Guidance For Classification And Construction

Part 3 Special Ships

Volume A

GUIDANCE FOR FRP AND WOODEN FISHING VESSEL UP TO 24 M

Consolidated Edition 2022

Biro Klasifikasi Indonesia

www.bki.co.id

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Foreword

This Guidance is a consolidated edition 2022 of Guidance for FRP & Wooden Fishing Vessels up to 24 m Part 3 – Special Ship, Volume A.

In this edition there are no new amendments added, only consolidate the 2015 edition, and Corrigenda No.1. The summary of previous edition and amendments including the implementation date are indicated in Table below:

	Edition / Rule Change Notice (RCN)	**Effective Date**	Link
1.	Edition 2015	10th October 2015	
2.	Corrigenda No.1, December 2017	-	

Note : *Full previous edition and amendments including its amendment notice is available through link above.*

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Further queries or comments concerning this Guidance are welcomed through communication to BKI Head Office.

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Section 1 Classification Survey

A. General

1. Guidance for Survey

This guidance is used to Classification Survey of the FRP/ Wood fishing vessel up to 24 m in length, and of any pertinent equipment is accordance with this guidance.

2. Scope

2.1 Classification Survey cover the ship's hull and machinery, including electrical installation and anchoring equipment.

2.2 BKI reserves the right to extend the scope of Classification Survey to all equipment and machinery used in the operation of ship, which by their arangement may impair the safety of human life of the ship and her cargo or of the environment.

3. Class Certificate

3.1 Assignment of Class, issuance of the Class Certificate, and assignment of the corresponding notation of Classification thereto are conditional upon proof being furnished of compliance with this guidance in force on the date of placing of the order.

3.2 BKI reserve the right to add special remarks in the Class Certificate, as well as information regarding operation of the ship which is relevance for the vessel Class.

3.3 At the completion of new building Classification Survey, the certificate of Classification are issued by BKI in accordance with the Surveyor's report and condition of the ship, and they are to be kept on board.

4. Register

4.1 The Classification data of each ship classified will be included in the BKI data file. An extract of these ship data will be entered in the register published by BKI. During the period of class, BKI will update these details on the basis of relevant report submitted by Surveyors.

5. Term and condition

Term and condition of this guidance subject to as referred in the Rules for Classification & Survey (Pt.1, Vol.I).

6. Validity of Class

6.1 The Hull and machinery classed to BKI have the period of class 5 (five) years for Class Notation **A100** an 4 (four) years for Class Notation **A90**/ **A80**.

B. Class Notation

The following Class Notation and definitions,

Table 1.1 Classification Notation

Application	Character of Classification	Definition
Hull	A100	The ship's hull fully complies with the requirements of the BKI Construction Rules or other Rules/ Guidance considered to be equivalent.
	A90	The ship's hull does not fully comply with the requirements of the BKI Construction Rules or other equivalent Rule/ Guidance; however, the Class may be maintained for a shorter period and/or with shorter survey intervals. The figures 100, 90, etc. indicate the maintenance condition of the ship's hull in relation to the requirements of the Construction Rules.
Machinery	SM	The machinery including electrical installations complies with the requirements of the BKI Construction Rules or other Rules/ Guidance considered to be equivalent.
	$\overline{SM}$	The machinery including electrical installations does not fully comply with the requirement of the Construction Rules/ Guidance of BKI, but functional safety and sea-worthiness are fulfilled for the envisaged service.
Anchoring equipments	$\textcircled{I_F}$	The ship’s anchoring equipments for fishing vessel comply with the requirements of these guidances.
Survey, Supervision of Construction	✠	Hull, machinery, and anchoring equipment have been constructed: – under the supervision and in accordance with the Rules of BKI at the shipyard and/or at subcontractors supplying construction components / hull sections – with certification by BKI of components and materials requiring inspection, subject to the BKI Construction Rules
		Ship which are constructed not under the supervision by BKI will have no construction supervision markings.

Table 1.2 Notations for Restricted Service Area

Notation	Service Area Restriction
II (Restricted Ocean Service)	This range of service is limited, in general, to the trade along the coast, provided that the distance to the nearest port of refuge and the offshore distance are not exceeding 200 nautical miles, or the trade within all Indonesian water.
III (Coasting Service)	This range of service is limited, in general, to the trade along the coast, provided that the distance to the nearest port of refuge and the offshore distance are not exceeding 50 nautical miles, as well as to the trade within enclosed seas, such as Riau Islands Sea Territory.
IV (Shallow Water Service)	This range of service is limited to the trade in calm seas, bays, harbors, or similar waters where there is no running of heavy seas
V (Inland Waterway Service)	This range of service applies to vessels intended for operation in inland waters only. Inland waters shall comprise : – all Indonesian inland water ways ther waters showing comparable conditions.
BKI may, on application, agree to the range of service being extended for a limited period and/or with certain reservations. This will have to be documented.	

Table 1.3 Notations for special ship types

Notation	Application / Underlying Rules
FISHING VESSEL	Fishing vessels in accordance with this guidance
FRP	Ship constructed with material of FRP
WOOD	Ship constructed with material of Wood

C. Classification Survey of New Building

1. Survey application and Application for Classification

1.1 The Survey application and the application of Classification for New Building are to be submitted to BKI by the owner or the shipyard. The form application Survey and form of application of Classification provided by BKI as follows:

- Survey application form
- Application of Classification form

2. Document/ Drawing for approved

2.1 To ensure conformity with this guidance, the following drawings and documents are to be submitted in quadroplate (drawing can also be submitted electronically) for verification and approval before field inspection commenced.

2.1.1 FRP Fishing Vessel:

- General Arrangement
- Lines Plan
- Transverse section
- Longitudional section
- Watertight bulkhead
- Fore peak and After peak
- Deck house
- Engine Foundation
- Rudder and Rudder Stock
- Preliminary and final Intact Stability Calculation
- Engine Room Arrangement
- Shafting System and Stern Tube
- Propellers
- Bilge System
- General Service and Fire Fighting System
- Fuel Oil System
- Cooling System
- Proposal the kind of FRP Materials used and their lamination process

2.1.2 Wood Fishing Vessel

- General Arrangement
- Lines Plan

- Transverse section
- Longitudional section
- Watertight bulkhead
- Fore peak and After peak
- Deck house
- Engine Foundation
- Rudder and Rudder Stock
- Preliminary and final Intact Stability Calculation
- Engine Room Arrangement
- Shafting System and Stern Tube
- Propellers
- Bilge System
- General Service and Fire Fighting System
- Fuel Oil System
- Cooling System
- Proposal the kind of FRP Materials used and their lamination process

2.2 The drawings to be submitted in Bahasa Indonesia or English have to contain all details required for examination in accordance with this guidance. BKI reserves the right to request additional information and particulars to be submitted.

2.3 The drawings to be submitted subject to approval will be examined by BKI in accordance with this guidance, where applicable at the completion of examination, they will be provided with a mark of approval and return one copy.

2.4 Any deviation from approval drawings require to be approved by BKI prior to being realized.

3. Supervision of Construction

3.1 General

3.1.1 BKI will assess the production facilities and procedures of the shipyard as to whether they meet the requirements of this guidance. In general approval based on such assessments are conditional for acceptance of product subject to testing.

3.1.2 Materials, components and installations subject to inspection are to be comply with the relevant section requirements of this guidance and presented for inspection and/ or construction supervision by BKI Surveyors.

3.1.3 For each inspection, an appointment is to be arranged in time with the BKI Branch Office.

3.1.4 In order to enable the Surveyor to fulfill his duties, he is to be given free assess to the ship and the workshop where parts requiring approval are manufactured, assembled or tested. For performance of the tests required, the shipyard are to give the Surveyor assistance by providing the staff and equipment necessary for such test.

4. Supervision of Construction

During the phase of construction of a vessel, BKI will satisfy themselves by surveys and inspection that:

- Part for hull and machinery requiring approval have been constructed in compliance with the approved drawing.
- All test and trials stipulated by this guidance are performed satisfactory.
- Workmanship is to compliance with current engineering standards and/ or guidance requirement.
- FRP lamination are produced by qualified Laminator.
- Wood connection are produced by qualified Carpenter.
- FRP test record with satisfactory result have been presented (the shipyard will have to ensure that only the pass test material will be delivered an installed).

5. Test at Manufacturers

As far as practicable, machinery and equipment will be subject to operational trials on the manufacturer engine test bed. Where the machinery, equipment or electrical installation are novel in design or have not yet sufficiently proved their efficiency under actual service condition on board ship. BKI may require performance of a trial under particularly severe conditions.

6. Shipboard trials

Upon completion of the ship or installation all hull, machinery and electrical installation will be subjected to operational trials in the presence of the Surveyor, prior to and during the sea trial. This will comprise:

- Tightness, operational and strength tests of tanks
- Tighness test of weather deck opening
- Operational and/ or load test of the machinery installation (propulsion plant, electrical installations, steering gear, etc.) of importance for safe operation.
- During the trials speed is to be increased in steps until either the turning circle angle of heel reaches 12 or the maximum speed is attained.

7. Final Survey

During final Survey, check will be made to ensure that any deficiencies found during sea trial have been eliminated.

8. Report and Certificate

Upon completion of the Classification Survey, the Surveyor will prepare construction report and issued the provisional Classification Certificate.

9. Certificate and reporting forms

Certificate and reporting forms to be used for the Classification Survey:

9.1 Classification Survey reports FRP Fishing Vessel

- Form of Survey Report for FRP Fishing Vessel
- Form of Ship Particulars
- Check list for FRP Fishing Vessel
- Report on trials of the Machinery and Electrical Plants

9.2 Classification Survey reports Wood Fishing Vessel

- Form of Survey Report for Wooden Fishing Vessel

- Form of Ship Particulars
- Check list for Wooden Fishing Vessel
- Report on trials of the Machinery and Electrical Plants

9.3 Provisional Classification Certificate

9.4 Classification Certificate

Section 2 Hull Structures & Stability

A. General Rules for the Hull

1. General

1.1 Application

These guidance apply to fishing vessel of length **L** from 6 to 24 m and provided that the fishing vessel classed and approved in accordance therewith are at all times employed exclusively under the conditions for which they have been designed, constructed and approved and that they are in the sense of good seamanship correctly handled and equipped and operated at a speed adopted to the respective seaway conditions.

1.2 Operating categories

The scantlings of hull primary structural members apply to operating category **I** without restriction.

Definitions of Operating Categories be assigned on the basis of the seaway conditions prevailing in the respective service area (e.g official seaway statistics).

I

Unrestricted voyages far away from coastlines, during which a vessel entirely left to its own devices has to be in a position to cope with emergency-situations for prolonged periods, without relying on outside assistance.

II

Voyages along the coastline, but restricted to a sea area located at a distance not exceeding 200 nautical miles, measured from the main land and/or from offshore islands situated at a distance not exceeding 400 nautical miles from the main land and/or from another island.

III

Voyages along the coastline confined to a sea area located at a distance of 20 nautical miles, measured from the main land1 and/or from offshore islands situated at a distance not exceeding 40 nautical miles from the main land and/or from another island.

IV

Day trips between close ports along the coastline within a relatively protected area. However, voyages are restricted to a sea area located at a distance not exceeding 3 nautical miles, measuring from the main land1 and/or from offshore islands situated at a distance not exceeding 6 nautical miles from the main land and/or from another island.

V

Trips on inland waterways and lakes. Also included are day trips off the coastline, confined to shallows and/or sea areas located at a distance not exceeding 0,75 nautical miles, measured from the shore and/or the main land1.

1.2.2 Restricted operating categories

.1 For fishing vessel intended to be classified only for one of the restricted operating categories **II**, **III**, **IV** and **V** the governing scantlings of the primary structural members of the hull may be reduced as follows :

Operating Category **II** : by 5%

Operating Category **III** : by 10%

Operating Category **IV**, **V** : by 15%

The reductions are effected by appropriate reduction factors to the design loads. Excluded from the reduction of the scantlings are:

- Rudders
- Propeller brackets
- Watertight bulkheads
- Tanks, masts and standing rigging
- Keel bolts

.2 The operating category of a fishing vessel to be classified may be restricted if closures according to Government Safety requirements do not meet the requirements of the operating category applied for.

1.3 Equivalence

Unusual type of Fishing vessel and/ or it has partly deviate from the construction rules, may be assigned a class certificate if their structural members are considered equivalent to those for this class.

1.4 Accessibility

Hull equipment components such as seacocks, through-hull fittings and connected pipelines shall be accessible for inspection and maintenance. Inside the vessel, good air circulation shall be ensured.

1.5 Definitions

1.5.1 Principal dimensions

Unless otherwise indicated, the following dimensions are to be substituted in the calculation formulae of the following sections with the dimensions in [m].

.1 Length of the hull L_H

The length L_H in [m] of the hull is the horizontal distance between the foremost and the aftermost part of the vessel. The length includes structural and integral parts of the vessel.

.2 Waterline length L_{WL}

The waterline length in [m] is the distance between the foremost and the aftermost intersections of the hull with the flotation plane.

.3 Scantling length L

The scantling length is determined by:

$$L = \frac{L_H + L_{WL}}{2} \qquad [m]$$

.4 Beam B

The beam **B** in [m] is the maximum breadth of the vessel measured from one shell outer edge to the other, disregarding any rubbing strakes etc.

.5 Depth H

The depth **H** in [m] is the vertical distance between the canoe body bottom and the top edge of the deck, measured at the side of the vessel halfway along L_{WL}, as in Fig. 2.1 and 2.2.

.6 Depth H_1

The depth H_1 in [m] is the depth **H** increased by 1/6 of the depth H_k of the keel, measured at the side of the craft halfway along L_{WL}, as in Fig. 2.1 and 2.2.

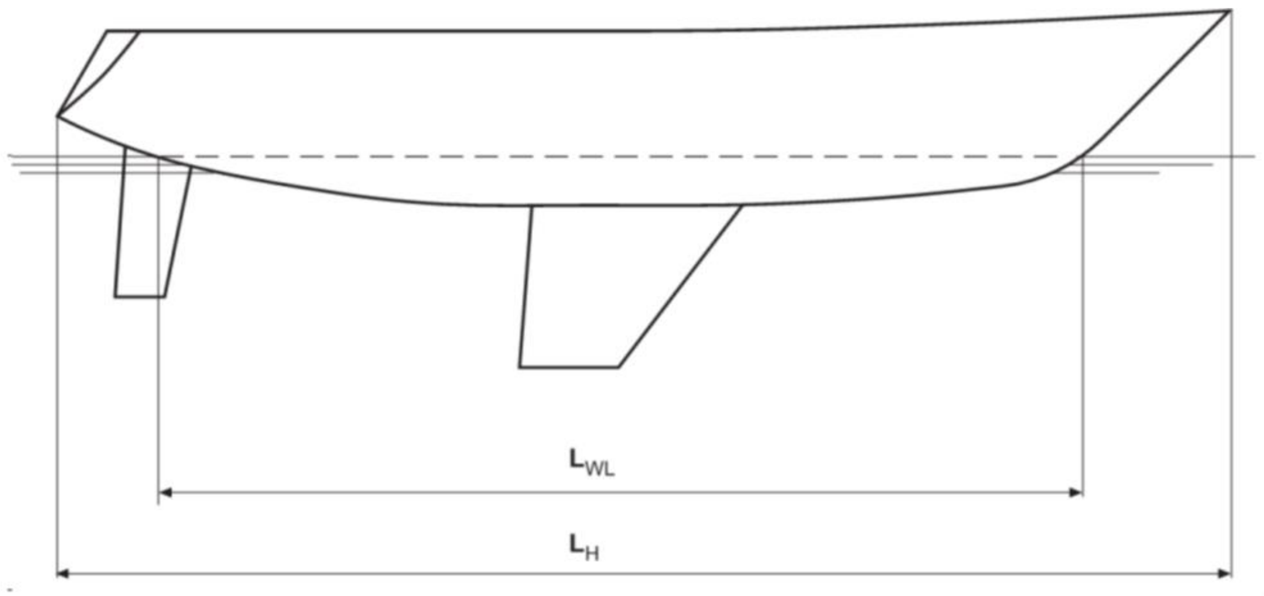


Fig. 2.1

.7 Depth H_k of the keel

The depth of the keel H_k in [m] is the distance measured amidships from the bottom edge of the keel to the lowest point of the hull, as in Fig. 2.1 and 2.2.

.8 Draught T

The draught **T** in [m] is the vertical distance, measured halfway along L_{WL}, between the flotation plane of the vessel in the ready to operate condition and the bottom edge of the keel.

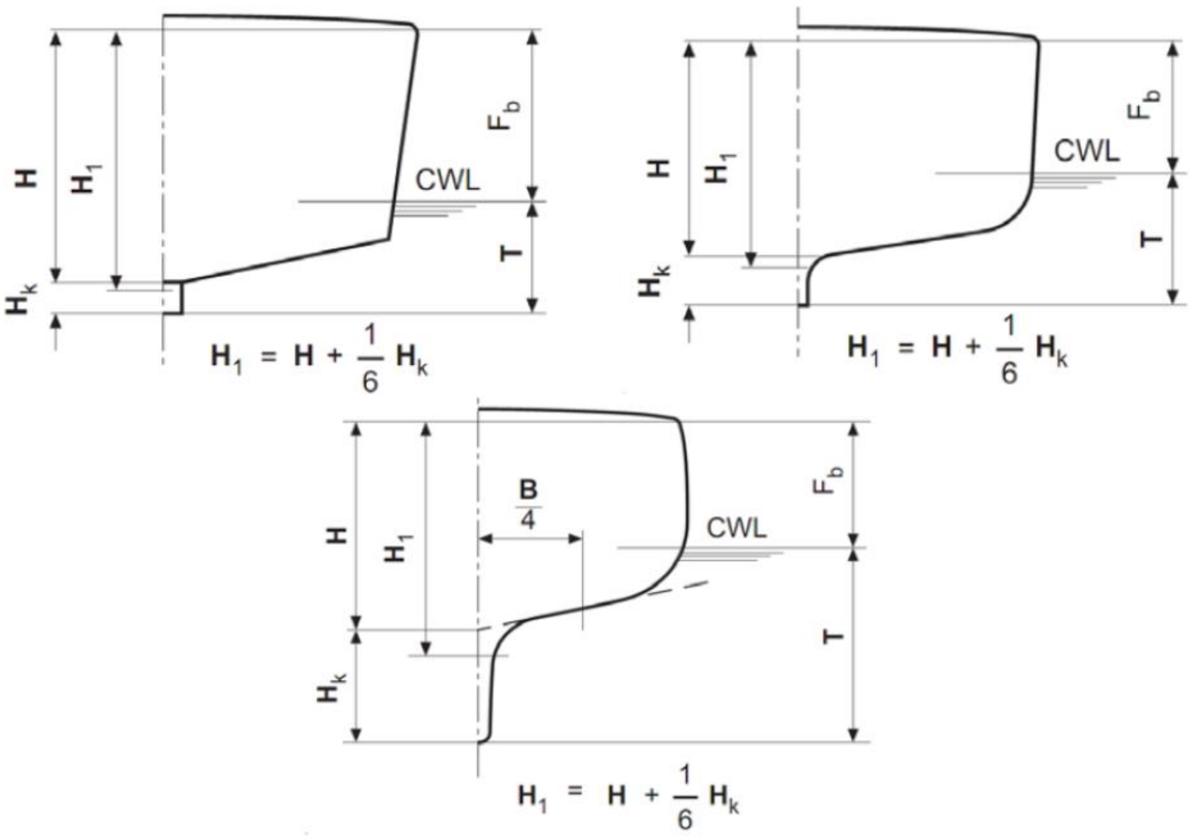


Fig. 2.2

.9 Freeboard F_b

In the case of open or partially decked vessel, the freeboard is the minimum distance between the flotation plane and the upper edge of the gunwale or an opening in the hull without a watertight closure. For decked vessel, the freeboard is to be measured to the upper edge of the deck at its lowest point.

.10 Frame spacing a

The spacing a in [m] of longitudinal and transverse frames is measured from moulding edge to moulding edge.

1.5.2 Speed v

The speed v is the expected maximum speed in knots [kn] of the vessel in the ready to operate condition in smooth water.

1.5.3 Displacement D

The displacement weight D in [t] is the weight of the vessel in the ready to operate condition, corresponding to the sum of the lightweight and the deadweight.

$$D = V \cdot \rho$$

ρ = density of the displaced water [t/m^3]

V = immersed volume up to line of flotation [m^3]

1.5.4 Distinction of vessels (tightness)

.1 Open vessel

Vessel without any deck, maximum permissible operating category is category **V**.

.2 Partially-decked vessel

Vessel with a foredeck whose length is at least 0,33**L** and an after deck, otherwise open. Permissible operating categories are categories **IV** and **V**.

.3 Decked vessel

Vessel with a continuous watertight deck from stern to stem, possibly interrupted by a self-bailing cockpit.

Permissible operating categories are categories **I** to **V**.

1.5.5 Types of vessels

Open, partially- decked and decked vessels propelled by fixed engines.

1.6 Materials

The materials of the structural members shall comply with Section 5. Materials with qualities differing from these guidances may be used only if specifically approved.

1.7 Submission of documents

1.7.1 To ensure conformity with the regulations, drawings and documents in triplicate are to be submitted which clearly show the arrangement and scantlings of the components plus their material designations.

Documents to be submitted are:

- General arrangements
- Lines plan
- Transverse section
- Longitudinal section
- Watertight bulkhead
- Fore peak & after peak
- Deck house
- Detail of connection, for wooden fishing vessel.
- Engine foundation
- Rudder & rudder stock
- Preliminary & final stability

Other data which appear to be necessary, e.g. strength calculations, may be requested by BKI.

Deviations from the approved construction drawings require approval before work commences.

1.7.2 Survey during construction will be based on the approved documentation which shall have been submitted before manufacturing starts.

1.9 Basic principles for load determination

1.9.1 General

A contains data concerning the design loads for the scantling determination of fishing vessel hull according to the dimensioning formulae of **B**.

1.9.2 Hull loadings

Table 2.1 Hull loadings

Hull area	Design Loadings [kN/m^2]
Shell bottom ≥ 0,4L ÷ fore < 0,4L ÷ aft	P_{dBM} 2,7 **L** + 3,29 2,16 **L** + 2,63
Shell side ≥ 0,4L ÷ fore < 0,4L ÷aft	P_{dBM} 1,88 **L** + 1,76 1,50 **L** + 1,41

1.9.3 Correction factors for speed

Table 2.2 Correction factors for speed

Loading area	Correction factor
Shell bottom	$F_{VB} = 0{,}34 \cdot \sqrt{\dfrac{v}{\sqrt{L_{WL}}}} + 0{,}355 \geq 1{,}0$
Shell side	$F_{VS} = \left(0{,}024 \cdot \dfrac{v}{\sqrt{L_{WL}}} + 0{,}91\right)(1{,}018 - 0{,}0024 \cdot \mathbf{L}) \geq 1{,}0$
Internal structural members Floors	$F_{VF} = \left(0{,}78 \cdot \sqrt{\dfrac{v}{\sqrt{L_{WL}}}} + 0{,}48\right)(1{,}335 - 0{,}01 \cdot \mathbf{L}) \geq 1{,}0$
Web frame at WL Bottom longitudinal frames	$F_{VBW} =$ $F_{VL} =$ $0{,}075 \cdot \dfrac{v}{\sqrt{L_{WL}}} + 0{,}73 \geq 1{,}0$
Transverse frames Webs at side	$F_{VSF} =$ $F_{VSW} =$ $\left(0{,}1 \cdot \dfrac{v}{\sqrt{L_{WL}}} + 0{,}52\right)(1{,}19 - 0{,}01 \cdot \mathbf{L}) \geq 1{,}0$
Side longitudinal frames	$F_{VSL} = \left(0{,}14 \cdot \dfrac{v}{\sqrt{L_{WL}}} + 0{,}47\right)(1{,}07 - 0{,}008 \cdot \mathbf{L}) \geq 1{,}0$
L_{WL} and v see A.5: $v_{max} = 12 \cdot \sqrt[4]{L}$ [kn]	

1.9.4 Deck and superstructure loadings

Table 2.3 Deck and superstructure loadings

Area			Design loads P_{dD} [kN/m²]
Main deck			0,26 **L** + 8,24
Cabins	h ≤ 0,5 m	Deck[1]	0,235 **L** + 7,42
		Wall	0,26 **L** + 8,24
Deckhouses	H > 0,5 m	Deck[1,2]	(0,235 **L** + 7,42) (1 – h'/10)
		Side wall[2]	(0,26 **L** + 8,24) (1 – h'/10)
		Front wall	1,25 (0,26 **L** + 8,24) (1 – h'/10)

[1)] minimum load for non walk on cabin decks $P_{dD,min}$ = 4 kN/m²
[2)] h' = 0,5 h (h is height of superstructure above main deck
[3)] the deck load may have to corrected as appropriate for additional loads present

1.10 General principles for scantling determination

1.10.1 The scantlings of structural members and components are to be determined by direct calculation if the vessel is of unusual design or shape, or has un- usual proportions, or if

- the speed v exceeds 35 knots or
- if $\frac{v}{\sqrt{L_{WL}}} \geq 10{,}8$ or
- **D** > 0,094 (**L**² – 15,8) and at the same time
- $\frac{v}{\sqrt{L_{WL}}} > 3{,}6$
- materials are intended to be used other than those listed in Section 5.

1.10.2 Scantling determination for the following Fishing vessel of GRP is carried out with the aid of add-on factors for plate thickness and section moduli see B.

2. Bulkheads

2.1 Arrangement of bulkheads

2.1.1 Collision bulkhead

It is recommended that each vessel be fitted with a collision bulkhead. The fishing vessels with a length **L** exceeding 17 m. Collision bulkheads shall be extended up to the weather deck.

3. Rudder and steering arrangements

3.1 General

3.1.1 Each fishing vessel shall be fitted with rudder and steering arrangements which provide adequate manoeuvrability.

3.1.2 The rudder and steering arrangement comprises of all components necessary for manoeuvring the vessel, from the rudder and the rudder operating gear to the steering position.

3.1.3 Rudder and steering equipment shall be so arranged that checks and performance tests of all components are possible.

3.2 Rudder force and torsional moment

3.2.1 Rudder force

The rudder force to be used for determining the component scantlings is to be calculated in accordance with the following formula:

$$C_R = 1{,}2 \cdot \kappa_1 \cdot 132 \cdot v_0^2 \cdot A \quad [N]$$

A = total surface area of rudder without that of skeg, in [m^2] e.g.

= $A = A_1 + A_2$

v_0 = highest anticipated speed of the vessel in knots [kn]

v_{0min} = $2{,}4\sqrt{L_{WL}}$ [kn]

v_{0max} = $12 \cdot \sqrt[4]{L}$

L_{WL} = in accordance with 1.5 in [m]

κ_1 = factor depending on aspect ratio of the effective rudder surface area A_0

Λ = $\dfrac{b^2}{A_0}$

b = mean height of rudder surface in [m]

A_0 = effective rudder surface [m^2]

= rudder surface plus effective part of skeg surface in accordance with Fig. 2.4 and 2.7.

Table 2.4

Λ	κ_1
0,50	0,66
0,66	0,83
0,75	1,00
0,83	1,12
1,00	1,21
1,00	1,29
1,25	1,36
1,12	1,41
1,50	1,45
1,21	1,48
1,75	1,50
1,29	1,52
2,00	1,53

κ_2 = factor, depending on type of vessel

3.2.2 Torsional moment

The torsional moment to be transmitted by the rudder operating gear is to be calculated in accordance with the following formula:

$$Q_R = C_R \cdot r \quad [Nm]$$

$r = x_c \cdot f$ [m], if the axis of rotation lies within the rudder

$= x_c + f$ [m], if the axis of rotation is forward of the rudder

x_c, f, r_{min} in [m] dependent on the type of rudder as in Fig. 2.3, 2.4, 2.5, 2.6 and 2.7.

$x_c = 0.3 \cdot c$

$r_{min} = 0{,}10 \cdot c$

$c = \frac{A_1}{b}$

$A_0 = A_1$

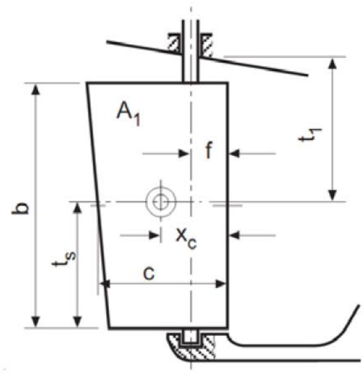


Fig. 2.3

$x_c = 0{,}5 \cdot c$

for $\frac{A_1}{A_3} \geq 2{,}0$

$r_{min} = 0.05 \cdot c$

$c = \frac{A_1 + A_3}{b}$

$A_0 = A_1 + A_3$

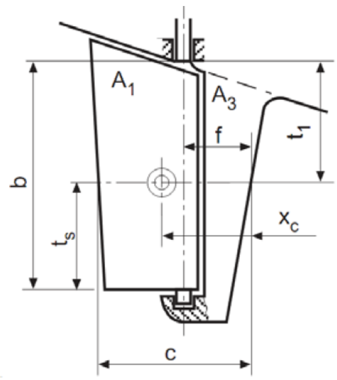


Fig. 2.4

$x_c = 0{,}25 \cdot c = r$

for $\frac{A_1}{A_3} < 2{,}0$

$r_{min} = 0.05 \cdot c$

$c = \frac{A_1}{b}$

$A_0 = A_1$

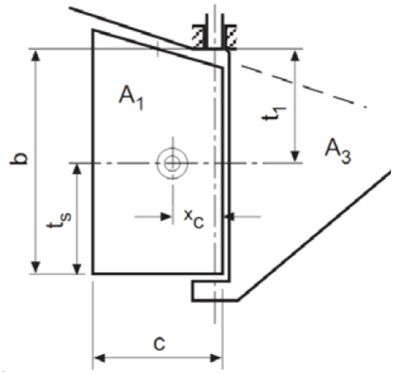


Fig. 2.5

$x_c = 0.3 \cdot c$

$r_{min} = 0{,}10 \cdot c$

$c = \frac{A_2}{b}$

$A_0 = A_2$

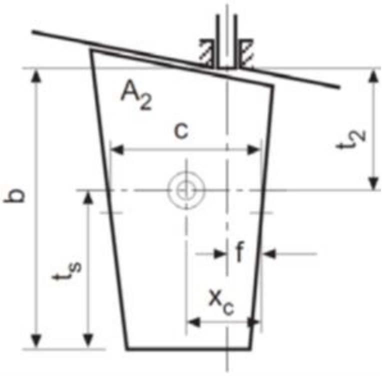


Fig. 2.6

$x_c = c\left[0{,}2 \cdot \frac{b_1}{b} + 0{,}3\right]$

$r_{min} = c\left[0{,}1 - 0{,}05 \cdot \frac{b_1}{b}\right]$

$c = \frac{A_1 + A_2 + A_3}{b}$

$A_0 = A_1 + A_2 + A_3$

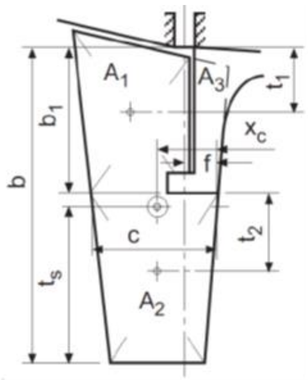


Fig 2.7

3.3 Scantlings of the rudder arrangement

3.3.1 Rudder stock

The rudder stock diameter required for transmission of the torsional moment shall not be less than:

$D_t = 3{,}8 \cdot \sqrt[3]{k \cdot Q_R}$ [mm]

k = material factor according to 6.2.2

Depending on their type of support, rudder stocks must additionally carry bending moments and are to be reinforced in accordance with the following formula:

$$D_v = D_t \cdot \kappa_3$$

κ_3 = factor depending on the type of rudder and support of rudder stock

For rudders according to Fig. 2.3, 2.4 and 2.5.

$$\kappa_3 = \sqrt[6]{\frac{1}{12} \cdot \left(\frac{t_1}{r}\right)^2 + 1}$$

For rudders according to Fig. 2.6 (spade rudder).

$$\kappa_3 = \sqrt[6]{\frac{4}{3} \cdot \left(\frac{t_2}{r}\right)^2 + 1}$$

For rudders according to Fig.2.7.

$$\kappa_3 = \sqrt[6]{\frac{4}{3} \cdot \left(\frac{A_2}{A_1 + A_2}\right)^2 \cdot \left(\frac{t_2}{r}\right)^2 + 1}$$

For rudders according to Fig. 2.3, 2.4, 2.5 and 2.7.

κ_3 = 1,0 if there is proof that the rudder stock is not subject to bending moments.

The rudder stock diameter D_v thus determined is to be maintained for at least 0,1 the distance between the lower main bearing and the next higher bearing above the lower bearing. The diameter may then be reduced to the diameter D_t necessary for the transmission of the torque at the tiller. Halfway along the shaft, the diameter may not be less than:

$$D_m = \frac{D_v + D_t}{2} \cdot 1,15 \quad [\text{mm}]$$

for spade rudders according to Fig. 2.6;

$$D_m = \frac{D_v + D_t}{2} \cdot 1,0 \quad [\text{mm}]$$

for rudders according to Fig. 2.3, 2.4, 2.5 and 2.7.

The diameter necessary for transmission of the torque from the emergency tiller shall not be less than $0,9 \cdot D_t$.

Where the rudder stock enters the top of the rudder body it shall have the rule diameter D_v for at least 0,1 of its length; the diameter may then be reduced linearly towards the lower end.

Tubular rudder stocks shall have the same section modulus as solid stocks. The relation between the diameters of the tubular rudder stock can be calculated from the following formula:

$$D_v = \sqrt[3]{\frac{D_a^4 + D_1^4}{D_a}}$$

D_a = outer diameter of the tubular stock [mm]

D_i = inner diameter of the tubular stock [mm]

The minimum wall thickness of the tubular stock shall not be less than:

$$t_{min} = 0{,}1 \cdot D_a \quad [mm]$$

The stock is to be secured against axial movement. The amount of permissible axial play depends on the design of the steering gear and the supporting arrangements.

3.3.2 Rudder couplings

Design of the couplings must be such that they are capable of transmitting the full torque applied by the rudder stock.

.1 Horizontal couplings

The diameter of the coupling bolts shall not be less than

$$d = 0{,}65 \cdot D_v \sqrt{\frac{235}{R_{eH} \cdot n}} \quad [mm]$$

D_v = shaft diameter according to 3.3.1 in [mm]

n = number of coupling bolts the minimum number of coupling bolts is 6

R_{eH} = yield strength of the bolt material in [N/mm^2].

The yield strength of the coupling bolt material shall not be less than 235 N/mm^2. Material with a yield strength above 650 N/mm^2 shall not be used.

The distance of the axis of the coupling bolts from the edges of the coupling flange shall not be less 1,2 times the bolt diameter. Where horizontal couplings are used at least two bolts must be forward of the shaft axis.

The coupling bolts are to be fitted. Nuts and bolts are to be securely fastened against inadvertent slacking-back, e.g. by tab washers in accordance with DIN 432.

The thickness of the coupling flange is to be determined in accordance with the above "Formula for the coupling bolt diameter". For ReH, the yield strength of the coupling flange material used is to be inserted. In order to reduce the load on the bolts, the coupling flanges are to be provided with a fitting key in accordance with DIN 6885.

The key may be omitted if the coupling bolt diameter is increased by 10%.

The coupling flanges are either to be forged onto the rudder stock or welded to a collar headed onto the stock. The collar diameter shall be 1,1 D_v (at least D_v + 10 mm) and its thickness shall be at least equal to that of the flange.

.2 Conical couplings

Conical couplings without any special arrangement for tightening or undoing them are to be in the form of a cone k ≅ 1 : 8 to 1 : 12, as shown in Fig. 1.8:

$$k_k = \frac{d_o - d_u}{\ell}$$

The coupling surfaces must be a perfect fit. Nut and pintle are to be reliably secured against unintentional slacking-back. The coupling between shaft and rudder is to have a fitting key.

3.3.3 Rudder construction

Rudder bodies may be made from FRP, steel or other metallic and non-metallic material. The body is to have horizontal and vertical stiffening members, to make it capable of withstanding bending- and torsional loads. Proof of adequate strength, either by calculation or by a performance test on the prototype, is required. The rudder scantlings of the plating is to be as for shell bottom plating.

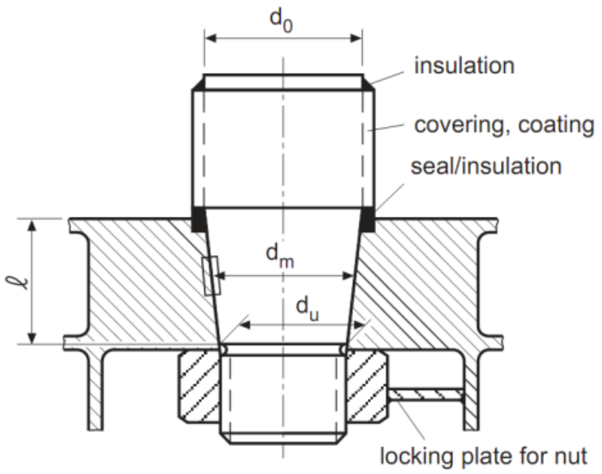


Fig. 2.8

3.3.4 Stoppers

The travel of the rudder quadrant or the tiller is to be limited in both directions by stoppers. The stoppers and their attachments to the hull are to be made so strong that the yield strength of the material used is not exceeded when the rudder stock reaches its yield bending moment.

3.3.5 Rudder heels

Rudder heels of semi balanced rudders and skegs according to Fig. 2.4, and sole pieces according to Fig. 2.9 shall be designed at the hull intersection in a way which ensures the moments and transverse forces arising to be transmitted without any problem.

.1 The section modulus of the sole piece about the z-axis shall not be less than:

$$W_z = \frac{B_1 \cdot x \cdot k}{80} \quad [cm^3]$$

B_1 = reaction of support in [N]

Where the rudder is supported both ends the support reaction without taking into account the elasticity of the sole piece is $B_1 = C_R/2$.

x = distance of the respective cross-section from the rudder axis in [m]; no value less than x_{min} = 0,5 m may be inserted.

x_{max} = e

k = material factor according to 6.2.2

.2 The section modulus relative to the y-axis shall not be less than:

– where there is no rudder post or rudder stock

$$W_y = \frac{W_z}{2}$$

– where there is a rudder post or rudder stock

$$W_y = \frac{W_z}{3}$$

.3 The cross-sectional area at x = e shall not be less than:

$$A_s = \frac{B_1}{48} \cdot k$$

.4 The equivalent stress from bending plus shear within the length e shall in no position be more than:

$$\sigma_v = \sqrt{\sigma_b^2 + 3\tau^2} = \frac{115}{k} \quad [N/mm^2]$$

$$\sigma_b = \frac{B_1 \cdot x}{W_z} \quad [N/mm^2]$$

$$\tau = \frac{B_1}{A_s} \quad [N/mm^2]$$

3.3.6 Rudder bearings

The rudder force C_R shall be distributed between the individual bearings according to the vertical position of the rudder's geometric centre of gravity.

The forces on the bearings are to be calculated as follows:

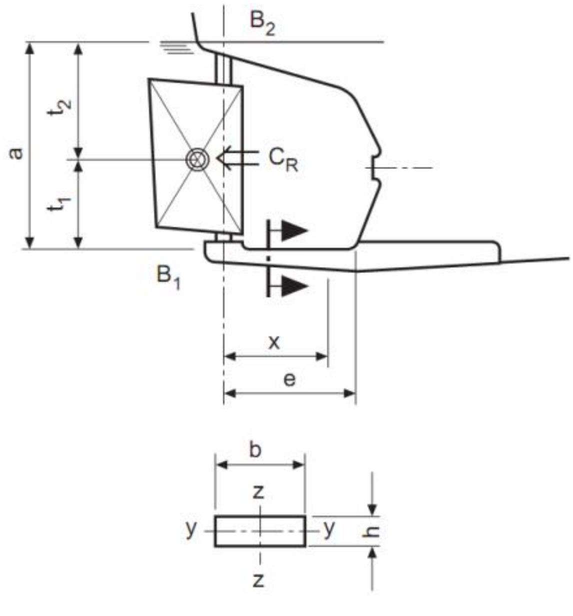


Fig. 2.9

Rudders with bearing in sole piece/skeg:

– Bearing force $B_1 = \frac{C_R \cdot t_2}{a}$ [N]

– Bearing force $B_2 = \frac{C_R \cdot t_1}{a}$ [N]

Bearings of spade rudders:

– Bearing force $B_1 = B_2 + C_R$ [N]

– Bearing force $B_2 = \frac{C_R \cdot t}{a}$ [N]

Bearings of semi spade rudders:

– Bearing force $B_1 = B_2 + C_R$ [N]

– Bearing force $B_2 = \frac{C_R \cdot t}{a}$ [N]

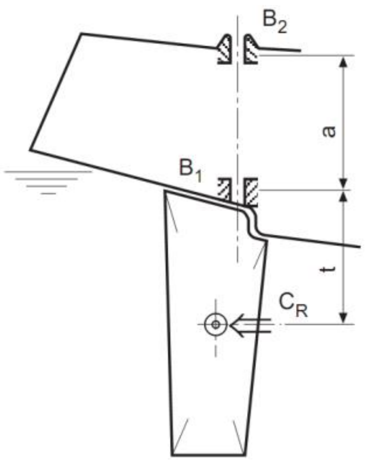


Fig. 2.10 Spade rudder

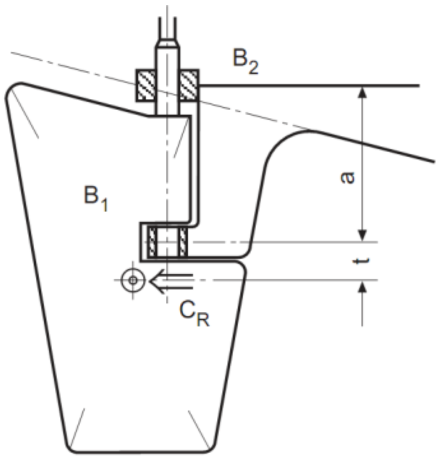


Fig. 2.11 Semi spade rudder

The mean surface pressure in the bearings shall not exceed the following values:

Table 2.6

Bearing material	P [N/mm²]
PTFE	2,5
PA PI	5,0
bronze steel Thordon XL	7,0

Trade names (selection) :
PTFE
(*polytetrafluoroethylene*) : Fluon, Hostaflon TF, Teflon
PA (polyamide) : Degamid, Ultramid B, Durethan, Rilsan, Vestamid, Trogamid
PI (polyimide): Kapton, Vespel

The mean surface pressure is to be determined as follows:

$$p = \frac{P}{d \cdot h} \quad [N/mm^2]$$

P = bearing force (B_1 or B_2) in [N]

d = bearing diameter in [mm]

h = bearing height in [mm]

The bearing height shall be at least 1,2 · d.

3.3.7 Rudder tube

Rudder tubes are to be strong enough to withstand the loads which arise. They are to be adequately supported longitudinally and transversely and connected to the longitudinal and transverse structural members.

The minimum thickness S of the tube wall is to be determined according to the following formula:

for metallic materials :

$$S = 0{,}9 \cdot \sqrt{L_{WL}} \cdot \sqrt{k}$$

L_{WL} in [m].

Fibre-reinforced plastic rudder tubes shall be of the same strength as the shell bottom laminate.

The tube is to extend up through the hull to the deck, or a stuffing box is to be fitted above the flotation plane of the vessel in the ready to operate condition.

Hoses or hose-type sleeves of suitable material may be used 200 mm above the flotation plane.

3.4 Tiller and quadrant

If the hub of tiller or quadrant is shrunk onto the rudder stock or designed as a split hub or conical connection, this connection is to be additionally secured by a fitting key. The hub external diameter may not be less than:

$$d = 1{,}9 \cdot D_t \cdot \sqrt{k} \quad [mm]$$

Split hubs must have at least two bolts on each side of the stock, whose total root diameter shall not be less than:

$$f = 0{,}22 \cdot \frac{D_t^3}{e} \cdot 10^{-2} \ [cm^2]$$

D_t = rudder stock diameter in [mm] according to 3.3.1

e = distance of bolt axis from stock centre line in [mm]

The arms of tiller and quadrant are to be so dimensioned that the equivalent stress from bending plus shear does not exceed 0,35 × times the material yield strength.

3.5 Cable-operated steering gear

The minimum breaking strength of the steering cables shall not be less than

$$P_s = \frac{Q_R \cdot 4}{e'}$$

Q_R = torsional moment according to 3.2.2 [Nm]

e' = distance of cable lead from rudder stock centreline [m]

The make of cables used is to be 6 × 19 DIN 3060 or equivalent.

3.6 Emergency steering gear

Mechanical or hydraulic rudder operating gear must be provided with emergency steering gear as a back-up.

Emergency tillers must be operable from the open deck unless there is a non-powered means of communication between the bridge steering position and the rudder compartment.

To allow the emergency tiller to be connected, the rudder stock is at the top end to be provided with a square of the following dimensions:

width across flats = $0{,}87 \cdot D_t$

height = $0{,}80 \cdot D_t$

D_t according to 3.3.1.

For dimensioning the emergency tiller and its components, the torsional moment Q_R according to 3.2.2 reduced by 25% is to be used as a basis.

4. Propeller brackets

4.1 Double arm brackets

The scantlings of full double arm propeller brackets of ordinary hull structural steel, based on the shaft diameter d are as follows:

strut thickness = $0{,}40 \cdot d_p$ [mm]

strut cross-sectional area = $0{,}40 \cdot d_p^2$ [mm^2]

each arm

length of boss = $2{,}70 \cdot d_p$ [mm]

boss wall thickness = $0{,}25 \cdot d_p$ [mm]

d_p = diameter [mm] of propeller shaft of non stainless steel in accordance with Section 3.

The scantlings apply to an arm length **L'** = $11 \cdot d_p$. For longer arms, the cross-sectional areas are to be increased in proportion with the length.

4.2 Single arm propeller brackets

The section modulus of the arm of hull structural steel at its clamped support (without taking into account possible rounding) is to be determined according to the following formula:

$$W_1 = 0{,}0002 \cdot d_p^3 \cdot k \quad [cm^3]$$

k = material factor according to 6.2.2

The section modulus at the boss, above any curvature, (W_2) may not be less than:

$$W_2 = 0{,}00014 \cdot d_p^3 \cdot k \quad [cm^3]$$

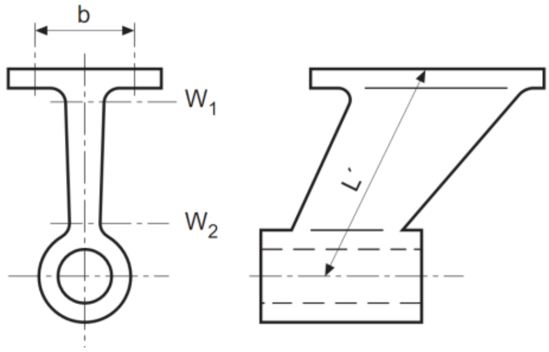


Fig 2.12

The section moduli apply to an arm length **L'** = 11 · d_p. For longer arms, the section modulus is to be increased in proportion with the length.

For final determination of the propeller bracket scantlings, BKI reserve the right to request a stress analysis with the following dynamic loads: The pulsating force which arises assuming loss of one propeller blade and a propeller rotational speed of 0,75 × nominal rpm is to be determined. In these circumstances the following bending stress is not to be exceeded:

$$\sigma_{dzul} = 0{,}4 \cdot R_{eH} \quad \text{for } R_{eH} = 235 \quad N/mm^2$$

$$= 0{,}35 \cdot R_{eH} \quad \text{for } R_{eH} = 335 \quad N/mm^2$$

R_{eH} = yield strength of the material used in [N/mm²]

4.3 Propeller bracket attachment

4.3.1 Screw connection of propeller bracket arms

The propeller brackets are to be carefully and directly fastened to floors and longitudinal bearers by means of flanges. The shell is to be reinforced in this area.

Number and diameter of screws of single-arm propeller brackets are to be taken from the following Table:

Table 2.7

Section modulus W_1	Spacing b of the two rows of bolts	Fixing bolts [1]	
		Number	Diameter
[cm³]	[mm]		[mm]
2	85	6	M 12
4	100	6	M 12
6	115	6	M 12
8	125	6	M 12
10	135	6	M 12
25	140	6	M 16
45	150	6	M 16
60	150	6	M 20
80	155	6	M 22
100	160	6	M 24

1) ordinary hull structural steel

The distance of the fixing bolts from the edge of the flange is to be at least 1,2 times the bolt diameter. The flange thickness is to be at least equal to the diameter of the fixing bolts.

4.3.2 Casting-in propeller bracket arms

Propeller bracket arms can be cast-in to hull of FRP as shown in the following principle sketch, using fibre reinforced resin. Propeller bracket arms must be provided with anchors of sea-water-compatible material in the area where they are cast-in. Such principles of construction are subject to special tests. BKI reserve the right to have performance tests conducted which can provide information about the fatigue strength of the bond, plus the vibration pattern under a variety of operating conditions.

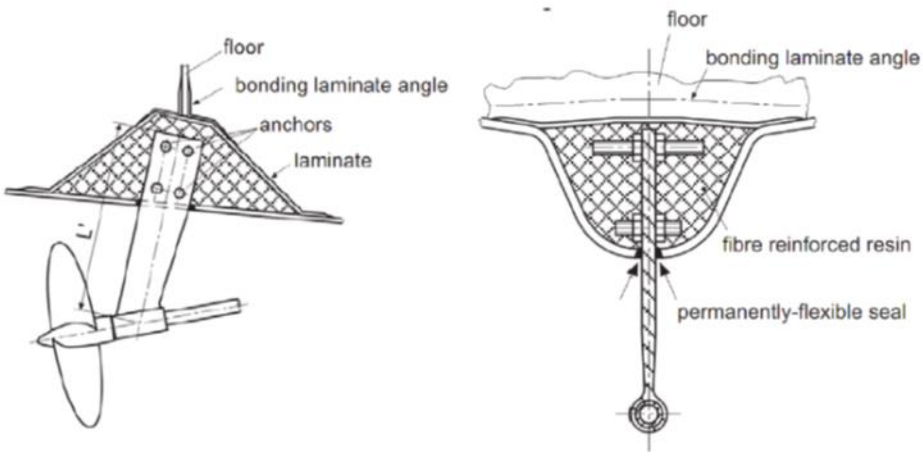


Fig. 2.13

5. Ballast keels

5.1 External ballast

5.1.1 The ballast keel may be of lead, cast iron, steel or other suitable material and is to be fastened to the adequately strengthened keel sole using keel bolts.

The top surface of the keel must be flat to ensure a tight fit to the hull. The keel/hull interface is to be provided with a suitable durable seal.

5.1.2 Keel bolts

The diameters of keel bolts arranged in pairs are to be calculated using the following formula:

$$d_k = \sqrt{\frac{2 \cdot W_k \cdot h_k \cdot b_{max}}{R_{EH} \cdot \sum b_i^2}} \quad [mm]$$

d_{kmin} = 12,0 mm where R_{eH} = 235 [N/mm^2]

d_k = keel bolt root diameter

W_k = ballast keel weight [N]

h_k = distance of keel CG from keel upper edge [mm] as in Fig. 2.14

b_{max} = maximum scantling width bi [mm]

b_i = scantling width at each pair of keel bolts [mm]

= $0{,}5 \cdot b_{bi} + 0{,}4 \cdot b_{ki}$

R_{eH} = yield strength of bolt material [N/mm^2]

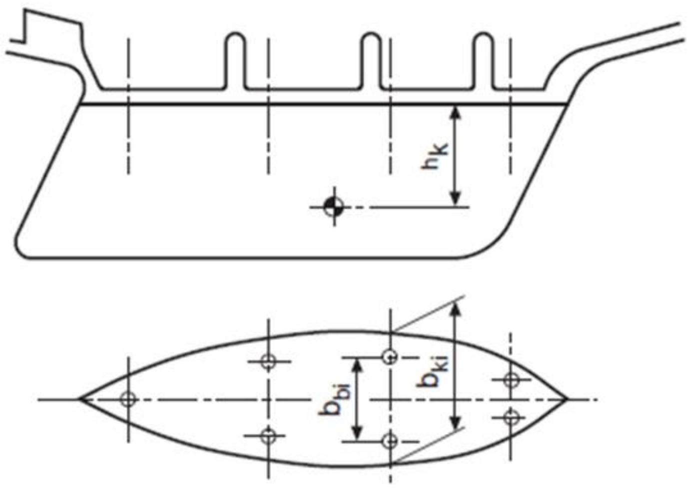


Fig. 2.14

Large washers with a diameter of 4 times and thick- ness of one quarter of the keel bolt diameter (d_k) are to be fitted under the head of each bolt. The thread must be long enough to allow fitting of lock nuts or other suitable locking devices.

Keel bolts must be made of material suitable for use in sea water. They are to be fastened in the ballast keel as required for the forces arising.

5.2 Internal ballast

Internal ballast must be accommodated in the hull securely fastened. It may be cast-in or inserted in blocks. It shall not stress the shell, but the load from it shall be transferred to keel, floors and other load- bearing structural members.

When casting-in lead ballast, suitable measures are to be taken to ensure that there is no adverse effect on the shell's grade of quality.

Voids resulting from inserting the ballast in form of blocks are to be filled with a suitable cast able material. In the case of FRP hull, the top surface of the internal ballast shall be covered with FRP laminate.

6. Water tanks and fuel tanks

6.1 General

Water and diesel fuel may be stored in integral or in detached tanks, securely fastened.

The fuel tanks must be so arranged that they cannot be unacceptably heated by the engine, the exhaust system or other sources of heat.

A coffer dam is to be provided between integral fresh water tanks and fuel/holding tanks, or other measures shall be taken to ensure that fuel cannot penetrate into the water tank.

The tanks are, as necessary, to be subdivided by internal wash plates so that the breadth of the liquid surface does not exceed 0,5 B or 1,0 m, whichever is the lesser. The wash plates need only be arranged halfway up the tank. For tanks more than 3,0 m long, transverse wash plates are recommended.

Wash plates are to be dimensioned in accordance with the prevailing forces; the total glass weight of their laminates must not be less than 2400 g/m^2.

The tanks are to be provided with hand holes. These must be large enough to allow all corners of the tanks to be reached for cleaning.

6.2 Scantlings

6.2.1 The plating thickness of flat-sided metallic tanks is calculated from:

$$s = 4 \cdot a \cdot \sqrt{h_1} \cdot F_p \cdot \sqrt{k} \quad [mm]$$

6.2.2 Stiffeners are to be fitted to stiffen the tank walls. The required section moduli of the stiffeners are calculated from:

$$W = a \cdot h_2 \cdot \ell^2 \cdot c_2 \cdot k \quad [cm^3]$$

a = stiffener spacing in [m]

h_1 = pressure head measured from plate bottom edge to top of filler tube in [m]

h_2 = pressure head measured from stiffener mid- length to top of filler tube in [m]

for the height of the filler tube above deck, the minimum values which shall be inserted are:

- 0,25 m up to **L** = 10 m
- 0,50 m up to **L** = 15 m
- 1,00 m for larger fishing vessel

$k = 1,0$

for ordinary steel with yield strength material R_{eH} is 235 [N/mm^2] and whose ultimate tensile strength R_m is 400 [N/mm^2].

$$k = \frac{635}{R_{eH} + R_m}$$

for higher or lower steel.

ℓ = length of stiffener in [m]

F_P = $(0,54 + 0,23\,R) \leq 1,0$

correction factor for the aspect ratio R of unsupported plate panels

$R = \frac{\ell}{a}$

c_2 = 5,0 where the stiffener end fastenings do not have bracket plates

= 3,4 where the stiffener end fastenings have bracket plates

The calculated section moduli apply to the stiffeners in conjunction with the tank plating to which they are welded.

6.2.3 In the case of detached tanks with curved walls, the plate thicknesses and section moduli determined in accordance with 6.2.1 and 6.2.2 may be reduced, if adequate rigidity and tightness is proven by means of a water pressure test at elevated pressure. The test pressure head is to be 1,5 times the height from the floor of the tank to the top of the filler tube at least 2 m.

6.2.4 Tanks more than 2 m wide or long shall be provided with a wash plate. Plate thickness and stiffener calculations are to be in accordance with 6.2.1 and 6.2.2.

6.2.5 Larger water and diesel fuel tanks shall be equipped with hand holes; very large ones with man holes. The hand holes must be large enough to reach all corners of the tank. The diameters of the bolts for hand hole and manhole covers shall at least be double the cover thickness; bolt spacing is not to exceed 8 to 9 times the plate thickness. Bolts are to have at least an M8 thread.

6.2.6 For fitting the tanks and containers with pipes, mountings, etc., see Section 3.

6.3 Vent pipes and filling arrangement

6.3.1 Each tank is to be provided with a vent pipe. This is to be extended above the open deck and so arranged that the tank can be filled completely.

6.3.2 It must be possible to fill water, diesel fuel and petrol tanks from the open deck. Filler caps, filler tubes, vent pipes and sounding tubes shall have watertight connection with the deck and shall be so located that fuel vapour (heavier than air) can flow into the accommodation or other spaces such as the cockpit and cockpit lockers, anchor chain lockers, water tanks or the surrounding water.

6.3.3 Each tank is to have a sounding tube, lead close to the tank bottom. A doubling plate is to be welded to the tank bottom underneath the sounding tube. Electric tank-sounding devices of proven design may be accepted.

6.4 Testing for tightness

6.4.1 All tanks are to be water or air pressure tested for tightness. The minimum test level is a water column up to the highest point of the overflow/vent pipe. The air pressure may not exceed 15 kPa (over-pressure). The increased risk of accidents involved in testing with air pressure is to be taken into account.

6.4.2 The test is generally to be carried out ashore, before application of the first coat of paint. Should, for the passage of pipes or for other reasons, the tank wall be penetrated after the test, a second tightness-test must be carried out if requested by the responsible surveyor. This test may be carried out afloat.

7. Special equipment

All mountings, fittings, equipment and apparatus, not referred to in these guidance, shall be suitable for the intended service in fishing vessel. They must not impair the safety of the vessel and its crew. Where applicable, the relevant rules, regulations and guidelines of the responsible authorities and institutions are to be complied with.

B. Glass Fibre Reinforced Plastic Hulls

1. Scope

1.1 These Guidances apply to the scantling determination of GRP hulls with **L** from 6 m to 24 m built by the hand lay-up method in single skin construction from E-glass laminate consisting of chopped strand mat (CSM) layers or alternate layers of CSM and bidirectional woven roving.

If it is intended to use glass-fibre-resin spray-up moulding for the production of primary structural parts, the conditions according to 2.3 are to be complied with. This applies also to the intermediate layers of composite laminates. Use of this method is limited to components which by virtue of their design principle, or position and configuration of the mould allow for a satisfactory structuring of the laminate.

2. Basic principles for scantling determination

2.1 The scantling determination of the hull primary structural members of fishing vessel are to be determined in accordance with Table 2.8 to 2.20, if laminates with mechanical properties in accordance with 3.1 are used.

2.2 The scantlings of 2.1 are to be multiplied by the following factors: 1,2 for the glass weight and 1,44 for the section moduli. Deck loads are to be corrected as appropriate for the additional loads present.

Hulls of fishing vessel, depending on the fishing method, shall be provided with local reinforcement in accordance with the Rules for Fishing Vessels (Pt.1, Vol.XII).

2.2.1 For vessel of unusual construction and special conditions of operation following safety factors are proposed to be applied at RT or 23 °C:

1) static loads: S = 1,1
2) extreme loads: S = 1,1
3) statistical loads (sea loads): S = 2,0

$$\sigma_{zul} = \frac{R_m \cdot R_1 \cdot R_2 \cdot R_3 \cdot \ldots\ldots \cdot R_8}{S} \quad [N/mm^2]$$

R_m = tensile strength of laminate

Reduction factors for laminates	
statistical long-term loading (sea loads)	$R_1 < 0,75$
statistical long-term loading (tank walls)	$R_2 < 0,5$
raised temeperature	$R_3 < 0,9$
ageing	$R_4 < 0,8$
manufacturing i.e. hand lay-up prepeg	 $R_5 = 0,9$ $R_5 = 1,0$
Fatigue N < 102 N < 103 N < 106	 $R_6 = 1,0$ $R_6 = 0,8$ $R_6 = 0,4$
Different material properties	$R_7 < 0,9$
moisture	$R_8 < 0,8$
N = number of load changes during life span of the structural member	

2.3 Scantling determination for structural members of spray-up laminate may be determined in accordance with Table 2.8 to 2.20 if the following conditions are fulfilled:

– The manufacturer shall provide proof of the suitability of its workshop, equipment and apparatus, plus the qualification of its personnel. Therefor a procedure test is to be carried out in the presence of the BKI surveyor.

– The following mechanical properties relevant for scantling determination are to be verified as part of the procedure test:

Glass content		ISO 1172
Tensile strength	dry	EN ISO 527-4
	wet	EN ISO 527-4[1, 2]
Young's modulus (tension)	dry	EN ISO 527-4
Flexural strength	dry	EN ISO 14125, Procedure A
	wet	EN ISO 14125, Procedure A[1, 2]
Water absorption		DIN EN ISO 62[3]

[1] No. of test pieces = 3

[2] Conditioning of 30 ± 1 days in distilled water at 23 °C. The conditioning period can be reduced by 50 % for each temperature increase of 10 °C. While conditioning, the dimensional stability temperature of the thermosetting resin shall not be exceeded.

[3] Total test duration 30 ± 1 days. Water absorption to be determined after 3 days, after 7 days and after 30 days.

– proof is to be obtained that the laminate minimum thicknesses as calculated are maintained on all parts of the structure. Since evenness of layer thickness depends on the skill of the sprayer doing the work, it is recommended that resin- and glass quantities each be exceeded by 10% relative to the calculated values to ensure attainment of the minimum thicknesses.

– The requirements in accordance with Rules for Non-Metallic Materials (Pt.1, Vol.XIV) Ch.1 are to be observed; excerpts are listed in Section 5.

3. Material properties

3.1 The values laid down in Table 2.8 to 2.20 embody the following mechanical properties of the basic laminate which consists of CSM layers. The properties given are minimum values which must be achieved by the actual laminate.

Mechanical properties of basic laminate (minimum values)		$\frac{N}{mm^2}$
Tensile strength (fracture)	σ_{zB}	85
Young's modulus (tension)	E_Z	6350
Flexural strength (fracture)	σ_{bB}	152
Compressive strength (fracture)	σ_{dB}	117
Shear strength (fracture)	τ_B	62
Shear modulus	G	2750
Interlaminar shear strength	τ_{ib}	17
Specific thickness = 0,70 mm per 300 g/m² glass reinforcement Glass content by weight Ψ = 0,30		

3.2 If the glass content by weight of the actual laminate differs from the value of 30% stated in 3.1, the mechanical properties are to be determined from the following formulae. This is generally the case if the laminate consists of CSM/woven roving combinations.

Tensile strength (fracture)

$$\sigma_{zB} = 1278 \cdot \Psi^2 - 510 \cdot \Psi + 123 \quad [N/mm^2]$$

Young's modulus (tension)

$$E_Z = (37 \cdot \Psi - 4{,}75) \cdot 10^3 \quad [N/mm^2]$$

Flexural strength (fracture)

$$\sigma_{bB} = 502 \cdot \Psi^2 + 106{,}8 \quad [N/mm^2]$$

Compressive strength (fracture)

$$\sigma_{dB} = 150 \cdot \Psi + 72 \quad [N/mm^2]$$

Shear strength (fracture)

$$\tau_B = 80 \cdot \Psi + 38 \quad [N/mm^2]$$

Shear modulus

$$G = (1{,}7 \cdot \Psi + 2{,}24) \cdot 10^3 \quad [N/mm^2]$$

Interlaminar shear strength

$$\tau_{iB} = 22{,}5 - 17{,}5 \cdot \Psi \quad [N/mm^2]$$

Ψ = glass content of laminate by weight

3.3 The individual layer thickness can be determined from the following formula:

$$t = 0{,}001 \cdot W \left(\frac{1}{\rho_F} + \frac{1-\psi}{\psi} \cdot \frac{1}{\rho_H} \right)$$

W = weight per unit area of reinforcement fibre [g/m²]

ρ_F = density of fibre (2,6 [g/cm³] for E-glass as reinforcing material)

ρ_H = resin density (1,2 [g/cm³] for unsaturated polyester resin matrix)

Mass- and volume content of glass fibres is to be taken from the following Table.

	Fibre mass Content	Fibre volume content
Mat laminate Sprayed laminate	Ψ = 0,30	Ψ = 0,17
Woven roving laminate	Ψ = 0,50	Ψ = 0,32

3.4 If the mechanical properties of laminates intended to be used do not achieve those determined according to 3.2, their properties and their glass content are to be determined by tests.

3.5 The test specimen for determination of properties and characteristic values in accordance with 3.4 are to be made using the same procedure and the same conditions, and given the same thermal treatment, as intended to be used for the construction of the hull. When determining the flexural strength, the gel coat side of the test specimen shall be stressed in tension. Proof of the properties and characteristic values is to be provided by means of test certificates from an official material testing institute.

3.6 The mechanical properties and characteristic values used for scantling determination of primary structural members and components must not exceed 90% of the mean values determined by the tests under 3.5.

4. Conditions for scantling determination

4.1 The scantling determination of the primary structural members of pleasure craft hulls is based on the loads in accordance with A.

4.2 The weights of laminate reinforcement required by these guidances represent the weight of the glass-fibre reinforcement material contained in 1 m^2 of laminate. The section moduli of the stiffeners apply to profiles in conjunction with the plate to which they are laminated. They apply to an effective plate width of 300 mm in accordance with 5.2 and 5.3.

4.3 Should the mechanical properties and/or the glass content by weight differ from the values stated in 3.1, the scantlings are to be adjusted in accordance with 4.4 and 4.5.

4.4 The required total weight of the laminate plus the corresponding nominal thickness are to be modified in accordance with the following criteria:

4.4.1 Laminate plates

The total weight of glass reinforcement determined according to Table.2.8, 2.9, 2.14, 2.15, 2,16 and 2.19 is to be multiplied by the factor K_w. This factor is to be calculated as follows:

.1 If the flexural strength (fracture) σ_{bB} and the glass content by weight of the laminate plate have been determined by tests in accordance with 3.4 to 3.6, the factor is

$$K_w = \frac{5{,}27 \cdot \psi}{1{,}88 \cdot \psi} \cdot \sqrt{\frac{152}{\sigma_{bB}}}$$

σ_{bB} = flexural strength (fracture) [N/mm^2]

Ψ = glass content of laminate by weight

.2 If the flexural strength (fracture) σ_{bB} and the glass content of the laminate plate have not been determined by tests in accordance with 3.4 to 3.6, the factor is:

$$K_w = 2{,}8 \cdot \Psi + 0{,}16$$

Ψ = glass content of laminate by weight.

4.4.2 The nominal thickness t of the laminate based on 0,70 mm per 300 g/m^2 weight of laminate reinforcement, determined in accordance with Table 2.8, 2.9, 2.14, 2,15, 2,16 and 2.19, is to be multiplied by the factor K_t obtained as follows:

.1 If the flexural strength (fracture) σ_{bB} of the laminate plate has been determined by tests in accordance with 3.4 to 3.6, that factor is:

$$K_t = \sqrt{\frac{152}{\sigma_{bB}}}$$

.2 If the flexural strength (fracture) σ_{bB} of the laminate plate has not been determined by tests in accordance with 3.4 to 3.6, that factor is:

$$K_t = \sqrt{\frac{1}{3{,}3 \cdot \psi^2 + 0{,}703}}$$

Ψ = glass content of laminate by weight

.3 **Correction factor for aspect ratio R of unsupported plate panels**

$$F_P = (0{,}54 + 0{,}23 \cdot R) \leq 1{,}0$$

.4 Curved plate panels

When dimensioning the laminates of plate panels with simple convex curvature, the effect of the curvature is taken into account by the correction factor f_k.

The initial value for dimensioning is the total weight of glass required for the basic laminate. The relevant values are to be corrected by multiplying with the curvature factor f_k.

This factor is to be determined from the following Table:

h/s	f_k
0 – 0,03	1,0
0,03 – 1	$1{,}1 - 3 \cdot \frac{h}{s}$
> 0,1	0,8

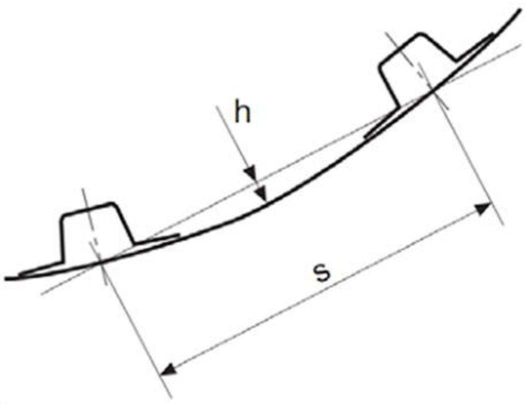


Fig. 2.15

The total weight of glass required, calculated using the factor fk must not be less than the corresponding minimum value from the Table 2.8, 2.9, 2.14, 2.15, 2.16 or 2.19.

Calculation of the corrected total weight of glass required respective the corrected nominal thickness required is to be in accordance with 4.4.1/4.4.2.

4.5 Stiffener sections

The section modulus determined from Table 2.11, 2.12, 2.13, 2.14, 2.15, 2.17, 2.18 and 2.20 is to be multiplied by the factor K_Z, obtained as follows:

$$K_Z = \frac{85}{\sigma_{zB}}$$

4.5.2 If the tensile strength (fracture) σ_{zB} of the laminate plate has not been determined by tests in accordance with 3.4 to 3.6, that factor is:

$$K_Z = \frac{1}{15 \cdot \psi^2 - 6 \cdot \psi + 1{,}45}$$

Ψ = glass content of laminate by weight

4.6 Each section modulus determined from Table 2.11, 2.14, 2.15, 2.17 and 2.20 and corrected in accordance with 4.5 applies to a stiffener of the same material as the laminate plate.

5. Section moduli and geometric properties of the stiffeners

5.1 The section moduli of the stiffeners are to be calculated directly from the profile dimensions and the effective width of plating.

5.2 The effective width of the connected laminate plate is measured from centre to centre of the unsupported panels adjoining the stiffener. It shall not exceed 300 mm.

5.3 The section modulus of stiffener and connected laminate plate is calculated from the following formula:

$$W = \frac{f \cdot h}{10} + \frac{t_s \cdot h^2}{3000} \cdot \left(1 + \frac{100 \cdot (F - f)}{100 \cdot F + t_s \cdot h}\right) \; [cm^3]$$

t_s = thickness of an individual web [mm]

5.4 Where the glass content of laminate by weight is Ψ = 0,30, the minimum thickness of the web may not be less than:

$$t_s = 0{,}025 \cdot h + 1{,}10 \; [mm]$$

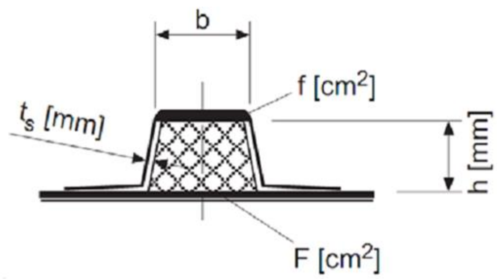


Fig. 2.16

5.5 Where the glass content by weight Ψ of the stiffener's web laminate differs from 0,30, the thickness determined from 5.4 is to be divided by the value K_s.

$$K_s = 130 \cdot \Psi + 0{,}61$$

5.6 Should the tensile properties of the materials in the stiffener differ from those of the laminate plate, the effective tensile modulus of the stiffener in conjunction with the laminate plate is to be determined by correction of the cross-sectional area and/or the width of the various laminate layers in the stiffener in the ratio of the tensile modulus of each of the materials in the stiffener to that of the laminate plate.

5.7 Calculation of the laminate thicknesses to determine the section modulus of a top-hat type profile and connected plate.

5.7.1 Thickness of the individual layer can be determined from the following formula:

$$t = 0{,}001 \cdot W \left(\frac{1}{\rho_F} + \frac{1 - \psi}{\psi} \cdot \frac{1}{\rho_H}\right) \; [mm]$$

W = weight per unit area of the reinforcing fibre [g/m²]

ρ_F = fibre density (2,6 [g/cm³] for glass reinforcement material)

ρ_H = resin density (1,2 [g/cm^3] for UP)

Ψ = glass content of laminate by weight

5.8 Frame spacing

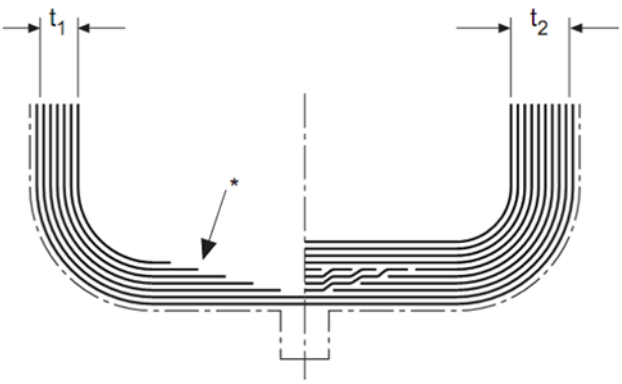
The following frame spacing is recommended for design:

$$a = (350 + L) \ [mm]$$

6. Shell laminate

6.1 General

6.1.1 It is recommended that fabrication of the shell be carried out in a single working cycle. If the hull is prefabricated in two halves, these are to be joined as shown in Fig. 2.17.

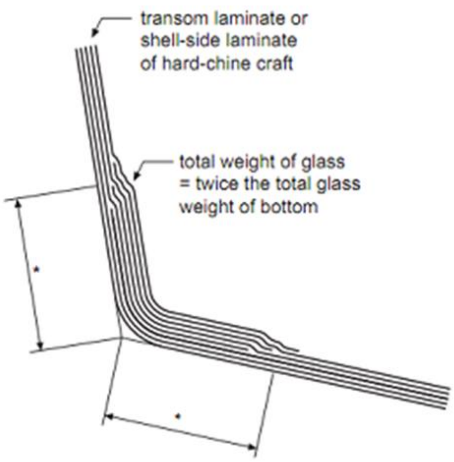


t_1 = laminate before joining the two prefabricated hull halves
t_2 = keel laminate
* = layers are to be stepped 25 mm per 600 g/m^2 glass fibre reinforcement.

Fig. 2.17 Joining-laminate

6.1.2 The outside of the hull shall be covered by a gel coat which shall have a thickness of 0,4 - 0,6 mm.

6.1.3 In the bilge and transom area and other comparable places, the individual layers are to be arranged as shown in Fig. 2.18 to act as a reinforcement.



* Width of overlap = 25 mm per 600 g/m^2 glass fibre reinforcement

Fig. 2.18

The reinforcement achieved by overlapping in Fig. 1.18 can also be achieved by the insertion of separate strips of reinforcement. The total weight of glass in the reinforced area must not be less than twice that in the shell side.

6.1.4 The hull laminate is to be reinforced locally in the areas of force transfer from propeller bracket, rudder tube, bollards, etc. The reinforcement is to be stepped at a ratio of 25 mm per 600 g/m^2.

6.2 Fishing Vessel

6.2.1 The total glass reinforcement weight of the shell laminate is to be determined from Table 2.8 (see also Fig. 2.19).

6.2.2 The nominal laminate thickness from Table 2.8 is calculated in accordance with 3.1 with 0,70 mm per 300 g/m^2 of reinforcement

6.2.3 The glass weight for the bottom determined in accordance with Table 2.8 applies over the entire length of the craft and is to be extended upwards to the chine or 150 mm above the flotation plane, whichever is higher.

6.2.4 The total glass weight of the keel laminate shall comply with the values stated in Table 2.8.

6.2.5 The minimum width of the keel laminate shall be:

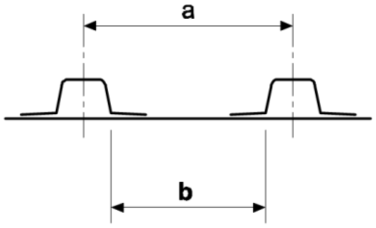
$(25 \cdot L + 300)$ [mm]

6.2.6 The keel laminate must extend from the stern/transom to the stem. Determination of the total glass weight shall be in accordance with 6.2.4. Reductions based on reduced frame spacing are not permitted (see also Fig. 2.19 and 2.20).

6.2.7 The stern or transom shall have the same glass weight as the shell side. In case of special propulsion systems (stern drives, "Aquamatic", etc.) reinforcement shall be provided as appropriate for the forces arising.

6.2.8 Chine and transom corners are to be built in accordance with 6.1.3.

Table 2.8

Total glass weight of shell laminate [g/m^2]	
Shell bottom	$G_{WB} = 1{,}57 \cdot b \cdot F_p \cdot F_{VB} \cdot \sqrt{P_{dBM}}$ $G_{WB\,(min)} = 1{,}10 \cdot (350 + 5 \cdot L) \cdot \sqrt{P_{dBM}}$ $G_{WB\,(min)} \geq G_{WS}$
Shell side	$G_{WS} = 1{,}57 \cdot b \cdot F_p \cdot F_{VS} \cdot \sqrt{P_{dSM}}$ $G_{WS\,(min)} = 1{,}10 \cdot (350 + 5 \cdot L) \cdot \sqrt{P_{dSM}}$ $G_{WS\,(min)} \geq 1200$
Keel	$G_{WB\,(min)} = 2{,}35 \cdot (350 + 5 \cdot L) \cdot \sqrt{P_{dBM}}$
	F_{VB} = See A.1.9.3 F_P = See 4.4.2.3 F_{VS} = See A.1.9.3 P_{dBM} = See A.1.9.2 P_{dSM} = See A.1.9.2

6.2.9 Should the flexural strength and/or the glass content of weight of the laminate differ from that stated in 3.1, the total glass weight or nominal thicknesses determined above are to be multiplied by the factor K_w or K_t in accordance with 4.4. Whatever the type of reinforcement, the minimum thickness of laminate must not be less than 2,5 mm.

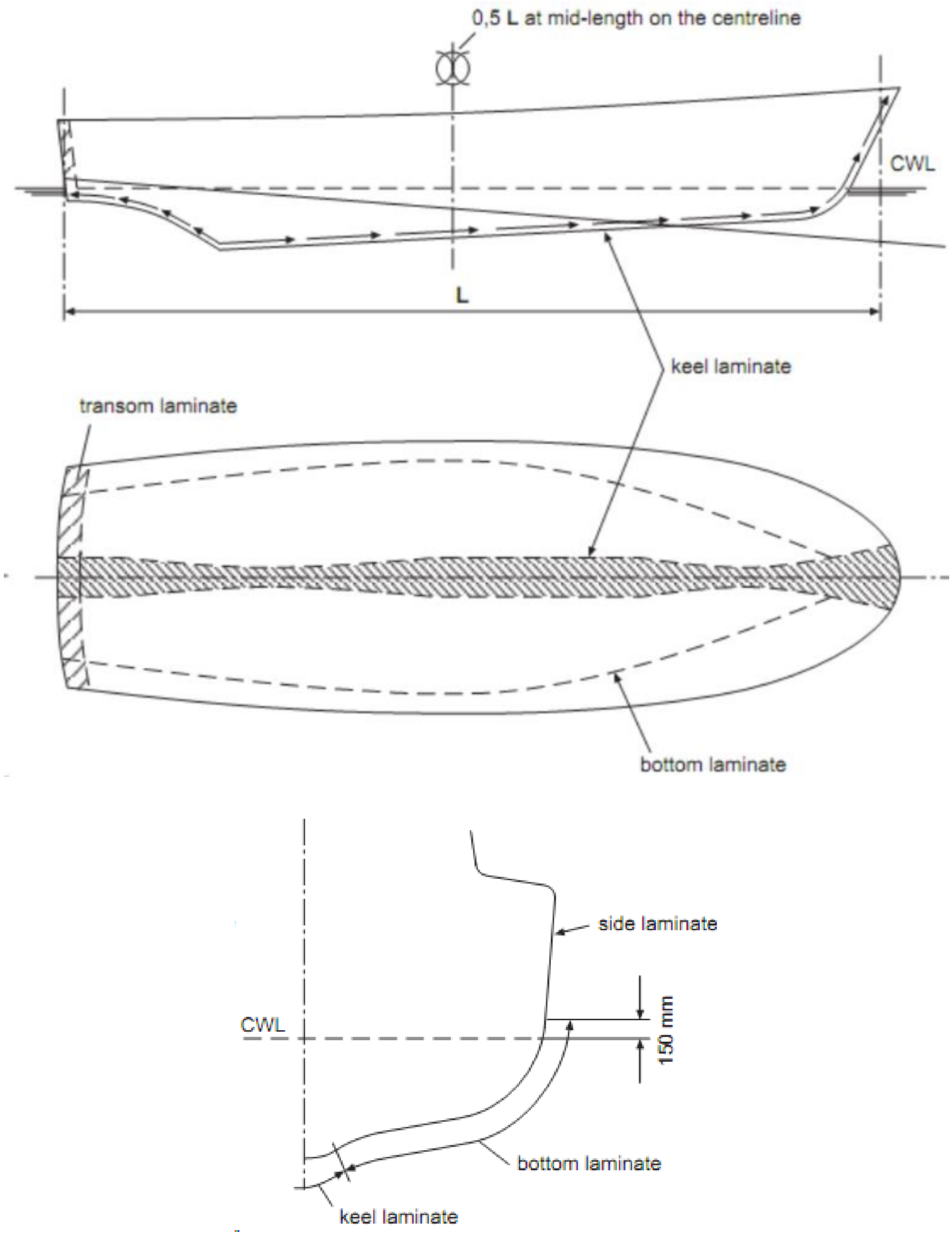
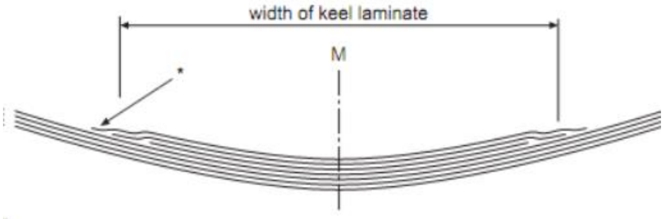
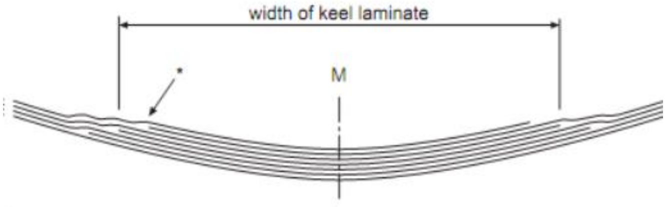


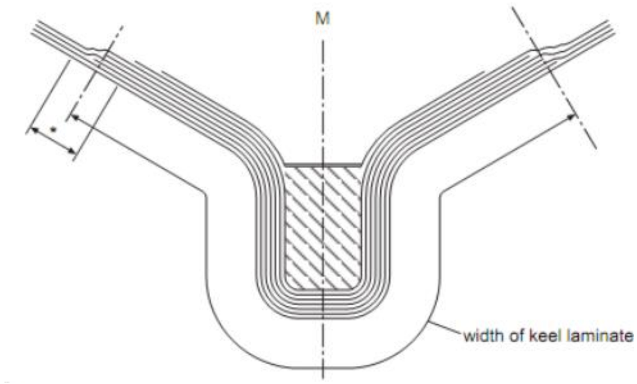
Fig. 2.19



Special reinforcement layers form the keel laminate



Pt and stbd glass reinforcement layers overlap and form the keel laminate



Port and starboard glass reinforcement layers overlap and form the keel laminate
Fin keel may be filled and covered with laminate whose total glass weight must be at least 50% of that of the shell bottom
*Widht of overlap = 25 mm per 600 g/m[2] glass fibre reinforcement

Fig. 2.20

7. Internal structural members of the hull

7.1 General

7.1.1 The hull shall be fitted with an effective system of transverse and/or longitudinal frames supported by web frames, bulkheads, etc.

7.1.2 Frames may be arranged in transverse or longitudinal direction; the internal structural members may also comprise of a combination of the two frame systems. For fishing vessel with a speed $v \geq 3{,}6 \cdot \sqrt{L_{WL}}$ in kn, longitudinal framing is recommended.

7.1.3 If certain parts of the accommodation shall be used for stiffening purposes, these must be of equivalent strength and structurally joined to the hull in accordance with 7.1.5. Proof of equivalent strength of integral inner shells/liners lies in the responsibility of the builder.

7.1.4 Where frames and stiffeners are of the top hat type, the width of the flange connection to the laminate plate shall be 25 mm for the first reinforcement layer plus 12 mm for all subsequent 600 g/m^2 glass weight of the laminate at least 50 mm total width.

7.1.5 Floors and bulkheads are to be bonded to the shell by laminate angles on both sides; the width of each flange must be 50 mm for the first reinforcement layer plus 25 mm for all subsequent 600 g/m^2 glass weight of the laminate.

7.1.6 Floors and bulkheads of solid GRP are to be bonded to the shell or laminate plate on both sides using laminate angles. The total glass weight of each laminate angle may not be less than 50% of that of the component to be attached; it must not be less than 900 g/m^2.

7.1.7 Should floors, bulkheads and similar members be made of plywood (specification see Section 5), the reinforcement weight of each laminate angle shall comply with the requirements according to Table 2.10.

7.1.8 For special bottom designs, proof of adequate strength is to be submitted to BKI.

7.1.9 Limber holes in floors shall be arranged as midships as possible.

7.2 Transverse frames

7.2.1 The scantlings of transverse frames and floors shall be determined in accordance with Table 2.11.

7.2.2 The floors shall be continuous over the bottom of the vessel; the section modulus at centre line may be gradually reduced to that of the side frame at bilge or chine.

7.2.3 Floors or equivalent stiffeners are to be fitted in the area of the ballast keel, bilge keels or the rudder heel or skeg, if applicable.

7.2.4 Watertight floors or floors forming the boundary of tank spaces shall also comply with 7.5.

7.2.5 If the tensile strength (fracture) of the shell laminate differs from that stated in 3.1, the section modulus determined is to be corrected in accordance with 4.5.

7.2.6 For determination of the section modulus, see 5.

Table 2.10

Laminate angles for connecting plywood structural members					
Scantling length L Thickness of plywood (mm)	Flange widths (mm) and total glass weights [g/m^2]	Fore body		Structural members behind main bulkhead	
	Main bulkhead both sides	one side	both sides	one side	both sides
up to 9 m 10 mm	50 1150	75 2250	50 1150	60 1800	50 900
up to 10 m 10 mm	50 1150	75 2250	50 1150	60 1800	50 900
up to 11 m 12 mm	60 1350	90 2700	60 1350	75 2250	50 1150
up to 12 m 15 mm	70 1700	105 3150	70 1700	90 2700	60 1350
up to 15 m 18 mm	90 2050	135 3800	90 2050	155 3250	75 1650
up to 17 m 20 mm	100 2350	150 4350	100 2350	130 3750	90 1900

7.2.7 Reduction for transverse frames

When dimensioning curved frames, the effect of the curvature is to be allowed for by the factor f_{kw}.

h/s	f_k
0 – 0,03	1,0
0,03 – 0,1	1,15 – 5 · (h/s)
≥ 0,1	0,65

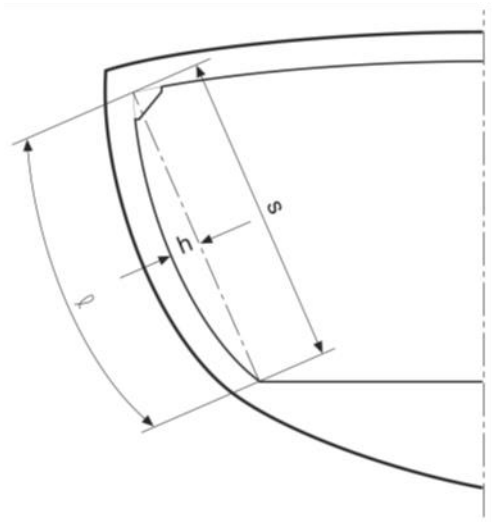


Fig 2.23

The section modulus determined in accordance with 7.2.6 is to be multiplied by the factor f_{kw}.

The required section modulus calculated using the factor f_{kw} must not be less than the appropriate minimum value, to be taken from Table 2.11.

7.3 Longitudinal frames

7.3.1 The scantlings of longitudinal and web frames for bottom and sides shall comply with Table 2.12 and 2.13. For dimensioning of curved web frames, see 7.2.7.

7.3.2 The longitudinal frames are to be supported by bulkheads or web frames.

7.3.3 Additional floors or transverse frames are to be arranged in way of engine foundations, rudder skegs, ballast and bilge keels and the bottom in the forebody. The scantlings of these floors must never be less than those required in accordance with Table 2.11.

7.3.4 If the tensile strength (fracture) of the shell laminate differs from that stated in 3.1, the section modulus determined is to be corrected in accordance with 4.5.

7.3.5 For determination of the section modulus, see 5.

7.4 Bottom girders, engine seatings

7.4.1 The engine seatings must be of sufficiently sturdy construction to suit power, weight and type of the engine(s).

7.4.2 The longitudinal girders forming the engine seatings must extend fore and aft as far as possible and are to be suitably supported by floors, transverse frames and/or brackets.

7.4.3 Additional centre and side girders may be required to be fitted to the shell bottom.

7.5 Fuel and water tanks

7.5.1 The scantlings of integral GRP tanks are to be determined in accordance with Table 2.14 (integral tanks are tanks whose walls also form part of the vessel shell). For the purpose of these regulations, "fuel" means only diesel oil with a flash point > 55 °C.

Note :

Depending on the operating category, drinking water should be stored in tanks and containers of the following number and type:

The quantity of drinking water depends on the number of persons permitted on board and the duration of the voyage, and should be at least 1,5 litres per person and day at sea.

Operating category

I	*The water must be stored in two separate tanks*
II	*At least half of the water reserves must be stored in a tank. The rest of the reserves may be stored in containers.*
III, IV, V	*The water must be stored in suitable containers*

7.5.2 Should the flexural strength and/or the glass content of the laminate differ from the values stated in 3.1, the total glass weights or nominal thicknesses determined above in accordance with 4.4 are to be multiplied by the factor K_w or K_t. The minimum thickness of the laminate must not be less than 5,0 mm.

7.5.3 If the tensile strength (fracture) of the tank laminate differs from that stated in 3.1, the calculated section modulus is to be corrected in accordance with 4.5.

7.5.4 The section moduli of tophat type stiffeners are to be determined in accordance with 5.

7.5.5 The internal surfaces of tanks must be suitable for the substances coming into contact with them and must not affect these adversely.

7.6 Bulkheads

7.6.1 Watertight bulkheads are to be provided in accordance with A.2. and shall be effectively joined to the hull in accordance with 7.1.5 to 7.1.7.

7.6.2 The scantlings of single skin GRP bulkheads must comply with Table 2.15.

7.6.3 Bulkheads not watertight or partial bulkheads supporting the longitudinal or transverse frames of the hull must have scantlings equivalent to those of the web frames in accordance with 7.3. The partial bulkheads are to be joined to the hull in accordance with 7.1.5 to 7.1.7.

7.6.4 Bulkheads or parts there of forming tank boundaries must also comply with the requirements in accordance with 7.5.

7.6.5 The nominal laminate thickness from Table 2.15 is calculated in accordance with 3.1 with 0,70 mm per 300 g/m^2 of reinforcement.

7.6.6 Should the flexural strength and/or the glass content by weight of the laminate differ from the values as stated in 3.1, the total glass weights or nominal thicknesses determined above in accordance with 4.4 are to be multiplied by the factor K_w or K_t.

The minimum laminate thickness may not be less than 2,5 mm.

7.6.7 If the tensile strength (fracture) differs from that stated in 3.1, the section modulus determined is to be corrected in accordance with 4.5.

Table 2.11

Section moduli of floors and transverse frames [cm³]	
Floors	$W_B = 3{,}21 \cdot e \cdot \ell^2 \cdot F_{VF} \cdot P_{dBM} \cdot 10^{-3}$
	$W_B = 3{,}21 \cdot e \cdot k_4^2 \cdot F_{VF} \cdot P_{dBM} \cdot 10^{-3} \geq W_S$
Transverse frames	$W_S = 2{,}18 \cdot e \cdot \ell^2 \cdot F_{VSF} \cdot P_{dSM} \cdot 10^{-3}$
	$W_S = 2{,}18 \cdot e \cdot k_4^2 \cdot F_{VSF} \cdot P_{dSM} \cdot 10^{-3} \geq L$
e = distance of floors/transverse frames [mm] ℓ = span (unsupported length of floor of frame) [m] F_{VF} = see A.1.9.3 F_{VSF} = see A.1.9.3 k_4 = 0,045 · L + 0,10 or 0,60 [m], the larger value to be used P_{dBM} = see A.1.9.2 P_{dSM} = see A.1.9.2	

Table 2.12

Section moduli of the longitudinal frames [cm³]		
Bottom frames	longitudinal	$W_{BL} = 2{,}14 \cdot e \cdot \ell^2 \cdot F_{VL} \cdot P_{dBM} \cdot 10^{-3}$
		$W_{BL\,(min)} = 2{,}14 \cdot e \cdot k_5^2 \cdot F_{VL} \cdot P_{dBM} \cdot 10^{-3} \geq L$
Bottom frames	longitudinal	$W_{BL} = 2{,}07 \cdot e \cdot \ell^2 \cdot F_{VSL} \cdot P_{dSM} \cdot 10^{-3} \geq L$
		$W_{BL\,(min)} = 2{,}07 \cdot e \cdot k_5^2 \cdot F_{VL} \cdot P_{dSM} \cdot 10^{-3} \geq L$
e = distance between longitudinal frames [mm] ℓ = span [m] F_{VF} = see A.1.9.3 F_{VSF} = see A.1.9.3 k_5 = (0,01 · L + 0,7) or 0,75, the larger value to be used P_{dBM} = see A.1.9.2 P_{dSM} = see A.1.9.2		

7.6.8 Partial bulkheads of plywood may be used to stiffen the hull. The bulkhead minimum thickness may not be less than:

$$t = \frac{P_{dBM} \cdot F_{VF} \cdot 1{,}45 \cdot \lambda}{\sigma_{dzul}}$$

λ = span (unsupported length) in [m]

F_{VF} = speed correction factor, see A.1.9.3

P_{dBM} = see A.1.9.2

$\sigma_{dzul} = \frac{\sigma_{dBrunch}}{S}$

see Table C.7 for durability groups and characteristic values of the wood types in Section 5.

S = 5,5

8. Decks, deckhouses and cabins

8.1 Decks

8.1.1 The scantlings for a single skin construction deck are to be taken from Table 2.16.

8.1.2 The nominal laminate thickness from Table 2.16 is calculated in accordance with 3.1 at 0,70 mm per 300 g/m^2 of reinforcement.

Table 2.13

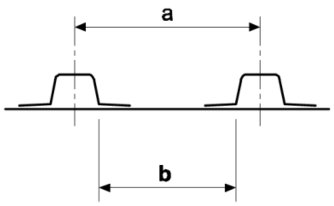
Section moduli of web frame of floors and [cm^3]	
Floors	$W_B = 3{,}21 \cdot e \cdot \lambda^2 \cdot F_{VBW} \cdot P_{dBM}$
	$W_{B(min)} = 3{,}21 \cdot e \cdot k_6^2 \cdot F_{VBW} \cdot P_{dBM} \cdot 10^{-3} \geq W_{RS}$
Transverse frames	$W_S = 2{,}18 \cdot e \cdot \lambda^2 \cdot F_{VSW} \cdot P_{dSM}$
	$W_{S\,(min)} = 2{,}18 \cdot e \cdot k_6^2 \cdot F_{VSW} \cdot P_{dSM}$

L = see A.1.5
e = distance of floors/transverse frames [mm]
λ = span (unsupported length of floor of frame) [m]
F_{VBW} = see A.1.9.3
F_{VSW} = see A.1.9.3
K_6 = 0,045 · L + 0,10 or 0,60 [m], the larger value to be used
P_{dBM} = see A.1.9.2
P_{dSM} = see A.1.9.2

Table 2.14

Total glass weight for water and fuel tank boundaries plus section moduli of water and fuel tank wall stiffeners	
Total glass weight [g/m^2]	$G_W = 5{,}40 \cdot b \cdot F_p \cdot \sqrt{h_1}$ $G_{W\,(min)} = 8{,}36 \cdot b \cdot F_p \geq 2700$
Section modulus [cm^3]	$W_T = 0{,}05 \cdot a \cdot h_2 \cdot \ell^2$ $W_{T\,(min)} = 0{,}037 \cdot a$

a = stiffener spacing [mm]
b = see below [mm]

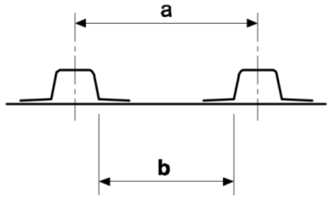


ℓ = stiffener length [m]
F_P = see 4.4.2.3
h_1 = vertical distance from tank bulkhead bottom edge to filler tube [m]
h_2 = vertical distance from the centre of the stiffener's unsupported length to the filler tube [m]

Table 2.15

Total glass weight for bulkhead plus section moduli of bulkhead stiffeners	
Total glass weight [g/m²]	$G_{WQ} = 5{,}40 \cdot a \cdot F_p \cdot \sqrt{h_3}$ $G_{WQ\,(min)} = 3{,}8 \cdot (350 + 5 \cdot L) \cdot \sqrt{h_3} \geq 1200$
Section moduli vertical stiffeners [cm³]	$W_{QV} = 0{,}017 \cdot a \cdot \ell^2 \cdot F_{fV} \cdot \left(h' + \frac{\ell}{2}\right)$ $W_{QV\,(min)} = 6{,}0 \cdot (350 + 5 \cdot L) \cdot F_{fV} \cdot 10^{-3}$
Section moduli horizontal stiffeners [cm³]	$W_{QH} = 0{,}03 \cdot b \cdot h_4 \cdot \ell^2 \cdot F_{fH}$ $W_{QV\,(min)} = 10{,}3 \cdot (350 + 5 \cdot L) \cdot F_{fH} \cdot 10^{-3}$

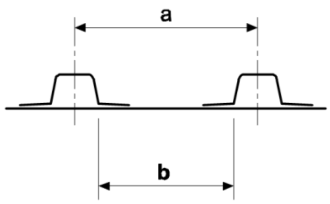
a = stiffener spacing [mm]
b = see below [mm]



ℓ = stiffener length [m]
F_P = see 4.4.2.3
h_3 = vertical distance from bulkhead bottom edge to deck edge [m]
h_4 = height of deck at side above top of stiffeners [m]
h' = vertical distance from centre of stiffener to deck edge [m]
F_{fV} = 1,0 for stiffeners with free ends
$= 0{,}8 - \frac{h'}{3{,}75(2 \cdot h + 1)}$ or stiffeners with bracket attachment at each end
F_{fH} = 1,0 for stiffeners with free ends
= 0,667 for stiffeners with bracket attachment at each end

Table 2.16

Total glass weight for deck laminate	
Total glass weight [g/m²]	$G_{WD} = 1{,}57 \cdot b \cdot F_p \cdot \sqrt{P_{dD}}$ $G_{WD} = 1{,}1 \cdot (350 + 5 \cdot L) \cdot \sqrt{P_{dD}}$ $G_{WD} \geq 1200$



a = stiffener spacing [mm]
b = see below [mm]
F_P = see 4.4.2.3
P_{dP} = see A.1.9.4

8.1.3 Openings in the deck for access hatches, skylights, etc. are to be provided with an adequate frame; the coaming is to be effectively bonded to the deck structural members. Skylights and access hatches shall comply with the requirements in E.

8.1.4 Supplementary reinforcement is to be provided in the area of bollards, chain plates, deck fittings, etc.

8.1.5 The walkways and working areas on deck and the cabin roof shall be finished with a non-skid surface.

8.1.6 Should the flexural strength and/or the glass content by weight of the laminate differ from the values stated in 3.1, the total glass weights or nominal thicknesses determined above in accordance with 4.4 are to be multiplied by the factor K_w or K_t. The minimum thickness of the laminate may not be less than 2,5 mm.

8.2 Deck supports and pillars

8.2.1 Decks are to be supported by a system of transverse and/or longitudinal stiffeners and pillars. The scantlings of the components are based on Table 2.17 to 2.20.

8.2.2 At the ends of large openings and in way of the mast deck transverses are to be arranged in-plane of the web frames.

8.2.3 The ends of supports and stiffeners are to be effectively anchored into the adjacent structure, or equivalent arrangements shall be provided.

8.2.4 Head and heel pieces of deck pillars plus supports shall be built appropriate for the forces to be transmitted and shall be joined to the strength members.

8.2.5 Stiffeners and supports of tank decks of water and fuel tanks must also meet the requirements of 7.5.

8.2.6 If the tensile strength (fracture) of the deck laminate differs from that stated in 3.1, the calculated section modulus is to be corrected in accordance with 4.5.

Table 2.17

Section moduli of main deck beams [cm^3]	
Weather deck beams	$W_D = 20{,}38 \cdot P_{dD} \cdot a \cdot \ell^2 \cdot 10^{-4}$ $W_{D\,(min)} = 11{,}54 \cdot P_{dD} \cdot (350 + 5 \cdot L) \cdot 10^{-4}$ $W_{D\,(min)} \geq 3{,}0$
Beams within deckhouses	$W_{DI} = 20{,}38 \cdot k_8 \cdot P_{dD} \cdot a \cdot \ell^2 \cdot 10^{-4}$ $W_{DI\,(min)} = 11{,}54 \cdot k_8 \cdot P_{dD} \cdot (350 + 5 \cdot L) \cdot 10^{-4}$ $W_{DI\,(min)} \geq 3{,}0$
a = stiffener spacing [mm] ℓ = stiffener length [m] P_{dD} = see A.1.9.4 K_8 = correction factor for vessel whose length **L** = 10,0 m = 0,9 – 0,01 · **L**	

Table 2.18

Section moduli of main deck beams [cm^3]	
Weather deck beams	$W_{DU} = 2{,}04 \cdot e \cdot \ell^2 \cdot P_{dD}$ $W_{DU\,(min)} = 1{,}65 \cdot e \cdot P_{dD}$
Girder within deckhouses	$W_{DUI} = 2{,}04 \cdot k_8 \cdot e \cdot \ell^2 \cdot P_{dD}$ $W_{DUI\,(min)} = 1{,}65 \cdot k_8 \cdot e \cdot P_{dD}$
e = distance of girders [mm] λ = unsupported length of girder [m] P_{dD} = see A.1.9.4 K_8 = correction factor for vessel whose length **L** = 10,0 m = 0,9 – 0,01 · **L**	

8.2.7 For calculation of the section modulus see 5.

8.3 Hull to deck joint

8.3.1 The connection between deck and hull must be made watertight, using laminate and/or mechanical fastenings. Design details are to be shown in the technical documentation submitted for approval.

8.3.2 Particular attention is to be given to the attachment of the chain plates and the forebody connections of fast motor craft.

8.3.3 The strength and watertightness of the hull must not be impaired by the attachment of rubbing strakes/rails, etc.

8.4 Cockpits

8.4.1 The scantlings of cockpit sides and bottom must be of equivalent strength to those for the deck in accordance with 8.1.

8.4.2 Cockpits must be provided with drain pipes in accordance with Section 5.

8.5 Deckhouses and cabins

8.5.1 The scantlings of single skin construction deckhouses and cabins are given in Table 2.19 and 2.20.

8.5.2 The nominal laminate thickness from Table 2.19 is calculated in accordance with 3.1 with 0,70 mm per 300 g/m^2 of reinforcement.

8.5.3 Should the flexural strength and/or the glass content of the laminate differ from the values as stated in 3.1, the total glass weights or nominal thicknesses determined above in accordance with 4.4 are to be multiplied by the factor K_w or K_t. The minimum thickness of the laminate must not be less than 2,5 mm.

8.5.4 Web frames or partial/wing bulkheads are to be provided to ensure transverse rigidity in large deckhouses. The strength members are to be suitably reinforced in the area of masts and other load concentrations.

8.5.5 If the tensile strength (fracture) of the deck laminate differs from that stated in 3.1, the calculated section modulus is to be corrected in accordance with 7.5.

8.5.6 For calculation of the section modulus see 5.

8.5.7 Openings for doors and windows are to be provided with frames of adequate strength.

8.5.8 With reference to doors and windows, see Section 5.

C. Wooden Hulls

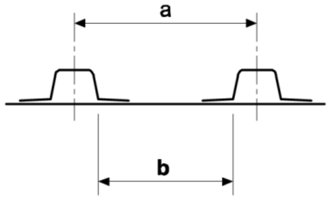
1. General

1.1 Scope

These guidances apply to the scantling determination of the structure of fishing vessel of normal monohull form, traditionally carvel or clinker built on transverse frames.

Table 2.19

Total glass weight of deckhouse and cabin laminate	
Total glass weight	$G_{WD} = 1{,}57 \cdot b \cdot F_p \cdot \sqrt{P_{dD}}$ $G_{WD} = 1{,}1 \cdot (350 + 5 \cdot L) \cdot \sqrt{P_{dD}}$ $G_{WD} \geq 1200$



F_P = see 4.4.2.3
P_{dP} = see A.1.9.4

Table 2.20

Section moduli of the deckhouse and cabin wall stiffeners [cm³]	
Deckhouse	$W_{SDH} = 6{,}92 \cdot P_{dD} \cdot a \cdot \ell^2 \cdot 10^{-4}$ $W_{SDH\,(min)} = P_{dD} \cdot (350 + 5 \cdot L) \cdot 10^{-4}$ $W_{SDH\,(min)} = 3{,}0$
Cabins	$W_{SK} = 10{,}38 \cdot P_{dD} \cdot a \cdot \ell^2 \cdot 10^{-4}$ $W_{SK\,(min)} = 5{,}77 \cdot P_{dD} \cdot (350 + 5 \cdot L) \cdot 10^{-4}$ $W_{sk\,(min)} = 3{,}0$

e = distance of girders [mm]
λ = unsupported length of girder [m]
P_{dD} = see A.1.9.4

1.2 Basic principles for scantling determination

1.2.1 Determination of the component scantlings of structural members shall be carried out in accordance with the Table 2.22 to 2.36 respecting the scantling numerals $B/3 + H_1$ or $L\,(B/3 + H_1)$. Structural members of hulls with larger dimensions or unusual proportions shall have the scantlings determined by individual calculations.

The scantlings given in Table 2.22 to 2.36 for the structural members listed below apply to timber with a bulk density of:

Structural member	Standar bulk density [g/cm^3][1]
Keel Stem Floors Frames Transom beams	0,70
Shell Sheer plank Reinforced deck beams Beam knees Carlines Engine seatings Deadwood	0,56
Decks Deck beams Planks, shelves	0,45
1) In standars atmosphere condition with a moisture content (according to "VG") of 12%	

1.2.2 If the bulk density of the wood intended to be used differs from the values in the above Table, the scantlings/section moduli listed in the Tables are to be increased/decreased proportionally with the bulk density ratio $\rho_{standard}/\rho_{actual}$.

1.2.3 Keel, stem/sternpost and other hull structural members may be lamellated. Scantlings are to be calculated in accordance with E.

1.3 Types of wood and materials

1.3.1 Wood

Timbers for load bearing components shall be best quality, adequately dried, sound, free from sap, knots and detrimental flaws. Twisted timber shall not to be used.

Timber in durability groups 1, 2 and 3 in accordance with section 5 is preferably to be used. Timber in groups 4 and 5 requires special approval from BKI.

For non-load-bearing components, e.g. interior parts, no particular types of wood are specified.

1.3.2 Plywood

Structural members from plywood exposed to the weather, such as decks, superstructures, deckhouses, etc. shall comply with Section 5.

1.4 Workshop requirements and quality assurance

Companies producing wooden hulls and components cold moulded by glueing shall be qualified for the work to be carried out regarding their workshop equipment, internal quality control, manufacturing process as well as the training and qualification of the personal carriying out and supervising the work. Providing the prerequisites for approval have been met, suitability will be certified for the works on application by a BKI shop approval.

2. Shell

2.1 Shell planks shall be quartersawn (riftsawn). Thickness and width are listed in Table 2.22 and 1.23. Planks around the bilge should be narrower than those for other areas. Plank thicknesses are the ones after shaping. If the frame spacing is increased compared with Table values, plank thickness is to be increased in proportion, a reduction of plank thickness is permissible if frame spacing is reduced.

2.2 For double-planked yachts whose scantling numeral **L** (**B**/3 + **H**$_1$) is greater than 28, the total thickness of the shell may be reduced by 10% in accordance with Table 2.22.

Spacing of butts in shell planking			
	under 20 mm	Plank thickness 20 - 33 mm	over 33 mm
if strakes adjoin	1,00 m	1,20 m	1,50 m
if there is one intermediate strake	0,70 m	0,90 m	1,20 m
if there are two intermediate strakes	0,40 m	0,60 m	0,90 m

2.3 Shell planking is to be fitted in as long lengths as possible. Planks in one strake may however be joined by glued joints or butt straps.

Where there are joints in two neighbouring strakes of planking, these must be at least three frame spaces apart. If there is one strake in between, they must be two frame spaces apart; if two, one frame space.

2.4 If the shell planking does not have glued joints, the planks are to be connected by butt straps. The distances between butts are to be taken from the Table above.

Plank butts in the plane of the same frame are only permitted if there are three intermediate strakes.

2.5 The butts in the shell planking are to be so arranged that they are not in the same plane as those of the beam shelf, the keel and the sheer plank.

2.6 Butt straps of wood or sea-water-compatible metal are to be arranged in between frames with drainage at both ends. They should be wide enough to overlap adjoining strakes by at least 10 mm. Wooden straps should be of the same thickness as the shell; metal ones are to have an equivalent strength. For arrangement details of butt straps see Fig. 2.24.

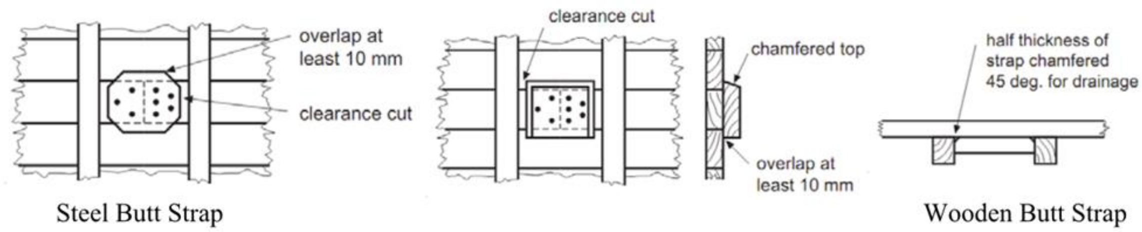


Fig. 2.24

2.7 Planks and butt straps are to be joined by means of threaded bolts, as follows:

Width of plank [mm]	Number of bolts in each plank end
up to 100	3
100 up to 200	4
200 up to 250	5

3. Bulkheads

3.1 Bulkhead plating

The thickness of the bulkhead plating shall not be less than:

$$s = a \cdot \sqrt{h_1 \cdot k} \cdot C \quad \text{[mm]}$$

a = stiffener spacing in [m]

h_1 = pressure head in [m] measured from bulkhead bottom edge to bulkhead deck

k = 12 as standard value for teak, kambala, oak, sipo-mahogany

= 16 as standard value for less firm wood, e.g. khaya-mahogany, sound pine

C = 4,0 in case of collision bulkhead

= 2,9 for bulkheads

The bulkhead plating need not be thicker than the shell if frame spacing and stiffener spacing correspond.

3.2 Bulkhead stiffeners

The section moduli of the stiffeners shall not be less than:

$$W = k \cdot C \cdot a \cdot (h_2 + 0{,}5) \cdot l^2 \quad [mm]$$

h_2 = pressure head in [m] measured from the center of the stiffener up to the bulkhead deck

l = length of stiffener in [m]

k = 12 for stiffeners of teak, kambala, oak, sipo-mahogany and laminated stiffeners

= 16 for stiffeners of less firm wood, e. g. khaya-mahogany, sound pine.

3.3 Non-watertight bulkheads

Components of non-watertight transverse or longitudinal bulkheads, wing bulkheads or such which serve to stiffen the hull are to be dimensioned in accordance with the same formulae.

4. Floors

4.1 Floors shall be fitted over 0,75 $\mathbf{L}_{WL}$ of the mid-body of the vessel at each frame; see Fig. 2.25. In the case of yachts with curved or lamellated frames, whose scantling numeral **L** (**B** /3 + **H**$_1$) is less than 20, floors may be spaced frames apart within 0,75 $\mathbf{L}_{WL}$ in accordance with Table 1.22; under the mast tabernacle however floors are required at each frame.

4.2 In the afterbody, a spacing of two frames suffices beyond 0,75 $\mathbf{L}_{WL}$, a spacing of three frames beyond Lm; in the forebody beyond $\mathbf{L}_{WL}$ a spacing of two frames. Where sterns hang over, as with conventional yacht sterns and retracted transoms, no floors are needed in the overhang beyond $\mathbf{L}_{WL}$ provided the frames are carried continuously from one side to the other.

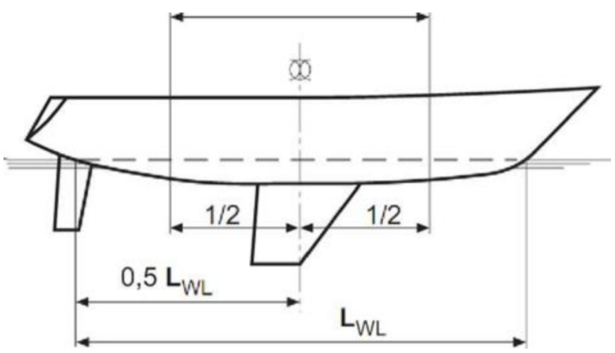


Fig. 2.25

4.3 Floors may be in the form of flat bar steel, angle bar steel and wood, steel plates or wooden planks. In place of steel flat bar, angle bar or plate floors, floors ofthe same strength of other metal may be fitted. Wooden floors shall be sawn from knee timber; the grain shall substantially run parallel with the shell. The grain of wooden plank floors runs horizontally.

4.4 Steel plate or wooden plank floors shall be fitted underneath the mast, and underneath the seatings of more powerful propulsion engines.

4.5 Floor scantlings are given in Table 2.24 and 2.25 based on the scantling numeral **B**/3 + H_1 and floor spacing, for the mid-body area of 0,75 $L_{WL.}$ If the spacing is greater than that in the Table, the floor scantlings are to be increased in the same proportion. For the floors beyond 0,75 L_{WL} whose spacing is increased in accordance with 4.2, increase in scant- lings is not required.

4.6 Beyond L_{WL}, arm lengths may be reduced to $^1/_3$ of the associated frame lengths.

4.7 Steel flat and angle bar floors may be fitted on top of or alongside the frames.

4.8 Angle bar floors fitted alongside the frames are to be bolted to the frame and the shell.

4.9 The arms of flat bar steel floors may be tapered off to the scantlings given in Table 2.25 for arm ends, from the first third onwards. Similarly, the projecting leg of angle bar floors may be tapered off to leg thickness from the first third of the arm length onwards.

4.10 The scantlings for wooden floors given in Table 2.24 and 2.25 apply to the centre of the floor. Towards the ends of the arms, the height may gradually be reduced to that of the frame.

If ballast keel bolts are taken through wooden floors, the floor width is to be increased by half a bolt diameter.

4.11 The heights given in Table 1.24 for steel plate or wooden plank floors are the heights above the top edge of the wood keel. Beyond L_{WL}, the height may gradually be reduced to twice that stated for naturally grown frames. The floors are to be extended high enough for the associated frames to be rigidly joined to them.

4.12 If ballast keel bolts are taken through the wooden plank floors, the thickness of the floors is to be increased correspondingly. It is to equal four times the bolt diameter.

4.13 Steel plate floors are to be joined to the wood keel and the shell by angle bars of the shape of the stipulated steel frames. However the profile flanges in contact with the keel must be wide enough to be at least $^1/_3$ of the flange width between bolt hole and profile edge. The upper edges of plate floors are to be flanged. Plate floors may in the region of 0,6 **B** amidships have lightening holes no greater in height than half the local web height and not exceeding the local web height in length.

5. Frames

5.1 Frames may either be prebent, bent-in, lamellated grown, of metal or made by a combination of these. Frame spacing is given in Table 2.22. Frame spacing may be altered if the thickness of shell planking is increased (see 2.1). Frame scantlings are to be determined from Table 2.26 and 2.27 based on the scantling numeral **B**/3 + H_1 and the frame spacing chosen.

5.2 Forward and aft of the length L_{WL}, the section modulus of bent, lamellated or steel frames may be reduced by 15 %; that of grown frames by 20 %.

5.3 Where bent frames have sharp bends, it is recommended that metal strips be fitted.

5.4 The cross section of bent and lamellated frames shall be the same from keel to deck. They are to be made of a single piece.

5.5 Grown frames shall have the same width from keel to deck, the height on the other hand may be gradually reduced from the top edge of the floor to the deck, down to the frame height shown in Table 2.27.

5.6 For grown frames, timber shall be used whose grain follows the shape of the frame. If such timber is not available in adequate lengths, the frames may be strapped. The following straps are permitted: the two ends overlap by at least 3,5 times the frame width, or the two parts butt and are joined along the sides by a strap with a cross section equal to the frame's and with a length 7 times the frame width.

5.7 Metal frames shall be welded to floor plates and beam knees.

5.8 If possible the reinforced frames shall be fitted in conjunction with reinforced deck beams, with which they are to be connected by hanging knees.

5.9 Steel web frames shall comply with the following Table:

L (B/3 + H_1)	Web plate
m^2	mm
over 62	200 · 4
over 70	220 · 4
over 78	230 · 5
over 88	250 · 5

The web plates may have round lightening holes with a diameter of $^1/_3$ of the web height. Hole edges shall be at least $^1/_4$ of the web height apart.

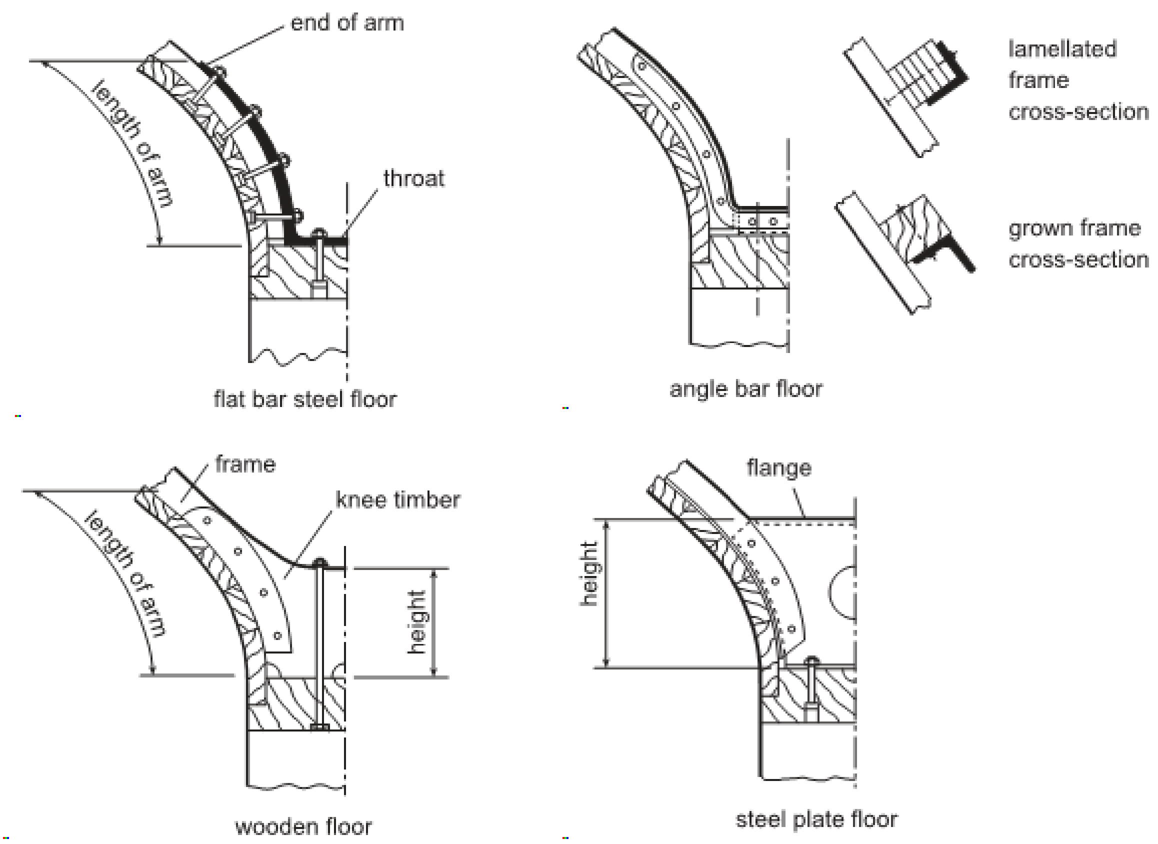


Fig. 2.26

5.10 The web frames are to be firmly welded to the floors and connected to the reinforced deck beams by hanging knees.

5.11 In lieu of steel web frames, wooden web frames of the same strength and also bulkheads or partial bulkheads of adequate strength are permitted.

6. Beam shelves and bilge planks

6.1 The cross sections required for the beam shelves and bilge planks on each side of the hull are given in Table 1.22. The shelves/planks shall extend from the stem to the transom. Beyond 0,75 $\mathbf{L}_{WL}$ towards the ends, their cross section may gradually be reduced to 75%. They shall be fitted in the maximum possible lengths. If they are butt joined or scarified, the butt length shall be at least six times the height of the shelf/plank. Butts shall not be located in way of the mast, the chain plates or other areas where forces are introduced into the structure. The port and starboard beam shelves shall be linked by bow pointers or stem knees at the stem and shall be connected to the transom by knees.

6.2 The beam shelves may be all in one piece or divided into a primary and a minor or secondary shelf, in which case the cross section of the primary shelf is to be about 65 % of the total given.

6.3 Preferably the deck beams shall not be embedded in the beam shelves. If they nevertheless are, the cross section according to the Table must remain unimpaired underneath the beams.

6.4 In way of the mast and the chain plates, secondary shelves shall be additionally fitted whose cross section is 75 % of that of the shelf in accordance with Table 2.22. The length of these secondary shelves shall be at least 0,3 $\mathbf{L}_{WL}$. If the shelves have been subdivided into primary and secondary ones, half the beam shelf cross section is sufficient for the additional secondary shelves near the mast.

7. Deck structure

7.1 Decks

7.1.1 Deck planks must be quartersawn (riftsawn) planks. Plank thickness is given in Table 2.22.

7.1.2 The widths of strip planking planks shall approximately match with the requirements of Table 2.23.

7.1.3 Plywood decks are permitted. The thickness of the plywood panels must be at least 65% of the thickness given in Table 2.22 for deck planks. Joints in the plywood deck are to be scarified. Scarfs in plywood must be at least ten panel thicknesses long.

7.1.4 Decks are to have a hardwood (mahogany, oak, teak or similar) plank sheer/gunwale capping plank around the outboard edge, at least as thick as the shell according to the Table and at least 3 to 5 times as wide as it is thick. The outer cut edges of plywood decks must be protected by means of fillets.

7.2 Deck beams and beam knees

7.2.1 Deck beam scantlings are to be determined in accordance with Table 1.28, based on their respective length and the beam spacing. The relevant beam length is that between the outer edges of the beam shelves. In the case of half beams or supported beams the relevant length is that between the shelf outer edge and the cabin or hatch longitudinal coaming or the support. The minimum length to be inserted is 0,5 **B**.

Note:

The deck loads given in Table 1.28 are empirical values and have no connection with the deck loads in B.

7.2.2 Beam spacing may be increased to about 1,25 times the frame spacing in accordance with Table 1.22. The beam section modulus is to be determined based on the actual spacing.

7.2.3 The heights of the deck beam cross sections determined in accordance with 7.2.2 may be reduced to 75% towards the beam ends.

7.2.4 The end beams of deck openings whose length exceeds one space between beams shall be reinforced. For determining their scantlings, the length of deck to be supported by these beams is to be inserted as the beam spacing.

7.2.5 The continuous deck beams in way of the mast and the beams at the ends of large deck openings, e.g those at the forward edge of the cabin and the after edge of the cockpit, are to be reinforced. If the beams are supported by bulkheads, their section modulus shall be increased by 50%; if they are unsupported, by 150 %. For calculating the section modulus of the deck beams at the ends of the cabin, the beam spacing inserted is to be equal to the frame spacing in accordance with Table 2.22.

7.2.6 Beams underneath anchor winches and deckhouses may be reduced at the ends to the height of adjacent beams to avoid weakening the beam shelves.

7.2.7 The height of reinforced deck beams may be reduced at the ends to the height of adjacent beams to avoid weakening the beam shelves.

7.2.8 The reinforced deck beams shall butt against the frames if possible. They are to be joined to these, or to sole pieces, by hanging knees.

7.2.9 The minimum number of hanging knees is given in Table 2.29, their arm lengths and scantlings in Table 1.30. In lieu of hanging knees, adequately strong bulkheads of partial bulkheads are also permitted.

7.2.10 The cross section of flat bar steel hanging knees may be gradually reduced to 40% beyond the first third of the arm length of the neck cross section. Similarly the projecting legs of angle bars may be tapered off beyond the first third of the arm length to leg thickness at the ends. Beyond $\mathbf{L}_{WL}$, the arm length of the hanging knees need not be more than $^{1}/_{3}$ of the frame or beam length.

7.2.11 At the ends of larger deck openings, horizon- tal wooden knees are to be fitted between deck beams and beam shelves at the corners. These knees are not needed in the case of plywood decks.

7.2.12 Floor beam scantlings may be determined in accordance with Table 2.28. Based on their length and spacing their section modulus may be reduced up to 75%.

8. Keel

8.1 Height and width of the wood keel halfway along $\mathbf{L}_{WL}$ are given based on the scantling numeral **L** (**B**/3+ $\mathbf{H}_1$). The height applies to the full length of the wooden keel; the width may be tapered off towards the ends, down to stem/sternpost width. The height of lamellated wooden keels may be 5% less than that of solid ones.

8.2 The frames are not to be embedded in the wood keel or the stem/sternpost.

8.3 The width of the keel rabbet shall be at least equal to half the tabular height of the wood keel, but anyway it shall be wide enough for the screws to be staggered (zig-zag).

8.4 The wooden keel shall consist of a single piece, if ever possible

8.6 The scarfs are to take the form of hook scarfs. The scarf length shall be at least six times the keel height. The keel scarfs shall have softwood stopwaters in the rabbet, see 11. and Fig. 2.27.

8.7 The wooden keel may be built up by glueing together separate laminated planks running horizontally If the mast stands on the stem-keel scarf or in the vicinity of this, a mast stool shall be provided on the floors. Mast steps must not be cut directly into the keel or keel scarfs.

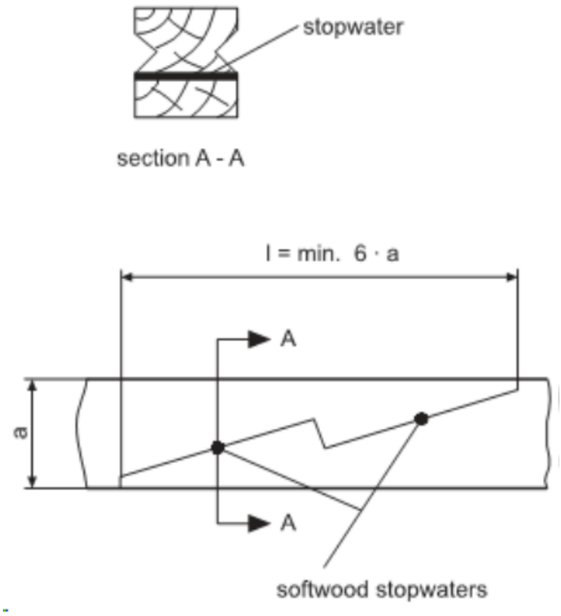


Fig. 2.27

9. Stem/sternpost and transom beam

9.1 The height of the stem on the design waterline must be at least 1,2 times the height of the wooden keel in accordance with Table 2.31. Between the rabbets the thickness of the stem shall be at least twice that of the shell planking. The width of the rabbet shall be at least 1,5 times the shell planking thickness. The leading edge of the stem and the trailing edge of the sternpost may be tapered.

9.2 The stem scarfs shall be made as hook scarfs or glued joints. The length of the scarf shall equal 6 times the stem height. In way of the rabbets, softwood stopwaters shall be fitted in the stem scarfs and the scarfs between stem and keel sole.

9.3 If the mast stands on the stem, this shall to be reinforced in particular regarding its height; additionally a mast stool shall be provided. Mast steps may not be cut into the stem.

9.4 If shafting is led through the sternpost, this shall be widened so as to leave at least 0,4 of the tabular sternpost width either side of the stern tube where this is taken through.

9.5 Stems/sternposts may be glued together from separate lamellated planks.

9.6 The transom beam shall be rigidly connected to the sternpost. The cross section of the transom beam at the forward end and in the area where the rudder stock/tube is taken through must at least equal the square of the height of the stem in accordance with 9.1. Towards the after end the cross section may be reduced to 75 %.The height of the transom beam shall be at least 2,5 times the height of the bent-in frames. The seat of the transom beam must be of adequate length. Care is to be taken to make sure that the bolting is adequate (recessed bolts if appropriate).

10. Coachroofs, deckhouses

10.1 Apertures in the deck shall be bordered by frames consisting of hatch end beams and deck carlines.

10.2 The scantlings of deck beams at the ends of superstructure, hatches and cockpits shall be determined in accordance with 6.2.

10.3 The cross sections of the deck carlines shall approximately match the data in Table 2.32; the height of the deck carlines shall be about half the height of the beams and their width shall be 4,5 times the thickness.

10.4 The thickness of side walls and deck planking of the superstructure is given in Table 2.32.

10.5 Superstructure side walls with extra large windows are to be strengthened.

10.6 The spacing of the superstructure deck beams (cabin beams) shall be about 25 % less than the frame spacing in accordance with Table 2.22; in the case of plywood decks however the beam spacing may be increased depending on the thickness of the deck and the camber of the cabin beam. The cabin beam scantlings are to be determined in accordance with Table 2.28, based on their spacing and their length, but their section modulus may be 20 % less.

10.7 Deck beams at the ends of apertures in the cabin deck shall be reinforced or supported as appropriate to the length of the aperture.

10.8 Hatch coamings shall be of adequate strength.

11. Bolting connection of structural members

11.1 General

11.1.1 The necessary data about interconnection of the individual members are given in Table 2.33 to 2.36.

11.1.2 The bolts used shall be of sea water resistant materials.

11.1.3 Nuts shall be of the same material as the bolts, if possible. Washer diameters shall be about three times the bolt diameter; washer thickness about 25 % of the bolt diameter.

11.2 Floors

11.2.1 Number and diameter of the bolts connecting the floors to shell and keel are given in Table 2.34.

11.2.2 Floors fitted alongside the frames shall be fastened to the shell and the frames. They shall be fastened to each shell plank by one bolt and to the frames by at least 3 or 4 bolts.

11.2.3 Steel floor plates shall be welded to the steel frames.

11.2.4 Frames in the afterbody extending from one side of the yacht to the other without any floors shall be fastened to the transom beam by bolts in accordance with Table 2.34.

11.3 Shell and frames

11.3.1 Each shell plank shall be fastened to each frame by at least 2 screws. The screws are to be staggered (zig-zag) to prevent the frames from splitting. Screw diameters are given in Table 2.35.

11.3.2 The length of the wood screws shall be at least 2 to 2,5 times the thickness of the shell planks.

11.3.3 The butt straps are to be fastened to each of the planks by screws of the same diameter as those for shell-to-frame connection in accordance with Table 2.35.

11.3.4 If grown frames have butt-strapped joints, the straps shall be fastened to each frame part by 3 bolts in the case of scantling numerals $B/3 + H_1$ up to 2; by at least 4 bolts in the case of larger scantling numerals.

11.3.5 The shell planking shall be fastened to the wooden keel and the stem/sternpost by wood screws. These screws shall be at least of the same diameter and length as those between shell and frames. The distance between adjacent screws shall not be more than 12 screw diameters. The screws are to be staggered to avoid the wood splitting.

11.3.6 Screws through the shell may be countersunk if they are capped with a plug whose height equals the screw shank diameter.

11.4 Deck beams, hanging knees and beam shelves

11.4.1 Each deck beam is to be joined to the beam shelf; the half deck beams also to the carlines. In those with higher scantling numerals, bolts and nuts shall be used.

11.4.2 The hanging knees shall be fastened to the frames and deck beams by rivets or wood screws in accordance with Table 2.36.

11.4.3 If hanging knees are replaced by bulkheads, the connection of these to frame, shell, deck beam and deck shall be of the same strength as would be that with hanging knees.

11.4.4 The beam shelves shall be screwed to every frame.

11.5 Deck beams

11.5.1 The gunwale/covering board is to be screwed to the shell. The diameters of the wood screws are given in Table 2.35. The length of the screws shall be at least twice the thickness of the planks and the distance between screws equal to twelve screw diameters. The gunwale/covering board shall be fastened to every deck beam.

11.5.2 The deck planks shall be fastened to each deck beam by screws or hidden nails. If the latter solution is used, and if the deck beam spacing is greater than the tabular frame spacing, the planks shall additionally be fastened to one another sideways between the beams by a sea water resistant nail. The ends of the deck planks shall have an adequate sup- porting surface.

11.5.3 Deck margin planks shall be screwed to the carlines/ledges and the deck beams.

11.5.4 The screw diameters are given in Table 2.35.

11.5.5 The length of wood screws in solid wood decks is to be at least twice the plank thickness. Screws in plywood decks may be shorter in line with the reduced thickness of the deck.

11.6 Diagonal braces

Diagonal braces shall be fastened to the frames/deck beams and each shell or deck plank by at least one screw in accordance with Table 2.35.

12. Workmanship

12.1 The scantlings given in the Tables are minimum values. If required to guarantee the adequate strength of a screwed/bolted or riveted connection between individual members, the component scantlings may have to be increased - e.g. for the connection of the shell to the stem and the sternpost, where a rabbet of adequate width shall be provided.

Table 2.22 Beam shelves, bilge planks, shell and deck

$L (B/3 + H_1)$	Frame spacing	Beam shelves	Bilge planks	Shell	Deck
m^2	mm	cm^2	cm^2	mm	mm
7	120	17	-	11	18
8,5	130	19	-	12	18
10	140	21	-	13	18
11,5	150	24	-	14	18
13	160	28	-	15	18
14,5	170	31	-	16	18
16	180	34	-	17	18
17,5	190	37	-	18	18
19	200	40	-	19	18
20,5	210	43	-	20	19
22	220	46	-	21	20
23,5	230	49	-	22	21
25	240	52	-	23	22
27	250	56	-	24	23
29	260	60	-	25	24
31	270	64	-	26	25
33	280	69	-	27	26
35	285	73	-	28	27
37	295	77	59	29	28
39	305	80	62	30	29
41	310	84	64	31	30
43	320	88	67	32	30
46	330	94	70	33	31
49	340	100	73	34	32
52	345	106	76	35	33
55	355	112	80	36	34
58	360	117	84	37	35
61	370	123	87	38	36
64	380	129	90	39	37
67	385	135	93	40	38
75	405	149	102	42	40
85	420	167	112	44	42
96	440	185	123	46	44
108	455	204	134	48	46
122	475	225	147	50	48
140	495	250	162	52	50

If the frame spacing is increased, the thickness of the shell planking and the deck is to be increased in the same ratio. A reduction of plank thickness and the deck are permissible if the frame spacing is reduced. The spacing given is for carvel built yachts.

The frame spacing of clinker built yachts may be increased by 65 % whilst keeping the shell plank thickness at the value given in column 5.

Table 2.23 Widths of shell and strip deck planks

Plank thickness	Max. Widths of planks	
	Shell	Deck
mm	mm	mm
12	75 to 85	40
16	85 to 100	42
20	100 to 110	46
25	110 to 120	50
30	120 to 135	54
36	130 to 150	57
41	140 to 160	60
46	150 to 170	62
52	160 to 180	64

Table 2.24 Floors

$B/3 + H_1$	Frame spacing	Steel plate floors		Wooden plank-floors	
		Height	Thickness	Height	Thickness
m	mm	mm	mm	mm	mm
1,4	115	140	2,5	140	24
1,4	170	145	2,5	145	30
1,5	130	145	2,5	145	24
1,5	195	150	3	150	30
1,6	140	150	3	150	24
1,6	210	155	3	155	32
1,7	145	155	3	155	26
1,7	220	160	3,5	160	34
1,8	155	160	3,5	160	27
1,8	230	165	3,5	165	35
1,9	165	170	3,5	170	28
1,9	250	175	3,5	175	37
2,0	180	175	3,5	175	30
2,0	270	180	4	180	40
2,2	200	190	4	190	32
2,4	220	200	4	200	35
2,6	240	210	4	210	38
2,8	260	220	4	220	41
3,0	275	235	4	235	44
3,2	290	245	4	245	47
3,4	305	255	4	255	49
3,6	320	270	4,5	270	52
3,8	340	280	4,5	280	55
4,0	360	290	4,5	290	57
4,4	385	320	5	320	63
4,8	415	345	5	345	69
5,2	425	375	5	375	75
5,6	435	400	5,5	400	80
If the frame spacing is changed, the thickness of the floors is to be altered in the same ratio					

Table 2.25 Floors

$B/3 + H_1$	Frame spacing	Arm length	Flat bar steel floors		Angle bar floors W	Wooden floors	
			Throat	Arm end		Height	Thickness
m	mm	mm	mm	mm	cm^3	mm	mm
1,4	115	175	22 · 5	17 · 4	0,60	37	15
1,4	170	175	23 · 7	20 · 5	0,85	48	18
1,5	130	180	20 · 7	17 · 5	0,92	46	17
1,5	195	180	25 · 8	24 · 5	1,37	53	23
1,6	140	190	21 · 8	20 · 5	1,27	50	20
1,6	210	190	26 · 10	22 · 7	1,90	58	28
1,7	145	200	26 · 7	22 · 5	1,54	53	23
1,7	220	200	28 · 10	24 · 7	2,30	68	27
1,8	155	210	26 · 8	21 · 6	1,95	58	25
1,8	230	210	31 · 10	28 · 7	2,90	77	28
1,9	165	225	30 · 8	24 · 6	2,38	63	27
1,9	250	225	36 · 10	31 · 7	3,60	82	31
2,0	180	235	26 · 10	22 · 7	2,88	69	29
2,0	270	235	36 · 12	32 · 8	4,35	89	33
2,2	200	260	33 · 10	28 · 7	3,92	82	32
2,4	220	280	37 · 12	33 · 8	4,65	91	37
2,6	240	300	38 · 14	31 · 10	6,02	98	44
2,8	260	320	44 · 14	37 · 10	7,40	100	50
3,0	275	340	47 · 15	35 · 12	8,66	109	54
3,2	290	360			9,91	118	58
3,4	305	380			11,40	125	62
3,6	320	400			13,20	131	67
3,8	340	420			14,60	141	71
4,0	360	440			17,70	150	75
4,4	385	480			21,00	167	84
4,8	415	520			24,40	180	93
5,2	425	560			27,50	195	99
5,6	435	600			29,80	209	101

If the frame spacing is changed, the thickness of the floors or the section moduli for steel angle bar floors given in column 6 are to be altered in the same ratio.

Table 2.26 Frames: Section moduli without effective width of plate

$B/3 + H_1$	Section moduli referred to a basic frame spacing of 100 mm			
	Curved	Laminated	Naturallygrown	Steel profiles
	W_{100}	W_{100}	W_{100}	W_{100}
m	cm^3	cm^3	cm^3	cm^3
1,4	0,70	0,68	2,0	0,105
1,5	0,85	0,83	2,5	0,127
1,6	1,02	0,99	3,1	0,150
1,7	1,20	1,17	3,7	0,177
1,8	1,39	1,36	4,3	0,206
1,9	1,59	1,55	4,9	0,236
2,0	1,81	1,75	5,6	0,266
2,1	2,04	1,97	6,2	0,300
2,2	2,29	2,19	7,0	0,334
2,3	2,56	2,42	7,8	0,370
2,4	2,85	2,66	8,6	0,409
2,5	3,17	2,94	9,5	0,453
2,6	3,51	3,25	10,4	0,502
2,7	3,88	3,58	11,4	0,555
2,8	4,27	3,94	12,5	0,606
2,9	4,70	4,32	13,7	0,671
3,0	5,16	4,74	14,9	0,739
3,1	5,65	5,17	16,2	0,807
3,2	6,18	5,65	17,6	0,884
3,3	6,75	6,15	19,2	0,965
3,4	7,37	6,71	20,8	1,055
3,6	8,75	7,93	24,5	1,25
3,8	10,32	9,30	28,8	1,48
4,0	12,09	10,82	33,6	1,73
4,2	14,06	12,57	39,0	2,01
4,4	16,32	14,43	45,0	2,32
4,6	18,60	16,49	51,6	2,66
4,8	21,17	18,61	58,8	3,02
5,0	23,95	21,00	66,8	3,43
5,2	26,97	23,55	75,5	3,84
5,4	30,23	26,30	84,9	4,32
5,6	33,71	28,20	94,9	4,82
5,8	37,43	32,30	105,5	5,35

The frame section moduli are given for a basic spacing of 100 mm. If the spacing selected differs from that, the section moduli are to be increased in the same ratio.

Table 2.27 Grown frames: section moduli and cross sections

W	Breadth × Height
cm^3	mm
3,00	23 · 28 / 23
3,60	24 · 30 / 24
4,44	26 · 32 / 26
5,23	27 · 34 / 27
6,05	28 · 36 / 28
7,21	30 · 38 / 30
8,54	32 · 40 / 32
9,97	33 · 42 / 33
11,20	35 · 44 / 35
12,86	36 · 46 / 36
14,60	38 · 48 / 38
16,69	40 · 50 / 40
18,50	41 · 52 / 41
20,9	43 · 54 / 43
23,0	44 · 56 / 44
25,2	45 · 58 / 45
28,2	47 · 60 / 47
32,4	49 · 63 / 49
37,0	51 · 66 / 51
42,9	54 · 69 / 54
48,5	56 · 72 / 56
54,3	58 · 75 / 58
61,0	60 · 78 / 60
68,0	62 · 81 / 62
75,4	64 · 84 / 64
84,5	67 · 87 / 67
93,0	69 · 90 / 69
106	72 · 94 / 72
120	75 · 98 / 75
135	78 · 102 / 78
149	80 · 106 / 80
167	83 · 110 / 83
186	86 · 114 / 86
209	90 · 118 / 90
232	93 · 122 / 93
254	95 · 126 / 95
276	98 · 130 / 98
303	101 · 134 / 101
328	103 · 138 / 103
358	106 · 142 / 106

The first height given for naturally grown frames is that in way of the floors, which may be gradually reduced to the second height towards the deck

Table 2.28 Deck beams, section moduli without effective width of plate

Beam length	Section moduli referred to a basic beam spacing of 100 mm			
	Wooden beams	Laminated beams	Steel sections	Deck load
	W_{100}	W_{100}	W_{100}	W_{100}
m	cm^3	cm^3	cm^3	kN/m^2
0,8	0,52	0,47	0,081	1,84
1,0	0,86	0,78	0,132	1,93
1,2	1,28	1,15	0,18	2,02
1,4	1,84	1,66	0,248	2,11
1,6	2,84	2,23	0,335	2,20
1,8	3,30	2,97	0,446	2,29
2,0	4,20	3,78	0,568	2,38
2,2	5,27	4,75	0,712	2,48
2,4	6,52	5,87	0,882	2,57
2,6	7,90	7,10	1,068	2,67
2,8	9,51	8,56	1,29	2,75
3,0	11,25	10,25	1,52	2,84
3,2	13,25	11,92	1,79	2,94
3,4	15,44	13,90	2,09	3,04
3,6	17,80	16,00	2,41	3,12
3,8	20,40	18,35	2,76	3,22
4,0	23,30	20,95	3,15	3,30
4,2	26,40	23,75	3,57	3,40
4,4	29,75	26,80	4,02	3,49
4,6	33,30	30,00	4,50	3,59
4,8	37,20	33,50	5,03	3,67
5,0	41,40	37,30	5,60	3,76
5,2	45,70	41,10	6,18	3,85
5,4	50,50	45,40	6,82	3,95
5,6	55,60	50,00	7,51	4,05
5,8	61,20	55,00	8,27	4,13
6,0	67,30	60,50	9,10	4,23
6,2	73,50	66,00	9,94	4,33
6,4	79,70	71,60	10,79	4,42
6,6	86,50	77,80	11,63	4,52

For each beam the section moduli may be determined on the basis of its specific length, but lengths less than half the breadth of the craft should not be inserted.

Table 2.29 Diagonal braces and number of hanging knees

L (B/3 + H_1)	Diagonal braces	Hanging knees
m^2	mm	number
to 13	-	3
to 20	-	4
to 27	-	5
to 30	-	6
to 35	50 · 4	6
to 40	50 · 4	6
to 45	60 · 4	6
to 50	50 · 4,5	7
60	80 · 4,5	7
70	90 · 5	8
80	100 · 5	8
90	100 · 6	9
100	110 · 6	9
110	120 · 6	10
120	130 · 6	10
130	145 · 6	11

Table 2.30 Scantlings of hanging knees

B/3 + H_1	Flat bar steel knee [1] Width × Thickness	Angle bar W	Arm length	Bracket Thickness	Wooden Leg Thickness
m	mm	cm^3	mm	mm	mm
1,60	19 · 7	0,8	290	2,5	16
1,75	19 · 8	0,9	300	2,5	18
1,90	22 · 8	1,0	310	2,5	20
2,10	25 · 9	1,3	325	3	22
2,30	26 · 11	1,6	340	3	26
2,50	28 · 12	1,8	360	3,5	28
2,70	30 · 13	2,1	380	3,5	30
2,90	30 · 15	2,4	400	3,5	32
3,15	33 · 16	2,8	420	4	35
3,40	37 · 17	3,3	440	4	38
3,65	40 · 18	3,7	460	4	41
3,90	44 · 19	4,1	480	4	44
4,15	47 · 21	4,7	500	5	47
4,40	49 · 23	5,3	520	5	50
4,65	53 · 24	5,8	540	5	53
4,90	55 · 26	6,5	560	5	56
5,20	60 · 27	7,3	580	6	59
5,50	65 · 28	8,2	600	6	62
5,80	66 · 30	9,0	620	6	65

[1] Width and height apply to the throat of the flat bar knee. The cross section may be gradually reduced to 40 % of the cross section at the throat, from the first third of the length onwards towards the end.

Table 2.31 Wooden keel and stem/sternpost

$L (B/3 + H_1)$	Sailing yachts	Wooden keel amidships	Motor yachts
	width	height [1]	width
m^2	mm	mm	mm
7	123	57	123
8	131	59	131
9	139	61	139
10	145	64	145
11	152	66	152
12	159	68	159
13	165	70	165
14,5	175	74	172
16	185	77	178
17,5	195	81	182
19	205	84	185
20,5	214	87	187
22	223	90	189
23,5	232	93	191
25	241	96	193
26,5	248	99	195
28	255	102	196
29,5	262	105	197
31	269	108	198
32,5	275	111	199
34	282	114	200
35,5	288	117	201
37	294	119	202
39	301	122	203
41	309	125	204
43	315	128	205
45	323	131	206
47	330	134	207
49	337	137	208
51	342	140	209
54	350	144	210
57	358	147	212
60	366	151	213
63	374	155	214
66	381	158	215
69	387	161	216
72	394	164	217
76	401	168	218
80	409	171	219
84	416	175	220
88	424	179	222
92	431	182	224
96	439	185	226
100	446	188	228
105	454	192	230
110	461	195	233
115	469	198	236
120	476	201	239
125	483	204	242
130	490	207	245
135	497	210	248

Table 2.31 Wooden keel and stem/sternpost (continued)

L (B/3 + H_1)	Sailing yachts	Wooden keel amidships	Motor yachts
	width	height [1]	width
m^2	mm	mm	mm
140	505	213	251

Towards the ends, the width of the wooden keel may be tapered off to that of the stem/sternpost.
The height of laminated wooden keels may be reduced by 5%
[1] Applies to sailing and motor yachts.

Table 2.32 Superstructure, carlines

L (B/3 + H_1)	Superstructure side walls		Superstructure deck		Carlines
	Solid wood	Plywood	Solid wood	Plywood	
m^2	mm	mm	mm	mm	cm^2
7	18	9	8	6	7
8,5	18	10	8	6	7
10	19	11	9	6	9
11,5	19	12	9	6	11
13	20	13	10	6	12
14,5	20	13	10	7	13
16	21	14	11	7	14
17,5	21	14	12	8	15
19	22	15	12	8	16
20,5	22	15	13	8	17
22	23	15	14	9	18
23,5	23	15	14	9	19
25	23	15	15	10	20
27	24	16	15	10	21
29	24	16	16	10	22
31	24	16	16	11	23
33	24	16	17	11	24
35	24	18	17	11	25
37	25	18	18	11	26
39	25		18	12	26
41	25		19	12	27
43	25		19	12	28
46	25		20	13	29
49	26		20	13	30
52	26		21	13	31
55	26		21	13	32
58	27		21	14	33
61	27		22	14	34
64	27		22	14	35
67	27		23	15	36
71	28		23	15	37
75	28		24	15	38
80	29		24	15	39
85	29		24	16	40
90	30		25	16	41
96	30		25	16	42
102	31		25	16	43
108	31		26	16	44
115	32		26	17	45
122	33		27	17	45
130	34		27	17	46
140	35		27	17	47

Table 2.33 Bolting-up keel, stem/sternpost, deadwood, transom beam, etc.

L (B/3 + H_1)	Keel, stem/sternpost, deadwood, transom beam	Horizontal knee
m^2	Bolt diameter in mm ∅	
to 10	9	6
10 to 12	10	6
12 to 15	11	6
15 to 19	12	6
19 to 23	13	8
23 to 28	14	8
28 to 32	15	8
32 to 37	16	8
37 to 41	17	8
41 to 46	18	8
46 to 60	20	10
60 to 75	22	10
75 to 140	25	10

Table 2.34 Connecting floors with keel and shell and frames

B/3 + H_1	Bolts		Bolts			
	In the arms		In the throat			
			for 0,8 LWL		at the ends of the yacht	
	Number	mm ∅	Number	mm ∅	Number	mm ∅
to 1,5	3	5,5	1	8	1	8
1,5 to 1,75	3	5,5	2	8	1	8
1,75 to 1,9	3	6	2	8	1	9
1,9 to 2,1	3	6	2	9	1	9
2,1 to 2,3	4	6	2	9	1	10
2,3 to 2,5	4	6,5	2 3	10 9	1 2	10 7
2,5 to 2,7	4	7	2 3	11 10	1 2	11 8
2,7 to 2,9	4	8	2 3	11 10	1 2	11 8
2,9 to 3,15	4	9	2 3	12 11	1 2	12 9
3,15 to 3,4	4	9	2 3	12 11	1 2	12 9
3,4 to 3,65	5	10	2 3	13 12	1 2	13 9
3,65 to 3,9	5	10	2 3	14 13	1 2	14 10
3,9 to 4,15	5	11	2 3	15 14	1 2	15 11
4,15 to 4,4	5	11	3	15	2	12
4,4 to 4,65	5	12	3	16	2	13
4,65 to 4,9	5	12	3	17	2	14
4,9 to 5,2	5	13	3	18	2	15
5,2 to 5,5	5	14	3	19	2	16
5,5 to 5,8	5	15	3	20	2	17

Table 2.35 Screws in shell and deck

Plank thickness	Shell with frames Screws	Deck planks to deck and shell beams screws
mm	mm ∅	mm ∅
to 15	4	4
15 to 17	4	4
17 to 19	4,5	4
19 to 23	5	4,5
23 to 26	5,5	5
26 to 29	6	5,5
29 to 32	6,5	6
32 to 35	7,5	7
35 to 38	8	7,5
38 to 41	8,5	8
41 to 44	9	8,5
44 to 47	10	9
47 to 50	10,5	9,5
50 to 53	11	10

Table 2.36 Screwing hanging knees and shelves to frames and deck beams

$B/3 + H_1$	Number	Screws
m		mm ∅
to 1,5	3	4,5
1,5 to 1,75	3	5
1,75 to 1,9	3	5,5
1,9 to 2,1	3	6
2,1 to 2,3	3	7
2,3 to 2,5	4	8
2,5 to 2,7	4	8
2,7 to 2,9	4	9
2,9 to 3,15	4	10
3,15 to 3,4	4	10
3,4 to 3,65	5	11
3,65 to 3,9	5	11
3,9 to 4,15	5	12
4,15 to 4,4	5	12
4,4 to 4,65	6	13
4,65 to 4,9	6	13
4,9 to 5,2	6	14
5,2 to 5,5	6	15
5,5 to 5,8	6	16

D. Anchoring, Towing and Warping Gear

1. Anchoring gear

1.1 General

Fishing vessel shall be equipped with anchoring gear which assures swift and safe laying out and heaving up of the stipulated anchors in all foreseeable situations, and which hold the vessel at anchor. The anchoring gear comprises of anchors, anchor chains or cables and possibly anchor winches or other equivalent equipment for laying out and heaving up the anchors and for keeping the vessel at anchor.

1.2 Equipment numeral

1.2.1 The required equipment with anchors, chains and cables shall be determined in accordance with Table 2.37 in Annex F according to the equipment numeral Z. The equipment numeral is obtained from the following formula:

$$Z = 0{,}6 \cdot \mathbf{L} \cdot \mathbf{B} \cdot \mathbf{H}_1 + A$$

L, **B**, $\mathbf{H}_1$ in accordance with A.1.5

A = 0,5 times the volume of the superstructures [m^3]

(Superstructures and deckhouses whose width is less than **B**/4 may be disregarded.)

1.2.2 In the case of small Fishing vessel whose displacement is less than 1,5 t, the equipment is to be based on the displacement.

1.3 Anchors

1.3.1 The anchor weights listed in Tables 2.37 apply to "High holding power" anchors.

A stock anchor may be used if its weight is 1,33 times that in the Table.

Other types of anchor require special approval. Procedure tests and holding trials shall be carried out in accordance with Rules for Materials (Pt.1, Vol.V).

1.3.2 The weight of each individual anchor may deviate up to 7% from the stipulated value, provided the combined weight of the two anchors is not less than the sum of the stipulated weights.

1.3.3 Materials for anchors must comply with the Rules for Materials (Pt.1, Vol.V). Anchors weighing more than 75 kg must be tested on a BKI approved tensile testing machine in the presence of a surveyor. For anchors below 75 kg and those intended for fishing vessel with a restricted operating category (II - V), proof is sufficient that anchors and chains have been reliably tested.

1.4 Cables and chains

1.4.1 Towing line

Each fishing vessel shall be equipped with a towing line in accordance with Table 2.37.

1.4.2 Anchor lines/cables and chains

1.4.2.1 On vessel with a displacement ≤ 1,5 t, the towing line may be used as anchor line.

If the displacement is ≥ 1,0 t, at least 3,0 m chain with 6,0 mm nominal thickness is to be shackled between anchor and line.

1.4.2.2 On fishing vessel with a displacement ≥ 1,5 t whose $\mathbf{L}_{WL}$ is ≤ 15 m, both anchors may be on chains or on lines with chain outboard shot.

Anchor chains shall be determined in accordance with columns 5 and 6 of Table 2.37.

Synthetic fibre anchor lines shall be 1,5 times as long as the stipulated anchor chain and fitted with a spliced-in thimble at one end. They shall have the same maximum tensile strength as the towing line. Regarding notes for the selection of other ropes, see Table 2.37.

1.4.2.3 Between line and anchor a chain outboard shot is to be shackled whose nominal thickness is determined in accordance with column 6 of Table 2.37 and whose length is obtained from the following Table:

Nominal thickness of chain outboard shot[1] [mm]	Length of chain outboard shot [m]
6 - 8	6,0
9 - 15	12,5

[1] ISO 4565
EN 24565
DIN 766

Anchor chains and chain outboard shots must have reinforced links at the ends. A swivel is to be provided between anchor and cable.

1.4.2.4 The chain end fastening to the hull must be so made that in the event of danger the chains can be slipped at any time from a readily accessible position without endangering the crew. As regards strength, the end fastening is to be designed for at least 15 % but not more than 30 % of the nominal breaking load of the chain.

1.5 Anchor winches

1.5.1 For anchors weighing 30 - 50 kg, anchor winches are recommended.

1.5.2 For anchors weighing more than 50 kg, winches are obligatory.

1.5.3 The winches shall correspond to Section 3, I. If anchors weighing more than 50 kg are to be worked by means of lines, the winch must be fitted with rope drums allowing rapid letting-go of the gear in all foreseeable situations. Practical proof of handling safety is to be provided.

1.6 Chain locker

1.6.1 Size and height of the chain locker shall be such that a direct and unimpeded lead of the chain to the navel pipes is guaranteed even with the entire chain stowed. A wall in the locker shall separate the port and starboard chains.

1.6.2 Precautions are to be taken to prevent flooding of adjoining spaces if the chain locker is flooded via the navel pipes.

2. Towing and warping gear

2.1 Towing bollard

2.1.1 Each fishing vessel shall be provided with a device suitable for fastening the towing line to at or near the stem. Suitable devices are:

- eyebolts fastened to the stem of small boats
- two belaying cleats either side on the foredeck
- a bollard mounted amidships on the foredeck

2.1.2 Towing bollards and cleats, plus any stem fittings, must not have any sharp edges.

2.1.3 The design strength of the connections to the deck and the substructure is to be at least 120 % of the maximum tensile strength of the rope.

2.2 Warping gear

2.2.1 Each fishing vessel shall be fitted with suitable equipment for mooring (bollards, cleats, eyes) forward and aft - and if appropriate for larger vessel, along the sides.

2.2.2 The size of the bollards or belaying cleats depends on the recommended rope diameter according to the Table below, each bollard or cleat being intended for belaying two ropes securely.

Bollards, cleats and eyes are to be positively joined to the hull.

2.2.3 It is recommended that each fishing vessel be equipped with 4 securing lines, i.e.

2 lines of 1,5 · L [m] each and

2 lines of 1,0 · L [m] each

The nominal rope diameter can be derived from the following Table.

Displacement [t]	Nominal rope diameter d_2 [1] [mm]
to 0,2	10
0,6	12
1,0	14
2,0	14
6,0	16
12,5	18
25,0	20
50,0	22
75,0	24
100,0	26

[1] Three-strand hawser-lay polyamide rope in accordance with DIN 83330
For notes concerning the choice of other ropes see Table F.3 in Annex F

Table 2.37 Anchors, anchor cables and lines of fishing vessel

Equipment numeral Z	Displacement D	Weight of		Anchor cable		Towing line	
		1. anchor[3]	2. anchor	Length [4]	Nominal thickness[1]	Length	Nominal diameter[2]
[m³]	[t]	[kg]	[kg]	[m]	[mm]	[m]	[mm]
–	up to 0,15	2,5	–	–	–	5 L_{WL}	12
–	at 0,20	3,0	–	–	–		12
–	at 0,30	3,5	–	–	–		12
–	at 0,40	4,5	–	–	–		12
–	at 0,50	5,0	–	–	–		12
–	at 0,60	5,5	–	–	–		14
–	at 0,75	6,5	–	–	–		14
–	at 1,00	7,5	–	–	–		14
–	at 1,50	8,7	–	–	–		14
up to 10	at 2,00	9,0	–	20,0	6,0		16
at 15	at 3,00	10,0	–	22,0	6,0		18
at 20	at 4,00	11,0	–	23,0	6,0		18
at 25	at 5,00	12,0	–	24,0	6,0		18
at 30	at 6,00	13,0	–	25,0	7,0		18
at 40	at 8,00	14,0	12,0	26,0	7,0		20
at 55	at 12,00	18,0	15,0	29,0	8,0		22

Table 2.37 Anchors, anchor cables and lines of fishing vessel (continued)

Equipment numeral Z	Displacement D	Weight of		Anchor cable		Towing line	
		1. anchor[3]	2. anchor	Length [4]	Nominal thickness[1]	Length	Nominal diameter[2]
[m³]	[t]	[kg]	[kg]	[m]	[mm]	[m]	[mm]
at 70	at 17,00	21,0	18,0	32,5	8,0		22
at 90	at 23,00	25,0	21,0	36,0	9,0	4.75 L_{WL}	22
at 110	at 29,00	29,0	25,0	38,5	10,0		24
at 130	at 36,00	34,5	29,0	42,0	10,0		24
at 155	at 44,00	40,0	34,0	47,0	11,0	4,5 L_{WL}	24
at 180	at 52,00	46,0	39,0	51,0	13,0		24
at 210	at 57,00	52,5	44,0	55,5	13,0		26
at 245	at 72,00	61,0	52,0	61,0	13,0		26
at 280	at 84,00	70,5	60,0	66,5	14,0	4,25 L_{WL}	26
at 300	at 100,00	79,5	67,5	70,0	16,0		26

Z Equipment numeral in accordance with Section 1, G.

1 Nominal thickness of round bar steel chain in accordance with ISO 4565, EN 24565, DIN 766.

2 3-strand hawser-lay polyamide line in accordance with DIN 83330.

3 May be reduced by 25 % if the vessel in question operates exclusively on inland waterways (Operating Category V) where strong currents and high seas can be excluded. A stock anchor of 1,33 times the weight may be used.

4 Applies for one anchor in each case.

E. Stability, Closure and Opening

Note:

This guidance refers to Rules for Small Vessel up to 24 m (Pt.3, Vol.VII). If there is an obscurity, see the Rules.

1. Stability criteria to be used

1.1 Vessel with a scantling length L ≤ 10,00 m also open vessel

An angle of heel of 12 shall not be exceeded with the vessel under the combined influence of the centrifugal moment from a turning circle manoeuvre and a personnel moment, in accordance with the following formula:

$$M = 0,25\ \mathbf{D}\ (v^2 / \mathbf{L})\ (0,75\ \mathbf{H} - 0,5\ \mathbf{T}) + n\ (0,2\ \mathbf{B} + 0,10) \quad [\text{kNm}]$$

where:

v = speed in [m/s]

n = number of persons on board

D, **L**, **H** and **T** in accordance with A.1.5.

Note:

Range service for open and partial decked vessel are limited for Operating Category V only.

1.2 Vessel with scantling length L > 10,00 m decked vessel

– GM ≥ 0,35 m
– righting lever at 30 inclination ≥ 0,20 m
– stability range 60 deg

– area under lever arm curve up to 30 inclination ≥ 0,055 mrad
– turning circle angle of heel 12 , to be determined by turning trials

During the trials the speed is to be increased in steps until either the turning circle angle of heel reaches 12 or the maximum speed is attained.

1.3 In exceptional cases, BKI may dispense with proof of stability in accordance with 1.2 for vessel with a scantling length **L** of

$$10{,}0\ \text{m} < \mathbf{L} < 15{,}0\ \text{m}$$

The proof is then to be provided in accordance with 1.1.

1.4 Other methods of determining the stability are acceptable provided they permit assessment of the stability with certainty.

2. Standard loading condition in stability evaluation

– departure conditions for the fishing grounds with full fuel, stores, ice, fishing gear, etc.;
– departure from the fishing grounds with full catch and a percentage of stores, fuel, etc., as agreed by BKI;
– arrival at home port with 10% stores, fuel, etc. remaining and full catch; and
– arrival at home port with 10% stores, fuel, etc. and a minimum catch, which should normally be 20% of full catch but may be up to 40% provided BKI is satisfied that operating patterns justify such a value.

3. Floatability, reserve buoyancy

3.1 Open and partially decked vessel shall be capable of remaining afloat with maximum deadweight when swamped, and have enough reserve buoyancy to serve as flotation aid for the occupants. A reserve buoyancy in the swamped condition of at least 15 kg per person is to be provided.

3.2 The buoyant chambers necessary to provide the reserve buoyancy shall be permanently installed and should be foam filled. If not foam filled, they shall comprise of at least two separate cells and shall demonstrate watertightness.

4. Lightship Parameter

For vessel whose scantling length **L** ≤ 10 m, lightship parameter need not be determined by means of inclining test. In this case, detail calculation of lightweight shall be provided and to be proven by draught measurement.

Note:

Smaller boats in particular may have their stability endangered under unfavourable circumstances in spite of remaining within the stated limiting values for stability. Good seamanship is therefore an essential prerequisite for a stability secure vessel.

5. Openings and closures in hull, deck and superstructure

The following is required:

Component	Requirements	
	Operating Category I, II	Operating Category III, IV, V
Deck hatches	[1]	[2]
Cockpit hatches	[1]	[2]
Sliding covers	[2] [8]	[2]
Cabin access	[2] [5]	[2] [3]
Ventilation ducts for accommodation	[2] [6]	[2]
Ventilation ducts for Machinery space	[2] [5] [6]	[2] [5]
Air pipes	[2] [5]	[2] [5]
Centreboard case	[1]	[2] [7]
Hawsepipe	[2]	[2]

[1] Weathertight closure

"Weathertight" means that whatever condition of the sea arises, no water can penetrate into the vessel. Weatherthightness is to be checked by spraying the closure from outside using a conventional water hose, from a distance of about 2,0 m (minimum jet pressure 1 bar).

[2] Spraytight closure

"Spraytight" means that no major quantities of water can penetrate into the vessel as a result of short-time immersion. Spraytightness is to be proven by shooting water from a bucket onto the closure from a distance of about 2 m.

[3] Height of coaming at least 50 mm. Removable coamings of vessel in Operating Category III must meet the requirements under [4].

[4] The heights of the coamings of the doors leading to the spaces below decks must not be less than the following values:

Position	Coaming height [mm]
In side- and back walls, accessible from main deck	150
In back walls, accessible from cockpit	380 above cockpit floor
anywhere if this access leads directly into the spaces	460

Removable coamings in door openings are to be capable of being secured in place.

[5] May only be located above the main deck in a sheltered place, so that even in bad weather the engines can be kept going for as long as possible.

[6] Shall be capable of being closed weathertight (e.g. canvas cover) in the event of heavy weather.

[7] The safety gap from the flotation plane to the lowest point not watertight shall be at least 100 mm. Parts of the centreboard case above that level are to be made spraytight.

[8] May only be located on a superstructure or deckhouse. Hatches with sliding covers in the forward part of the vessel shall have a coaming height of 150 mm above the superstructure

6. Closure condition

6.1 All openings, cut-outs, passages, etc. in the shell must be designed to be closed by means of suitable devices, fittings, etc. that no water can enter the inside of the vessel. This does not apply to cockpit drain pipes.

6.2 Doors, hatch and ventilation duct covers plus their hinges, lock tumblers and securing arrangements must be adequately dimensioned. Details are to be submitted for approval.

6.3 All doors and escape hatches must be operable from both sides.

6.4 Regarding in and outlet fittings on the shell for the cooling and bilge water and sewage lines, see Section 3.

7. Windows, skylights and port lights

7.1 In any case windows opening into enclosed spaces shall be watertight and adequately dimensioned for the intended Operating Category. Machinery space windows must be fixed ones.

7.2 Windows in the hull which can be opened must be kept closed when at sea. Where the vessel is used for commercial purposes or for public use, this must be suitably ensured. The bottom edge of windows in the hull shall be at least 500 mm above the flotation plane. Windows in the hull are not permitted in machinery spaces.

7.3 Deadlights are to be carried on board for all windows in the hull, windows in walls facing forward and those whose surface area exceeds 0,20 m^2. If there are windows of the same size on the port and the starboard side, deadlights are only needed for one side.

Deadlights may be dispensed with if:

- glass thickness is twice that required under 7.7, or
- the vessel is due to operate in category IV and the windows are above the weather deck, or
- the vessel is due to operate in category V.

7.4 Window panes shall preferably be made of toughened or tempered safety glass ("ESG"), but laminated glass ("MSG"), acrylic and polycarbonate sheet material or equivalent material may also be used.

Machinery space window panes in deckhouses must be of toughened/tempered safety glass; if not, an external deadlight shall be provided. In Operating Categories I and II, plastic panes shall be UV-stabilised.

7.5 Hull windows with silicate glass ("ESG", "MSG") panes shall have metal frames which can be tightly bolted to the shell. The bearing width of the glass against the frame must be at least 6,0 mm.

Panes of acrylic or polycarbonate sheet material are to be fixed by frames. They may also be bolted directly to the shell or external wall, provided the bolting is capable of resisting the stresses arising and guarantees lasting watertightness. The bearing width of the glass is to be 3 % of whichever is the shortest side of the pane, but at least 20 mm.

Designs offering equivalent safety are permitted. The strength is to be proven by tests and/or calculation.

7.6 Rubber clamping sections may be used only in Operating Categories IV and V, provided the shorter side of the window is no longer than 300 mm and the corner radius is at least 50 mm.

7.7 The window glass thicknesses are to be determined as follows:

$$t = n\sqrt{\frac{F \cdot Fb}{y}}$$

F = surface area of pane in [m^2]

F_b = freeboard in accordance with Annex H in [m]

y = height of window centre above flotation plane in [m]

n = factor in accordance with Table below

t_{min} = minimum thickness, see Table below

7.8 Only acrylic or polycarbonate sheet material may be used for skylights and hatches. The thickness of the panes in these must be 25 % greater than that of the shell windows or forward facing windows in accordance with 7.7, but at least 7,0 mm.

7.9 Port holes are treated like windows.

8. Cockpit

8.1 Cockpit floor plus longitudinal and transverse walls count as primary structural members, the scantling of which shall be in accordance with Section 1. Cockpits shall be watertight to the inside of the vessel.

8.2 Regarding closures and coaming heights of hatches and doors of adjoining storage and living spaces, see 5. and 6.

8.3 The cockpit floor must be sufficiently high above the flotation plane to drain water that has entered immediately through drain pipes or clearing ports under all foreseeable states of heel and trim of the vessel.

8.4 Each cockpit shall be provided with at least one drain pipe each side. The total cross section of the pipes on both sides shall be determined as follows:

$$F = 15 \cdot V \text{ [cm}^2\text{]}$$

V = cockpit volume in [m^3] measured to top edge of cockpit coaming at its lowest point.

The total cross section of all drain pipes may not be less than:

f_{min} = 25,0 cm^2 in Operating Category I

f_{min} = 12,5 cm^2 in Operating Categories II and III

f_{min} = 10,0 cm^2 in Operating Categories IV and V

The cross section values determined are also required in the area of any strainers that may be present.

8.5 Cockpits extending all the way across the vessel must have clearing ports or drain pipe cross sections in accordance with 9.2.

8.6 Cockpit drain pipes shall be equal in strength to the surrounding hull. Cockpit drain pipes may only be replaced by hoses with special permission. Valves in cockpit drain pipes must be kept permanently open.

8.7 Short hose sleeves are permissible under the following conditions:

- The distance between sleeve and waterline shall be at least 100 mm.
- The sleeve shall still be above the waterline with the vessel heeled 15.
- The hose used shall be in accordance with DIN 20022.
- Two corrosion resistant clips are to be fitted at each end of the sleeve.

9. Deck drainage

9.1 An adequate number of outlets or scuppers shall be fitted to allow water to drain from the weatherdeck(s).

9.2 If a bulwark is envisaged, this must have sufficient clearing ports of adequate size. The clear opening A of all the ports on one side of the vessel is to be determined in accordance with the following formula:

$$A = 0{,}01 \cdot l \cdot h + 0{,}035 \cdot l \cdot h^2 \quad [m^2]$$

l = length of bulwark in [m] of one ship's side

h = height of bulwark in [m]

9.3 The clear opening of the clearing ports in a superstructure bulwark shall not be less than 50 % of the opening determined in accordance with 9.2.

9.4 The bottom edges of the clearing ports and bulwark cut-outs are to be as close to the deck as possible. If the clear height of a port or cut-out is more than 230 mm, a rail is recommended as protection against falling overboard.

9.5 Deck drain pipes shall match the surrounding hull in strength. Deck drain pipes may only be replaced by hoses with special permission. Valves are not permitted in deck drain pipes.

9.6 Short hose sleeves are permitted. The conditions in accordance with 8.7 are to be observed.

Section 3 Machinery Installations

A. General Guidance and Notes

1. General

1.1 These guidances apply to the machinery of fishing vessel up to a length (**L**)[1] of 24 m in operating categories **III** to **V**.

If the length of 24 m, or the operating category, is exceeded, Rules for Machinery Installations (Pt.I, Vol.III) apply.

1.2 Installations deviating from the guidance may be accepted if they have been assessed by BKI for their suitability and have been approved as equivalent.

This guidance shall not apply to fishing vessel with propulsive power ≥ 400 kW.

This guidance shall apply to permanent inboard engine only.

For the purpose of these regulations, "fuel" means only diesel oil with a flash point > 55 °C

1.3 For machinery and technical installations not included in these guidances, BKI may set special stipulations based on relevant rules and technical regulations if deemed necessary for the safety of the vessel.

Furthermore BKI reserve the right for all types of installations to state requirements beyond these guidances, if deemed necessary due to newly-acquired knowledge or operating experience.

1.4 National and regional rules and regulations beyond the requirements of these Guidances remain unaffected.

2. Documents for examination

2.1 For checking compliance with these Guidances, drawings and documentation giving clear indication of the arrangement and dimensions of the components are to be submitted in triplicate. To facilitate a smooth and efficient approval process. the drawings could be submitted in electronic format. If necessary these are to be supplemented by descriptions and data sheets.

The following document including all the details necessary for approval are :

- engine room layout
- ventilation system

[1] Definition see Section 2, A.

- shafting & stern tube detail
- propeller
- bilge system
- general service system
- domestic supply system
- fuel oil system
- sea water cooling system

Supervision of construction is based on the approved documentation which shall be submitted before commencing construction.

2.2 The approved documentation is binding. Any subsequent changes shall have BKI approval.

3. Construction of machinery installations

3.1 Scantlings of structural parts and components

All parts shall be able to withstand the specific stresses due to the vessel's motion, heel, trim, vibration, increased corrosive action and, if applicable, also slamming. Where guidance for the scantling of components are not available, acknowledged engineering rules/guidances shall be applied.

3.2 Environmental conditions

3.2.1 Heel and trim

Unimpaired operation of the machinery installation is to be safeguarded for :

- continuous heel of up to 15° (static)
- short-term heel of up to 30° (dynamic)
- short-term trim of up to 20° (dynamic)

3.2.2 Temperatures

Design of the machinery installation shall be subject to the following conditions:

- outside air temperature 45 °C
- outside water temperature 32 °C

the ambient temperature during operation in the vicinity of internal combustion (IC) engines shall not exceed 60 °C.

3.2.3 Other environmental conditions

Basic assumptions for all compartments shall be salt- laden air and a relative humidity of up to 100 % at a reference temperature of 45 °C, plus the occurrence of condensation. Oil vapors have to be taken into account additionally in engine spaces.

Equipment on the open deck shall be resistant against saltwater spray and short-term immersion in sea water.

3.3 Arrangement

3.3.1 Machinery installations shall be arranged with adequate access for operation, checking and routine maintenance.

3.3.2 In the case of IC engines which can also be started manually, the cranking position is to be arranged with sufficient space and ergonomically favourable.

3.3.3 IC engines shall be installed separate from other spaces of the vessel.

3.4 Foundations

Machinery installations shall be securely fastened to the vessel, taking into account the loads to be expected. Foundations and seatings shall be properly integrated into the structure of the hull.

3.5 Bilges

3.5.1 Where oil or fuel leakage is likely to occur, the bilges are to be designed as to prevent such leakages from spreading to other parts of the vessel. Drip trays are to be provided as appropriate .

3.5.2 Means for collecting oil leakages, or parts of the vessel where oil or fuel leakage may occur, may not be connected to the common bilge system. Suitable equipment is to be provided for the environmentally safe disposal of oil or oily water.

3.6 Ventilation

Machinery spaces are to be sufficiently ventilated so as to ensure that when machinery therein are operating at full power in all weather conditions, including heavy weather, a sufficient supply of air is maintained to the spaces for the operation of the machinery.

This sufficient amount of air is to be supplied through suitably protected openings arranged in such a way

that they can be used in all weather conditions The arrangement of ventilation shall not endanger structural integrity or safety of the vessels.

3.7 Protective equipment, insulation

3.7.1 Machinery installations shall be such that the risk of accidents is substantially excluded.

Exposed moving parts and rotating shafts are to be protected by means of suitable guards. This may be dispensed with if moving parts and rotating shafts are adequately protected by other permanently installed equipment.

3.7.2 Crank handles of IC engines which can also be crank-started are to disengage automatically when the engine starts and to be kick-back proof.

3.7.3 Insulating material for machinery installations at least shall be not readily ignitable, e.g. acc. to engine maker or equivalent. The insulation shall be suitably protected against penetration by moisture and leaking oil.

3.7.4 Components of the installation having a high surface temperature (> 80 °C), such as exhaust lines, are to be fully insulated.

3.8 Painting

Only fire retardant paints are to be used on machinery and in areas where machinery is installed.

3.9 Environtmental Control

Any environtmental control and management where not stipulated to this guidance are left to National Regulation.

4. Operating and monitoring equipment

4.1 General

Operating and monitoring equipment is to be arranged suitably and distinct, and be provided with permanent identification.

4.2 Means of reversing

Vessel with propulsive power ≥ 5 kW are to be equipped with means of reversing the direction of travel. Reversing levers are to be so arranged that their operating direction matches the desired direction of travel.

4.3 Scope of monitoring equipment

For permanently installed engines with propulsive power ≥ 5 kW, the control position is to be provided at least with visual or audible alarm for oil pressure and cooling water temperature. The alarm thresholds are to be set in accordance with the engine manufacturers instructions.

For other permanently installed machinery alarm are to be provided analogously, unless dangerous operating conditions are prevented by automatic shut-down arrangements.

5. Trials

Trials of the completed machinery installation are carried out in accordance with this guidance.

B. Internal Combustion Engines

1. General

The engines for main propulsion or auxiliary propulsion, or prime movers of essential auxiliaries shall be approved for use with fishing vessels in accordance with these Guidances. The rated power at associated rated revolutions declared by the engine manufacturers shall be the continuous power.

For the dimensioning of major engine components, Rules for Machinery Installations (Pt.I, Vol.III) are to be applied analogously.

2. Foundations

2.1 Main engines

2.1.1 Main engines should be flexibly mounted on their foundations/ seatings. The recommendations for installation given by the engine manufacturers shall be observed.

2.1.2 If the mounting is flexible, the connections for fuel, cables plus operating and monitoring equipment are to be made flexible.

2.1.3 Oil proof elastic mounts shall be used.

3. Safety devices on the engine

3.1 Each diesel engine is to be equipped with a safety or speed regulator which prevents the engine's rated rotational speed being exceeded by more than 15 %.

3.2 In the case of diaphragm-type fuel supply pumps, the installation has to ensure that fuel cannot either leak or get into the engine lubricating oil circuit if the diaphragm is damaged.

3.3 Regarding monitoring devices, see A.4.3.

4. Equipment

4.1 For the routing and securing of pipe and hose connections to the engine, E. is to be applied analogously.

4.2 Only pipe connectors with metallic sealing shall be used in diesel engine fuel injection pipes.

4.3 Filters

4.3.1 Filters are to be fitted in fuel supply lines and on the discharge side of lubricating oil pumps.

In lubricating oil lines of these engines, switch-over double filters, automatic filters or equivalent devices of an approved type, which can be cleaned without interrupting operation, are to be fitted in the main oil flow downstream of the pumps.

4.3.2 Casings of filters fixed to the engine shall be of suitable metallic material.

Filters in the fuel system screwed-on from underneath shall be secured against becoming unscrewed.

4.4 Cooling system

4.4.1 To prevent deposits in the coolant passages in raw water cooled engines, the outlet temperature of the cooling water is to be limited to 55 °C.

4.4.2 In case of fresh-water-cooled engines, data and recommendations supplied by the engine manufacturers are to be observed for dimensioning the heat exchanger.

Fresh cooling water lines to and from keel coolers, or alike, shall be fitted with shut-off devices.

4.4.3 The discharged air from air-cooled engines shall not cause any unacceptable heating of the machinery space. If appropriate, the discharge is to be led directly into the open.

4.4.4 Air duct outlets are to be made spray-water proof.

4.5 Regarding exhaust lines, see E.

5. Starters

5.1 Starters shall be reliable and safe to operate.

5.2 Small IC engines with electric starters should also be provided with alternative manual starting arrangements as far as practicable.

5.3 Engines which can only be started electrically are to be equipped with electric generators to provide automatic charging of the starter batteries.

It is recommended that the starter batteries be dedicated and be separated from electrical circuits other than the motor circuits.

5.4 The total capacity of the starter batteries depends on the size of the engine and shall be sufficient for at least six successive starts without recharging, at an ambient temperature of 45 °C.

6. Tests and trials

6.1 Tests of materials

For crankshafts and con-rods, proof of material quality is to be provided by acceptance test certificates in accordance with engine manufacture.

6.2 Pressure tests

The individual components of IC engines are to be subjected to pressure tests where supervised by the engine manufacturer.

6.3 Engine Acceptance

For engine < 400 kW, BKI reserve the right to require part material report and trial report from Engine Manufacturers in accordance with this Guidance and Rules for Materials (Pt.1, Vol.V).

C. Propeller Shafts, Propellers, Gearing, Couplings

1. General

The following applies to permanently installed propeller shaft arrangements including propellers, reduction gear and flexible couplings, of permanently installed propulsion engines.

2. Propeller shaft

2.1 The propeller shaft in terms of these guidances is the shaft linking propeller and gear, flexible coupling or cardan shaft.

2.2 Standard values for the propeller shaft diameter may be determined from 6.1.

2.3 If these shafts or couplings not BKI type approved, BKI reserve the right to require proof of adequate dimensioning and materal informaton from the manufacturers.

2.4 Propeller shafts permanently installed in the hull are to be so supported that displacement of individual bearings caused by flexing of the hull does not cause excessive bearing pressures in the adjoining bearings or in the gear bearings. Bearings should be as wide apart as practicable. As a guidance for the maximum distances between bearings the following may be applied:

$$l_{max} = C \cdot \sqrt{\frac{d}{n}} \quad [mm]$$

l_{max} = maximum distance between bearings

d = shaft diameter [mm]

n = shaft revs. [min^{-1}]

C = 12 000 for steel shafts

= 8 000 for bronze shafts

Where engine and gear are flexibly mounted and with the stern tube bearings of rubber, the C-value in above formula should be at least C = 6000 if the propeller shaft is led directly from the gear output flange to the propeller. In such cases flexible mounting of the stern seal to the stern tube is to be applied.

2.5 Guidance for permissible values of bearing pressures P_{max}, peripheral speeds Y_{max} and bearing clearance S_L in stern tube bearings:

Type of bearing	P_{max} [N/mm^2]	Y_{max} [m/s]	S_L [mm]
Grey cast iron or bronze bearing, grease lubricated	0,5	2,5 - 5	~ 0,6
Rubber bearing, water lubricated	0,2	6	~ 0,5
White metal bearing, oil lubricated	0,8	> 6	~ 0,4

2.6 If the material of the propeller shaft is not corrosion-resistant, the propeller hub shall be suitably sealed against entry of water.

3. Propellers

3.1 These requirements apply to screw propellers. Any design differing from these shall be approved by BKI.

3.2 Propellers should preferably be made of a cast copper alloy or alluminium alloys suitable for use in sea water.

Propellers should in general be fastened to the propeller shaft taper by means of a key and cap nut. The cap nut shall be suitably secured.

3.3 For the dimensioning of the blades of fixed and variable pitch propellers 6.2 applies.

3.4 Propeller materials shall possess the properties specified in this Guidance or Rules for Materials (Pt.1, Vol.V). This shall be demonstrated by an acceptance test certificate approved by BKI.

4. Gearing

4.1 The design of gearing for the propulsion of fishing vessel is considered to be suitable as per engine manufacture.

5. Flexible couplings

Flexible couplings between engine and gearing or between the flexibly mounted engine plus gearbox and the propeller shaft shall be of a proven type or approved by engine manufacturer. The permissible loads recommended by the manufacturers of the coupling shall not be exceeded.

6. Calculations and guidance for permissible stresses

6.1 Propeller shaft diameter

The propeller shaft diameter d_p can be determined as a guidance as follows:

$$d_p = k \cdot \sqrt[3]{C \cdot \frac{P}{n_2}} \quad \text{[mm]}$$

P = propulsive power [kW]

n_2 = propeller shaft revs. [min^{-1}]

k = 100 for shafts of non-corrosion-resistant steel not protected against seawater

= 90 for shafts of corrosion-resistant steel[2], wrought copper alloys[3], nickel alloys (Monel)[4] or for non-corrosion resistant steel if the shaft is protected against contact with seawater

with:

C = 1,2 for vessel in operating category III[5] with one propulsion line

= 0,8 for vessel in operating categories IV and V

= 1,0 for vessel with two propulsion units and operating category III

6.2 Thickness of propeller blades

Standard values for the thickness $t_{0,25}$ of propeller blades at a radius of 0,25 R can be determined as follows:

$$t_{0,25} = K \cdot \sqrt{C \cdot \frac{P \cdot 10^3}{B \cdot z \cdot n_2}} \quad \text{[mm]}$$

P = propulsive power [kW]

n_2 = propeller revs. [min^{-1}]

B = width of blade at 0,25 R [mm]

z = number of blades

k = 60 for propellers of cast brass

= 75 for propellers of an alluminium alloy (cast in chill mould)

= 100 - 120 for propellers of synthetic material

C = 1,2 for craft in operating category III

= 0,8 for craft in operating categories IV and V

D. Storage of Liquid Fuels

1. General

1.1 Fuel tanks shall be made of a suitable corrosion-resistant material, if necessary fitted with wash plates and securely fastened to the vessel.

1.2 Portable fuel tanks are to be securely fixed.

1.3 Galvanised steel shall not be used for diesel fuel tanks.

1.4 Walls of tanks for fuel tanks shall not be walls of fresh water or sewage tanks.

1.5 Special approval is required for fuel tanks of plastics.

[2] Preferably austenitic steels with 18 % chrome and 8 % nickel
[3] e.g. wrought copper-nickel zinc alloy Cu Zn 35 Ni in acc. with DIN 1766
[4] Nickel content > 60 %, tensile strength σ_B > 400 N/mm^2
[5] Fishing with auxiliary propulsion engine(s) also in operating categories I and II.

2. Arrangement of fuel tanks

2.1 Fuel tank shall be arranged such that unacceptable heating is avoided.

3. Fuel tank equipment

3.1 General

3.1.1 Pipe connections are preferably to be arranged in the tank top. They shall not weaken the tank; welded doubles are to be provided if necessary. Through-bolts are not permitted in tank boundaries.

3.1.2 Appliances which are not part of the tank equipment may be attached to the tank only via intermediate supports. In this case, the tank boundaries are to be adequately strengthened.

3.1.3 Diesel fuel tanks shall be provided with hand holes for cleaning. In the case of small tanks which can easily be removed and flushed such hand holes can be dispensed with.

3.1.4 Regarding hoses for filling- and vent lines plus hose connections, see E.2.2.2.

3.1.5 Tanks and filler necks are to be earthed with a bonding wire of at least 4 mm^2.

3.2 Filling arrangements

3.2.1 Fuel tanks shall be filled from the deck through a permanently installed filling line of at least NB 40.

Filler necks are to be so arranged that in the event of an overflow fuel cannot get into the inside of the boat. The filler neck is to be clearly marked with the type of liquid.

3.2.2 The filling line shall terminate inside the tank at not less than $^1/_3$ tank height. Short filling lines directed to the side of the tank may be admissible or the fuel flowing against side fuel tank.

3.3 Tank vent line

3.3.1 Each fuel tank is to be equipped with a fixed vent line led to the open. The vent line shall be run such that fuel cannot be trapped.

3.3.2 The cross-sectional area of the vent line depends on the method of fueling:

- 10 mm for open filling through filler neck
- 1,25 times the filling line cross-sectional area for filling via a fixed connection

In case of fuel systems with more than one tank and transfer pump(s), also the discharge pipe diameter of the transfer pump shall be considered for the determination of the vent line diameter as appropriate.

3.3.3 Ingress of water and the spillage of fuel when heeled shall be prevented by suitable routing of the lines.

For air pipes of 32 mm in diameter and above, automatic closures are to be provided.

3.4 Fuel extraction lines and spill lines

3.4.1 The suction of the extraction line is to be arranged sufficiently high above the tank bottom to prevent dirt and water being sucked in.

3.4.2 Spill lines are to be connected to the tank at the tank top.

3.5 Tank drainage

3.5.1 Diesel storage and supply tanks are to be provided with suitable drainage arrangements.

On diesel supply tanks drainage arrangements may be omitted if an adequately sized water separator is fitted in the extraction line.

3.5.2 Drainage fittings near the tank bottom shall be equipped with a self-closing valve which additionally is to be provided with a cap or plug.

3.5.3 Tank drainage may also be facilitated via a line introduced into the tank from the tank top, using a suitable pump (e.g hand pump with appropriate connections, also transportable).

3.5.4 All drainage arrangements shall be easily accessible and located conveniently to allow safe drainage into a collecting receptacle.

3.6 Tank sounding equipment

Each fuel tank is to be provided with means for hand- sounding from the deck or with a proven remote level indicator.

Gauge glasses, sight glasses or float indicators with mechanical transmission are not permitted. Unless, means are to be provided to prevent external damage.

4. Tests

Fuel tanks including all connections shall be subjected to pressure testing with the hydrostatic pressure.

E. Piping, Fittings, Pumps

1. General

These guidances apply to piping systems, including pumps and fittings, for the operation of the machinery; as well as for the operation of the vessel insofar as its safety is concerned.

These guidances are also to be applied to piping systems referred to in other parts of this Section.

2. Materials

2.1 General

2.1.1 Materials for piping and fittings shall be suitable for their purpose. Regarding welding of pipes and fittings, see Annex D.

2.1.2 Piping and fittings are preferably to be made of metal. Where plastic pipes or hoses are used due to the installation conditions, the special requirements stated under 2.2 are to be observed.

2.1.3 The pumps are to be constructed and manufactured on the basis of standards generally used in vessel building. BKI reserve the right to require pump housing material report and performance test report from manufacturers in accordance with this Guidance and Rules for Materials (Pt.1, Vol.V).

2.2 Plastic pipes and hoses

2.2.1 Plastic pipes

.1 The use of plastic pipes is restricted to systems conveying water, like drinking water, seawater, bilge water, waste water/sewage.

.2 Plastic pipes are not allowed for piping leading to overboard without shut-off at the shell or for bilge piping lines within machinery spaces. In FRP hulls, however, cockpit drains without shut-off may be of a material corresponding to that of the hull.

.3 Plastic pipes and pipe fittings shall comply with an acknowledged standard. The limiting operating pressures and temperatures stated in the standard are to be adhered to.

.4 For pipes made of rigid PVC with glued joints and pipe fittings, National Standard or equivalent applies.

Processing and pipe laying shall be carried out in accordance with National Standard or equivalent.

.5 When laying plastic pipes, attention shall be paid to providing adequate and proper fastening devices, and protection against unacceptable external heating.

2.2.2 Flexible hoses

.1 Hoses shall be suitable for the media envisaged to be conveyed, operating pressures and temperatures. For hoses not complying with any standard, proof of suitability is to be provided. Such hoses shall have continuous marking which allows for identification even of short lengths.

.2 Only hoses with a textile or wire-mesh intermediate layer may be used.

.3 Hoses for drinking water shall be of a quality suitable for handling foodstuff.

.4 For hoses connecting to overboard without seacock, such as cockpit drains, hoses with a textile or wire-mesh intermediate layer in accordance with National Standard or equivalent are to be used. If passing through a machinery space, type approved fire resistant hoses are to be used or else a rigid standpipe extending at least 100 mm above the water- line shall be provided. This standpipe shall at least match the strength and fire resistance of the shell in the area of the outlet opening.

.5 Hoses for exhaust lines with water injection are to have a wire-mesh intermediate layer in accordance with National Standard or be of equivalent quality.

.6 For liquid fuels, lubricating oil or hydraulic oil, only type-approved fire resistant hoses are permissible.

.7 For connection to consumers, fittings, pipes, etc., hoses with fixed end fittings are to be used.

.8 Hose connections in systems conveying water may also be made using standard hose fitting ends or to suitably-shaped pipe ends. Fastenings to raw pipe ends are not permissible. Proven stainless steel hose clamps are to be used for fastening.

Hoses in systems connecting to overboard are to be fastened to the fitting ends by double clamps.

.9 Hose lines are to be so routed and fastened that movement due to vibration or motion of the vessel, chafing and unacceptable heating is avoided and so that visual checking is possible at any time.

Hoses runs piercing structural components are to be suitably protected in way of the penetration.

3. Hull fittings

3.1 Except for cockpit drains, all connections to the hull below or near the waterline are to be provided with seacocks.

3.2 Seacocks shall be easy to reach; if necessary, extension rods are to be provided.

3.3 If the seacock is not fitted directly to the shell, the pipe between the shell and the seacock shall at least match the strength and fire resistance of the shell in the area of the outlet opening.

3.4 Seacocks and through hull fittings shall be of ductile metallic material. Other materials, e.g. fibre reinforced plastics, may be allowed if proof of adequate strength and fire resistance at least equal to that of the hull has been provided.

4. Pumps

4.1 Pumps are to be located accessibly and securely fixed.

4.2 Power pumps of the displacement type are to be fitted with means of over pressure protection if there are valves or cocks fitted in the piping system on the discharge side of the pump.

4.3 Centrifugal pumps shall not be damaged if operated with a closed shut-off fitting over a lengthy period of time.

5. Fuel lines

5.1 Fuel lines are generally to be made of corrosion-resistant metal with as few disconnectable pipe connections as practicable. Pipe joints may be made by welding or brazing. Brazed joints are to be made using fittings and hard solder.

The number of breakable connections shall be kept to a minimum, respective of the particular arrangement.

5.2 Only metal-to-metal screwed connections are permissible. Threaded sleeve joints requiring hemp, sealing strip, etc. in order to safeguard tightness may not be used.

5.3 As a general guidance the use of hoses is only permitted for the connection of consumers to rigid piping.

The use of hoses is to be limited to short lengths 2.2.2 is to be observed.

5.4 Fuel lines are to be securely fastened and be arranged protected against damage.

5.5 The arrangement of fuel lines in the vicinity of machinery parts with high surface temperatures and of electrical appliances is to be avoided.

5.6 Extraction pipes are to be fitted with a valve or cock directly at the tank. Such valve or cock shall be capable of being closed from deck or the steering position. This also applies to other tank connections which if damaged would release the contents of the tank, e.g. equalizing or transfer lines.

5.7 The valve or cock may be omitted if the connection and piping is arranged such that fuel cannot be released from the tank in the event of damage to the piping. Siphoning action of the connected piping is to be considered if applicable.

5.8 If any, spill lines are to be connected at the tank top of the service tank. Means of closure may not be fitted in the spill line. If the spill is connected to more than one tank, changeover valves are to be fitted, which also in the intermediate position safeguard that at least one way is always open.

5.9 Casings of fuel filters or water separators are to be of metal. Glass casings may be used only for diesel fuel. If so, the arrangement shall be protected and easily visible.

5.10 If any, in fuel systems with power-driven transfer pumps, it shall be possible to maintain the full fuel supply to the engines also in case of failure of a transfer pump. In systems with only one power-driven pump, this requirement is considered to be met if fuel can also be supplied to the engines directly from all the storage tanks fitted, or if additionally there is a hand pump for topping-up the supply tank.

6. Exhaust lines

6.1 Engine exhaust lines are to be led to the open separately and so insulated and run that combustible material cannot catch fire on the pipes and no detri-mental heating effect on the environment can arise.

Temperatures of brackets and of bulkhead/deck/shell penetrations shall not exceed 80 °C.

6.2 Thermal expansion is to be compensated.

6.3 If exhaust lines terminate near the waterline, measures shall be taken to prevent water from entering the engine(s).

6.4 Main and auxiliary engine exhaust lines shall have effective silencers fitted. Depending on the type of silencer, means for cleaning and draining are to be provided.

6.5 For hoses in exhaust lines 2.2.2.5 shall be observed.

6.6 Thermoplastic components may be used in exhaust lines with water injection only and on condition of monitoring of the cooling water flow or the temperature in the exhaust line immediately down-stream of the point of water injection.

7. Cooling water lines (raw water)

7.1 A filter is to be fitted in the raw-water supply line. For small auxiliary engines an inlet strainer on the hull is sufficient.

7.2 Drain fittings are to be arranged as necessary. It shall be possible to drain the entire raw-water system.

7.3 Shell or keel coolers are to be fitted with vent valves at the highest point.

7.4 For the cooling water supply to the engines, one cooling water pump per engine is sufficient, unless in accordance with Rules for Machinery Installations (Pt.I, Vol.III) are to be applied analogously.

7.5 If the installation is such that the bilge pump is also used as reserve cooling water pump for the engine and can take suction from overboard, the bilge suction lines shall be so connected to the pump that ingress of water from overboard into the bilge system is prevented.

7.6 Use of copper alloy pipes suitable for sea water is recommended. Steel pipes shall be internally galvanised or provided with other suitable corrosion protection.

As regards the use of hoses, 2.2.2 is to be observed.

7.7 In the case of engines with cooling water injection into the exhaust line, measures are to be taken to prevent that, after the engine has stopped, cooling water can enter the cylinders of the engine via the water inlet and the exhaust line. Siphoning shall be prevented by providing an automatic vacuum-breaker as appropriate. The vacuum breaker is to be arranged at the highest point at the pressure side of the cooling water line, raised above the water line.

8. Bilge pumping arrangements

8.1 Scope

8.1.1 Each vessel is to be equipped with a bailer.

8.1.2 Vessel within operating categories IV and V and with a length **L** of 6 m or more are to be provided with at least one fixed manual bilge pump in accordance with Table 3.1.

The nominal flow rate of manual bilge pumps shall be based on 45 strokes per minute.

8.1.3 The power-driven bilge pump may also be coupled to the main or auxiliary propulsion engine.

8.2 Bilge piping, bilge suctions

8.2.1 Bilge piping are to be so arranged that also with unfavorable trim the bilges can be drained completely.

Table 3.1 - Bilge pumps

Lenght L (m)	Hand pump flow rate (m^3/h)	Power pump flow rate (m^3/h)	Bilge pipe NB (mm)	
			main pipe	branch pipe
< 8	3	5	32	
< 10	5	6	32	
< 15	5	7,5	40	
< 20	6	9	50	40
< 24	6	10,5	50	40

8.2.2 In vessel with watertight subdivisions or sub divided bilges, every bilge pump shall be capable of taking suction from every compartment aft of the forepeak bulkhead.

The pumps are to be connected to a bilge main with branch pipes leading to the compartments. The branch pipes are to be connected to the main via closable non- return valves or equivalent.

8.2.3 The forepeak shall not be connected to the common bilge system. For larger vessel, the forepeak should be connected to a suitable power pump which shall not have any direct connection with the common bilge system, e.g. the raw-water or the fire pump. Alternatively the forepeak may be drained to the adjoining compartment aft, through a self-closing valve fitted to the forepeak bulkhead, or by means of a separate hand pump.

8.2.4 If several bilge pumps are connected to a common discharge line, a closable non-return valve or a combination of shut-off fitting and non-return valve is to be provided on the discharge side of each pump.

8.2.5 If several power-driven bilge pumps are fitted, one of these is to have a direct bilge suction device from the machinery space.

8.2.6 Plastic bilge piping is not permitted in machinery spaces. Regarding use of hoses see 2.2.2.

8.2.7 In the arrangement of bilge suction devices the following is to receive attention:

– free access for the bilge water,
– each suction device to have a strainer,
– accessibility for checking and maintenance.

8.3 Overboard connections

8.3.1 It shall be warranted that water cannot enter the vessel through the bilge pumping line even in the event of mal-operation. The outlet from the line is to be arranged as high above the waterline as possible and the line is to be run to this via a pipe bend taken up to the deck. If that arrangement is not possible, two non- return devices shall be fitted between the outlet and the inlet (bilge suction). At least one of these devices is to be mounted at the hull.

The outlet at the vessel's side, however, shall always be closable. (See also 3.).

8.3.2 In the case of pumps which can also take a suction from the sea, the impossibility of seawater entering the vessel is to be guaranteed by the installation of three-way cocks with L-plugs, angle cocks or similar, into the suction line.

8.4 Arrangement of bilge pumps

The manual bilge pump is to be operable from the steering position/the cockpit. In larger vessel the power-driven pump may be operable from the steering position alternatively, if the height of installation of the manual pump would reduce the required output.

9. Fresh water, sanitary installations

9.1 Fresh water system

9.1.1 Walls of tanks for fresh water shall not be walls of fuel or sewage tanks.

9.1.2 If the storage tank is filled via a fixed connection, the bore of the filling pipe is to be used for dimensioning the vent line. If filling is not under pressure, a vent pipe with a nominal bore of 10 mm is sufficient.

9.1.3 Filling connections are to be identified un-mistakably.

9.2 Sanitary equipment

9.2.1 General

.1 When installing sanitary equipment, the official regulations applicable to the area of operation are to be observed.

.2 Sewage discharge lines are to be so arranged or equipped that it is impossible for water to enter the craft from outboard. See also 3.

.3 Each sanitary discharge is to have a gate valve or sea cock at the hull penetration. See also 3.

F. Fire Extinguishing Equipment

1. General

1.1 Fishing vessel with accommodation or permanently installed IC engines are to be equipped with portable fire extinguishers suitable for A, B and C class fires according Table 3.2.

Table 3.2 - Classification of extinguishing media

Fire class	Nature of burning material	Extinguishing media
A	Solid combustible materials or organic nature (e.g wood, coal, fiber materials)	Water, dry powder, foam
B	Inflammable liquids (e.g. oils, tars petrol)	Dry power, foam, carbon dioxide
C	Gases (e.g acetylene, propane)	Dry power, carbon dioxide

Preferably only dry chemical powder extinguishers should be used (see "Note" at the end of F).

For machinery spaces CO_2 extinguishers are also acceptable.

1.2 The charge of an extinguisher shall be at least 2 kg and is not to exceed 6 kg.

1.3 The extinguishers are to be arranged conveniently and with suitable brackets.

1.4 Fire extinguishers are to be checked by an acknowledged expert every 2 years.

1.5 For fighting a fire in the machinery space, a closable inlet opening is to be provided allowing the application of the extinguishing agent without prior removal or opening of parts of the machinery space casing.

1.6 For machinery spaces with IC engines up to a total installed power of 375 kW the amount of extinguishing agent determined in accordance with Table 3.2 for permanently installed engines may be reduced by up to 6 kg if a fixed fire extinguishing system in accordance with 4. is fitted.

1.7 Vessel with a length **L** of 15 m or more are to be provided with a water fire extinguishing installation in accordance with 3.

1.8 All craft are additionally to be provided with:

– vessel up to 15 m: at least one draw bucket

– vessel of 15 m and upwards: at least 2 draw buckets

2. Number of fire extinguishers

The number of extinguishers required is to be selected based on the total weight of extinguishing agent, to be determined from the Table 3.3.

Table 3.3

Application	Minimum weight of extinguishing agent [kg]
Inboard engines	
- Up to 50 kW	2
- Up to 100 kW	4
- Up to 100 kW per extra 100 kW or part thereof	an additional 2
Additionally for craft with accommodation	
- Up to 10 m	2
- Up to 15 m	4
- Up to 20 m	8
- Up to 24 m	12

3. Water fire extinguishing installation

3.1 The water fire extinguishing installation is to be so designed that a solid jet of water can be directed to every part of the vessel.

3.2 A suitable permanently installed manual pump is to be provided, which with its associated lines and the sea-suction is to be located outside the machinery space.

3.3 A suitable fire hose of NB 25 with a nozzle of at least 6 mm nozzle diameter and suitable couplings is to be provided. The length of the hose is to be approx. $^{2}/_{3}$ of the length of the craft, but not more than 15 m.

3.4 In case of a power-driven pump, the fire main is to be fitted with at least one closable valve with hose coupling fitting the fire hose (fire hydrant) which shall be located on deck.

Note:

The use of extinguishers containing Halon and the installation of Halon fire-extinguishing systems is no longer permitted.

G. Steering Gear

1. Scope

The following applies to steering gear. This comprises of the steering engine and all elements of the transmission from the steering position to that engine.

2. Design

2.1 Modes of drive

Both, power and manual, drive may be applied. Means of emergency steering are to be provided, e.g. emergency tiller (see also Section 2, A.3)

Emergency steering drive shall be such as to be readily available. In the case of power steering, it is to be ensured that in the event of failure of the power steering the emergency steering remains operable.

2.2 Steering gear for outboard motors

The outboard motor is to be fitted with a suitable tiller arm for connecting to the steering gear. Twin-engine plants are to have the two engines positively connected.

2.3 Rudder position indication

The midship position of the rudder shall be distinguishable at all times. Power driven steering gear is to be provided with a rudder position indicator.

2.4 Rudder angles

2.4.1 Power steering gear are to be provided with suitable devices (e.g. limit switches) limiting the possible travel such that the admissible rudder angle cannot be exceeded.

2.4.2 Regarding end stops for tillers, quadrants, etc., see Section 2, A.3.

3. Power and dimensioning

3.1 Power

The steering gear is to be so designed that can be put from hard-over to hard-over to either side without undue effort.

The time taken for this shall as a guidance not exceed 35 s.

3.2 Dimensioning of transmission elements

3.2.1 The stresses arising in the transmission elements shall lie below the yield strength of the materials employed.

3.2.2 For the dimensioning of tillers and quadrants, Section 2, A.3 is to be observed.

4. Testing

4.1 After installation the steering gear is to be submitted to a final survey and performance test.

4.2 In case of hydraulic gear a pressure test at 1,5 times the pressure setting of the safety valve is to be carried out.

H. Anchor Windlasses

1. Scope

The following applies to anchor windlasses required in accordance with Section 2, D.

2. Design

2.1 Driving mode

2.1.1 Manual drive is permissible as primary drive. Hand cranks shall be kick-back proof.

2.1.2 For power-driven windlasses, an emergency drive independent of the primary drive is recommended. If the emergency drive is to be manual, this is to be so arranged that switching on the power drive cannot cause any danger.

2.2 Overload protection

An overload protection device is to be provided to limit the moment of the driving unit.

2.3 Clutches

Windlasses are to have clutches between chain sprocket and drive shaft.

2.4 Brakes

Windlasses shall be fitted with chain sprocket brakes which guarantee safe braking action and holding power of anchor and chain when the sprocket is unclutched. Furthermore in the case of non self locking gear, means are to be provided which prevent the chain from running out, if the drive fails with the chain sprocket clutched.

2.5 Chain sprockets

Chain sprockets shall have at least 5 teeth.

3. Power and dimensioning

3.1 It shall be possible to raise the threefold weight of the anchor at a mean speed of 3 m/min. In the case of manually driven windlasses, a manual force of 15 kg at a crank radius of about 35 cm and a cranking rate of about 30 rev/ min is not to be exceeded.

3.2 The drive's capability of delivering a short duration overload for breaking-out the anchor is to be ensured.

3.3 The dimensioning of the transmission elements is to be carried out in accordance with standard engineering practice.

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Section 4 Electrical Installations

A. General

1. Scope

1.1 These guidances apply to the vessel wiring systems up to an operating voltage of 250 V.

1.2 These guidances apply to permanently installed electrical systems and equipments.

2. Rules and standards

Where specifications for electrical installations and equipment are not provided in these guidances, the application of other rules and standards will be agreed if appropriate. Amongst these are (e.g.) the publications of the IEC, particularly all IEC-92 publications (Electrical installation in ships-small vessel).

As well as the BKI Rules, existing national rules and guidances are to be observed.

3. Principle requirements

3.1 Dimensioning of components

All parts shall be designed to meet the special operating stresses due to (e.g.) vessel motion, heel, trim, vibration and be protected against moisture and corrosion.

3.2 Environmental conditions

Trouble-free operation of the electrical installation is to be ensured under:

– continuous heel of up to 15°
– short time heel of up to 30°
– short time longitudinal inclinations of up to 20°
– ambient temperature up to 45 °C

For fishing vessel intended to operate only in restricted areas, BKI may permit deviating conditions.

4. Survey

4.1 The installation is to be inspected and tested by the Surveyor and is to be their satisfaction.

4.2 The insulation resistance of the completed installation is to be measured. In general, the insulation resistance of all circuits and apparatus should be at least 1 MΩ.

B. Approval Documentation

The drawings and documents listed below are to be submitted to BKI, at least, in triplicate for examination. To facilitate a smooth and efficient approval process, the drawings could be submitted in electronic format.

1. One line diagram of the installation, including cable size and normal working load in the circuit; type of cable; type and make of circuit-breakers and fuses, rating of batteries and alternators.

2. Electrical power balance (main and emergency supply).

C. Protective Measures

1. General

1.1 Materials for electrical machinery, cables and other electrical components must be capable of withstanding humid air and sea water mist, sea water and oil vapour. They must not be hygroscopic; shall be hard to ignite and self-extinguishing.

For areas where sea air need not be taken into account, appliances designed to Industrial Standards may be used.

2. Protection against foreign bodies and water

2.1 The grade of protection of electrical components against foreign bodies and water shall be suitable for the location where they are installed.

2.2 In the compartments listed below, the minimum grade of protection considered for electrical components shall be :

– machinery spaces, operating spaces: IP 23
– below deck, living spaces, cabins: IP 20
– enclosed steering position: IP 23
– open deck, open steering positions: IP 55
– appliances which may be flooded: IP 56
– storage battery spaces; lockers; boxes: IP 44

2.3 The grades of protection are to be ensured by the appliances directly or by appropriate constructional measures when installing them.

3. Protection against lightning

It is recommended that a lightning protection system be fitted. The following requirements should apply.

3.1 Conductors

Lightning conductors shall be made of copper (strip or stranded) and shall be not less than 70 mm^2 in cross-section. They shall be secured to a copper spike not less than 12 mm in diameter, projecting at least 300 mm above the top of the mast. The lower end of conductor shall be earthed.

3.2 Installations

Lighting conductors shall be installed external to the vessel. They should run as straight as possible and sharp bends should be avoided. Bolted, riveted or welded joints only shall be used.

3.3 Earthing

The lower end or the lightning conductor shall be connected to an earthing plate of copper or other conducting material compatible with sea-water, not less than 0,25 m^2 in surface area, secured to the outside of the hull in an area reserved for this purpose and located below the light-load water line so that it is immersed under all conditions of heel.

The earthing plate for the lightning conductor shall be additional to, and separate from the earthing plate used for the power-system earthing or earth bonding systems.

D. Electrical Machinery

1. General

1.1 All motors and generators must meet a standard accepted by BKI, provided no special data are contained in the rules that follow.

1.2 Terminals must be located in an easily accessible position and dimensioned in accordance with the cross-section of the cable to be connected. The terminals are to be clearly identified.

1.3 Each generator and motor is to have a manufacturer's name and capacity plate fitted which contains all important operating data as well as the manufacturing number.

E. Storage Batteries

1. General

1.1 These guidances apply to permanently installed storage batteries.

1.2 Storage batteries shall be so made that they retain their rated capacity up to an inclination of 22,5° and leakage of electrolyte is prevented up to 40° of inclination (50° in the case of sailing yachts). Cells without covers are not permitted.

1.3 Storage battery ratings are to be shown on a rating plate.

2. Location

2.1 Storage batteries are to be so located that escaping gases or electrolyte can neither endanger persons nor damage equipment.

2.2 Storage batteries must not be located where they are exposed to unacceptably high, or also low, temperatures, spray or other influences which might impair their ability to function or reduce their service life. The minimum protective grade to be provided is IP 12.

2.3 When locating the storage batteries, the output of the associated chargers is to be taken into account. The charging capacity of the batteries is to be calculated from the charger maximum current and the battery rated voltage.

Depending on operating mode, service and utilization of the storage battery to be charged and the nature of the charging process (charger characteristic), following agreement with BKI, the maximum current may be deviated from as the basis for calculation of the charging capacity.

If several storage batteries are assembled in one place, the sum of their charging capacities is to be used as the basis.

2.4 Storage batteries with a charging capacity of damaging effect of the electrolyte, should an escape of electrolyte be possible.

2.5 Storage batteries shall be safeguarded against slipping. Straps or supports must not impair ventilation.

3. Equipment in battery compartments

3.1 Lights, ventilation fan motors and space heaters in battery compartments shall be ignition protected.

The following minimum requirements are to be met:

- Explosion Group II C
- Temperature Class T 1

3.2 The internal walls of battery compartments, boxes and lockers including all supports, troughs, containers and racks shall be protected against the damaging effect of the electrolyte, should an escape of electrolyte be possible.

4. Ventilation

4.1 All battery compartments, lockers and boxes must be so constructed and ventilated that any build up of ignitible gas mixture is prevented.

4.2 The ventilation supply and exhaust opening are to be so arranged that there is a flow of fresh air over the entire battery.

4.3 The minimum volume of air to be extracted is up to 2 kW may be located below deck, open in a well-ventilated locker or housing.

$$Q = 0{,}11 \cdot I \cdot n$$

Q = the volume of air extracted in [m3/h]

I = strength of current according to charger characteristic, but at least 1/4 of the maximum current of the charging system or of the charging current reduced in accordance with 2.3.

n = number of cells in the battery.

4.4 In case of natural ventilation, the conditions of 4.5. are considered being met if ducts are rated as set out below, where an air velocity of 0,5 m/sec is used as a basis.

The slope of the ducts must not exceed 45° to the vertical.

4.5 For forced ventilation, a suction fan is to be used preferably. The fan motors shall either be ignition protected (see 3.1) and electrolyte-proof, or be located outside the area of danger (preferred solution).

The fan impellers shall be of a material which does not create sparks if it touches the casing, and which does not conduct any static charges.

The ventilation systems shall be independent of those of other compartments.

4.6 Where battery charging and switching-on of the ventilation fan are automatic when charging starts, continued ventilation is to be ensured for at least one hour after charging has ended.

Table 4.1 Cross-section of extraction air ducts

Charging capacity P [Watts]	Cross section of extraction air ducts [cm2]	Cross section of extraction air ducts [cm2]
	Lead batt.	Lead batt.
P < 1000	80	80
1000 < P < 1500	120	120
1500 < P < 2000	160	160
2000 < P < 3000	240	240
P > 3000	Cross section of extraction air ducts [cm^2]	Cross section of extraction air ducts [cm^2]
P < 1000	Forced ventilation	

4.7 Where sealed-cell batteries with internal oxygen consumption are used exclusively, the outgoing air duct cross sections may be reduced by half.

5. Miscellaneous

5.1 Charging devices have to be provided which are able to charge the batteries within 10 hours up to 80 % of the battery capacity.

5.2 Storage batteries are to be protected against discharge by reverse current by suitable means in the charging system, and against short circuits by fuses nearby. The fuses must however not be fitted in the battery container or compartment itself. Regarding battery switches see F.3.

5.3 Installation of the appropriate measuring instruments for indicating battery voltage and charging and discharging current is recommended. The functioning of generators is to be monitored.

5.4 The battery capacity must be designed to be sufficient to supply important users (e.g. navigation lights) for at least 8 hours without a boosting charge.

5.5 Where IC engines are fitted which cannot be started manually, provision of separate batteries for starting and for general use is recommended.

F. Distribution Systems

1. General

1.1 If it is required to earth one pole of components e.g., radio or electronic equipment, it is to be carried out on the same pole as that used for earthing of the system.

1.1.1 Metallic fuel oil pump and pipes are to be effectively earthed. Where FRP fuel oil tanks are used, the mettalic parts of valves, manhole covers, etc. fitted up in the tanks and the fuel oil pipes are to be electrically connected effectively, and they are to be earthed.

1.1.2 Earthing connections are to be made to the alternator frame, engine bed-plate and earthing plate (if fitted). Earthing connections are not to be made to hull sheathing, skin fittings or plumbing.

1.2 Protective conductor

The protective conductor(s) shall be provided with a final connection to the hull of a metallic hull vessel, or if the vessel has a non-metallic hull to the external main earthing plate of the vessel.

The protective conductor final connection shall be made at a location above any anticipated water accumulation.

1.3 Earthing of the protective conductor for non-metallic hull

The earthing plate to which the protective conductor shall be connected shall be of copper or other conducting material compatible with sea-water and shall have a surface area of not less than 0.25 m^2. It shall be secured to the outside of the hull in an area reserved for this purpose and located below the light-load water line so that it is immersed under all conditions of heel.

2. Electrical panel and switchgear

2.1 Electrical panel and switchgear locations are to be easily accessible.

2.2 Electrical panel housings are to be made of metal or of a hard-to-ignite and self extinguishing material.

2.3 Electrical panel are subject to test on board in the presence of the Surveyor.

3. Fuses and switches

3.1 A main switch for disconnecting the on-board mains batteries is to be provided close to these. The length of cable between batteries and main switch shall be as short as possible.

3.2 Each generator shall be provided with short-circuit and overload protection. Deviations are permissible for small installations, comprising of a dynamo and associated governor.

3.3 Fuses acting as overload and short-circuit protection are to be provided in the electrical panel or the distribution boards on the positive pole for each consuming device or user group. Provision of a switch to disconnect the mains is recommended for every user outlet protected by fuses. Fuses are to have an enclosed fuse link.

For non-fused battery outlets, e.g. starter cables, see 4.7.

3.4 Operationally important users are to be individually fused in principle, and if necessary individually switched.

3.5 Position lights and other lights significant for navigation shall be fused and able to be switched independently from other users, at least as a separate group.

4. Cables, lines and laying them

4.1 Cables and insulated lines shall be of a BKI approved make. Examples of such as cables and lines according to IEC-92 or DIN 89150 and made in accordance with the standards and rules quoted in these.

The conductors in the cables must be of electrolytic copper and multi or fine stranded.

4.2 In the case of lengthier cable runs, permissible voltage-drops are to be taken into account.

Permanently installed power cables shall have a minimum cross sectional area of 1,5 mm^2; control cables of 0,75 mm^2.

4.3 Cable cross sections for the electric starters of IC engines are to be dimensioned in accordance with the data furnished by the engine manufacturer.

4.4 The voltage drop between power source and consuming device must not exceed 7%; for navigation lights 5% respectively.

4.5 Cables and lines are to be so laid on the cable support and fastened that the movements of the craft cannot cause them to shift, and that they are not exposed to unacceptable ambient temperatures.

They are to be laid at a safe distance from exhaust ducts and other sources of heat.

4.6 Non-fused cables, e.g. battery cables, are to be laid safe from short circuits, i.e. they must be laid in such a way that the possibility of a short circuit can be excluded even if the insulation should fail.

4.7 Multi-core cables or lines are preferably to be used.

4.8 Cables and lines must be hard-to-ignite and self-extinguishing.

5. Cable accessories and installation material

5.1 Cable and line connections shall, in principle, be made by using terminals with core protection, or via screwed connections by means of crimped lugs. Soldered connections must not be used.

5.2 Cable feed-through passing decks and water-tight bulkheads shall have stuffing boxes or be sealed by means of a BKI approved pourable sealing compound. Further refrence see the Guidance for The Approval and Type Approval of Materials and Equipment for Marine Use (Pt.1, Vol.W).

G. Spares

1. Spares

It is recommended that the following spares be taken on board:

1 set of electric bulbs for navigation lights

1 set of fuses unless all appliances are protected by automatic cut-outs.

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Section 5 Materials

A. Fiber Reinforced Plastics (FRP)

1. FRP materials

Fiber Reinforced Plastics (FRP) is heterogeneous materials, consisting of a thermosetting resin as the matrix and an embedded reinforcing material.

1.1 Thermosetting resin

Two-component mixture consisting of resin and hardener as well as possible additives.

1.1.1 Gelcoat and Topcoat resin

Gelcoat and topcoat resins shall protect the surface of the laminate from mechanical damage and environmental influences. Therefore, in a cured stage, the resin is to have a high resistance to existing media (e.g. fuel, river and sea water), to maritime and industrial environments), and to abrasion, in addition to low water absorption capabilities. Thixotropic agents and colouring pigments are the only permitted additives for gelcoat resins. In topcoat resins, additives for low styrene evaporation are also permitted.

1.1.2 Laminating resin

Laminating resins shall have good impregnation characteristics when being processed. In a cured stage, they shall be resistant to fuels, river and sea water, and shall exhibit a high resistance to ageing. Furthermore, adequate resistance to hydrolysis shall be ensured when used with permissible additives and filling materials. When using unsaturated polyesters (UP) as the resin, the resistance to hydrolysis shall be significantly higher than that of standard UP resin (for example through the use of a resin with an isophtalic acid basis).

1.1.3 Additives

1.1.3.1 All additives (catalysts, accelerators, filling materials, colouring pigments etc.) shall be suitable for the thermosetting resin and shall be compatible with it as well as the other additives, such that a complete curing of the resin can be ensured. The additives shall be dispersed carefully throughout the resin, in accordance with the guidelines of the manufacturer.

1.1.3.2 Catalysts, which initiate the hardening process, and accelerators, which control the working time (pot life, gel-time) and the cure time, shall be used in accordance with the processing guidelines provided by the manufacturer. For cold-setting systems, catalysts shall be proportioned in such a way that complete curing is ensured between temperatures of 16 °C and 25 °C. Cold-setting systems that are to cure at temperatures outside of this range, as well as warm- curing systems, may be used after consultation with BKI Head Office.

1.1.3.3 Filling materials shall not significantly impair the properties of the cured resin. The type and quantity of the filling materials shall be approved by BKI Head Office and shall not lead to non-compliance with the minimum properties of the resin (see Rules for Non-Metallic Materials (Pt.8, Vol.II), Ch.1, Sec.2.A.2.5). In general, the proportion of filling materials in the laminating resin compound shall not exceed 12 % by weight (including a maximum of 1,5 % by weight of the thixotropic agent). If a smaller value is specified by the manufacturer, this value shall apply. The proportion of thixotropic agent in the gelcoat resin compound shall not exceed 3 % by weight. Laminates used for fuel and water tanks shall not contain filling materials.

1.1.3.4 Colouring pigments shall be climate-proof and consist of inorganic or non-fading organic dyes. The maximum permissible proportion shall not exceed the value specified by the manufacturer; if no value is specified, then it shall not exceed 5 % by weight.

1.2 Reinforcing materials

Materials generally in the form of fibre products which are embedded in a matrix in order to improve certain properties. Fibres of different materials displaying isotropic or anisotropic properties are processed in the form of semi-finished textile products (mats, rovings, fabrics, non-wovens).

Various types of reinforcing materials:

Mat : Irregular layering of continuous filaments (fleeces), or chopped rovings (minimum 50 mm long) which are joined together by means of a binder.

Fabric : Rovings woven together by means of the weaving techniques used in the textile industry, such as binding cloth, satin, body, atlas etc. Different materials and/or filament thicknesses are possible for warp and weft.

Non-woven fabric : Unidirectional layers of fibres which are laid on each other in an arbitrary manner. The layers are fixed by thin fibre strands, either together or on mats. Different materials and/or filament thicknesses are possible in the individual layers.

2. Approval of materials

2.1 All materials to be used during production of components from FRP shall first be assessed and approved by BKI. Approval by other organizations can be recognized following agreement by BKI, provided that the tests required for approval are in accordance with BKI requirements.

2.2 Before production starts, the required material approvals shall be submitted to BKI Head Office and/or BKI Branch office. If no approvals, or not all required approvals have been obtained, then as an exception and following agreement with BKI Head Office, proof of the properties of the basic material can be demonstrated as part of material testing of the component laminate.

2.3 The packaging or wrapping material shall bear a reference to the approval.

3. Workshop

Workshops intended to manufacture FRP ships and their facilities are to be in accordance with the requirements below.

The workshops with manufacture FRP ships intended to be registered to BKI, are to submit detailed data on the facilities of the moulding shops and the storage facilities for raw materials, and are to be inspected by the Surveyor. (Form Laporan Pemeriksaan Workshop Plastik Diperkuat Serat (FRP))

3.1 Laminating shops

3.1.1 Laminating shops shall be closed spaces capable of being heated and having supply and exhaust ventilation.

3.1.2 The laminating shops are to be so arranged as to be properly subdivided or partitioned in order that the shops are separated from each other during laminating operation.

3.1.3 The laminating shops are to be of such construction as to be free from penetration of draught, dust, moisture, etc.

3.1.4 Ventilation facilities shall be arranged in such a manner that no inadmissible amounts of solvents are removed from the laminate, and also that no inadmissible workplace concentrations (MAC values) occur.

3.1.5 In order to control the climatic conditions, thermographs and hydrographs shall be provided. During laminating and curing, a room temperature of between 16 °C and 25 °C and a maximum relative humidity of 70 % shall be maintained, provided that the manufacturer of the laminating resin compound does not specify otherwise. The equipment shall be set up following agreement with BKI, their number and arrangement depending on operational conditions. The equipment shall be calibrated in accordance with statutory regulations. The recordings shall be kept for at least 10 years and submitted to BKI on request. If necessary, suitable dehumidifying appliances to be provided.

3.1.6 The workplaces shall be illuminated adequately and suitably, but at the same time precautionary measures shall be taken to ensure that the controlled curing of the laminating resin compound is neither impaired through sunlight nor lighting equipment. The skylights and windows of the laminating shops are to be provided with suitable means of shielding so that the laminates are not exposed direct to the sun.

3.1.7 The laminating shops are to be provided with suitable dust collectors in order to get rid of dusts yielded during laminating operation. During laminating and bonding in the laminating shop, no dust-generating machinery shall be operated nor any painting or spraying operations carried out. As a matter of principle, such work shall take place in separate rooms.

3.2 Storage facilities for raw materials

3.2.1 Laminating resins shall be stored in accordance with the manufacturer's instructions. If no such instructions are provided, then they shall be stored in dark, dry rooms at a temperature between 10 °C and 18 °C. The temperature of the storage-rooms shall be recorded continuously by means of thermographs.

3.2.2 Hardeners, catalysts and accelerators shall be stored separately in well-ventilated rooms in accordance with the manufacturer's instructions. If no instructions are provided, they shall be stored in dark, dry rooms at temperatures between 10 °C and 18 °C.

3.2.3 The fibreglass reinforcements, fillers and additives shall be stored in closed containers, in dry and dust-free conditions.

3.2.4 Storage shall be arranged in such a way that the identification of the materials, their storage conditions and maximum period of storage (expiry date) as prescribed by the manufacturer are clearly visible. Materials whose duration of storage exceeds the expiry date shall be removed immediately from the stores.

4. FRP material tests

4.1 The FRP material tests are to be carried out prior to the commencement of moulding of FRP ships.

4.2 The test specimens for FRP material tests are to be cut from FRP samples which are of the same laminate composition (excluding gelcoats) and moulded by the same procedure and at the same workshop as the actual hull laminates. The test specimens are to be tested on the items listed in the following:

a. Glass content (ISO 1172)

The determination of glass content shall be carried out on 3 (three) specimens which are as near identical as possible. The result of the test is the average of the measurements on 3 specimens. The test specimen shall be fully representative of the sample examined. It is recommended that the specimen be cut out from the thickest part of the sample in a shape which allows them to fit into a silica boat or porcelain crucible.

The mass of each specimen shall be within the range of 2 to 10 grams. A test specimen is weight and subsequently calcinated at a defined temperature (625 °C ± 20 °C). The specimen then reweighed and the non-combustible matter (glass) obtained by determining difference in mass of a test specimen before and after calcination. The test method requires that all weighings be made at constant mass after repeated calcination and/or drying.

b. Tensile strength & Young's modulus (ISO 527-4)

Prepare panel in accordance with specified procedure (see Fig. 1).

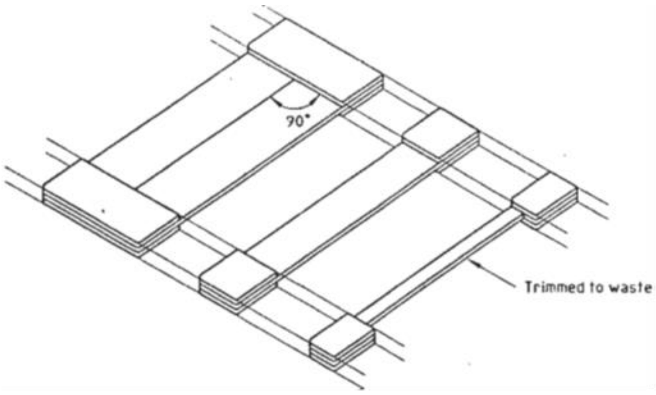
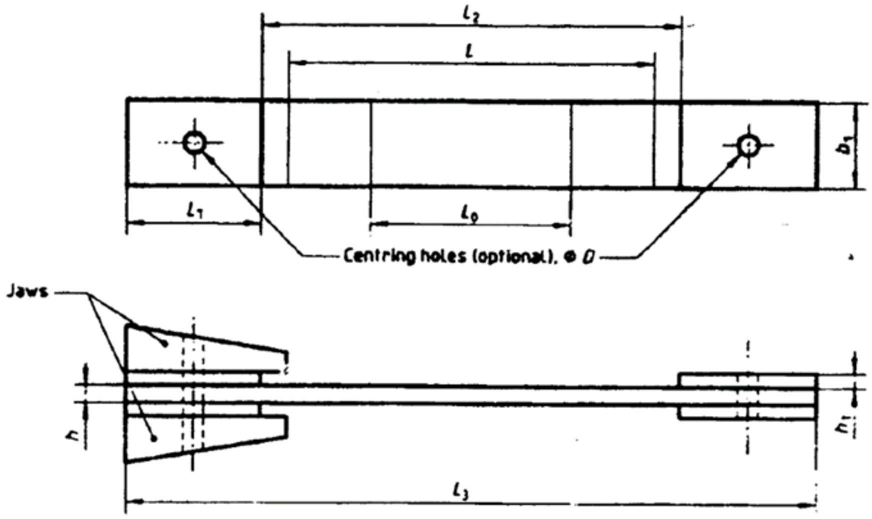


Fig. 1 Tabbed panel for specimen preparation

Cut individual specimen from the panel. It is recommended that test specimens be prepared with their major axes parallel to the direction of the fiber. Six specimens shall be prepared according to Fig. 2.



Overall length, L_3	=	≥ 250 mm
Distance between end tab, L_2	=	150 ± 1 mm
Initial distance between grips, L	=	136 mm
Thickness, h	=	according to sample thickness (mm)
Width, b_1	=	25 or 50 mm
Length of end tab, L_T	=	50 ± 1 mm
Thickness of end tab, h_T	=	1 up to 3 mm

Fig. 2 Tensile test specimen

Young's modulus (E) is measured at strain values ε = 0,0005 (0,05%) and ε = 0,0025 (0,25%), see Fig. 3.

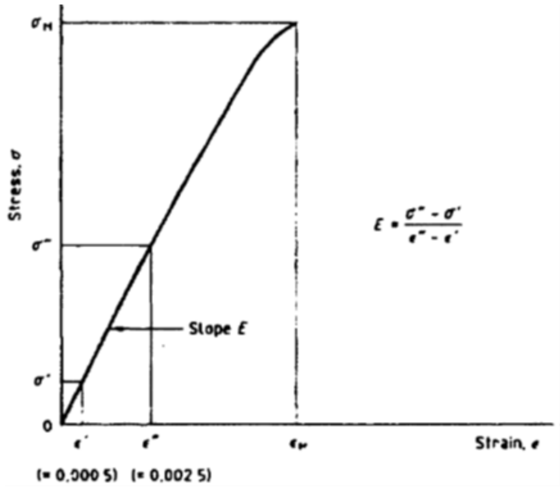


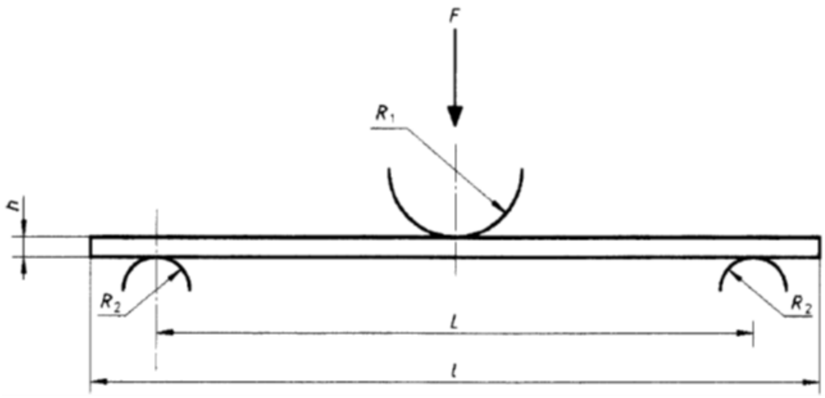
Fig. 3 Stress – strain curve

The test result is not valid if the specimen breaks near or in the grips.

c. **Flexural strength (ISO 14125)**

The dimensions of the specimen shall comply with Fig. 4. The cross-section shall be rectangular and without rounded edge. Six test specimens giving valid failures shall be tested.

The test specimen, supported as a beam, is deflected at a constant rate until the specimen fractures or until the deformation reaches some pre-determined value. During this procedure, the force applied to the specimen and the deflection are measure. It applies to a freely supported beam, loaded in three-point flexure. The gelcoat side of the test specimen shall be stressed in tension.



Thickness, h	=	thickness of sample ± 0,2 (mm)	
Overall length, ℓ	=	20 × h (+10 / −0) (mm)	
Width, b	=	15 ± 0,5 mm	for 1 < h ≤ 10
		30 ± 0,5 mm	for 10 < h ≤ 20
		50 ± 0,5 mm	for 20 < h ≤ 35
		80 ± 0,5 mm	for 35 < h ≤ 50
Outer span, L	=	(16 x h) ± 1 (mm)	
Mandrel radius, R_1	=	5 ± 0,2 (mm)	
Support radius, R_2	=	2 ± 0,2 mm	for h ≤ 3 mm
		5 ± 0,2 (mm	for h > 3 mm

Fig. 4 Flexural test specimen

The results from test specimens that rupture outside the central one-third shall be discarded and new specimens tested in their place. Tensile-initiated and compression-initiated, remote from the loading points, are acceptable failure modes. Failures initiated by interlaminar shear are not acceptable. Different types of failure modes are given in Fig. 5.

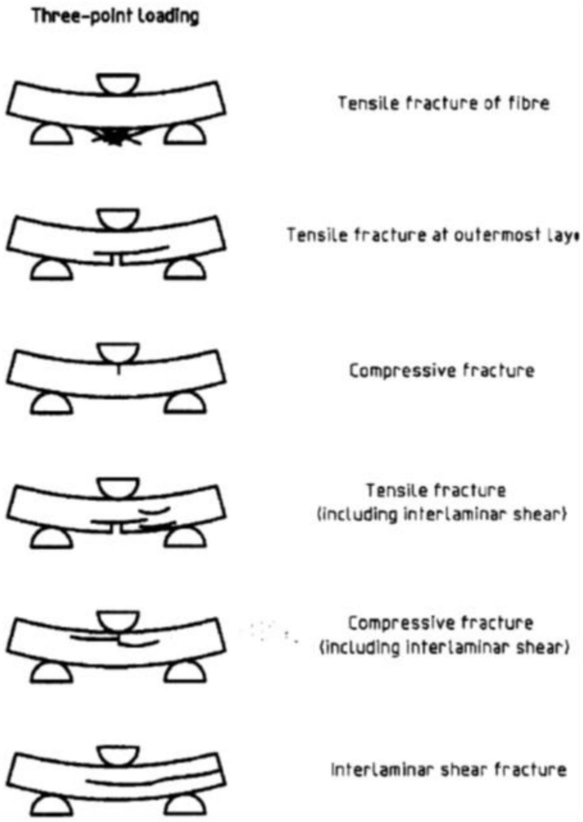


Fig. 5 Examples of possible failure modes

4.3 The FRP material tests are to be carried out, at least on the structural members listed in the following:

1) Bottom shell laminates,
2) Side shell laminates,
3) Upper deck laminates,

4.4 The result of FRP material tests is not to be less than from the following values:

- Tensile strength: $Rz = 1278\ \Phi^2 - 510\ \Phi + 123$ [MPa]
- Young's modulus (tension): $E = [37\ \Phi - 4{,}75] \times 10^3$ [MPa]
- Bending strength: $RB = 502\ \Phi^2 + 106{,}8$ [MPa]

where:

Φ = glass content of laminate by weight

4.5 The result of FRP material tests is to be reported using form "Laporan Uji Laminasi FRP".

5. Guidelines for Processing

5.1 Requirements for moulds

5.1.1 The moulds shall be made of a suitable material that has adequate stiffness to prevent inadmissible deformations while laminating or curing. Moulds made of FRP may be used only after complete curing and subsequent tempering.

5.1.2 The surface of the moulds shall be as smooth as possible and shall have no sharp edges.

5.1.3 Before commencing with the laminating, the surface of the moulds shall be treated with a sufficient quantity of a suitable release agent. The surfaces shall be dry and free of dust. It is not permissible to use release agents with a silicon base.

5.2 Building up the laminate

5.2.1 If the surface protection is to be achieved by providing a gelcoat, then the gelcoat resin compound shall be applied with a uniform thickness of between 0,4 and 0,6 mm, using a suitable process.

5.2.2 The first laminate layer shall be applied as soon as possible after application of the gelcoat. A fibre mat or fabric with low weight per unit area and a high resin content shall be used (e.g. for glass fibres: a maximum of 450 g/m^2 and a maximum of 30 % glass by weight).

5.2.3 Air shall be adequately removed from the reinforcing layers and these layers shall be compacted in such a manner to ensure that the required proportion of resin is achieved (recommended using metal roller). Resin enrichment shall be avoided.

5.2.4 Transitions between different thicknesses of laminate shall be made gradually. A minimum value (for glass fabric in the fibre direction) of 25 mm per 600 g/m^2 reinforcing material can be used.

5.2.5 If cutting of reinforcing layers is unavoidable in the case of complicated mouldings, then the cut edges shall overlap, or reinforcement strips shall be provided. In the butt or seam region of laminates, every reinforcing layer shall overlap by at least 25 mm per 600 g/m^2.

5.3 Curing and tempering

5.3.1 Completed components may only be taken from the moulds after adequate curing of the thermosetting resin compounds. The required cure time generally depends on the manufacturer's instructions. Otherwise, a minimum cure time of 12 hours at 20 °C shall be observed for cold-setting systems.

5.3.2 Immediately after curing, the components should receive post-treatment at increased temperature (tempering). The tempering time depends on the resin in question and the temperature attained within the component during tempering, whereby this shall be below the temperature for dimensional stability under heat and shall be agreed on with BKI.

5.3.3 Cold-setting systems which are not subsequently tempered shall be stored for 30 days at a temperature of 16 °C, and for correspondingly shorter periods at temperatures up to 25 °C.

5.3.4 This period can be shortened with the consent of BKI, provided the relevant manufacturer's specifications regarding post-curing are available, or post-curing values exist which are supported by experimental results. If such values are not available, then in general the following tempering conditions can be used (polyester/epoxy resin):

– at least 16h at 40 °C/50 °C or
– at least 9h at 50 °C/60 °C

5.4 Manufacturing surveillance

5.4.1 During production and on completion of production, the component shall be subjected to visual inspections. In particular, attention shall be paid to voids, delamination, warping, discoloration, damage etc. In addition, the general quality, e. g. surface finish, shall be assessed.

5.4.2 By means of suitable testing procedures, the quality of the components shall be determined, if possible during production, and at the latest on completion of production. Special attention shall be paid to the bonding and to the degree of curing of the component.

B. Wood for Boatbuilding

Timber products for structural members shall meet the following requirements:

1. Only timber in durability groups 1, 2 or 3 of Table 5.1 may be used for primary structural members and load bearing components of the hull.

2. Timber differing from that specified in Table 5.1 may be used if it can demonstrate equivalent durability. Timber with durability class I, II, III according to Table 5.2 may be used.

3. The timbers to be used must be long fibred and of best quality (free from sap, shakes, harmful knots and other defects).

4. For components not exposed to water or weather, and without demands on their strength, timber of lower durability may be used.

5. The timber used is to be radially cut (quarter sawn), the angle of the annular rings to the lower cut edge to be not less than 45°.

6. The bulk density of the wood intended to be used is to be verified and shall be complied with density stated in approved drawing.

7. Bulk density for the structural members are as follows:

Structural member	Standard bulk density [g/cm^3] [1)]
Keel Stem Floors Frames Transom beams	0,70
Shell Sheer plank Reinforced deck beams Beam knees Carlines Engine seatings Deadwood	0,56
Decks Deck beams Planks, shelves	0,45
[1] In standard atmosphere condition with a moisture content (according to “VG”) of 12%.	

Table 5.1 Timber durability groups and characteristic values in accordance with DIN 68364

Wood type	Durability Group[1)]	Bulk density[2)] [g/cm³]	Mean breaking strengths [3)]			Young's modulus		Shear modulus	Trans-verse contraction µTL
			Tension [N/mm²]	Com-pression [N/mm²]	Bending [N/mm²]	EL long. [N/mm²]	ET rad. [N/mm²]	G_{LT}^3 [N/mm²]	
Coniferous European Spruce	4	0,47	80	40	68	10000	800	600	0,33
Fir	4	0,47	80	40	68	1000			
pine	3 - 4	0,52	100	45	80	11000	1000	0,30	
Oregon pine	3	0,54	100	50	80	12000	900	800	0,46
larch	3	0,59	105	48	93	12000			
spruce	4	0,47	85	35	65	9500	870	680	0,34
Deciduous Khaya-Mahogany	3	0,50	75	43	75	9500	1040	830	0,59
True-Mahogany	2	0,54	100	45	80	9500	990	770	0,44
True-Mahogany	2	0,54	100	45	80	9500	990	770	0,44
Mahogany	3	0,64	85	57	69	9800			
Sipo-Mahogany (Utile)	2	0,59	100	58	100	11000	1300	1140	0,53
Meranti, red	3	0,59	129	53	105	13000			
Iroko	1 - 2	0,63	79	55	95	13000	1450	1080	0,59
Makore	1 - 2	0,66	85	53	103	11000	1390	1160	0,42
Oak	2	0,67	110	52	95	13000	1580	1150	
Beech	5	0,69	135	60	120	14000	2280	1640	0,52
Birch	5	0,65	137	60	120	14000	1130	1200	0,36
Ash	5	0,69	130	50	105	13000	1500	880	0,55
Teak	1	0,69	115	58	100	13000	1490	1040	0,55
Yang	3	0,76	140	70	125	16000	1850		

1) Criterion for the durability group is the service life and the resistance of the wood against fungi and animal pests (but not the marine borer, teredo navalis) in contact with soil under central European conditions; the meanings are:

1 = high resistance

2 = resistance

3 = moderate resistance

4 = little resistance

5 = no resistance

2) Bulk density in reference atmosphere standardised condition with 12 % moisture content in accordance with DIN 52183.

3) In the radial place.

8. The workshops for building wooden vessels shall be fully enclosed spaces with heating as well as supply and exhaust ventilation. If load bearing structural members of hull shall be glued or laminated, the following requirements shall be observed.

8.1 The rules of the producers of the glue regarding storage and use of the glues and hardeners shall be observed. Glues and hardeners are to be stored in their original containers well sealed in a cool, dry place. The indicated shelf life must not be surpassed.

8.2 Principles for making glued wood joints

8.2.1 The moisture content of the components to be glued must meet the following requirements. When being glued the wood moisture content must not be less than 8% and not more than 14%. The moisture content of components to be glued together is to be roughly equal; the difference may not exceed 4%. The final moisture content of the timber shall always be controlled before any further working/glueing.

8.2.2 The temperature of the surfaces to be glued must match that of the environment; this must not be less than 15 °C.

8.2.3 Surfaces to be glued must be free from any kind of foreign substance or contamination (e.g. grease, oil, paint, dirt, dust, wood or metal chips). Components to be glued shall be free from wood preservatives. In exceptional cases, i.e. if the components are treated with preservatives before glueing, the compatibility of these preservatives with the glue to be used shall be demonstrated to BKI by a procedure test.

8.2.4 The ambient air temperature must not drop below 15 °C during glueing and curing. The air humidity shall be at least 45%.

8.2.5 The glue is to be made up in accordance with the mamufacturer's instructions and the usage guidelines shall be observed.

8.2.6 The glue ready for use is applied evenly with (e.g.) a roller or paint brush or other means to both surfaces to be joined. Sufficient glue is to be applied for a little surplus to be squeezed out of the joint when this is subject to pressure. The aim should be a thin joint; joints more than 1 mm thick are not permitted. During the time under pressure, care shall be taken to assure that the pressure on the veneers to be joined is adequate.

9. Companies producing wooden hulls and components cold moulded by glueing shall be qualified for the work to be carried out regarding their workshop equipment, internal quality control, manufacturing process as well as the training and qualification of the personnel carrying out and supervising the work.

Table 5.2 Type of wood may be used for structural members

No.	Local name (Capital letter) Other name (normal letter)	Wood species (Family name in bracket)	Class		Specific density (U = 15 ± 3%)			Usage	Place of origin
			Durability	Strength	Min	Max	Average		
1	2	3	4		5			6	7
1.	AMPUPU	Eucalyptus Alba Reinw (Myrtaceae)	II-III	I-II	0,68	1,02	0,89	Frames, Longitudinals, plank, Deck Plank	Maluku, Nusa Tenggara
2.	BALAM Nyatoh, Suntai, Maneo, Somaran, Sambun, Arupa, Gofiri, Headf	Palaquin ridloyi K. Ot G, (Sapotacone)	II	I	0,90	1,12	1,04	Plank, Framer, Longitudinals, Deck Beam, Deck Plank	Seluruh Indonesia
3.	BALAU Damar Laut, Balau, Sinantok, Pooti, Benuas, Kelepek, Bangkirai, Resak, Minyak, Damadere	Shorea Spp., Hopea Celebica Burek (Dipterocarpaceae)	I	I-II	0,65	1,22	0,98	Plank, Frames, Longitudinals, Deck Beam, Deck Plank	Sumatera, Sulawesi, Kalimantan
4.	BANGKIRAI Benuas, Selangan batu, Tokam, Bengkirai, Anggelam	Shore laevifolia Endert (Dipterocarpaceae)	I(I-III)	I-II	0,60	1,16	0,91	All Structural Members	Kalimantan
5.	BEDARU Daru-daru, Garu Buaya, Tusan	Cantleya cormiculata Howard (Icainaeae)	I	I	0,84	1,36	1,04	Keel, Stem /Stern Post, Frame, Engine Girder, Plank, Strength Member	Sumatera, Sulawesi, Nusa Tenggara Barat
6.	BELANGERAN Kawi, Kohooi	Shorea balangeran Burck (Dipterocarpacene)	II(I-III)	(I)-II	0,73	0,98	0,86	Plank, Frames, Longitudinals, Deck Beam, Deck Plank	Sumatera, Kalimantan
7.	BERUMBUNG	Adina Minuriflora Val. (Rubiaceae)	II	I-II	0,74	0,94	0,85		Sumatera, kalimantan
8.	BITANGUR Nyamplung, Punaga, Kapurraya, Betawa, Bentango, Balitoko	Callopyllum Spp. (Guttiferae)	III	II-III	0,37	1,07	0,78	Inner Construction, Mast Head	Sumatera, Jawa, Kalimantan, Sulawesi, Nusa Tenggara, Maluku
9.	BUGIS, K Kelembiring, Siuri	Koordersiodendron pinnatum Merr. (Anacardiaceae)	III-IV	II-III	0,41	1,02	0,8	Frames	Kalimantan, Sulawesi, Maluku, Irian Jaya
10.	BUNGUR Wungu ketangi, Oindolo, Langoti	Lagerstroemia speciosa Pers. (Lythraceae)	II-III	I-II	0,62	1,01	0,8	Plank, Frames, Longitudinals, Deck Beam, Deck Plank	Sumatera, Jawa, Kalimantan, Sulawesi, Maluku, Nusa Tenggara
11.	CEMARA Angin, Embun, Ruwow	Casuarina Spp. (Casuarinaceae)	II-III	I-II	1,04	1,18	-	All Structural Members	Sumatera, Jawa, Kalimantan Barat, Sulawesi, Maluku, Nusa Tenggara, Irian Jaya

Table 5.2 Type of wood may be used for structural members (continued)

No.	Local name (Capital letter) Other name (normal letter)	Wood species (Family name in bracket)	Class		Specific density (U = 15 ± 3%)			Usage	Place of origin
			Durability	Strength	Min	Max	Average		
1	2	3	4		5			6	7
12.	CEMPAGA Pondongio motaha, Kayuroda	Dysoxylum densiflorum Miq. (Meliaceae)	II-III	II	0,57	0,90	0,71	Keel, Stem /Stern Post, Frame, Engine Girder, Plank, Strength Member	Sumatera, Jawa, Kalimantan, Sulawesi, Maluku, Nusa Tenggara
13.	CENGAL Awangukung, Tekanm, Cangar, Mata kucing, Gagil	Hopea Sangal Korth (Santalaceae)	II-III	II-III	0,51	0,89	0,7	Plank, Frames, Longitudinals, Deck Beam, Deck Plank	Sumatera, Jawa
14.	DUNGUN Dungun-dungun, Dasi kambing, palapi	Herifiera Letteralis Orxand (Sterculicceae)	I	I	0,88	1,23	0,98		Seluruh Indonesia
15.	GADOK Gerunjing, bintangun, Palentuna, Polo	Bischoffia Javanica Bi (Euphorbiaceae)	II-III	II-(III-I)	0,55	1,00	0,75	Plank, Frames, Longitudinals, Deck Beam, Deck Plank	Sumatera, Jawa, Sulawesi, Maluku, Nusa Tenggara, Irian Jaya
16.	GELAM	MeJa]euca leucadendron L (Myrtaceae)	III	II	0,73	0,85	-	Plank, Frames, Longitudinals, Deck Beam, Deck Plank	Seluruh Indonesia
17.	GIA Hiya, Aliwowas, Samal, Samarbatu	Homallwn foetidwn, Beoth (Flacourtiaceae)	I-(II)	I-(II)	0,77	1,06	0,91	Keel, Stern Stem Post, frames , Stringer, Plank	Sulawesi, Maluku. Kalimantan,Irian Jaya
18.	GIAM Resak tembaga, Resak dam lebar	Cotylelobiwn Sperdiv (Dipterocarpaceae)	I	I	0,83	1,15	0,99	Keel, Frames, Stern Stem Post, Plank, Longitudinals, Plank, Deck Plank	Sumatera, Kep. Riau, Kalimantan
19.	GISOK, Gisok gunung	Shorea Ouiso BI (Dipterocarpaceae)	II-III	I-II	0,73	0,97	0,83	Keel, Frames, Stern Stem Post, Plank, Longitudinals, Plank, Deck Plank	Sumatera, Kalimantan
20.	GOFASA Gofasa Batu,Biti,Tempira, Walata, Kalban	Vitex cofassus Reinw.(Verbenaceae)	II-III	II-III	0,57	0,93	0,74	Frames, Plank, Deck Plank	Sulawesi, Maluku, Irian Jaya
21.	JATI Teak, Taok,Jatos, Deleg, DodoIan, Jate, Kiati	Tectona grandis Lf (Verbenaceae)	I-(II)	II	0,59	0,82	0,70	All Structural Members	Jawa, Sulawesi,Nusa Tenggara

Table 5.2 Type of wood may be used for structural members (continued)

No.	Local name (Capital letter) Other name (normal letter)	Wood species (Family name in bracket)	Class		Specific density (U = 15 ± 3%)			Usage	Place of origin
			Durability	Strength	Min	Max	Average		
1	2	3	4		5			6	7
22.	JOHAR	Cuia siamea Lamie.(CaesaJpiniaceae)	I-II	II-I	0,68	0,96	0,84	Deck Planking, Deckhouse Wall	Jawa, Sumatera
23.	KAPUR Kamper, Sintok, Petanang, Kuras, Burnes, Champer wood	Dryobalanops lanceolata Burck (Dipterocarpaceae)	II-III	I-II	0,63	0,94	0,81	Plank, Deck Plank, Frames, Deck Beam, Deck House, Longitudinals, Stringer	Sumatera, Kalimantan
24.	KEMPAS Manggerls, Hampas. Tualang, Bengaris	Koompassia maJacceusis Maing (Caesalpiniaceae)	III-IV	I-II	0,68	1,29	0,95	Keel, Stem /Stern Post, Frame, Engine Girder, Plank, Strength Member	Sumatera, Kalimantan
25.	KERUING Palahlar,Keladan, Logam Ariung.Kayu Kawan.Tempulan, Dermala, Andhiri, Kakap	Dipterocarpus Specdiv (Dipterocarpaceae)	III	(I) -II	0,51	1,01	0,79	Plank, deck plank, Frames	Sumatera, Jawa, Kalimantan
26.	KETAPANG Sirise	Terminalla balerica Roxb, Terminalia edulis blanco, Termina1ia gigantea V.SI (Combretaoeae)	III-V	II-III	0,41	0,85	-	Frames, Deck Plank, Longitudinals, Deck Beam	Seluruh Indonesia
27.	KOLAKA Bunga	Parinari Corymbosa Miq.(Rosaceae)	III	I	0,73	1,09	0,96	Frames, longitudinals, Deck Beam, Deck Plank, Plank	Seluruh Indonesia
28.	KOSAMBI Kesambi	Schleichera oleosa Merr.(Sapindaceae)	III	I	0,94	1,10	1,01	Keel, Stern Stem Post, frames , Stringer, Deck Plank	Jawa, Sulawesi, Maluku, Nusa Tenggara
29.	KRANJI Keranji	Dialium platysepalum Baber(Caesalphinia)	I	I-II	0,84	1,04	0,98	Frames, Longitudinals, Keel, Stern Stem Post	Sumatera, Jawa, Kalimantan
30.	KUKU	Pericopsismooniana Thw.(Papilionaceae)	II	I	-	-	0,87	Frames, Plank, Longitudinals, Stringer, deck Plank, Deck Beam, Deck house	Sumatera, Kalimantan, Silawesi, Maluku, Irian Jaya

Table 5.2 Type of wood may be used for structural members (continued)

No.	Local name (Capital letter) Other name (normal letter)	Wood species (Family name in bracket)	Class		Specific density (U = 15 ± 3%)			Usage	Place of origin
31.	KULIM Kayu hawang.Kundar	Scorodocarpus borneensis Becc.(Olacaceae)	I-(II)	I	0,73	1,08	0,94	Keel, Stem /Stern Post, Frame, Engine Girder, Plank, Strength Member	Sumatera Kalimantan
32.	KUPANG	Ormosia Sumatrana Prain (Papilionaoeae)	II-IV	II-III	0,54	0,78	-	Structural members, above Water Line	Sumatera, Jawa, Kalimantan, Maluku, Sulawesi
33.	LABAN Leban, Kiheyas, Pampa halban	Vilex pubesceus Vahl. (Verbenaceae)	I	I-II	0,74	1,02	0,88	Shell, deck planks, frame, keel, longitudinals, post, etc.	Sumatera, Kep. Riau, Kalimantan
34.	LARA Mangi, Momosi, Motulu, Nani, Masili	Metrosiderus petiolata Kds. (Myrtaceae)	I	I	0,98	1,23	1,15	Keel, frame, post, engine foundation, longitudinals and primary members	Sulawesi, Maluku
35.	LEDA	Eucalyptus de-Glupta BI. (Myrtaceae)	IV (V-II)	III (I-IV)	0,39	0,81	0,57	Construction member above waterline	Sulawesi, Maluku
36.	MAHANG Kapur	Macaranga by-poleuca Meuli Arg. (Eupborb ia-ceae)	IV-V	II-IV	0,30	0,55	-	Deck house plank, deck plank and Construction member above waterline	Sumatera, Jawa, Kalimantan
37.	MAHONI	Swietenia mahagoni Jocq. Swie-tenia Machro-pylla King (Meliaceae)	III	II-Ill	0,56	0,76	0,64	Sheel, deck plank, frame, longitudinals, beam	Jawa
38.	MALAS, k Gelam tenbago, Ampalang	Parastemoll Uro-pbyllum A.DC (Rosaceae)	II-Ill	I	0,95	1,15	1,04	All member construction	Sumatera, Kalimantan
39.	MATOA Kasai,Galung-Gung ,Kase, Jagir, Hatobu motoa, Iseh	Pometia Spp (Sapindaceae)	III-IV	II(I-III)	0,50	0,99	0,77		Sumatera, Jawa, Sulawesi, Maluku, Nusa Tenggara, Papua
40.	MEDANG Kisereh, Kayu lada, Selasihan, Marawali, Palio	Litsea fmna Ho-ok, f Debaasia caesia BI (Lauraceae)	III-V	II-V	0,36	0,85	-	Deck plank, Construction member above waterline	Seluruh Indonesia

Table 5.2 Type of wood may be used for structural members (continued)

No.	Local name (Capital letter) Other name (normal letter)	Wood species (Family name in bracket)	Class		Specific density (U = 15 ± 3%)			Usage	Place of origin
			Durability	Strength	Min	Max	Average		
1	2	3	4		5			6	7
41.	MERANTI BATU	Sborea platic1a-Dos (Dipterocarpaceae)	II-IV	II-IV	0,29	1,01	0,55	Keel, post, shell, deck plank, frame	Sumatera, Kalimantan, Sulawesi, Maluku
42.	MERANTI MERAH Banio, Damar, Lampung, Seraya lanan, Uban salak	Shorea acumi-nata Dyer. (D ipterocarpaceae)	III-IV	II-IV	0,29	1,01	0,55	Deck plank, Construction member above waterline	Sumatera, Kalimantan, Sulawesi, Maluku
43.	MERANTI PUTIH Kayu takan, Honi, Damar cermin, Mesegar, Meranti bodat	Shorea lamellata (Dipterocarpa-ceae)	III-IV	II-IV	0,29	0,96	0,54	Deck plank, Construction member above waterline	Sumatera, Kalimantan, Sulawesi, Maluku
44.	MERAWAN Nyerekat, Damar lilin, Dasal, Ma-nirawan, gagil, andorie, boamo, sam, wapei	Hopea daasyrrachis VSI, Hopea dryobalanoides Mig, Hopea fer mginea Parijs, Hopea Mengarawan Mig, Hopea Sericea-BI (Dipterocarpaceae)	II-III	II-III	0,42	1,03	0,70	Deck plank, Construction member above waterline	Sumatera, Kalimantan
45.	MERBAU Ipil, Merboo, Bayam, Kayu besi	Intsia bijuga 0, Ktze, Intsia pa-lembanica Mig. (Caesalpiniaceae)	I-II	I-(II)	0,52	1,04	0,80	Member above waterline	Seluruh Indonesia
46.	NYIRIH	Xylocarpus gra-natum Koen (Meliaceae)	II-III	II	0,70	0,74	-	Construction member above waterline	Seluruh Indonesia
47.	PASANG Hampening, paning-paning, begung, hoting,karamajo, bataruwa, wrakas, palele	Quercus lineata BI, Lithocarpus sundaicus (Fagaceae)	II-IV II-IV	I III	0,94 0,50	1,10 0,69	1,00 0,58	Frame, lonitudinals, beam, members above waterline	Seluruh Indonesia Sumatera, Jawa, Kalimantan
48.	PATIN, k Selumar	Mussaendopsis - beccariana Baili (Rubiaceae)	I	I-II	0,82	1,02	0,92	Frame, longitudinals, shell, deck beam, deck plank	Sumatera, Kep. Riau, Kalimantan
49.	PELAWAN	Tristania Maingayi Duthie (Myrtaceae)	I-II	I	1,00	1,19	--	Keel, post, frame, shell, and primary member	Sumatera, Kalimantan
50.	PBREPAT DARAT	Combretocarpus rotundatus Dans (Bhizophoraceae)	III	II	0,67	0,85	0,76	Construction member above waterline	Sumatera, Kalimantan

Table 5.2 Type of wood may be used for structural members (continued)

No.	Local name (Capital letter) Other name (normal letter)	Wood species (Family name in bracket)	Class		Specific density (U = 15 ± 3%)			Usage	Place of origin
			Durability	Strength	Min	Max	Average		
1	2	3	4		5			6	7
51.	PBREPAT LAUT Rambai papan, perepak, beropa	Sonneratia alba Smith (Sonneratiaceae)	III -II	II-I	0,62	1,00	0,78	Frame, shell, deck plank, deck beam	Seluruh Indonesia
52.	PETALİNG Petatar, Ampilung	Ochanostachys amentacea Mast. (Olacaceae)	I -II	I-II	0.72	1,09	0,91	Keel, post, frame, longitudinals ., shell	Sumatera, Kalimantan
53.	PETANANG	Dryobalanops Oblongifolia Dyer (Dipterocarpaceae)	III	II	0,62	0,91	0,75		Sumatera
54.	PIMPING	Sterculia foetida L. (Sterculiaceae)	III-V	I-IV	0,35	0,64	--		Seluruh Indonesia
55.	PINANG, k	Pentace Triptera (Tiliaceae)	III-IV	II-III	0,47	0,87	0,66	Beam above waterline	Sumatera, Kalimantan
56.	POLAPI Papan Polapipoote, piratu kalapi	Kallapia celebica Kastern (Capsalponiaceae)	I-III	II	0,59	0,71	0,61	Plank	Kalimantan, Sulawesi
57.	PUNAK Papan Penagit	Tetramerista glabra Miq. (Theaceae)	III-IV	II	0,55	0,90	0,76	Deck plank, side wall, deck house frame	Sumatera, Kalimantan
58.	PUSPA, Madang keladi	Schbna wallichii Korth (Theaceae)	III	II	0,62	0,71	--	Frame, shell, longitudinals , deck plank	Sumatera, Jawa, Kalimantan
59.	PUTAT Telisai, Wiwa	Planchonia Valida BI (Lecythidaceae)	II-III	I-II	0,80	0,89	--	Deck plank, shell, frame	Seluruh Indonesia