BRIDGE AND NAVIGATIONAL EQUIPMENT C17

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1 WHEELHOUSE

1.1 There shall be clear visibility from the wheel-house forward, to the sides and astern. In addition, the front windows shall be so arranged that they can be kept free of rain, splash and condensation.

1.2 The arrangement in the wheelhouse shall be as follows:

- Instruments, control handles, control lamps, etc shall be suitably positioned;
- Details at the steering panel and in the field of vision shall, as far as practicable, be made of non-reflecting material;
- The free height shall normally be at least 1.98 metres.

2 COMPASSES

2.1 Any boat shall be equipped with a magnetic compass which shall comply with the national requirements.

3 SOUND SIGNALS

3.1 Boats with a length of at least 12 metres shall have fixed mounted whistle and ship bell.

3.2 Whistles and ship bells shall comply with the requirements of the International Regulation for Preventing Collisions at Sea, 1972, Annex III.

4 LIGHTS

4.1 All boats shall have fixed mounted lights (lanterns). In respect of size, type, location and arrangement they shall comply with the International Regulations for Preventing Collisions at Sea, 1972, with later revisions.

4.2 A combined side light may be used. In boats with a length overall of less than 12 metres a combined top and aft light may also be used.

For fishing boats special provisions apply during fishing activities.

4.3 Lights shall be approved and marked by one of the Nordic Maritime Administrations or be provided with individual certificates in accordance with national provisions.

4.4 Lights shall, if necessary, be screened off in order to avoid confusing reflexes.

SIMPLIFIED STRENGTH REQUIREMENTS FOR GRP BOATS
C18

Table of contents

1 GENERAL

1.1 Boats of GRP may be built in accordance with the following provisions of this chapter provided

A that the speed of the boat does not exceed 15 knots;

B that the construction is built up as single laminate;

C stiffenings, bulkheads and other structural parts shall be accessible for control. Thickness and measurement shall be possible to carry out on the bottom, sides and deck of the hull.

1.2 If the above limitations cannot be complied with, the boats shall be built in accordance with chapters C21, C22 and C26.

2 MATERIALS

2.1 During the construction it shall be documented that raw material according to the requirements in chapters MC2 and MC3 or equivalent is used.

2.2 It shall be documented that the properties of the finished laminate complies with the requirements in chapter MC2.

2.3 If such documentation is not available a material sample shall be taken for testing.

3 MANUFACTURING PREMISES

3.1 Manufacturing premises shall be arranged so that the following can be complied with.

1 During the moulding and curing the air temperature shall be uniform and minimum 18 degrees Celsius;

2 The necessary ventilation system must not cause draught;

3 Direct sunlight is not acceptable in places where moulding and curing are in progress;

4 Grinding work must not take place in the same premises as that where moulding is in progress.

4 WORKMANSHIP

4.1 The laminate moulding shall be carried out with customary good workmanship and the laminate shall be well cured and not discoloured.

Laminate which will be subjected to water shall be protected by gelcoat or topcoat.

5 DIMENSIONING

5.1 The minimum dimensions shall be in accordance with the following table:

Area	Extension	Dimension
Keel and stem laminate	80 * Bmax from the centre in mm	tk = 7.0 + l.3 * Loa
Bottom laminate	Up to the full load waterline	tb = 6.0 + 0.7 * Loa
Laminate in the side and super-structures, strength and tank bulkheads	Above the load waterline	td = 3.0 + 0.6 * Loa
Laminate in deck and deckhouses		ts = 6.0 + 0.8 * Loa
Bilge	100 mm on each side	tc = 6.0 + 0.8 Loa

5.2 Maximum frame distance and minimum section modulus for stiffeners shall be in conformity with the table below:

Frame	Maximum frame distance in mm	Minimum section modulus in cm^3
Bottom	5.4 * Loa + 400	$Wb = 0.006 * Loa * S * L^2 * 10^{-6}$
Side	16 * Loa + 400	$Ws = 0.0038 * Loa * S * L^2 * 10^{-6}$
Deck	26 * Loa + 300	$Wd = 0.87 (0.01 + 0.002 * Loa) S * L^2 * 10^{-6}$

5.3 Floors shall be installed with a maximum relative distance of 1.0 metre and they shall have a height of at least hb above the keel:

$hb = B/3 * 100 * S$ mm, minimum 100 mm

where S is the distance between the floors in mm.

5.4 Bulkheads of plywood shall be made of water proof material and have a thickness of at least

$t = 2 * Loa - 2$ mm

Bulkheads of other materials shall be dimensioned to equivalent strength.

6 CONTROL

6.1 The requirements in the above tables and the documentation and the workmanship shall be controlled for each individual boat during the final survey according to chapter C1.

SIMPLIFIED STRENGTH REQUIREMENTS FOR STEEL BOATS
C19

Table of contents

1 GENERAL

1.1 Steel boats can be built in accordance with the paragraphs in this chapter on condition that:

A The speed of the boat must not be greater than 15 knots;

B Bulkheads, frames, floors and other structural elements shall be accessible for control and thickness measurement shall be possible to carry out in respect of the bottom, sides and deck of the hull.

1.2 If the above conditions are not fulfilled, the boat shall be built in accordance with chapter C21, C23 and C27.

2 MATERIALS

2.1 During the construction it shall be documented that materials used are of ship quality with certificates issued by a classification society or a Maritime Administration and with at least the following properties:

Minimum yield stress	240 N/mm^2
Tensile strength	410 N/mm^2
ultimate strain	22 %

3 WORKMANSHIP

3.1 Adjusting of materials, welding and detailed performance shall normally be carried out in accordance with chapter C27.

4. DIMENSIONING

4.1 The minimum dimensions shall be in accordance with the table. Interpolation shall be used for boats with a length overall between 8 and 15 metres.

5 CONTROL

5.1 The requirements in the above table and the material documentation and the workmanship shall be controlled for each individual boat at the final survey in accordance with chapter CI.

5.2 Control of welded joints by x-ray or similar method can be carried out in cases were such a control is considered necessary.

Designation	Loa < 8.0 m	Loa = 15.0 m	Remarks
Frame distance	Max 500 mm	Max 500 mm	-
Bar keel	Sectional area 15 cm^2	Sectional area 15 cm^2	Where bar keel is omitted keelplate = 1.5 x t bottom. Total breadth 30 x Loa mm
Centerkeel	Sectional area 15 cm^2. Min. thickness 6 mm	Sectional area 20 cm cm^2. Min. thickness 6 mm	Required only where the bar keel is omitted
Floor	Height 200 mm thickness 4.5 mm	Height 250 mm thickness 3.5 mm	Required only at every third frame on the other frames sceleton floors
Flange on top of floor	50 x 3.0 mm	50 x 5.5 mm	May be omitted where cement is inserted up to the top of the floors
Keelson	UNP 100	UNP 120	Required only where center keel is omitted
Frames	90 x 6.0 mm (9.5 cm^3)	100 x 6.5 mm (18.0 cm^3)	-
Bottom plates	4.5 mm	7.0 mm	Keel plates and stem plates to be increased with 1.0 mm
Shell plates	4.0 mm	6.0 mm 1	-
Bulkheads	4.5 mm	6.0 mm	-
Bulkhead stiffeners	50 x 6.0 mm (6 cm^3)	50 x 6.5 mm (7 cm^3)	Max. spacing 750 mm
Deck	4. 0 mm	6. 0 mm	-
Deck beams	90 x 8 mm (22 cm^3)	90 x 8 mm (22 cm^3)	Maximum distance 500 mm. Maximum span 3.5m
Bulkwark	4.0 mm	5.0 mm	Stiffener 50 x 6 mm. Maximum distance 500 mm
Superstructure/ deckhouse	4.0 mm	5.0 mm	Stiffener 50 x 6 mm. Maximum spacing 500 mm

SIMPLIFIED STRENGTH REQUIREMENTS FOR ALUMINIUM BOATS C20

Table of contents

1 GENERAL

1.1 Boats of aluminium can be built in accordance with the following paragraphs in this chapter on condition that:

A The speed of the boat must not be greater than 15 knots.

B Bulkheads, frames, floors and other strength elements shall be accessible for control and thickness measurement shall be possible to carry out on the bottom, sides and deck of the hull.

1.2 If the above conditions are not fulfilled the boats shall be built in accordance with chapters C21, C24 and C28.

2 MATERIALS

2.1 During the construction shall be documented that materials of seawater resistant aluminium with certificates issued by classification society or a Maritime Administration and with at least the following properties:

$\sigma_2 = 170$ N/mm^2

3 WORKMANSHIP

3.1 Workshops and fitting of materials, welding, riveting, glueing and detailed construction shall normally be carried out in accordance with chapter C28.

4 DIMENSIONING

4.1 Minimum dimensions shall be in accordance with the table. Interpolation shall be used for boats with a length overall between 8 and 15 metres.

5 CONTROL

5.1 The requirements in the above table and material documentation and workmanship shall be controlled for each individual boat at the final survey in accordance with chapter CI.

5.2 Control of welded joints by x-ray or similar method can be carried out in case such control is considered necessary.

Designation	Loa < 8.0 tn	Loa = 15.0 m	Remarks
Frame spacing	Max 300 mm	Max 300 mm	-
Bar keel	Sectional area IB cm^2. Min. thickness 16 mm	Sectional area 24 cm^2. Min. thickness 20 mm	Where bar keel is omitted keelplate = 2.5 x t bottom. Total breadth 30 x Loa mm
Centerkeel	Sectional area 18 cm^2. Min. thickness 6 mm	Sectional area 24 cm^2. Min. thickness 8 mm	Required only where the bar keel is omitted
Floor	Height 200 mm thickness 5.0 mm	Height 250 mm thickness 6.0 mm	Required only at every third frame on the other frames sceleton floors
Flange on top of floor	50 x 5.0 mm	50 x 6.0 mm	May be emitted where cement is inserted up to the top of the floors
Keelson	UNP 100	UNP 120	Required only where center keel is omitted
Frames	90 x 8.0 mm (22 cm^3)	100 x 8.0 mm (27 cm^3)	-
Bottom plates	4.5 mm	7.0 mm	Keel plates and stem plates to be increased with 1.0 m
Shell plating	4.0 mm	6.0 mm	-
Bulkheads	4.5 mm	6.0 mm	-
Bulkhead stiffeners	50 x 6.0 mm (6 cm^3)	50 x 8.0 mm (8 cm^3)	Maximum distance 500 mm
Deck	4.0 nun	6.0 mm	-
Deck beams	90 x 8 mm (27 cm^3)	90 x 8 mm (27 cm^3)	Maximum distance 300 mm. Maximum span 3.5 m
Bulwark	4.0 mm	5.0 mm	Stiffener 50 x 6 mm. Maximum distance 600 mm
Superstructure	3. 0 mm	5.0 mm	Stiffener 50 x 6 mm. Maximum distance 300 mm

LOADS C21

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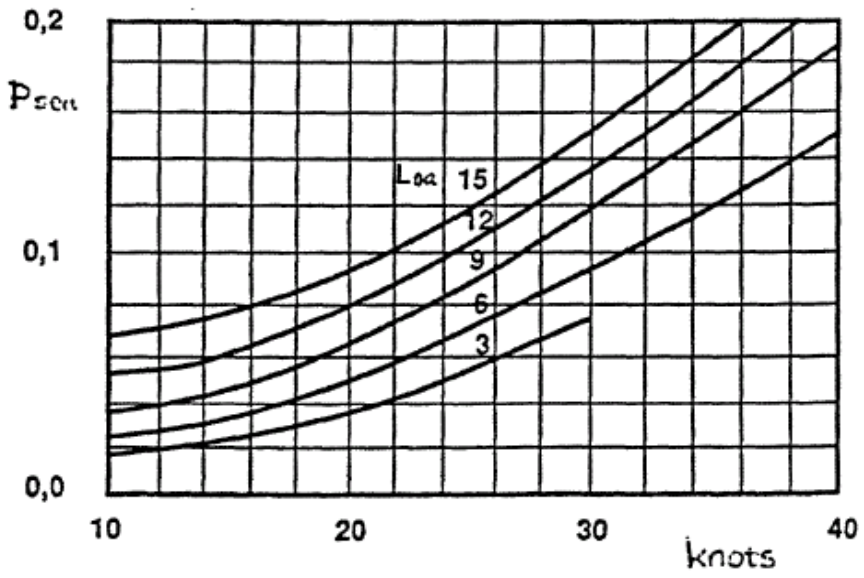
1 HULL LOADS

1.1 Wells, decks, floorings and superstructures shall be dimensioned for sea loads in relation to the size, speed, displacement and height above the waterline.

1.2 The following figure gives maximum sea loads with the maximum speed the boat can reach with little load.



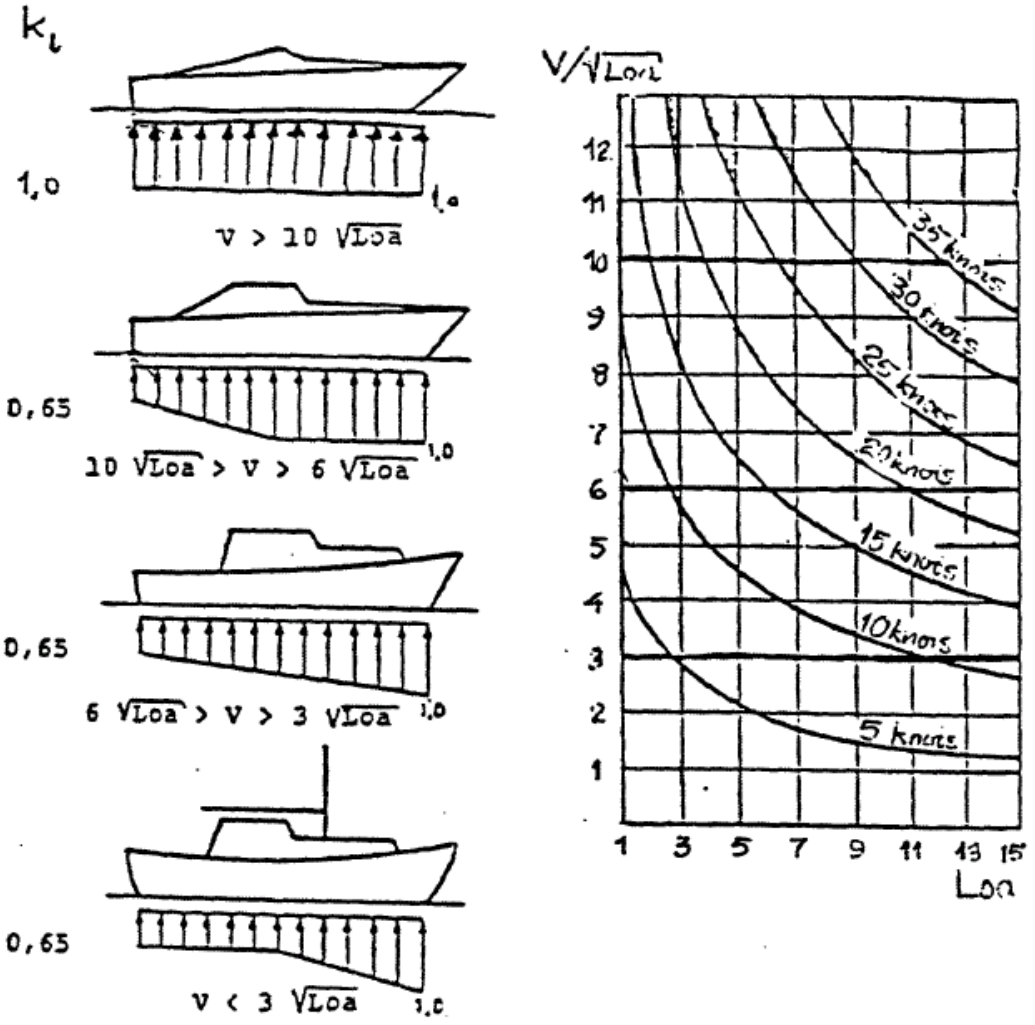
The length overall Loa in metres. Intermediate values will be obtained by interpolation. Dimensions shall not be calculated for a speed of less than 10 knots.

The dimensioning load (p) for the bottom is taken as the greater of

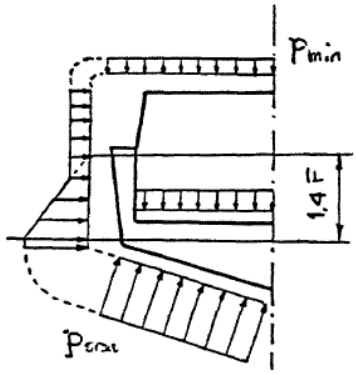
$p = k_1 * P_{sea}$
$p = p_{min}$

where k_1 is the longitudinal correction in 1.3.
p_{min} the minimum pressure in 1.6

1.3 The sea load correction factor k_1, varies longitudinally as shown in the following figures. When the bottom rise angle amidships is less than 12 degrees, 1.0 p is maintained for the whole length of the boat if V/ √Loa > 6.



1.4 The sea load correction factor (k_1) varies with the height above the waterline as shown in the figure below. The height of the sea load is determined in relation to the freeboard height (F) according to chapter C3 2.1 (a) and (b).



1.5 The load which determines the dimension for sides, deck and soles (floorings) is calculated as follows:

For height (h) to load on sides:

$$p = k_1 (1.4 * F - h) * p_{sea} / (1.4 * F),$$

however, minimum side load:

$$p = 0.3 * p_{sea}$$

For superstructure sides on a closed boat:

$$p = 0.2 * p_{sea}$$

For deck and flooring:

$$p = 0.01 + 0.002 * Loa + 0.06 * p_{sea}$$

For deck and flooring for load (g) in tons/m^2:

$$p = 0.08 * g$$

1.6 The general minimum load and the load for structural bulkheads are taken as:

$$P_{min} = 0.003 * Loa$$

DIMENSIONING OF GRP BOATS C22

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1 SCOPE

1.1 The following dimensioning requirements apply to boats with conventional design.

2 MATERIALS

2.1 Glassfibre and polyester shall be in accordance with chapters MC2 and MC3.

2.2 Glassfibre reinforced polyester shall have at least the following mechanical properties:

tensile strength	Rm	80	N/mm^2
flexural strength	Rmb	130	N/mm^2
tensile modulus		7000	N/mm^2

flexural modulus 6000 N/mm^2

2.3 Tensile strength and modulus shall be determined in accordance with ISO 3268. Test specimens should be taken at right angles. Flexural strength and modulus shall be determined in accordance with ISO 178. Test specimens should be taken at right angles. The mould face shall be subjected to compression.

2.4 The mean value of the results from the abovementioned tests shall comply with the stipulated requirements. No single value must be lower than 80% of the value used in the calculation.

2.5 The glass content in the cured laminate shall be at least 27% and no more than 45% by weight measured in accordance with ISO/R 1172-1975. The glass content must not vary with more than ± 4%. All individual values must comply with these requirements.

3. DEFINITIONS

3.1 Unless otherwise expressly stated, the following terms apply:

p	dimensioning load
V	highest speed of the boat in knots
t	thickness of the laminate
W	section modulus in mm^3
W/s	section modulus per breadth unit mm^3/mm
1	span in mm of frames, stiffeners and beams
s	stiffener/frame/beam spacing in mm.

4. CORRECTIONS

4.1 The correction factors for laminate thickness according to 4.2 - 4.5 shall be used for calculating a resulting correction factor:

$$f = f1 * f2 * f3 * f4$$

however, always at least 0.7.

4.2 In case the laminate has a greater flexural strength than 130 N/mm^2, the laminate thickness according to formulae where (f) is a factor, may be multiplied by a factor:

$f1 = \sqrt{(l30/Rmb)}$

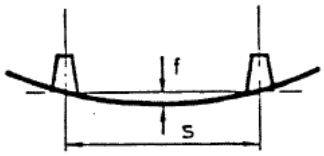
where Rmb is the flexural strength of the laminate.

4.3 When the ratio (a/b) between the sides in a not stiffened laminate panel (where (a) is the length of the greatest side and (b) the smallest) is less than 2, the laminate thickness according to formulae where (f) is a factor may be multiplied by a factor:

$f2 = 0.6 + 0.2\ a/b$

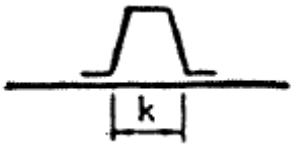
4.4 If the laminate has a significant curving, the laminate thickness according to formulae where (f) is a factor may be multiplied by a factor:

$f3 = 1 - h/s$, however, at least 0.8.



4.5 If the core of the frames has a greater breadth (k) than 0.1 * s, the laminate thickness according to formulae where (f) is a factor may be multiplied by a factor:

$f4 = 1.1 - k/s$, however at least 0.7.



4.6 The requirements in respect of section modulus are based on a tensile strength of at least 80 N/mm^2. When a laminate of higher tensile strength is applied, the requirements to section modulus may be reduced accordingly by multiplying with the factor:

$fw = 80/Rm$

where Rm is the tensile strength of the laminate.

5 SANDWICH PANELS

5.1 The following requirements apply to load carrying sandwich panels consisting of a core with face laminates on both sides.

5.2 In these strength requirements it is considered that normal and flexural stress is carried by the faces while the shear stresses are carried by the core.

5.3 A sandwich-panel shall at least have the same strength as that specified for an equivalent single skin construction in those rule formulae where the stiffener spacing (s) is included. This is considered fulfilled when the section modulus per breadth unit (W/s) for the sandwich panel complies with the requirements in 11.2, 13.3 and 13.4. For the calculation (s) shall be taken as 1 mm and as 1 is taken the shortest side of the panel.

Examples of section modulus for panels are shown in figure 22.5. The requirements in respect of section modulus may be multiplied by the factor f6 shown in the figure in 5.5.

5.4 The core material in sandwich constructions must not have a lower shear strength than:

$$\tau = 0.25 * f7 * p * l/d \qquad N/mm^2$$

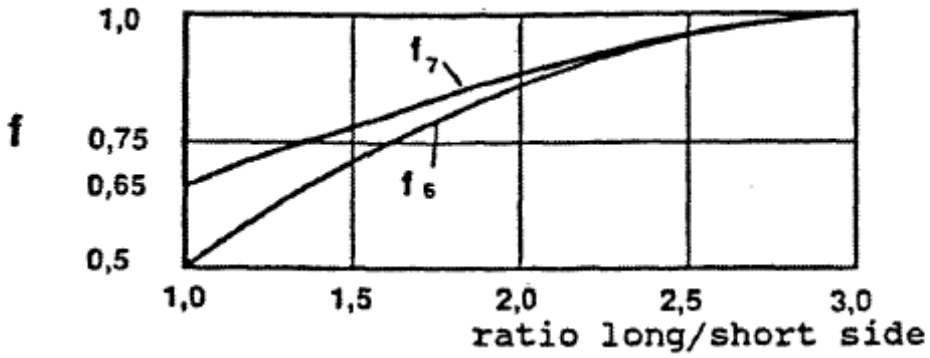
and must not be thinner than 0.01 l. In bottom panels the shear strength must not be lower than:

$$\tau = 0.046 * V \qquad N/mm^2,$$

however at least 0.7 N/mm^2, where

d distance between the middle of the faces
l the shortest side of the panel
f7 correction factor according to 5.5.

5.5 If the ratio between the long and short sides is less than 3 the required section modulus per breadth unit may be multiplied by the factor (f6) and the required shear strength by the factor (f7) shown in the figure below.



5.6 The thickness of the outer face laminate in the keel, stem, bottom, bilge and sides

should normally not be less than 40 per cent and in deck 60 per cent of the requirement for a single skin construction given in the formulae where the stiffener spacing (s) is not included.

Thinner face laminates may be accepted in bottom and sides, provided it is verified by testing that the impact strength of the sandwich panel is at least equivalent to that of a single skin panel with minimum laminate thickness for the boat type in question.

5.7 The ratio between the thickness of the thinnest and thickest face laminate should normally not be less than 0.75.

6 KEEL

6.1 The basic requirement for laminate thickness is:

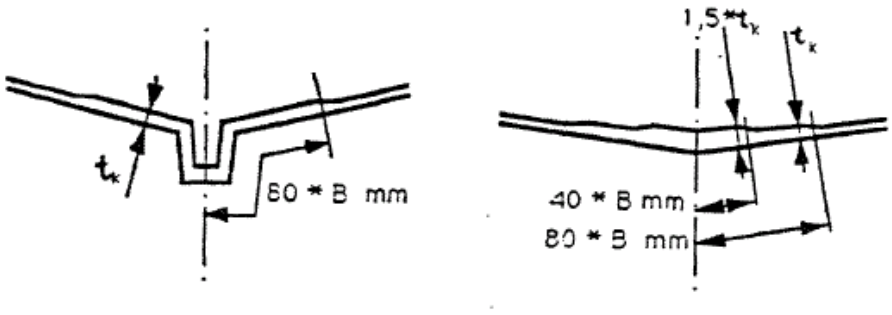
$$tk = 1.15 (2.9 + 0.9 * f1 * Loa + 0.1 * V) \text{ mm}$$

A keel of type 1 shall have a section modulus of at least:

$$W = 3.45 * G * Loa \text{ mm}^3$$

where G is the lightweight of the boat in kg.

In this section modulus may be included laminate out to 5 * t from the profile. The thickness requirement is shown in the following figure:

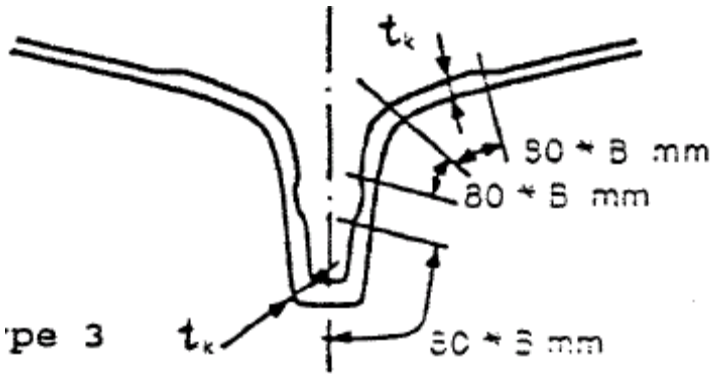


Keel type 1 Keel type 2

B is the breadth of the boat in metres.

6.2 Keels of type 2 and skegs shall at least have thicknesses in accordance with the figure above. The thickness (tk) shall be kept at least down to the upper edge of the ballast moulded in. When a keel profile or equivalent inside strengthening is not fitted, the laminate thickness shall be at least as indicated in the figure for a type 3 keel.

6.3 For hulls which are made in two halves, the laminate joining the two halves shall have the thickness required for a keel. The thickness of the original halves shall be tapered smoothly towards the joining line over a width not less than 20 times the thickness of the laminate.



Keel type 3

7 STEM AND BULWARK

7.1 The laminate in the stem shall have a thickness of at least

$$t = 1.15\ (2.9 + 0.9 * f1 * Loa) \quad \text{mm}$$

7.2 This laminate thickness shall be maintained over a transverse distance from the stem of at least 80 * B mm, but it need not have a breadth of more than 200 mm. A laminate joining of hull halves shall have the thickness which is required for a stem. The thickness of the original halves shall be tapered smoothly towards the joining line over a width not less than 20 times the thickness of the laminate.

8 BOTTOM

8.1 The bottom laminate is to extend at a constant thickness up to the larger of the following heights:

- up to the deepest load waterline
- up to a pronounced bilge

8.2 The thickness of the bottom laminate is to be not less than the greater of:

$$tb = 0.081 * f * s * \sqrt{p} \quad \text{mm}$$

$$tb = 1.15\ (1.4 + 0.5 * f1 * Loa + 0.08 * V) \quad \text{mm}$$

8.3 At a skeg or fin keel the difference in thickness between bottom laminate and keel laminate is to be tapered over a width of at least 40 times the thickness difference.

9 SIDE

9.1 The laminate thickness in the sides and in structural bulkheads must not be less than the greater of:

$$ts = 0.062 * f * s * \sqrt{p} \quad mm$$

$$ts = 1.15 (1.7 + 0.5 * f1 * Loa) \quad mm$$

Superstructures shall have a thickness of at least 75% of that given by the latter formula.

10 BILGE

10.1 If the radius of curvature in the bilge (chine) is less than 20 times the rule thickness of the bottom laminate, for a width of at least 100 mm on each side, the laminate thickness (t) is not be less than:

$$tc = 1.15 (2.4 + 0.7 * f1 * Loa + 0.06 * V)$$

in mm, however not less than the actual bottom laminate thickness.

11 DECK AND SOLE

11.1 The laminate thickness of deck and soles (flooring) must not be less than the greater of:

$$tc = 0.063 * f * s * \sqrt{p} \text{ mm}$$

$$td = 1.05 (1.6 + 0.4 * fl * Loa) \text{ mm}$$

11.2 At the centre of their span the beams must not have a section modulus of less than:

$$W = 0.76 * fw * s * p * l^2 * 10^{-3} \quad mm^3$$

11.3 For small decks not exposed to loads, the required stiffening may be reduced.

12 SUPERSTRUCTURES AND DECKHOUSES

12.1 Superstructures and deckhouses exposed to sea loads shall be given scantlings as required for the hull sides. Sea load is considered to extend to a height stipulated in chapter C21.

12.2 The scantlings of superstructure decks and cabin tops, etc which are expected to be exposed to load by persons shall be in accordance with the requirements of paragraph 11.

13 LONGITUDINAL STIFFENING

13.1 When calculating the section modulus the effective flange shall be taken as the sum of 20 * t and the width of the stiffener.

13.2 Boats for a maximum speed of more than 6 * L knots should be longitudinally stiffened in the bottom.

13.3 The section modulus of longitudinal bottom frames should not be less than:

$$W = 1.15 * fw * s * p * l^2 * 10^{-3} \text{ mm}^3$$

Longitudinal steps and spray strips may be considered as stiffening.

13.4 The section modulus of longitudinal frames in the sides and stiffeners on structural bulkheads and superstructures subjected to sea loads should not be less than:

$$W = 0.725 * fw * s * p* l^2 * 10^{-3} \text{ mm}^3$$

Longitudinal steps and spray strips may be considered as stiffening.

13.5 Longitudinal frames are normally to be supported by transverse girders or transverse bulkheads.

13.6 Transverse girders for longitudinal frames are to be calculated as transverse frames. For boats with a pronounced keel profile the length is measured from the center line.

13.7 For planing boats without longitudinal stiffening in the form of a pronounced keel the bonding of the girders into the hull sides is to have a shear area not less than:

$$A = 0.0006 * s * b * p \quad \text{mm}^2$$

where

$S = 0.5 * l_1 + 0.5 * l_2$

l_1 and l_2 are the lengths of the span fore and aft of the transverse stiffener.

14 TRANSVERSE STIFFENING

14.1 Boats with a maximum speed of up to 6 √L knots may have transverse stiffening with frames and only the keel construction as longitudinal stiffening.

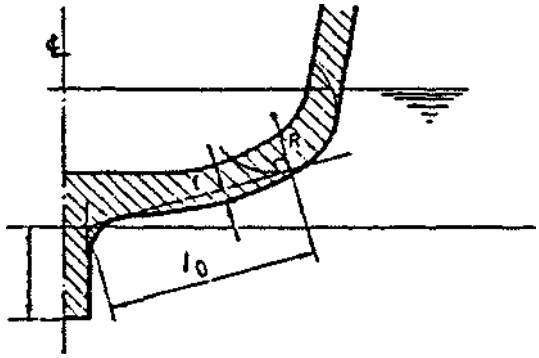
14.2 The transverse frames shall either be continuous across the keel or connected to transverse floors. The top of the frames shall be supported transversely by deck beams, deck laminate or longitudinal girders.

14.3 To the upper part of the bilge (chine) the section modulus of the transverse frames must not be lower than:

$$W = 0.69 * fw * s * p * l^2 * 10^{-3} \text{ mm}$$

where

$l = l_0 - 3 * f + 0.3 * R$ (the length of the frame in accordance with the figure below).



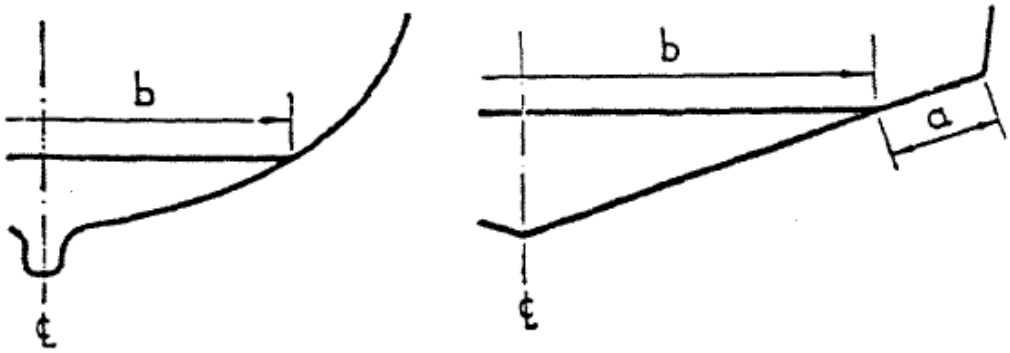
14.4 In the sides the section modulus at the upper part of the frame shall be at least 40% of the value required for the bottom. The tapering from the top of the bilge shall be uniform.

15 OTHER TYPES OF STIFFENING

15.1 Benches, flooring or other accommodation may replace side stiffeners if they are bonded properly to the hull along their full length.

15.2 The specified requirements for stiffening structure may be reduced provided the hull geometry itself contributes to the transverse or longitudinal strength.

15.3 In open boats the bottom stiffening may be wholly or partly made by a fixed bonded-in flooring. The breadth (b) must not be less than 0.25 * B. The distance (a) to the bilge (chine) must not be less than 0.15 * B.



15.4 If the hull is stiffened by foam, the foam is to have a sufficient compression and shear strength to provide adequate total stiffening of the bottom panels. The type of foam, its quality and the foaming process will be considered for approval in each individual case.

16 TRANSOM

16.1 Transom not subjected to loads from engine or rudder installation shall have scantlings as required for side laminate.

16.2 Transom for outboard motor mounting should be built as a sandwich-panel with a core of waterproof plywood or equivalent material. The lowest permitted total thickness for the parts of the transom subjected to loads from the engine installation is given in the table below:

Engine power as specified by the manufacturer		Total thickness of transom
kw	hk	mm
18 - 30	25 - 40	30
30 - 60	40 - 80	35
60 - 150	80 - 200	40

For higher power output the transom construction is considered in each individual case.

16.3 The transom for I/O units shall be built in accordance with 16.2, the total

thickness shall, however, be increased by 5 mm beyond the table values.

16.4 The inner laminate on the core should not have a thickness of less than 60% of that for the side and the outer not less than 60% of that for the bottom. Here is referred to the formulae where the stiffening spacing (s) is not included. The inside laminate shall extend in the sides and bottom of the boat and be gradually tapered in thickness.

17 DESIGN DETAILS

17.1 Structures of glassfibre reinforced plastics should as far as practicable be designed with well rounded transitions and without sharp edges. Where sharp edges cannot be avoided, e.g. at steps and imitated lap strakes, which are subjected to high flexural stresses, compensation shall be provided by additional reinforcement strips or overmoulding with additional laminate. The geometry must not be too complicated and constructions which make survey and repair difficult shall be avoided.

17.2 Structural designs which will introduce tensile stresses (dragpåkänningar) perpendicular to the laminate shall be avoided where such stress may lead to delamination or peel-off.

17.3 The stiffening members must not have significant discontinuities. Load carrying ends shall be sniped or connected to other structural parts.

17.4 Thickness transitions shall have a smooth taper of at least 20 times the thickness difference and in case of heavily loaded laminates at least 4 0 times the thickness difference.

In the design of sandwich panels the following shall be taken into account:

- the face layers shall be carried continuously through frames and other stiffeners
- in transitions from sandwich panels to single skin laminates, the core shall be tapered smoothly over a distance of two times the core thickness
- in way of local compression loads perpendicular on the panel the face laminate shall be reinforced or a massive core inserted for efficient load distribution
- where frames, bulkheads and similar members are fastened the thickness of the face layer shall be at least equal to that of the fastening laminate. The face layer shall be tapered smoothly over a distance of 20 times the thickness difference.

18 ENGINE FOUNDATION

18.1 If the engine is mounted directly on longitudinal bottom stiffeners they shall be interconnected in the transverse direction and their scantlings shall be increased.

The engine foundations shall be designed so that there will be sufficient stiffening between engine and shaft bearing.

18.2 The foundation shall be so designed that forces from engine, gear, pumps and shaft arrangements are properly transferred to the hull.

19 BALLAST KEEL

19.1 In the area of attachment of the ballast keel, the hull shall be stiffened.

19.2 Instead of an external ballast keel, ballast may be placed loose in a moulded keel built integral with the hull. The thickness of the laminate in way of the keel and its transition to the hull is determined on the basis of the expected loads on the structures. Loose ballast shall be moulded over to prevent any movement. Ballast of concrete may. be placed only in a space where the laminate is coated with topcoat or protected in another way.

20 CLEATS

20.1 The hull and deck where cleats are attached shall be reinforced in such a way that a sufficient distribution of the loads is achieved.

20.1 The reinforcement may be extra thickness of laminate, embedded plywood, metal plate or similar. When working out these extra reinforcements the size and direction of the loads shall be taken into account. The matting-in shall cover a sufficiently large area around the insert and the individual layers of the laminate shall overlap well.

21 CONNECTIONS

21.1 Connections shall be of simple design and easily accessible for inspection. The construction shall be such that there will be no risk of delamination of the connected laminates.

21.2 Rivets, bolts and washers shall be of corrosion resistant material or be protected against corrosion.

21.3 Holes for rivets and bolts shall be drilled and shall have the same diameter as the rivet or bolt. The distance from the laminate edge shall be at least 2.5 times the hole diameter for rivets and 3 times the hole diameter for bolts.

21.4 In stressed connections the bolt head and the nut shall be fitted with washers of

external diameter at least 2 times the hole diameter and a thickness of at least 0.1 times the hole diameter, minimum 0.5 mm. If the dimensions of the bolt head meet the requirements stipulated for the washer, the latter may be dispensed with. In highly stressed connections larger washers can be required.

21.5 In watertight connections a sealing agent shall be applied to the rivets/bolts before they are inserted.

21.6 Self tapping screws may be accepted in lightly stressed joints after consideration in each individual case. The screws shall be fitted perpendicular to the laminate. The laminate holding the screw shall have a sufficient thickness (at least 5 mm). Alternatively another screw hold may be fitted in or on the back of the laminate.

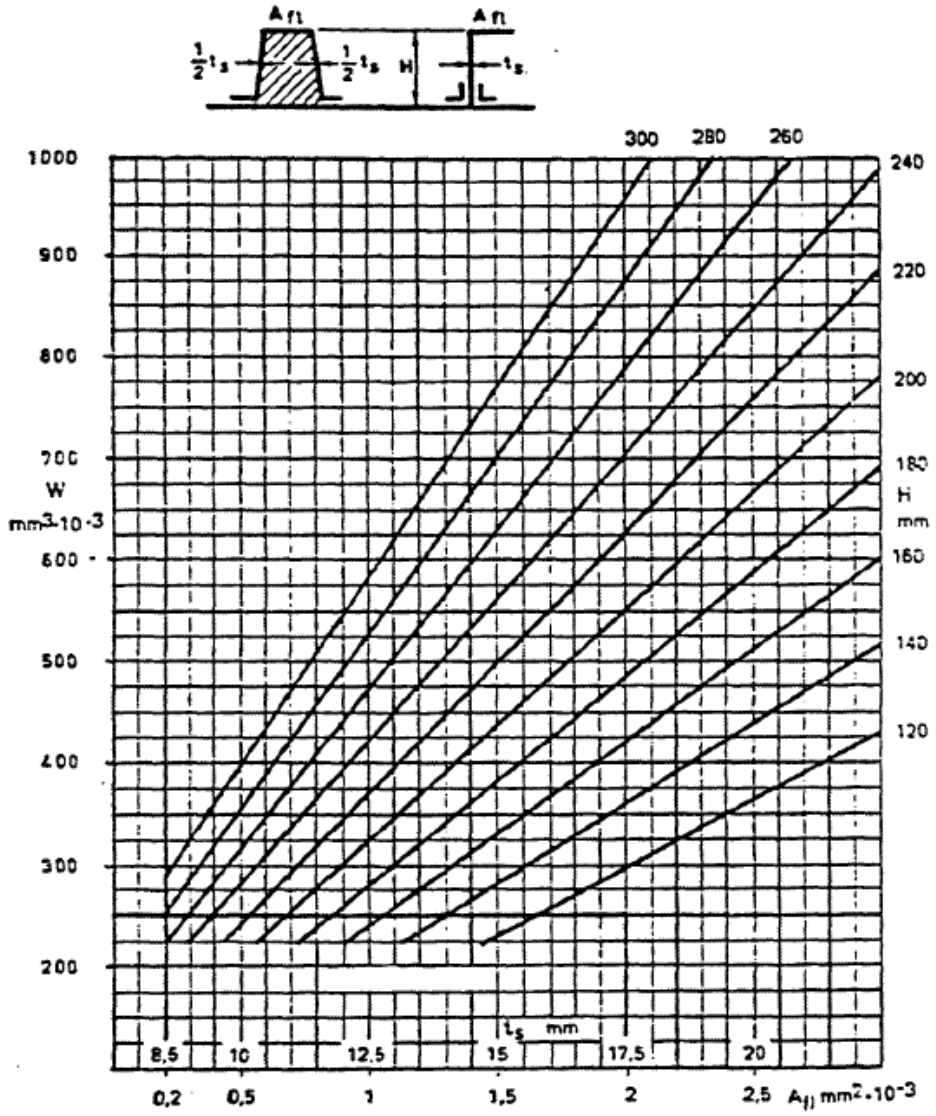


Figure 22.1
Section modulus, including contribution from the main laminate, for sections as

function of flange area Afl, core height H and web thickness ts.

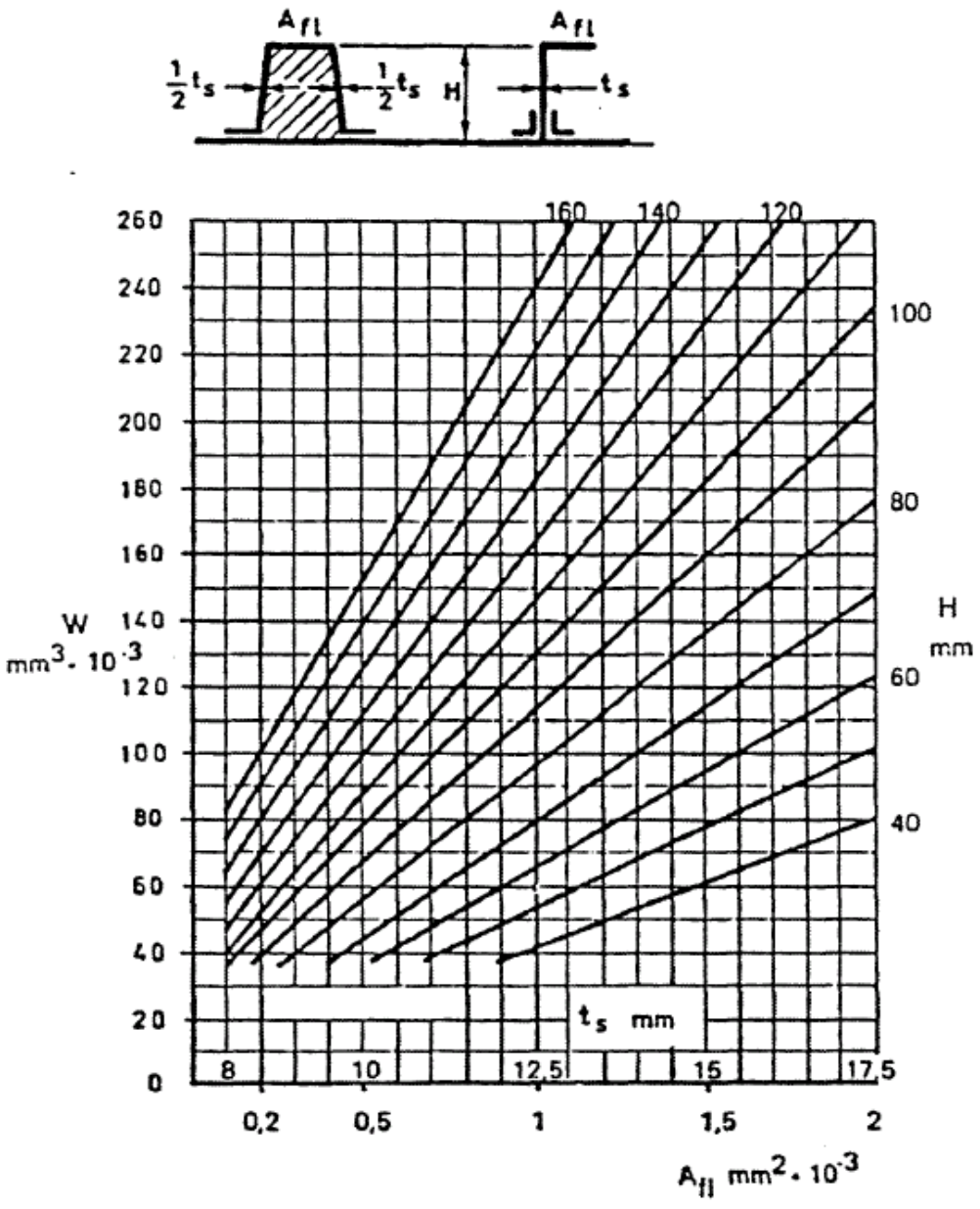


Figure 22.2
Section modulus, including contribution from the main laminate, for sections as function of flange area Afl, core height H and Web thickness ts.

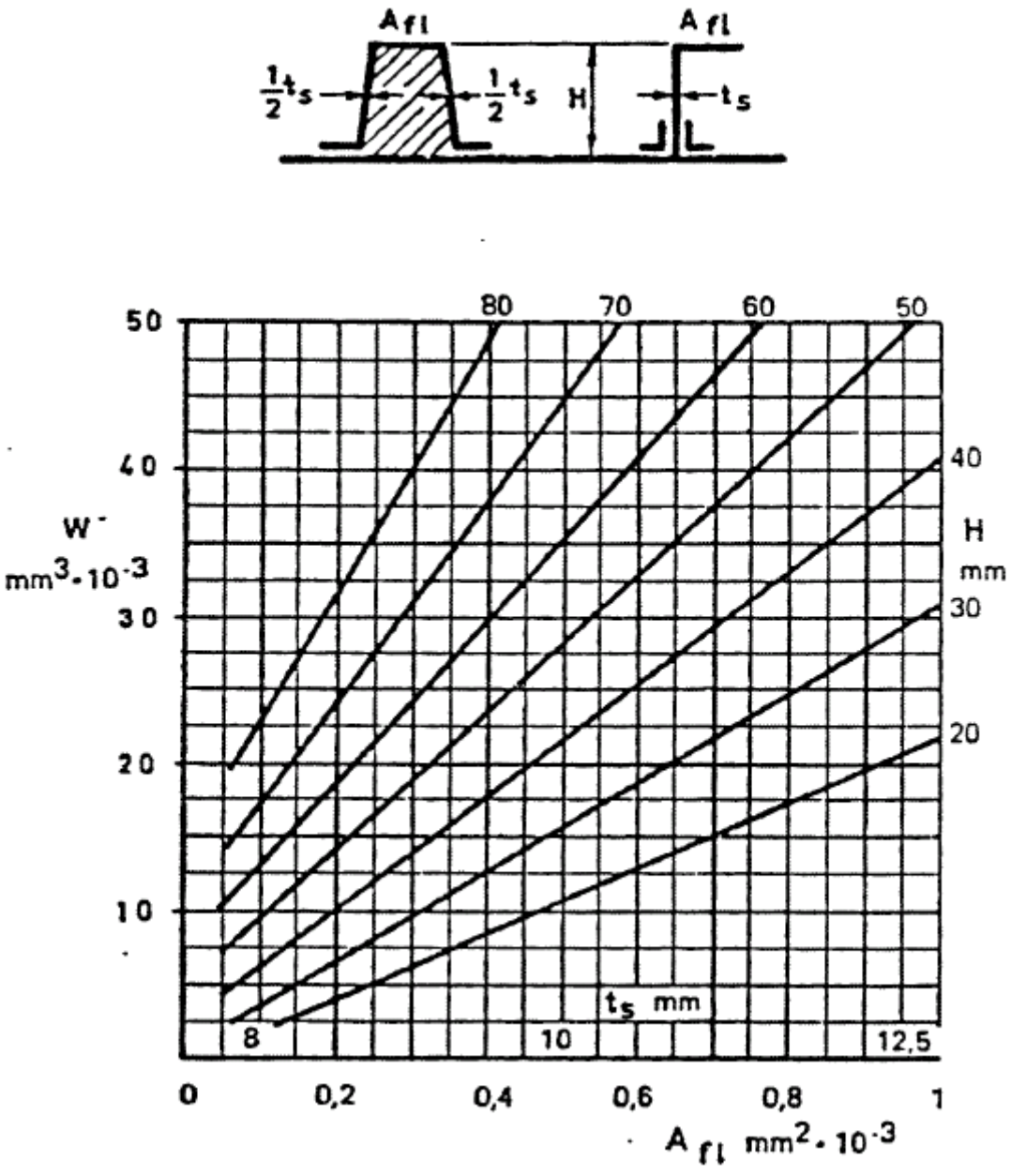


Figure 22.3
Section modulus including contribution from the main laminate of sections as funcition of flange area Afl, core height H and veb thickness ts.

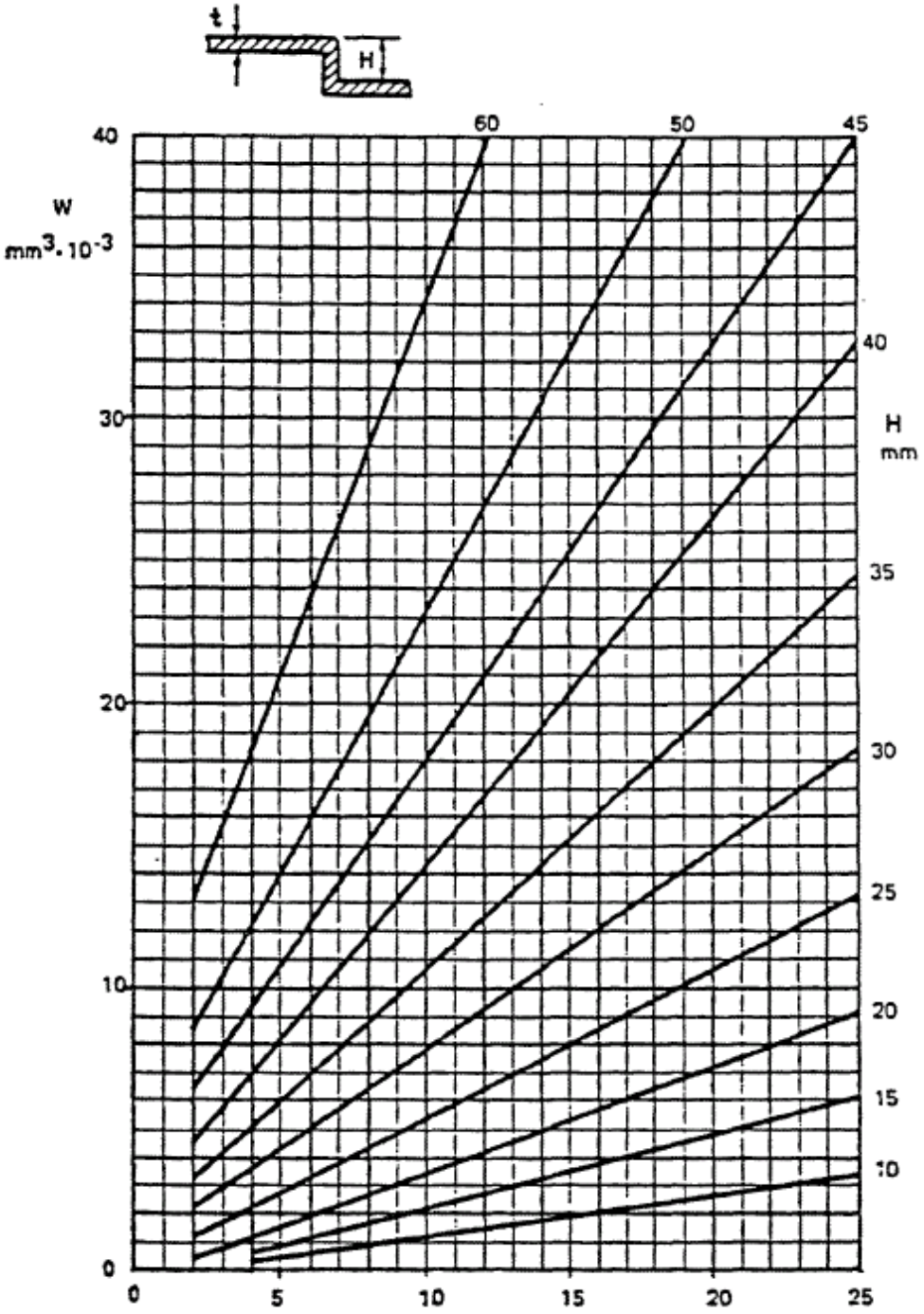


Figure 22.4
Section modulus of skin laminate steps as function of step height H and laminate thickness t.

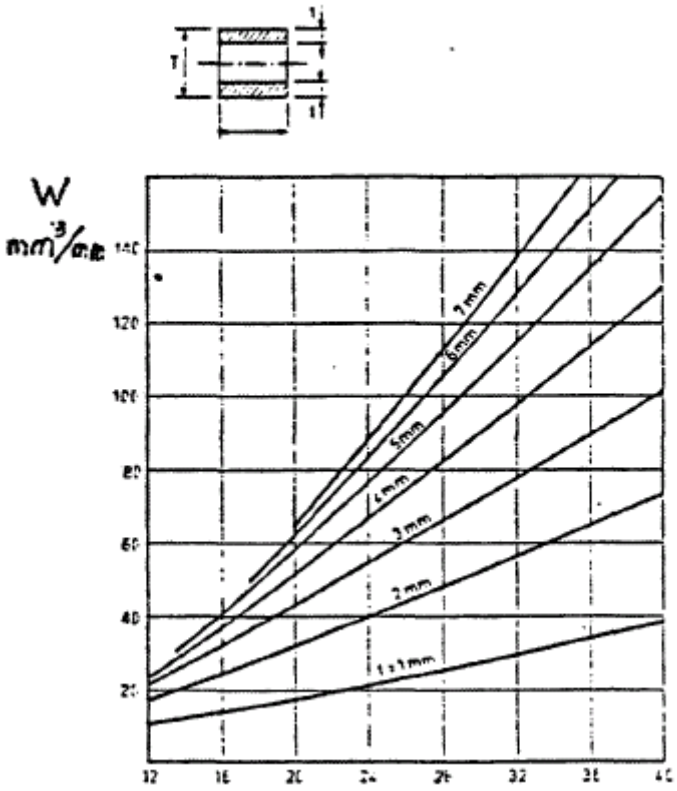


Figure 22.5
Section modulus per 1 mm breadth W/s for sandwich panels with skins of equal thickness.

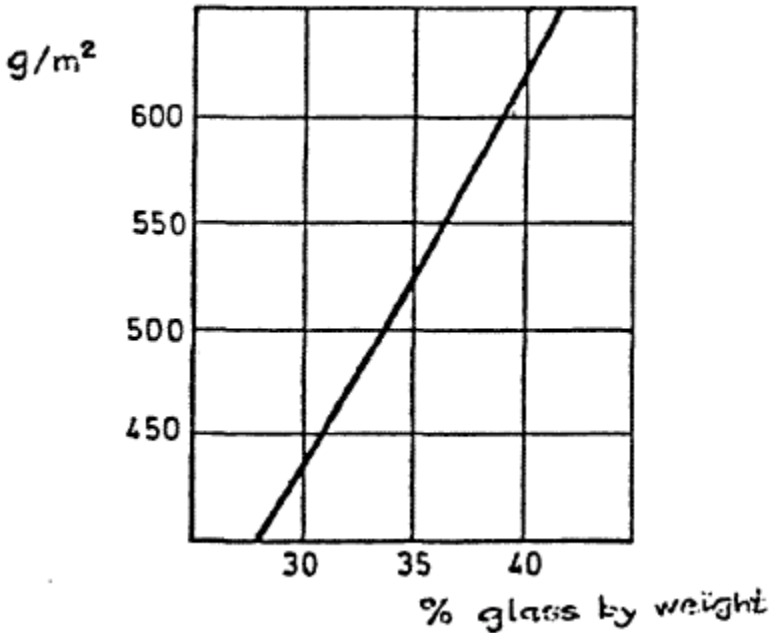


Figure 22.6
Weight reinforcement in g/m^2 to obtain 1 mm laminate thickness without air bubbles.

DIMENSIONING OF STEEL BOATS C23

Table of contents

1 MATERIALS

1.1 Normal shipbuilding steel shall have at least the following mechanical properties:

yield stress	240	N/mm^2
tensile strength	410	N/mm^2
ultimate strain	22	%

2 CORRECTIONS

2.1 The dimensioning is based on a material with yield stress σ_{02} = 240 N/mm^2. If steel with another yield stress is used the requirement to plate thickness may be multiplied by:

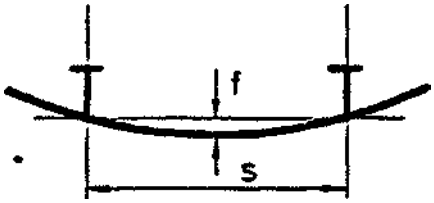
$$f1 = \sqrt{(240 / \sigma_{02})}$$

2.2 When the ratio (a/b) between the sides in an unstiffened panel (where (a) is length of the largest side and (b) is length of the shortest side) is less than 2, the requirement to plate thickness may be multiplied by:

$$f2 = 0.6 + 0.2 * a/b$$

2.3 If the plate has a significant curvature, the requirement to thickness may be multiplied by:

$$f3 = 1 - 0.8 * f/s, \text{ however at least } 0.85$$



2.4 For thickness of plates the correction factors are combined as follows:

$f = f1 * f2 * f3$

2.5 If the material has another yield stress than 240 N/mm^2, the section modulus may be multiplied by:

$fw = 240 / \sigma_{0.2}$

3 KEEL AND STEM

3.1 The keel and stem stiffening shall normally consist of a profile.

3.2 The section modulus for the keel profile with an effective flange (20 t) shall be at least:

$W = 1.04 * G * Loa\ mm^3$

where G is the lightweight of the boat.

3.3 If there is no profile keel, intended as a wear keel, the thickness of the plates at centre line shall be increased to:

$t = 1.5 * tb\ mm$

where tb is the thickness of the bottom plates according to 4.2.

The total breadth of the keel plate shall be at least

$b = 10 * Loa\ mm$

4 BOTTOM PLATING

4.1 The thickness of plates in the bottom shall be continued to the greatest of the following heights:

- up to the bilge (chine);
- up to the load waterline.

4.2 The thickness of the plates in the bottom shall be equal to the greater of the following values:

$tb = 0.049 * f * s \sqrt{p}$ mm

$tb_{min} = 1.15 (0.4 + 0.2 * f1 * Loa + 0.04 * V)$

5 SIDE PLATING AND BULKHEADS

5.1 The thickness of plates in the sides and in structural bulkheads shall be at least equal to the greater of the following values:

$ts = 0.023 * f * s \sqrt{p}$ mm

$ts_{min} = 1.15 (0.2 * f1 * Loa + 0.04 * V)$ mm

$tbulkhead_{min} = 0.75 * ts_{min}$ mm

6 DECK PLATING

6.1 The thickness of plates in decks shall be at least equal to the greater of the following values:

$td = 0.032 * f * s \sqrt{p}$ mm

$td = 1.05 (0.8 + 0.2 * fl * Loa)$ mm

7 STIFFENINGS

7.1 As effective flange may be taken (20 t) of the plate panel, however not more than (s).

7.2 The section modulus of stiffenings in the bottom shall be at least:

$W = 1.73 * fw * s * p * l^2 * 10^{-4}$ mm^3

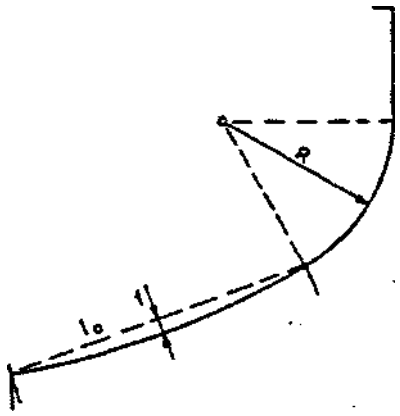
7.3 The section modulus of stiffenings in the sides and in structural bulkheads shall be at least:

$W = l,27 * fw * s * p * l^2 * 10^{-4}$ mm^3

7.4 When calculating the section modulus of transverse frames an (1) according to

the following formula is used:

$l = l_0 - 3 * f + 0.3 * R$ (the length of the frame in accordance with the figure below).



7.5 Deck beams shall have a section modulus of at least:

$$W = l{,}68 * fw * s * p * l^2 * 10^{-4} \quad mm^3$$

7.6 Stiffeners should normally be profiles with flanges. If a plate profile without flange is used the stiffness against buckling should be checked

8 TRANSOM AND ENGINE FOUNDATION

8.1 The transom for outboard motors and stern drive (I/O units) shall be constructed so that the forces from the engine are transferred to the stiffening system in the hull.

8.2 The thickness of plates in the transom for outboard motors and stern drives is considered in each individual case but must never be less than the thickness required for the bottom. In case of larger outboard motors and stern drives the transom shall be strengthened with a beam construction which takes up the forces from the engine.

8.3 A transom which is not subjected to loads from the motor shall have scantlings as required for the side plating.

8.4 Inboard engines shall be mounted on an engine bed which shall be interconnected in the transverse direction. The engine bed shall be waningly extended beyond the ends of the engine for a distance equal to the length of the engine, however, at least 0.5 metre. The extension shall be carried regardless of bulkheads or other longitudinal stiffenings.

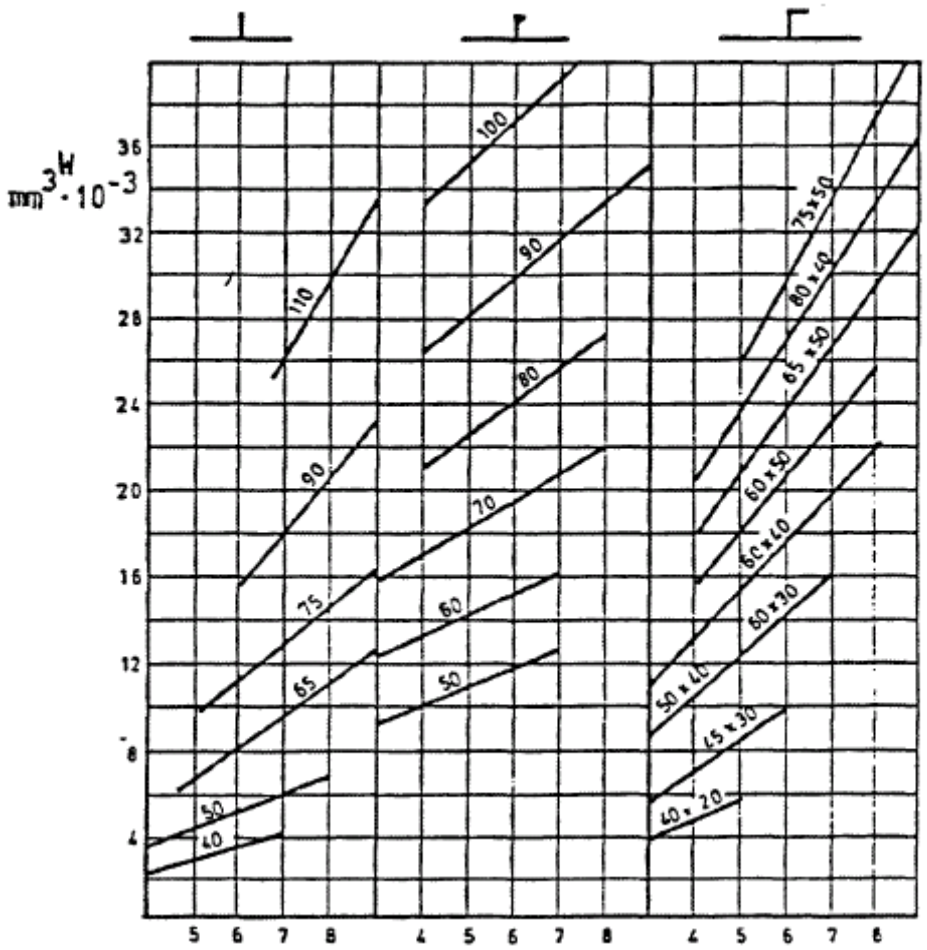
9 SUPERSTRUCTURE, DECKHOUSE AND STRENGTHENINGS

9.1 Superstructures and deckhouses exposed to sea pressure shall be dimensioned as required for the side plating.

9.2 Superstructure decks, cabin tops, etc which are expected to be exposed to loads by persons shall be dimensioned as for decks.

9.3 Outlets and holes in the hull with a diameter of more than 250 mm shall be strengthened.

9.4 Hull and deck where cleats shall be attached shall be strengthened so that a sufficient distribution of the load is achieved.



Section modulus for profiles welded to plates with a thickness of 4 to 6 mm. The values at the curves refer to profile height in mm.

DIMENSIONING OF ALUMINIUM BOATS C24

Table of contents

1 MATERIALS

1.1 Materials of the following categories shall normally be used:

category 1 non-heat treatable alloy examples

content limitations	ASTM	DIN 1725
	5052	AlMg2.5
	5083	AlMg4.5Mn
	5086	AlMg4Mn
	5154	AlMg3
	5454	A1M2.7Mn

category 2 treatable alloy examples

content limitations		ASTM	DIN 1725
		6005	AlMgSi0.7
Cu max	0.4%	6063	AlMgSiO,5
Fe max	0.5 %	6351	AlMgSil

In table 24.1 some common alloys and their strength properties are listed.

2. CORRECTIONS

2.1 The dimensioning is based on materials with a yield stress of:

$\sigma_{02} = 170$ N/mm^2

If aluminium with another yield stress is used, the plate thickness shall be corrected by the following factor:

$f1 = \sqrt{(170 / \sigma_{02})}$

For welded constructions the yield stress is calculated as follows if not otherwise documented:

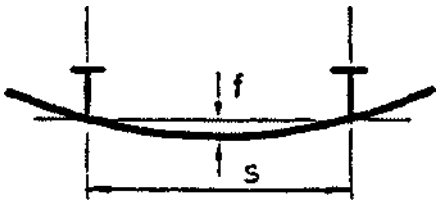
$\sigma_{02\ welded} = \sigma_{02}\ \sigma_{8\ weled} / \sigma_{8}$**e**

2.2 When the ratio (a/b) between the sides of an unstiffened panel (where (a) is the length of longest side and (b) the length of the shortest side) is less than 2 the plate thickness may be multiplied by the factor f2:

$f2 = 0.6 + 0.2 * a/b$

2.3 If the plating has a pronounced curvature the plate thickness may be multiplied by the factor f3:

$f3 = 1 - 0.8 * f/s$, however at least 0.85



2.4 If the stiffeners have a breadth (k) greater than (0.1 s), the plate thickness may be multiplied by the factor f4:

$f4 = 1.1 - k/s$, however at least 0.7

2.5 If more than one correction is used at the same time the total correction of the thickness will be:

$f = f1 * f2 * f3 * f4$

2.6 Sandwich constructions shall be performed after the same principle as that in chapter C22 section 5.

2.7 If aluminium with another yield stress than 170 N/mm is used, the section modulus shall be corrected by the factor fw:

$fw = 170/ \sigma_{02}$

where σ_{02} is the yield stress, for a welded construction the $\sigma_{02\ welded}$ shall be used, see 2.1

3 KEEL, STEM AND BILGE

3.1 The reinforcement of the keel and the stem shall normally be a profile.

3.2 The section modulus for the keel profile with an effective-flange (20 t) shall be at least:

$$W = 1.44 * G * Loa \quad mm^3$$

where G is the lightweight of the boat.

3.3 If there is no profile keel, intended as a wear keel, the thickness of the plates at the centre line shall be increased to:

$$t = 1.5 * tb \quad mm$$

where tb is thickness of the bottom plates according to 4.

The total breadth of the keel plate shall be at least:

$$b = 10 * Loa \quad mm$$

3.4 Keel, stem, bilge area and other parts which are particularly exposed to wear shall be designed so that the strength in joints are not significantly decreased through wear.

4 BOTTOM PLATING

4.1 The thickness of the plates in the bottom shall be continued to the greatest of the following heights:

- up to the bilge
- up to the load waterline.

4.2 The thickness of the plating in the bottom shall be equal to the greater of the following values:

$$tb = 0.049 * f * s * \sqrt{p} \quad mm$$

$$tb = 1.15 (0.4 + 0.2 * f1 * Loa + 0.04 * V) \quad mm$$

5. PLATING IN THE SIDES AND IN BULKHEADS

5.1 The thickness of plates in the sides and in structural bulkheads shall be at least equal to the greater of the following values:

$$ts = 0.028 * f * s * \sqrt{p} \quad mm$$

$$ts_{min} = 1.15 (0.2 * f1 * Loa + 0.04 * V)$$

for bulkheads $0.75\ ts_{min}$

6. DECK PLATING

6.1 The thickness of plates in decks shall be at least equal to the greatest of the following values:

$$td = 0.038 * f * s * \sqrt{p} \quad mm$$

$$td = 1.05 (0.8 + 0.2 * f1 * Loa), \text{ min } 1.5 \text{ mm}$$

7. STIFFENINGS

7.1 As effective flange may be taken (20 t) of the plate panel, however not more than (s).

7.2 The section modulus of stiffenings in the bottom shall be at least:

$$W = 2.4 * fw * s * p * l^2 * 10^{-4} \quad mm^3$$

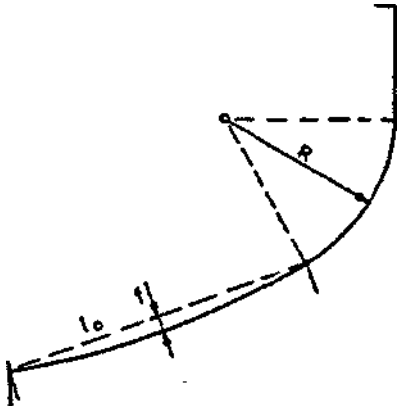
7.3 The section modulus of stiffenings in the sides and in structural bulkheads shall be at least:

$$W = 1.5 * fw * s * p * l^2 * 10^{-4} \quad mm^3$$

7.4 When calculating the section modulus of transverse frames an (1) according to the following formula is used:

$$l = l_0 - 3f + 0.3\ R$$

where lo is length of the straight part of the frame in the bottom as shown in the sketch below.



7.5 Deck beams shall have a section modulus of at least:

$$W = 2.4 * fw * s * p * l^2 * 10^{-4} \quad mm^3$$

7.6 The stiffenings should normally be of a profile with a flange. If a plate profile without flange is used the stiffness against buckling should be controlled.

8 TRANSOM AND ENGINE FOUNDATION

8.1 The transom for outboard motors and stern drive (I/O units) shall be constructed so that the forces from the engine are transferred to the stiffening system in the hull.

8.2 The thickness of plates in the transom for outboard motors and stern drives (I/O units) is considered in each individual case but must never be less than the thickness required for the bottom. In case of larger outboard motors and stern drives (I/O units) the transom shall be strengthened with a beam construction which takes up the forces from the engine. For outboard motors below 7.4 kW (10 hk), strengthenings of plywood on the transom can be accepted.

8.3 A transom which is not subjected to loads from the engine shall have scantlings as required for the side plating.

8.4 Inboard engines shall be mounted on an engine bed which shall be interconnected in the transverse direction. The engine bed shall be waningly extended beyond the ends of the engine for a distance equal to the length of the engine, however, at least 0.5 metre. The extension shall be carried regardless of bulkheads or other longitudinal stiffenings.

9 SUPERSTRUCTURES, DECKHOUSES AND STRENGTHENINGS

9.1 Superstructures and deckhouses exposed to sea pressure shall be dimensioned as required for the side plating.

9.2 Superstructure decks, cabin tops, etc which are expected to be exposed to loads by persons shall be dimensioned as for decks.

9.3 Outlets and holes in the hull with a diameter of more than 250 mm shall be strengthened.

9.4 Hull and deck where cleats shall be attached shall be strengthened so that a sufficient distribution of the load is achieved.

Table 24.1
Examples of category 1 marine grade aluminium. Three conditions are listed for each alloy.

Alloy	Condition 1)	Yield stress $\sigma_{0.2}$ N/mm^2	Ultimate strength $\sigma_{0.2}$ N/mm^2	Elongation A_5 %	Ultimate strength as welded $\sigma_{8\ welded}$ N/mm^2
ISO A1MQ2.5					
DIN AlMg2.5	W17(.10)	60	170	20	170
AA 5052	0	65	170	17	170
DIN AlMg2.5	F23 (.26)	180	230	5	170
AA 5052	H34	180	235	4	170
DIN AlMg2.5	F27(.30)	240	270	3	170
AA 5052	H38	220	270	4	170
ISO AlMg3Mn					
DIN AlMg2.7Mn	F22(0.7)	100	215	17	215
AA 5454	0	85	215	12	215
DIN AlMg2.7Mn	G25(.25)	180	245	10	215
AA 5454	H32	180	250	5	215
DIN AlMg2.7Mn	G27(.27)	200	270	9	215
AA 5454	H34	200	270	4	215
ISO AlMa3					
DIN AlMg3	W19(.10)	80	190	20	190
AA 5154	0	75	205	13	205
DIN AlMg3	F24(.26)	190	240	5	190
AA 5154	H32	180	250	6	205
DIN AlMg3	F29(.30)	250	290	3	190
AA 5154	H36	220	290	5	205
ISO AlMa4Mn					
DIN AlMg4Mn	W24(.10)	100	240	18	240
AA 5086	0	95	240	16	240
DIN AlMg4Mn	F30(.26)	240	300	5	240
AA 50B6	H34	235	300	5	240

DIN AlMg4Mn	F33(.28)	270	325	4	240
AA 5086	H36	260	325	4	240
ISO AlMa4. 5Mn					
DIN AlMg4.5Mn	W28(.10)	125	275	17	275
AA 5083	0	125	275	16	275
DIN AlMg4.5Mn	G31(.25)	205	310	10	275
AA 5083	H32	235	310	8	275
DIN AlMg4.5	G35(.27)	270	345	6	275
AA 5083	H34	270	345	6	275

Examples of category 2 marine grade aluminium. Profiles and rods according to DIN 1748 and ASTM B 221 standards. Two conditions are listed for each alloy. The conditions given within brackets refer to "werkstoff no." according to DIN 17007.

Alloy	Condition 1)	Yield stress $\sigma_{0.2}$ N/mm^2	Ultimate strength $\sigma_{0.2}$ N/mm^2	Elongation A_5 %	Ultimate strength as welded $\sigma_{8\ welded}$ N/mm^2
ISO Al-SiMg					
DIN AlMgSi0.7	-				
AA 6005	T1	105	170	14	130
DIN AlMgSi0.7	F27 (.61)	225	270	8	160
AA 6005	T5	240	260	8	155
ISO Al-MgSi					
DIN AlMgSi0.5	F13(.51)	65	130	15	100
AA 5052	T4	70	130	12	100
DIN AlMgSi0.5	F22(.71)	160	215	12	110
AA 6063	T6	170	205	7	115
ISO Al-Si1MgMn					
DIN AlMgSi1	F21(0.51)	110	205	14	160
AA 6351	T4	130	220	14	175
DIN AlMgSi1	F28(.71)	200	275	12	170
AA 6351	T6	255	290	8	180

DIMENSIONING OF WOODEN BOATS C25

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1 DEFINITIONS

1.1 Unless otherwise stated, the following symbols apply:

p load factor
v maximum speed of the boat in knots
t material thickness in mm
W section modulus in mm^3
1 length of span of frames, stiffeners and beams in mm
s spacing of frames, stiffeners and beams in mm measured between their centrelines.

2. GENERAL

2.1 The dimensioning requirements for boats with transverse frames are based on that the speed does not exceed 15 knots.

2.2 The dimensioning requirements for planing boats with a speed of more than 15 knots are based on that the boats have longitudinals in the bottom.

2.3 Boats with longitudinal planking shall have transverse framing.

3. WEIGHT CLASSES FOR TIMBER

3.1 The requirements for scantlings and moduli are based on use of air-dried timber which shall have the following standard weights at 15% moisture content:

Double grown frames Bent frames Engine seats	vr = 720 kg/m^3
Keel Keelson Hog Stem Sternpost Counter timber Knees	vr = 640 kg/m^3
Outside planking, except clinker Longitudinals Laminated frames Stringers Deck beams Covering board	vr = 560 kg/m^3
Clinker planking Deck planking Deckhouse	vr = 430 kg/m^3

3.2 Boats with a length of less than 6 metres may be built of timber weighing less than stated in the table above on condition that the necessary strength can be achieved.

4 CORRECTIONS

4.1 If the weight of the timber used is different from the table values, the scantlings shall be correct in direct proportion:

$f_1 = vr/va$, minimum 0.9

where

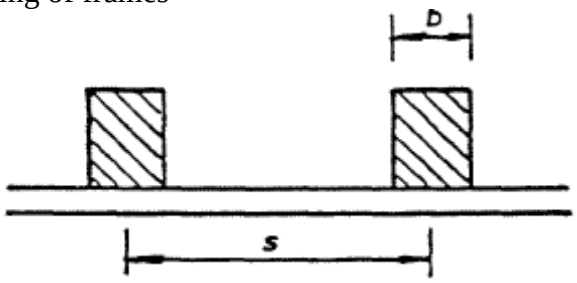
vr is the weight of timber according to table
va actual weight of the timber concerned

4.2 Where the width of the frames exceeds (0.1 s), the thickness of the outside planking required by a formula where (f) appears, may be corrected by multiplication by the factor (f2):

$f_2 = 1.1 - b/s$, minimum 0.8

where

b is width of frames
s spacing of frames



4.3 If both corrections are used the correction factor is as follows:

$f = f_1 * f_2$

5 KEEL AND STEM

5.1 The section modulus of keel and stem for massive timber shall not be less than:

$W = 8 * f * Loa^2 * 10^3 \ mm^3$

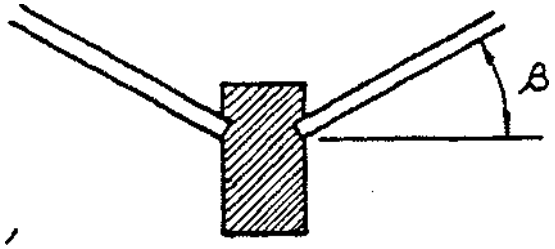
and for laminated timber not less than:

$W = 6.4 * f * Loa^2 * 10^3 \quad mm^3$

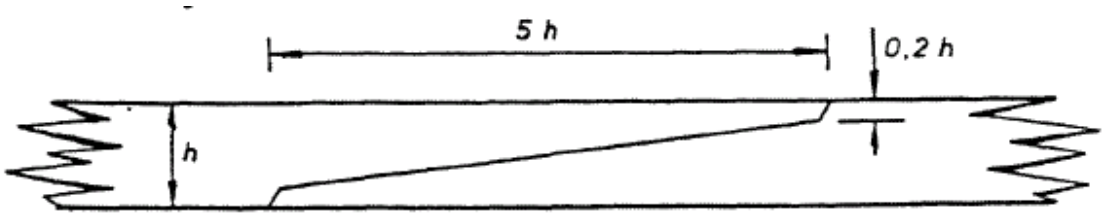
The aspect ratio of moulding/siding is not to be less than 2 and not to exceed 3.

The section modulus may be corrected for raised bottom and acute angle of outside planking to stem by multiplying the rule demand with the following factor:

$k = 1.5 - 0.025 * \beta$, minimum 0.5.



5.2 The keel should preferably be built in one unit. When a scarf is necessary, its length shall be at least 5 times the height of the keel. The scarf shall be bolted by minimum 6 bolts, three on each side of the centre line. A scarf must not be at the location longitudinally of the engine seating ends. Boats intended for running up on the shore shall be provided with an extra wear keel and strengthened stem.



5.3 Displacement boats with a length overall of more than 8 metres shall within 0.7 Loa amidships have a keelson with dimensions not less than:

breadth (b) = 12 * Loa mm

height (h) = 10 * Loa - 40 mm

5.4 On boats with a length overall of more than 6 metres the frames shall be fastened to the keel by through bolts of diameters of not less than:

$$d = 1.0 * Loa \quad mm$$

The keel bolts shall go through keel, inner keel, keelson and frame or floor and shall be fitted in a zigzag manner.

5.5 On boats with a length overall of less than 6 metres the keel may be fastened by screws to the frames and floors or vice versa. There shall be two screws in each frame and their diameter shall not be less than 6 mm.

5.5 The ballast keel shall be sufficiently fastened by bolts of stainless steel or equivalent material with respect to the keel material. The number and diameter of the bolts is determined in each individual case.

5.7 For boats with clinker planking or plywood planking the contact surface of the inner keel against the planking shall have a thickness and breadth of at least 1.5 times the thickness of the planking.

If necessary in order to achieve a sufficient contact surface against the planking, an inner stem (apron) shall be built-in and have a thickness of at least:

$$t = 20 + 4 * Loa \quad mm$$

The inner stem shall be fastened to the stem by through bolts of the same diameter as the keel bolts.

5.8 The thickness of the stern post on each side of the sterntube shall be at least 3 Loa mm.

5.9 The thickness of deadwoods shall not be less than the thickness of the keel and stem. The length of the arms on each side of the joint between keel and stem shall be at least:

$$l = 150 + 40 * Loa \quad mm$$

The deadwoods shall be fastened to the keel and stem with at least two bolts with the same diameter as the keel bolts in each arm of the deadwoods.

6 DOUBLE GROWN FRAMES

6.1 By double grown frames is meant that two frames are bolted together with their butts staggered (overlapping in the middle). If the frame is straight enough to be without butts, e.g. in the foreship, the frames may be single.

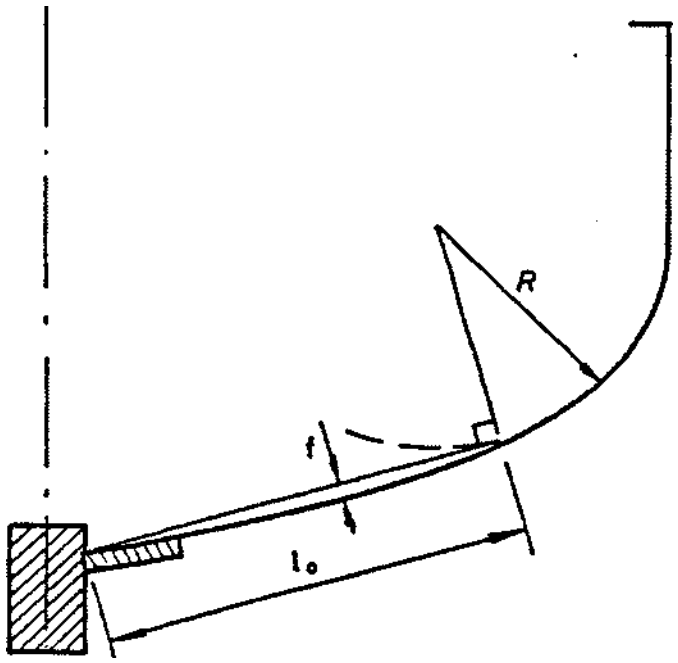
6.2 The section modulus of each frame section in the bottom shall not be less than:

$$W = 4.8 * f * s * p * l^2 * 10^{-3} \quad mm^3$$

where

$l = l_0 - 3 * f + 0.3 * R$ (the length of the frame in accordance with the figure below).

The ratio height/breadth shall not exceed 1.5.



6.3 The section modulus above the bilge may be reduced gradually to 0.5 W by the top of the frames.

6.4 Double grown frames shall normally be fastened together by at least three 10 mm bolts.

6.5 Butts shall be fitted closely and stagger at least:

$$1 = 100 + 100 * B \quad mm$$

where B is the extreme breadth of the hull in metres.

6.6 When the angle of frame against the planking in the fore and aft ship exceeds 60 degrees, the frames shall be fitted perpendicularly to the planking.

7 LAMINATED FRAMES

7.l The section modulus of the frames in the bottom shall not be less than:

$$W = 3.7 * f * s * p * l^2 * 10^{-3} \quad mm^3$$

7.2 The section modulus above the bilge may be reduced gradually to 0.5 W by the top of the frames.

7.3 The height of the frames must not be greater than the breadth.

7.4 Where the frames are continuous across the keel, the height in the centre line shall not be less than that required for floors.

8 LONGITUDINALS

8.1 The section modulus of the longitudinals must not be less than:

$$W = 4.6 * f * s * p * l^2 * 10^{-3} \quad mm^3$$

8.2 The section modulus of the uppermost longitudinal shall be not less than 1.3 times that required for longitudinals in the side of the boat and it shall extend from stem to stern. On boats with a raised deck forward, the longitudinal below the forecastle shall extend from stem to stern.

8.3 Longitudinals shall normally be supported by bulkheads or web frames.

9 WEB FRAMES

9.1 The section modulus of web frames shall not be less than:

$$W = 3.7 * f * s * p * l^2 * 10^{-3} \quad mm^3$$

where

$$S = 0.5 * l_1 + 0.5 * l_2$$

l_1 and l_2 are the lengths of the span fore and aft of the transverse stiffener.

10 BENT FRAMES

10.1 The section modulus of bent frames shall be at least:

$$W = 3.7 * f * s * p * l^2 * 10^{-3} \quad mm^3$$

10.2 Several bent frames may be installed one after the other and the section modulus may be calculated for the collected thickness. Each layer shall not be less than 15 mm.

10.3 Where a bent frame is continuous across the keel, the necessary spacer blocks shall be inserted as an alternative to floors. The spacer block and the frame shall together fulfill the requirement for floors.

10.4 Carvel built boats shall not be built with only bent frames. In boats where it is used a combination of built (laminated/double grown frames) and bent frames, the number of bent frames shall not exceed three between each built (shaped) frame.

10.5 When intermediate bent frames do not fulfill the requirements in 10.1, this shall be taken into account in the correction of the requirement in respect of built frames by multiplying the spacing of the built frames with the following factor:

$$f = 1 - 0.5 * W_{bent} / W_{built}$$

where

W_{built} is the retirement for built frames
W_{bent} sum of bent frames between built frames.

11 ENGINE SEATS

11.1 The engine seat shall be arranged in the longitudinal direction and be mounted on floors. It shall be dimensioned with respect to the frame spacing and size of the engine.

11.2 The engine seat shall be sufficiently stiffened sideways if the floors do not give a sufficient transverse support.

11.3 The engine seat shall be through bolted to floors and planking. The number and dimension of the bolts shall be at least equal to those for the engine fastening bolts. The bolts shall be accessible for tightening also after the engine has been installed.

11.4 The engine seat longitudinals shall extend at least 500 mm forward and aft of the engine.

12 FLOORS

12.1 Floors shall be installed (mounted) at each transverse frame.

12.2 The floors shall have at least the same breadth as the frames and the height in the center line (hi) shall be at least:

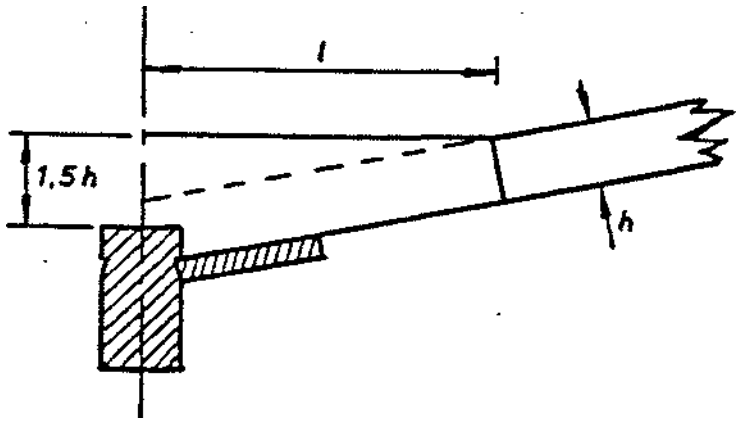
$$hi = 1.5 * h \quad mm$$

where h is the height of the frames in the bottom in mm.

12.3 The length of the floors from the center line shall be at least:

$$l = 100 + 100 * B \quad mm$$

where B is the greatest breadth of the hull in m.



13 CLINKER PLANKING

13.1 The thickness of the planking shall not be less than the greater of the following values:

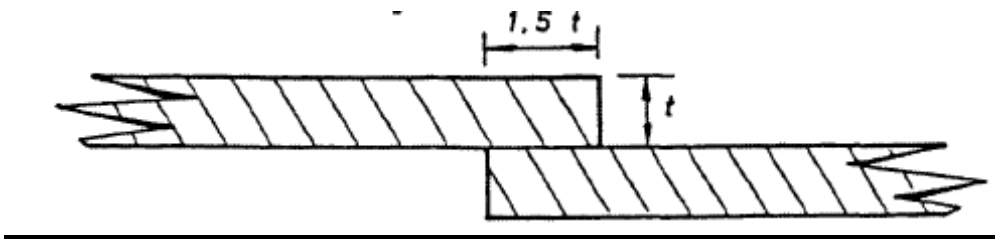
$$t = 0.39 * f * s \sqrt{p} \quad mm$$

$$t = 2.0 + 2.2 * Loa \quad mm, \text{ however minimum } 12 \text{ mm.}$$

13.2 The thickness of the sheer strake on 0.5 Loa midship shall be at least 1.5 times the thickness of the planking. On boats with a transom the increased thickness shall extend to the transom.

13.3 The breadth of each plank shall not exceed 200 mm.

13.4 The overlap of clinker shall be at least 1.5 times the plank thickness. The increased thickness of the sheer strake does not require an increased overlap.



13.5 The spacing of rivets shall not exceed 110 mm. Overlaps shall be clenched to each frame except where through bolts are in way of a beam stringer and bilge stringer, etc.

13.6 Butts in the planking shall be strapped between frames. The thickness of the butt straps shall not be less than the thickness of the planking and the length not less than:

$$l = 30 + 5 * t \text{ mm}$$

where t is the thickness of the planking.

The butt straps shall be clenched to the planking.

14 CARVEL PLANKING

14.1 The thickness of the planking shall not be less than the greater of the following values:

$$t = 0.52 * f * s \sqrt{p} \quad \text{mm}$$

$$t = 2.0 + 2.4 * \text{Loa} \quad \text{mm, however min. 15 mm.}$$

14.2 The thickness of the sheer strake on 0.5 Loa midship shall not be less than 1.2 times the thickness of the planking. On boats with a transom the increased thickness shall be extended to the transom.

14.3 The planking shall be fastened to double grown frames and laminated frames by:

- two nails or screws in planks 150 mm wide or less
- three nails or screws in planks wider than 150 mm
- two nails or screws in butt ends

and to intermediate bent frames by:

- two rivets

Nails and screws may be omitted, where through bolts are used in way of beam

stringer.

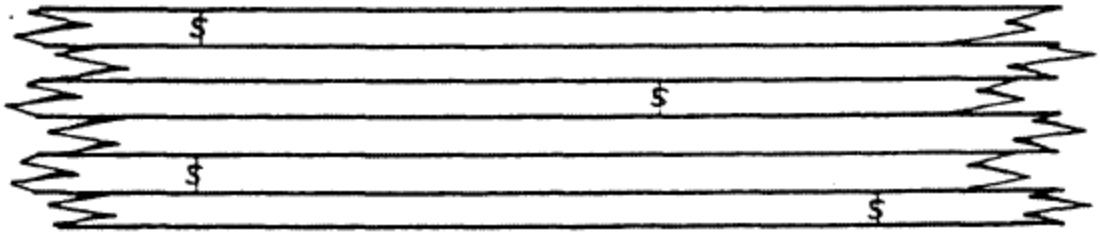
14.4 Spacing of butts shall not be less than:

600 + 30 * Loa mm where butts are on adjacent strakes

400 + 20 * Loa mm where one passing strake is between the butts

200 + 10 * Loa mm where two passing strakes are between the butts.

At the same frame where three passing strakes are between the butts.



14.5 Butts in the planking shall either be placed on a double grown frame or strapped between frames. The thickness of the butt strap shall not be less than the thickness of the planking and the length not less than:

$l = 30 + 5 * t$ mm

where t is the thickness of the planking.

The width of the butt strap shall be sufficient to overlap the adjacent planks by at least 50 mm. The butt strap shall be clenched to both planks and adjacent planks.

15.1 The thickness of the planking shall not be less than the greater of the following values:

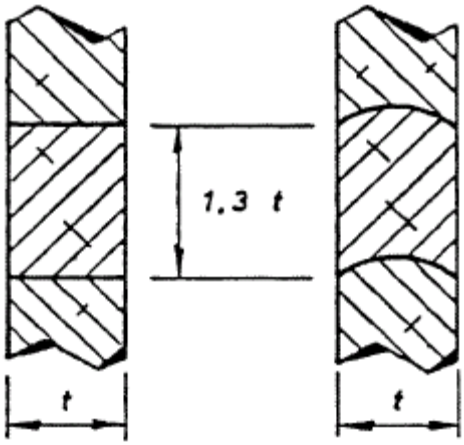
$t = 0.39 * f * \sqrt{p}$ mm

$t = 2.0 + 2.2 * Loa$ mm, however min. 12 mm

15.2 The thickness of the sheer strake on 0.5 Loa midship shall be at least 1.2 times the thickness of the planking. On boats with a transom the increased thickness shall extend to the transom.

15.3 The width of the strips shall normally be 1.3 times the thickness. Strips at the deck and at the keel may have a breadth of up to 200 mm.

15.4 The strip edges may be planed or rounded and shall be such that the joining surfaces fit close to each other.



16 PLYWOOD PLANKING

16.1 The thickness in the bottom shall not be less than the greater of the following values:

$t = 0.2 * f * s \sqrt{p}$ mm

$t = 2.0 + 1.2 * Loa$ mm, however min. 6.0 mm.

16.2 The thickness in the sides shall not be less than the greater of the following values:

$t = 0.2 * f * s \sqrt{p}$ mm

$t = 2.0 + 1.4 * Loa$ mm, however min. 4.0 mm.

The plywood shall be fitted in as large panels as practicable.

17 LAMINATED PLANKING

17.1 The thickness of the planking shall not be less than the greater of the following values:

$t = 0.2 * f * s \sqrt{p}$ mm

$t = 2.0 + 1.4 * Loa$ mm, however min. 6.0 mm.

17.2 The thickness of each individual layer shall not be more than 3.5 mm and the width shall not exceed 130 mm.

17.3 The veneers shall normally have an angle of 45 degrees against the keel line.

18 TRANSOM

18.1 The thickness of the transom shall not be less than the thickness of the planking.

18.2 The transom shall be sufficiently fastened to the bottom and sides by frames and knees.

18.3 Transoms for outboard engines shall be strengthened in such a way that the load is distributed to the stiffening system of the boat.

19 BEAM STRINGERS AND BILGE STRINGERS

19.1 Boats with a length overall of more than 8 metres, without longitudinals, shall have beam stringers extending from stem to stern and bilge stringers on 0.5 Loa midships. On boats with a raised deck the lower beam stringer shall extend from stem to stern.

19.2 The scantlings of beam stringers and bilge stringers shall be at least:

width:	10 + 11 * Loa	mm
thickness:	0.3 * b	mm

where b is the breadth of the planking.

19.3 The bilge stringer shall be fitted on the center of the bilge or where a straight line from the under side of the keel touches the planking of the bilge at amidship.

19.4 Beam stringers and bilge stringers shall be fastened to each frame with a bolt of the same diameter as the bolt fastening the frame to the keel.

20 DECK BEAMS

20.1 The section modulus of the beams shall be at least, for massive timber:

$$W = 1.2 * f * s * p * l^2 * 10^{-3} \quad mm^3$$

and for laminated timber:

$$W = 0.9 * f * s * p * l^2 * 10^{-3} \quad mm^3$$

20.2 The beams shall have a camber of at least 22 mm for each metre of the breadth

of the boat.

20.3 Each beam shall normally be fastened to a frame. Beams fastened to beam stringer or other longitudinal stiffening between the frames, may be accepted.

20.4 Deck beams below a superstructure, mast, deck fitting, etc shall be supported by a bulkhead or pillars.

20.5 The thickness of beam knees shall be at least 0.75 times the beam height. The length of the arms shall be at least:

$$l = 200 + 40 * B \quad mm$$

20.6 Beam knees shall be fastened to frame and beam with at least two bolts in each arm of the knee.

21 BREASTHOOK AND AFTERHOOK

21.1 All boats shall have a breasthook and afterhook closely fitted to the uppermost longitudinal stiffening, the top of the frames or to the uppermost planking strake.

21.2 The breasthook and afterhook shall have an arm length of at least:

$$l = 300 + 20 * B \quad mm$$

where B is the greatest breadth of the hull in metres.

21.3 A breasthook and afterhook shall be fastened by at least five 10 mm through bolts, the bolt in the middle shall go through the stem and the others through frame and planking. On boats with longitudinal stiffenings on the top of the frames the breasthook and afterhook may be glued and fastened with screws to the longitudinal stiffening.

22 DECK PLANKING

22.1 The thickness of the deck planking shall when the planks are glued to each other be at least equal to the greater of the following values:

$$t = 0.27 * f * s \sqrt{p} \quad mm$$

$$t = 2.0 + 2.1 * Loa \quad mm, \text{ minimum } 12 \text{ mm}$$

and when the planks are not glued to each other:

$t = 0.00042 * f * s^2 \sqrt{p}$ mm

$t = 2.0 + 2.4 * Loa$ mm, minimum 15 mm.

22.2 The width of the deck planks shall not exceed 130 mm. If the decking is glued, the width of the planks shall not exceed 80 mm.

22.3 The deck planks shall be fastened to each beam in the following way:

- one nail or screw when the plank is less than 80 mm
- two nails or screws when the breadth of the plank is 80 mm or more

Butt ends shall be fastened in the same way. Nails and screws shall be countersunk by 0.3 times the thickness of the planks. The holes shall be plugged.

22.4 The butt spacing shall be at least

- two beam spacings if the butts are on adjacent planks
- one beam spacing if one passing plank is between the butts
- on the same beam if three passing planks are between the butts.

Butts shall be arranged on beams and shall normally be of a square butt type.

22.5 A covering board shall have at least the same thickness as that required for decks and a breadth of at least 160 mm. The covering board shall be fastened to the deck beams in the same way as the deck planking.

23 PLYWOOD DECK

23.1 The thickness of plywood decks shall be at least equal to the greater of the following values:

$t = 0.21 * f * s \sqrt{p}$ mm

$t = 2.0 + 1.6* Loa$ mm, minimum 12 mm.

23.2 The plywood shall be fitted in as large panels as practicable.

23.3 Butts shall not be arranged in the same longitudinal position as butts in the side planking or at hatch ends, masts, mooring fittings or other fittings that may cause load.

23.4 If a plywood deck is to be sheathed with glass reinforced polyester, the sheathing shall not be taken into account when thickness of the plywood is determined. The workmanship of the glass reinforcement shall nevertheless be

in accordance with chapter C26.

24 SUPERSTRUCTURES AND DECKHOUSES

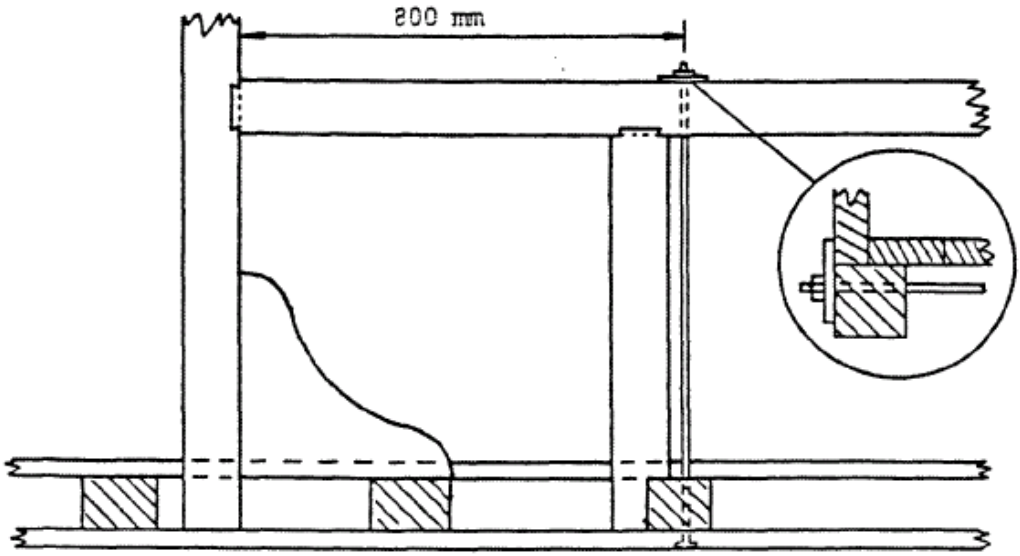
24.1 Superstructures and deckhouses which are subjected to sea loads shall be dimensioned as hull sides.

24.2 Superstructures and deckhouses other than those referred to in 24.1 shall be dimensioned at least in accordance with the minimum loads in chapter C21.

24.3 Superstructures and deckhouses shall be fastened to the deck beams with through bolts or glue and screws.

Beams in a superstructure deck shall be fastened to the side stiffeners.

24.4 Tie rods shall be fitted under the deck at openings. The distance between the rods or from the end of the opening to the first rod shall not exceed 800 mm.



25 WATERTIGHT BULKHEADS

25.1 Watertight bulkheads shall be dimensioned as the hull sides for the respective type of timber.

25.2 Watertight bulkheads shall be stiffened and fastened to the hull in such a way that they withstand the water pressure which can arise at either side of the bulkhead.

26 CLEATS

26.1 Mooring cleats, winches, etc shall be fastened to deck beams with through bolts.

27 THWARTS

27.1 Open boats shall have thwarts with appropriate distances.

27.2 Thwarts shall be fitted on the frames and supported with knees fastened with at least one bolt through the thwart and one bolt through the frame and planking.

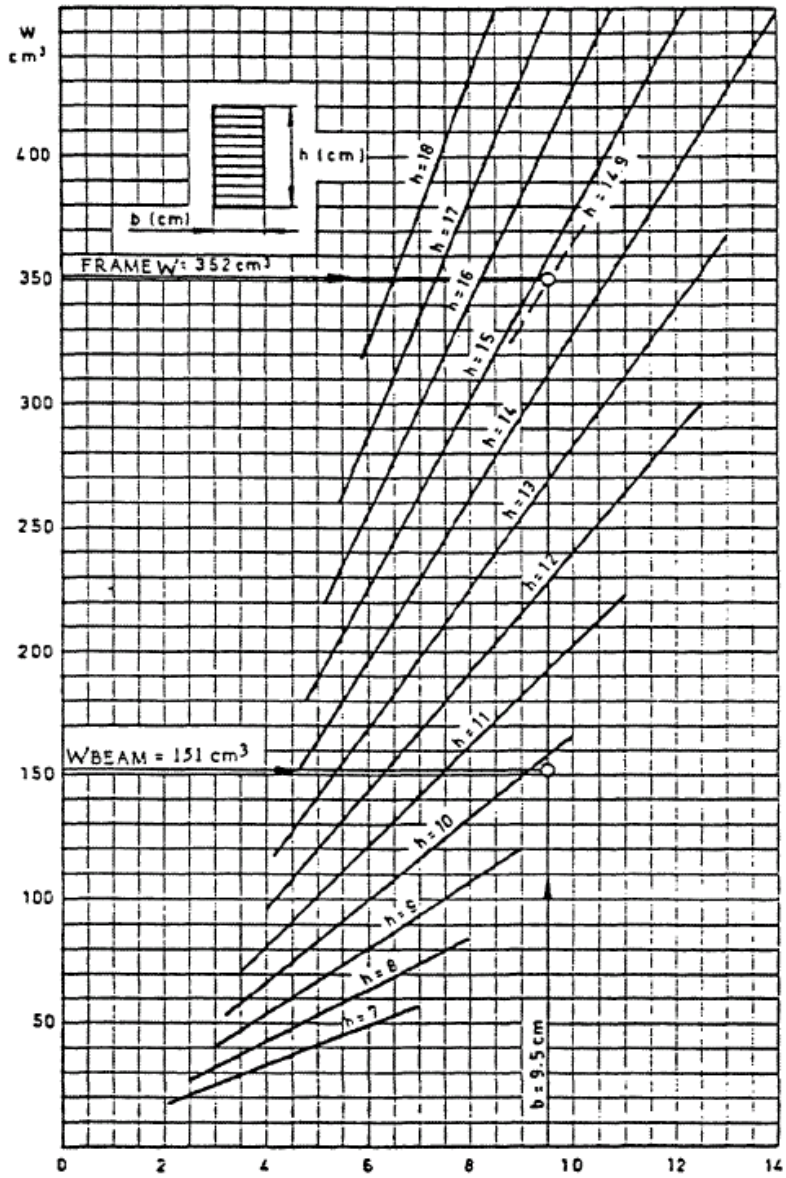


Figure 25 A

Section modulus $W = b * h^2/6$ for a section with breadth b (cm) and height h (cm).
Section modulus W (mm^3) = 10^3 * W (cm^3)

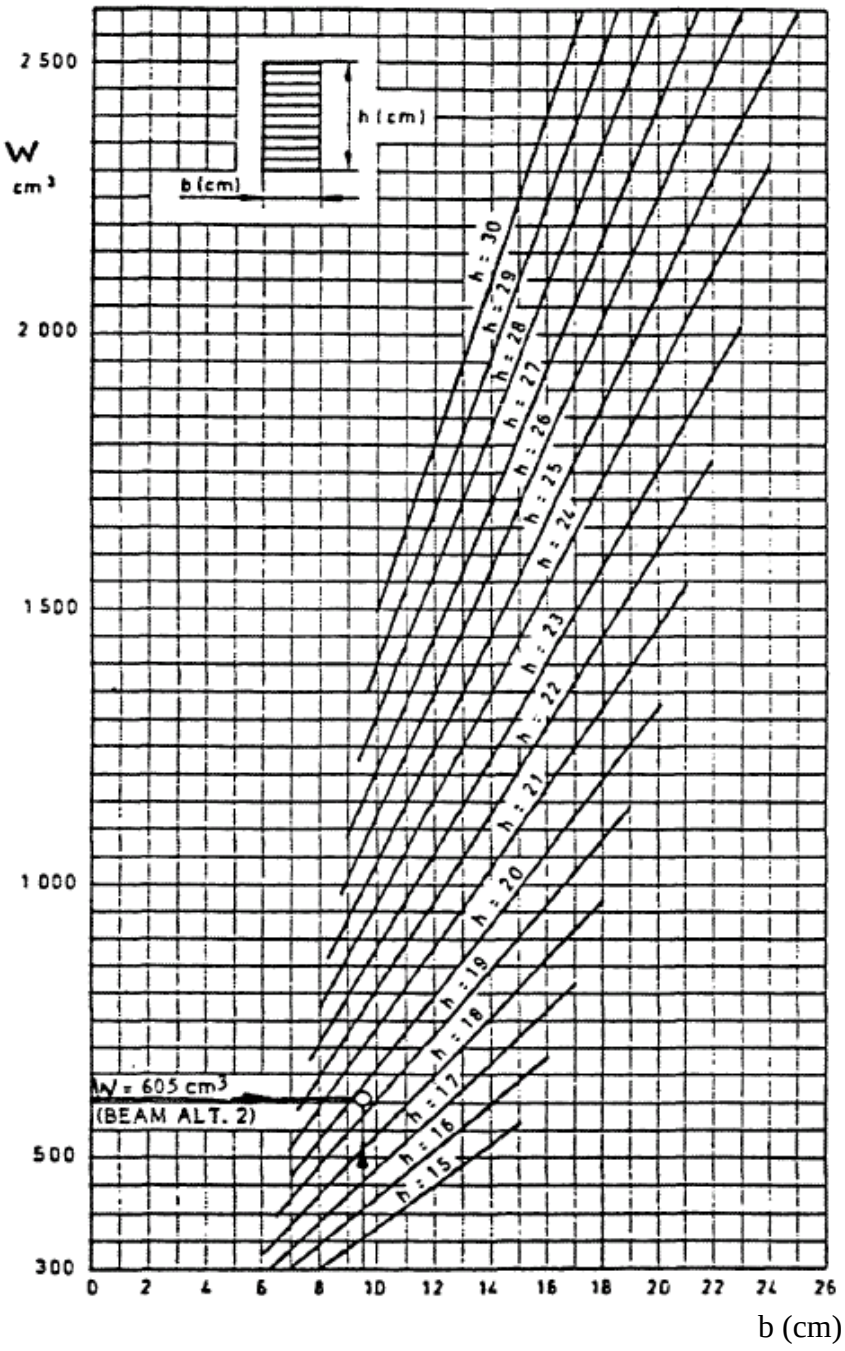


Figure 25 B
Section modulus $W = b * h^2/6$ for a section with breadth b (cm) and height h (cm).
Section modulus W (mm^3) = 10^3 * W (cm^3)

BUILDING OF GRP BOATS C26

Table of contents

1 GENERAL

1.1 The following provisions apply to boats made of fibre reinforced plastic which are surveyed individually during the building.

1.2 It is assumed that the manufacturer complies with the guidelines given by the raw material manufacturer concerning the various products used for the building of glass-reinforced polyester.

2 MANUFACTURING PREMISES

2.1 The moulding premises shall be draught free so that a uniform temperature can be maintained during the moulding process.

2.2 The air temperature in the moulding premises shall not be lower than 18 degrees Celsius and the temperature during the moulding process shall not vary by more than 6 degrees Celsius.

2.3 The moulding premises shall be insulated or built in such a way that the indoor temperature is not significantly affected by the outdoor temperature or sun heating.

2.4 Windows, if fitted, shall, if necessary, be over-painted or screened off if they will be subjected to direct sun radiation.

2.5 The moulding premises shall be tight so that they during a heavy rain will not

allow any water to penetrate into the premises.

2.6 The moulding premises shall be kept clean and free of dust.

2.7 The moulding premises shall be well illuminated and arranged in such a way that light will come down to the moulds used.

3 MATERIALS

3.1 It shall be documented that gelcoat, polyester, glass-reinforcement, core material, adhesives and topcoat are approved for the use concerned.

3.2 Polyester materials shall not be stored too long so that the storing affects their qualities.

3.3 Polyester shall not be added additives other than those required for the necessary thixotropic property.

3.4 A curing and accelerating system which is adapted to the polyester concerned and to the moulding times and temperatures shall be used.

3.5 Plywood which is moulded-in or fastened shall be of a waterproof type.

4 LAMINATE LAY-UP

4.1 All laminates shall at the outside have a layer of gelcoat with a uniform thickness or be coated with an equivalent surface protection after the moulding.

4.2 Below the waterline at least one layer of a powder bound mat moulded by isophtalic resin shall normally be applied next to the gelcoat.

4.3 If ortophtalic resin is used in the hull or in other construction which are permanently exposed to water, the laminate shall be given at least two extra layers with surface protection outside the gelcoat.

4.4 Emulsion bound mats shall not be used in connection with isophtalic resins.

4.5 A light mat of maximum 450 g/m^2 on surfaces with sharp curvature and maximum 600 g/m on plane surfaces shall normally be applied against the gelcoat.

4.6 The reinforcement lay-up of the laminate shall be laid in the approved sequence.

4.7 A suitable topcoat shall be applied on the inside of the laminate in the keel and in bilge wells where it can be assumed that water can be accommodated.

4.8 Where the laminate is not covered with topcoat or the like, the last layer of polyester shall contain wax so that the curing against air will be satisfactory.

5 HAND LAY-UP

5.1 The overlap of two layers of reinforcement material shall be at least 50 mm.

5.2 Polyester resin shall be applied uniformly on each layer of reinforcement.

5.3 For at least every second reinforcement layer, the laminate shall be rolled so that the polyester becomes uniformly distributed and the laminate so free as practicable from gas and air pockets.

5.4 All fibres shall be well wetted but there shall be no surplus of polyester on the surface.

5.5 The time interval between each layer of reinforcement shall be adapted to the ongoing curing process. Lamination shall not be continued on a previous layer which develops exothermic heat during the curing. The time between each layer in a laminate shall on the other hand not be so long that the previous layer is fully cured. If it has been fully cured, the requirements for secondary bonding shall be complied with.

5.6 During rolling over sharp edges, corners, etc it shall be ensured that the amount and thickness of the reinforcement will not be less than required.

6 SPRAY LAMINATION

6.1 When spraying glass and polyester the dosage device shall be adjusted to the glass percentage the laminate shall have.

6.2 The glass cutter of the spraying equipment shall be so adjusted that the fibre length will be at least 20 mm.

6.3 The spraying equipment shall be so adjusted that it gives a uniform distribution of glass and polyester.

6.4 The spray operator shall distribute the material uniformly over the laminate surface. If necessary, it can be required that spray roving with colour indicator is used for control of uniform distribution.

6.5 It shall be ensured that the work conditions are such that no part of the laminate will be lying in the spray shadow.

6.6 Next to the gelcoat the laminate thickness after the first rolling out shall be not more than 1.5 mm.

6.7 Subsequent rollings shall be carried out so that there is not more than 2.5 mm thickness increase between each rolling.

6.8 A hull made of spray moulded laminate shall contain at least one layer of woven roving.

7 SANDWICH IN MOULDS

7.1 The type and weight per cubic metre of the core material shall be in accordance with the approved specification.

7.2 Core material with open cells in the surface shall be coated with polyester so that the cells are filled before the core material is laid against another laminate.

7.3 Grid cut core material laid down in a wet laminate shall be added so much polyester that a surplus comes up in the cuts.

7.4 When core material is laid in wet laminate the latter shall be at least 450 g/m^2 on plane surfaces and 900 g/m^2 on curved surfaces.

7.5 Core material of stiff foam or plywood shall, if necessary, be loaded so that it is pressed totally into the polyester during the curing process.

7.6 All joints in the core material shall be filled before further lamination.

7.7 The wet laminate in which the core material is laid shall be allowed to cure to some extent before further moulding on the core material is permitted.

8 SANDWICH WITHOUT MOULD

8.1 When building up the core, all joints in the core shall be glued with an adhesive material or equivalent.

8.2 The core material shall not be bent so much that the properties of the core are affected.

8.3 The surface of the core shall be ground removing all irregularities in particular at joints.

8.4 The core shall be primed before further lamination.

8.5 Mat reinforcement shall always be laid against the core.

9 SECONDARY BONDING

9.1 If a further lamination shall be carried out on a laminate which has cured for more than 48 hours, the laminate shall be ground so that the glass fibres are exposed in the surface.

9.2 If there is wax on the surface on which further lamination shall take place, the laminate shall always be cleaned unless it is not fully gelled and the wax can dissipate in the next layer of laminate.

9.3 Topcoat shall always be ground away before further lamination.

10 STIFFENERS

10.1 Stiffeners shall be fixed to the laminate with a breadth of at least 20 times the thickness of the fastening.

10.2 Stiffeners shall have at least the same moulding breadth of the fastening at the ends.

10.3 If a stiffening ends at an unstiffened panel, the fastening material shall be laid also in the prolongation of the stiffener.

11 CURING

11.1 Gelcoat shall not have cured for more than 24 hours before lamination.

11.2 Laminates shall not be loaded or worked at during the curing process except for trimming of the edges.

11.3 Curing shall not take place at so high a temperature that the laminate is discoloured.

11.4 The curing shall take place at the temperature and for the time the polyester system requires.

12 MOULDED LAMINATE

12.1 After a construction has been moulded, the obtained thickness of the laminate shall, when necessary, be compared with the nominal thicknesses which are approved.

12.2 The thickness can be measured including gelcoat and topcoat but then it shall be taken into account that the measured thickness is respectively about 0.6 and 1.0 mm higher than the actual laminate thickness.

12.3 The nominal thickness of the laminate is considered to be fulfilled if the mean value of 20 measuring points on the same laminate is higher than the requirement and no single value is lower than 85 per cent of the nominal thickness requirement.

12.4 The variation coefficient V_L for a laminate with the same reinforcement lay-up shall normally be less than 0.14:

$$VL_{max} = S/t$$

where

$S = \sqrt{((t_i - t_o)^2/(n-1))}$
t_i single measured value
t_o mean value
t required nominal thickness
n number of measured values

12.5 If spray lamination is applied, thickness measurements are to be carried out.

12.6 Documentation shall be available showing that the reinforcement materials and the polyester which are used give the mechanical properties on which the approval is based with the glass percentage assumed.

12.7 The glass percentage in the bottom laminate shall be calculated based upon the stated reinforcement weight and the mean thickness in question.

BUILDING OF STEEL BOATS 27

Table of contents

1 GENERAL

1.1 The following provisions apply to steel boats which are surveyed individually during the building.

2 MATERIALS

2.1 Documentation shall be available in the form of Class Society certificates or yard certificates stating that plates and profiles are of the types and qualities which are approved for the building number in question.

2.2 The materials shall be dry and without corrosion attacks.

2.3 Each plate shall have a mean thickness which at least corresponds to the nominal thickness of the plate.

3 ALIGNMENT OF MATERIALS

3.1 The construction and welded joints in the material shall be such that there is good accessibility for the welding work.

3.2 The alignment of plates and profiles shall be so satisfactory that the welded joints will get a correct scantling corresponding to the thickness of the material.

3.3 The cutting of plates shall be done satisfactorily so that a good welded connection can be achieved.

4 WELDING

4.1 All welding work shall be carried out professionally. Any failure or unsatis-

factory piece of work shall be corrected before the material is covered with paint, etc.

4.2 The welding of the hull shall be carried out under supervision and be inspected upon completion by an approved welder.

4.3 When welding at low temperatures or damp weather, preheating of the steel shall be arranged.

4.4 At welding of plates thicker than 4 mm either a 30 degrees joint shall be used or also welding on the back side.

4.5 Double continuous welding shall always be used in case of:

- foundations
- end connections and brackets for stiffeners.

4.6 Continuous welding shall always be used for plates in:

- the hull plating
- deck and superstructures
- tanks
- bulkhead connection to bottom and sides.

4.7 Double intermittent welding may be used in other cases. The interruptions shall not be longer than the length of the welding and the total length of weldings shall at least correspond to that of a continuous welding.

4.8 One-sided intermittent welding may be used for fastening of stiffeners which are not subjected to a load, e.g. buckling stiffeners.

4.9 Fillet welds shall normally have an a-measure of at least 3.5 mm.

5 DETAILED CONSTRUCTION

5.1 Structural continuity is to be maintained at all primary structural members.

5.2 Knee plates shall be used where necessary in order to achieve a sufficient fastening area.

5.3 Stiffeners shall be welded to the web frames and girders also where the stiffeners are all continous through.

BUILDING OF ALUMINIUM BOATS C28

Table of contents

1 GENERAL

1.1 The following provisions apply to aluminium boats which are surveyed individually during the building.

2 STORAGE OF MATERIAL

2.1 Plates, profiles and other aluminium materials shall be stored horizontally so that the materials are not damaged or deformed.

2.2 Storage premises for welding equipment and electrodes shall be kept dry and clean.

2.3 Aluminium materials shall not be stored together with other metallic materials.

3 MANUFACTURING PREMISES

3.1 Work up and welding of aluminium shall be carried out at a dry place under roof and screened off for weather and wind.

3.2 The work place shall be kept clean and free of work on other metallic materials.

3.3 If a lower temperature than 0 degrees Celsius can occur, the manufacturing premises shall be so arranged that it can be made tight and heated.

4 MATERIALS

4.1 Documentation shall be available in the form of Class certificates or Yard certificates stating that plates and profiles are of the types and qualities which are approved for the building number in question.

4.2 The material used shall be straight and undamaged and have the required scantlings.

4.3 Plates which shall be used for the hull shall be sea water resistant and shall normally have the following material composition:

Cu max 0.2%
Fe max 0.5%
Mg max 2.0%

The following examples fulfill these requirements:

ASTM: 5052, 5083, 5086, 5154, 5454
DIN 1725: AlMg2.5, AlMg4.5Mn, AlMg4Mn, AlMg3, AlMg2.7 Mn

4.4 Stiffeners and profiles shall normally have the following material composition:

Cu max 0.4%
Fe max 0.5%

The following examples fulfill these requirements:

ASTM: 6005, 6063, 6351
DIN 1725: AlMgSi0.7, AlMgSiO,5, AlMgSil

5 SHAPING OF MATERIALS

5.1 Hardened aluminium materials shall normally not be shaped with heat added and cold shaping shall only be used when there is a low tension in the material. Aluminium materials shall normally be straight or shaped by rolling.

5.2 Curving of plates shall normally be made by rolling. Bending to 90 degrees shall not be made unless the inner bending radius (R) is at least:

$$R = f * t$$

where f is the bending factor according to the table below;

t is the thickness of the material.

Alloy	Condition	Bending factor for material thickness (t) in mm					
		1.0	1.5	3.0	4.5	6.0	9.0
AlMg2.5	02	0	0	0	1	1	1.5
	14	0	1	1.5	2	3	3
	08	2	3	4	5	6	7
AlMg4.5Mn	02	-	0.5	1	1	1.5	2
	32	-	1.5	3	3	3.5	

5.3 The cutting of materials shall be done so that the edges become straight and without burns or other damages.

6 WELDING

6.1 Welding shall not be carried out at a lower temperature than + 5 degrees Celsius.

6.2 Welding of hull and deck shall be carried out only by welding operators who have passed a welding operator qualification test for the materials and equipment used.

6.3 Normally welding electrodes of AlMg4.5Mn or AlMg6 are to be used unless it is documented that another electrode will give a better result.

6.4 All welding shall have full burning through and a smooth surface without burrs or edge burns.

6.5 All plates and fastening of watertight bulkheads shall be welded with continuous welding.

6.6 If intermittent welding is used, the length of weld shall be at least as long as the spacing and always end with a continuous weld.

6.7 The welding shall comply with the dimensions approved in beforehand.

6.8 The weld at representative places shall be controlled with penetrating liquids. Surface cracks are not accepted.

7 RIVETING

7.1 Riveting may be used in decks and superstructures but not in the hull plating.

7.2 Rivets fitted from only one side are not permitted in constructions subjected to loads except when tested and approved in beforehand.

7.3 Rivets shall normally have a diameter of at least 3 times the thickness of the plates and a rivet spacing of maximum 15 times the thickness of the plates.

8 GLUING

8.1 Gluing shall be used only if a static and dynamic test of the type of glue connection in question is undertaken in beforehand and the use is approved in each case.

8.2 Only glue types with documented good long term properties when exposed to moisture environment within the temperature areas in question shall be used.

8.3 An approved procedure for the glue process shall be available.

9 OTHER JOININGS

9.1 Joints between aluminium and acid proof steel are accepted without insulation. In joints with other metals the materials shall be insulated from each other.

BUILDING OF WOODEN BOATS C29

Table of contents

1 GENERAL

1.1 The following provisions apply to boats which are surveyed individually during building.

1.2 Deviations from the provisions of this chapter can be accepted if it can be documented that an alternative solution by experience has given an acceptable result. If such modification is accepted it shall be reported to the Authorities.

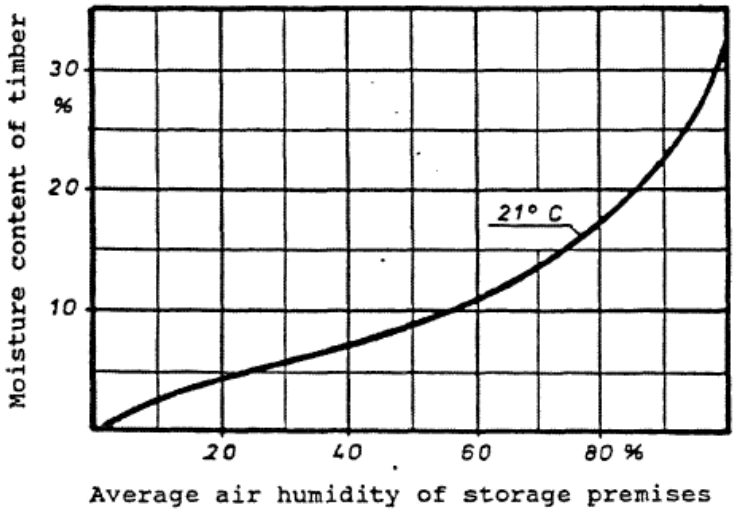
1.3 It is assumed that the glue and other materials which are used are in accordance with the guidelines issued by the deliverer of the raw material.

2 MATERIAL STORAGE

2.1 Timber shall be stored in dry and well ventilated premises where it is protected from direct sunlight and dampness.

2.2 Timber shall be stored horizontally and each layer shall be laid upon transverse strips so that a good air circulation is achieved around each piece. Plywood sheets shall be stored flat on a level bed.

2.3 The moisture content in stored materials may be based on the humidity in the storage premises according to the following figure.



3 MANUFACTURING PREMISES

3.1 Wooden boats shall be built in a well ventilated workshop where the temperature is at a sufficient level to prevent moisture content in the timber to increase during the building period.

3.2 Boats with bonded hull, deck or superstructure shall be built in premises where the temperature is not below 10 degrees Celsius during the building period.

4 TIMBER MATERIAL

4.1 Timber material shall be of first class quality specially selected for boat building.

4.2 Timber material shall be free from heart, insect attack, splits, loose knots, sapwood, decay or other imperfections which decrease the material quality.

4.3 The moisture content in timber material shall normally not exceed 20 per cent and not exceed 15 per cent in materials which shall be bonded.

4.4 The timber for use in outside planking, deck planking and laminated or bent frames shall be straight grained parallel with the length direction and quarter sawn.

5 PLYWOOD

5.1 Plywood for use in outside planking, deck and superstructure shall be of

marine quality complying with B.S. 1088-1966, B.S. 4079-1966 or equivalent specification.

5.2 Plywood shall be of first class quality and selection. Face veneers shall have good solid surface free from visible defects.

5.3 Plywood used for non-structural purpose where requirements are not provided for in respect of strength and quality may be of lower selection but shall be bonded with weather and boil proof resin according to B.S. 1203-1979 or equivalent specification.

5.4 Where plywood boards are scarfed the breadth of the scarf shall be at least 8 times the thickness of the board. Where plywood boards are abutted the breadth of the scarf shall be at least 18 times the thickness of the board.

6 GLUED JOINTS

6.1 Glue shall be weather and boil proof complying with B.S. 1204-1979 WBP or equivalent specification.

6.2 All faying surfaces shall be satisfactorily fitted for gluing. Faying surfaces shall be clean and free from dust, grease, etc which can weaken the glued joint.

6.3 Glued joints shall be fastened with nails, screws or bolts. For plywood the distance must not be greater than 10 times the plywood thickness.

7 LAMINATED CONSTRUCTIONS

7.1 Boat builders using laminated constructions are subject to special approval. The boat builder shall possess all necessary equipment for lamination, such as pressure devices, gauge to measure moisture content, machine to mix the glue, etc.

7.2 The layers comprising the laminated construction shall be of similar material and have the same moisture content.

7.3 The thickness of each layer shall not exceed 30 mm. Layers bent at the lamination must not be thicker than that a uniform and good glue joint between the layers can be achieved.

7.4 The spacing of scarf joints of layers shall not be less than:

25 * t where the scarf joints are on adjacent layers

20 * t where one passing layer is between the scarf joints

12 * t where two passing layers are between the scarf joints

where t is the thickness of the layers.

7.5 The pressure during gluing shall be at least 0.6 N/mm . When laminating hardwood the pressure shall be at least 1.2 N/mm^2. The pressure shall be checked and adjusted 15-30 minutes after joining.

7.6 The strength of the adhesion shall be tested. Test sample shall be taken from the end of the laminated construction and be representative for the materials, glue, the pressure during the gluing, curing, etc which are used for the construction in question.

8 BOLTING AND NAILING

8.1 Nails, screws and bolts shall be of corrosion resistant material or hot-dipped galvanized. Bolts, nuts, rivets and washers connected together shall be of equal material.

8.2 Washers of external diameter at least two times the bolt diameter shall be fitted under the bolt heads and the nuts. Washers may be dispensed with if the dimension of the bolt head has a satisfactory diameter. In highly stressed construction larger washers can be required.

8.3 For fastening of hull planking and deck planking shall be used screws or nails with a length (1) of at least:

$l = 2.0 * t$ mm for screws
$l = 25 + 2.0 * t$ mm for nails

where t is the thickness of the planks in mm.

8.4 Screws and bolts shall normally be fitted perpendicularly to the planking. The planking shall be bored in beforehand.

9 VENTILATION OPENINGS AND WOOD PRESERVATION

9.1 All closed constructions shall be fitted with a necessary ventilation. Specially good ventilation shall be arranged on top of frames and behind tanks and linings.

9.2 Timber material in closed constructions, faying surfaces and between double grown frames shall be treated with recognized wood preservatives.

ADDITIONAL REQUIREMENTS FOR FISHING BOATS C30

Table of contents

1 GENERAL

1.1 The requirements in this chapter are additional to those in the other chapters and apply to boats which shall be approved as fishing boats.

2 INCREASE OF THE FREEBOARD

2.1 The load waterline must not at any place be above the lower edge of any drainage flap and the free board (F), amidships shall never be less than 350 mm in case of boats with drainage flaps as in 7.1 for direct drainage from covered service spaces.

2.2 The freeboard (F) amidships shall never be less than 500 mm in case of boats with freeing ports as in 7.2 for direct drainage from covered service spaces.

3 STABILITY OF CLOSED FISHING BOATS

3.1 The GM of the loaded condition shall be at least 0.35 m.

3.2 The righting arm (GZ) between 4 0 and 65 degrees shall be at least 0.10 and the GZ-curve shall be positive up to an angle of 70 degrees when all closing arrangements are closed.

3.3 For boats with a lifting gear or corresponding mechanical fishing gear, the area below the GZ-curve shall in addition be at least 0.03 metre-radians between 30 and 40 degrees.

3.4 For boats with hatchways complying with 4.1, the volumes of the hatchways may, when calculating the area in 3.3, be included in the buoyancy to the heeling angle where the lowest edge of the hatchway will be submerged.

4 OUTSIDE OPENINGS TO ENCLOSED SERVICE SPACES ON THE FREEBOARD DECK

4.1 Side hatch and stern hatch which may be kept open during fishing shall have a limited size and shall normally have a sill height above the deck of at least 1000 mm.

4.2 Closing appliances for such hatch openings shall have at least the same strength as the super structure in which they are arranged. The openings shall at any time be capable of being closed rapidly by one person without use of tools.

4.3 If a side hatch can be closed from the wheelhouse, an alarm shall be provided at the hatch place which warns when the closing is started.

4.4 Side and stern hatch shall be clearly marked with a sign indicating that the hatch shall be kept closed when not in use during fishing and when there is a danger for water filling the service deck.

5 DRAINAGE/WELLS IN THE FREEBOARD DECK IN A COVERED SERVICE SPACE WITH OPENINGS IN SIDES

5.1 In each service space which is enclosed by a bulkhead shall where the freeboard deck is the lowest have a drainage well in each side of the deck wingward.

If the breadth of the service space is less than 0.5 B for the whole length, a drainage well only in one side can be accepted.

5.2 The volume of each drainage well shall be at least equal to the greater of the

following:

$V = 0.5 * A * l * b \quad dm^3$

$V = 150 \quad dm^3$

where

A is area of outside side opening in m^2
l the length of the service space in metres
b the breadth of the service space in metres.

5.3 The depth of drainage wells shall be at least 350 mm.

6 DRAINAGE OF THE FREEBOARD DECK IN A COVERED SERVICE SPACE WITH OPENINGS IN THE SIDES

6.1 The drainage of the freeboard deck shall normally be by separate pumps in each drainage well.

6.2 Pumps shall be of a type which can serve both in submerged condition and stand operation in "dry" condition. They shall have manual stop and start.

6.3 The arrangement of drainage wells and pumps shall be such that the suction side of the pumps will not easily be blocked by angle, fish waste, etc. The pumps shall also be capable of pumping some fish waste, etc. overboard together with the water.

6.4 The total drainage capacity for the pumps in each service space which is limited by bulkhead shall at least be equal to the greater of the following values:

$Q = 3 * B * A$

Q = 1.25 times the maximum washing capacity in the service space

where

Q is capacity in m^3/hour
A area of outside side opening in m
B breadth in metres.

6.5 The outlets overboard from the pumps shall be located at least 600 mm above the freeboard deck. The outlets shall have a closable flap-valve which can be maneuvered from an easily accessible place at least one metre above the freeboard deck.

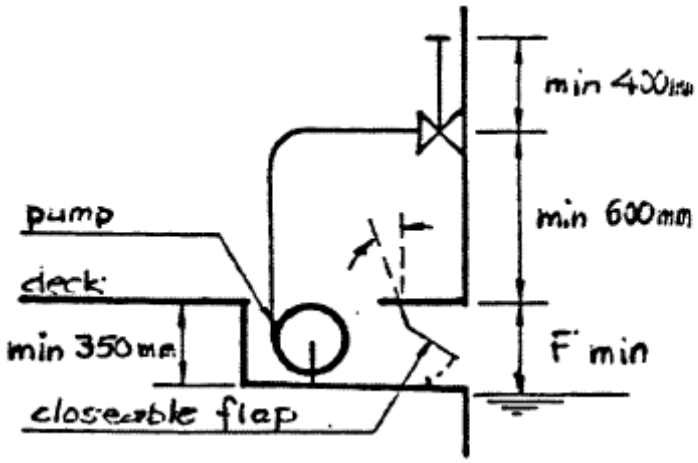
6.6 Discharge pipes from the pumps shall have a diameter which is adapted to the capacity of the pump and shall have a material thickness (godstjocklek) of at least 5 mm or equivalent.

6.7 The freeboard deck shall be provided with a level alarm coupled to the wheelhouse which is activated when drainage wells are full.

7 OTHER DRAINAGE OF THE FREEBOARD DECK IN A COVERED SERVICE SPACE WITH OPENINGS IN SIDES

7.1 In addition to the pumps referred to in 6, drainage flaps in drainage wells for direct drainage overboard as shown in the figure below may be accepted to the following conditions:

- the drainage flaps shall be let in from the hull side
- the drainage flaps shall in closed condition be watertight and easily accessible for cleaning and supervision
- the drainage flaps shall be arranged for remote closing from the wheel-house
- a panel in the wheelhouse shall show which drainage flaps are open/ closed
- drainage flaps shall also be capable of being closed from a place at least one metre above the deck
- the opening for a drainage flap shall not be greater than 0.06 m^2.



7.2 As an alternative to separate pumps from the drainage wells, drainage from the freeboard deck direct overboard can be arranged through normal freeing ports in the sides subject to the following conditions:

- the arrangement and area of the freeing ports shall be as specified in 5.1.1 - 5.1.5
- covered service spaces must not be included in the buoyancy for stability.

8 DRAINAGE OF WEATHERTIGHT ENCLOSED SERVICE SPACES ON THE FREEBOARD DECK WITHOUT OPENINGS IN THE SIDES

8.1 Drainage can be by separate pumps in drainage wells and discharge as specified in paragraphs 5 and 6.

8.2 Alternatively drainage pipes from the drainage wells may be connected to the normal bilge system.

8.3 The total drainage capacity shall in both cases be at least 1.25 times the maximum washing capacity on the freeboard deck (service deck).

8.4 Drainage flaps referred to in 7.1 are not allowed.

9 GARBAGE DUCTS IN COVERED. OR WEATERTIGHT ENCLOSED SERVICE SPACES ON THE FREEBOARD DECK

9.1 The discharge outlet overboard shall have a height above deck and closing arrangements as specified in 6.5 and 6.6.

9.2 The arrangement of garbage ducts shall be easy to supervise.

10 ERECTIONS WHICH CAN PREVENT DRAINAGE OF THE DECK ON CLOSED BOATS

10.1 Open deckhouses with side walls at the sides of the boat, separate sidewalls at the sides of the boat for protection during navigation or similar erections on deck are normally not permitted because such erections will prevent a rapid and effective drainage of water on deck. In the case of such sidewalls, freeing ports in accordance with chapter C5 are not considered as an effective drainage arrangement. A bulwark with a height of more than 1000 mm will be considered as a sidewall.

10.2 If bins are arranged on deck, a good drainage from the bins and overboard shall be provided.

11 DRAINAGE OF THE FLOORING ON OPEN BOATS

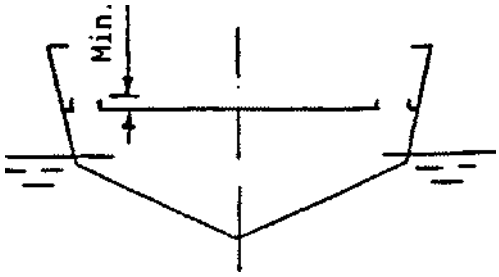
11.1 If the flooring is located above the waterline on the boat in light condition and is so tight that water can assemble on the flooring, at least the following conditions for safeguarding the stability of the boat shall be complied with:

- Drainage openings shall be arranged at both sides of the flooring for

drainage of water to the bottom of the boat (see the figure below)

- The drainage area shall be at least 75 per cent of the requirement for freeing ports for drainage of the deck overboard

- The intake to the bilge pump shall be easily accessible.



12 FISHING LIGHTS x)

12.1 Fishing boats with a length overall of more than 7.0 metres shall be provided with fishing lights, two all-round light, one of them one metre vertically above the other. The lower light shall be white and on boats engaged in trawling the upper light shall be green. On boats for other types of fishing the upper light shall be red.

x) See Rule 26 of the Collision Regulations

13 PERSONAL SAFETY AT WINCHES

13.1 Net and line winches shall be secured so that the winches stop when a person is drawn into the winch.

14 SCANTLING CORRECTIONS

14.1 All formulae for thickness and section modulus which are given in the chapter for dimensioning of various construction materials shall be multiplied by a factor for field of application in accordance with the following table.

Bottom and bilge	1.05
Side and transom	1.05
Deck and forecastle deck	1.15
Superstructure	1.10

As the coefficient for shear strength of the core in sandwich panels 1.05 shall be used.

15 LOCAL STRENGTHENINGS

15.1 Areas loaded by trawling equipment or equivalent shall be dimensioned for the load which occurs. Plastic and wooden boats shall also be strengthened for local wear.

ADDITIONAL REQUIREMENTS FOR PASSENGER BOATS C31

Table of contents

1 GENERAL

1.1 The requirements in this chapter apply together with the other chapters to boats which shall be approved for conveying passengers.

2 PROTECTION AGAINST WATER FILLING

2.1 Passenger boats shall have such protection that a significant leakage at the following places does not lead to an immediate water filling of adjacent spaces:

- stem
- bottom forward on high speed boats
- bottom in the after part of boats with free lying rudder or propeller.

The adjacent spaces shall be capable of being drained by the main bilge system in the boat.

2.2 At a door which shall be tight if the boat shall be considered as a closed boat, the required sill height of 380 mm may be reduced to 100 mm on condition that the freeboard nowhere is less than 500 mm.

3 STABILITY

3.1 The stability range for closed boats shall be at least 50 degrees (the GZ-curve shall be positive up to at least 50 degrees), however 40 degrees is acceptable on condition that the area below the curve between 30 and 40 degrees is at least 0.03 metre-radians.

3.2 The heeling in a passenger boat must not be greater than 12 degrees when a weight corresponding to the greatest permitted number of passengers is placed as far to the side of the boat as possible distributed with 300 kg/m2. No weight may be placed nearer to the center line than 0.2 B. The freeboard with this

weight distribution must nowhere be less than 200 mm.

4 FUEL

4.1 Installations for fuel with a flashpoint of less than 60 degrees Celsius are not permitted.

5 FIRE INSULATION AND SURFACES

5.1 Bulkheads, linings and similar arrangements in the accommodation which are combustible shall be covered by a surface layer which fulfils the requirements according to NT Fire 004.

5.2 Glassfiber reinforced polyester above the flooring in the engine room should have a protection against fire consisting of a 15 mm thick rigid mineral wool block or expanding fire protection paint with a corresponding insulation effect. Also the insulation effect of a self extinguishing sandwich core may be credited.

5.3 In boats with the greatest permitted number of passengers of more than 12, the engine room shall be fire insulated so that smoke and flame will not penetrate within a period of 30 minutes fire exposition in accordance with ISO 834. Hull sides of steel and bottom constructions need not fulfil this requirement.

6 PROTECTION AGAINST FALL

6.1 Rails which constitute a protection against falling overboard at passenger spaces must not be detachable. The height shall be at least 1000 mm.

6.2 The boat shall be provided with an arrangement such that embarkation and disembarkation can take place without danger, e.g. through an opening in the rail for a gangway.

6.3 Stairways shall be arranged longitudinally.

7 PASSENGER SPACES AND MEANS OF ESCAPE

7.1 Seats shall have a breadth of at least 0.5 m and a free height of at least 0.9 m above the back of the seat and at least 0.75 b leg space counted from the back support. Loose arrangements or foldable seats are not considered as seats.

7.2 The passenger spaces shall be fitted with at least the same number of seats as the permitted number of passengers.

7.3 The passengers shall be able easily to move to and from the passenger space. Stairs and doors shall have a breadth of at least 750 mm. Each passenger space shall have two exits. The escape routes shall, except stairs and doors have a breadth of at least 800 mm. This requirement applies also to the space between transverse seat rows where more than four persons may need to escape. The smallest escape opening shall be at least 600 x 600 mm. The route to the escape not normally used shall be clearly marked "EMERGENCY ESCAPE".

7.4 Spaces for passengers and passages to passenger spaces shall have a free height of at least 1.98 m. Other accommodation spaces shall have a free height of at least 1.80 m. A lower height may be accepted in door openings, emergency escapes and above seats.

8 TOILET, TANK AND PUMPING ASHORE

8.1 Boats with a greatest permitted number of persons greater than 10 but not greater than 50 shall have at least one toilet. If the number is greater than 50 the boat shall have at least two toilets. Toilets shall be connected to a holding tank.

8.2 The retention system shall be designed to allow emptying by means of vacuum through a shore connection in accordance with ISO 4567 or be constructed as indicated in 8.3 and 8.4.

8.3 Systems constructed with pipeline and pump for pumping the toilet waste ashore shall have a shore connection flange with dimensions in accordance with the table below.

8.4 The pipeline for pumping toilet waste ashore shall be capable of being flushed preferably with sea water. The pipeline system on the pressure side of the pump and the connection shall be constructed*for a pressure of at least 0.6 MPa. The pump must not be able to give a higher pressure.

STANDARD DIMENSIONS OF FLANGES FOR DISCHARGE CONNECTIONS

Description	Dimension
Outside diameter	210 mm
Inner diameter	Minimum 38 mm

Bolt circle diameter	170 mm
Slots in flange	4 holes 18 mm in diameter equidistantly placed on a bolt circle of the above diameter, slotted to the flange periphery. The slot width to be 18 mm
Flange thickness	16 mm
Bolts and nuts	4 pieces, each of 16 mm diameter and a suitable length

The flange shall be designed to accept pipes up to a maximum internal diameter of 100 mm and shall be of steel or other equivalent material having a flat face.

ADDITIONAL REQUIREMENTS FOR TUGS C32

Table of contents

1 DEFINITIONS

1.1 A "tug" is a boat which is intended for towing other vessels, timber rafts or floating objects with a cable and which for this purpose is equipped with hook, winch, bollard or similar device.

A boat, the propulsion machinery of which has a power of less than 150 kW, and which is not arranged for towing of vessels which use their own propulsion machinery or for towing of a vessel in co-operation with a tug, is not considered as a tug.

2 STABILITY REQUIREMENTS

2.1 For the control of the stability of a tug, the righting arm curve and the heeling arm curve, calculated in accordance with 3.1 for the most unfavourable towing condition shall be plotted in the same diagram. The resulting area above the heeling arm curve between the healing and the righting arm curves, calculated up to a heeling angle of 40 degrees shall be at least 0.01 metre-radians.

For tugs intended for assistance of vessels which use their own propulsion machinery or which assist vessels in co-operation with other tugs, a special approval of the stability is required.

3. HEELING MOMENT

3.1 The curves for the heeling arms shall be calculated in accordance with the following formula:

$$k = 0.07 * C * T (h*\cos\alpha - 0.8*\sin\alpha + 5 * d) / \Delta$$

where

C 4 * l/L, but not greater than 1.0

r radius of the towing arc in metres. If the radius varies: the distance from the centerline of the boat to the centre of effort of the hook when the pull is acting atwarthships

d the mean draught of the ship in metres

h the height of the towing point above the waterline

k nominal heeling arm in metres

L the length between perpendiculars of the boat in metres

l the horizontal distance between the towing point and the aft perpendicular in metres

T the static bollard pull in kilonewtons

A the displacement of the boat in metric tons

α heeling angle.

4 SPECIAL REQUIREMENTS

4.1 The towing cable shall be capable of being rapidly released at full load.

4.2 The towing hook with winch system shall be dimensioned on the basis of the maximum traction force with a safety factor of 5 in relation to the tensile strength of the material.

ICE STRENGTHENING C33

Table of contents

1 DEFINITIONS

"Ice area": The hull from fore to after end within an area of 3 00 mm above the full load waterline and down to 300 mm below the waterline without cargo. The area shall in addition comprise the whole bottom within 0.2 Loa counted from the stem.

2 DESIGN AND CONSTRUCTION

The ice strengthening consists of the following strengthening construction elements:

- stem profile
- strengthened keel
- ice lining on the ice area in wooden boats
- strengthened hull in the ice area strengthened frames in the ice area
- strengthened propeller shaft.

2.1 Stem profile

A stem profile with an area of 80 Loa mm^2 shall be mounted on the stem. The stem profile shall go from the foremost point of the stem to one metre aft of the dividing point between the stem and the keel.

2.2 Strengthened keel

The section modulus of the keel shall be doubled in relation to those given in chapters C22-C25.

2.3 Ice lining on wooden boats.

Ice lining shall be arranged on wooden boats in the whole ice area. The ice lining shall be of iron, aluminium or copper. The thickness of the lining shall be adapted to the size of the boat and it shall be properly attached. Aluminium and copper plates must not be in contact with iron parts.

2.4 Strengthened hull

The requirements in respect of the thickness of the hull shall be calculated as follows:

$t_{ice} = 1.3 * t + 1.5$ mm

where t is the laminate/plating/planking thickness requirement according to chapters C2 2-C25.

2.5 Strengthened frames

The flexural strength requirements for frames according to chapters C22-C25 shall in the ice area be multiplied with 1.5.

2.6 Strengthened propeller shafts

The requirement for propeller shaft diameter according to chapter CIO shall be multiplied with 1.15.