PART XVI. HULL STRUCTURE AND STRENGTH OF GLASS–REINFORCED PLASTIC SHIPS AND BOATS

1. GENERAL

1.1 APPLICATION

1.1.1 The requirements of the present Part of the Rules apply to:

.1 displacement ships of glass-reinforced plastic from 12 to 30 m in lengthhaving the speed $\upsilon \le 3{,}05L^{1/2}$ knots, and the dimension ratio with foll0wing limits:

length to depth ratio
L/D = 6…10;
breadth to depth ratio
B/D = 2…2,5;
length to breadth ration
L/B = 3…5.

Where the dimension ratios are beyond the specified limits, the structure and scantlings of the hull are subject to special consideration by the Register;

.2 lifeboats from 4.5 to 12 m in length.

1.1.2 The requirements of the present Part are also applicable to :

.1 displacement ships from (5) up to 12 m and those over 30 m in length , the structure of ships over 30 m inlength being subject to special consideration by the Register;

.2 hydrogliders,air-cushion vehicles and hydrofoil ships, the structure of such ships being subject to special consideration by the Register.

1.2 DEFINITIONS AND EXPLANATIOS

The definitions and explanations relating to the general terminology of Rules are given in the General Provisions on technical supervision activities and 1.1 of Part I "Classification" of Rules for classification and construction of vessels[1].

The definitions of dimensions of ships comply with the provisions of Part II "Hul ".

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

Single-skin construction is a construction comprising a single-skin laminate stiffened by framing members.

Double-skin construction is a construction comprising two single-skin laminates interonnected by framing members.

Sandwich construction is a construction comprising two single-skin laminates interconnected by a core of plastic foam, honeycomb structure, etc.

1.3 GENERAL

1.3.1 The requirements of the present Part apply to:

.1 hulls moulded either as a whole or in two
halves (starboard and portside), which are jointed together along the keel, stem and sternframe;

.2 ships with the following connections of hull sections:

shell skin along the centre line;
deck to side;
superstructurss and deckhouses to deck;

.3 ships with shell, deck and strength bulkheads of single-skin construction;

.4 ships with deckhouse and superstructure sides and ends of single-skin and sandwich construction;

.5 lifeboat hulls of single-skin, double-skin and sandwich construction.

1.3.2 The scantlings of structural members of sandwich and double-skin hull structures of ships as well as application of composite structures are in each case subject to special consideration by the Register unless special requirements are given in the present Part.

1.3.3 On drawings of glass-reinforced plastic structures the thickness of laminates, in mm, as well as the number of reinforcing material layers and the total mass of reinforcement in kg per square metre of the laminate area shall be shown.

1.3.4 The hull moulding technique is subject to approval by the Register in each case.

1.3.5 Types of structures other than those stated in the present Part may be approved by the Register, provided the requirements of 1.3.4.1 General Provisions on technical supervision activities are observed.

1.4 SCOPE OF SURVEYS

1.4.1 The general provisions for survey of the hull are set forth in General Provisions on Technical Supervision Activities.

1.4.2 After consideration and approval of the technical design of a ship as a whole, the following items shall undergo survey by the Register during the hull construction:

.1 basic materials for moulding hull structures;

.2 condition and microclimate of working shops;

.3 equipment to be used in moulding hull structures;

.4 moulding of shell assemblies with relevant framing;

.5 moulding of deck assemblies;

.6 moulding of bulkheads;

.7 moulding of tanks;

.8 moulding of superstructures and deckhouses;

.9 moulding of seatings for main machinery as well as for other machinery and arrangements subject to survey by the Register;

.10 moulding of coamings, companions and similar guards for openings in hull;

.11 stems and sternframes, shaft brackets.

1.4.3 Prior to making structures listed in 1.4.2 the Register must be submitted for approval with the technical documentation on the hull to the extent prescribed in 4.2.3 of Part I "Classification".

1.4.4 During construction the hull structures mentioned in 1.4.2 are subject to survey as regards the compliance with the requirements of Part XIII "Materials" and with the technical documentation approved.

1.4.5 The procedure and results of tests for rigidity and strength of completed structures are in each case subject to special consideration by the Register. The control systems, organization and quality of production is subject to control

1.4.6 At the request of the Register manufacturer must fix the deficiencies before the start of production. Register must ensure that the manufacturer has everything needed to build vessels according to the requirements of the Rules.

1.5 MATERIALS

1.5.1 In the present Part the use of glass-reinforced plastics of the types given in Appendix 1 is specified.

1.5.2 In addition to the plastics mentioned in Appendix 1, glass-reinforced plastics containing reinforcements and binders in alternative combinations as well as with alternative reinforcement schemes may be used, provided that detailed information on their mechanical properties, which is submitted, is approved by the Register.

1.5.3 Detailed requirements for materials used are set forth in Sec. 7.

1.6 FRAMING SYSTEM AND SPACING

1.6.1 The present Part deals with the transverse system of framing of ship's hull.

In the case of longitudinal or combined system of framing the hull structure design and scantlings are subject to special consideration by the Register.

1.6.2 For standard spacings of transverse framing, refer to Table **1.6.2.** Where the spacing adopted is different from that given in Table 1.6.2, the thicknesses and scantlings of framing members are recalculated in accordance with the requirements of 2.2, 2.3 and 2.5.

1.6.3 The frame spacing in the fore peak shall not exceed:

300 mm with *L* from 12 (5) to 15 m;

350 mm with *L* over 15 and below 25 m;

400 mm with *L* from 25 to 30 m (inclusive).

Table 1.6.2. **Average Spacing**

Ship's length, m	Spacing, мм
12 (5)...15	350
15 < *L* < 25	400
25...30	450

1.6.4 The spacing of stiffeners of the watertight transverse bulkheads is assumed to be equal to the spacing of the hull framing.

For the fore peak bulkhead the spacing of stiffeners is assumed to be equal to the spacing at the fore end.

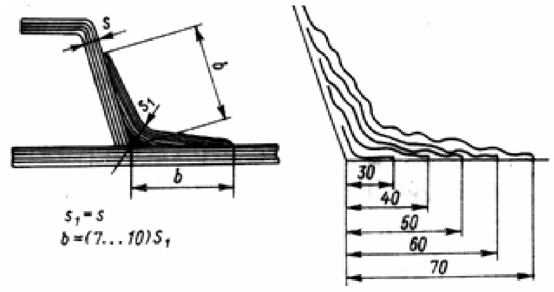
For the superstructure and deckhouse sides the spacing shall be equal to that of the single-skin construction hull.

1.7 PREFORMING AND CONNECTIONS

1.7.1 The connection of longitudinal and transverse framing members is made by means of matting-in angles (wet angles), which are formed in situ and in which glass mats are used as reinforcement. By way of exception glass fabric of satin or plain weave may be used The use of glass roving cloth is not permitted. The surfaces to be jointed shall be thoroughly cleaned prior to laying-up the matting-in connections

On agreement with the Register, the matting-in angles may be moulded by spraying.

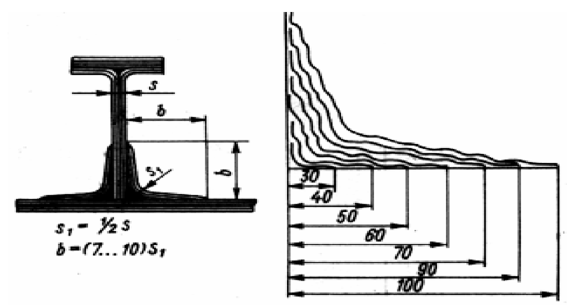
1.7.2 The thickness of the matting-in angle shall be equal to half the thickness of the stiffener web in the case of tee-shaped sections and to a full thickness of the stiffener web in the case of closed box sections. The width of the matting-in angle flange and the diagram of laying-up the reinforcement shall be in accordance with Figs. 1.7.2-1 and 1.7.2-2. In any case, the width of the matting-in angle flanges shall not be less than 30 mm for stiffeners and 50 mm for transverse watertight bulkheads.



a ***b***

Fig.1.7.2-1:
a **- scantling of matting-in connection;*b*** **- diagram of laying-up layers of glass mat or glass fabric strips**

s_1, мм	3	4	5	6	8	10
b, мм	30	30	40	50	60	70



a ***b***

Fig.1.7.2-2**:** ***a*** **- scantlings of matting-in connection;** ***b*** **- diagram of laying-up layers of glass mat or glass fabric strips**

s_1, мм	3	4	5	6	8	10	12	14
b, мм	30	30	40	50	60	70	90	100

1.7.3 The thickness of matting-in angles of bulkheads, platforms, superstructures and deckhouse sides and ends shall be equal to that of the bulkhead sheathing, platform planking, superstructure or deckhouse side and end, respectively

1.7.4 For bolted connections the

following conditions shall be met:

.1 bolting shall not be less than three bolt diameters away from the edge of the laminate;

.2 the bolt diameter shall be equal to the thickness of the thickest laminate to be connected;

.3 bolts shall not be closer spaced than four diameters apart;

.4 parts of the bolted connections shall be protected with anticorrosive coating or made of corrosion-resistant materials;

.5 washers of not less than 2,5 times the bolt diameter shall be fitted under the bolt head and nut, the washer thickness being 0,1 times the bolt diameter, but not less than 1,5 mm.

1.7.5 Connections made with the use of riveting shall be specially considered by the Register.

1.7.6 Non-essential or low-stresses connections are permitted to be made by means of matting-in butts (Fig. 1.7.6 and table 1.7.6). The contact surfaces shall be thoroughly cleaned prior to the laying-up of strap layers.

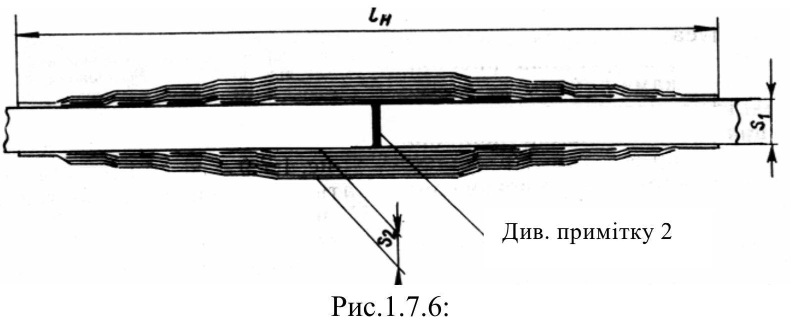


Рис.1.7.6:
$L_н$ – **width of the matted-on strap** ($L_н$ = 200 + 15s_1, mm); s_1 – **thickness of the matted-on strap**
s_2 – **thickness of the laminates being connected;** (s_2 = 0,5s_1)

Table 1.7.6.

s_1, mm	s_2, mm	Glass fabric layer numbers													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
		Width of the matted-on strap, mm													
6	3	100	150	150	200	200	250	300	–	–	–	–	–	–	–
8	4	100	100	150	150	150	200	250	250	300	–	–	–	–	–
10	3	100	100	150	150	200	200	250	250	300	300	–	–	–	–
14	7	100	100	150	150	200	200	250	250	300	300	330	350	400	400

Note:: 1. The glass fabric warp shall be oriented perpendicularly to the butts in the laminates.
2. The space between the laminates shall be 1 to 2 mm.
3. The strap material is a laminate on the basis of glass fabric of satin or plain weave. Glass mats are not permitted.

1.7.7 Where the hull is moulded in two (starboard and port) halves, they shall be connected along the centre line by means of matted-on straps (Fig. 1.7.7). The straps shall be moulded of glass-reinforced plastics of type III or IV for any length of the hull. The thickness *s* of each strap shall be 0,7 times the keel plate thickness s_k (refer to Table 2.2.1). The entire width of the matted-on straps shall not be less than 200 mm + 15$S_к$.

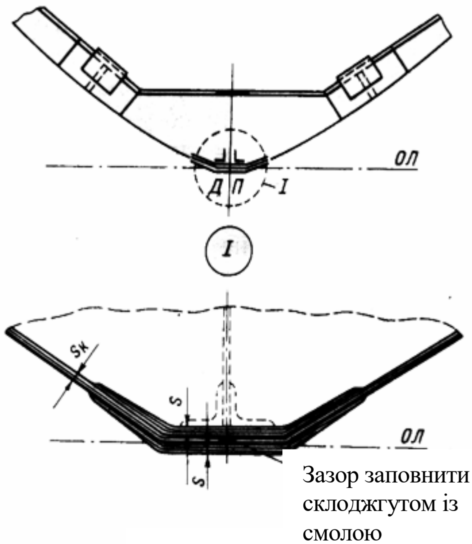


Fig.1.7.7

1.7.8 The thickness of the matted-on straps shall reduce towards the edges down to the thickness of one layer of glass fabric. This reduction in thickness is achieved by gradual increase in the width of the laid up tapes, the first layer based on a 100 mm tape (50 mm on each side) and subsequent layers formed by tapes 140 mm, 180 mm and so on wide laid up **ii** the number of one or from two to three at a time

1.7.9 Deck-to-side connection shall be made by means of inner and outer matting-in angles (straps) in accordance with Fig. 1.7.9. The angles shall be moulded of glass-reinforced plastics of type III or IV. The width of both flanges of the matting-in angles *(2b)* shall not be less than 200 mm+15 S_{sh} (where S_{sh} – **is** the shearstrake thickness). The thickness of the matting-in angle shall be taken equal to 0,7 S_{sh}.

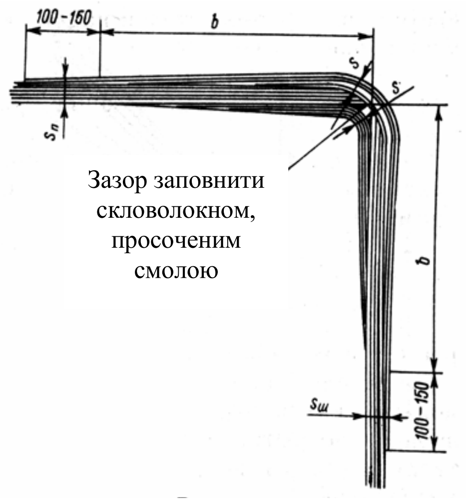


Рис.1.7.9

S_{sh} – **sheerstrake thickness**; S_d – **deck laminate thickness**; S – **thickness of the matting-in single angle**; b – **half width of flanges of the matting-in angle**.

Note. **Additional layer of fabric shall be laid onto the outer surface of the deck and side shell laminate to overlap the matting-in angle for 100 to 150 mm on each side, the direction of fabric warp being along the hull.**

1.7.10 The layers in the matting-in angles shall be distributed as specified in 1.7.2.

2. HULL AND SUPERSTRUCTURES

2.1 GENERAL

2.1.1 The thickness of the shell and deck laminates as well as of the bulkhead and other laminates shall be determinated from Figs. 2.1.1-1, 2.1.1-2 and 2.1.1-3 depending on the permissible bending moment $m_{доп}$, acting on a strip 1 cm wide, which is given in Table 2.2.1.

.1 The thickness of laminates with the glass content as specified in line No. 1 of Tables 1 to 6 presented **i**i Appendix 2 shall be determined from Fig. 2.1.1-1.

.2 The thickness of laminates with the glass content as specified in lines Nos. 2 and 3 of the above-mentioned Tables shall be determined from Figs. 2.1.1-2 and 2.1.1-3.

.3 The reinforcement schemes given in lines Nos. 1 and 2 of Tables 1, 2, 5 and 6 of Appendix 2 are used for moulding sides and bottom shell, decks, divisions, etc.

.4 The reinforcement scheme given in line No. 3 of Tables 3 and 6 and in line 2 of Table 1 is used for framing members, which shall be moulded and squeezed in special devices during manufacture.

2.1.2 The present Part provides for hull framing members to be made of closed box sections of glass-reinforced plastics, type I_2, and of T-shaped sections with a face plate of glass-reinforced plastics, type III_3, and the web of glass-reinforced plastics, type I_2.

2.1.3 The scantlings of framing members shall be determined from Figs. 2.1.3-1, 2.1.3-2 and 2.1.3-3 depending on the section modulus of stiffeners with The scantlings of T-shaped stiffeners are deter-
the associated face plate.
mined from Figs. 2.1.3-2 and 2.1.3-3, Fig. 2.1.3-3

The scantlings of stiffeners of closed box section being the scaled-up original of Fig. 2.1.3-2. are determined from Fig. 2.1.3-1.

The scantlings of bottom stiffeners (centre girder and side girders) shall be determined in accordance with 2.3.5.

The recommended structural types of closed-box and T-shaped sections are shown in Figs. 2.1.3-4 and 2.1.3-5.

2.1.4 The scantlings of the framing members are permitted to be determined according to Appendix 3.

2.1.5 The width of the associated plate is taken to be 1/6 of the stiffener span, provided that the panel is of glass-reinforced plastics, types I, V, VI, VII and VIII, or 1/10 of the stiffener span, provided that the panel is of glass-reinforced plastics, type II, but ii shall not be more than the distance between adjacent parallel stiffeners.

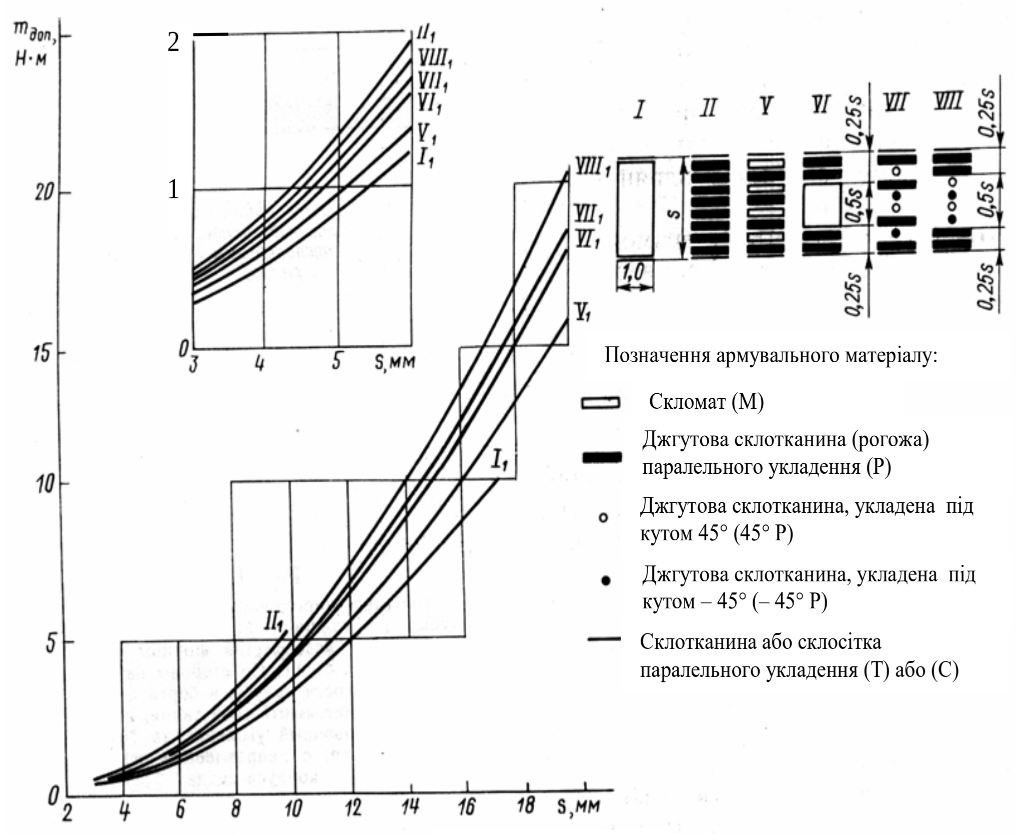

mдоп, Н·м
S, мм
II₁
VIII₁
VII₁
VI₁
V₁
I₁
I
II
V
VI
VII
VIII
0,25s
0,5s
s
1,0
Позначення армувального матеріалу:
Скломат (М)
Джгутова склотканина (рогожа) паралельного укладення (Р)
Джгутова склотканина, укладена під кутом 45° (45° Р)
Джгутова склотканина, укладена під кутом – 45° (– 45° Р)
Склотканина або склосітка паралельного укладення (Т) або (С)

Fig.2.1.1-1

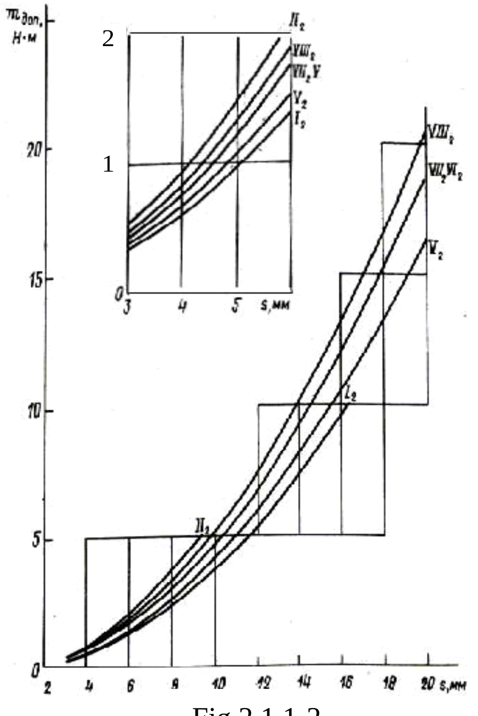


Fig.2.1.1-2

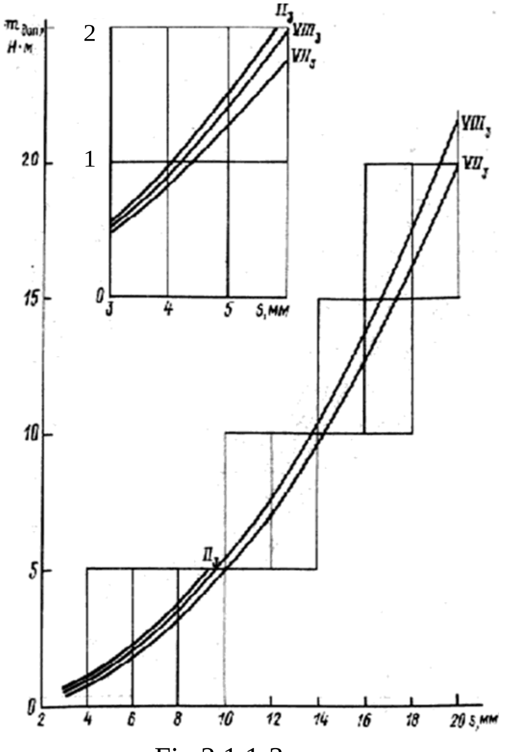


Fig.2.1.1-3

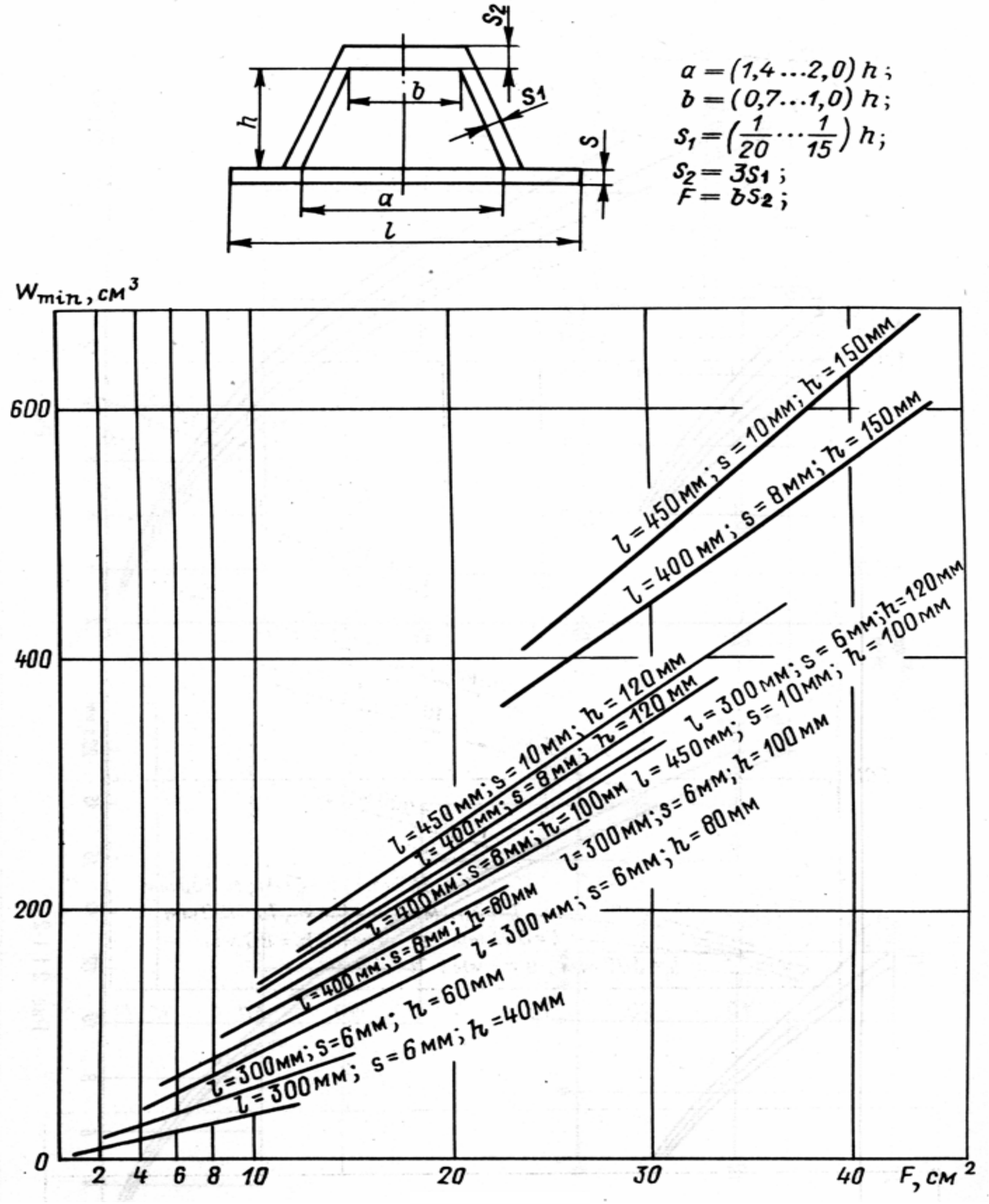


Fig.2.1.3-1

Note: Stiffener with associated plate of glass plastic type I_2.

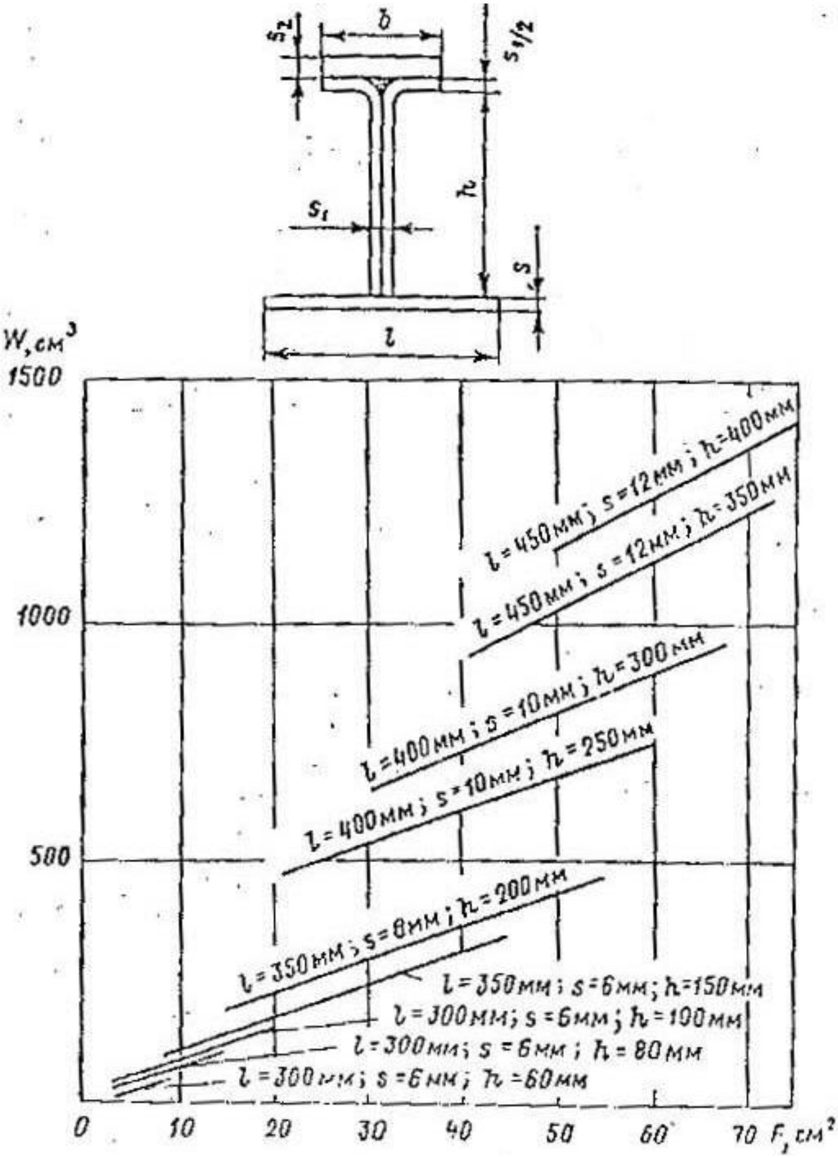


Fig.2.1.3-2

b	s_1	s_2
(0,67…0,77)h	(0,1…0,05)h	(2...3)s_1
$F = bs_2$		

Note: 1. Face plate of glass plastic type III$_3$, the associated plate of glass plastic type VII$_2$, with $\cong 0{,}7E_{III}$ **(where *E* is the modulus of elasticity).**

2. Web of glass plastic type I$_2$

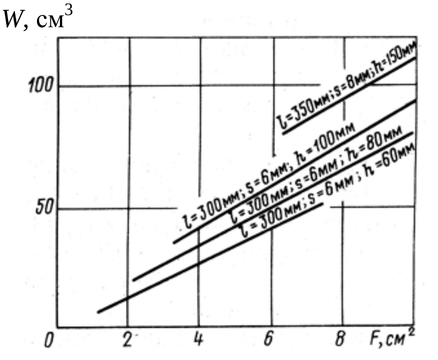


Fig.2.1.3-3

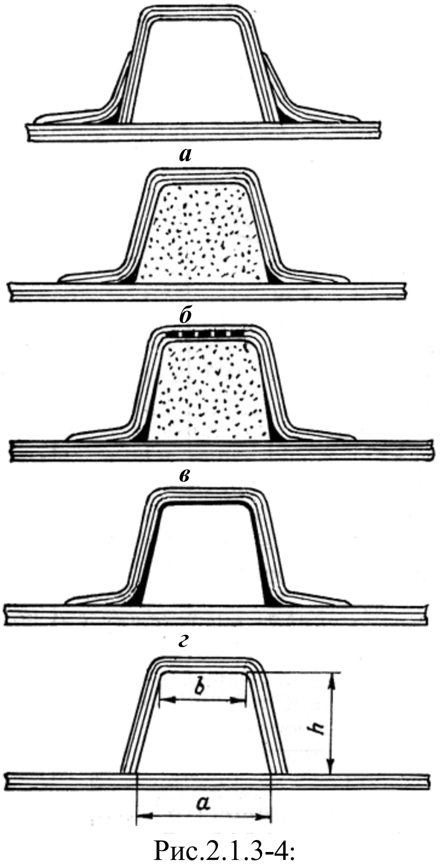


Рис.2.1.3-4:

a - pre-moulded stiffener; *b* - stiffener moulded in situ, with core of foamed plastic; *c* - ditto, with face plate reinforced; *d* - stiffener moulded in situ over a former of sheet aluminium

Notes: 1. Reinforcement in face on the basis of glass fabric or glass rovings.

2. These sketches do not indicate the relations for longitudinal framing members.

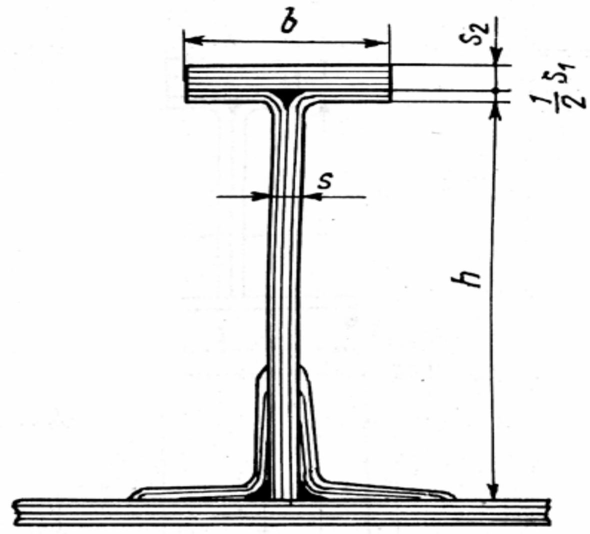


Fig.2.1.3-5

B	s_1	s_2
(0,67…0,77)*h*	(0,1…0,05)*h*	(2...3)s_1

Note: The warp of glass fabric in face plate shall be directed along the stiffener.

2.2 SIDE AND BOTTOM SHELL

2.2.1 The thickness of the side and bottom shell shall be determined from Figs. 2.1.1-1 and 2.1.1-2 depending on the permissible bending moment value given in Table 2.2.1.

2.2.2 The minimum side and bottom shell thickness shall not be less than:

.1 4 mm for sides and 5 mm for bottom in case of single-skin construction with reinforcement of any type;

.2 3 mm for sides and 4 mm for bottom in case of double-skin or sandwich construction.

2.2.3 Side and bottom shell is permitted to be moulded of glass-reinforced plastics of the following types:

I - for hulls from 12(5) to 15 m in length;

II - for hulls from (5) to (10) m in length;

V - for hulls from 12(5) to 30 m in length;

VII - for hulls from 12(10) to 30 m in length.

2.2.4 In the case of shell thickness between 3 and 6 mm provision shall be made for a 40 mm overlap of butts in reinforcements. Seams are formed without overlapping.

In the case of shell thickness of 6 mm and above the butts and seams in reinforcements need not be overlapped, the number of reinforcing material layers being not less than 8.

2.2.5 The butts and seams in each adjacent layer of the reinforcing material shall be spaced not closer than 100 mm apart.

Butts and seams are permitted to be coincident in one section after 6 layers at least.

2.2.6 Woven rovings in layers of the diagonal lay-up shall not have butts.

2.2.7 The thickness and width of the plate keel and sheerstrake shall be determined in accordance with Table **2.2**.1 (refer to Note 3).

2.2.8 The thickness of the stern laminates (transom included) shall not be less than that of the bottom laminates.

2.2.9 The thickness of the shell and sheerstrake laminates in way of the fore peak shall be taken equal to that of the midship portion.

2.2.10 The plate keel and sheerstrake shall be moulded by addition of reinforcing material layers, which shall be uniformly distributed between the shell basic layers and alternate with the latter.

The change in thickness shall be made in accordance with Table **2.2**.1 (refer to Note 5).

Table 2.2.1

Length of ship, m	**Spacing, mm**	m_{perm}, H·m		**Width, mm**	
		Bottom shell	**Side shell**	**Plate kee**	**Sheerstrake**
1	2	3	4	5	6
(5)	(350)	(1,4)	(0,8)	(400)	(300)
(7,5)	(350)	(2,0)	(1,3)	(475)	(400)
(10)	(350)	(3,1)	(2,0)	(550)	(475)
12	350	4,2	2,8	600	575
15	350/400	5,2/6,7	3,5/4,5	675	650
17,5	400	8,0	5,2	750	750
20	400	9,0	6,0	825	825
22,5	400	10,2	6,7	875	925
25	400/450	11,4/13,6	7,5/9,5	950	1000
27,5	450	14,8	10,3	1025	1100
30	450	16,0	11,0	1100	1200

N o t e s : 1 . Where the design spacing differs from that given in column 2 $m_{доп}$ shall be modified in the ratio of (actual spacing / Table spacing)

2. For intermediate ship lengths m_{perm} shall be determined by interpolation.

3.The thickness of the plate keel and sheerstrake is taken equal to 1,5 times the bottom shell thickness.

4. In column 5 the entire width of the plate keel is shown.

5. Reduction in thickness shall be made across the width of 50 mm for each 5 mm difference in thickness.

6. For ships of 15 and 25 m in length shown in the numerator is the smaller spacing and in the denominator - the greater spacing.

7. The following areas are considered as bottom shell:

in ships of hard chine form - from the keel line up to the bilge;

in ships of rounded chine form - from the keel line to1/3*D*.

2.3 BOTTOM FRAMING

2.3.1 Floors shall be fitted at each frame.

2.3.2 Floors of increased section modulus shall be fitted at all web frames. The depth of flooor of increased section modulus shall be taken equal to that of the centre girder and side girders, whichever is greater.

2.3.3 The scantlings of floors are taken in accordance with 2.1.2 depending on the section modulus given in Table 2.3.3.

Table 2.3.3.

Length of ship, m	Design load, кPa	Section modulus for floors of closed-box section, cm^3, for 400 mm spacing, with the span, m					
		0,50	0,75	1,00	1,50	2,00	2,50
(5,0)	(20,0)	(15)	(25)	(50)	(100)	–	–
(7,5)	(30,0)	(20)	(40)	(70)	(150)	(260)	–
(10,0)	(40,0)	(30)	(50)	(90)	(200)	(350)	–
12,0	25,0	15	30	60	130	220	350
15,0	30,0	20	40	70	150	270	420
17,5	35,0	25	50	80	180	310	490
20,0	38,0	30	60	90	200	350	560
22,5	43,0	35	70	100	230	400	630
25,0	47,0	–	80	110	250	440	690
27,5	51,0	–	–	120	280	490	760
30,0	55,0	–	–	–	300	530	830

N o t e s : 1. The section modulus shown in the Table are given for the spacing of 400 mm, for other spacings the section modulus shall be modified in proportion to the ratio of : spacing, mm/400.

2. Where T-shaped sections are used, the section modulus may be reduced by the factor of three.

3. The span is measured between the floor ends where the keel is omitted; from the keel to the floor end where the keel is omitted and the side girder is omitted; from the keel to the side girder or from the side girder to the floor end, whichever is greater.

4. For ships between 5 and 10 m in length, the design load is taken with account of water impact against the bottom likely to occur when the ship is dropped into water.

5. For ships over 10 m in length, the design load is taken equal to the maximum side depth obtained at $L:D$ = 6 + 0,5 m.

6. Where the design load differs considerably from that given in the Table, the section modulus may be reduced in proportion to the ratio of design load/tabulated load

2.3.4 The minimum thickness of floors shall be 2 mm in the case of closed-box sections and 4 mm in the case of T-shaped sections.

2.3.5 Where the half-breadth measured along the top edge of the floor is in excess of 0,75 m, a centre girder is required to be fitted. Where this value is in excess of 2,5 m, the fitting of one side girder on each side is required in addition to the centre girder.

The scantlings of the centre girder and side girders are given in Table 2.3.5.

2.3.6 The intersection of the side girders with floor shall be effected in accordance with Figs. 2.3.6-1 and 2.3.6-2 without the floors being cut.

The intersection of side girders with floors of increased section modulus shall be made by means of an edge cross-lap joint (refer to Fig. 2.4.6).

2.3.7 The depths of non-continuous longitudinals shall be reduced to the floor depth within at least three spacings at each longitudinal end.

2.3.8 In floors and side girders water courses shall be provided. The recommended structural design of a water course is shown in Fig. 2.3.8.

2.3.9 The connection of the bottom framing to the side framing may be effected by means of matting-in or matting-on connections.

Table 2.3.5.

Length of ship,m	Spacing, mm	Centre girder, mm			Side girder, mm		
		Height, mm	Thickness, mm	Section of face plate, mm^2	Height, mm	Thickness, mm	Section of face plate, mm^2
(5,0)	(350)	(150)	(8)	(60×12)	–	–	–

(7,5)	(350)	(180)	(9)	(70×14)	–	–	–
(10,0)	(350)	(210)	(10)	(80×15)	–	–	–
12,0	350	240	11	90×15	–	–	–
15,0	350	270	12	100×15	200	10	80×15
17,5	400	300	13	110×16	225	11	90×15
20,0	400	330	14	120×18	250	12	100×15
22,5	400	370	15	130×20	275	13	110×16
25,0	400	410	16	140×22	300	14	110×16
27,5	450	440	17	150×24	325	15	120×18
30,0	450	470	18	160×26	350	16	130×20

Note:: 1. The scantlings shown in the Table are given for a T-shaped section with the face plate of glass-reinforced plastic, type III3, and the web of glass-reinforced plastic, types I2, V2, VII2.

2. Where closed-box sections of glass-reinforced plastic, type I_2, are used, the section moduli shall be increased by the factor of three.

3. The scantlings of longitudinal framing members are given for compartments, which length amounts to 30 per cent of the ship's length for ships between 12(5) and 20 m in length, and to 20 per cent for ships between 20 and 30 m in length. In the case of compartments of greater lengths the scantlings of the longitudinal framing members shall be considered specially.

4. Where the actual spacing differs from that shown in the Table, the scantlings of the centre girder and side girders shall not be modified.

5. For intermediate ship lengths the section modulus is determined by interpolation.

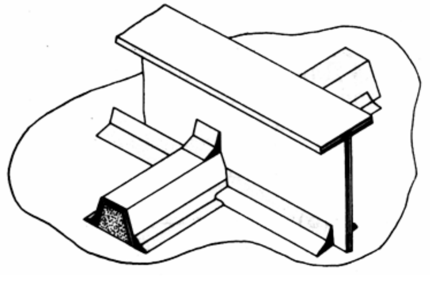


Fig. 2.3.6-1

Note. The framing member, which is formed the first, shall not be cut at a deep member.

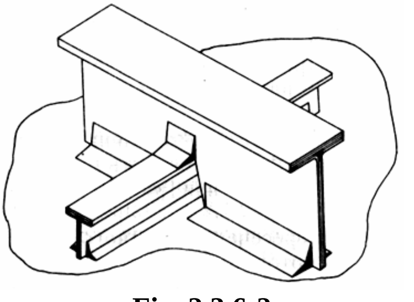
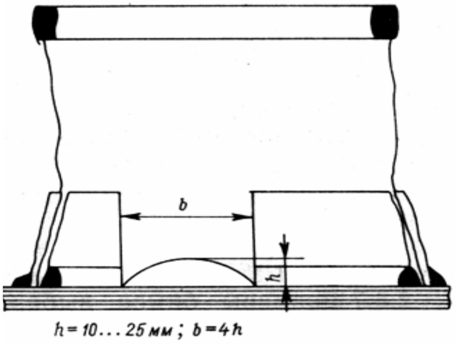


Fig. 2.3.6-2

N o te . The framing member, which is formed the first, shall not be cut at a deep member.



h=10...25Mu;b-4h

Fig. 2.3.8

N o te s .. The hole is cut at 1/4 of the spacing distance from the intersection with a floor.

2.4 SIDE FRAMING

2.4.1 The scantlings of frames shall be taken in accordance with 2.1.2 depending on the section modulus given in Table 2.4.1.

Table 2.4.1.

Span, m	Section modulus, cm³					
	Closed-box section, with spacing, mm			T-shaped section, with spacing, mm		
	350	400	450	350	400	450
1,0	47	54	61	12	18	20
1,2	76	87	98	29	29	33
1,4	107	128	138	35	41	46
1,6	147	159	180	47	53	59
1,8	200	228	256	70	76	85
2,0	290	330	370	93	110	123
2,2	369	420	470	123	140	157
2,4	500	570	640	150	189	210

Note. Where a side stringer is fitted, the section modulus of the frame shall be taken equal to 1,5 times the section modulus determined from the Table for a span measured from the deck to the side stringer or from the side stringer to the floor, whichever is greater.

2.4.2 The distance between adjacent bulkheads and web frames shall not exceed 6 spacings.

2.4.3 The section modulus of a web frame shall not be less than 5 times the frame section modulus.

2.4.4 Where the frame span is in excess of 2,4 m, a side stringer shall be fitted.

2.4.5 The section modulus of a side stringer shall be equal to that of a web frame.

2.4.6 The intersection of a web frame and a side stringer shall be effected by means of an edge cross lap joint only (Fig. 2.4.6).

2.4.7 The intersection of a side stringer and a frame shall be made as shown in Figs. 2.3.6-1 and 2.3.6-2 without cutting the
frame.

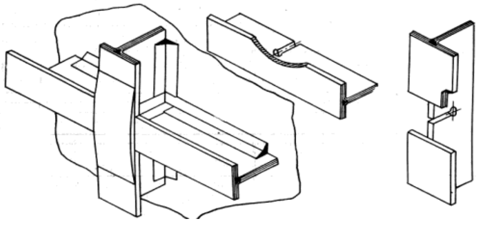


Fig. 2.4.6

Notes: 1. Deep members are jointed by means of an edge cross lap.

2. The length of the outer strap shall not be more than three widths of the flange of longitudinal framing member. A 20 mm overlap in adjacent layers shall be provided. The strap thickness shall be equal to that of the flange of transverse framing member.

2.5 DECKS AND DECK FRAMING

2.5.1 Upper deck laminate thickness shall be determined according to fig. 2.1.1-1 and2.1.1-2 depending on the allowable bending moment, set forth in Table 2.5.1.

2.5.2 The minimum deck laminate thickness shall be 4 mm

2.5.3 The thickness and width of a deck stringer shall be determined in accordance with table 2.5.1.

Table 2.5.1.

Length of ship, m	Spacing, mm	m_{perm}, N·м	Deck stringer width, mm
(5)	(350)	(0,8)	(300)
(7,5)	(350)	(1,3)	(400)
(10)	(350)	(2,0)	(475)
12	350	2,8	575
15	350/400	3,5/4,5	650
17,5	400	5,2	750
20	400	6,0	825

22,5	400	6,7	925
25	400/450	7,5/9,5	1000
27,5	450	10,3	1100
30	450	11,0	1200

N o t e s : 1. Where the spacing differs from the Table value, m_{perm} shall be modified in proportion to the ratio**:** actual spacing/table spacing

2. The deck stringer thickness is taken equal to the shearstrake thickness (ref. Table 2.2.1).

3. For intermediate length of ships m_{perm} is dtermined by interpolation.

2.5.4 The deck is permitted to be constructed of glass-reinforced plastics of the following types:

I-for hulls from 12(5) to 15 m in length;

VI - for hulls from 12(5) to 30 m in length;

VIII - for hulls from 12(10) to 30 m in length.

Decks of ships between (5) and (10) m in length may be constructed of glass-reinforced plastic of type II.

2.5.5 The reinforcing material shall be laid up in accordance with the requirements of 2.2.4 to 2.2.6.

2.5.6 Areas, which are subject to intense wear, shall be increased in thickness by means of straps not less than 3 mm thick, unless the deck in these areas has a special protective coating.

2.5.7 The scantlings of beams are taken in accordance with the requirements of 2.1.2 depending on the section modulus given in Table 2.5.7.

2.5.8 Deep beams having the 5 times the bottom section modulus shall be fitted at every web frame.

2.5.9 The scantlings of the deck girders are taken according to 2.1.2 depending on the section modulus given in Table 2.5.9.

2.5.10 Intersection of deck framing members shall be made in accordance with Figs. 2.3.6-1, 2.3.6-2 and 2.4.6.

2.6 PILLARS

2.6.1 The present Rules provide for the fitting of tubular pillars manufactured of aluminium alloys. Alternaiive materials may be used for construction of pillars on agreement with the Register.

In any case, the pillar material shall be in compliance with the requirements of Part XIII "Materials".

2.6.2 The scantlings of pillars of aluminium alloys shall be taken according to Table **2.6.2.**

2.6.3 The pillars shall be connected to the framing by pillar heels made of aluminium alloys or steel and fastened to the framing by bolts.

Table 2.5.7.

Span of beam, m	**Section modulus, cm^3**					
	Closed-box section, with spacing, mm			**T-shaped section, with spacing, mm**		
	350	400	450	350	400	450
1,0	16	18	20	–	–	–
1,2	24	27	30	–	–	–
1,4	33	38	43	–	–	–
1,6	43	49	55	15	17	19
1,8	52	59	66	18	20	22
2.0	65	74	83	23	25	27
2,2	80	90	100	26	30	34

2,4	98	110	124	32	37	42

Note. The design span of the beam is measured between the ends of the beam brackets, from the bracket end to the deck girder or between the deck girders, whichever is greater.

Table 2.5.9.

Span of deck girder, m	Section modulus, cm^3, at supported deck breadth, m				
	1,0	1,25	1,50	1,75	2,0
1,8	95	120	140	165	190
2,0	120	150	180	210	240
2,2	140	175	210	250	280
2,4	170	210	250	300	340
2,6	200	250	300	350	400
2,8	230	290	345	400	460

Notes: 1. The section moduli are given for a T-shaped section. Where closed-box section is used, the Table section modulus shall be increased by the factor of three.

2. Deck girder span is the greatest of the deck girder spans measured between two supports (centres of pillars, bulkheads, end hatch beams).

TAble 2.6.2.

Supported area $l \times b$, m^2	Height of pillar, m						
	1,8	2,0	2,2	2,4	2,6	2,8	3,0
1,8	85/70	85/70	85/70	85/70	85/70	85/70	95/80
2,5	85/70	85/70	85/70	85/70	95/80	95/80	105/90
3,0	85/70	95/80	95/80	95/80	95/80	105/90	105/90
4,0	85/70	95/80	95/80	105/90	105/90	110/90	110/90
5,0	95/80	95/80	105/90	105/90	110/90	110/90	120/90
6,0	95/80	105/90	105/90	105/90	110/90	120/90	120/90

Notes: 1. Shown in the nominator and denominator are the outside and inside tube diameters, in mm, respectively.

2. / - distance between the centres of adjacent spans of a deck girder, in m; *b* - breadth of deck supported by deck girder, in m. м

2.7 BULKHEADS

2.7.1 The thickness of bulkhead laminates shall be determined from Figs. 2.1.1-1, 2.1.1-2 and 2.1.1-3 depending on the permissible bending moment values given in Table 2.7.1.

Table 2.7.1.

Overall height of bulkhead, m	m_{perm}, N·m, with spacing, mm			
	300	350	400	450
1,25	0,9	–	–	–
1,50	1,1	1,5	–	–
1,75	1,3	1,8	2,3	–
2,00	1,5	2,0	2,7	3,4
2,25	1,7	2,3	3,0	3,8
2,50	1,9	2,6	3,3	4,2
2,75	2,1	2,8	3,7	4,6
3,00	2,2	3,1	4,0	5,1
3,25	2,4	3,3	4,3	5,5
3,50	2,6	3,6	4,7	5,9
3,75	2,8	3,8	5,0	6,3
4,00	3,0	4,1	5,3	6,8
4,25	3,2	4,3	5,7	7,2
4,50	–	4,6	6,0	7,6
4,75	–	–	6,3	8,0
5,00	–	–	–	8,4

Notes: 1. m_{perm} is given for the bottom strake of the bulkhead panels.
2. The bulkhead thickness may be reduced in height, the bulkhead thickness at the upper deck shall not be less than half the bottom strake thickness.
3. The width of each strake shall be 0,7...1,0 m.
4. For bulkheads of intermediate height m_{pmrm} is determined by linear interpolation.

2.7.2 The minimum plate thickness of laminates for watertight bulkheads shall be 4 mm.

2.7.3 Bulkhead panels may be manufactured of glass-reinforced plastics type I_2, V_2 or VII_3.

2.7.4 The scantlings of bulkhead stiffeners are taken according to 2.1.2 depending on the section modulus given in Table 2.7.4.

2.7.5 The maximum span of the stiffeners shall not exceed 3 m. Where the bulkhead height exceeds 3 m, a horizontal girder with a section modulus of not less than 5 times the section modulus of the stiffener shall be fitted.

2.7.6 Where a horizontal girder is provided, a stiffener of the same section modulus as the horizontal girder shall be fitted at the centre line.

2.7.7 The design of openings in the bulkheads shall comply with the requirements of 2.10.

2.7.8 The longitudinals shall not be cut at bulkheads. The slots in the bulkheads for the longitudinals shall be 3 to 4 mm higher and wider than the longitudinals proper and after the installation of bulkheads shall be filled with glass rovings and covered with not less than 3 layers of glass fabric.

2.7.9 The horizontal girders of bulkheads shall be fitted in one plane with side stringers and inter-
connected by means of brackets, which arm length shall be equal to the web depth of the side stringer.

2.7.10 The bulkhead stiffeners supported by longi-tudinal framing members shall be connected thereto by means of straps and mattings-in.

2.7.11 The bulkhead stiffeners receiving support from the bottom or deck shall be interconnected with the nearest transverse member by means of short longitudinals, which depth shall be equal to the stiffener depth. The connection of these short longitudinals to stiffeners shall be effected in accordance with 2.7.9.

Table 2.7.4.

Span of stiffener, m	**Section modulus of bulkhead stiffener, cm^3**							
	Stiffener span from deck to bottom or horizontal girder, with spacing, mm				**Stiffener span from horizontal girder to bottom, with spacing, *mm***			
	300	350	400	450	300	350	400	450
1,25	15	18	20	23	20	25	30	35
1,50	25	29	33	37	35	40	45	50
1,75	40	45	50	55	55	60	70	80
2,00	55	63	70	80	75	85	100	110
2,25	75	85	95	105	105	115	135	150
2,50	100	110	125	140	140	155	175	200
2,75	130	145	165	185	180	200	230	260
3,00	160	185	210	240	225	260	300	335

Notes : 1. The section moduli are given for stiffeners of T-shaped section.

2. For stiffeners of closed-box section with the face plate reinforced with glass mats the table section modulus shall be increased by the factor of three.

2.8 TANKS

2.8.1 The thickness of the laminates for the tank boundary structures shall be determined from Figs. 2.1.1-1 to 2.1.1-3 depending on the value of permissible bending moment m_{perm} given in Table 2.7.1. In so doing, the distance up to the top of the air pipe shall be used in lieu of the full height of the bulkhead shown in Table 2.7.1 (refer also to 2.7.2).

2.8.2 The scantlings of tank framing members shall be determined in accordance with Table 2.8.2.

2.8.3 The thickness of the margin plate in way of the double bottom tanks shall be equal to the thickness of shell laminates in this area.

2.8.4 The sides and tops of tanks may be constructed of glass-reinforced plastics type I_2, II_2 or V_2.

2.8.5 Fuel tanks constructed of glass-reinforced plastics shall be provided with earthing arrangements for discharging static electricity approved by the Register.

2.8.6 The construction of tank manholes and covers shall ensure the watertightness of the tanks.

The recommended design of a manhole fitted in the crown of tank is shown in Fig.
2.8.6.

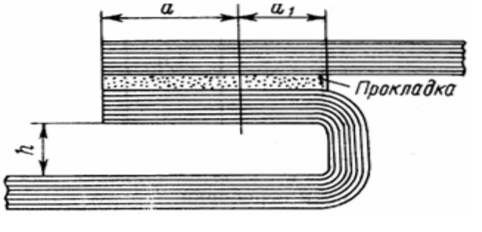


Fig.2.8.6:

a - minimum distance from the edge to bolts; a ≥ 3d (d is a diameter of bolt); h – depth of suit bolt or nut fitfing; $a_1 \geq 1{,}5d$.
Note: Bolts shall be spaced not more than 4d apart

2.8.7 The framing members situated inside the tanks shall be provided with water courses and air holes.

Table 2.8.2.

Head of water, m	**Section modulus of closed-box section, cm³, with 400 mm spacing and span, m**			
	0,50	0,75	1,00	1,25
2,00	10	25	50	70
2,50	15	30	60	85
3,00	20	40	70	100
3,50	25	45	80	120
4,00	30	50	90	140
4,50	35	55	100	160
5,00	40	65	110	175

Notes :: 1. In this table scantlings for a closed-box section are given. Material used is glass-reinforced plastic on the basis of glass mats type I_2. Where T-shaped section with a flange of glass-reinforced plastic, type III_3, is used, the sectton modulus may be reduced by the factor of three.
2. The section moduli in the Table are given for a 400 mm spacing. For other spacings the section modulus value shall be modified in proportion to the ratio of spacing, mm/400.
3. The design head of water is measured from the mid-length of stiffener or from the crown to the air pipe top.

4. The span of stiffener is measured from the bottom to the crown. The span of beams is measured between the sides or between the side and the collision bulkhead.

2.9 SUPERSTRUCTURES AND DECKHOUSES

2.9.1 The superstructure outer shell, which is the continuation of the ship's side plating, shall be integral with this plating. The laminate thickness of the superstructure shall be equal to that of the hull sides. The thickness reduction from the sheerstrake to the superstructure sides shall be in accordance with Table 2.2.1.

2.9.2 The sides of superstructures not extending to the hull sides and deckhouses may be of single-skin or sandwich construction. The material to be used for superstructure and deckhouse sides is glass-reinforced plastic on the basis of glass mats or woven rovings (type *h* or II_2). The framing members shall

2.9.3 The double--kin ccnstructioo oo fuperstructures and deckhouse is subject to special consideration by the Register.

2.9.4 In sandwich constructions the thickness of the foam plastic core shall be 30 to 50 mm. Thh average density of the foam plastic core for superstructure sides shall not be less than 100 and more than 200 kg/m^3.

2.9.5 The laminate thicknesses for the end bulkheads of superstructures as well as for all outer ends and sides of deckhouses shall be taken according to Table 2.9.5-1 for single-skin construction and Table 2.9.5-2 for sandwich construction.

Table 2.9.5-1. **Ends and sides of superstructures and deckhouses of single-skin construction, spacing 400 mm**

Length of ship, m	Plate thickness, mm
(5)	(4)
(10)	(6)
15	8
20	10
25	10
30	10

Notes: 1. For other spacings the thickness shall be modified in proportion to the ratio of spacing, mm/400, but it shall not be less than 4 mm.
2. Material used is glass-reinforced plastic on the basis of glass mat (type I_2).
3. For inttrmediate ship llngths tth ehickness shall be determined by linear interpolation.

2.9.6 The scantlings of stiffeners of the superstructure and deckhouse ends and sides are determined from Table 2.9.6-1 for single-skin construction and Table 2.9.6-2 for sandwich construction.

Table 2.9.5-2. **Ends and sides of superstructures and deckhouses of sandwich construction with core thickness 30 to 50 mm, spacing 800 mm**

Length of ship, m	Laminate thickness, mm	
	outer	inner
(5)	(3)	(2,5)
(10)	(4)	(3)
15	7	3,5
20	8	4
25	8	4
30	8	4

Note. For other spacings the outer laminate thickness shall be modified in proportion to the ratio of spacing, mm/800 but it shall not be less than 3 mm.

Table 2.9.6-1. **Stiffeners in superstructures and deckhouses of single-skin construction, spacing 400 mm**

Span of stiffener, m	Modulus of closed-box section, cm^3	Span of stiffener, m	Modulus of closed-box section, cm^3
1,0	18	1,8	58
1,2	26	2,0	72
1,4	35	2,2	87
1,6	46	2,4	105

Notes : 1. For other spacings the section modulus shall be modified in proportion to the ratio of: spacing, mm/400.
2.For intermediate values of stiffener spans the section modulus shall be determined by linear interpolation.

Table 2.9.6-2. **Stiffeners in superstructures and deckhouses of sandwich construction, spacing 800 mm**

Span of stiffener, m	Section modulus of closed-box section, cm^3	Span of stiffener, m	Section modulus of closed-box section, cm^3
1,0	36	1,8	116
1,2	52	2,0	144
1,4	70	2,2	174
1,6	92	2,4	210

N o t e s : 1. For other spacings the section modulus shalK be modified in proportion to the ratio of: spacing, mm/800.
2. The spacing for superstructure sides shall be brought in compliance with the beam spacing of the superstructure deck.
3. For intermediate values of stiffener spans the section modulus is determined by linear interpolation.

2.9.7 The deck laminate thickness and the scantlings of the deck framing of superstructures and deckhouses are taken in accordance with the requirements of 2.5 and 2.6.

2.10 OPENINGS IN STRUCTURES

2.10.1 Round openings cut in the shell, deck and watertight bulkheads with a diameter less than 150 mm are permitted not to be reinforced.

2.10.2 Round openings cut in the shell with a diameter of 150 mm and over shall be reinforced with glass fabric of satin weave or woven rovings in accordance with Fig. 2.10.2.

The reinforcements of openings having other shapes are subject to special consideration by the Register.

2.10.3 Round openings cut in decks with a diameter of 150 mm and over as well as rectangular openings of any diameter shall be reinforced with glass fabric of satin weave or woven rovings.

The recommended reinforcement of openings is shown in Figs. 2.10.3-1 and 2.10.3-2.

2.10.4 Lightening holes are not permitted to be made in the webs of framing members.

2.10.5 Openings cut in the framing member webs for the passage of cables, pipes, etc. and having diameters more than 1/3 of the web depth shall be strengthened with straps.

2.10.6 Dimensions of openings and the structure of closures in the outer shell and watertight bulkheads of ships, which subdivision is regulated by Part V "Subdivision", shall be specially agreed with the Register.

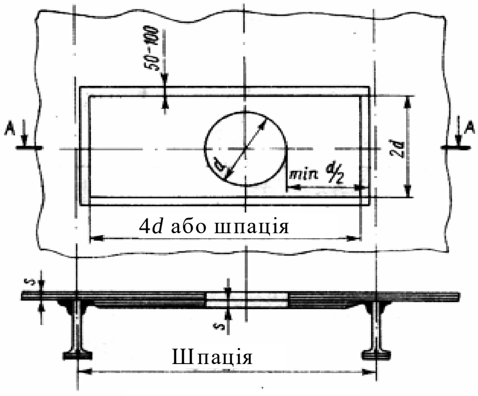


Fig.2.10.2

Notes : 1. Reinforcing shall be made only with glass fabric whose warp is oriented along the hull.

2. The thickness of the strap shall be equal to that of the structure. If the position of the openings is specified beforehand, the strap is moulded into the basic layers of the laminate, otherwise it shall be matted onto the inner face of the laminate between the frames, within one spacing as shown in the Figure.

3. Openings are not permitted to be positioned closer than *d*\2 to the frame.

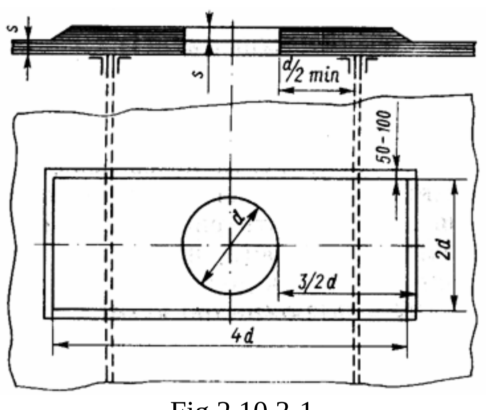


Fig.2.10.3-1

Notes : 1. Reinforcing shall be made only with glass fabric, which warp is oriented along the hull.

2. The thickness of the strap shall be equal to that of the structure. The strap is matted into the basic layers of the laminate of the position of the openings is known beforehand or moulded onto the upper surface of the deck.

Direction of fabric warp in the strap

Напрямок основи тканини на накладці

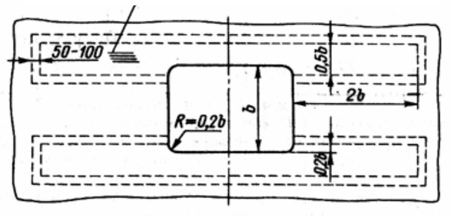


Fig.2.10.3-2

Notes: 1. Reinforcing shall be made only with glass fabric.

2. The fabric layers forming the strap shall be laid between the reinforcement layers of the deck laminate.

3. The total thickness of the reinforcing fabric layers shall be equal to the deck laminate thickness.

2.11 BULWARK

2.11.1 The bulwark thickness shall be equal to half thethicknessofthesidelaminatebutnotlessthan4mm.

2.11.2 The bulwark stays shall be fitted at alternate beams.

2.11.3 In ships over 15 m in length the bulwark laminate shall not form an integral part of the side laminate, and its sectional area shall not be taken into account when the hull section modulus is determined.

2.11.4 The structure of bulwarks in ships, which can moor at sea, shall be specially considered by the Register.

2.12 ENGINE SEATINGS

2.12.1 Side girders shall be used as far as possible as bearers of the main engine seatings. Where this is not feasible, additional bottom longitudinals shall be fitted with the web thickness equal to that of the side girder.

2.12.2 The engine seating girders shall extend forward and aft beyond the machinery space bulkheads for at least three spacings and be tapered at the end of the third spacing to floor depth.

2.12.3 The seating girders shall be reliably connected with transverse brackets fitted at every frame.

2.12.4 Seatings are permitted to be built of steel and aluminium alloys on special agreement with the Register.

2.12.5 The fastening of the engine bed flanges may be made by metal flats moulded into the flanges of the girders by fitting of metal angle sections bolted to the girder top edge or by other means approved by the Register.

2.13 STEMS, STERNFRAMES, PROPELLER SHAFT BRACKETS AND BILGE KEELS

2.13.1 Stems may be moulded of glass-reinforced plastic or may be of composite structure with the use of metal.

2.13.2 For the reinforcing of the stem laminate glass fabrics, woven rovings and glass-fibre bundless (rovings) are used.

The use of glass mats is not permitted.

2.13.3 Metal parts of the stem may be of aluminium alloys or of steel reliably protected by corrosion-resistant coating.

As a rule, they shall be moulded into the stem.

2.13.4 The stem moulded of glass-reinforced plastic shall be shaped as a rectangle with the width *b* and length / calculated by the formulae, in mm:

$$b = 1{,}5L + 30;$$
$$l = 2{,}5b,$$

where L – length of ship, m.

The thickness of the stem laminate reinforced with glass fabrics (types II, III or IV) shall be 1,5 times the sheerstrake thickness. The space inside the stem shall be filled with plastic reinforced with glass-fibre bundles, which shall be directed along the stem.

2.13.5 In the case of composite stems the width b_1 of the aluminium alloy core, length l, and total width b_2 of the stem are calculated by the formulae, in mm:

$$b_1 = 0,4L + 10; \quad b_2 = b_1 + 2s; \quad l_1 = 2,5b_2;$$

where L – ship's length, m;

s – stem laminate thickness determined as specified in 2.13.4.

2.13.6 The steel core width may be equal to 3/4 of the aluminium core width (refer to 2.13.5). The core length is calculated in accordance with 2.13.5.

2.13.7 The sternframe, if fitted, may be metal composite (glass-reinforced plastic with metal core).

The scantlings and structure of the sternframe are subject to special consideration by the Register.

2.13.8 The shaft brackets shall be as required in 2.10.4 Part II "Hull". The flanges of the brackets shall be attached to the hull by means of bolting. Straps of glass-reinforced plastic having a thickness equal to twice the shell thickness and fitted on the reverse side in way of bracket attachment as well as stiffening for framing members, which shall be agreed with the Register shall be provided in this area.

2.13.9 Bilge keels, if fitted, shall be of glass-reinforced plastic of type II. The attachment of bilge keels to the hull shall be effected by means of matting-in double angles (without using bolts), which shall be fitted on both sides of the keel laminate. The thickness of the matting-in double angles shall be equal to that of the keel laminate. The structural design of bilge keels shall be such that no damage would be caused to the shell in case of bilge keel loss.

2.14 CASINGS OF ENGINE AND BOILER ROOMS, HATCH AND FAN COAMINGS

2.14.1 The structure and scantlings of engine and boiler room casings, hatch and fan coamings are subject to special consideration by the Register.

2.15 GAS EXAUST SYSTEM

2.15.1 Gas exaust system made of reinforced plastic, must be of water injector type with normal operating temperature of 60-70°C and the maximum operating temperature of 120° C.

2.15.2 Gas exaust pipes, mufflers and separators must be type-approved. Installed in accordance with the requirements of the manufacturer.

Gas exaust systems of unapproved types are considered by the Register separately.

2.15.3 The resins, which are used when installing the exaust gas system must be approved by the Register and have a high thermal and chemical resistance and high deformability and thermal performance. The use of epoxy and vinyl ester resins is recommend, but polyester resin with a high degradation temperature is also allowed. The Register may require testing of samples depending on the configuration of the equipment and materials used.

2.15.4. Use of pigments and additives is not recommend unless the results of the tests prove that they do not disrupt the mechanical properties of the resin.

In addition, aging-resistant resin must be used.

2.15.5 Exhaust chamber must be covered by at least three layers of glass mat with a surface weight of 600 g / m2 with the temperature and flame resistant resin as a binder.

2.16 BALLAST

2.16.1 When filling voids with resin compound is necessary to take measures to reduce the amount of heat generated at the same time, which can affect the mechanical properties of glass reinforced plastic.

2.16.2 Information on the ballast material and the method of their placement should be provided in the design documentation.

3. STRENGTHENING IN SHIPS FOR NAVIGATION IN ICE

3.1 GENERAL

3.1.1 Ships with glass-reinforced plastic hull over 12 m in length and ice strengthening in accordance with the requiremenss stated below obtain the mark **Ice2** in their class notation.

3.1.2 The definitions of ice category marks are given in 2.2.3, Part I "Classification".

3.2 ICE STRENGTHENING IN SHIPS OF CATEGORY ICE2.

3.2.1 An ice belt shall be provided on the shells, the upper edge of which shall be extended 0,5 m above the winter load waterline, while the lower edge shall be 0,5 m below the waterline in the ballast condition.

3.2.2 The ice belt shall extend from the stem to the transom or sternframe over the entire length of the ship.

3.2.3 The ice belt in ships from 12 to 30 m in length is formed as a strap, which is moulded of glass-reinforced plastics of types II$_1$, III$_1$ and IV$_1$ matted layer by layer onto the finished hull.

3.2.4 Prior to laying up the strap the shell surface in the area shall be thoroughly cleaned.

3.2.5 The thickness of the ice belt strap shall not be less than 1**/3** of the shell thickness in the area. The thickness of the strap shall be tapered over a width of 100 mm upwards from the lower edge and 100 mm downwards from the upper edge of the ice belt.

3.2.6 The scheme of the strap reinforcement in way of the stem shall preclude the tear-off of the fore edge of the ice belt. To this end, a strap of glass-reinforced plastic of type II, III or IV as thick as the sheerstrake shall be fitted along the stem in way of the ice belt. The strap shall overlap the ice belt for one spacing. The strap thickness shall be tapered in the aft direction beginning from the spacing middle.

3.2.7 The use of synthetic materials for the ice belt is permitted on special agreement with the Register.

3.2.8 For ships under 12 m in length, the scantlings of the ice belt may be reduced on agreement with the Register.

3.2.9 For ships of 15 m and over in length a side stringer is required to be fitted at the level of the winter load waterline.

4. **3.2.10** For ships of 15 m and over in length the spacing shall be reduced by 50 mm as compared to that given in 1.6. The section modulus of frames is then adopted in accordance with 2.4 without regard to the spacing reduction.

4. LIFEBOAT HULL

4.1 GENERAL

4.1.1 The determination of scantlings and selection of the required type of glass-reinforced plastic shall be made in accordance with Section 2 unless special requiremenss are given in the present Section.

4.1.2 The scantlings are permitted to be deter mined by calculation in accordance with Appendix 3.

4.2 SHELL

4.2.1 For hulls of lifeboats the following types of glass-reinforced plastics are permitted to be used:

1. for hulls up to 8 m in length - plastics based on glass mats or woven rovings of parallel lay-up with one or two layers of glass mat or woven rovings on the faces to preclude the passage of water into the laminate and impart necessary smoothnsss to the laminate surface (types I and II). The mass of 1 m^2 of glass mat and of woven roving fabric shall not exceed 0,8 kg and 0,7 kg, respectively;

2. for hulls over 8 m in length **-** plastics based on glass mats (type I) or woven rovings of parallel and diagonal lay-up with one or two protective layers of glass mats (type VII) on the faces or a combination of woven rovings of parallel lay-up (50 per cent of the laminate thickness) and glass mats (50 per cent of the laminate thickness) of type V. In any case, at least one layer of glass mats or glass fabric shall be laid on the laminate faces

4.2.2 Seams and butts of strips of reinforcing material in members with parallel and diagonal reinforcement shall be formed as butts without overlap for any thickness exceeding 6 mm; for thicknesses between **2** and 6 mm, the overlap shall be at least 50 mm.

The butts and seams in each adjacent layer shall be spaced not closer than 100 mm apart. Butts and seams are permitted to be coincident in one section after 6 layers at least.

4.2.3 The minimum thickness of shell laminate in the case of single-skin construction shall be 4 mm, the outer and inner skins in the case of sandwich construction shall be 3 mm and 2 mm, respectively.

4.2.4 The thickness of shell laminate in the case of single-skin construction shall be determined from Figs. 2.1.1-1, 2.1.1-2 and 2.1.1-3 depending on the value of m_{perm} given in Table 4.2.4 and according to the plastic type chosen and the glass content by mass.

4.2.5 The laminate thickness of air cases of glass-reinforced plastic of type I or II shall be from 2 mm (for a length of 4,5 m) to 4 mm (for a length of 12 m).

For air cases serving at the same time as seats the laminate thickness shall be increased by 3 mm.

4.2.6 For double-skin and sandwich constructions, the laminate thickness of the outer skin shall be 75 per cent and the thickness of the inner skin -50 per cent of the thickness of the single-skin construction, respectively (refer to Table 4.2.4).

Table 4.2.4. **Shell laminate (single-skin construction)**

Length of life-boat, m	**Spacing, mm**	m_{perm}, **N-m**	
		днища	борту
4,5	300	1,2	0,8
6,5	350	1,8	1,3
8,0	400	2,3	1,7
10,0	450	2,8	2,1
12,0	450	3,2	2,4

N o t e s : 1. For intermediate hull lengths m_{perm} is determined by linear interpolation.
2. For conversion to the spacing other than given in this Table, refer to Table 2.2.1.
3. The thickness adopted for the bottom shell shall be maintained from the keel to a level not less than 1/3 of the side depth.

4.2.7 Special care shall be given to the quality of the lifeboat shell coating with decoraiive polyester binder.

4.2.8 Any necessary increase in the hull laminate thickness shall be formed by additional reinforcing material layers, which shall be uniformly distributed between the basic layers and be alternate with same.

4.2.9 Connection of the hull halves along CL is permitted only in well-founded cases.

4.2.10 Connection of the lifeboat side to the deck or gunwale shall be effected by means of bolts or matting-in angles of glass-reinforced plastics of type III or IV, the thickness of fach matttng-in nngle being not less than 0,7 times the side thickness, and the flange width being 80 mm + $5s_s$, where s_s, is the thickness of the side shell laminate, in mm.

4.3 FRAMING

4.3.1 The section moduli of frames in a lifeboat of single-skin shell construction shall not be less than stated in Table 4.3.1.

4.3.2 In the case of double-skin construction, the section modulus of the frame enclosed between the outer and inner skin in conjunction with the skin strips as wide as the spacing shall not be less than that given in Table 4.3.1.

4.3.3 In the case of sandwich construction the necessity of fitting transverse framing and the scantlings of same are subject to special consideration by the Register.

Table 4.3.1.

Length of life-boat, m	**Spacing, mm**	**Section modulus, cm^3**
4,5	300	28
6,5	350	42
8,0	400	56
10,0	450	70
12,0	450	77

Note: 1. The section moduli are given for closed box section frames moulded of glass-reinforced plastic, type I_2. For tee-shaped frames with flanges of glass-reinforced plastic of type II_3 and webs of glass-reinforced plastic of type I_2 the section moduli may be reduced by the factor of three.
2. Where the spacing differs from the Table value, the section modulus shali be modified in proportion to the ratio of the actual spacing to the Table spacing.

4.3.4 The scantlings of the keel girder shall be chosen in accordance with Fig. 4.3.4.

4.3.5 The recommended design of the keel is shown in Fig. 4.3.5.

4.3.6 In lifeboats between 8 and 12 m in length keelsons shall be fitted (one on each side). The section moduli of the keelsons shall be found in Table 4.3.6.

Table 4.3.4. **Розміри перерізу кільової балки**

Length of lifeboat, m	**Scantlings of section, mm**				
	h	b	s	s_1	s_2

4,5	70/90	60/80	4,5/5,0	9,0/10,0	15,0/20,0
6,5	110/140	80/100	5,5/7,0	10,0/12,0	20,0/25,0
8,0	135/180	100/120	6,0/8,0	12,0/14,0	24,0/30,0
10,0	190/240	120/140	7,0/9,0	14,0/16,0	30,0/35,0
12,0	220/260	130/150	8,0/9,0	16,0/18,0	35,0/40,0

N **o** e s **::** 1. Given in the numerator are the scantlings for glass-reinforced plastics, types II, V and VII, in the denominator — those for type I.

2. The density of laying up the reinforcing glass fabric (percentage content of glass by mass) is in compliance with the second lines of Tables 1 to 6, Appendix 2. 3. 3. Thickness s_2 is obtained by addition of rovings to be laid inside the keel.

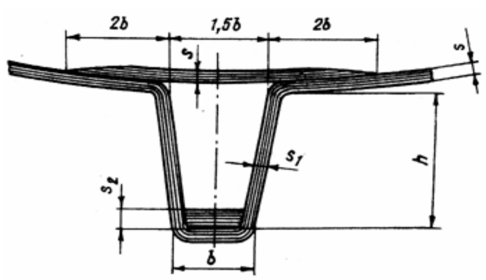


Fig.4.3.4

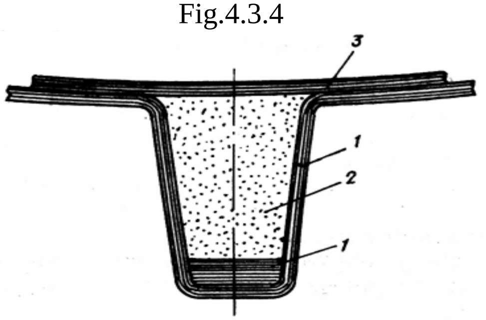


Fig. 4.3.5:
1 — glass-reinforced plastic;
2 — foam plastic;
3 — glass-reinforced plastic laid up inside the keel

4.4 ATTACHMENT OF LIFTING GEAR AND EQUIPMENT

4.4.1 The attachment of lifting gear to the lifeboat hull shall ensure the transfer offorces to the hull during the lowering of the lifeboat sustaining possible impact overloads due to a sudden braking of the winch, ship's motion and seaways at ship's sides under any possible conditions of ambient temperature.

*Table 4.3.6***.**

Length of lifeboat, m	Section modulus, cm3
4,5	–
6,5	–
8,0	150
10,0	400
12,0	600

Notes: 1. The section moduli of keelsons are given for tee-shaped sections with the face plate of glass-reinforced plastic, type III_3 and the web of type I_2.
2. For closed-box sections of glass-reinforced plastic, type I_2, the section modulus shall be increased by the factor of three.
3. Keelson shah be fitted at 0,35 to 0,45 of the lifeboat half-breadth *(B/2)* from CL.
4. Where the lifeboat arrangement requires fitting of two keelsons on each side, the section modulus of each keelson shall not be less than 0,75 of the value given in this Table.

4.4.2 The strength of attachment of each lifting hook to the lifeboat hull shall be checked by a static load equal for each lifting hook to 0,75 times the mass of the lifeboat when loaded with full complement of persons and equipment, which shall be applied for at least 5 min.

4.4.3 The structure of the mounts for lifting gear parts shall preclude the creep effect of glass-reinforced plastics.

The operation of lifting gear parts for separation from the lifeboat hull is not permitted.

The recommended design of the mounts is shown in Fig. 4.4.3.

4.4.4 The recommended design of the

mounts for engine seatings, platforms and pipes is shown in Figs. 4.4.4-1, 4.4.4-2 and 4.4.4-3.

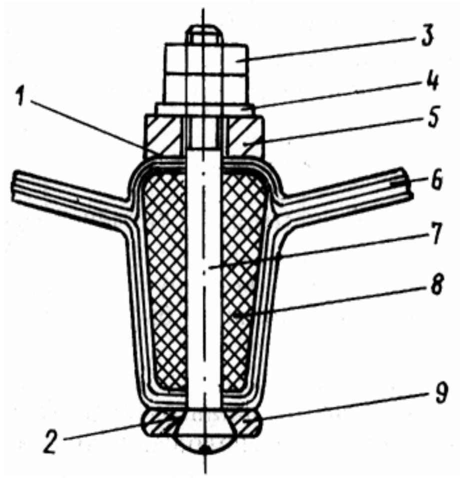


Fig.4.4.3

1,2 — tarpaulin gaskes; *3* — nut; *4* — washer; *5* — lifting lug; *6* — deck laminate; 7 — bolt; *8* — insert; *9* — base plate

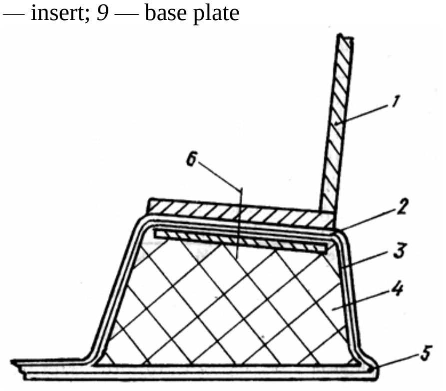


Fig.4.4.4-1

1- engine bearer; *2* -steel plate;
girder moulded integral with the inner shell skin;

4 - core; *5* - inner shell skin; *6*-screw

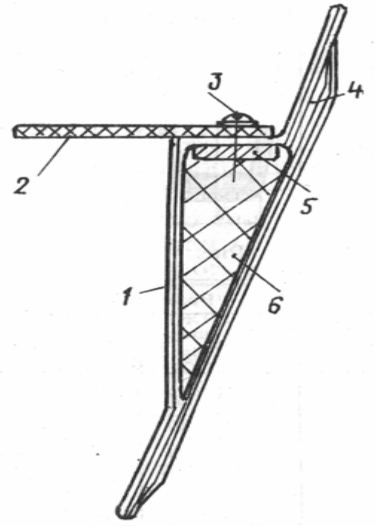


Fig.4.4.4-2

1 - step moulded integral with the inner shell skin;
2 - platform (thwat); *3* - screw;
4 - inner shell skin; *5* - steel plate; *6* - core

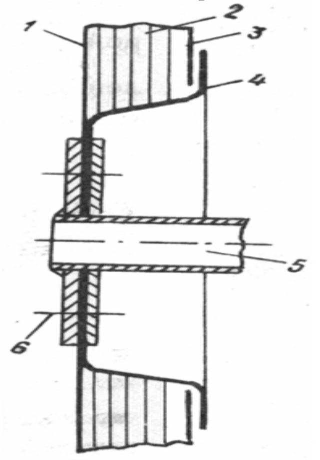


Fig.4.4.4-3:

1 - outer shell skin; 2 - core; 3 - inner shell skin;
4 - glass-reinforced plastic lined hole in the inner shell skin and core;
5-pipeline; 6-bolt

5. MANUFACTURING PROCESS

5.1 GENERAL

5.1.1 The provisions of this section concerning the construction of ships of glass-reinforced plastics based on thermosetting resins.

5.1.2 This section contains the general requirements of the Rules for vessels made of glass-reinforced plastics, built under the supervision of the Register. In the absence of clear requirements must be guided by the experience of industrial practice.

5.1.3 Ships constructed of materials unintended by the Register or non-standard technologies (ref. 1.1.1), are subject to special consideration by the Register.

5.2 CONSTRUCTION OF FORMS

5.2.1 Form must be made of materials which ensure the stability of its size.

5.2.2 Heating of matrix should not cause its deformations above approved construction accuracy.

5.2.3 Forms' material should not influence the process of hardening of the binder.

5.2.4 Lifting equipment shall be designed so that it has a minimal effect on the equipment. To avoid changing the shape of form equipment during hardening need to be secured.

5.2.5 The quality of the forms' surface must match their purpose. The final quality of the form surface is consistent with the customer and the manufacturers of forms.

5.2.6 Jointing of matrix composite structure sections must be carefully verified and checked by the surveyor of the Register prior to the formation. The slots between the sections should be rectified.

5.2.7 The number of welds on the metal frame should be kept to a minimum to avoid changing of the form.

5.2.8 Anti adhesive mixture should be recommended by the manufacturer of resins and not affect the hardening of resin.

5.2.9 Before using the forms their temperature must be brought to the shop temperature.

5.2.10 To ensure easy access to the workplace necessary external and internal scaffolding should be arranged.

5.3 PREPARATION OF BINDER

5.3.1 Reagents for resin hardening, plaster and pigments are added strictly in accordance with the requirements of the supplier.

5.3.2 Before use all resins need to be mixed thoroughly, deaerated and lead to temperature of the workshop in accordance with the supplier's recommendations.

5.3.3 All measuring devices must be certified. Calibration certificates are attached to quality control documentation.

5.3.4 Adjustment of pressure blower and measuring equipment is performed in accordance with the manufacturer's requirements, and calibration certificate is attached to the quality control documentation.

5.3.5 The QC documentation shall contain characteristics of resins and additives thereto, components' dispensing, and lot numbers of materials that are used.

5.4 LAMINATE LAYING UP

5.4.1 The process should be conducted in accordance with the technical documentation agreed with the Register.

5.4.2 Laying of laminate shall be carried out by employees, whose experience and qualification meet the requirements of the manufacturer and the Register.

5.4.3 Prior to treatment with anti adhesives forms need to be thoroughly cleaned, dried and lead to temperature of the work shop. The anti adhesive lubricant should not have an inhibitory effect on the outer layer of resin.

5.4.4 Coating gel that is applied by brush, roller or spray, should form an even film with nominal thickness of 0.4-0.5 mm.

5.4.5 When using coating gel based on polyester or vinyl ester resins, it is necessary to reinforce the layer with light material to binder powder with a density of not more than 300 g / m2 so that the final weight of the filler content does not exceed 0.28. To prevent damage to the layer of reinforcing material should be gel coat should be carefully rolled over. Surface material must be pressed into a layer a coating gel when the resin is not sticky, but is still soft.

5.4.6 The entire formed construction shall be made of thoroughly compacted, to achieve the desired glass mass content of the reinforcing material layers stacked in sequence and orientation in accordance with approved technical documentation.

5.4.7 In glass reinforced plastics based on woven materials the filler can be laid on a fabric layer, provided that the interlayer shear strength is not less than 13.8 MPa; otherwise fabric layers shall be alternate with layers of randomly directed filler.

5.4.8 It's necessary to avoid excessive exothermic heat exaust by very thick laminate layer (more than recommended by the resin manufacturer). When laying thick laminates manufacturer in the presence of an inspector of the Register must prove that the heat that is exaust during solidification of glass-reinforced plastic, obtained by wet-laying, does not impair its mechanical properties.

5.4.9 Glass-reinforced plastic laying process shall be arranged so that the time between laying of successive layers is in the range indicated by resins supplier; relevant information shall be recorded into the binder quality control documentation. Similarly, the time interval between the formation and adhesion (preforming) of structural elements should be within the prescribed limits, and if it is not technologically, laminate surface should be prepared to improve adhesion as recommended by the supplier.

5.4.10 With the resumption of laying after a break and use of resins non epoxy as the first layer is put a material of chopped glass-reinforced plastic or other material that provides an interlayer laminate strength. Before laying the operating portion must be processed with soft abrasive, then with a solvent which must be dried.

5.5 CONTENT OF FIBER AND THICKNESS OF GLASS-REINFORCED PLASTIC

5.5.1 In order to ensure that the thickness of the resulting structure is not less than the required, nominal weight content of fibers in each layer and throughout the whole laminate is controlled based on weighting of witness samples.

5.5.2 In order to confirm the degree of filling it is necessary to carry out continuous monitoring of the use of the resin / filler, the results of which are recorded in the quality control documentation.

5.5.3 Methodology of laminate thickness confirmation is agreed between the Register and the manufacturer. When using the electronic methods measuring equipment is calibrated on a similar laminate structure.

5.5.4 The thickness of the internal plastic construction of the ship is confirmed by witness samples obtained from the shell laminate (ie, holes, cutouts in the deck, etc.).

5.5.5 Data on areas with insufficient thickness and those that require laying additional layers (as well as areas with a thickness of no more than necessary) should be made to the quality control documentation.

5.5.6 Data on thickness measurement should be recorded and included in the quality control documentation; when there is insufficient thickness the additional layers of filler should be layed until reaching the required value.

5.6 SCHEME OF LAYING UP

5.6.1 Scheme of laying defines the cutting of the reinforcing material and its location on the matrix, the orientation of each filler layer of fibers relative to the matrix, overlapping layers of space.

5.7 FORMATION BY SPAYING

5.7.1 Equipment for spraying of binder and chopped fiberglass is tested when auditing the enterprise, in which the test sample is sprayed. Documentary evidence of the installation and calibration of equipment, catalyst content, fiber length and fiber mass content is made in quality control documentation. Installation for spraying should ensure the even application of the components in accordance with the supplier's recommendations, and should be approved by the Register surveyor.

5.7.2 Measures shall be taken to ensure appropriate working environment, ventilation and implementation of quality control.

5.7.3 In any case, the fiber length shall not be less than 25 mm.

5.7.4 Personnel working with the installation for spraying should be experienced and competent, and qualification certificates shall be recorded in the quality control documentation. The use of this type of formation is limited to areas to which free access to ensure quality control of spraying is provided.

5.7.5 Control of the ratio of the glass / resin is performed by measuring the mass of filler and resin. Calibration of equipment is checked using samples which are periodically sprayed.

5.7.6 When the sprayed glass layer with resin is a supporting layer for gel, glass filler mass must not exceed 300 g / m2 with its mass content not exceeding 0.28. After carefull compaction via rollers this layer should be left to harden to a state required to install subsequent layers.

5.7.7 Compacting must take place as soon as possible after spraying, in general, when the weight of the filler is equivalent to thickness of 2-3 mm. The thickness of the sprayed fiberglass should be periodically measured and recorded.

5.8 SOLIDIFICATION AND REMOVAL FROM THE FORM

5.8.1 On completion of laying the product remains in the form during the time required for solidification. This time is determined by the outside temperature, the type of resin and product complexity, but generally at least 12:00 hours (if there is no appropriate recommendations of resins supplier).

5.8.2 In order to prevent damage and maintain the shape of the hull, deck and other large parts during the removal from the matrix they need to be reinforced and strengthened.

5.8.3 End-products shall not stand outside the work shop until it reaches the degree of solidification, specified by the supplier for a specific type of resin that is done to prevent exposure to the environment.

5.8.4 In general, the product shall remain in the work shop in order to stabilize at least for 24 hours or at a time that is recommended by the supplier of resins.

5.8.5 Details of measures от further solidification while heating shall be provided to the inspector of the Register.

5.8.6 The degree of solidification of the product is determined by the Barcol's hardness tester or other certified equivalent method.

5.8.7 When using, the device shall be checked regularly on the reference surfaces.

5.8.8 Removal from the form shall not be performed until the hardness, which is recommended by the supplier of resins or the value of 30 units (Barcol) is reached. Subsequently, the formed product shall not leave the premises with controlled environmental conditions until the hardness recommended by the supplier of the resins, or the value of 35 units (Barcol) is reached.

5.9 ADDITITONAL OPERATIONS FOR SANDWICH STRUCTURES

5.9.1 Dry or wet filler compound with fiberglass plates and also laying of laminate directly over fillers (on the punch) is used for sandwich structures.

5.9.2 On transitions from sandwich laminate structure to the solid thickness of the material the filler shall have a bevel at least 2: 1.

5.9.3 In those cases, where the filler material is molded on the laminate, it is necessary to be done after the exothermic peak appearing at solidification.

5.9.4 In those cases where the filler material is layed over solidified surface, special care to ensure complete contact along the surfaces of the elements to be connected is required. In the case of of filler material laying up over an uneven laminate surface the Register may require additional layering over the surface or filler material contouring.

5.9.5 When using non epoxy resins a mat of chopped glass should contact with both sides of the filling material.

5.9.6 The documentation submitted must contain a clear description of the stepwise layers sequence in transverse and longitudinal direction. Generally, the bevel should be 50 mm per layer. If the GRP layer which covers the filler material is thin, the increment value is taken individually.

5.9.7 Before connecting the surface of the filling material must be cleaned and treated with primer in accordance with the recommendations of the supplier. The primer should not prevent further hardening of materials, which is also due to jointing technology of the supplier. The primer should cover the full panel of the filling material, including the gaps between its units (in contouring foam plastic), but without complete filling of the surface pores.

5.9.8 In applying the hard foam fillers the use of dry technology of vacuumization is required.To ensure the effective removal of air out of the foam sheet ventilation openings should be provided, the number and size of which is determined by the recommendations of the supplier of the filler material and the specific requirements of the supplier of the adhesive binder paste. After the vacuumization the binder paste must remain in the air vents.

5.9.9 A detailed description of the wet vacuum formation (with or without filling material) is supplied to the Register for consideration.

5.9.10 The number, size and distribution of the ventilation holes in the panel of rigid filler material to be recommended by the supplier. In general, the openings have a diameter d = 3 mm, and the distance between their centers - 50 mm.

5.9.11 Vacuum pressure value at the initial stage of compaction and hardening should not exceed that which is recommended by the supplier of the materials used to avoid effervescence and excessive loss of monomer.

5.9.12 Heat of filler material to give it the form must be in accordance with the recommendations of the supplier. Temperature limits must be strictly observed.

5.9.13 When using contoured filler material panels, is necessary to make sure that the panel is cut through the thickness of the material and can take the necessary form. The manufacturer shall show that the amount of adhesive is sufficient to fill the gaps between the blocks completely. The use of panels of material blocks glued on fabric is recommended

5.9.14 With all the technological procedures the excess adhesive pastes shall be removed and the filler panel purified and treated with primer before laying the last layer of fiberglass.

5.10 FITTING MEMBERS

5.10.1 Stacking of supporting or embeded elements shall be carried out so that the load is effectively transmitted to the adjacent structure. The contact surface of these elements shall be properly prepared and free of defects.

5.10.2 In the course of the fittings attachment substrates or liners shall be arranged. The contact surface of the liners must be properly prepared and cleaned of contamination.

5.10.3 Materials of embedded elements in sandwich constructions shall be resistant to crushing, and carefully insert themselves glued to the filler and to the plates in accordance with the procedure approved by the Register.

5.10.4 Grooves shall be provided on the surface of embedded elements for the movement of the binder paste under vacuumization.

In places of possible local sandwich panel destruction is recommended the use of larger diameter washers, sleeves, embedded parts, and combinations thereof.

5.10.5 If plywood or high density foam material is the embeded part, the cutting angle should not exceed 45º

5.11 СТИКУВАННЯ

5.11.1 Data concerning the quantities and characteristics of the joining, assembly tolerances must be provided in the design documentation.

5.11.2 To ensure effective force transmission cutting single-skin panels shall be oriented within a half thickness of a thinner beam. For sandwich structures admission is determined individually depending on the size of panels and structures of continuous joints.

5.11.3 Data on all malfunctioning connections must be indicated in the accompanying construction documents.

6. PRODUCTION FACILITIES

6.1 GENERAL

6.1.1 Relative humidity in the forming shop shall be as low as possible, preferably below 70%; significant variations of humidity which can lead to condensation on the matrices and materials are not allowed.

6.1.2 When using conventional layering techniques either manually or by spraying, over the entire period of formation and hardening stable temperature of at least 16 ° C and typically not exceeding 25 ° C shall be kept within work area. In exceptional cases and for short periods of time, the temperature can be reduced to a minimum (13 ° C) after the product has been maintained at a temperature of 16 ° C for at least 24 hours. If the temperature is above 25 ° C, the composition of the binder should be chosen accordingly.

6.1.3 When using other types of forming the room temperature is determined in accordance with the recommendations of the manufacturers of materials.

6.1.4 Data on the temperature and humidity measured by appropriate instruments must be recorded and stored in accordance with the requirements of the quality system.

6.2 STORAGE FACILITIES

6.2.1 Resins should be stored in dry conditions, which, in accordance with the manufacturer's recommendations, are well ventilated. The temperature in the storage area should not exceed 20 ° C, or recommended by the manufacturer and must not fall below 0 ° C.

6.2.2 Where the composition of the resin temperature falls below 16 ° C, should be arranged costly structure with a minimum temperature of forming workshop. Materials that are stored at a temperature below 16 ° C, should be heated to a temperature of a workshop.

6.2.3 When storing vessels with resins outdoor, the manufacturer shall ensure compliance with the recommended storage conditions of the supplier.

6.2.4 Hardener agents should be stored separately in a dry and clean place that is well ventilated in accordance with the recommendations of the supplier.

6.2.5 Fillers and additives should be stored in closed containers, impervious to dirt and moisture.

7.MATERIALS

7.1 GENERAL

7.1.1 The method of obtaining, endorsement of the approval certificates and further treatment of the materials is included into the manufacturer's quality control procedure, which is carried out by them to verify that the materials are clean, not damaged and comply with the stated requirements.

7.1.2 Storage should be organized in such a way that the materials used were from the same lot.

7.1.3 The materials should not be used after the expiry date, except with the prior approval of the Register and obtaining of new approval certificates from the supplier; their details should be recorded into the quality control documentation.

7.1.4 Substandard materials shall be rejected in accordance with the supplier's rules regarding quality control.

7.1.5 Waste materials shall be especially noted and stored separately.

7.1.6 Pumps for the resin and a catalyst, included into the spraying equipment, should work in accordance with the manufacturer's instructions. Maintenance, calibration and metering are carried out in accordance with the documentary procedures attached to the equipment.

7.1.7 Types of binders used for fiberglass and used in shipbuilding, must be approved by the Register. At the discretion of the Register control samples can be taken from lots of resins for testing.

Other materials that come into contact with fiberglass, should not adversely affect its solidification.

7.1.8 Solidification regime should meet the manufacturer's recommendations for the specific case in order to provide solidification of the binder within a specified time and in accordance with the required scheme.

7.1.9 If the composition includes a binder ingredient, prone to precipitation, the responsibility of the manufacturer is to carry out the recommendations of the supplier regarding mixing and preparation of the system before using it.

7.1.10 The plasticized construction purposes resins shall be type-approved and used in accordance with manufacturer's recommendations.

7.1.11 Data on the resin shall be included in the list of materials in the initial stage of the documentation. Specific purpose of each kind of resin shall be clearly stated in the submitted documents, as well as the method of surface preparation for subsequent preforming and gluing.

7.1.12 It is necessary to prevent the appearance of pores, which can reduce the effectiveness of future structural connections.

7.2 GEL COATINGS

7.2.1 Gel coatings based on orthophthalic polyester resins are not used for the outer layers of fiberglass. All gel coatings shall be used in strict accordance with the recommendations of the supplier.

7.2.2 In case of adding pigments it is necessary to follow the manufacturer's recommendations, the gel coating must settle the necessary time to release trapped air.

7.2.3 If the gel coating temperature is lower than in the store, it is necessary to bring the level to ambient environment

temperature before use.
Equipment should be checked by the surveyor of the Register prior to application of the gel coating. Register is also entitled to demand its presence during the coating gel application.

7.2.4 If the gel coating is not applied to the Register should be reported on water protection coatings that are used.

7.2.5 When applying the outer layer of paint instead of the gel coating, use of primers according to the paint supplier recommendations is provided.

7.2.6 During the manufacture of the sandwich construction on the punch the question of applying the waterproof coating on the outer surface is considered by the Register separately.

7.3 SOLIDIFICATION SYSTEMS

7.3.1 The amount of the reagents for the preparation of resins shall comply with the recommendations of the supplier to ensure complete polymerization of the resin.

7.4 GELATION TIME

7.4.1 Gelation time should be chosen so as to ensure complete impregnation of the reinforcing filler without dripping down vertical surfaces or evaporating of monomer.

7.4.2 The gelation time may be varied in accordance with the terms of the changes in the workshop (temperature). For polyester resins and vinyl ester resins it is controlled by the amount of the accelerator, but no catalyst. The amount of catalyst should not be less than 1% of the resin weight.

7.4.3 All resins should be mixed in accordance with the recommendations of the supplier.

7.5 PIGMENTS

7.5.1 Types of pigments that are used should not affect the solidification of resin.

7.5.2 The pigments may be introduced both by the supplier of the resins and by the moulder; in the latter case, the pigment shall be delivered as a paste dispersed in the same or joint resin. It is recommended to use pre-stained gel coatings.

7.5.3 Introduction of solid pigments in an amount greater than 5% relative to the weight of the resin requires a special testing and approval.

7.5.4 It is not recommended to introduce pigments into the gel coat or laminate resins used for the underwater hull, as well as in the locations of the tanks with oil, fuel or water.

7.5.5 Adding of pigment shall not greatly affect the gelation time of the binder and the physical properties of the gel coating that covers laminate; relevant written confirmation of the supplier of resins or pigments shall be registered in the documents relating to quality control.

7.6 FILLERS

7.6.1 Fillers that are added by the manufacturer shall be dispersed. Their number is determined by the recommendations of the supplier of resins and shall not alter the viscosity of the resin considerably and also affect the physical and mechanical properties of glass fiber reinforced plastic. With the introduction of the amount of filler in excess of 13% by weight of the resin (if recommended by the resin supplier) special tests and approval are required.

7.6.2 When calculating the total filler content such deemed pigments, thixotropic additives and additives increasing the fire resistance.

7.6.3 After thoroughly mixing the filler with the resin it is necessary to leave it for a while for emission of trapped air. It is necessary to adhere to the recommendations of the supplier while stirring.

7.6.4 Fillers can not be added into glass-reinforced plastic used in the location of oil, water and fuel tanks.

7.6.5 Data about all fillers and flame retardants should be recorded into the list of materials at an early stage of consideration of documents.

7.6.6 The amount of additives that increase the fire resistance may exceed specified in 7.6.1 provided that smaller values of the mechanical characteristics are taken in the calculations of stiffeners.

7.7 ADDITIVES INCREASING FIRE RESISTANCE

7.7.1 If plastic is needed to be non-flammable or combustible few, suggestions about giving these properties must be submitted to the approval of the Register. If using special additives their type and content must conform the recommendations of the supplier of resins. Results of tests or independent testing of non-combustible or non-flammable materials shall be provided.

7.7.2 All non-combustible binders should be used in strict accordance with the recommendations of the supplier.

7.8 REINFORCING FILLERS

7.8.1 Fiberglass reinforcing filler shall be made from alkali borosilicate glass E with alkali content not exceeding 1% and of type approved by the Register.

7.8.2 Reinforcing materials shall be stored in accordance with the recommendations of the supplier. Rolls should remain in its original packaging in order to reduce the possibility of contamination of the filler. Information provided by the supplier of each lot must be entered into the documentation of the quality control.

7.8.3 Materials shall be free from defects, differences in color, inclusions or other impurities.

7.8.4 Materials pre-impregnated (for example prepregs), shall be stored in spaces adapted for this purpose. Details on the storage conditions are recorded into the quality control documentation.

7.8.5 Light surface materials used for the reinforcement of surfaces with excessive resin layer must be compatible with the resin. The material data and weight content of the fibers are recordedinto the statement of the materials.

7.9 FILLERS FOR SANDWICH CONSTRUCTIONS

7.9.1 Rigid materials for sandwich constructions must be approved by the Register.

7.9.2 All fillers must be used according to the supplier's recommendations, a copy of which is attached to the corresponding drawings of the ship.

7.9.3 Requirements for rigid foam weight:

a) closed type of porosity, resistance to water, fuel and oils;

b) stability and durability;

c) compatibility with the binder;

d) retention of mechanical properties up to 60 ° C;

d) characteristics and mechanical properties must not be other than those specified in Table 3.9.1;

e) woven backing materials and adhesives used in the manufacture of fillers in the form of flexible sheets or small blocks must be compatible with the laminating resin and dissolved therein.

7.9.4 Requirements to the balsa wood:

a) the wood must be dried in an oven and treated with antifungal and insecticide mixture;

b) the material must undergo sterilization;

c) the average humidity should not exceed 12%;

d) fabric substrate must be soluble in the resin that is used.

7.9.5 In some cases, foams filler should be conditioned according to the supplier's recommendations. The process is conducted at a temperature above the operating temperature to ensure removal of gaseous substances remaining in the pores.

7.9.6 Other types of fillers are considered separately under this Regulation, depending on their characteristics and applications.

7.10 WOOD

7.10.1 The use of wood-based materials is the subject of separate consideration, depending on their type and purpose.

7.10.2 The wood must be of high quality and properly prepared (dried). It should be released from the more, does not have decayed portions, insect damages, cracks and other defects that reduce the effectiveness of the material as well as snags, except strong internal snags.

7.10.3 Permissible wood moisture, which is used in the joints or as skin with use of polyester or epoxy resins - 15%. When using resorcinol resin adhesives a slight excess of this value, and for phenolic or urea-formaldehyde resins slight decrease is recommended.

7.11 ANTI ADHISIVES

7.11.1 Anti adhesives shall not delay the solidification of the gel coating, and are recommended by the supplier.

APPENDIX 1

RECOMMENDED TYPES OF GLASS-REINFORCED PLASTICS

1. The following eight types of glass-reinforced plastics are recommended for use in hull structures of ships and life-boats:

type I: plastic reinforced with glass mats, which may be coated on the outer face or on both faces with one or two layers of glass net or glass fabric to impart better surface smoothnsss to it (designation *X);*

type II: plastic reinforced with woven rovings of plain weave and parallel orientation, i.e. all layers are laid with their warp in one direction (designation *P);*

type III: plastic reinforced with glass fabric of satin weave with parallel orientation (designation *7);*

type IV: plastic reinforced with glass fabric or glass net of plain weave wiih parallel orieetatioo (designation *T* or Q*;*

type V: plastic reinforced both with glass mats and woven rovings of parallel orientation, each amounting to 50 per cent in thickness, the layers of mats and woven rovings being alternately laid through the entire thickness of the laminate;

type VI: plastic with the same reinforcement thickness ratio as for type V, but with mats concentrated in the middle and woven rovings laid on the outer and inner faces and amounting to 1/4 of the thickness on each side;

type VII: plastic with parallel and diagonal reinforcement of woven rovings at angles + 45° and -45°, which layers, laid parallel to the warp, shall amount to half the laminate thickness, while the diagonal parts plied at + 45° and -45° to the layers of parallel orientation shall amount to 1/4 of the laminate thickness each, the layers of parallel reinforcement being alternately laid throughout the entire thickness;

type VIII: layers arranged diagonally shall occupy the middle portion of the laminate thickness while those of parallel reinforcement shall form the outer and inner faces of the laminate (packet arrangemen)..

Glass-reinforced plastics, types II, V, VI, VII and VIII shall be overlaid on both faces with one or two layers of glass fabric or glass net.

2. The schemes of reinforcement for the above plastics types are shown in Fig. 1.

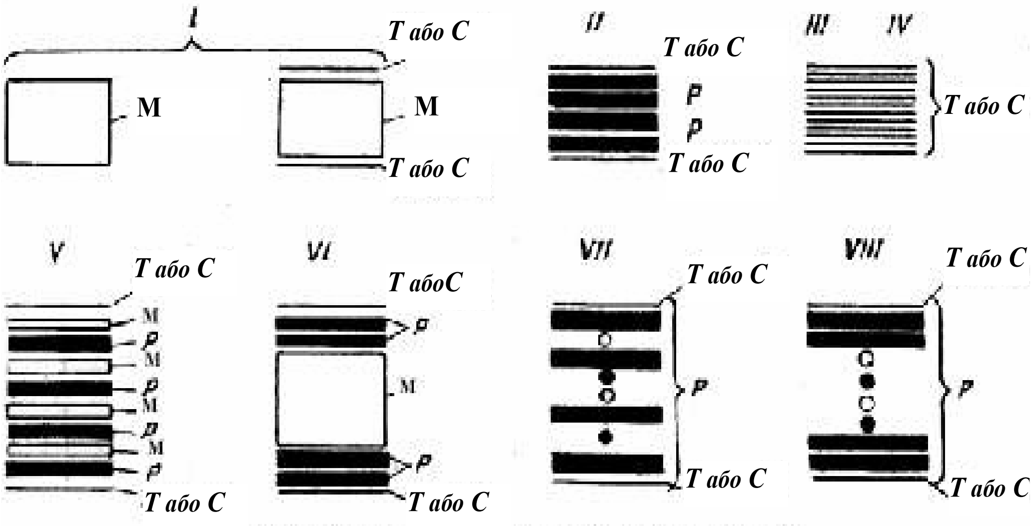


Fig. 1
Schemes of reinforcement. Reinforcing material:
X - glass mat, *P* - woven rovings (plain weave), parallel orientation of layers: woven rovings, plied at + 45° or -45°; Γ or C - glass fabric or glass net, parallel orientation of layers. Types of glass-reinforced plastics (shown in per cent is the fraction of thickness composed by layers of the given reinforcement): type *I-X* 100 %; type II-*P* 100 %; types III and IV- *T*100 % (or C100%); types V and *VI-X*50 %, *P* 50 %; types VII and VIII - 0° *P* 50 %, + 45°*P*25 %, -45° *P* 25 %

APPENDIX 2

PHYSICAL AND MECHANICAL PROPERTIES OF GLASS-REINFORCED PLASTICS

Physical and mechanical properties of glassreinforced plastics depending on the reinforcement schemes included in Appendix 1 shall be in accordance with the values stated in Tables 1 to 6.

For each type of plastic depending on the fibreglass content in per cent by mass the tables contain respective values of physical and mechanical properties. The values of physical and mechanical properties such as glass content by volume, average density, shear modulus, Poisson's ratio and shear strength in the laminate plane are determined only during approval tests of a particular type of plastic.

Table 1

Nos	Type	Glass content, %		Average density, kg/m³	Modulus, MPa		Poisson's ratio	Strength, MPa		
		by mass	by volume		Young's *E*	Shear in laminate in plane *G*, MPa		Tensile	Compression	Shear in laminate plane
1	I_1	25	15	1450	$0{,}60\cdot10^4$	$0{,}22\cdot10^4$	0,35	80,0	110,0	40,0
2	I_2	30	18	1500	$0{,}70\cdot10^4$	$0{,}26\cdot10^4$	0,35	90,0	120,0	50,0

N o t e s: 1. Glass content by volume and average density of plastics are given for the average density of glass 2550-2600 kg/m³ and average density of binder as cured 1200-1250 kg/m³.
2. Young's modulus is given for ttnsson-and-compression.
3. For thicknesses of 4 mm and less the tensile strength is reduced by 20 per cent against the Table value.

Table 2. **Physical and mechanical properties of glass-reinforced plastics with woven rovings of parallel orientation and a polyester binder (type П). Tested in dry condition at 20 °C**

Nos	Type	Glass content, %		Average density, kg/m³	Modulus, MPa		Poisson's ratio	Strength, MPa		
		by mass	by volume		Young's *E*	Shear in laminate in plane *G*, MPa		Tensile	Compression	Shear in laminate plane
1	II_1	45	28	1600	$\frac{1{,}30\cdot10^4}{1{,}30\cdot10^4}$	$0{,}21\cdot10^4$	$\frac{0{,}12}{0{,}12}$	$\frac{170{,}0}{170{,}0}$	$\frac{105{,}0}{105{,}0}$	60,0
2	II_2	50	32	1640	$\frac{1{,}50\cdot10^4}{1{,}50\cdot10^4}$	$0{,}25\cdot10^4$	$\frac{0{,}12}{0{,}12}$	$\frac{200{,}0}{200{,}0}$	$\frac{110{,}0}{110{,}0}$	70,0
3	II_3	55	37	1700	$\frac{1{,}70\cdot10^4}{1{,}70\cdot10^4}$	$0{,}29\cdot10^4$	$\frac{0{,}12}{0{,}12}$	$\frac{230{,}0}{230{,}0}$	$\frac{115{,}0}{115{,}0}$	80,0

N o t e s: 1. Glass content by volume and average density of plastics are given for the average density of glass 2550 - 2600 kg/m³ and average density of binder as cured 1200-1250 kg/m³.
2. Young's modulus is given for ttnsson-and-compression.
3. Shown in the numerator are the values for the warp direction, in the denominator - for the weft direction.
4. For woven rovings the ratio of breaking strength in the warp and weft direction is 1:1.

Table 3. **Physical and mechanical properties of glass-reinforced plastics with glass fabric of satin weave and parallel orientation, and a polyester binder (type Ш). Tested in dry condition at 20 °C**

Nos	Type	Glass content, %		Average density, kg/m³	Modulus, MPa		Poisson's ratio	Strength, MPa		
		by mass	by volume		Young's *E*	Shear in laminate in plane *G*, MPa		Tensile	Compression	Shear in laminate plane
1	III_1	45	28	1600	$\frac{1{,}7\cdot10^4}{1{,}1\cdot10^4}$	$0{,}28\cdot10^4$	$\frac{0{,}15}{0{,}10}$	$\frac{270{,}0}{170{,}0}$	$\frac{200{,}0}{150{,}0}$	80,0
2	III_2	49	31	1640	$\frac{1{,}8\cdot10^4}{1{,}2\cdot10^4}$	$0{,}30\cdot10^4$	$\frac{0{,}15}{0{,}10}$	$\frac{290{,}0}{180{,}0}$	$\frac{210{,}0}{160{,}0}$	85,0

Nos	Type	Glass content, %		Average density, kg/m³	Modulus, MPa		Poisson's ratio	Strength, MPa		
		by mass	by volume		Young's *E*	Shear in laminate in plane *G*, MPa		Tensile	Compression	Shear in laminate plane
3	III_3	52	34	1670	$\frac{1,9\cdot 10^4}{1,3\cdot 10^4}$	$0,32\cdot 10^4$	$\frac{0,15}{0,10}$	$\frac{300,0}{190,0}$	$\frac{220,0}{170,0}$	90,0

N o t e s:1. Glass content by volume and average density of plastics are given for the average density of glass 2550 - 2600 kg/m³ and average density of binder as cured 1200-1250 kg/m³.
2. Young's modulus is given for ttnsson-and-compression.
3. Shown in the numerator are the values for the warp direction, in the denominator - for the weft direction.
4. For the glass fabric the ratio of the breaking strength in the warp and weft direction is 2:1

Table 4. **Physical and mechanical properties of glass-reinforced plastics with glass net or glass fabric of plain weave and parallel orientation, and a polyester binder (type IV). Tested in dry condition at 20 °C**

Nos	Type	Glass content, %		Average density, kg/m³	Modulus, MPa		Poisson's ratio	Strength, MPa		
		by mass	by volume		Young's *E*	Shear in laminate in plane *G*, MPa		Tensile	Com-pression	Shear in laminate plane
1	IV_1	45	28	1600	$\frac{1,3\cdot 10^4}{1,3\cdot 10^4}$	$0,28\cdot 10^4$	$\frac{0,13}{0,13}$	$\frac{220,0}{220,0}$	$\frac{160,0}{160,0}$	80,0
2	IV_2	49	31	1640	$\frac{1,4\cdot 10^4}{1,4\cdot 10^4}$	$0,30\cdot 10^4$	$\frac{0,13}{0,13}$	$\frac{230,0}{230,0}$	$\frac{170,0}{170,0}$	85,0
3	IV_3	52	34	1670	$\frac{1,5\cdot 10^4}{1,5\cdot 10^4}$	$0,32\cdot 10^4$	$\frac{0,13}{0,13}$	$\frac{240,0}{240,0}$	$\frac{180,0}{180,0}$	90,0

Notes: 1. Glass content by volume and average density of plastics are given for the average density of glass 2550-2600 kg/m³ and average density of binder as cured 1200-1250 kg/m³.
2. Young's modulus is given for ttnsson-and-compression.
3. Shown in the numerator are the values for the warp direction, in the denominator - for the weft direction.
4. For the glass fabric the ratio of the breaking strength in the warp and weft direction is 1::1

Table 5. **Physical and mechanical properties of glass-reinforced plastics with composite reinforcement of 1/2 of the thickness by glass mats and 1/2 of thickness by woven rovings of parallel orientation on the basis of polyester binder (type V and VT). Tested in dry condition at 20 °C**

Nos	Type	Glass content, %			Average density, kg/m³	Модуль, МПа		Poisson's ratio	Strength, MPa		
		Glass mats	Woven rovings	Glass		Young's *E*	Shear in laminate in plane *G*, MPa		Tensile	Compression	Shear in laminate plane

1	V_1 / VI_1	25	50	37,5	1550	$1{,}05\cdot10^4$ / $1{,}05\cdot10^4$	$0{,}24\cdot10^4$	0,21 / 0,21	135 / 135	77 / 77	55,0
2	V_2 / VI_2	30	55	42,5	1600	$1{,}2\cdot10^4$ / $1{,}2\cdot10^4$	$0{,}28\cdot10^4$	0,21 / 0,21	160 / 160	80 / 80	65,0

Note: 1. Average density of plastics is given for the average density of glass 2550-2600 kg/m^3.
2. Young's modulus is given for ttnsson-and-compression.
3. Shown in the numerator are the values for the warp direction, in the denominator - for the weft direction.

Table 6. **Physical and mechanical properties of glass-reinforced plastics with parallel-and-diagonal reinforcement by woven rovings, one half of which is of parallel orientation and the remainder of diagonal orientation, i.e. 1/4 at +45° and 1/4 at -45° and a polyester binder (types VH and VIII). Tested in dry condition at 20 °C**

Nos	**Type**	**Glass content by mass, %**	**Average density, kg/m³**	Модуль, МПа		**Poisson's ratio**	**Strength, MPa**		
				Young's E	**Shear in laminate in plane** G**, MPa**		**Tensile**	**Com-pression**	**Shear in laminate plane**
1	VII_1 / $VIII_1$	45	1600	$1{,}1\cdot10^4$ / $1{,}1\cdot10^4$	$0{,}37\cdot10^4$	0,30 / 0,30	140 / 140	80 / 80	56,0
2	VII_2 / $VIII_2$	50	1650	$1{,}3\cdot10^4$ / $1{,}3\cdot10^4$	$0{,}45\cdot10^4$	0,30 / 0,30	170 / 170	95 / 95	68,0
3	VII_3 / $VIII_3$	55	1700	$1{,}5\cdot10^4$ / $1{,}5\cdot10^4$	$0{,}52\cdot10^4$	0,30 / 0,30	200,0 / 200,0	110,0 / 110,0	79,0

N o t e :: 1. Average density of plastics is given for the average density of glass 2550 - 2600 kg/m^3 and the average density of binder as cured 1200-1250 kg/m^3.
2. Young's modulus is given for ttnsson-and-compression.
3. Shown in the numerator are the values for the warp direction, in the denominator - for the weft direction.
4. For the glass fabric the ratio of the breaking strength in the warp and weft direction is 1:1.

APPENDIX 3

GUIDANCE FOR DETERMINATION OF HULL MEMBER SCANTLINGS OF SHIPS AND LIFEBOATS BY CALCULATION

1.SHIP'S HULL

1.1 In addition to the table method of fhe hhll scantlings determination as given in this Part of the Rules, this may be done by a calculation method approved by the Register.

1.2 The basic data for recalculation of separate hull members as well as calculation of the longitudinal and local strength of the hull as a whole are given in Tables 1,2 and 3.

1.3 The permissible stress is taken as a part of design tensile, compression or shear strength. For permissible stress in the case of alternating tension-and-compression and bending, either tensile or compressive stresses shall be taken, whichever are less.

1.4 Design values for Young's modulus and shear modulus are taken equal to

$$E_p = 0{,}6E \text{ i } G_p = 0{,}6G,$$

where E and G - Young's modulus and shear modulus determined for dry material at 20 °C (refer to Appendix 2).

1.5 For hull structural components the factor of safety against buckling shall be taken not lower than that given in Table 4.

1.6 Permissible deflection values calculated with consideration of shear are taken as follows:

1/400 of length for the hull as a whole;
1/50 of spacing for the shell;
1/100 of span for framing members.

Table 1.

Ship's length[1], m	Maximum bending moment at general bending, k№m
5–10	$1{,}66\Delta Lg$
15–30	ΔLg

N o t e s : L– length of ship, m;
Δ – full loaddisplacenment of the ship, t;
g = 9,81 m/s^2.

[1] For ships from 10 to 15 m in length the bending moment is determined by linear interpolation.

Table 2.

Type of load	Design formula or value
Local load on bottom and side shell	$h_p=10(h_1+\Delta h)$, kPa
Local load on the upper deck: **forward of the fore peak bulkhead** **elsewhere**	 15 кPa 5 кPa
Ditto for ships of restricted area of navigation III: **forward of the fore peak bulkhead** **elsewhere**	 10 кPa 4 кPa
Water impact against the bottom, when dropped in an emergency: L = 5 m L = 10 m	 20 кPa 40 кPa

N o t e s : l. h_1– distance from the member under consideration to the upper deck; Δh = 0,5 м – for any region, with the exception of the shell in way of the fore peak; Δh = 1,5 м – for the region forward of the fore peak bulkhead.

2. For ships of intermediate length the load is determined by linear interpolation.

Table 3.

Type of load	Permissible stress
Stresses due to general and local bending:	
at instantaneous load: for glass-reinforced plastic of type I	$\sigma = 0{,}25R_m$ $\tau = 0{,}25\tau_m$
for glass-reinforced plastic of types II-VIII	$\sigma = 0{,}30R_m$ $\tau = 0{,}30\tau_m$
at permanent load for all types of glass-reinforced plastics	$\sigma = 0{,}10R_m$ $\tau = 0{,}10\tau_m$
at shear in the laminate plane for all types of glass-reinforced plastics	$\tau = 0{,}30\tau_m$

at shear in matting-in connections and at interlaminar shear	$\tau = 0{,}60\tau_m$
Stresses in matting-in connections subject to pull: **at instantaneous load** **at permanent load**	 σ = 2 МПа σ = 1 МПа

Notes: σ – permissible normal streess; τ – permissible shear stress; R_m and τ_m – tensile strength and shear strength obtained on dry specimens at t = 20 °C (refer to Appendix 2).

Table 4.

Structural component to be calculated	Safety factor
Centre girder, side and deck girders	3
Plate keel, sheerstrake and deck stringer	1,5

1.7 For the shell and upper deck the reduction coefficient may be used. The moment of inertia with consideration of the reduction coefficient shall then not be less than 95 per cent of the moment of inertia calculated in the first approximation without regard to the reduction coefficient.

2 LIFEBOAT HULL

2.1 It is recommended that recalculations of scantlings of separate structures may, if necessary, be based on the following

.1 For loads used in checking the longitudinal strength of the lifeboat hull, the bending moments and shearing forces acting on the hull during the lowering of a fully loaded lifeboat suspended from two hooks shall be taken. In this case, the maximum bending moment is determined, in kN-m, by the formula

$$M = 1{,}25 \cdot 10^{-3} Ql,$$

where Q = mass of fuUy loaded lifeboat with 50 per cent overloading, kg; l = lifeboat length between hooks, m.

The maximum shearing force value is determined, in kN, by the formula

$$N = 0{,}005\ Q.$$

The equivalent static design pressures on the bottom with regard to dynamical loads due to water impact against the hull are given in Table **5** according to the lifeboat mass.

The design pressure on the side is taken to be **80** per cent of the relevant pressure on the bottom.

.2 In calculating the longitudinal and local strength of the lifeboat hull the permissible normal stress is taken equal to **0,30** of the tensile or compression strength for glass-reinforced plastics of type II - VIII (whichever **i**i sess) and to **0,25** for type I plastics. The permissible shear stress is taken equal to **0,30** of the shear strength in the laminate plane (for all types of glass-reinforced plastics);

Table 5.

Mass of lifeboat loaded with its full complement of persons and equipment, kg	Design pressure, MPa	Mass of lifeboat loaded with its full complement of persons and equipment, kg	Design pressure, MPa
1000	0,04	8000	0,06
2000	0,04	10000	0,07
3000	0,05	15000	0,07
5000	0,05	20000	0,08
7000	0,06		

Note. For intermediate mass values the pressure shall be determined by linear interpolation.

.3 In calculating the longitudinal and local strength the permissible deflections are taken as follows:

1/333 of length for the lifeboat hull as a whole;

1/50 of spacing for shell and bulkheads;

1/100 of span for frames.

The permissible variation in the lifeboat's breadth shall be 1/333L

For the design values of Young's modulus and shear modulus in calculating deflections and checking buckling strength 0,60 of the corresponding values for dry material in initial state at 20 °C shall be taken;

.4 The factors of safety against buckling shall not be less than:

3 for side girders and keel;

1,5 for gunwale;

1 for shell.

In this case, the local buckling strength only shall be checked.

2.2 Testing of finished hulls of lifeboat for strength and rigidity shall be effected in accordance with the requirements 5.2 of Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships.