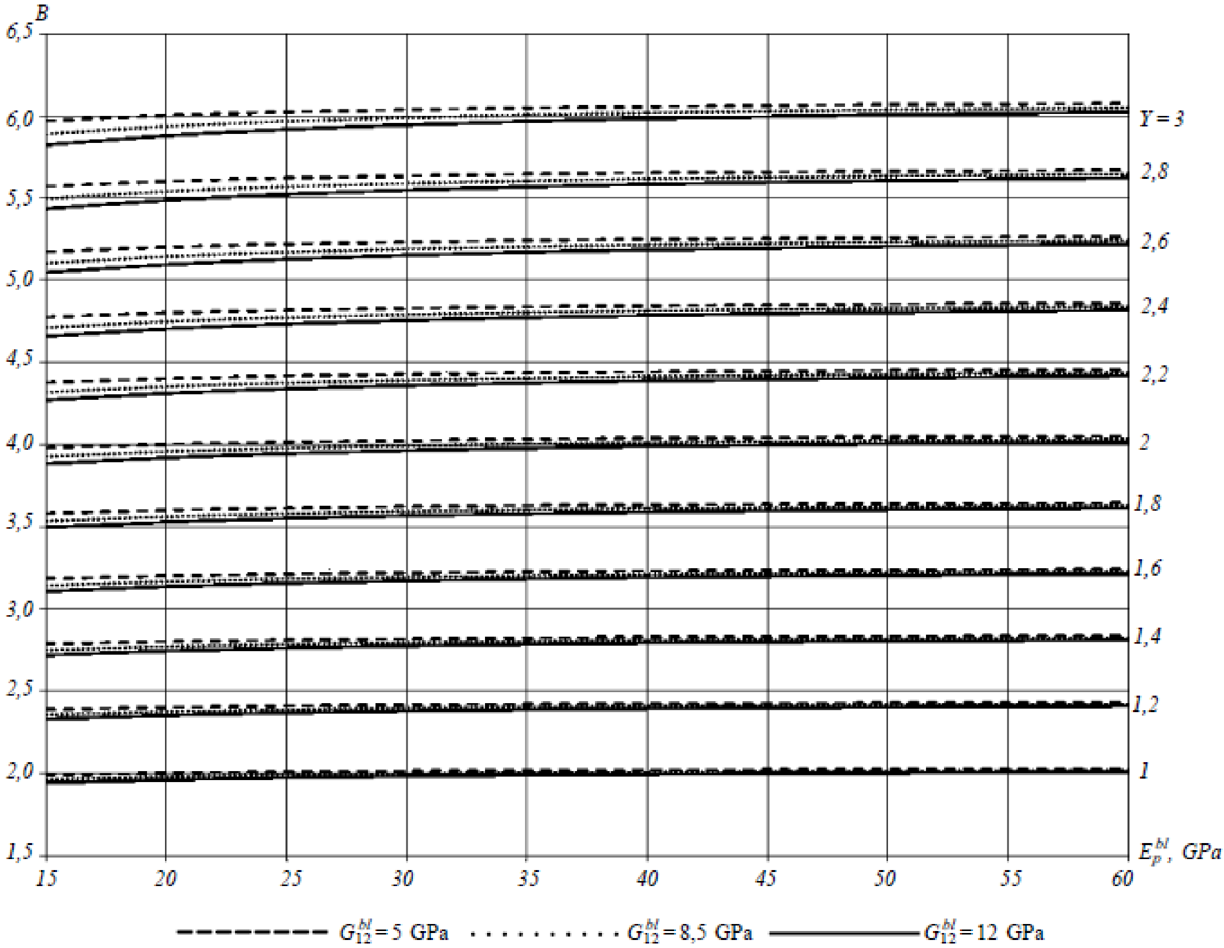


Fig. 5.1-1 Values of factor *B* depending on the aspect ratio of plate sides at $\gamma \geq 1$

.2 at γ = 0,5:

$\tau_{buck} = B(t/b)^2$,

where:

$$B = 0{,}00952\frac{\pi^4}{1-\nu_1\nu_2}\sqrt{D-\sqrt{D^2-9{,}58C}};$$

where:

$$C = E'\,\overline{E}\cdot\hat{E}\cdot\widetilde{E};$$
$$D = 4{,}82E'\,\overline{E} + 1{,}31E'\,\widetilde{E} + 0{,}64\hat{E}\cdot\widetilde{E} + 0{,}101\overline{E}\cdot\hat{E};$$
$$E' = E_1 + 2E_3 + E_2;$$
$$\overline{E} = 16E_1 + 18E_3 + 5{,}06E_2;$$
$$\hat{E} = E_1 + 8E_3 + 16E_2;$$
$$\widetilde{E} = 16E_1 + 50E_3 + 39E_2;$$
$$E_3 = E_1\nu_2 + 2(1-\nu_1\nu_2)G.$$

Values of factor *B* for γ = 0,5 are specified in Table 5.1.2 and in Fig. 5.1-2;

Table 5.1.2 **Values of factor *B* depending on the aspect ratio of plate sides at γ = 0,5**

G^{bl}_{12} \ E_p^{bl}	15	20	25	30	35	40	50	60
5	347,76	426,46	505,05	583,58	662,07	740,54	897,41	1054,25
8,5	425,38	504,45	583,32	662,06	740,71	819,31	976,39	1133,37
12	502,45	581,89	661,05	740,02	818,87	897,63	1054,96	1212,13

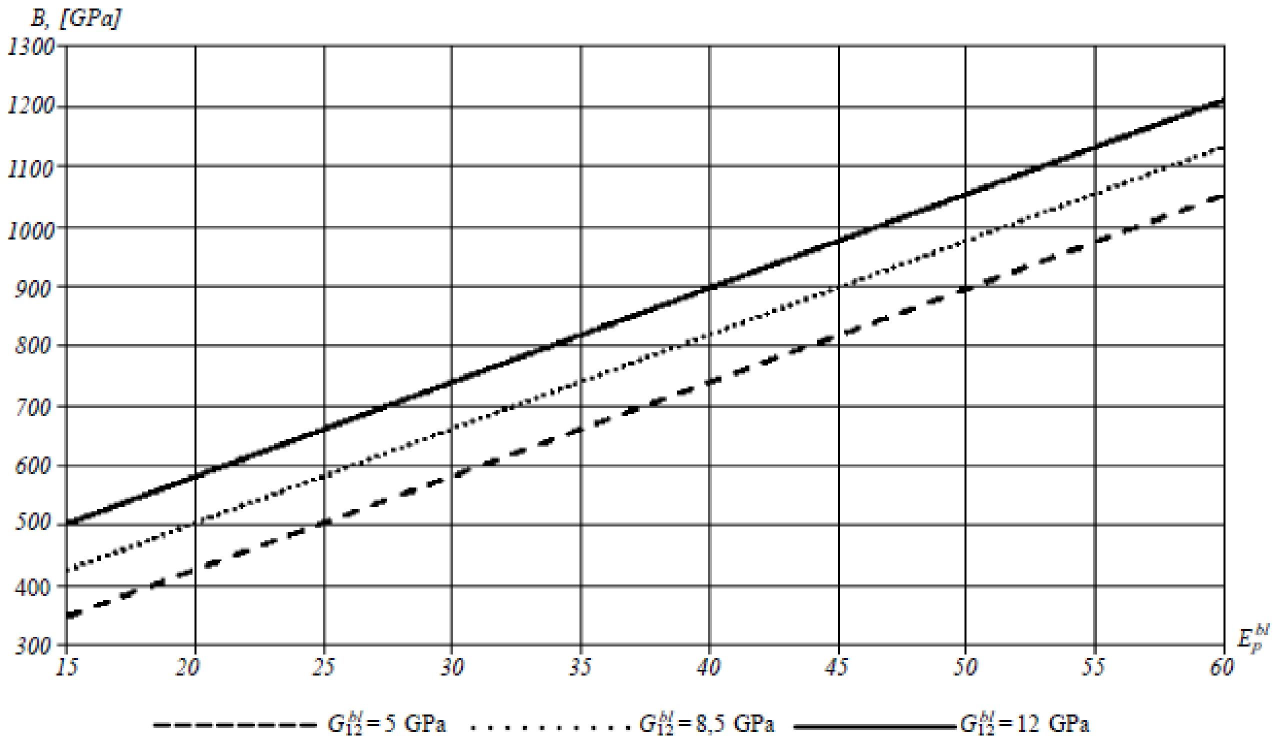


Fig. 5.1-2 Values of factor *B*, in GPa, depending on the aspect ratio of plate sides at γ = 0,5

6 STRESS-STRAIN BEHAVIOR OF SANDWICH PLATES AT CYLINDRICAL BENDING

This Section contains the formulae to determine maximum deflections, maximum normal stresses in load-bearing layers and maximum shear stresses in the core for sandwich plates with isotropic core of the FRP hull structures. Transverse deflection of cylindrical plate bending taking into account various modes of plate edge attachment is considered. In all cases, the load shall be perpendicular to the plate plane.

S y m b o l s.

For the purpose of this Section, the following symbols have been adopted:

δ - thickness of each load-bearing layer, in m;

h - half thickness of the sandwich plate core, in m;

E_{ll} - Young's modulus of load-bearing layers made of isotropic material, in Pa;

G_{ll} - shear modulus of load-bearing layers, in Pa;

μ_{ll} - Poisson's ratio of load-bearing layers;

E_{core} - Young's modulus of the isotropic core, in Pa;

G_{core} - shear modulus of the isotropic core, in Pa;

μ_{core} - Poisson' ratio of the isotropic core;

q - uniformly distributed transverse load per surface area, in N/m^2;

p - uniformly distributed transverse load per unit length, in N/m;

W - maximum deflection of load-bearing layers of the plate, in m;

σ_x, σ_y - maximum normal stresses in load-bearing layers, in Pa;

τ_{xz}, τ_{yz} - maximum shear stresses in the isotropic core, in Pa.

Where load-bearing layers are made of the same isotropic material and have the same thickness, the following conditions shall be met:

$E_i^1 = E_i^2 = E_{ll}$, $\mu_{ij}^1 = \mu_{ij}^2 = \mu_{ll}$, $\delta_1 = \delta_2 = \delta$,

where: i, j = 1, 2, 3 - directions of coordinate axes;

E_i^1, E_i^2 - Young's moduli of load-bearing layers;

μ_{ij}^1, μ_{ij}^2 - Poisson's ratios of load-bearing layers;

δ_1, δ_2 - thicknesses of load-bearing layers.

For the core made of isotropic material, the following conditions shall be met:

$E_i^{core} = E_{core}$, $\mu_{ij} = \mu_{core}$,

where: E_i^{core} - Young's modulus of the core;

μ_{ij} - Poisson ratio of the core.

The formulae specified in this Section may be used where the following conditions are met:

$$2{,}0\cdot10^{-4} \leqslant G_{core}/\overline{E} \leqslant 2{,}0\cdot10^{-4},\ 0{,}1 \leqslant \delta/h \leqslant 0{,}25,\ \frac{2h}{a}\sqrt{1+(a/b)^2} \leqslant 0{,}1,$$

where

$$\overline{E} = E_{ll}/(1-\mu_{ll}^2).$$

The formulae may be used for calculation of sandwich plates with orthotropic load-bearing layers, where their Young's moduli do not vary more than 20 % (relative to the highest value of the moduli), i.e. if the following condition is met:

$(1-E_2/E_1)\cdot100 < 20\%$ at $E_1 > E_2$.

In this case, the arithmetic mean shall be taken as the Young's modulus for calculations.

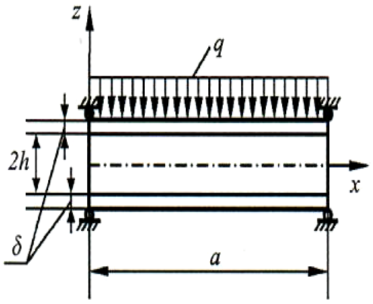
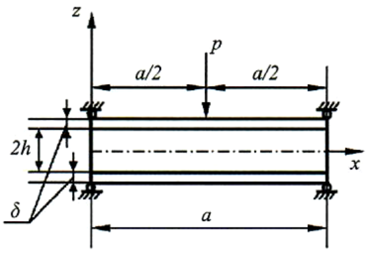
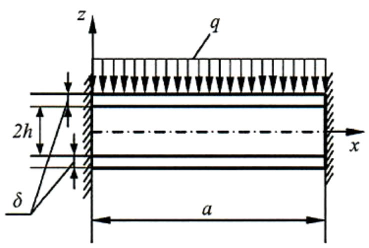
The values used in the formulae specified in Table 7 are determined by the following formulae:

$$B_{ll} = \frac{E_{ll}\delta}{1-\mu_{ll}^2},\ B_{core} = \frac{2E_{core}h}{1-\mu_{ll}^2},\ D_{ll} = \frac{E_{ll}\delta^3}{12(1-\mu_{ll}^2)},\ D_{core} = B_{core}\frac{h^2}{3},$$

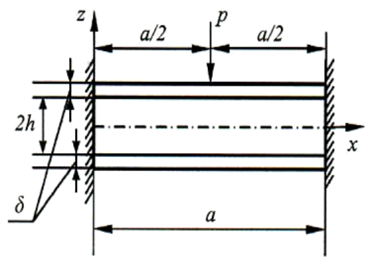
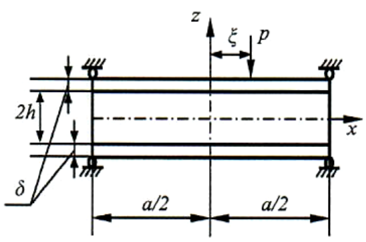
$$k = \frac{\pi^2 B_{core} h_{long}}{G_{core} a^2},\ \gamma = \frac{\pi}{a}\sqrt{1/\left(k\frac{2D_{ll}\eta}{D_{pl}}\right)},\ h_{long} = h\left(1+\frac{D_{core}}{2B_{ll}h^2}\right),$$

$$\eta = 1+\frac{D_{core}\delta^2}{8h_{long}hD_{ll}},\ D_{pl} = 2(D_{ll}+B_{ll}(h+\delta/2)^2)+D_{core},\ \overline{E} = \frac{E_{ll}}{1-\mu_{ll}^2}.$$

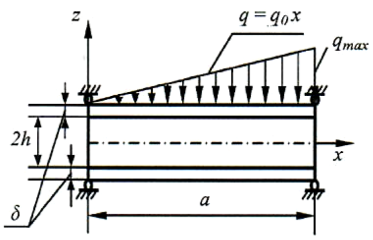
Table 6 **Calculation of stress-strain behavior of sandwich plate at cylindrical bending**

Type of load	Stresses	Deflections
 Plate edges are freely supported, the transverse load is uniformly distributed	Normal stresses in load-bearing layers are maximum at $x = a/2$; $z = \pm(h+\delta)$: $\lvert\sigma_x\rvert = \left\lvert \frac{qa^2}{8D_{pl}} \cdot \frac{B_{II}(h+\delta)}{\delta} m_2 \right\rvert$, shear stresses in the core are maximum at $x = 0, a$; $z = 0$: $\lvert\tau_{xz}\rvert = \left\lvert \frac{qa}{4(h_{long}+\delta/2)} \cdot \frac{h_{long}}{h} m_3 \right\rvert$, where $m_2 = 1 + \frac{4k}{\pi^2}\Big(\frac{\delta}{h_{long}} + \frac{4D_{II}\eta}{D_{pl}} - \frac{2+\delta/h_{long}}{1+\delta/h}\Big)\times$ $\times\Big(\frac{\delta}{h} + \Big[\frac{2D_{II}}{D_{pl}}\Big(1 - \frac{D_{core}\delta}{4hD_{II}}\Big) -$ $-\Big(\frac{\delta}{h(2+\delta/h_{long})}\Big(1 - \frac{2D_{II}\eta}{D_{pl}}\Big)\Big]\mathrm{sch}\Big(\frac{\gamma a}{2}\Big)\Big)\Big)$, $m_3 = \Big(1 - \frac{2D_{II}\eta}{D_{pl}}\Big)\Big(1 - \frac{4k}{\pi^2}\cdot\frac{2D_{II}\eta}{D_{pl}}\, th\Big(\frac{\gamma a}{2}\Big)\Big)$.	Plate deflection is maximum in the section at $x = a/2$: $\lvert W\rvert = \left\lvert \frac{5}{384} \cdot \frac{qa^4}{D_{pl}} m_2 \right\rvert$, where $m_1 = 1 + \frac{48k}{5\pi^2}\Big(1 - \frac{2D_{II}\eta}{D_{pl}}\Big)\times$ $\times\Big(1 - \frac{8k}{\pi^2}\cdot\frac{2D_{II}\eta}{D_{pl}}\Big(1 - \mathrm{sch}\Big(\frac{\gamma a}{2}\Big)\Big)\Big)$.
 Plate edges are freely supported, the transverse load is uniformly distributed in the center section	Normal stresses in load-bearing layers are maximum at $x = a/2$; $z = \pm(h+\delta)$: $\lvert\sigma_x\rvert = \left\lvert \frac{pa^2}{4} \cdot \frac{B_{II}(h+\delta)}{\delta D_{pl}} m_2 \right\rvert$, shear stresses in the core are maximum at $0 \le x \le a$; $z = 0$: $\lvert\tau_{xz}\rvert = \left\lvert \frac{p}{4(h_{long}+\delta/2)} \cdot \frac{h_{long}}{h} m_3 \right\rvert$, where $m_2 = 1 - \frac{1}{(1+\delta/h)\eta} \cdot \frac{2th(\gamma a/2)}{\gamma a}\times$ $\times\Big(\Big(1 + \frac{\delta}{2h_{long}}\Big)\Big(1 - \frac{D_{core}\delta}{4hD_{II}}\Big) + \frac{\delta}{2h}\Big(\eta - \frac{D_{pl}}{2D_{II}}\Big)\Big)$, $m_3 = \Big(1 - \frac{2D_{II}\eta}{D_{pl}}\Big)\Big(1 - \mathrm{sch}\Big(\frac{\gamma a}{2}\Big)\Big)$.	Plate deflection is maximum in the section at $x = a/2$: $\lvert W\rvert = \left\lvert \frac{pa^3}{48D_{pl}} m_1 \right\rvert$ where $m_1 = 1 + \frac{12k}{\pi^2}\Big(1 - \frac{2D_{II}\eta}{D_{pl}}\Big)\times$ $\times\Big(1 - \frac{2th(\gamma a/2)}{\gamma a}\Big)$.
 Plate edges are fixed, the transverse load is uniformly distributed	Normal stresses in load-bearing layers are maximum at $x = a/2$; $z = \pm(h+\delta)$: $\lvert\sigma_x\rvert = \left\lvert \frac{\bar{E}qa^2}{12D_{pl}}(h+\delta) \right\rvert$, shear stresses in the core are maximum at $x = 0, a$; $z = 0$: $\lvert\tau_{xz}\rvert = \left\lvert \frac{p}{4hD_{pl}} qa \right\rvert$, where $\bar{D} = 2B_{II}h(h+\delta/2) + D_{core}$.	Plate deflection is maximum in the section at $x = a/2$: $\lvert W\rvert = \left\lvert \frac{1}{384} \cdot \frac{qa^4}{D_{pl}} m_1 \right\rvert$, where $m_1 = 1 + \frac{48k_1}{\pi^2}$, $k_1 = \frac{\pi^2 B_0 h}{2G_{core}a^2}$ $B_0 = 2B_{II} + B_{core}/3$

Continue of Table 6

 Plate edges are fixed, the transverse load is uniformly distributed in the center section	Normal stresses in load-bearing layers are maximum at $x = a/2$; $z = \pm(h+\delta)$: $\lvert\sigma_x\rvert = \left\lvert\frac{pa}{8}\cdot\frac{B_{II}(h+\delta)}{\delta D_{pl}} m_2\right\rvert$, shear stresses in the core are maximum at $0 \le x \le a$; $z = 0$: $\lvert\tau_{xz}\rvert = \left\lvert\frac{p}{4(h_{long}+\delta/2)}\cdot\frac{h_{long}}{h} m_3\right\rvert$, where $m_2 = 1 - \frac{th(\gamma a/4)}{\eta(1+\delta/h)(\gamma a/4)} \times$ $\times\left(\left(1-\frac{D_{core}\delta}{4hD_{II}}\right)\left(1+\frac{\delta}{2h_{long}}\right) - \frac{\delta D_{pl}}{4hD_{II}}\left(1-\frac{D_{II}\eta}{D_{pl}}\right)\right)$, $m_3 = \left(1-\frac{2D_{II}\eta}{D_{pl}}\right)\left(1-\mathrm{sch}\left(\frac{\gamma a}{4}\right)\right)$.	Plate deflection is maximum in the section at $x = a/2$: $\lvert W\rvert = \left\lvert\frac{1}{192}\cdot\frac{pa^3}{D_{pl}} m_1\right\rvert$ where $m_1 = 1+\frac{48k_1}{\pi^2}\left(1-\frac{2D_{II}\eta}{D_{pl}}\right)\times$ $\times\left(1-\frac{4th(\gamma a/4)}{\gamma a}\right)$.
 Plate edges are freely supported, the transverse load is uniformly distributed in the random section	In such case, for G_3/E the following condition shall be met:: $2{,}0\cdot10^{-4} \leqslant G_{core}/E \leqslant 2{,}0\cdot10^{-3}$. $2{,}0\cdot10^{-4} \leqslant G_{core}/E \leqslant 2{,}0\cdot10^{-3}$. The formulae may be used where the following condition is met: $-a/2 \le x \le \xi$.	
	Normal stresses in load-bearing layers are maximum at $x = \xi$; $z = \pm(h+\delta)$: $\lvert\sigma_x\rvert = \left\lvert\frac{p}{D1_{pl}}\cdot\frac{E_{II}}{1-\mu_{II}^2}(h+\delta)\left[2C_3\xi + C_4 + \frac{k1^2}{h+\delta}\times\right.\right.$ $\left.\left.\times\left(\frac{D_{II}}{B_{II}(h+\delta/2)}-\delta/2\right)(C_5\cdot\mathrm{sh}(k1\xi)+C_6\cdot\mathrm{ch}(k1\xi))\right]\right\rvert$, shear stresses in the core are maximum at $a/2 \le x \le \xi$; $z = 0$ (at $\xi \le 0$): $\lvert\tau_{xz}\rvert = \frac{p}{D1_{pl}} 2B_2(h+\delta/2)\left[C_3 + \frac{D_{II}k1^3}{2B_{II}(h+\delta/2)^2}\times\right.$ $\left.\times(C_5\cdot\mathrm{ch}(-k1a/2)+C_6\cdot\mathrm{sh}(-k1a/2))\right]\rvert$ where $D1_{pl} = 2(D_{II}+B_{II}(h+\delta/2)^2)$, $k1 = \sqrt{\frac{G_{core}D1_{pl}}{2B_{II}D_{II}h}}$, $C_3 = \frac{a/2-\xi}{2a}$, $C_4 = \frac{a/2-\xi}{2}$, $C_5 = \frac{B_{II}(h+\delta/2)^2\cdot\mathrm{sh}(k1(a/2-\xi))}{2D_{II}k1^3\cdot\mathrm{sh}(k1a/2)}$, $C_6 = \frac{B_{II}(h+\delta/2)^2\cdot\mathrm{sh}(k1(a/2-\xi))}{2D_{II}k1^3\cdot\mathrm{ch}(k1a/2)}$.	Plate deflection is determined by the formula $\lvert W\rvert = \left\lvert\frac{p}{D1_{pl}}\left(C_2 - C_1x +\right.\right.$ $\left.+\frac{2B_{II}(h+\delta/2)}{G_{core}} - \frac{x^2}{3}\right)x - \frac{C_4x^2}{2} +$ $\left.+C_5\cdot\mathrm{sh}(k1/x)+C_6\cdot\mathrm{ch}(k1/x))\right\rvert$, where $C_1 = \frac{a/2-\xi}{2a}\left(\frac{2B_{II}(h+\delta/2)^2}{D_{II}k1^2\cdot d} - \frac{\xi}{3}(a-\xi)\right)$, $C_2 = \frac{a/2-\xi}{4}\left(\frac{2B_{II}(h+\delta/2)^2}{D_{II}k1^2} + \frac{\xi}{3}(a-\xi)\right)$, $C_3 = \frac{a/2-\xi}{2a}$, $C_4 = \frac{a/2-\xi}{2}$, $C_5 = \frac{B_{II}(h+\delta/2)^2\cdot\mathrm{sh}(k1(a/2-\xi))}{2D_{II}k1^3\cdot\mathrm{sh}(k1a/2)}$, $C_6 = \frac{B_{II}(h+\delta/2)^2\cdot\mathrm{sh}(k1(a/2-\xi))}{2D_{II}k1^3\cdot\mathrm{ch}(k1a/2)}$, $D1_{pl} = 2(D_{II}+B_{II}(h+\delta/2)^2)$, $k1 = \sqrt{\frac{G_3D1_{pl}}{2B_{II}D_{II}h}}$, $d = \frac{B_{II}h(h+\delta/2)}{D_{II}+(B_{II}d/2)(h+\delta/2)}$, Plate deflection is maximum in the section, with coordinate $\partial W/\partial x = 0$ and within the range $a/2 \le x \le \xi$; (plate deflection at $x = \xi$ differs from the maximum value by not more than 10 %)

End of Table 6

 Laminate edges are free-standing, the transverse load is distributed according to the triangular law	Normal stresses in load-bearing layers are maximum at and determined by the formula $\lvert\sigma_x\rvert = \Big\lvert \frac{q_0 x_2}{2h+\delta} \times$ $\times \Big(\frac{2(h+d)}{d(2h+\delta)} \Big(\frac{hB_{II}}{G_{core}} + \frac{a^2 - x_2^2}{6} \Big) - \frac{hB_{II}}{\delta G_{core}} \Big) \Big\rvert,$ shear stresses in the core are maximum at $x = a$; $z = 0$: $\lvert\tau_{xz}\rvert = \Big\lvert \frac{q_0 a^2}{3(2h+\delta)} \Big\rvert,$ where $q_0 = \frac{q_{max}}{a},$ q_{max} - maximum distributed transverse load per surface area.	Plate deflection is maximum in the section at $x = x_2 = \sqrt{\frac{3m_1(10a^2 + m_2) - \sqrt{m_3}}{30m_1}};$ and determined by the formula $\lvert W\rvert = \Big\lvert \frac{q_0 x_1}{180B_{II}(2h+\delta)^2} \times,$ $\times (7a^4 - 10a^2 x_1^2 + 3x_1^4 + 60 \frac{hB_{II}}{G_{core}} (a^2 - x_1^2))$ where $m_1 = \frac{q_0 1}{180B_{II}(2h+\delta)^2},$ $m_2 = \frac{60hB_{II}}{G_{core}},$ $m_3 = (3m_1(10a^2 + m_2))^2 -$ $- 60m_1^2(7a^4 + m_2 a^2),$ where $q_0 = \frac{q_{max}}{a},$ q_{max} - maximum distributed transverse load per unit area.

8 STRESS-STRAIN BEHAVIOR OF SANDWICH PLATES AT BENDING

8.1 Plate edges are freely supported, the transverse load is uniformly distributed (design scheme refer to Fig. 8.1).

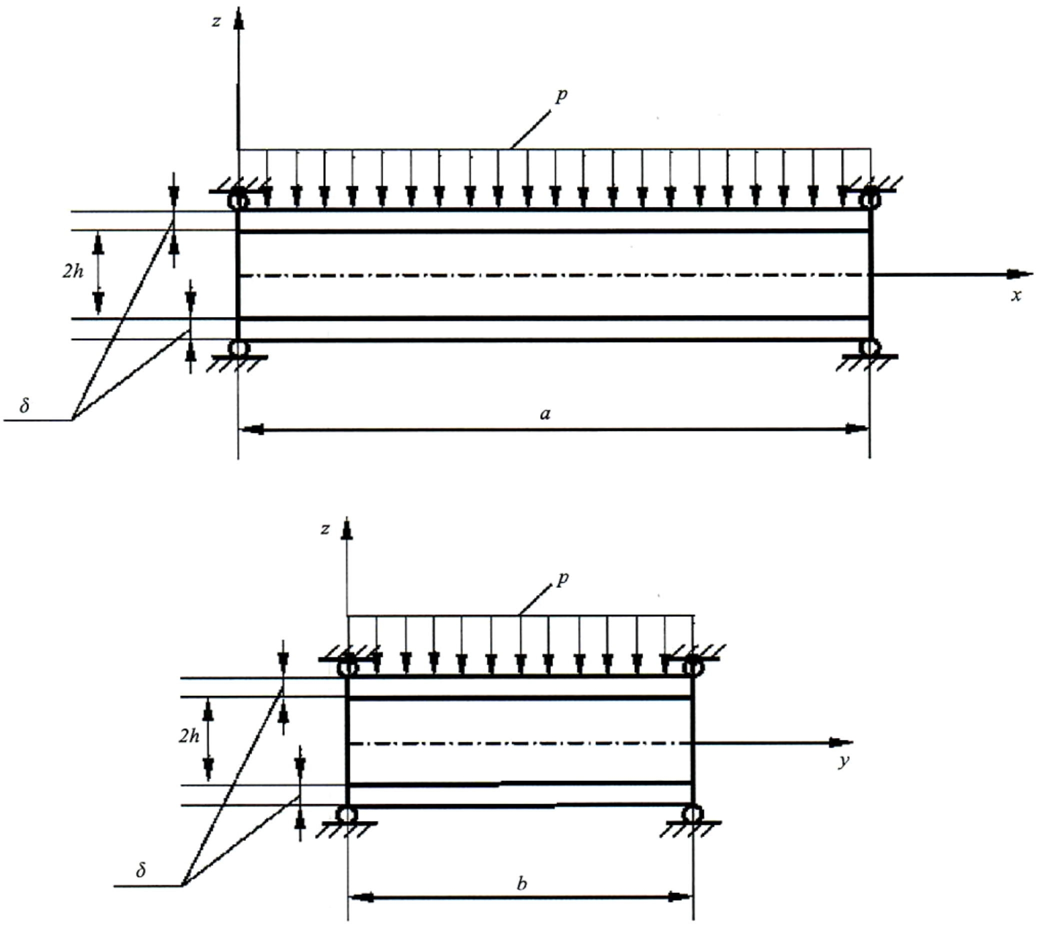


Fig. 8.1 Load type of the sandwich plate

8.2 Plate deflection is maximum at point x = *a*/2, *y* = *b*/2 and determined by the formula

$$|w|_{x=a/2,\ y=b/2} = \frac{8p}{\pi^2 G^{core}} m_1,$$

where *a* - plate length;

b - plate width;

p - uniformly distributed load;

G^{core} - shear modulus of the core in the sandwich plate;

$$m_1 = \sum_{i=0}^{N}\sum_{j=0}^{N}\left((-1)^{(m-1)/2}(-1)^{(n-1)/2}\frac{1}{dmnr}\right)\left(k_1 \mathrm{ch}(r_1 h) + \frac{B_{ll} r}{G^{core}} \mathrm{sh}(r_1 h)\right);$$

$$B_{ll} = \frac{E_p^{ll}\delta}{1-\nu_{12}^{ll2}},$$

where: E_p^{ll} - young's modulus of load-bearing layers of the sandwich plate;

δ - thickness of the load-bearing layer of the sandwich plate;

ν^{ll}_{12} - Poisson's ratio of the material of load-bearing layers in the sandwich plate;

2*h* - core thickness of the sandwich plate;

$m = 2i + 1$, $n = 2j + 1$, $\alpha = m\pi/a$, $b = n\pi/b$;

$r^2 = \alpha^2 + \beta^2$, $r_1 = rk_1$;

$$k_1 = \sqrt{\frac{E_p^{core}}{(1-\nu^{core2})G^{core}}},$$

where ν^{core} - Poisson's ratio of the core of sandwich plate;

$$d = \left(h + \frac{B\delta^2 r^2}{3G^{core}}\right) r_1 \mathrm{ch}(r_1 h) - \left(1 - Br^2 G^3\left(h + \delta + \frac{B\delta^2 r^2}{12G^3}\right)\right)\mathrm{sh}(r_1 h).$$

Values of factor m1 are specified in Fig. 8.2-1 – 8.2-3.

Normal stresses in load-bearing layers σ_x and σ_y are maximum at $x = a/2$, $y = b/2$ and determined by the following formulae:

$$|\sigma_x|_{x=a/2,\ y=b/2} = \frac{8pE_p^{ll}}{(1-\nu_{12}^{ll2})\pi^2 G^{core}} m_2,$$

$$m_2 = \sum_{i=0}^{N}\sum_{j=0}^{N}(-1)^{(m-1)/2}(-1)^{(n-1)/2}\frac{1}{dmnr^2}(\alpha^2+\nu_{12}^{ll}\beta^2)\left(\delta r_1 \mathrm{ch}(r_1 h)+\left(1+\frac{B\delta r^2}{2G^{core}}\right)\mathrm{sh}(r_1 h)\right);$$

$$|\sigma_y|_{x=a/2,\ y=b/2} = \frac{8pE_p^{ll}}{(1-\nu_{12}^{ll2})\pi^2 G^{core}} m_3,$$

$$m_3 = \sum_{i=0}^{N}\sum_{j=0}^{N}(-1)^{(m-1)/2}(-1)^{(n-1)/2}\frac{1}{dmnr^2}(\beta^2+\nu_{12}^{ll}\alpha^2)\left(\delta r_1 \mathrm{ch}(r_1 h)+\left(1+\frac{B\delta r^2}{2G^{core}}\right)\mathrm{sh}(r_1 h)\right).$$

Values of factors m_2 and m_3 are specified in Figs. 8.2-4 – 8.2-6 and 8.2-7 – 8.2-9 accordingly.

Shear stresses in the core τ_{xz} are maximum at $x = 0$; a, $y = b/2$; and determined by the formula

$$|\tau_{xz}|_{x=0;\,a,\,y=b/2} = \frac{8pB}{\pi a G_{core}} m_4,$$

$$\text{where } m_4 = \sum_{i=0}^{N}\sum_{i=0}^{N}\left[(-1)^{(n-1)/2}\frac{1}{dn}+\left(\mathrm{sh}(r_1 h)+\frac{r_1\delta}{2}+\frac{r_{1p}G^{core}}{Br^2}(\mathrm{ch}(r_1 h)-1)\right)\right.$$

Values of factor m_4 are specified in Figs. 8.2-10 – 8.2-12.

Shear stresses in the core τ_{xz} are maximum at $x = a/2$, $y = 0$; b and determined by the formula

$$|\tau_{yz}|_{x=a/2,\,y=0;\,b} = \frac{8pB}{\pi b G_3} m_5,$$

$$\text{where } m_5 = \sum_{i=0}^{N}\sum_{j=0}^{N}\left[(-1)^{(m-1)/2}\frac{1}{dm}+\left(sh(r_1 h)+\frac{r_1\delta}{2}+\frac{r_{1p}G^{core}}{Br^2}(ch(r_1 h)-1)\right)\right.$$

N is taken so that the difference between values of neighboring terms of series does not exceed 5 %.

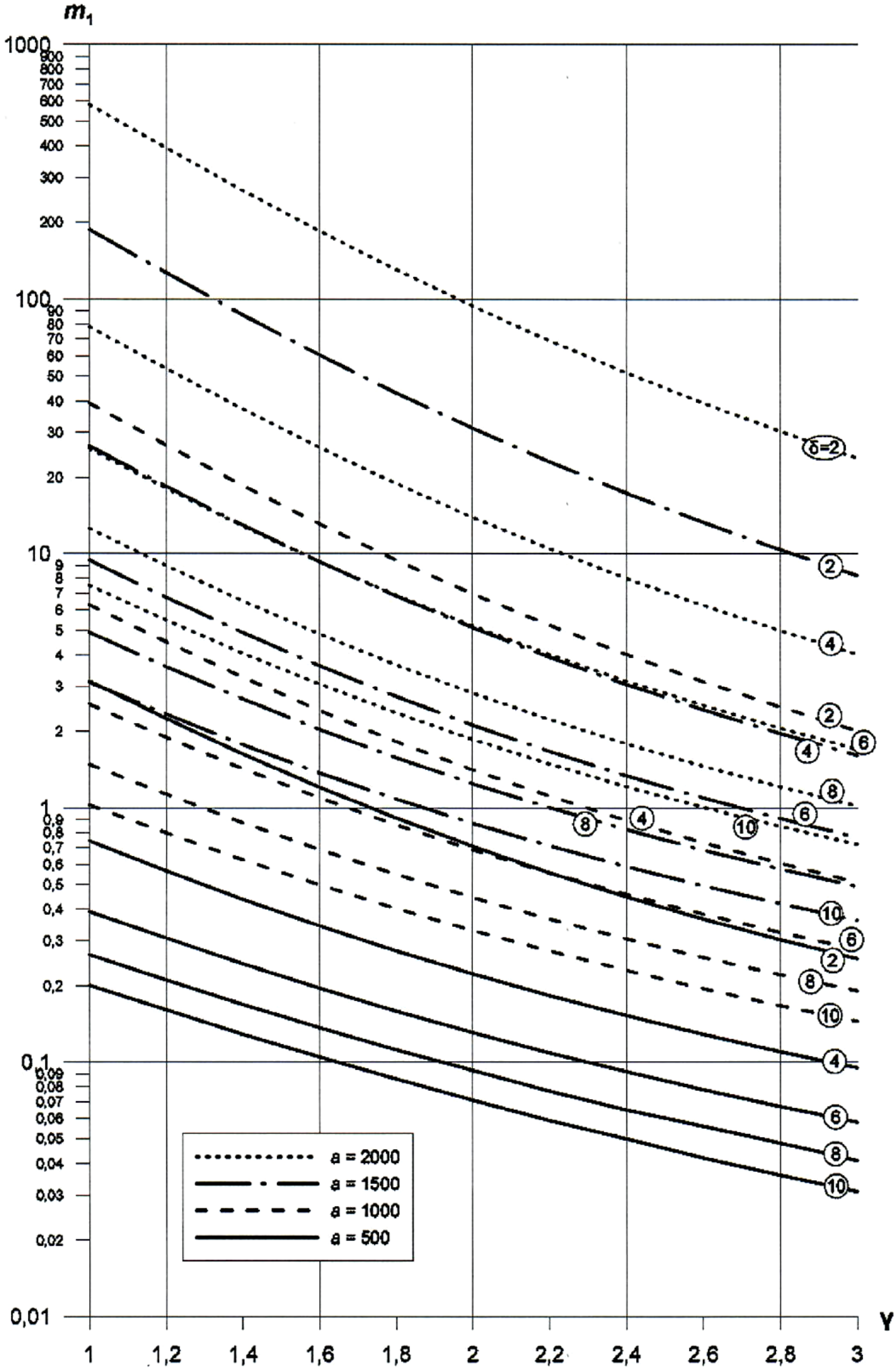
Values of factor m_5 are specified in Figs. 8.2-13 ÷ 8.2-15.

Values of γ and η are determined by the following formulae (refer to Figs. 8.2-1 ÷ 8.2-15):

$\gamma = a/b$;

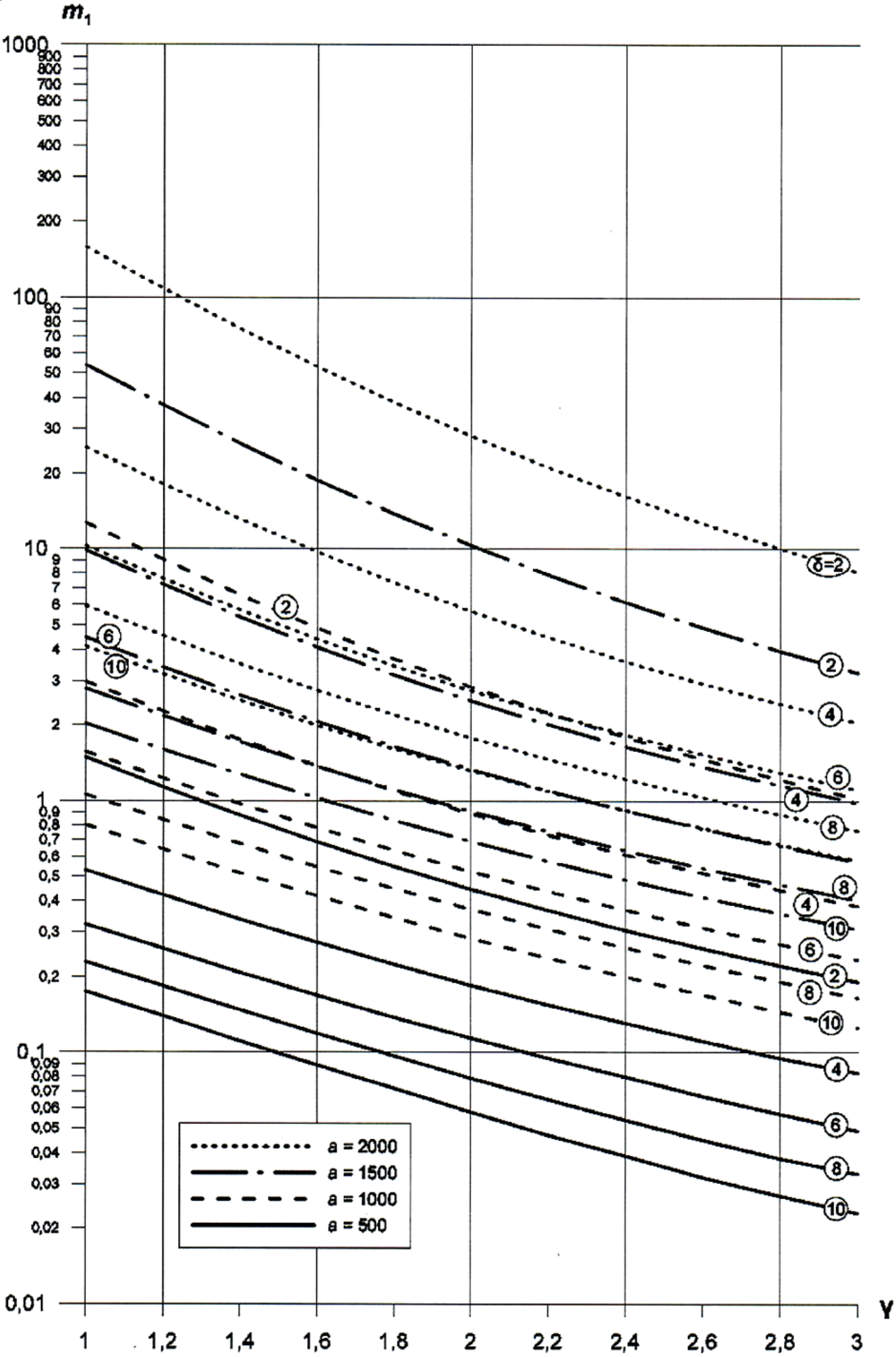
$\eta = E^{ll}{}_p/E^{core}$,

where E^{core} - Young's modulus of the core in the sandwich laminate.



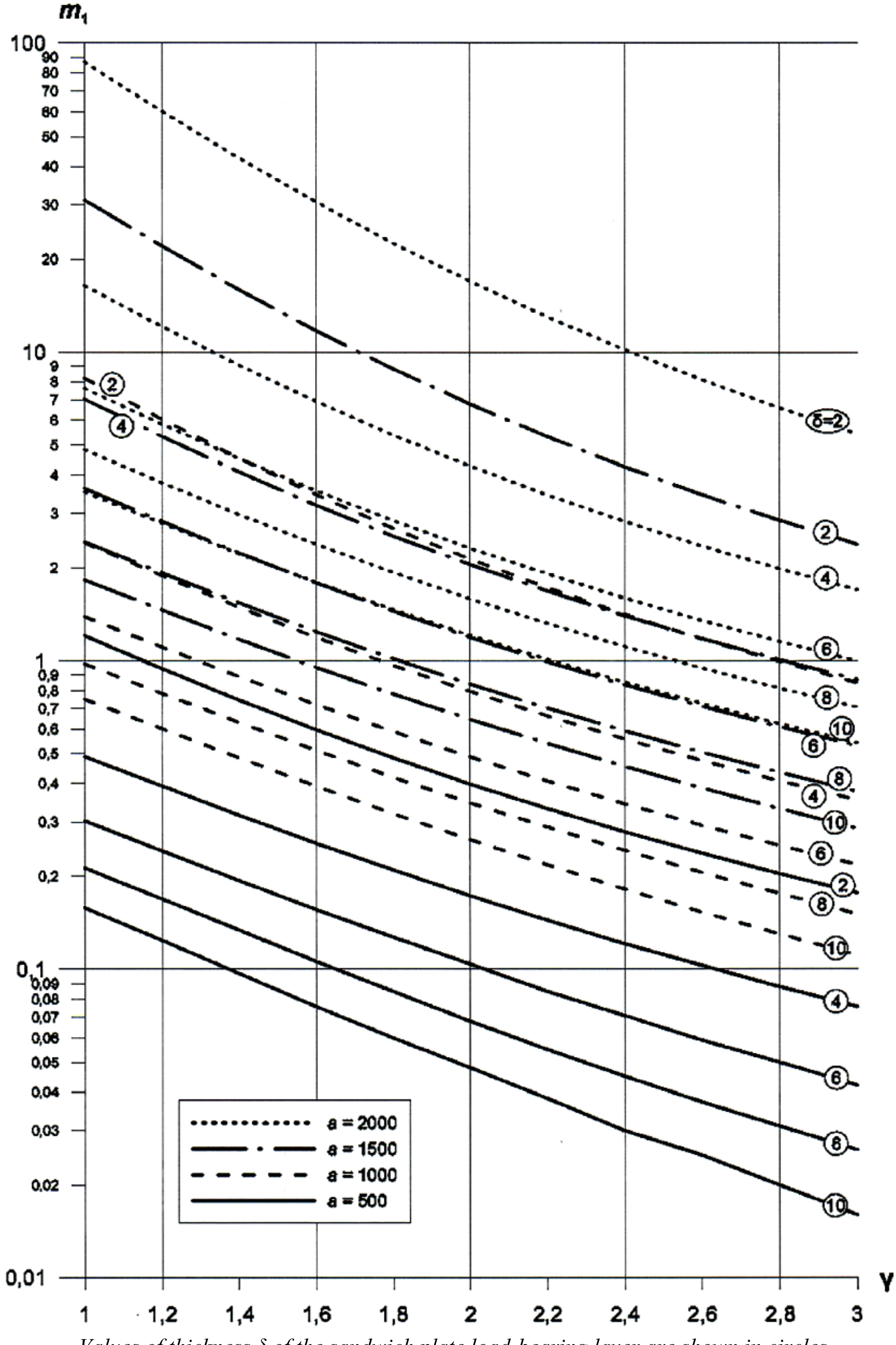
Values of thickness δ of the sandwich plate load-bearing layer are shown in circles

Fig. 8.2-1 Values of factor m_1 at η = 100



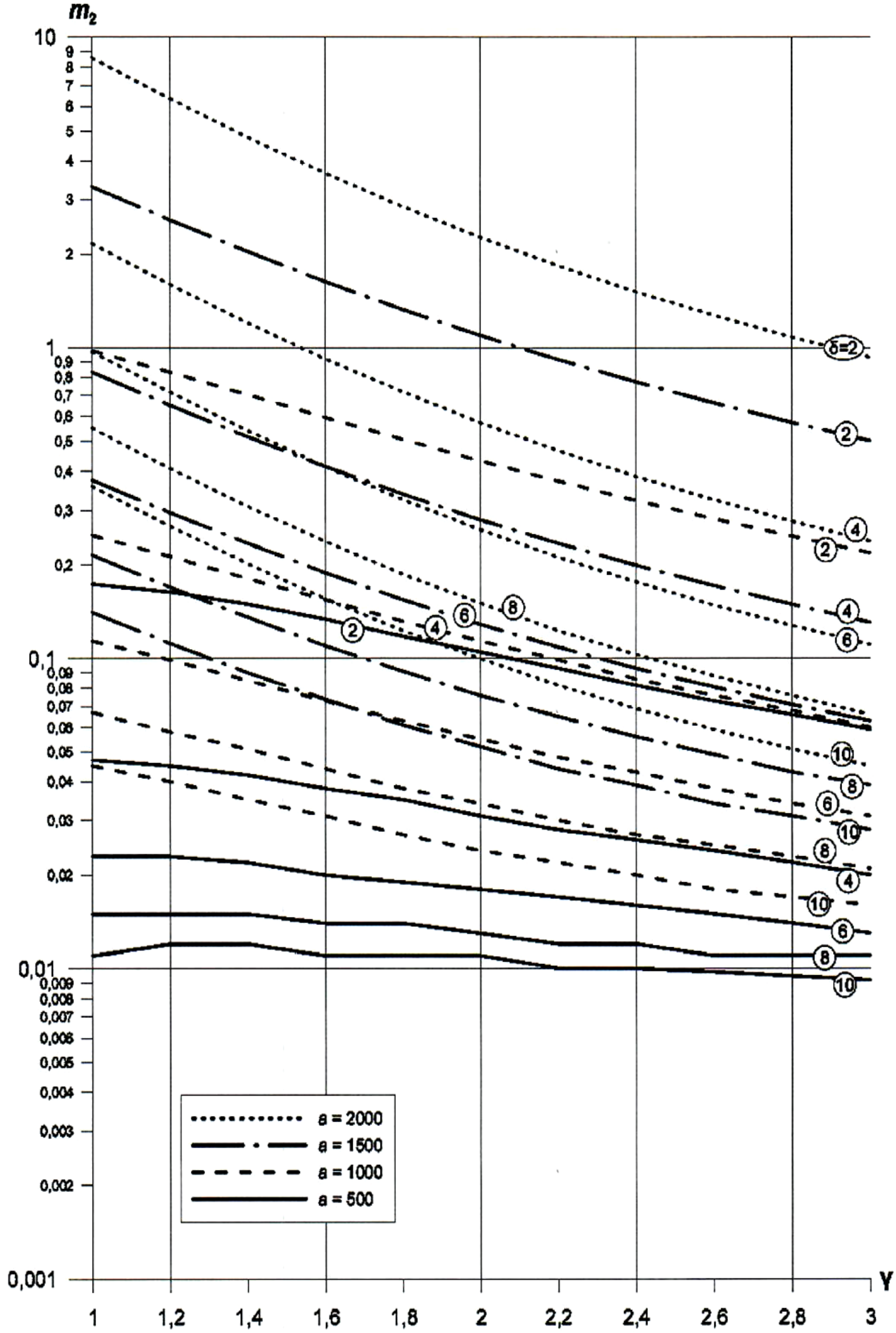
Values of thickness δ of the sandwich plate load-bearing layer are shown in circles

Fig. 8.2-2 Values of factor m_1 at $\eta = 400$



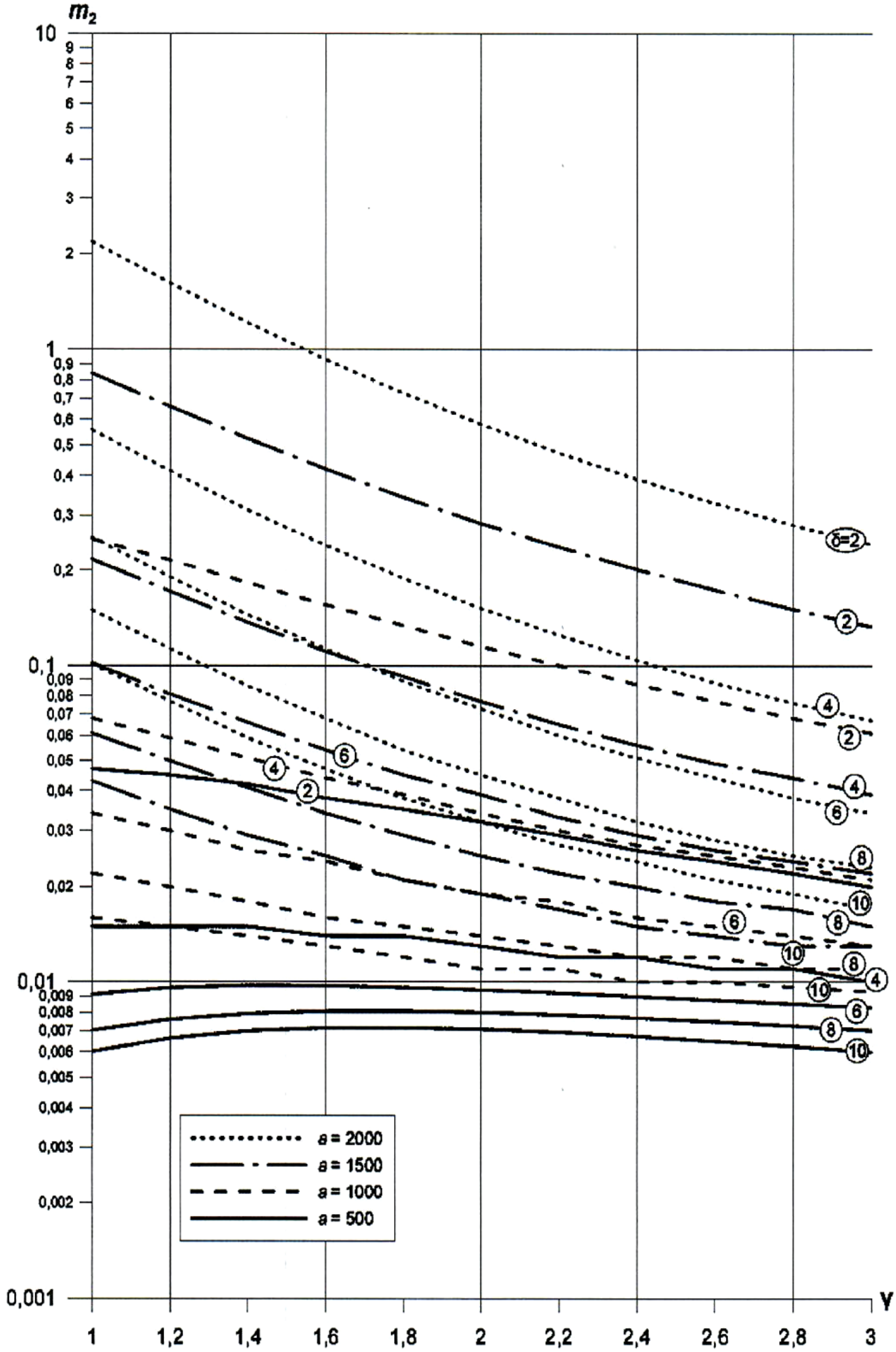
Values of thickness δ of the sandwich plate load-bearing layer are shown in circles

Fig. 8.2-3 Values of factor m_1 at $\eta = 800$



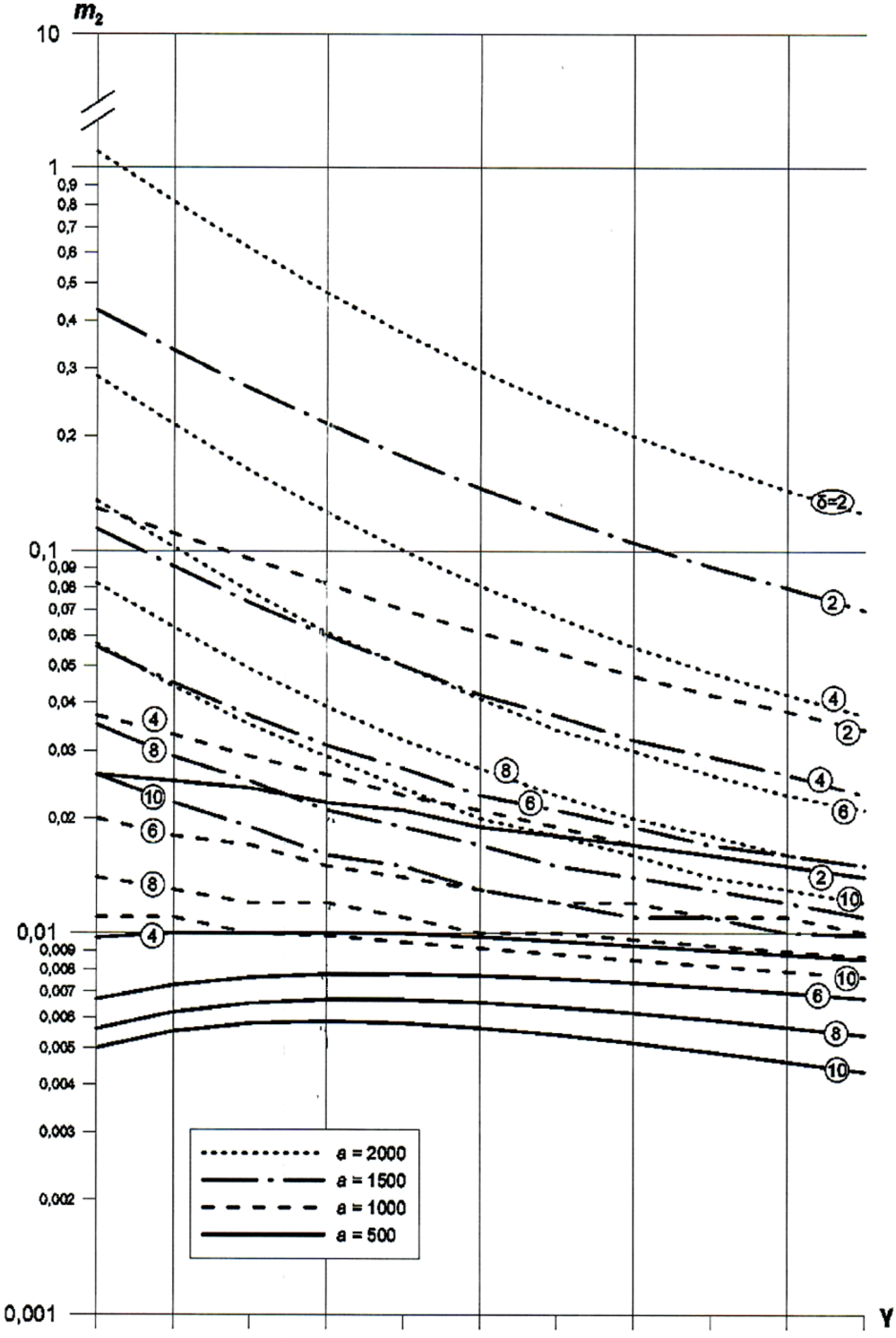
Values of thickness δ of the sandwich plate load-bearing layer are shown in circles

Fig. 8.2-4 Values of factor m_1 at $\eta = 100$



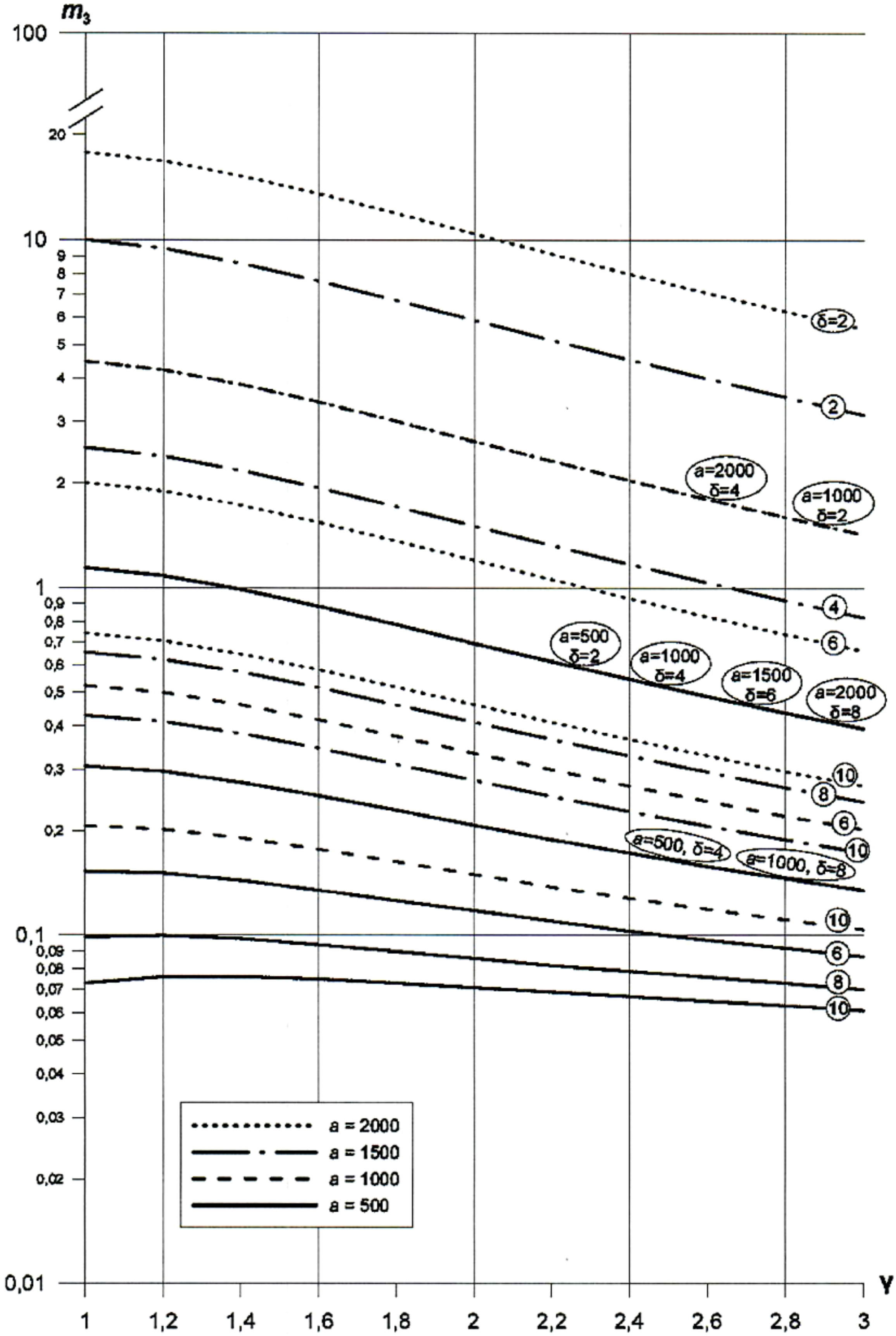
Values of thickness δ of the sandwich plate load-bearing layer are shown in circles

Fig. 8.2-5 Values of factor m_2 at η = 400



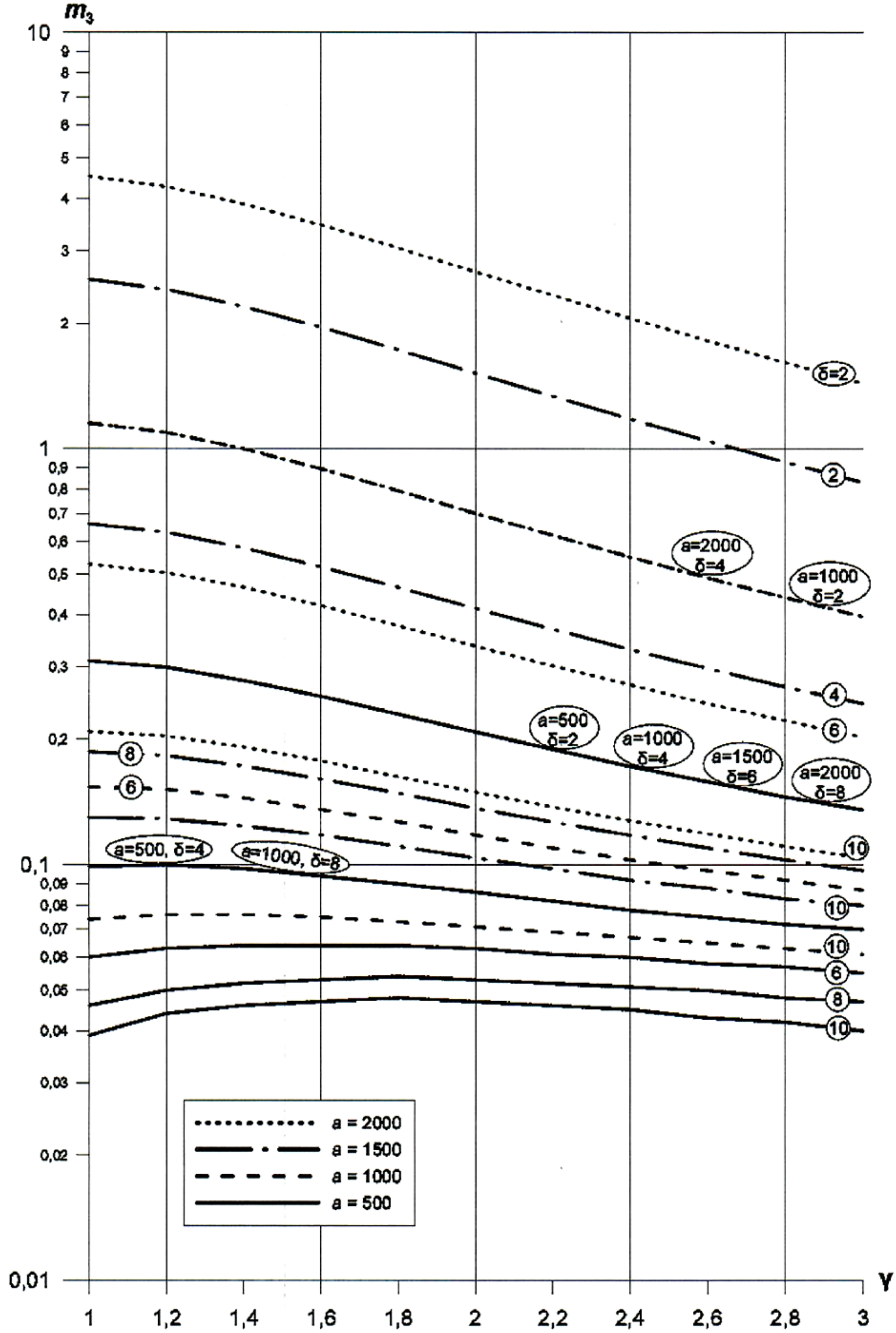
Values of thickness δ of the sandwich plate load-bearing layer are shown in circles

Fig. 8.2-6 Values of factor m_2 at $\eta = 800$



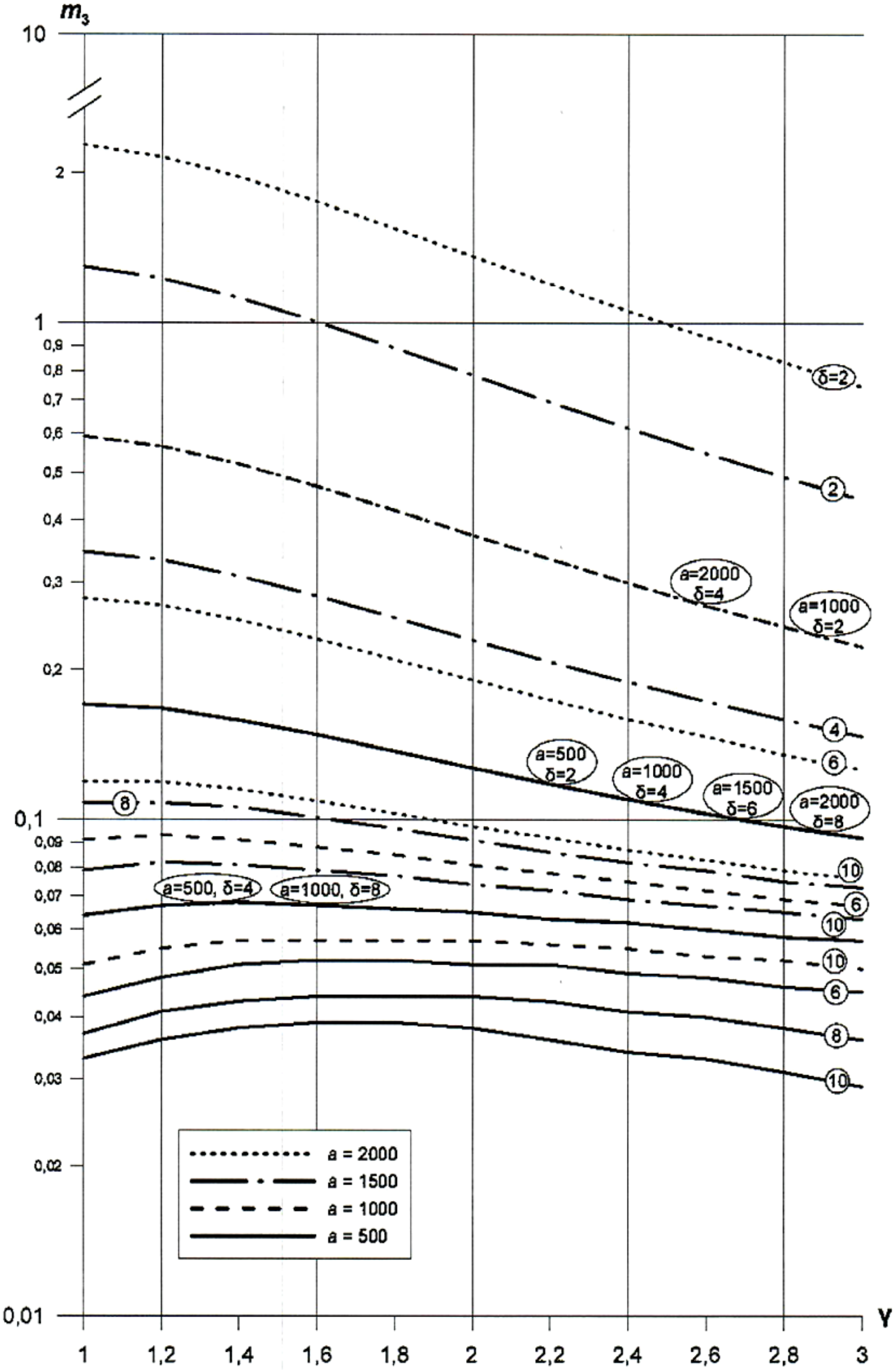
Values of thickness δ of the sandwich plate load-bearing layer are shown in circles

Fig. 8.2-7 Values of factor m_3 at η = 100



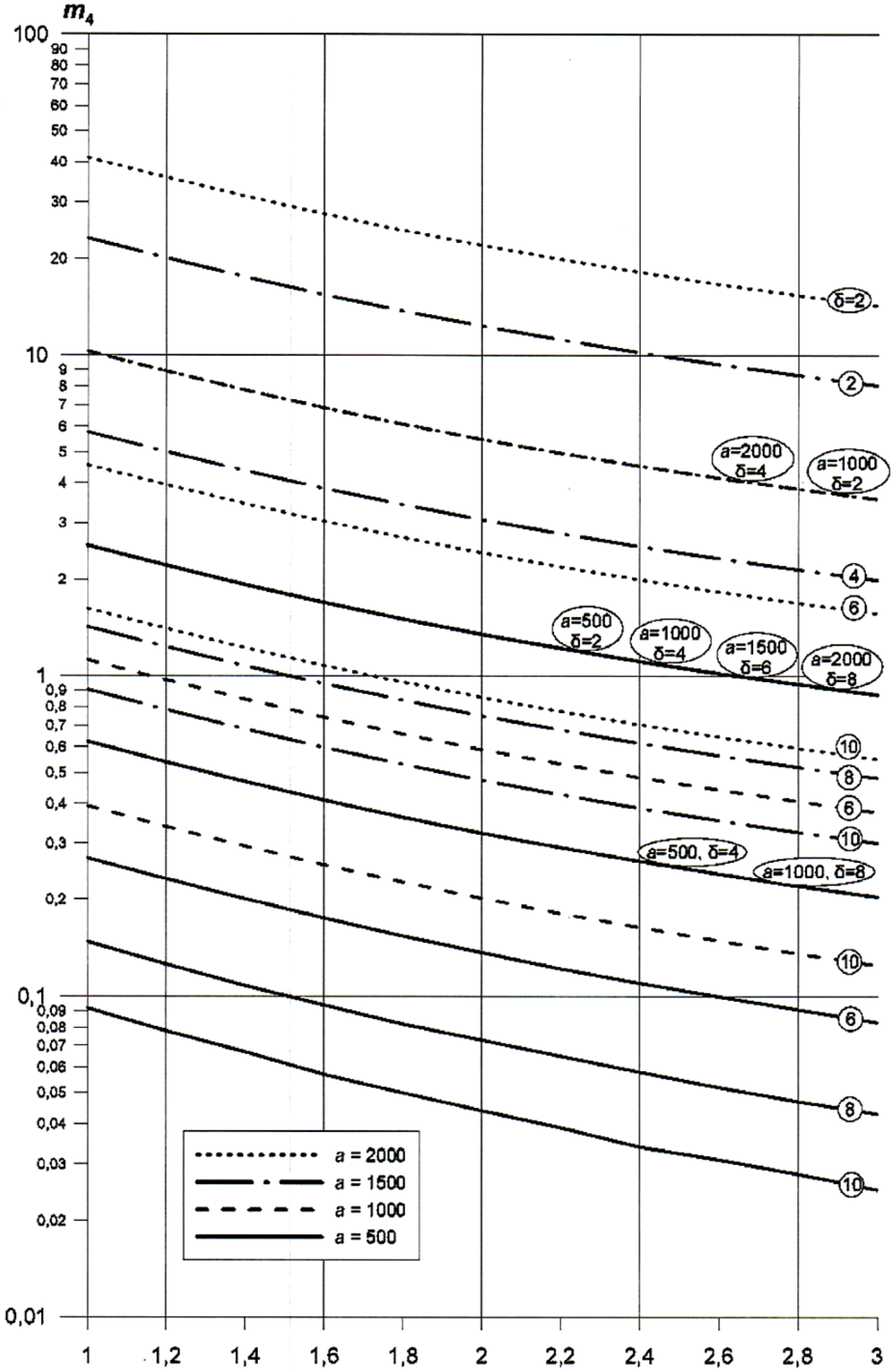
Values of thickness δ of the sandwich plate load-bearing layer are shown in circles

Fig. 8.2-8 Values of factor m_3 at $\eta = 400$



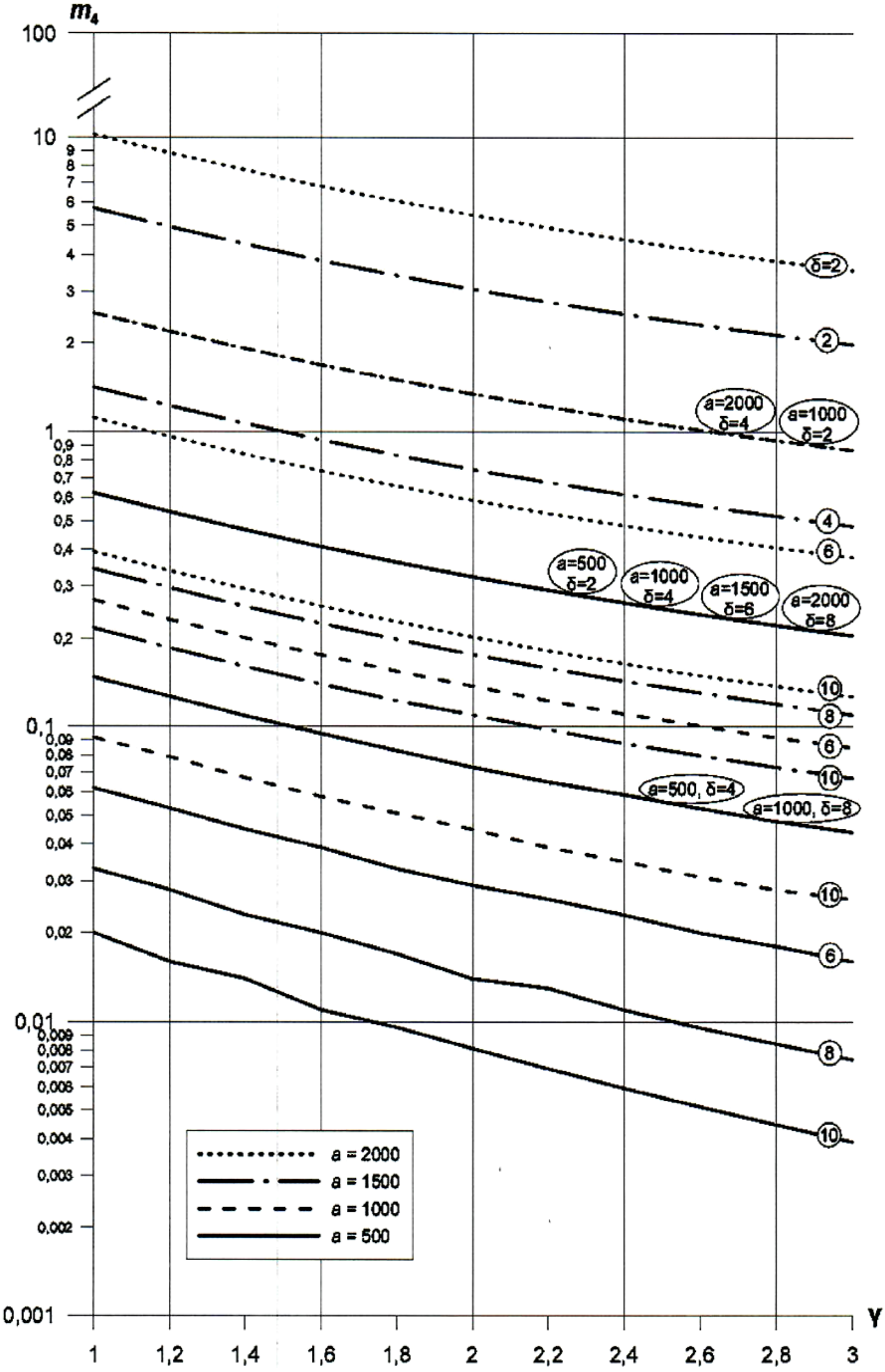
Values of thickness δ of the sandwich plate load-bearing layer are shown in circles

Fig. 8.2-9 Values of factor m_3 at η = 800



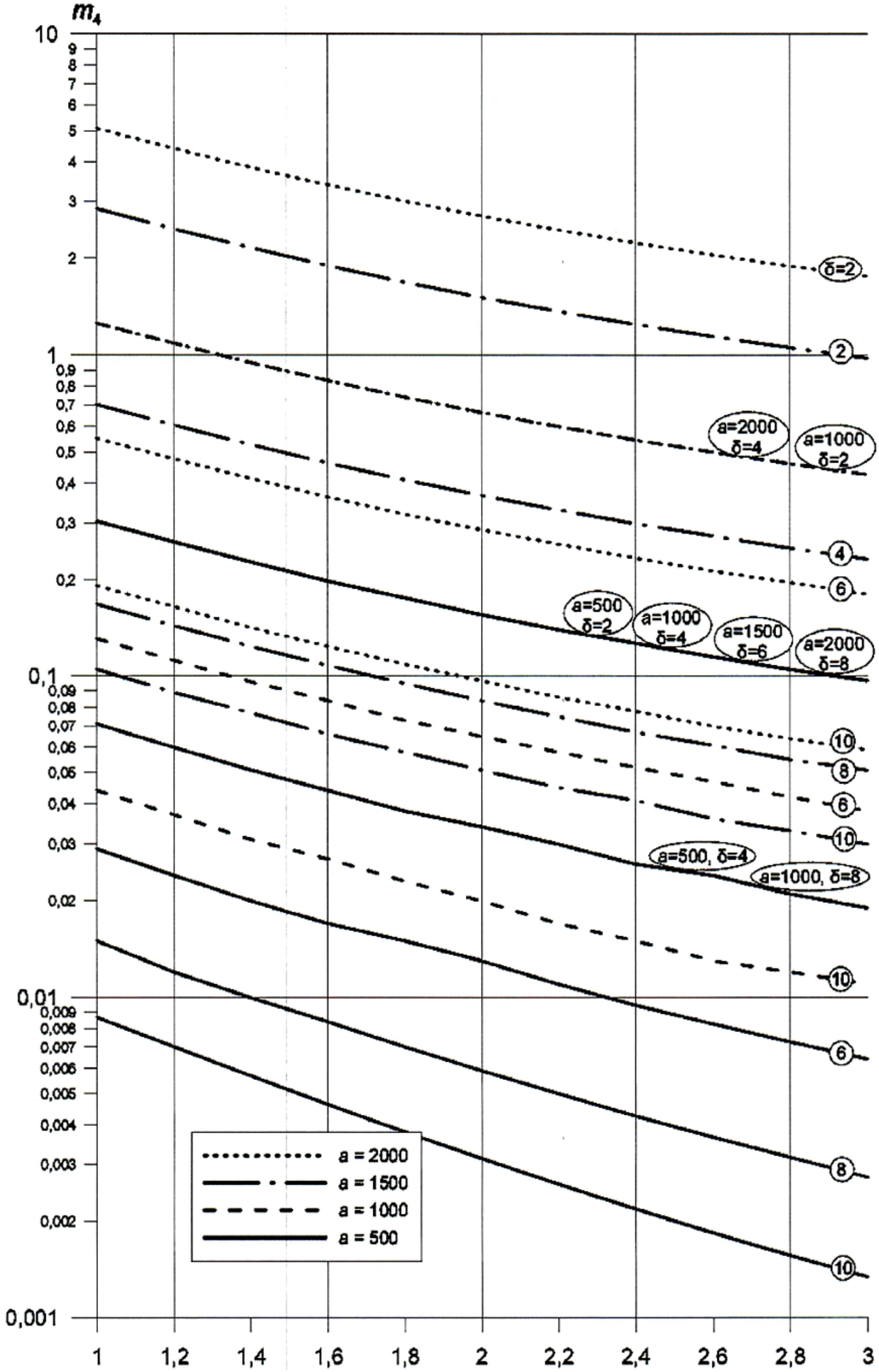
Values of thickness δ of the sandwich plate load-bearing layer are shown in circles

Fig. 8.2-10 Values of factor m_4 at η = 100



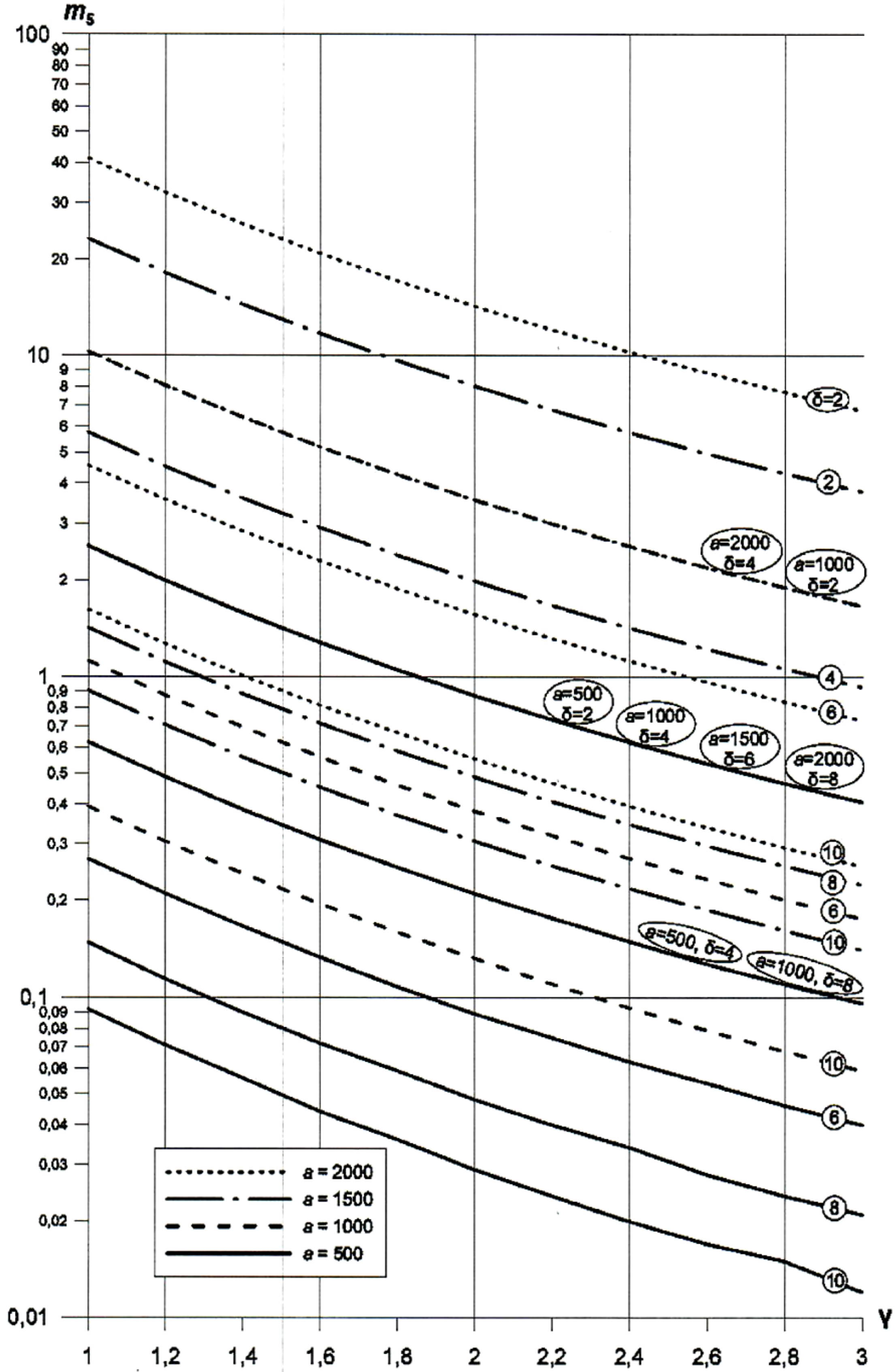
Values of thickness δ of the sandwich plate load-bearing layer are shown in circles

Fig. 8.2-11 Values of factor m_4 at η = 400



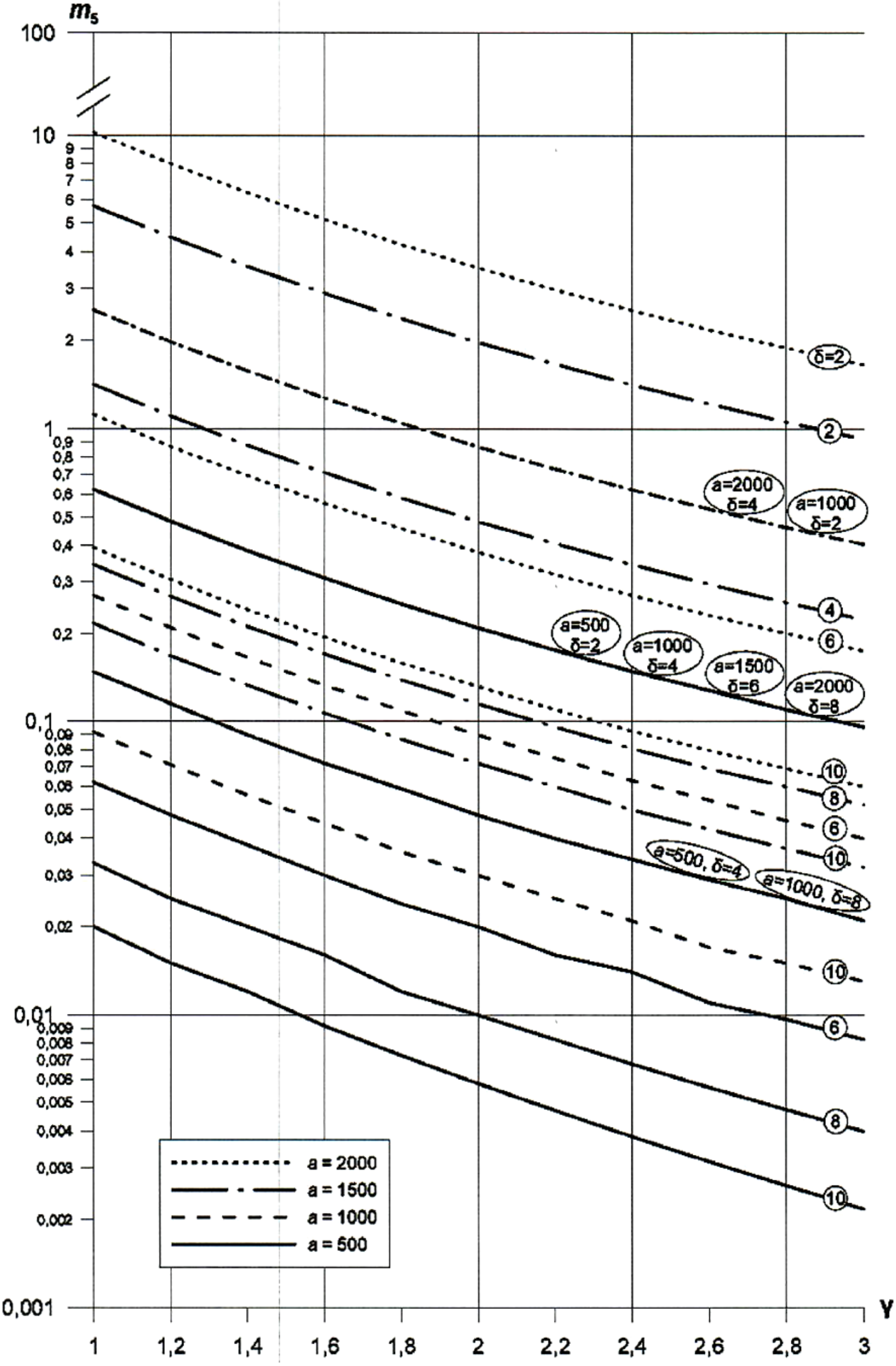
Values of thickness δ of the sandwich plate load-bearing layer are shown in circles

Fig. 8.2-12 Values of factor m_4 at η = 800



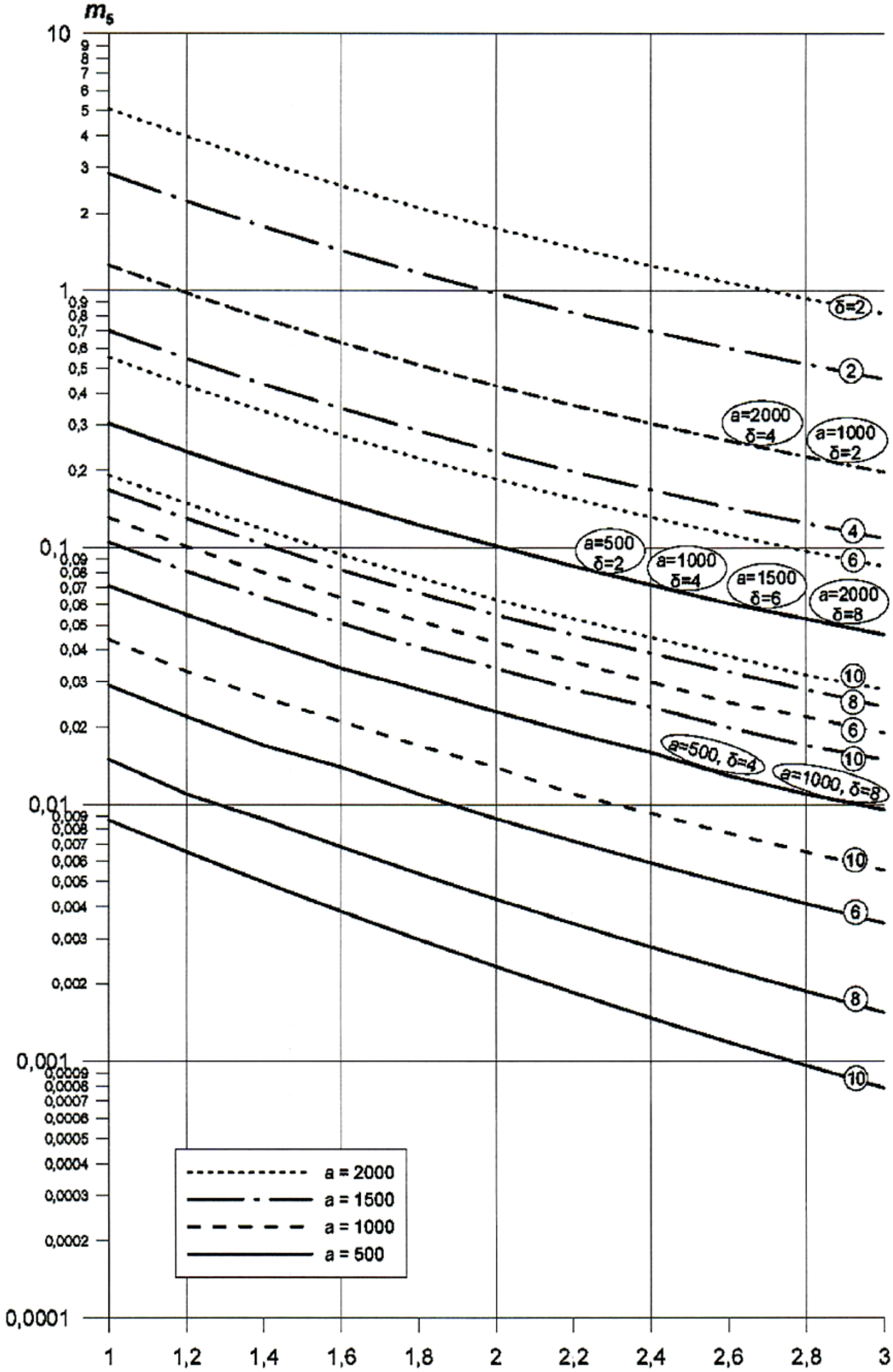
Values of thickness δ of the sandwich plate load-bearing layer are shown in circles

Fig. 8.2-13 Values of factor m_5 at $\eta = 100$



Values of thickness δ of the sandwich plate load-bearing layer are shown in circles

Fig. 8.2-14 Values of factor m_5 at $\eta = 400$



Values of thickness δ of the sandwich plate load-bearing layer are shown in circles

Fig. 8.2-15 Values of factor m_5 at η = 800

8.3 Plate edges are fixed along the supporting contour (design scheme refer nto Fig. 8.3-1).

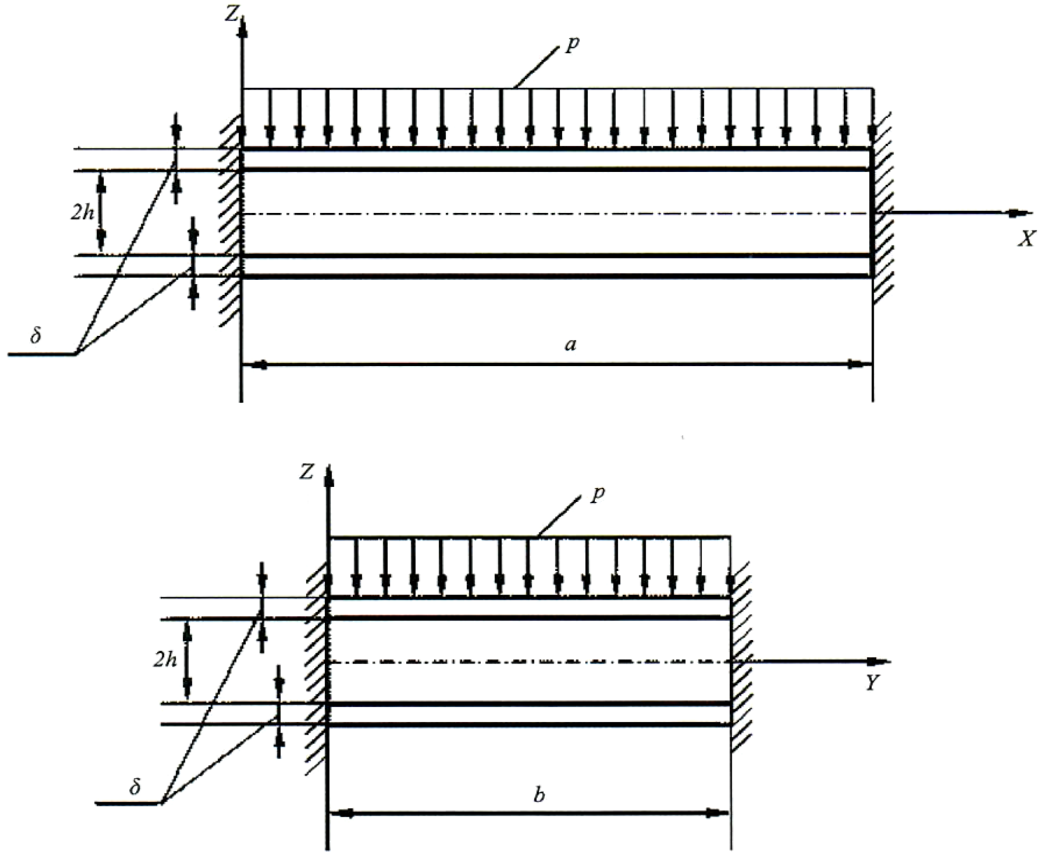


Fig. 8.3-1 Load type of the sandwich plate

Plate deflection is maximum at $x = a/2$, $y = b/2$ and determined by the formula

$$|w|_{x=a/2,\ y=b/2} = \frac{pb^2}{10^3(2h+\delta)}\left[\frac{m^1 b^2}{E_p^{bl}\delta(2h+\delta)} + \frac{\overline{m}_1}{G^{core}}\right],$$

where: a - length of the sandwich plate;
b - width of the sandwich plate;
$2h$ - core thickness of the sandwich plate;
δ - thickness of the load-bearing layer of the sandwich laminate;
p - uniformly distributed load;
E_p^{bl} - Young's modulus of load-bearing layers of the sandwich plate;
G^{core} - shear modulus of the core in the sandwich plate;
m_1, $\overline{m}_1$ - factors.

Values of factor m_1 depending on Poisson's ratio ν and ratio of plate sides $\gamma = a/b$ are specified in Fig. 8.3-2.

Values of factor $\overline{m}_1$ depending on the ratio of plate sides $\gamma = a/b$ are specified in Fig. 8.3-3.

Normal stresses σ_x are maximum at $x = 0; a$, $y = b/2$ and determined by the formula

$$|\sigma_x|_{x=0;\,a,\,y=b/2} = pb^2\frac{1+h/\delta}{(1+2h/\delta)^2}m_2,$$

where m_2 – factor.

Normal stresses σ_y are maximum at $x = a/2$, $y = 0; b$ and determined by the formula

$$|\sigma_y|_{y=a/2,\,y=0;\,b} = pb^2\frac{1+h/\delta}{(1+2h/\delta)^2}m_3,$$

where m_3 – factor.

Values of factors m_2 and m_3 depending on Poisson's ratio ν and ratio of plate sides $\gamma = a/b$ are specified in Figs. 8.3-4 and 8.3-5 accordingly.

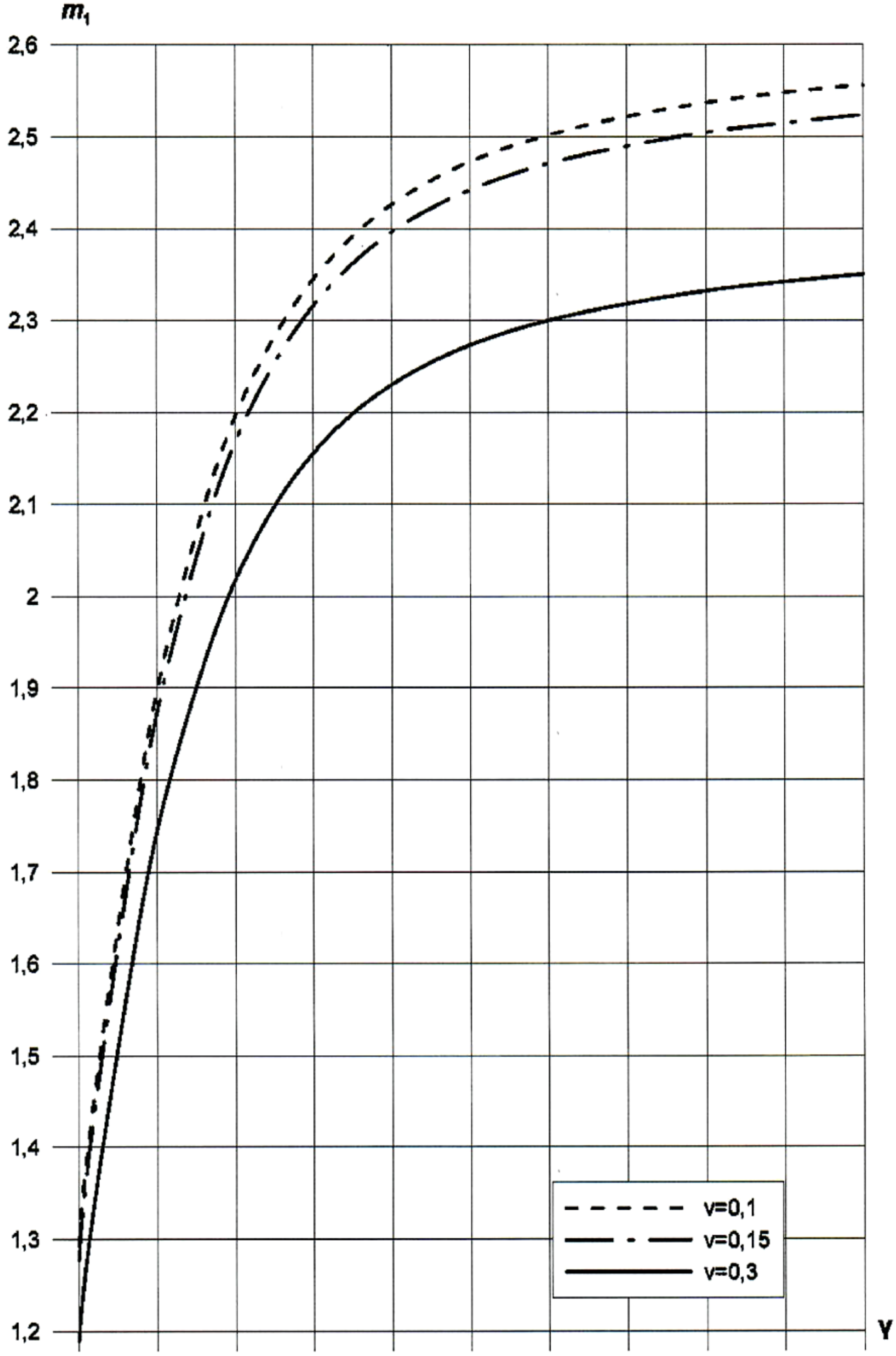


Fig. 8.3-2 Values of factor m_1

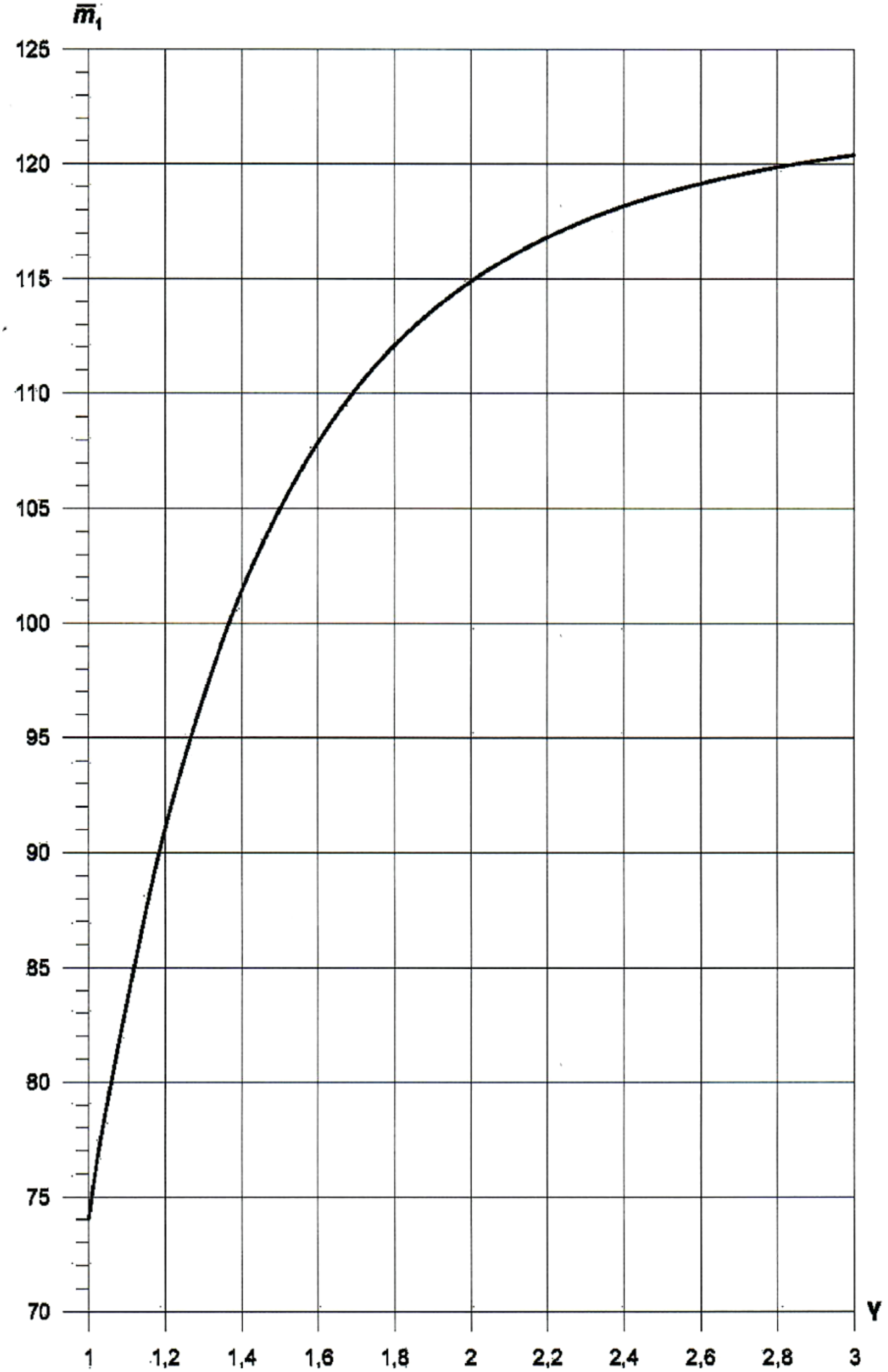


Fig. 8.3-3 Values of factor $\overline{m}_1$

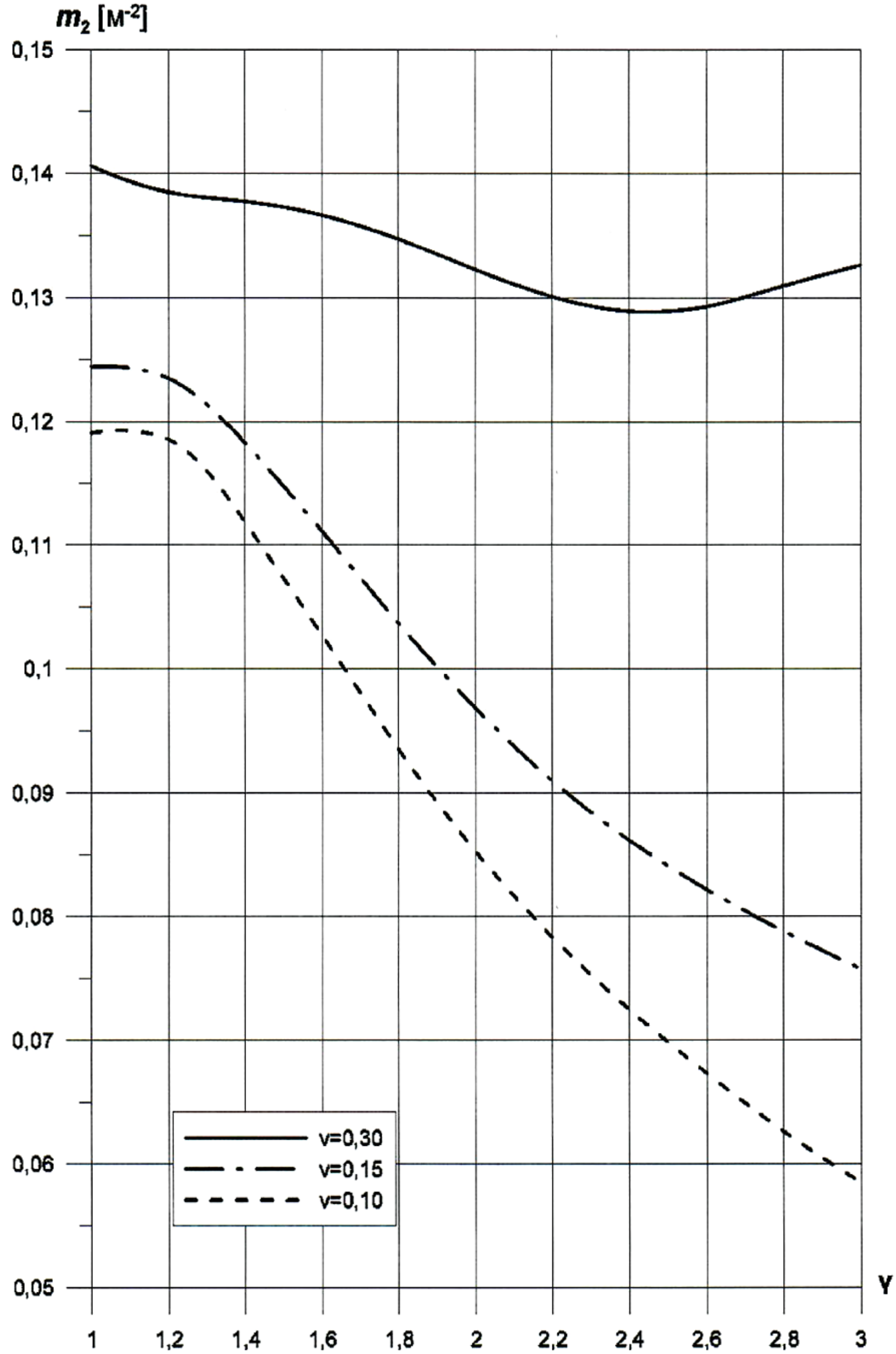


Fig. 8.3-4 Values of factor m_2

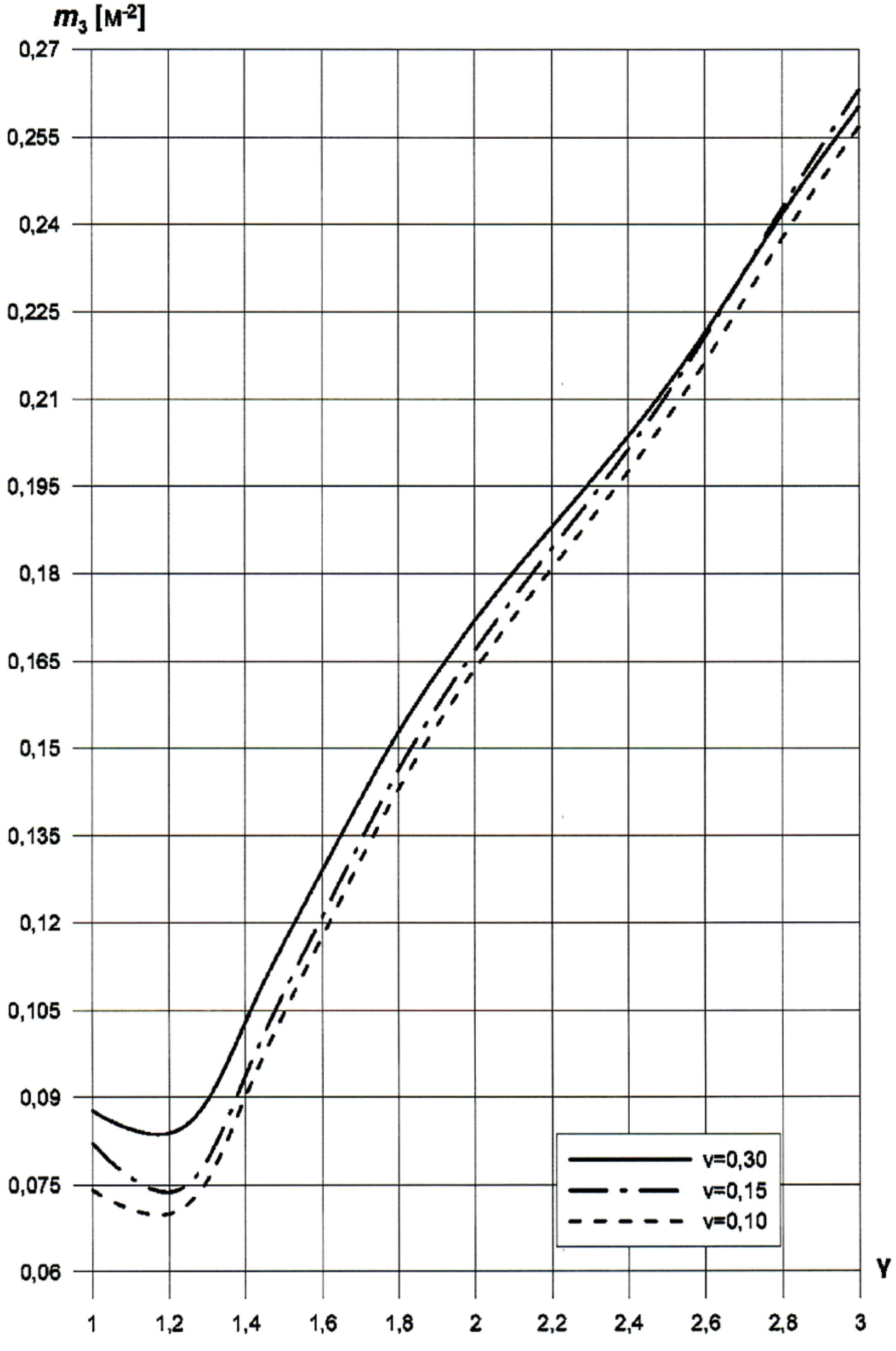


Fig. 8.3-5 Values of factor m_3

9 BUCKLING STRENGTH OF SANDWICH PLATES

This procedure is intended for buckling strength calculation of sandwich plates with isotropic core. The procedure allows determining the critical buckling load at one-sided uniform compression, with edges attached in different ways.

The calculation procedure is applied to rectangular symmetric plates over thickness $\delta_1 = \delta_2 = \delta$. Load-bearing layers and core are isotropic materials, i.e. for load-bearing layers and the core the following conditions are met accordingly:

$E_i^{(k)} = E_p^{ll}$; $\nu_{ij}^{(k)} = \nu^{ll}{}_{12}$;

$E_i^{core} = E_p^{core}$; $G_{ij}^{core} = G^{core}$; $\nu_{ij}^{k} = \nu^{core}$.

This procedure may be also used for calculation of stress-strain behavior of sandwich plates with orthotropic load-bearing layers when $E_{p1}^{ll} > E_{p2}^{ll}$ and $(1- E_{p1}^{ll}/E_{p2}^{ll})\cdot 100\% < 20\%$, whereas the following conditions for geometric properties and elastic characteristics are met:

$0{,}01 \le G^{core}/E_p^{ll} \le 0{,}1$; $0{,}01 \le \delta/h \le 0{,}25$;

$$\frac{2h}{a}\sqrt{1+(a/b)^2} \leqslant 0{,}3.$$

In such case, the core takes up only transverse loads preventing contact between the layers.

9.1 Ratio of plate sides 0,5 < *a*/*b* <3 (design scheme refer nto Fig. 9.1).

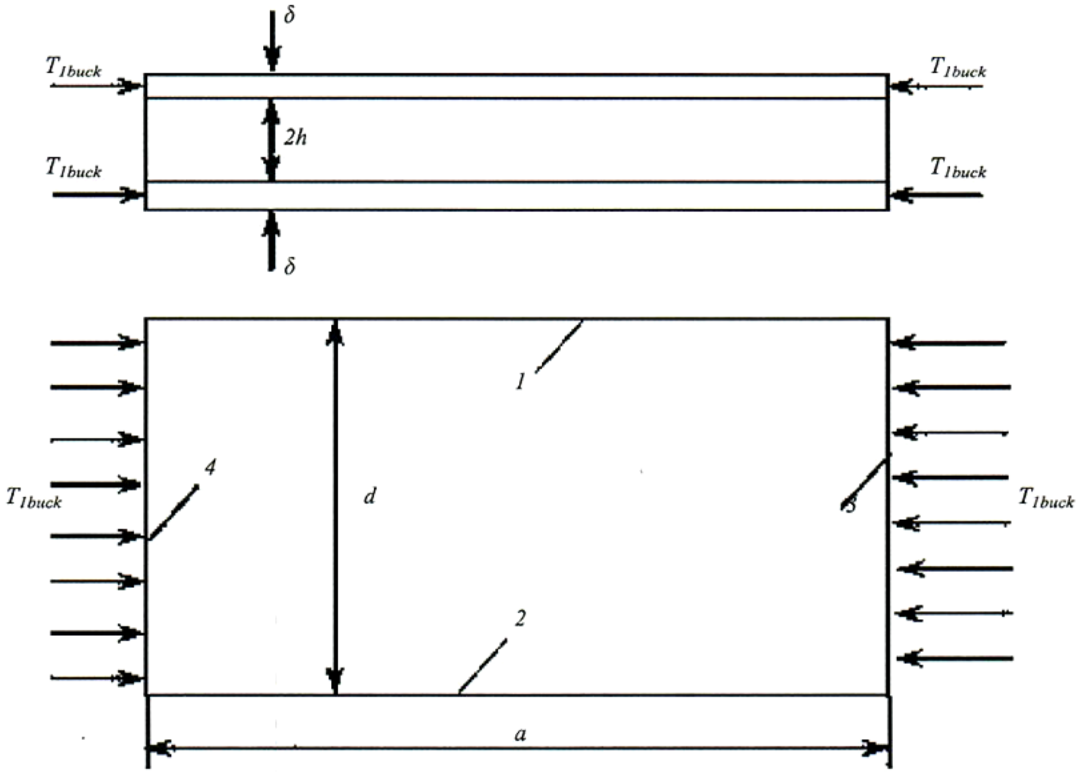


Fig. 9.1 Load type of a rectangular sandwich plate

9.2 Buckling load is determined by the formula

$$T_{1buck} = m_t \frac{\pi^2 D}{b^2},$$

where $D = 2D_1 + D^{з} + 2B_1(h+\delta/2)^2$;

$$D_1 = \frac{E_p^{ll}\delta^3}{12(1-\nu_{12}^{ll2})};$$

$$B_1 = \frac{E_p^{ll}\delta}{1-\nu_{12}^{ll2}};$$

$$D^{core} = \frac{2E_p^{core}h}{3(1-\nu^{core2})}.$$

Where $h/\delta = 5$ buckling load is determined by the formula

$$T_{1buck} = m_t m_1 \frac{\pi^2 E^{core}}{b^2},$$

where $m_1 = \eta \dfrac{2\delta^3 (216 - 125 \nu_{12}^{II^2} - 91 \nu^{core})}{3(1 - \nu^{core^2})(1 - \nu^{core})}$

Values of factor m_1 are determined according to the diagrams provided in Fig. 9.2-1.

Values of factor m_t are determined according to the diagrams depending on the way in which the plate is supported (refer to Figs. 9.2-2 – 9.2-5), while stiffness characteristics are determined by the formulae specified in **1.1**.

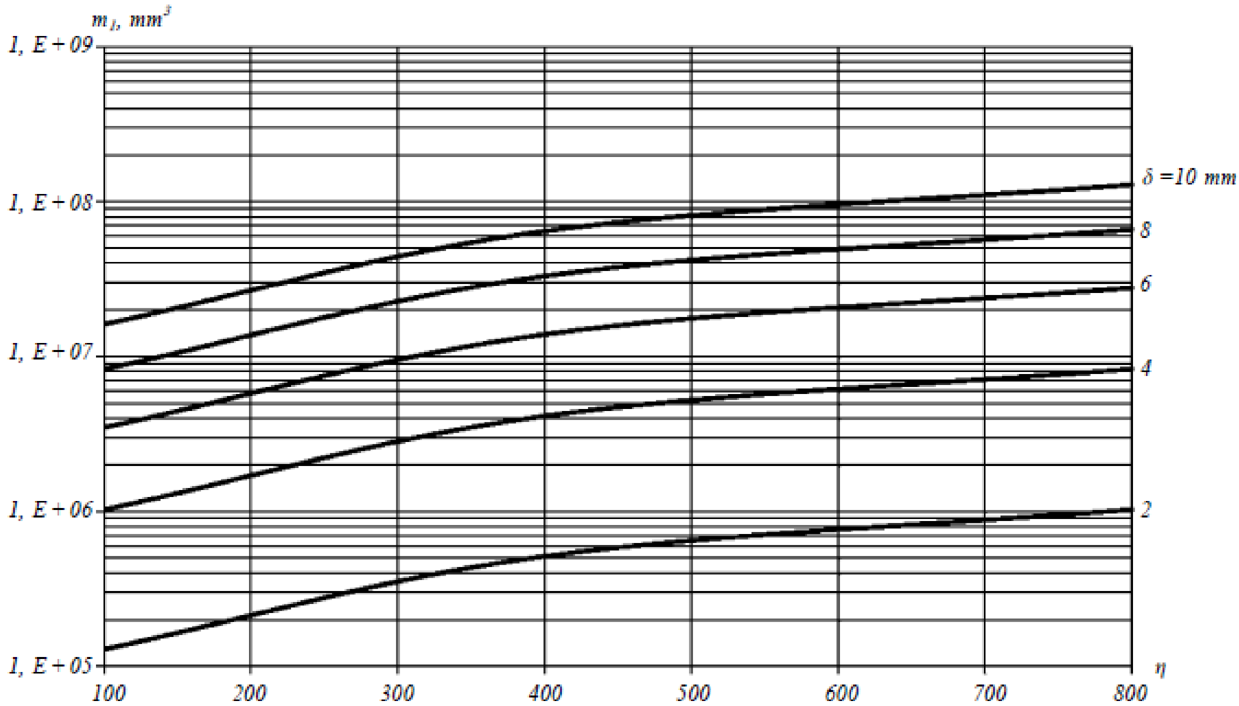


Fig. 9.2-1 Dependency diagram of factor m_1 on ratio of plate sides *a*/*b*, with all edges hinge-supported

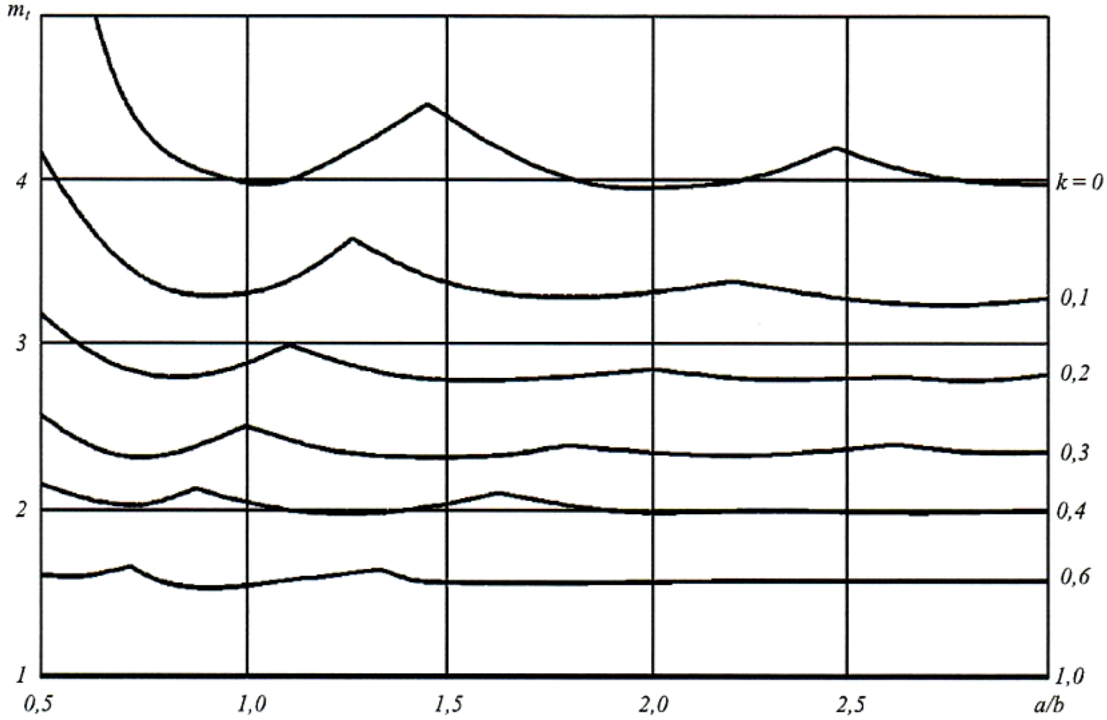


Fig. 9.2-2 Dependency diagram of factor m_t on ratio of plate sides *a/b*, with all edges hinge-supported

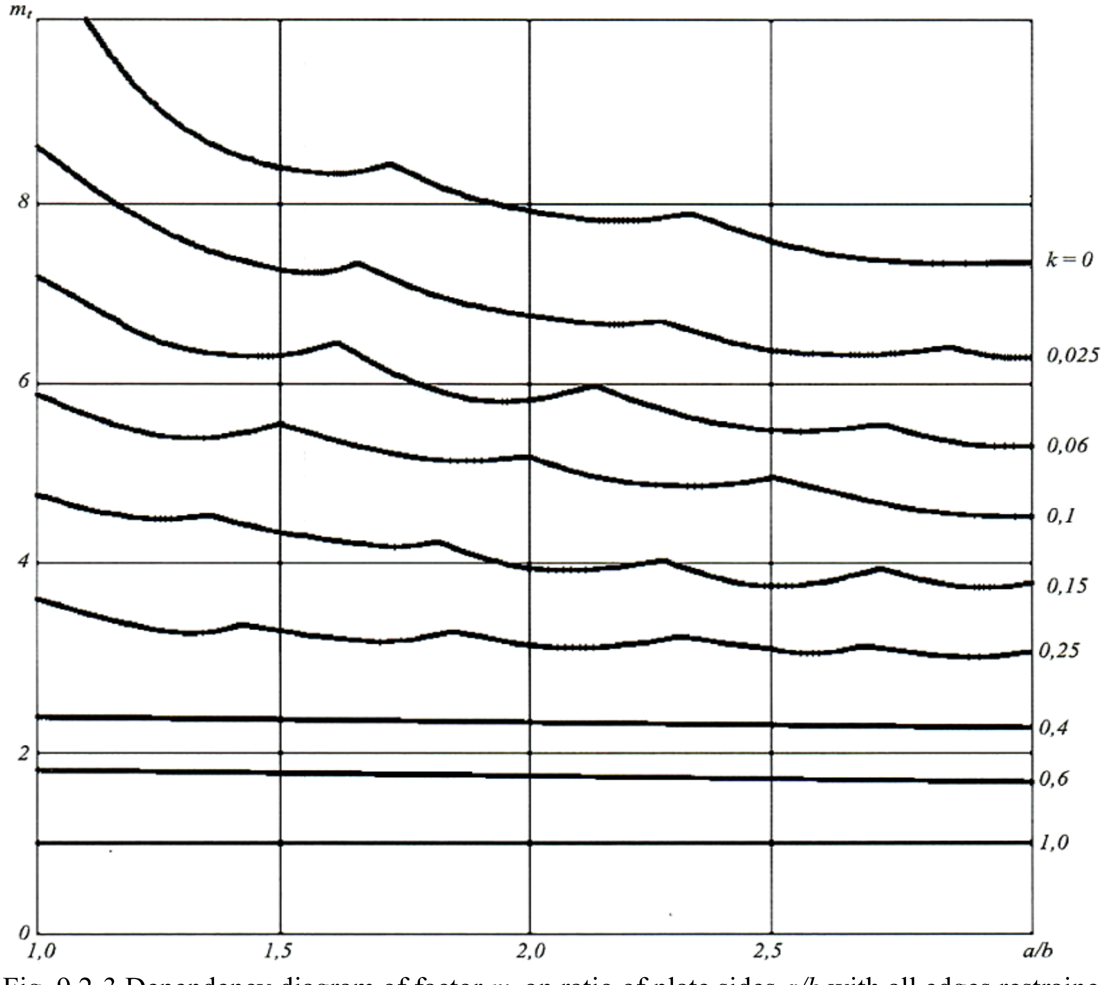


Fig. 9.2-3 Dependency diagram of factor m_t on ratio of plate sides *a/b* with all edges restrained

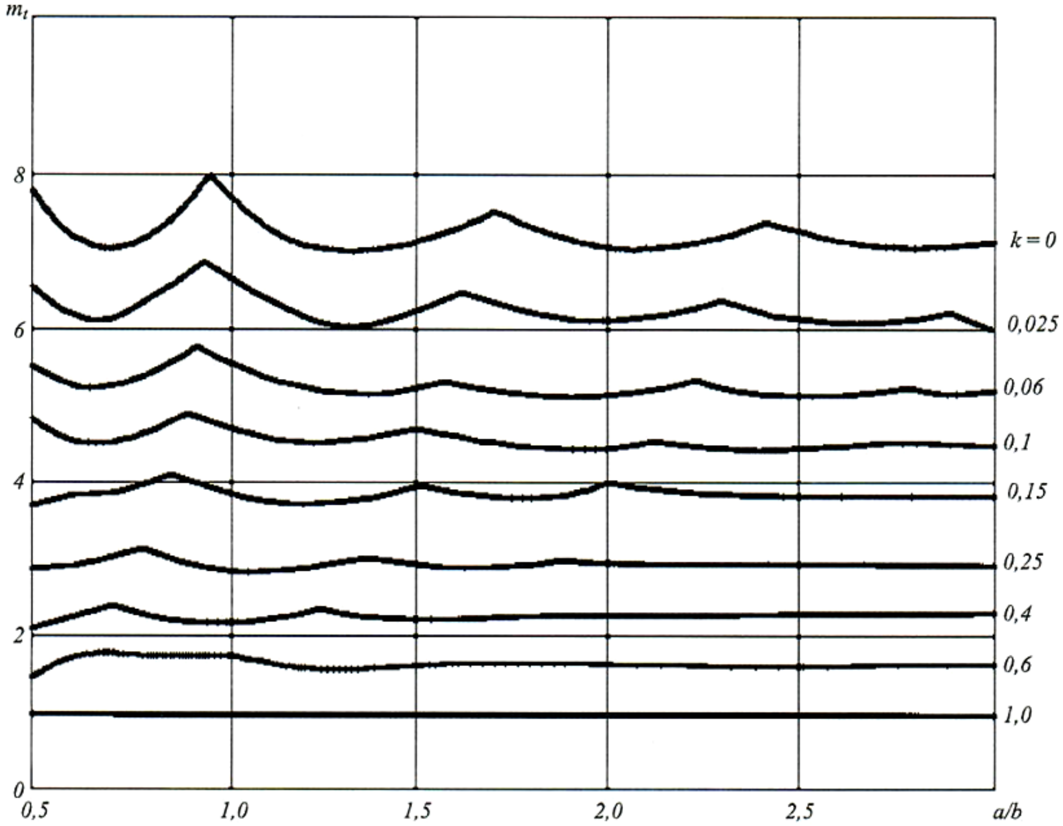


Fig. 9.2-4 Dependency diagram of factor m_t on ratio of plate sides *a/b*, with edges *1*, *2* - restrained; edges *3*, *4* - hinge-supported

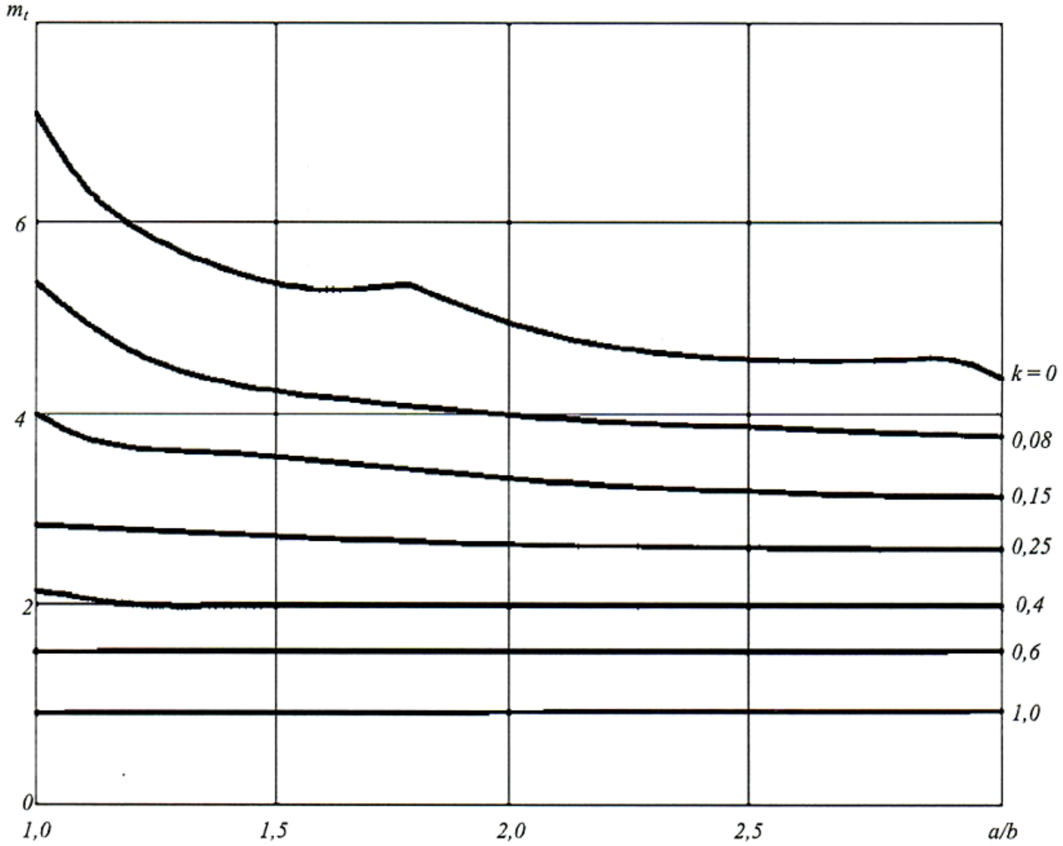


Fig. 9.2-5 Dependency diagram of factor m_t on ratio of plate sides *a/b*, with *1*, *2* - hinge-supported; edges *3*, *4* - restrained

APPENDIX 2

STANDARD TEST PROGRAM FOR SAMPLES OF NEW FRPS AND TYPE STRUCTURES AND ASSEMBLIES MADE OF THEM

1. GENERAL

1.1 This Appendix contains the nomenclature and scope of new FRPs not specified in this Part of the Rules for the purpose of their acceptance and approval by the Register for their further application in hulls and hull structures.

1.2 This test program applies to FRPs based on glass, carbon, aramid reinforcement materials as well as polyester, vinylester or epoxy binders.

Tests of FRPs based on other basic components under this test program is allowed upon agreement with the Register.

1.3 This test program applies to cold- and hot-curing FRPs manufactured by contact moulding, spraying, vacuum injection (infusion technique, RTM techniques), autoclave moulding, pressing, and pultrusion.

Application of other techniques for manufacture of FRPs shall be agreed with the Register.

1.4 This test program is also applied to lightweight cores used in sandwich (multi-layered) structures. These cores include form plastics (PVC and PUR foams, polyepoxy foams, etc.), and lightweight mats.

The above-mentioned cores reinforced with structural elements, and structural orthotropic (nonhomogeneous) cores related to structures shall be tested according to special programs approved by the Register.

1.5 This test program is not applied to adhesion compounds (glues) used for connection of elements of hull structures and products, and to sealant compounds.

Test programs for adhesion and sealant compounds shall be developed by designers of these compounds and shall be approved by the Register.

1.6 According to this test program, FRPs shall be tested as part of specimens, type structures and assemblies to confirm the possibility of the FRP application and processing technique to hull structures of the ship.

These tests shall be carried out according to the methods of international and/or national standards, and other reference documents upon agreement with the Register.

1.7 The test program regulates the following:

complete list of new FRP types and check methods, which are mandatory when approved by the Register, and the list of supplementary checks performed upon the request of the Register, designers and other organizations involved in development, acceptance and production launch of the material;

scantlings and manufacturing techniques of laminates (blanks) used for cutting out test specimens;

cutting-out diagram of test specimens from laminates (blanks);

structure and manufacturing procedure of typical structures and assemblies;

test procedures;

procedure for supervision during test procedure;

procedure of processing and recording test results.

1.8 The relevant procedures specified and regulated by this test program, the scope of testing, their sequence and procedure, as well as the procedure of processing and recording test results are mandatory.

1.9 The scope of FRP testing as part of specimens, typical structures and assemblies shall ensure complete data on mechanical, process, and other properties of the material, which are required to confirm possibility of its application as part of structures and products, for which the material is intended.

1.10 Where the nomenclature and scope of testing under this program are not sufficient to substantiate the assessment of this material application in shipbuilding, or supplementary tests are required to determine special characteristics, development of supplementary test program approved by the Register may be required.

1.11 Appropriate certified testing equipment and measuring equipment checked (calibrated) in the established order shall be used when carrying out testing under this program.

The testing and measuring equipment used shall be certified and provided with the relevant document confirming certification as well as calibration certificates valid at the date of testing.

2 ITEMS UNDER TEST

2.1 The following items are subject to testing:

specimens of FRPs made of monolayers with the use of the same binder and reinforcement material with the same reinforcement scheme;

specimens of lightweight core;

type structures made of these FRPs and lightweight core;

type assemblies made of the same FRPs.

2.2 The following materials may be used as reinforcement materials for a monolayer of homogeneous FRP (depending on the laying method):

one-directional tapes;

woven fabrics of satin, plain, twill, etc. weave types;

mats;

multiaxial fabrics (biaxial, triaxial, quadriaxial).

2.3 Where monolayers of hybrid FFP are made of hybrid reinforcement materials with fibers of different chemical nature, e.g. glass and carbon fibers, may be subjected to testing under this program.

2.4 Type structures and assemblies are basic design and technology solutions used in hulls and hull superstructures of hulls made of FRPs..

2.5 Type structures and assemblies are tested to determine whether FRP under question and its processing techniques may be applied for manufacture of hull structures and products, and confirmation of required strength and operability characteristics of FRPs as part of such structures and assemblies.

2.6 FRPs, type structures and assemblies subject to the Register recognition, including those with the use of the lightweight core shall be manufactured according to the procedure for FRP hulls and superstructures applied at firm (manufacturer), or according to the procedure developed for a particular item.

Where the manufacture procedure or some conditions thereof changed, FRP shall be subjected to retesting in a full or reduced scope, depending on the changes made.

3 SCOPE AND TYPES OF TESTS FOR FRPS AND LIGHTWEIGHT CORES

3.1 FRPs and lightweight cores subject to the RS recognition shall be tested under this program, as part of specimens, to determine the following characteristics:

physical and mechanical properties in the initial state, considering the operating factors (exposure to sea water, high temperature, cyclic and long-term loads, etc.);

process characteristics;

fire risk.

3.2 Specimens of FRPs and lightweight core are cut out of laminates (blanks) in specified directions and from required areas of these laminates.

Specimens of a lightweight core such as foam plastic are cut out of completed laminates or blocks supplied by the firm (manufacturer).

Laminates (blanks) for cutting out specimens of FRPs and lightweight core based on mats are moulded using the technique developed for manufacture thereof (refer to **2.6** and **2.7**). Reinforcement schemes of FRP shall be determined in accordance with **2.1** and **2.2**.

3.3 Laying density of reinforcement materials during moulding of laminates (blanks) shall comply with the requirements for the adopted moulding technique. Percentage of reinforcement materials, depending on their types, for the most common moulding techniques shall be not lower than that specified in Table 3.3.

Table 3.3 **Percentage of reinforcement materials by mass for moulding techniques**

Moulding technique	Type of reinforcing material			
	Glass mats	Fiber glass	Carbon fibers	Glass roving
Contact moulding	at least 0,3	at least 0,5	at least 0,35	--
Closed (vacuum) moulding	--	0,65…0,7	0,4…0,6	--
Spraying	--	--	--	не менше 0,35

Laying density of reinforcement materials shall vary so that binder percentage at different points of laminates (blanks) differs from its average value by not more than:

for the contact moulding technique - 2 %;

for closed (vacuum) moulding techniques - 0,5 %;

for the spraying technique - 3 %.

3.4 Quality of laminates (blanks) and cutting of their specimens shall comply with the requirements of this Appendix and/or a standard agreed with the Register.

3.5 Tests to determine physical and mechanical properties.

3.5.1 Elastic and strength characteristics of FRPs in the initial state when exposed to short-term loading shall be determined in accordance with the list and test procedures specified in Table 3.5.1.

Table 3.5.1 **List of FRP characteristics determined in the initial state and test procedures under short-term loading**

№	Characteristic	Direction of the test specimens, deg.	Test procedure
1	Density	--	ISO 1183, ASTM D 792, ASTM D 1505, NF T 57-102, GOST 15139-69
2	Binder percentage	--	ISO 1172, ASTM D 792, ASTM D 2734, ASTM D 3171, SACMA RM 10, GOST 32652
3	Young's modulus	0°, 45°, 90°	ASTM D 638 (Type 1), ASTM D 3039/D 3039M
4	Shear modulus in the reinforcement plane	0°, 45°, 90°	ASTM D 3518, ASTM D 4255
5	Interlaminar shear modulus [1]	0°, 45°, 90°	ASTM D 2344, ASTM D 2733, SACMA SRM 8R
6	Poisson's ratio and tensile elongation	0°, 45°, 90°	ASTM D 3039/D 3039M, ASTM D 638 (Type 1)
7	Tensile strength at break	0°, 45°, 90°	ДСТУ EN ISO 527, EN ISO 527, ISO 527, ISO 3268, ASTM C 393/C 393M, ASTM D 638/D 638M, ASTM D3039/D3039M, ASTM D 54502, NF T 57-101, SACMA RM4, SACMA RM9
8	Compression strength at break	0°, 45°, 90°	ASTM D 638, ASTM D 695, ASTM D 3410, ASTM D 5449, ASTM D 5467, ASTM D 6484/D 6484M ISO 527, SACMA RM 1, SACMA RM 6
9	Flexural breaking strength[1]	0°, 45°, 90°	ДСТУ EN ISO 178, EN ISO 178, ISO 178, ISO 14125, ASTM C 393/C393M[2], ASTM D 790, NF T 57-105, GOST 4648-71, GOST 25.604-82
10	Shear breaking strength in the reinforcement plane	--	ISO 1922, ASTM C 273, ASTM D 3518/D 3518M, ASTM D 4255, ASTM D 5379, ASTM D 5448, SACMA RM 7
11	Interlaminar shear strength at break[1]	0°, 45°, 90°	ISO 4585, ASTM D 2344, ASTM D 2733, ASTM D 5379/D 5379 M-12[2], ASTM E 143, NF T 57-104, SACMA RM 8

[1] FRP characteristics at an angle of 45° are determined based on biaxial diagonal fabrics (+45°/-45°).
[2] Applied to FRP one-directional reinforcement scheme.

3.5.2 Elastic and strength characteristics of FRPs in the initial condition under repeated static and continuous loading shall be determined in accordance with the list and test procedures specified in Table 3.5.2.

Table 3.5.2 **List of FRP characteristics determined in the initial state and test procedures under repeated permanent and continuous loading**

№	Characteristic	Direction of test specimens, deg.	Test procedure
1	Endurance limit tensile strength at $2x10^6$ cycle[1]	0°, 45°	ДСТУ EN ISO 527, EN ISO 527, ISO 527, ASTM D 3479
2	Endurance limit in compression at $2x10^6$ cycles[1]	0°, 45°	ДСТУ EN ISO 527, EN ISO 527, ISO 527, ISO 13003, GOST 33845
3	Bending endurance limit at $2x10^6$ cycles[1]	0°, 45°	ISO 13003, ISO 14125, ASTM D 7774, GOST 33845
4	Endurance limit at interlaminar shear at $2x10^6$ cycles[1]	0°, 45°	ISO 13003, ISO 14130, GOST 33845
5	Creep rupture tensile strength at 10^3 h[1]	0°, 45°	ASTM D 2990, GOST P 57714

[1] Refer to Note 1 to Table 3.5.1.

3.5.3 Tests of FRP specimens at an elevated temperature of 60 8C shall be carried out to determine the characteristics in items **3 - 5**, **8**, **11** of Table 3.5.1. Depending on the supposed operation conditions, tests of FRP specimens may be carried out under other values of elevated temperatures.

3.5.4 Water absorption tests of FRPs shall be carried out in accordance with **2.3.9** of Part XIII "Materials".

Influence of water on FRP resistance is determined from variation of the characteristics specified in items **3 - 5**, **7**, **8**, **11** of Table 3.5.1. At first, FRP specimens shall be subject to accelerated water exposure according to the procedure provided in **2.3.12** of Part XIII "Materials".

3.5.5 Lightweight core specimens are tested for water absorption under short-term loading as well to determine elastic and strength characteristics. The list of characteristics to be determined and test procedures are specified in Table 3.5.5.

Table 3.5.5 **List of lightweight core characteristics to be estimated1 and test procedures**

№	Characteristic	Test procedure
1	Ultimate water absorption	ISO 2896, GOST 203869-75
2	Young's modulus	ASTM E1875-13, ASTM D 1621, ASTM D 1623[2], GOST 18336-73, GOST 17370-71[2]
3	Shear modulus	ASTM C 273
4	Tensile strength at break	ASTM D 1623, GOST 17370-71
5	Compression strength at break	ASTM D 1621 , GOST 23206-78
6	Shear breaking strength	ASTM C 273, ASTM C393/C393M

[1] 1Elastic and strength characteristics of the lightweight core based on mats shall be determined in 0° and 90 ° directions in the mat laying plane, with 0° direction positioned along the mat fabric.

[2] These standards determine the technique of tensile test of specimens without specifying the technique of Young's modulus determination.

3.5.6 To determine whether FRPs may be applied in specific structures and products, additional characteristics according to Table 3.5.6 may be considered.

3.5.7 Depending on operating conditions, the following shall be determined:

impact of oil and petroleum products on mechanical properties;

impact of salt fog on mechanical properties;

linear (volumetric) expansion and thermal conductivity.

3.5.8 List of additional characteristics may be specified based on the results of tests conducted.

Table 3.5.6 **List of additional characteristics of polymer composites and their estimation techniques**

№	Characteristic	Test procedure
1	Ultimate tensile-compression strength in transversal direction	ASTM D 6415, ASTM C 297
2	Crack resistance (Modes I and II)	ASTM D 5528-01 (Mode I), Method of bending a framing member with a notch on one side (ENF) (Mode II)
3	Charpy's impact strength	ДСТУ EN ISO 179-2, EN ISO 179-2, ISO 179-2, GOST 4647-80
4	Tension-compression creep	ASTM D 2990, GOST P 57714

3.6 Tests to determine technological properties.

3.6.1 Tests to determine process characteristics are carried out to determine the workability, i.e. the ability of basic components - reinforcement materials and binder to be processed in a structure (product) made of FRPs by means of the selected manufacture technique (contact moulding, spraying, vacuum injection (injection technique, RTM techniques), autoclave moulding, pressing, pultrusion), with stability and proper quality performance ensured.

3.6.2 To determine workability of basic components, the following characteristics shall be determined:

binder viscosity;

temperature of exothermic reaction during binder polymerization;

extent and time of binder polymerization;

amount of binder shrinkage upon its polymerization;

impregnability and resin-saturation of the reinforcement material;

binder percentage in FRPs;

permissible thickness of FRPs in case of continuous moulding;

maximum temperature and time of FRP heat treatment by hot curing;

amount of thixotropic agents and ability to mold vertical surfaces.

3.6.3 Dynamic viscosity is determined according to the procedure of ASTM D2196-05 or GOST 1929-87.

3.6.4 Temperature of exothermic reaction during binder polymerization is determined according to ISO 584 (GOST 21970-76).

3.6.5 Extent and time of binder polymerization are dependent on the glass transition temperature as per ДСТУ ISO 11357 or ISO 11357, time of binder polymerization (gel time) - ISO 2535 (GOST 22181-91).

3.6.6 Binder shrinkage upon its polymerization is determined according to ISO 2577 and GOST 18616-80.

3.6.7 Impregnability and resin-saturation of the reinforcement material (determination of impregnation speed for comparative testing) and resin-saturation are determined according to the procedures specified in item **2** of Table 3.5.1.

3.6.8 Binder percentage in FRPs is determined according to the procedures specified in item **2** of Table 3.5.1.

4 SCOPE AND TYPES OF TESTS OF TYPE STRUCTURES AND ASSEMBLIES

4.1 Type structures and assemblies shall represent basic members and elements of hull structures, have representative scantlings and allow manufacturing with the use of the selected technique to confirm that this technique may be applied for manufacturing hull structures and ensures process stability and proper quality performance.

4.2 Type structures and assemblies shall be made of the FRP subject to recognition, including that using the lightweight core, by the technique adopted considering **2.6.**

Type structures and assemblies may be used in FRPs based on other reinforcement materials of the chemical nature similar to that subject to recognition, and on the same binder. In such case, these FRPs shall be recognized or may undergo the recognition procedure together with the first FRP.

4.3 Type structures and assemblies shall be manufactured in accordance with lists of construction and production documentation sets.

4.4 In this program, type structures and assemblies comprise:

single-skin laminates;

sandwich laminates;

closed box section framing member;

butt joint assembly;

T-joint assembly.

4.6 Single-skin laminates and their test procedure.

4.6.1 Single-skin laminates are made of the FRP under consideration, of the specified reinforcement scheme (refer to **2.1** and **2.2**), with the reinforcement material fabric laid along the longer side of the laminate.

4.6.2 Laminates are made by the adopted technique (refer to **2.6**) in two positions - horizontal and vertical, one laminate per position (refer to Fig. 4.6-1). In the first position, a laminate shall not be smaller than 1500x1000 mm, in the second position - not smaller than 2000x1000 mm, with the longer side positioned vertically. In both cases, the laminate thickness shall be equal to 10 mm.

During manufacture of a vertical laminate, amounts of thixotropic agents and glue (to secure dry reinforcement material when the vacuum injection technique is used) shall be strictly limited.

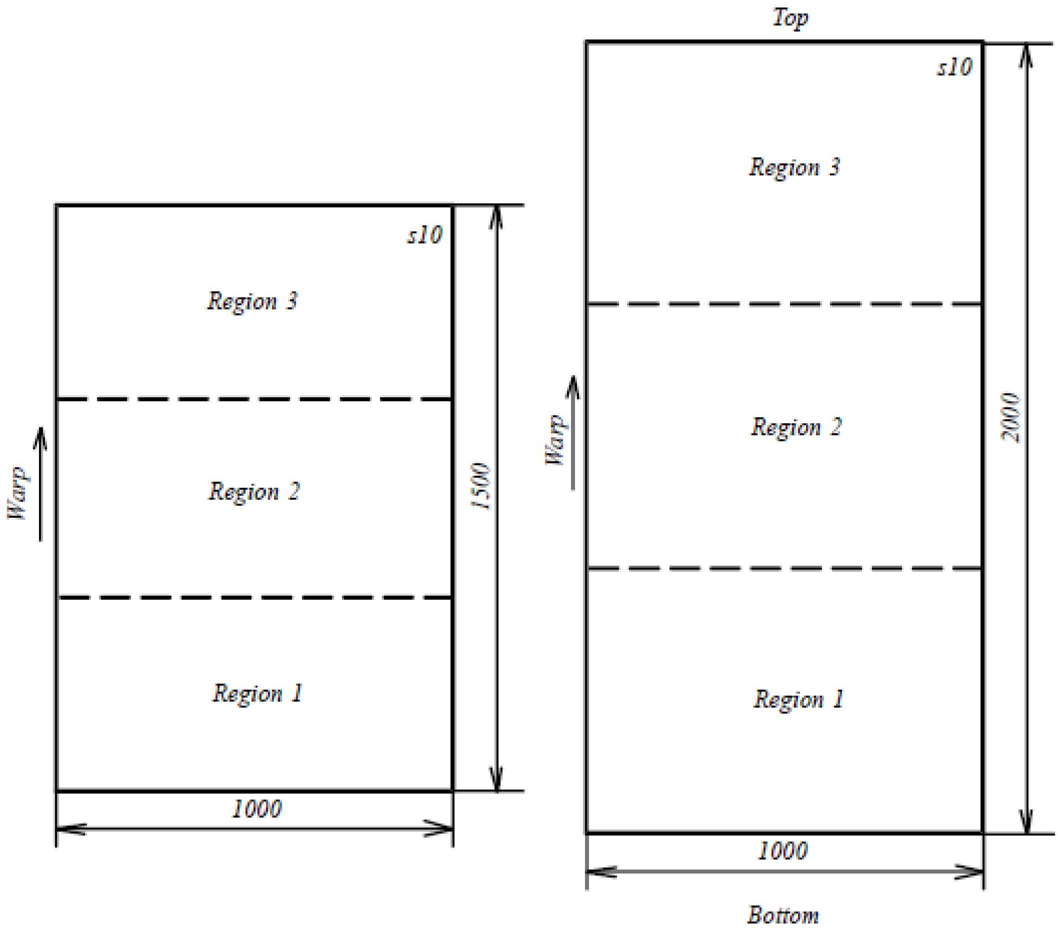


Fig. 4.6-1 Single-skin laminates made of FRPs by horizontal (left) and vertical (right) moulding

4.6.3 From laminates in three different regions (near shorter sides and in the middle) prismatic specimens are cut out (refer to Fig. 4.6-2):

for static bending test according to the procedures specified in item **9** Table 3.5.1 (dimensions 200x20 mm), 10 pcs per reinforcement direction;

for interlaminar shear test according to the procedures specified in item **5** and **11** Table 3.5.1 dimensions 60610 mm, 10 pcs per reinforcement direction;

for determination of density according to the procedures specified in item **1** Table 3.5.1;

for determination of binder percentage according to the procedures specified in item **2** of Table3.5.1.

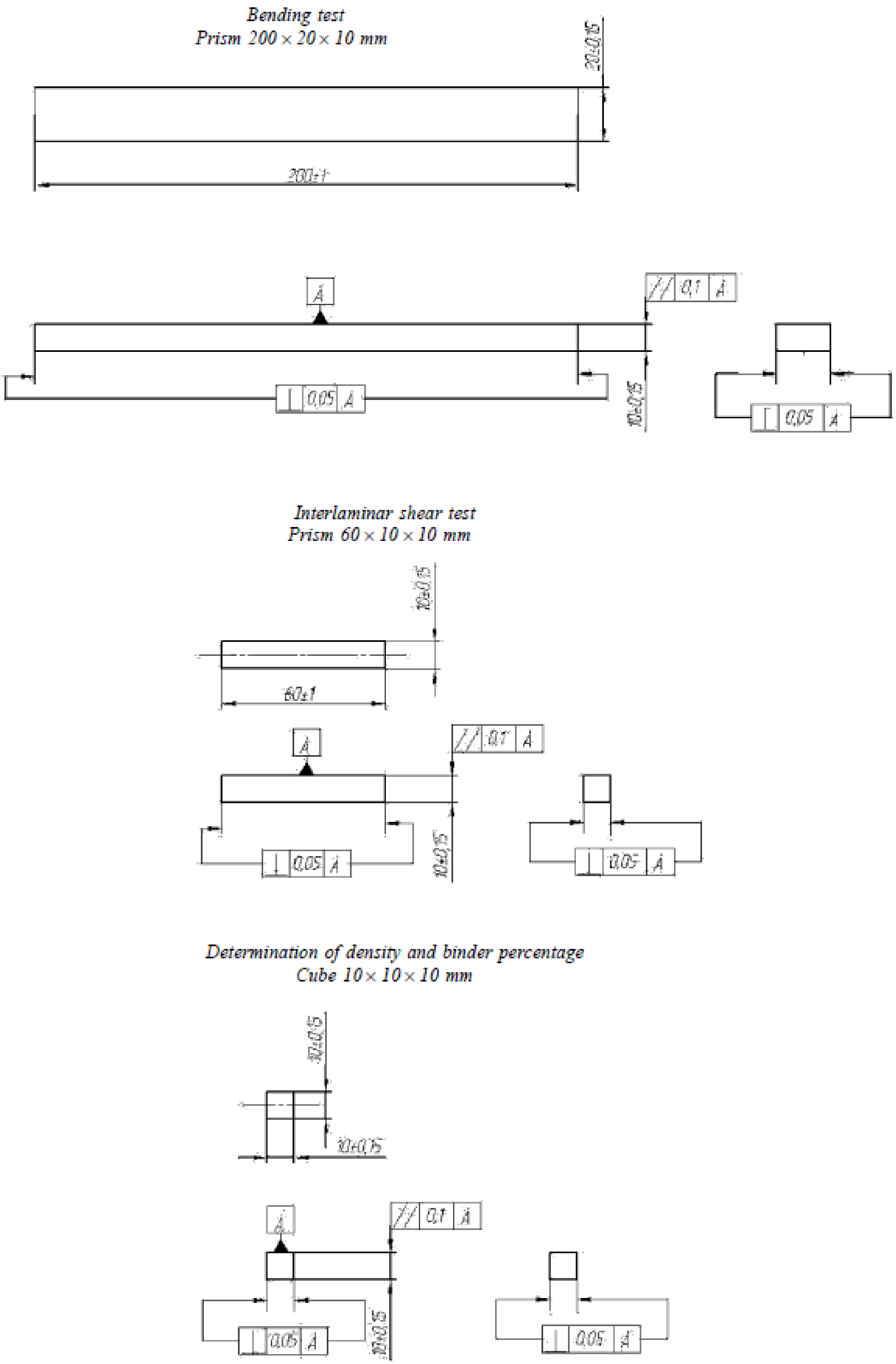


Fig. 4.6-2 FRP specimens for physical and mechanical tests in the initial state, cut out from laminates made of horizontal and vertical moulding (refer to Fig. 4.6-1)

4.6.4 Half of specimens for bending tests (according to a three-point bending scheme) and interlaminar shear tests shall be tested under short-term loading, the other half - under repeated static loading as per standard recognized by the Register, at 10^4 cycles of 50 % loading level of the average breaking load determined from static test results. Where the specimen has not failed as a result of repeated static tests, it shall be tested under short-term loading until failure occurs.

4.7 Sandwich laminates and their test procedure.

4.7.1 In sandwich laminates load-bearing layers are made of the Register recognized FRP of the specified reinforcement scheme (refer to **2.1** and **2.2**), with the reinforcement material fabric laid along the longer side of the laminate. The lightweight core, or the core which has been already recognized and provided with the Type Approval Certificate (CTO) shall be used as the core. Where polyvinylchloride foam of PVC type or PUR foam is used, its density shall be 100 - 150 kg/m^3.

4.7.2 Laminates are manufactured similarly to single-skin ones (refer to **4.6.2**). Scantlings of laminates for two moulding positions shall be not less than 200061000 mm. In such case, the thickness of loadbearing layers shall be equal to 4 mm, and that of the core - 40 mm.

4.7.3 From laminates in three different regions (near shorter sides and in the middle) prismatic specimens are cut out (refer to Fig. 4.7):

for bending tests as per ASTM D790/ASTM C393/C393M (dimensions 750650648 mm), 6 pcs per reinforcement direction;

for short beam test as per ASTM D2344/SACMA SRM 8R (dimensions 300650648 mm), 6 pcs per reinforcement direction.

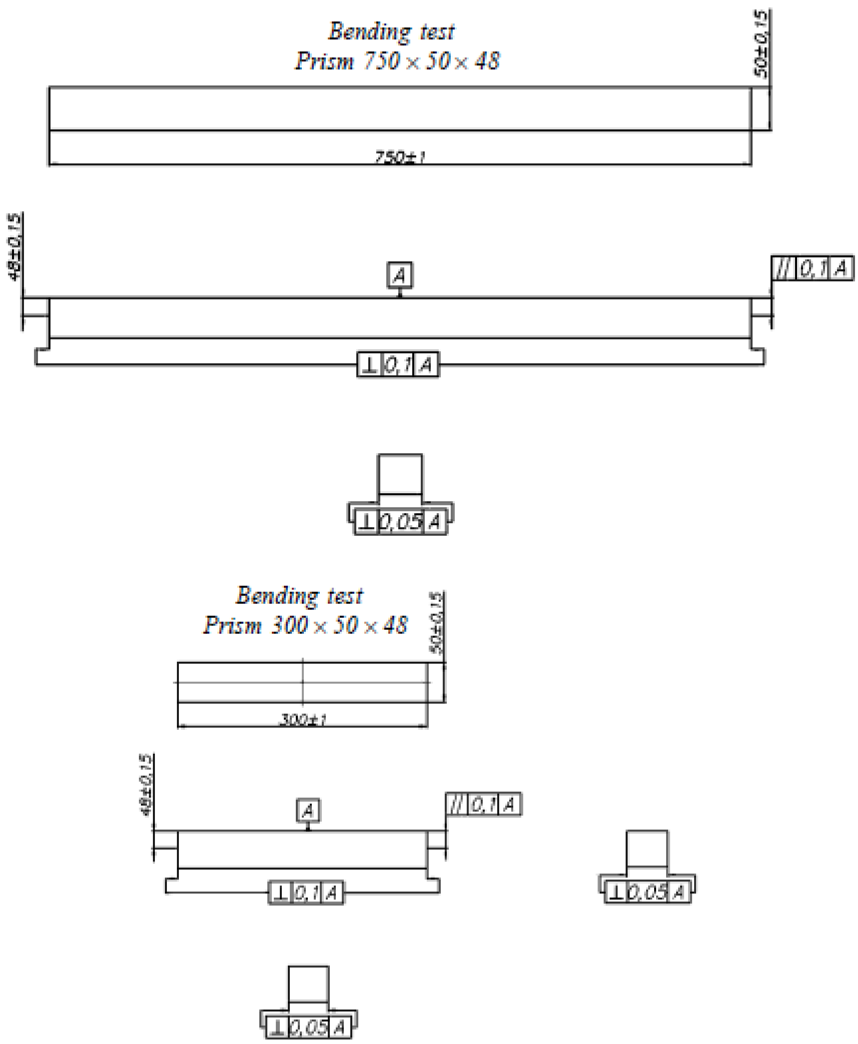


Fig. 4.7 FRP specimens for physical and mechanical tests in the initial state,
cut out from laminates made of horizontal and vertical moulding (refer to **4.7.1** and **4.7.2**)

4.7.4 Half of specimens for bending tests (according to a four-point bending scheme) and short beam tests shall be tested under short-term loading, the other half - under repeated static loading as per the standard or procedure approved by the Register, at 10^4 cycles of 50 % loading level of the average breaking load determined from static test results. Where the specimen has not failed as a result of repeated static tests, it shall be tested under short-term loading until failure occurs.

4.8 Closed box section framing members and their testing procedure.

4.8.1 Closed box section framing members consist of an effective flange, section's core, its sheathing tapered into flanges, and additional elements such as brackets/knees, brackets and straps mounted for stiffening the section where concentrated loads are applied during bending tests of members (refer to Fig. 4.8).

The effective flange and sheathing of the section are made of the tested FRP based on the same reinforcement material of the specified reinforcement scheme (refer to **2.1** and **2.2**), except for biaxial diagonal fabrics and mats, or on two tested FRPs of different reinforcement materials. In the latter case, percentage of these FRPs relative to one another shall be specified in the detailed design and construction documentation for manufacture of these members. Polyvinylchloride foam of PVC type or PUR foam of 80 - 150 kg/m^3 density, which shall be recognized by the Register, are used as a core.

Members have the core depth of 150 mm and effective flange thickness of 12 mm (refer to Fig. 4.8).

4.8.2 Members are manufactured according to the adopted procedure (refer to **2.6**). In this case, manufacture and matting-in of brackets, matting-on of straps in places of stiffening shall be performed by the contact moulding technique.

4.8.3 Members shall have the 800 mm length for short beam tests according to a three-point bending scheme, on the 700 mm span, and manufactured according to the procedure approved by the Register. The load shall be applied to members from the effective flange side.

Six members shall be manufactured. Half of members shall be tested under short-term loading until failure, the other half shall be subject to repeated static tests at 104 cycles, at the maximum load value per cycle equal to 50 % of the average breaking load determined from static test results.

4.9 Butt joint assembly and its test procedure.

4.9.1 The butt joint assembly consists of two laminates 10 mm thick connected with two-side straps, without edge preparation (refer to Fig.4.9). Laminates and connecting straps shall be made of the certified FR based on the same reinforcement material, of the specified reinforcement scheme (refer to **2.1** and **2.2**), except for biaxial diagonal fabrics and mats.

4.9.2 Manufacture of laminates and matting-on of connecting straps shall be performed by the adopted procedure of manufacture - either infusion or contact moulding techniques (refer to **2.6**). In such case, depending on the procedure recognized by the Register, laminates may be manufactured using the infusion technique, and connecting straps may be matted on by the contact moulding technique, and vice versa.

4.9.3 Six butt joint assemblies shall be made to perform tensile testing according to the procedure approved by the Register. Half of assembly specimens shall be tested under short-term loading until failure, the other half shall be subject to repeated static tests at 10^4 cycles, at the maximum load value per cycle equal to 50 % of the average breaking load determined from static test results. Where the specimen does not failed as a result of repeated static tests, it shall be tested under short-term load until failure to determine the residual strength.

4.10 T-joint assembly and its test procedure.

4.10.1 T-joint assembly consists of two laminates 10 mm thick connected with moulding-in angles (refer to Fig. 4.10). Laminates and moulding-in angles shall be made of the tested FRP based on the same reinforcement material, of the specified reinforcement scheme (refer to **2.1** and **2.2**), except for biaxial diagonal fabrics and mats.

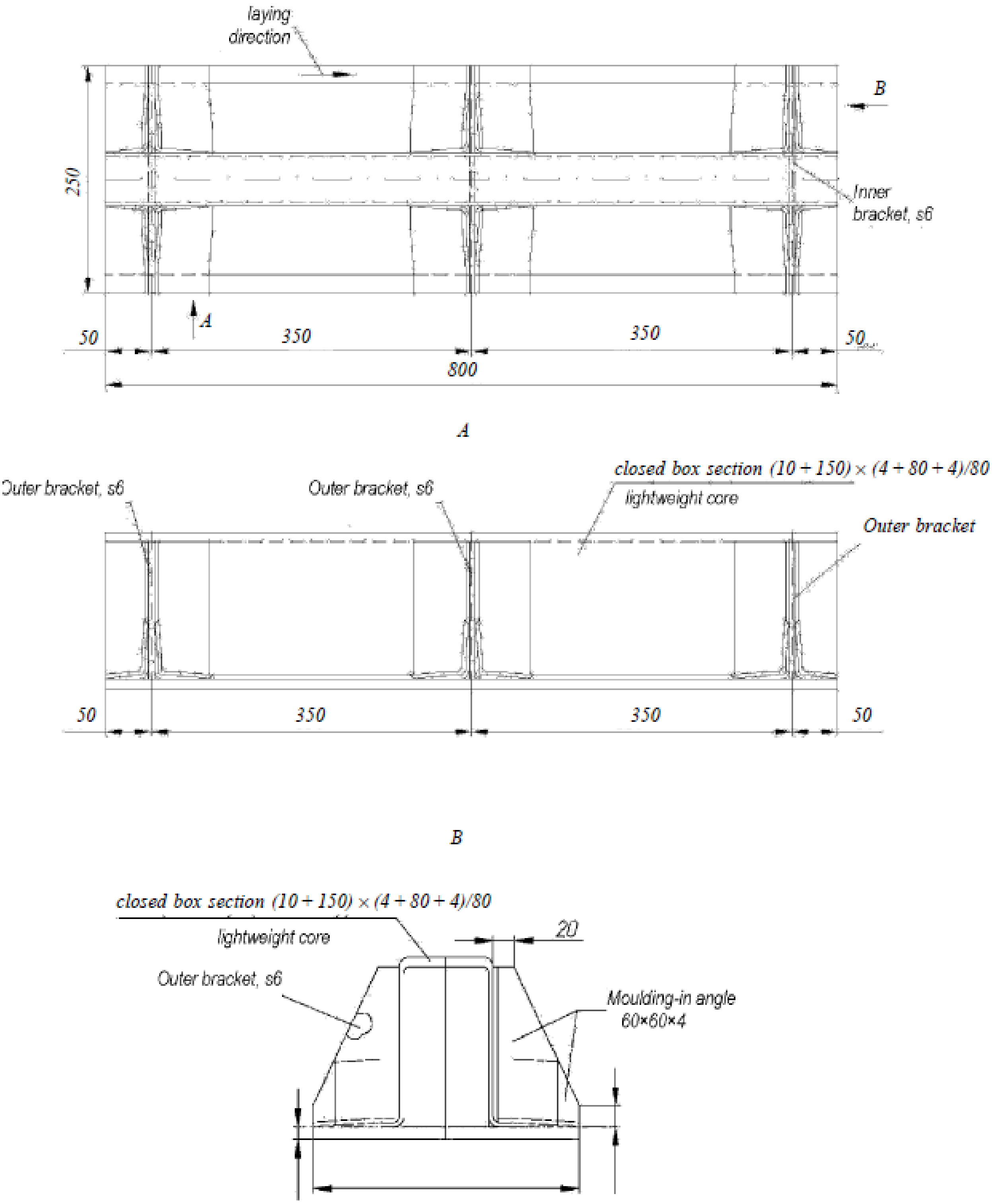


Fig. 4.8 General view of the closed box section framing members for short beam tests
10 - face plate thickness, in mm; *150* - depth of lightweight core, in mm,
4 - thickness of section's sheathing webs, in mm;
80 - core width, in mm; 80 as a denominator - core density, in kg/m^3

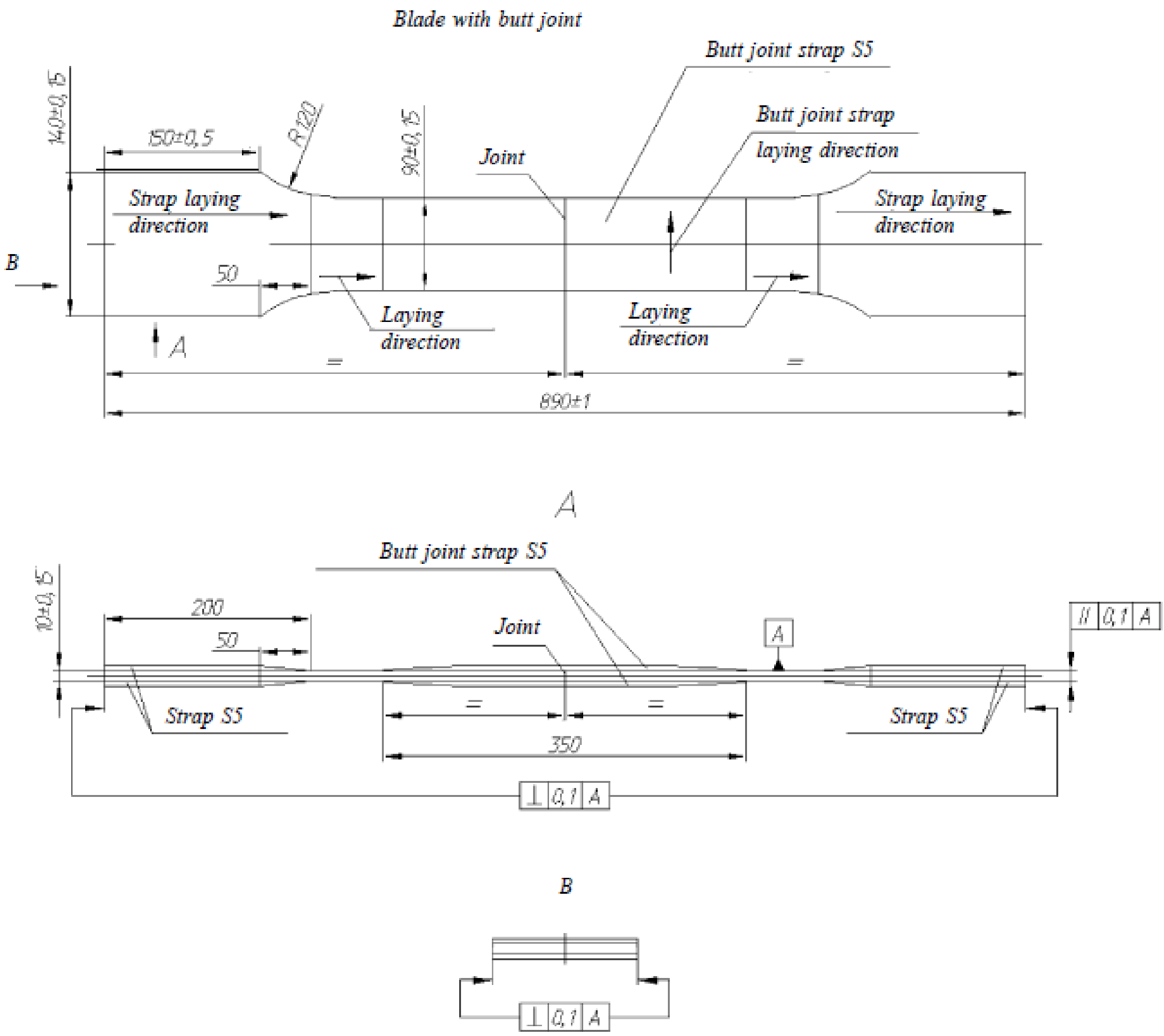


Fig. 4.9 Butt joint assembly for tensile testing

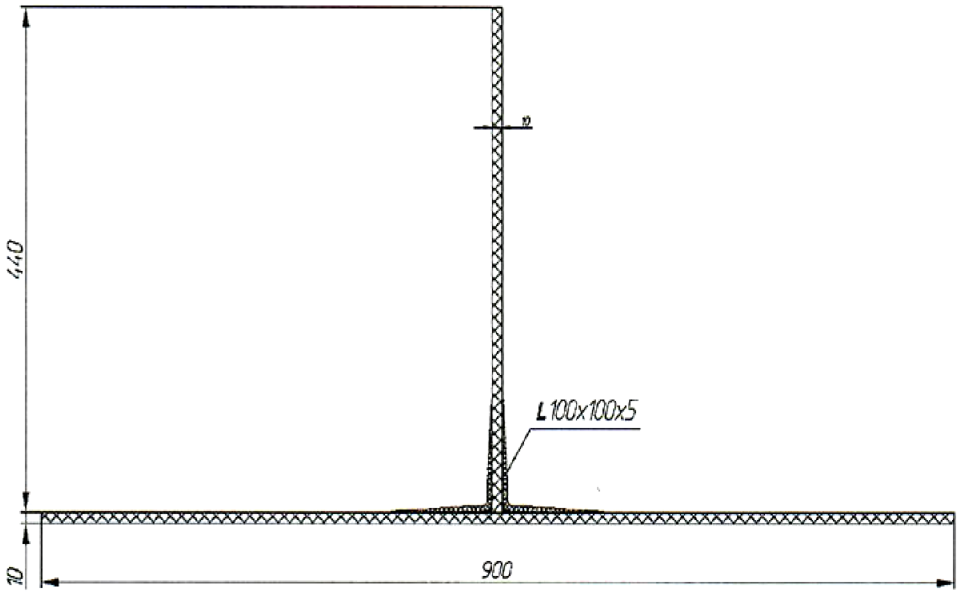


Fig. 4.10 T-joint assembly for uniform separation test

4.10.2 Selection of a laminate manufacture technique and moulding-in of angles shall be performed similarly to the procedure for butt joint assembly (refer to **4.9.2**).

4.10.3 Six T-joint assemblies shall be made for the purpose of uniform separation test according to the procedure approved by the Register (refer to Fig. 4.10). Half of specimens shall be tested under short-term loading until failure, the other half shall be subject to repeated static tests at 10^4 cycles, at the maximum load value per cycle equaling to 50 % of the average breaking load determined from static test results.

Where the specimen has nor failed as a result of repeated static tests, it shall be tested under short-term load util failure to determine the residual strength.

5 INTRODUCTION OF AMENDMENTS INTO THE TEST PROGRAM

5.1 Proposals on amendments to be introduced into the test program are submitted by designers of FRP ships, firms (manufacturers) engaged in manufacture of structures and products using these materials, and by other interested organizations, with the technical background that such amendments are necessary.

5.2 Proposed amendments shall be reviewed by the Register, and if approved, the test program shall be amended accordingly.

TEST REPORT SAMPLE

1 GENERAL

1.1 Item under test ______________________________
(item description (name) and characteristics)

1.2 Type of test ______________________________
(designation of the testing method with reference to the documents, in accordance with which the test has been conducted)

1.3 Ground for testing ______________________________
(contract No., name and address of the customer)

1.4 The test was attended by ______________________________
(full names and positions of the customer's representatives or official observers of the authorized body)

1.5 Date of delivery ______________________________

1.6 Test period ______________________________
(test dates)

1.7 Test location ______________________________
(name and address of the testing laboratory)

1.8 Test condition ______________________________
(environmental conditions)

2 TESTING AND MEASURING EQUIPMENT

2.1 Testing equipment ______________________________
(list of the testing equipment used, last certification date, certificate No. and validity periods)

2.2 Measuring equipment ______________________________
(list of measuring equipment used, their metrological performance, last calibration (verification) dates,
____
certificate Nos. (calibration certificates) and validity periods)

3 DOCUMENTATION

List of normative and technical documentation used (performance specification, test program, test and measurement procedures, standards, technical specifications, etc.) shall be provided).

4 TEST PROCEDURE (upon customer's request)

Brief description of the test procedure, including test conditions (temperature, humidity, etc.) shall be provided.

5 DEVIATIONS ______________________________

(list of deviations from the test and measurement procedures)

6 SAMPLES ______________________________

(works performed shall be listed)

7 TEST RESULTS

Test results shall be provided in a form complying with the consumer's requirements, with indication of allowable tolerances.

8 ВИСНОВОК

Test results shall be provided in a form complying with the consumer's requirements, with indication of allowable tolerances.

9 APPENDIX

Initial data of test results processing, and other relevant information shall be provided.

Notes: 1. Upon the customer's request, the information to be provided in the Sections may be extended.
2. Test results are valid only for the items tested.