

Rules For Classification And Construction

Part 3 Special Ships

Volume IX

Rules for Yacht

2019

Biro Klasifikasi Indonesia



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Foreword

This is a new BKI's Rules for Yacht. Reference sources of the rules are derived from BKI Technical Rules, IACS Unified Requirements, Procedural Requirements, SOLAS, ICLL, and inputs from BKI Branch Offices and Technical Division BKI Head Office.

The summary of current amendments for each section including the implementation date are indicated on the page of Rules Amendment Notice.

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

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Section 1 General Requirements

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A. Application, Scope

1. Application

1.1 These Rules apply to large, seagoing motor and sailing yachts with a length $L \geq 24,0$ m for private, recreational use, provided that the yacht classed and approved in accordance therewith is at all times employed exclusively under the conditions for which it has been designed, constructed and approved and that it is equipped and handled in the sense of good seamanship, and operated at a speed adopted to the respective seaway conditions.

Designs which deviate from these Rules may be approved, provided that such designs have been examined by BKI for suitability and have been recognized as equivalent.

Note

1. *Passage printed in italics generally contains notes as are not part of Classification Rules*
2. *Ships with $24 \text{ m} \leq L \leq 48 \text{ m}$ intended for commercial purposes which do not carry more than 12 passengers, may be dimensioned according to [Section 2, D. and E.](#) of these Rules, taking supplementary factors into account, which have to be agreed upon with BKI. The length L is defined in [Section 2, A.6.](#)*

1.2 Whether and/or to which extent [Rules for High Speed Craft \(Pt.3, Vol.III\)](#) may have to be applied to a particular design will be decided in the individual case.

1.3 Yachts with a length $6 \text{ m} \leq L \leq 24 \text{ m}$ are covered by [Rules for Small Vessel up to 24 m \(Pt.3, Vol.VII\)](#) and are not subject of these Rules.

2. Special aspects for yachts

Contrary to merchant ships the following aspects will usually apply regarding the operation of yachts:

- less severe operating conditions as for ships in regular trade
- limited yearly sea hours in relation to harbour hours
- special care by the owner and usually good maintenance

These Rules were developed assuming these characteristics.

3. Scope

3.1 The requirements of these Rules do not substitute the independent judgement of professional designers. This is particularly valid for those aspects not addressed in these Rules and for which the designers are solely responsible.

3.2 The Rules envisage primarily technical safety matters. Aesthetical and comfort aspects, usually important in yacht design, are not considered and must be subordinated to the safety requirements in conflict cases.

4. Scope of Examination/Classification according to BKI Rules

4.1 Plan approval

Plan approval will only be carried out once appropriate and sufficient documentation has been submitted to BKI.

4.2 Hull Construction Certificate

The scope of examination and construction survey related to the issuance of a Hull Construction Certificate refers to the hull structure only. The hull structure has to be in compliance with the relevant scantling requirements of these Rules.

4.3 Classification

If a yacht is subject to Classification, all aspects in addition to the hull structure, i.e. machinery and electrical installations and ship safety matters have to be considered and must comply with the requirements of these Rules. The BKI Surveyors will supervise the complete construction phase of the yacht. As Class is granted only for a limited period of time, the complete surveying procedures during service of the yacht have to be established if Class of the yacht shall be maintained.

For more details about Classification and Class Notations see [Guidance for Class Notation \(Pt.0, Vol.B\)](#).

5. Types of yachts

In addition to the Character of Classification, yachts will be characterized by Special Notations affixed, describing their type and envisaged use, as shown in the following examples.

Sailing

Motor

Special

Note

The term "special" applies to yachts of unusual shape/dimensions and with special technical equipment, if any. BKI reserve the right of determining whether the BKI Rules are applicable and how they are to be interpreted.

6. Consideration of national regulations

BKI is prepared to include in its supervisory procedures the national regulations of the various flag state of the yacht if the owner of the yacht wants to include this additional service and if BKI is authorized by the particular flag state to do so.

7. Range of service

Yachts complying with the Construction Rule requirements for a restricted range of service only will have the Notations specified below affixed to their Character of Classification.

P (Restricted Service Area)

This range of service is limited, in general, to voyages along the coast, provided that the distance to the nearest port of refuge and the offshore distance do not exceed 200 nautical miles. This applies also to voyages in the North Sea and within enclosed seas, such as the Mediterranean, the Black Sea and waters with similar conditions. Voyages to Iceland, Spitzbergen and the Azores are exempted.

L (Coastal Service Area)

This range of service is limited, in general, to voyages along the coasts, provided that the distance to the nearest port of refuge and the offshore distance do not exceed 50 nautical miles. This applies also to voyages within enclosed seas such as the Baltic Sea and gulfs with similar seaway conditions.

Where a permissible distance of less than 50 nautical miles has been fixed for a yacht, the relevant distance will be added in brackets behind the Notation **L** in the Class Certificate.

T (Sheltered Water Service Area)

This range of service is limited to voyages in shoals, bays, haffs and firths or similar waters, where heavy seas do not occur.

The Notations may possibly be assigned on the basis of the seaway conditions prevailing in the respective service area (e.g. official seaway statistics).

Observance of the range of service boundaries is a prerequisite for validity of the Class.

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.

8. Ambient conditions

8.1 General operating conditions

The selection, layout and arrangement of the yacht's structure and all shipboard machinery, equipment and appliances shall be such as to ensure unobstructed continuous operation under the ambient conditions specified in these Rules.

8.2 Inclinations and movements of the yacht

The design limits for yacht inclinations and movements are defined in [Table 1.1](#).

Account is to be taken of the effects of distortion of the yacht's hull on the machinery installations.

Table 1.1 Design limits for yacht inclinations and movements

Type of movement	Type of inclination	Standard requirements
Static condition	Inclination athwartships: ¹ Main and auxiliary machinery	15° ²
	Other installations ³	22,5° ²
	No uncontrolled switches or functional changes	45° ²
	Yacht's structure	acc. to stability requirements
	Inclination fore and aft: ¹ Main and auxiliary machinery	15°
	Other installations ³	10°
	Yacht's structure	acc. to stability requirements
Dynamic condition	Rolling: Main and auxiliary machinery	22,5°
	Other installations ³	22,5°

Table 1.1 Design limits for yacht inclinations and movements (continued)

Type of movement	Type of inclination	Standard requirements
Dynamic condition	Pitching: Main and auxiliary machinery	7,5°
	Other installations ³	7,5°
¹ athwartships and fore and aft inclinations may occur simultaneously ² for sailing yachts special considerations may be relevant ³ yacht's safety equipment, switch gear and electric/electronic equipment		

8.3 Environment of the yacht

The design environmental conditions of a yacht are defined in [Table 1.2](#).

Table 1.2 Design environmental conditions

Environmental area	Parameters	Assumed conditions
Outside the yacht/air	Temperature: – at atmospheric pressure – at relative humidity of	– 25 to + 45 °C ¹ 1 000 mbar 60 % ²
	Max. salt content	1 mg/m ³ withstand salt-laden spray
	Dust/sand	to be considered
	Wind velocity (lateral)	63,6 – 71,7 kn ³
Outside the yacht/seawater	Temperature ⁴	– 2 to + 32 °C
	Density acc. to salt content	1,025 t/m ³
	Flooding	withstand temporarily
Outside the yacht/navigation in ice	Ice Class Notations	see Rules for Hull (Pt.1, Vol.II) Sec. 15
Entrance to the yacht	Air temperature	– 15 to + 35 °C
	Max. heat content of the air	100 kJ/kg
	Seawater temperature	– 2 to + 32 °C
Inside the yacht/all spaces	Air temperature: – at atmospheric pressure – at relative humidity of up to	0 to + 45 °C 1 000 mbar 100 % (+ 45 °C)
	Max. salt content	1 mg/m ³
	Condensation	to be assumed
Inside the yacht/ airconditioned areas	Max. air temperature	+ 45 °C
	Max. relative humidity	80 %
	Recommended ideal climate for manned computer systems	Air temperature 20 to 22 °C at 60% rel. humidity
Inside the yacht/ in electrical devices with higher degree of heat dissipation	Air temperature	0 to +55 °C
	Max. relative humidity	100 %
¹ higher temperatures due to radiation and absorption heat have to be considered ² 100 % for layout of electrical installations ³ according to Beaufort 12, see Section 3, D 7.2.2 . ⁴ BKI may approve lower limit water temperatures for yachts operating only in special geographical areas		

9. Vibrations and noise

Vibrations are defined as structural oscillations in the frequency range of 1 Hz to 80 Hz. Noise is defined as audible air pressure variations, generated for instance by main engines and propellers, auxiliary machinery, equipment and persons within the frequency range of 16 Hz to 16 000 Hz.

9.1 Vibrations

9.1.1 On board yachts vibration may become important with respect to the following issues:

- annoyance of owner, passenger or crew
- functioning of electronic devices, main and auxiliary machinery
- integrity of structures

9.1.2 It is recommended that in the building specification maximum vibration levels are agreed on. If desired, BKI can give guidance in this respect.

9.1.3 It is recommended that theoretical investigations will be performed from an early design stage in order to identify critical points of the individual design. If desired, BKI can give guidance in this respect.

9.1.4 Electric or electronic devices relevant for the ship's safety and functionality have to withstand the vibration loads as defined by type testing procedures in [Rules for Electrical Installations \(Pt.1, Vol.IV\), Sec.1, Table 1.8](#).

9.1.5 Masts shall be constructed in such a way that no resonance of basic vibration modes with relevant excitation frequencies is present. The mast foundation shall be constructed as stiff as possible.

9.1.6 Vibration may damage machinery or equipment. Vibration can be self-excited, as in the case of propulsion machinery, or is caused by excitation from its foundation. In any case machinery and equipment shall withstand vibration loads without loss of intended function.

9.1.7 Vibration limits regarding reciprocating main engines and auxiliary machinery are defined in [Rules for Machinery Installations \(Pt.1, Vol.III\), Sec.1, C.2](#).

9.1.8 The main tuning frequencies of resilient machinery supports must be compared to the relevant excitation frequencies which occur on the individual ship. The properties of the mounting elements must be chosen in such a way that the safety margin between those frequencies is sufficient.

9.1.9 Excessive vibration may damage the ship's structure. Therefore, it has to be ensured that local structures in vicinity of the propellers or the main machinery are not vibrating in resonance with one of the relevant excitation frequencies created by the propeller or other machinery.

9.2 Noise

Suitable precautions are to be taken to keep specified sound level limits, particularly in the owner and guest accommodations, crew quarters, etc.

Regarding crew's quarters the IMO code on noise levels on board ships may be taken as guidance. Sound level limits for owner and guest spaces should be agreed on between owner and yard.

If requested by the yard and/or owner BKI is prepared to carry out a noise review in the pre-contract or early design state as well as reviewing the building specification with reference to noise matters.

Further services e.g. detailed noise prediction, noise measurements, acoustic factory tests, etc. can also be provided by BKI upon request.

B. Hull Structures

1. Special requirements for yachts

The requirements for the hull structures and the related equipment are defined in [Section 2](#).

2. Relevant other BKI Rules and Guidelines

For the design of the hull structure the following other Rules for Classification and Construction of BKI will mainly be referred to:

- Rules for Classification and Survey (Pt.1, Vol.I)
- Rules for Hull (Pt.1, Vol.II)
- Rules for High Speed Craft (Pt.3, Vol.III)
- Guidelines for Rigging Technology
- Guidelines for Certification of Lifting Appliances (Pt.7, Vol.1)
- Peraturan Kapal Kayu (Pt.3, Vol.VI) ¹
- Rules for Materials (Pt.1, Vol.V)
- Rules for Welding (Pt.1, Vol.VI)
- Rules for Non-Metalic Materials (Pt.1, Vol.XIV)

C. Machinery Installations

1. General

On principle yachts shall meet the requirements of [Rules for Machinery Installations \(Pt.1, Vol.III\)](#) for "cargo ships" as far as applicable.

The exceptions from this principle and/or special, deviating requirements for yachts are defined in the following.

2. Special requirements for yachts

2.1 General rules and instructions

2.1.1 Ambient and general operating conditions

The conditions are defined in [A.8](#). Special attention shall be given to the operating conditions of sailing yachts.

2.1.2 Propulsion plant, turning appliances

Turning appliances for main engines need not be provided unless specified by the engine manufacturers as standard.

Yachts with more than one propulsion system shall be equipped with shaft brakes unless the gearbox is designed for operation under trolling conditions or an independent trolling pump is fitted. All propulsion systems of sailing yachts with non-declutchable propeller shafts/gearboxes shall have a shaft brake.

¹ Translation: "Peraturan Kapal Kayu" (not available in English)

3. Main shafting

3.1 Shaft dimensions, minimum diameter

For determining the minimum shaft diameter the factor F for the type of propulsion installation may be taken as $F = 95$ and the actual tensile strength R_m shall be used for calculating the material factor C_w , see [Rules for Machinery Installations \(Pt.1, Vol.III\), Sec.4, C.2.](#)

3.2 Temperature indication

An indication of the temperature of the stern tube bearing or of the lubrication oil need not to be provided for yachts of a length $L \leq 48$ m.

4. Gears, couplings

The minimum safety margins for endurance limits for contact stress and percentage area of contact as defined in [Tables 5.4 and 5.6 Rules for Machinery Installations \(Pt.1, Vol.III\), Sec.5](#) shall be applied.

5. Propeller

5.1 Controllable pitch propellers, indicators

Controllable pitch propeller systems are to be provided with a mechanical indicator at the controls in the engine room, showing the actual setting of the blades. Further blade setting indicators are to be provided on the bridge.

5.2 Balancing

The finished propeller and the blades of controllable pitch propellers are required to undergo static balancing. For propeller revolutions above 500 rpm also dynamic balancing is recommended.

6. Steam boilers, pressure vessels

For yachts of a length $L \leq 48$ m all equipment under pressure shall be in accordance with a recognized standard. For yachts of a length $L > 48$ m the pressure equipment has to meet the BKI Rules [Rules for Machinery Installations \(Pt.1, Vol.III\), Sec.7a and 8.](#)

7. Pipes, valves, fittings and pumps

7.1 Testing of materials

For yachts of a length $L \leq 48$ m, material certificates 3.1.B according to DIN EN 10204 for fittings and valves in pipe classes I and II may be provided.

7.2 Oil fuel systems, filters

Any internal combustion engine, regardless of its intended use, shall be equipped with duplex type water separators incorporating pre-filter elements. Changing of filter elements and draining of the separator shall be possible with the engine operating.

7.3 Service tanks

For motor yachts of a length $L \leq 48$ m and all sailing yachts fuel oil service tanks need not be provided.

7.4 Lubricating oil system

For internal combustion engines single lubricating oil filters are acceptable for sailing yachts and motor yachts with more than one propulsion engine.

7.5 Lubricating oil pumps, main engines

Yachts for restricted service or with more than one main propulsion system need not have redundant lubricating pumps. Yachts for unrestricted service and with a single propulsion plant shall have a redundant lubricating pump or carry on board a spare lubricating pump.

7.6 Bilge systems

7.6.1 Calculation of pipe diameters

.1 Main bilge pipes

The diameter d_H of the bilge main shall be calculated according to the following formula. The actual inside diameter of the bilge main shall be rounded to the next higher nominal standard:

$$d_H = 25 + 1,68\sqrt{L(B + H)}$$

d_H = the calculated inside diameter of the main bilge pipe [mm]

L = the length of the yacht [m] as defined in [Section 2, A.6.](#)

B = for monohull yachts, the breadth of the yacht in [m] as defined in [Section 2, A.6.](#); for multihull yachts the breadth of one hull at the design waterline [m]

H = the moulded depth of the yacht [m] as defined in [Section 2, A.6.](#)

.2 Branch bilge pipes

The inside diameter is given by the formula:

$$d_z = 25 + 2,15\sqrt{\ell(B + H)}$$

d_z = calculated inside diameter [mm] of the branch pipes

ℓ = length [m] of the watertight compartment

.3 Minimum diameter

The inside diameter of main and branch bilge pipes is not to be less than 50 mm. For yachts with $L \leq 48$ m, the inside diameter may be reduced to 40 mm.

7.6.2 Bilge pumps

The number of bilge pumps is to be evaluated as prescribed for cargo ships.

7.6.3 Bilge pumping for various spaces

.1 Machinery spaces

On yachts of more than 100 gross tons, the bilges of every machinery space must be capable of being drained as follows:

- through the bilge suctions connected to the main bilge system

- through one direct suction connected to the largest independent bilge pump
- through an emergency bilge suction connected to the independent cooling water pump of the main propulsion plant or through another suitable emergency bilge system

For yachts with a length $L \leq 48$ m inclusive, the emergency bilge suction need not be provided, if an independent power driven sea water cooling pump or any other suitable pump is not available.

.2 Bilge suctions for other spaces

Bilge suction is to be arranged for the shaft tunnel (if applicable), fore and after peaks, cofferdams, pipe tunnels and void spaces as well as chain lockers.

7.6.4 Bilge testing

For yachts with a length L above 48 m all bilge arrangements are to be tested under BKI supervision.

7.6.5 Equipment for the treatment and storage of bilge water, fuel and oil residues

.1 Oily water separating equipment

Note

Also for yachts of less than 400 gross tons it is not permitted to discharge oily bilge water as well as fuel and oil residues into the sea ². It is therefore recommended to provide also for such yachts equipment for collecting these liquids and to discharge them to reception facilities.

7.7 Cooling systems

All internal and external cooling systems of any internal combustion engine have to be in compliance with the manufacturer's installation recommendation.

If the manufacturers recommend coolant treatment and checks, the design of the piping system has to be such, that applying of additives and taking of samples is easily possible. All coolant venting lines have to be arranged with upwards slope throughout.

7.8 Seawater cooling system, sea chests

For motor yachts of a length $L \leq 48$ m and all sailing yachts a second sea chest need not be provided.

7.9 Clearing sea chest gratings

All sailing yachts need not be provided with a device for sea chest clearing. Motor yachts with an auxiliary system producing compressed air shall be equipped with means for clearing sea chests.

7.10 Seawater cooling pumps, diesel engine plants

Yachts for unrestricted service and a single propulsion plant should have a stand-by seawater pump or carry a spare seawater pump on board. If feasible, the same applies to internal coolant circuit water pumps. At least one repair kit per each seawater pump type has to be carried on board.

² With regard to the installation on yachts of oily water separators, filter plants, oil collecting tanks, oil discharging lines and a 15 ppm alarm device in the water outlet of oily water separators, compliance is required with the provisions of the International Convention for the Prevention of Pollution from Ships, 1973 (MARPOL) and the Protocol 1978, as applicable.
BKI Form is to be submitted for approval, if a IOPP certificate is applied for.

Yachts for restricted service or with more than one main propulsion system need not have stand-by seawater cooling pumps.

7.11 Air, overflow and sounding pipes

Each tank is to be fitted with air pipes, overflow and sounding pipes. The air pipes are in general to be led to above the exposed deck. The height from the deck to the point where the water may have access is to be at least 760 mm on the freeboard deck and 450 mm on a superstructure deck. These heights may be reduced in agreement with BKI if the point of water access is suitably arranged.

Suitable closing appliances are to be provided for these pipes. For air pipes of 32 mm in diameter and above automatic closures are to be provided. In yachts for which flooding calculations are to be made, the ends of the air pipes are to be above the damage waterline in the flooded condition. Where they immerse at intermediate stages of flooding, these conditions are to be examined separately.

Sounding pipes are to be extended to directly above the tank bottom. Striking plates have to be provided under the sounding pipes.

8. Steering gears, hydraulic control systems

A hydraulic locking alarm shall be provided to indicate failure of single control components.

9. Operating instructions, tools, spare parts

9.1 Operating instructions

All necessary operating and maintenance instructions as well as spare parts lists recommended by the manufacturers of machinery and ancillary equipment shall be available on board.

9.2 Tools

Sufficient tools are to be carried to allow for repair or maintenance work to be carried out as described in the operating and maintenance instructions. Scope of maintenance (and subsequently tooling) necessary will be subject to the range of service and the type of the yacht.

9.3 Spare parts

If extended voyages of yachts are intended, it is the operator's responsibility to carry on board additional tools, accessories, consumables and spares in accordance with the recommendations of the engine/component manufacturers and with the foreseeable needs and/or availability conditions during the particular voyage.

10. Fire protection and fire extinguishing equipment

This equipment is defined in [Section 3, C](#).

D. Electrical Installations

1. General

For the electrical installations of large yachts no special rules and guidelines are contained in these Rules. The already existing international standards and BKI Rules as defined below shall be used, as applicable.

In particular, justified cases deviations from these requirements may be accepted by BKI on special request.

2. Special requirements for yachts with $L \leq 48$ m

For all types of yachts with a length $L \leq 48$ m the following International Standard has to be applied:

- International Electrotechnical Commission IEC 60092 – Part 507: "Electrical installations in ships – Pleasure craft".

This standard is valid for unrestricted service and all other ranges of service.

Note

1. *This part of IEC 60092 incorporates and coordinates, as far as possible, existing requirements for electrical installations relevant to pleasure craft as published in other parts of the IEC 60092 series, the publications of ISO technical committee 188 and the IEC 60364 series.*
2. *The first edition of this standard has been issued 2000-02 and the committee has decided that the contents of publication will remain unchanged until 2005-06.*

3. Special requirements for yachts with $L > 48$ m

For all types of yachts with a length $L > 48$ m the following BKI Rules have to be applied:

- Rules for Electrical Installations (Pt.1, Vol.IV)
- Rules for Automation (Pt.1, Vol.VII)

E. Documents for Approval

1. General requirements

1.1 All documents have to be submitted in electronic format to BKI in Indonesia or English languages.

1.2 The survey of the yacht's construction will be carried out on the basis of approved documents. The drawings must contain all data necessary for assessment and approval. Where deemed necessary, calculations and descriptions of the yacht's elements are to be submitted. Any non-standard symbols used are to be explained in a key list. All documents must show the number of the project and the name of the owner and/or shipyard.

1.3 Submitted calculations shall contain all necessary information concerning reference documents, literature and other sources.

The calculations have to be compiled in a way which allows to identify and check all steps.

Where appropriate, results of calculations shall be presented in graphic form. A written comment to the main conclusions resulting from the calculations has to be provided.

1.4 BKI reserve the right to demand additional documentation if that submitted is insufficient for an assessment of the ship or essential parts thereof. This may especially be the case for plants and equipment related to new developments and/or which are not tested on board to a sufficient extent.

1.5 The drawings are to be submitted in electronic format, all calculations and supporting documentation in one print for examination at a sufficiently early date to ensure that they are approved and available to the Surveyor at the beginning of the manufacture of the ship or the installation of important components.

1.6 Once the documents submitted have been approved by BKI they are binding on the execution of the work. Subsequent modifications and extensions require the approval of BKI before becoming effective.

2. Guidance for submission of documents

2.1 Upon request the list of required documents for classification will be provided by BKI.

2.2 An excerpt of this list confined to examination of the hull structure regarding issuance of a Hull Construction Certificate is given in the following.

List of Documents to be submitted for the Examination Scope "Hull Construction Certificate"

As far as applicable for an individual yacht the following documents have to be submitted:

- **Hull structural drawings :**
 - General Arrangement Plan
 - Lines Plan
 - Deck Layout
 - Main Particulars (including L_H , L_{WL} , B , B_{WL} , H , T , Δ , v_0)
 - Tank Arrangement Plan
 - Specification of Construction Materials
 - Shell Expansion and Specification of Welded Joints for Metal Hulls
 - Hull Lay-up Plan and Secondary Bonding of Structural Members for Composite Hulls
 - Locations and Size of Openings in the Hull Shell
 - Bulkheads (transverse, longitudinal and wash bulkheads, tank boundaries including positions of overflow)
 - Longitudinal Section (longitudinal and transverse hull structure, location of watertight bulkheads, tank boundaries, deck supporting structures)
 - Midship Section (longitudinal and transverse hull structure, details of anchoring and mooring equipment)
 - Typical Cross Sections of the Aft and Fore End Area
 - Bottom Structure (longitudinal and transverse structure, watertight subdivision of double bottom, if applicable)
 - Engine Room Structure (including main engine foundation)
 - Decks (scantling of deck structures, pillars, location of openings)
 - Bulwark Plating and Structure
 - Superstructures (plating, structural members and support of superstructures like bulkheads and pillars, openings)
 - Propeller Brackets and Shaft Exits, if applicable
 - Bow Thruster, if applicable
 - Windlass and Chain Stopper Seating (including substructure and details on loads to be transmitted)
 - Typical Structural Details
- **Rudder :**
 - Steering Arrangement (if applicable waterjet arrangement)
 - Structure of the Rudder Body
 - Rudder Horn and Structural Integration, if applicable
 - Position and Specification of Rudder Bearings
 - Rudder Stock and Material Specification

- Rudder Bearing Seats
- **Keel of sailing yachts :**
 - Bottom Structure in Way of the Ballast Keel Attachment to the Hull
 - Keel Geometry, Weight and Centre of Gravity
 - Keel Root and other Relevant Cross Sections of the Ballast Keel Structure
 - Details of the Keel's Structural Attachment to the Hull
- **Chain plates of sailing yachts :**
 - Sail Plan and Size of Standing Rigging
 - Hull Structure in Way of Mast Step and Chain plates
 - Details of all Chain plates including Structural Attachment to the Hull

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Section 2 Hull Structures

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A. General, Definitions

1. Notations

1.1 Restricted service ranges

For determining the scantlings of the longitudinal and transverse structures of yachts intended to operate within one of the restricted service ranges **P**, **L** and **T** according to [Section 1, A.7.](#), the design loads may be reduced as specified in the particular case.

1.2 Strengthening for navigation in ice

For yachts with $24\text{ m} \leq L \leq 48\text{ m}$ additional requirements have to be agreed upon with BKI in each individual case.

For yachts with $L > 48\text{ m}$ reference is made to the [Rules for Hull \(Pt.1, Vol.II\), Sec.15.](#)

1.3 Further notations

Further Class Notations are given in [Guidance for Class Notation \(Pt.0, Vol.B\).](#)

2. Equivalence

Yachts deviating from the BKI Rules for Construction and Classification in their type, equipment or in some other parts may be classed, provided that their structures or equipment is found to be equivalent to BKI's requirements for the respective class.

3. Ambient conditions

The ambient conditions including inclinations and movements of the yacht, its environment as well as vibrations and noise to be experienced are described in [Section 1, A.8.](#) and [A.9.](#)

4. Accessibility

All parts of the hull shall be accessible for survey and maintenance, as far as feasible.

5. Stability

The requirements for stability of yachts are defined in [Section 3, D](#).

6. Definitions

6.1 General

Unless noted otherwise, the dimensions according to [6.2](#) and [6.3](#) are to be inserted in [m] into the formulae stated in the following.

6.2 Principal dimensions

6.2.1 Length L

The length L of the yacht is the distance on the waterline at full displacement, from the fore side of the stem to the centre of the rudder stock. L is not to be less than 96 % and need not to be greater than 97 % of the extreme length of the full displacement waterline. In yachts with unusual stern and bow arrangement, the length L will be specially considered.

6.2.2 Length L_c (according to ICLL 66, MARPOL 73/78, IBC-Code and IGC Code)

The length L_c is to be taken as 96 % of the total length on a waterline at 85 % of the least moulded depth H_c , measured from the top of the keel, or as the length from the foreside of the stem to the axis of the rudder stock on that waterline, if that be greater. In yachts designed with a rake of keel the waterline on which this length is measured shall be parallel to the design waterline.

For the definition of the least moulded depth H_c see ICLL 66, Annex I, Chapter I, Regulation 3(5).

6.2.3 Length L^* (according to SOLAS 74, Chapter II-1, Reg. 2)

The length L^* of the yacht is the length measured between perpendiculars taken at the extremities of the deepest subdivision loadline.

6.2.4 Subdivision length L_s

Reference is made to the definition in SOLAS 74, Chapter II-1, Reg. 25 – 2.2.1.

6.2.5 Forward perpendicular FP

The forward perpendicular coincides with the foreside of the stem on the waterline on which the respective length L , L_c , L^* is measured.

6.2.6 Aft perpendicular AP

The aft perpendicular coincides with a point at the distance L aft of FP.

6.2.7 Breadth B

The breadth B is the greatest moulded breadth of the yacht.

Note

The moulded breadth depends on the construction material of the hull:

- steel and aluminium hull: referring to inner edge of the shell
- all other materials: referring to outer edge of the shell

The term "moulded" applies for other dimensions accordingly.

6.2.8 Depth H

The depth **H** is the vertical distance, at the middle of the length **L**, from the base line to top of the deck beam at side on the uppermost continuous deck.

In way of effective superstructures, the depth is to be measured up to the superstructure deck for determining the yacht's scantlings.

6.2.9 Draught T

The draught **T** is the vertical distance, at the middle of the length **L**, from base line to full displacement waterline.

6.2.10 Hull draught T_H

The hull draught T_H is the maximum draught of the canoe body of the yacht.

6.3 Frame spacing **a**

The frame spacing **a** will be measured from moulding edge to moulding edge of frames.

6.4 Block coefficient C_B

Moulded block coefficient at full displacement draught **T**, based on the rule length **L**:

$$C_B = \frac{\nabla}{L \cdot B \cdot T}$$

∇ = moulded volume up to the full displacement waterline [m³]

6.5 Yacht's speed v_0

The yacht's speed v_0 [kn] is the expected maximum ahead speed of the yacht in calm water, at the full displacement waterline.

6.6 Moulded displacement Δ

The moulded displacement Δ is the weight of the yacht [t] at draught **T**.

6.7 Definition of decks

6.7.1 Bulkhead deck

Bulkhead deck is the deck up to which the watertight bulkheads are carried.

6.7.2 Freeboard deck

Freeboard deck is the deck upon which the freeboard calculation is based.

6.7.3 Strength deck

Strength deck is the deck or the parts of a deck which form the upper flange of the effective longitudinal structure.

6.7.4 Weather deck

All free decks and parts of deck exposed to the sea are defined as weather decks.

6.7.5 Shelter deck

Decks which are not accessible to guests and which are not subject to sea pressure. Crew can access such deck with care and taking account of the admissible load, which is to be clearly indicated.

6.7.6 Accommodation deck

Accommodation deck is a deck which is not exposed to the sea and serves as a basis for usual crew or guest accommodation.

6.7.7 Superstructure deck

The superstructure decks situated immediately above the uppermost continuous deck are termed forecastle deck, bridge deck and poop deck.

6.8 Coordinate system

For the description of the yacht's geometry the fixed, right-handed coordinate system O, x, y, z as defined in Fig. 2.1 is introduced. The origin of the system is situated at the aft perpendicular, at centreline and on the moulded baseline at the yacht's keel. The x -axis points in longitudinal direction of the yacht positive forward, the y -axis positive to port and the z -axis positive upwards. Angular motions are considered positive in a clockwise direction about the three axes.

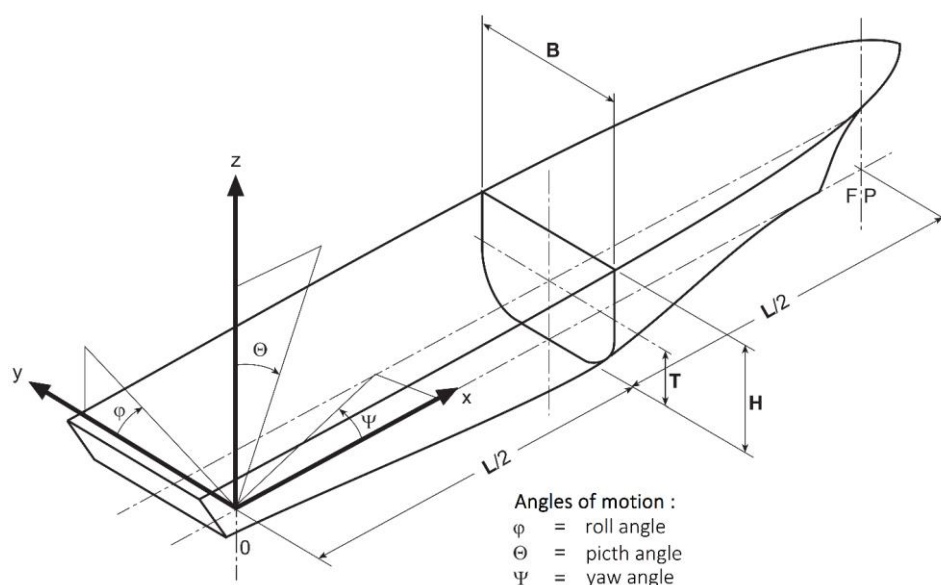


Fig. 2.1 Coordinate system and angles of motion

7. Computer programs

7.1 General

7.1.1 In order to increase the flexibility in the structural design of yachts, BKI also accepts direct calculations with computer programs. The aim of such analyses should be the proof of equivalence of a design with the rule requirements.

7.1.2 Direct calculations may also be used to optimise a design; in this case only the final results are to be submitted for examination.

7.2 General programs

7.2.1 The choice of computer programs according to the "State of the Art" is free. The programs may be checked by BKI through comparative calculations with predefined test examples. A generally valid approval for a computer program is, however, not given by BKI. BKI reserve the right to refuse computer programs.

7.2.2 Direct calculations may be applied regarding:

- global strength
- longitudinal strength
- beams and grillages
- strength of structural details

7.2.3 For such calculations, the structural model, boundary conditions and load cases are to be agreed upon with BKI.

Calculation documents are to be submitted including input and output. During the examination it may prove necessary that BKI perform independent comparative calculations.

8. Workmanship

8.1 Requirements to be complied with by the manufacturer

8.1.1 Every manufacturing plant participating in a yacht project must be provided with suitable equipment and facilities to enable proper handling of the materials, manufacturing processes, structural components, etc. BKI reserve the right to inspect the plant accordingly or to restrict the scope of manufacture to the potential available at the plant.

The manufacturing plant must have at its disposal sufficiently qualified personnel. BKI must be advised of the names and areas of responsibility of all supervisory and control personnel. BKI reserve the right to require proof of relevant qualification.

8.1.2 The shipyard or manufacturing plant and its subcontractors must get approval from BKI for the type of work provided for the manufacture and installation of yachts. Approval can only be awarded if the conditions defined in detail in [Rules for Materials \(Pt.1. Vol.V\)](#) and [Rules for Welding \(Pt.1, Vol.VI\)](#) are fulfilled

8.1.3 The fabrication sites, stores and their operational equipment shall comply also with the requirements of the relevant Safety Authorities and Professional Associations. The shipyard or manufacturing plant is alone responsible for compliance.

8.2 Quality control

8.2.1 It is recommended that the shipyard operates a quality assurance system, like ISO 9001 or equivalent.

8.2.2 As far as required and expedient, the manufacturer's personnel has to examine all structural components both during the manufacture and on completion, to ensure that they are complete, that the dimensions are correct and that workmanship is satisfactory and meets the standard of good shipbuilding practice.

8.2.3 Upon inspection and corrections by the manufacturing plant, the structural components are to be shown to the BK Surveyor for inspection, in suitable sections, normally in unpainted condition and enabling proper access for inspection.

8.2.4 The Surveyor may reject components that have not been adequately checked by the plant and may demand their re-submission upon successful completion of such checks and corrections by the plant.

9. Structural details

9.1 Details in manufacturing documents

9.1.1 All significant details concerning quality and functional ability of the components concerned shall be entered in the manufacturing documents (workshop drawings, etc.). This includes not only scantlings but, where relevant, such items as surface conditions (e.g. finishing of flame cutting edges and weld seams), and special methods of manufacture involved as well as inspection and acceptance requirements and, where relevant, permissible tolerances.

For details of welded joints see [Rules Welding \(Pt.1, Vol.VI\)](#), [Annex 6 for Steel](#) and [7 for Aluminium](#).

For details of adhesive joints see the [Rules for Non-Metalic Materials \(Pt.1, Vol.XIV\) Chapter 1 - Fibre Reinforced Plastics and Bondings](#) and [Chapter 3 – Guidelines for Elastomeric Adhesive and Adhesive Joints](#)

9.1.2 If, due to missing or insufficient details in the manufacturing documents, the quality or functional ability of the component cannot be guaranteed or is doubtful, BKI may require appropriate improvements. This includes the provision of supplementary or additional parts (for example reinforcements) even if these were not required at the time of plan approval or if – as a result of insufficient detailing – such requirement was not obvious.

9.2 Cut-outs, plate edges

9.2.1 The free edges (cut surfaces) of cut-outs, hatch corners, etc. are to be properly prepared and are to be free from notches. As a general rule, cutting drag lines, etc. must not be welded out, but are to be smoothly ground. All edges should be broken or in cases of highly stressed parts, should be rounded off.

9.2.2 Free edges on flame or machine cut plates or flanges are not to be sharp cornered and are to be finished off as laid down in [9.2.1](#). This also applies to cutting drag lines, etc., in particular to the upper edge of shear strake and analogously to weld joints, changes in sectional areas or similar discontinuities.

9.3 Cold forming

9.3.1 For cold forming (bending, flanging, beading) of plates the minimum average bending radius should not fall short of 3 times the plate thickness t . For the welding of cold formed areas special requirements have to be agreed.

9.3.2 In order to prevent cracking, flame cutting flash or sheering burrs must be removed before cold forming. After cold forming all structural components and, in particular, the ends of bends (plate edges) are to be examined for cracks. Except in cases where edge cracks are negligible, all cracked components are to be rejected. Repair welding is not permissible.

9.4 Assembly, alignment

9.4.1 The use of excessive force is to be avoided during the assembly of individual structural components or during the erection of sub-assemblies. As far as possible, major distortions of individual structural components should be corrected before further assembly.

9.4.2 Girders, beams, stiffeners, frames, etc. that are interrupted by bulkheads, decks, etc. must be accurately aligned. In the case of critical components, control drillings are to be made where necessary, which are then to be welded up again on completion.

9.4.3 After completion of welding, straightening and aligning must be carried out in such a manner that the material properties will not be influenced significantly. In case of doubt, BKI may require a procedure test or a working test to be carried out.

9.5 Combination of different materials

9.5.1 Preventive measures are to be taken to avoid contact corrosion associated with combination of dissimilar metals with different potentials in an electrolyte environment, such as sea water.

9.5.2 The selection of different materials has to take into account the fact that also combination of composite materials, like fibre reinforced plastics, sandwich constructions, etc. and wood with each other or also with metals may lead to contact corrosion.

9.5.3 In addition to selecting appropriate materials, steps such as suitable insulation, an effective coating and the application of cathodic protection can be taken in order to prevent contact corrosion.

9.5.4 The selected solutions for protection have to be presented to BKI for approval.

10. Corrosion protection

[B.6.](#) is to be observed.

B. Materials, Corrosion Protection and Joining Technology

1. General

All materials to be used for the structural members mentioned in these Rules are to be in accordance with the [Rules for Materials \(Pt.1, Vol.V\)](#), [Rules for Non-Metalic Materials \(Pt.1 Vol.XIV\)](#), and [Rules for Welding \(Pt.1, Vol.VI\)](#). Materials the properties of which deviate from these rule requirements may only be used upon special approval by BKI.

2. Steel materials and welding

2.1 Normal strength hull structural steel

Normal strength hull structural steel is a hull structural steel with a minimum nominal upper yield point R_{eH} of 235 N/mm² and a tensile strength R_m of 400 – 520 N/mm².

2.1.1 The material factor k in the formulae of C., D., G., J. in the following is to be taken 1,0 for normal strength hull structural steel.

2.1.2 Normal strength hull structural steel is grouped into the grades KI-A, KI-B, KI-D, KI-E, which differ from each other in their toughness properties. For the application of the individual grades for the hull structural members see 2.3.

2.1.3 If for special structures the use of steels with yield properties less than 235 N/mm² has been accepted, the material factor k is to be determined by:

$$k = \frac{235}{R_{eH}}$$

2.2 Higher strength hull structural steels

Higher strength hull structural steel is a hull structural steel, the yield and tensile properties of which exceed those of normal strength hull structural steel. For three groups of higher strength hull structural steels the nominal upper yield stress R_{eH} has been fixed at 315, 355 and 390 N/mm² respectively. Where higher strength hull structural steel is used, for scantling purposes the values in Table 2.1 are to be used for the material factor k mentioned in C., D., G., J. of the following:

Table 2.1 Material factors for higher strength hull structural steel

R_{eH} [N/mm ²]	k
315	0,78
355	0,72
390	0,66 Provide that a fatigue assessment of the structure is performed to verify compliance with the requirements of BKI
	0,68 In other cases

For higher strength hull structural steel with other nominal yield stresses, the material factor k may be determined by the following formula:

$$k = \frac{295}{R_{eH} + 60}$$

Note

Especially when higher strength hull structural steels are used, limitation of permissible stresses due to buckling and fatigue strength criteria may be required.

2.2.1 Higher strength hull structural steel is grouped into the following grades, which differ from each other in their toughness properties:

KI-A 32/36/40

KI-D 32/36/40

KI-E 32/36/40

KI-F 32/36/40

In [Table 2.2](#) the grades of the higher strength steels are marked by the letter "H".

2.2.2 Where structural members are completely or partly made from higher strength hull structural steel, a suitable notation will be entered into the yacht's certificate.

2.2.3 In the drawings submitted for approval it is to be shown which structural members are made of higher strength hull structural steel. These drawings are to be placed on board in case any repairs are to be carried out.

2.2.4 Regarding welding of higher strength hull structural steel, see [Rules for Welding \(Pt.1, Vol.VI\) Sec. 12](#).

2.3 Material selection for the hull

2.3.1 Material classes

For the material selection for hull structural members material classes as given in [Table 2.2](#) are defined.

2.3.2 Material selection for longitudinal structural members

Materials of the various structural members are not to be of lower grades than those obtained from the [Table 2.3](#). Depending on the categories of structural members (Secondary, Primary and Special) for structural members not specifically mentioned in [Table 2.3](#), grade A/AH material may generally be used. Single plate strakes within 0,4 L amidships for which class III or E/EH material is required are to have a breadth $b = 800 + 5 L$, max. 1800 mm.

Table 2.2 Material classes

Thickness t [mm] ¹		> 15	> 20	> 25	> 30	> 40	> 50
Material class	≤ 15	≤ 20	≤ 25	≤ 30	≤ 40	≤ 50	≤ 100 ³
I	A/AH	A/AH	A/AH	A/AH	B/AH	D/DH	D/DH ²
II	A/AH	A/AH	B/AH	D/DH	D/DH ⁴	E/EH	E/EH
III	A/AH	B/AH	D/DH	E/EH	E/EH	E/EH	E/EH

¹ Actual thickness of the structural member.
² For thicknesses t > 60 mm E/EH.
³ For thicknesses t > 100 mm the steel grade is to be agreed with BKI.
⁴ For nominal yield stresses $R_{eH} \geq 390 \text{ N/mm}^2$ EH.

Table 2.3 Material class or grade for longitudinal structural members

Structural member category	Material class or grade	
	Within 0,4 L amidships	Outside 0,4 L amidships
Secondary: <ul style="list-style-type: none"> - Longitudinal bulkhead strakes, other than that belonging to the Primary category - Deck plating exposed to weather other than that belonging to the Primary or Special category - Side plating 	I	A/AH

Table 2.3 Material class or grade for longitudinal structural members (continued)

Structural member category	Material class or grade	
	Within 0,4 L amidships	Outside 0,4 L amidships
Primary: <ul style="list-style-type: none">- Bottom plating, including keel plate- Strength deck plating ¹, excluding that belonging to the Special category- Continuous longitudinal plating of strength members- Upper strake in longitudinal bulkhead- Vertical strake	II	A/AH
Special: <ul style="list-style-type: none">- Shear strake at strength deck- Stringer plate in strength deck- Deck strake at longitudinal bulkhead	III	II (I outside 0,6 L)
	<ul style="list-style-type: none">- Bilge strake in ships with double bottom over the full breadth and length less than 150 m	

¹ Class III or grade E/EH to be applied in positions where high local stresses may occur.

2.3.3 Material selection for local structural members

.1 The material selection for local structural members, which are not part of the longitudinal hull structure, may in general be effected according to [Table 2.4](#).

Table 2.4 Material class for local structural members

Structural member	Material class
Hawse pipe, stern tube, pipe stanchion ³	I
Face plates and webs of girder systems	II ¹
Rudder body ² , rudder horn, sole piece, stern frame, propeller brackets	II
¹ Class I material sufficient, where rolled sections are used or the parts are machine cut from normalized plates ² See 2.3.3.2 ³ For pipe stanchions for cargo reefer holds Table 2.12 is applicable.	

.2 Rudder body plates, which are subjected to stress concentrations (e.g. in way of lower support of semi-spade rudders), are to be of class III material.

.3 Members not specifically mentioned, may be of class I material.

For top plates of machinery foundations located outside 0,6 L amidships, grade A normal strength hull structural steel may also be used for thicknesses above 40 mm.

2.3.4 Structural members which are stressed in direction of their thickness

.1 In case of high local stresses in the thickness direction, e.g. due to shrinkage stresses in single bevel or double bevel T-joints with a large volume of weld metal, steels with guaranteed material properties in the thickness direction according to [Rules for Materials \(Pt.1, Vol.V\), Sec.4, I.](#) are to be used.

2.4 Forged steel and cast steel

Forged steel and cast steel for stem, stern frame, rudder post, etc. is to comply with [Rules for Materials \(Pt.1, Vol.V\)](#). The tensile strength of forged steel and of cast steel is not to be less than 400 N/mm². Forged steel and cast steel are to be selected under consideration of 2.3. In this respect beside strength properties also toughness requirements and weldability shall be observed.

2.5 Austenitic steels

2.5.1 Stainless steels with a pitting resistance equivalent W (W = % Cr + 3,3·% Mo) exceeding 25 are suitable for sea water without special corrosion protection, see [Table 2.5](#).

Table 2.5 Designation and mechanical properties of austenitic stainless steels (in welded condition)

Material number	Designation according to EN 10088	Sweden SS	USA AISI / SAE	Tensile strength R _m [N/mm ²]	Yield strength R _{p0,2} [N/mm ²]	Pitting resistance equivalent W
1.4306	X2CrNi19-11	2333	340 L	500 – 650	200	18
1.4404	X2CrNiMo17-12-2	2348	316 L	520 – 670	220	23
1.4435	X2CrNiMo18-14-3	2353	316 L ¹	520 – 670	220	25
1.4438	X2CrNiMo18-16-4	2367	317 L	520 – 720	220	27
1.4439	X3CrNiMoN17-13-5	—	—	580 – 780	270	33
1.4541	X6CrNiTi18-10	2337	321	500 – 700	200	17
1.4462	X2CrNiMoN22-5-3	2324	329	640 – 840	460	31
1.4571	X6CrNiMoTi17-12-2	2350	316 Ti	520 – 670	220	24
¹ valid for Mo > 2,5 %						

2.5.2 Where austenitic steels are applied having a ratio

$$\frac{R_{p0,2}}{R_m} \leq 0,5$$

on special approval the 1 % proof stress R_{p1,0} may be used for scantling purposes instead of the 0,2 % proof stress R_{p0,2}.

2.6 Welding

The following information summarizes some principle aspects to be considered for the design of Yachts. Detailed requirements are contained in the [Rules for Welding \(Pt.1, Vol.VI\)](#).

2.6.1 Information contained in manufacturing documents

.1 The shapes and dimensions of welds and, where proof by calculation is supplied, the requirements applicable to welded joints (the weld quality grade, detail category) are to be stated in

drawings and other manufacturing documents (parts lists, welding and inspection schedules). In special cases, e.g. where special materials are concerned, the documents shall also state the welding method, the welding consumables used, heat input and control, the weld build-up and any post-weld treatment which may be required.

.2 Symbols and signs used to identify welded joints shall be explained if they depart from the symbols and definitions contained in the relevant standards (e.g. ISO standards). Where the weld preparation (together with approved methods of welding) conforms both to normal shipbuilding practice and to these Rules and recognized standards, where applicable, no special description is needed.

2.6.2 Materials, weldability

.1 Only base materials of proven weldability may be used for welded structures. Any approval conditions of the steel or of the procedure qualification tests and the steelmaker's recommendations are to be observed.

.2 For normal strength hull structural steels grades A, B, D and E which have been tested by BKI, weldability is considered to have been proven. No measures beyond those laid down in these welding rules need therefore to be taken.

.3 Higher strength hull structural steels grade AH/DH/EH/FH which have been approved by BKI in accordance with the relevant requirements of [Rules for Welding \(Pt.1, Vol.VI\)](#), have had their weldability examined and, provided their handling is in accordance with normal shipbuilding practice, may be considered to be proven.

.4 High strength (quenched and tempered) fine grain structural steels, low temperature steels, stainless and other (alloyed) structural steels require special approval by BKI. Proof of weldability of the respective steel is to be presented in connection with the welding procedure and welding consumables.

.5 Cast steel and forged parts testing by BKI. The carbon content of components for welded structures must not exceed 0,23 % C (piece analysis not exceeding 0,25 % C).

.6 Welding consumables used are to be suitable for the parent metal to be welded and are to be approved by BKI. Where filler materials having tensile properties deviating (downwards) from the parent metal are used (upon special agreement by BKI) this fact must be taken into account when dimensioning the weld joints.

2.6.3 Manufacture and testing

.1 The manufacture of welded structural components may only be carried out in workshops or plants that have been approved by BKI. The requirements that have to be observed in connection with the fabrication of welded joints are laid down in [Rules for Welding \(Pt.1, Vol.VI\)](#).

.2 The weld quality grade of welded joints without proof by calculation (see [2.6.1.1](#)) depends on the significance of the welded joint for the total structure and on its location in the structural element (location relative to the main stress direction) and on its stressing. For details concerning the type, scope and manner of testing, see [Rules for Welding \(Pt.1, Vol.VI\), Sec.12, I](#).

2.6.4 General design principles

.1 During the design stage welded joints are to be planned such as to be accessible during fabrication, to be located in the best possible position for welding and to permit the proper welding sequence to be followed.

.2 Both the welded joints and the sequence of welding involved are to be so planned as to enable residual welding stresses to be kept to a minimum in order that no excessive deformation occurs. Welded joints should not be over dimensioned.

.3 When planning welded joints, it must first be established that the type and grade of weld envisaged, such as full root weld penetration in the case of HV or DHV (K) weld seams, can in fact be perfectly executed under the conditions set by the limitations of the manufacturing process involved. If this is not the case, a simpler type of weld seam shall be selected and its possibly lower load bearing capacity taken into account when dimensioning the component.

.4 Highly stressed welded joints, which therefore, are generally subject to examination, are to be so designed that the most suitable method of testing for faults can be used (radiography, ultrasonic, surface crack testing methods) in order that a reliable examination may be carried out.

.5 Special characteristics peculiar to the material, such as the lower strength values of rolled material in the thickness direction or the softening of cold worked aluminium alloys as a result of welding, are factors which have to be taken into account when designing welded joints.

.6 In cases where different types of material are paired and operate in sea water or any other electrolytic medium, for example welded joints made between unalloyed carbon steels and stainless steels in the wear-resistant cladding in rudder nozzles or in the cladding of rudder shafts, the resulting differences in potential greatly increase the susceptibility to corrosion and must therefore be given special attention. Where possible, such welds are to be positioned in locations less subject to the risk of corrosion (such as the outside of tanks) or special counter-measures are to be taken (such as the provision of a protective coating or cathodic protection).

2.6.5 Design details

For design details see the [Rules for Hull \(Pt.1, Vol.II\) Sec.19](#).

3. Aluminium alloys and welding

The following information is based on the [Rules for Materials \(Pt.1, Vol.V\) Sec.10](#) with the aim of summarizing aspects applicable for the design of Yachts.

3.1 General

3.1.1 The following requirements are applicable to products made from wrought aluminium alloys having a product thickness of 3 to 50 mm inclusive. Requirements applicable to products having thicknesses outside this range are to be specially agreed with BKI.

3.1.2 Alloys and material conditions which differ from the specified requirements given below, but which conform to national standards or the manufacturer's material specifications may be used provided that their properties and suitability for use, and also their weldability have been checked by BKI and that BKI has approved their use.

3.1.3 Alloy designations and material conditions specified herein comply with the designations of the Aluminium Association. With regard to the definition of the material conditions ISO 2107 (Aluminium and aluminium alloys - Wrought products - Temper designations) is applicable.

3.2 Requirements to be met by manufacturers

Manufacturers wishing to supply products in accordance with these requirements must be approved by BKI for the alloys and product forms in question.

3.3 General characteristics of products

3.3.1 The products must have a smooth surface compatible with the method of manufacture and must be free of defects liable to impair further manufacturing processes or the proposed application of the products, e.g. cracks, laps, appreciable inclusions of extraneous substances and major mechanical damage.

3.3.2 Surface defects may be repaired only by grinding provided that this is accomplished with a gentle transition to the adjacent surface of the product and that the dimensions remain within the tolerance limits. Repair by welding is not permitted. For repair purposes only tools are to be used which are exclusively applied for aluminium processing.

3.4 Aluminium alloys without post treatment for hardening

3.4.1 Aluminium alloys of 5000 series in O condition (annealed) or in H111 condition (annealed flattened) retain their original mechanical characteristics and therefore are not subject to a drop in mechanical strength in the welded areas.

3.4.2 These types of aluminium alloys are used for plates, strips and rolled sections and a representative list is defined in Table 2.6. This list, as well as the list of Table 2.7, is not exhaustive. Other aluminium alloys may be considered provided the specification (manufacture, chemical composition, temper, mechanical properties, welding, etc.) and the scope of application is submitted to BKI and approved.

3.4.3 Unless otherwise specified, the Young's modulus of aluminium alloys is equal to 70.000 N/mm² and the Poisson's ratio equal to 0,33.

Table 2.6 Material condition and strength properties of plates and strips made of wrought aluminium alloys (with thickness $t = 3,0$ to 50 mm) ¹

Alloy number	Material condition	$R_{p0,2}$ min. [N/mm ²]	R_m [N/mm ²]	Material factor $k_{A\ell}$
KI AW-5083 (AlMg4,5Mn0,7)	O/H111/H112	125	275 – 350	1,59 – 1,34
	H116	215	≥ 305	1,22
	H32	215	305 – 380	1,22 – 1,07
	Welded	125	275	1,59
KI AW-5086 (AlMg4)	O/H111/H112	100	240 – 310	1,87 – 1,55
	H116	195	≥ 275	1,35
	H32/H321	185	275 – 335	1,38 – 1,22
	Welded	100	240 – 310	1,87 – 1,55
KI AW-5754 (AlMg3)	O/H111/H112	80	190 – 240	2,35 – 1,98
	H32	165	≥ 240	1,57
	Welded	80	190 – 240	2,35 – 1,98
KI AW-5456	O	130-205	290-365	1,51 – 1,11
		125-205	285-360	1.54 – 1,12
	H116	230	315	1.17
		215	305	1.22
		200	285	1.31
	H321	230-315	315-405	1.61 – 0.88

Table 2.6 Material condition and strength properties of plates and strips made of wrought aluminium alloys (with thickness $t = 3,0$ to 50 mm) ¹ (continued)

Alloy number	Material condition	$R_{p0,2}$ min. [N/mm ²]	R_m [N/mm ²]	Material factor $k_{A\ell}$
KI AW-5456	H321	215-305	305-385	1.22 – 0.92
		200-295	285-370	1.31 – 0.95
KI AW-5454	O/H111	85	≥ 215	2.12
	H32	180	≥ 250	1.48
KI AW-5383	O/H111	145	≥ 290	1.46
	H116/H321	220	≥ 305	1.21
KI AW-5059 (AlMgMn0,8ZnZr)	O/H111	≥ 160	≥ 330	1,30
	H116	≥ 260	≥ 360	1,02
	H321	≥ 260	≥ 360	
	Welded	≥ 160	≥ 300	1,38

¹The strength properties are applicable to both longitudinal and transverse specimens.

Table 2.7 Material condition and strength properties of extruded sections, bars and pipes made of wrought aluminium alloys (with thickness $t = 3,0$ to 50 mm) ¹

Alloy number	Material condition	$R_{p0,2}$ min. [N/mm ²]	R_m [N/mm ²]	Material factor $k_{A\ell}$
KI AW-5059	H112	200	≥ 330	1,20
KI AW-5083 (AlMg4,5Mn0,7)	O/H111	110	270 – 350	1,67 – 1,38
	Welded	125	275	1,59
KI AW-5086 (AlMg4)	O/H111	95	240 – 350	1,90 – 1,43
	Welded	100	240	1,87
KI AW-5383 (AlMg4,5Mn0,9)	O/H111	145	≥ 290	1,46
	H112	190	≥ 310	1,27
KI AW-6005A (AlSiMg(A))	T5/T6	215	≥ 260	1,34
	Welded	115	165	2,27
KI AW-6061 (AlMg1SiCu)	T5/T6	240	≥ 260	1,27
	Welded	115	155	2,35
KI AW-6082 (AlSi1MgMn)	T5/T6	260	≥ 310	1,11
	Welded	125	185	2,05

¹The strength properties are applicable to both longitudinal and transverse specimens.

3.5 Hardened aluminium alloys

3.5.1 Aluminium alloys can be hardened by work hardening (Series 5000 other than condition O or H111) or by heat treatment (series 6000).

3.5.2 These types of aluminium alloys are used for extruded section, bars and pipes and a representative selection is defined in [Table 2.7](#).

3.6 Material selection

3.6.1 The choice of aluminium alloys according to [Table 2.7](#) is mainly recommendable for extrusions and where no excessive welding will be necessary. Otherwise only the mechanical characteristics of O or H111 conditions can be taken into account. Higher mechanical characteristics to be used must be duly justified.

3.6.2 In case of structures subjected to low service temperatures or intended for other particular applications, the alloys to be employed are to be defined in each separate case by BKI, which will state the acceptability requirements and conditions.

3.6.3 For forgings and castings to be applied, requirements for chemical composition and mechanical properties are to be defined in each separate case by BKI.

3.7 Welding

3.7.1 General requirements

For welding of aluminium the requirements of relevant BKI Rules apply. In particular, existing welding procedure qualifications may be approved by BKI or BKI will decide if new qualifications will become necessary. Welding shops and the employed welders have to be approved for the relevant welding procedures.

3.7.2 Influence of welding on mechanical characteristics

.1 Aluminium alloys of series 5000 in O condition (annealed) or in H111 condition (annealed flattened) are not subject to a drop in mechanical strength in the welded areas. But welding heat input lowers the mechanical strength of alloys of series 5000 with other conditions and of that of series 6000, which are hardened by heat treatment.

.2 For heat-affected welding zones the mechanical characteristics of series 5000 to be considered are, normally, those of condition O or H111. Higher mechanical characteristics may be taken into account, provided they are duly justified.

.3 For heat-affected zones the mechanical characteristics of series 6000 to be considered are, normally, to be indicated by the supplier.

.4 The heat-affected zone may be taken to extend 25 mm on each side of the weld axis.

3.7.3 Preparation for welding

Edge cutting, to be carried out in general by machining, is to be regular and without burrs or cuts.

The structural parts to be welded as well as those adjacent, even if they have been previously pickled, are to be cleaned carefully before welding, using suitable mechanical means, such as stainless steel wire brushes, so as to eliminate oxides, grease or other foreign matter which could give rise to welding defects.

3.7.4 Welding processes

.1 In general, the welding of the hull structures is to be performed with the MIG (metal-arc inert gas) or the TIG (tungsten-arc inert gas) processes using welding consumables recognized as suitable for the base material to be used. For joints with extreme stress and execution requirements (gas and liquid tight, etc.) the TIG method is recommendable, otherwise the MIG method may be used. Welding processes and filler materials other than those mentioned are to be individually considered by BKI at the time of the approval of welding procedures.

.2 For the authorization to use welding procedures in production, the following details are to be stated:

- grade and temper of parent and filler materials
- weld execution procedures: type of joint (e.g. butt-joint, fillet joint); edge preparation (e.g. thicknesses, bevelling, right angle edges); welding position (e.g. flat, vertical, horizontal) and other parameters (e.g. voltage, amperage, gas flow capacity)
- welding conditions (e.g. cleaning procedures of edges to be welded, protection from environmental atmosphere)
- special operating requirements for butt-joints, for example for plating: welding to be started and completed on end pieces outside the joint, back chipping, arrangements for repairs consequent to possible arc restarts
- type and extent of controls during production

.3 Establishing high welding speeds to reduce the transfer of thermal loads is recommended.

.4 Impermissible reinforcements of seams and hardened transition areas in the basic material shall be carefully removed.

3.7.5 Inspections

.1 Inspections of welded connections by BKI Surveyors are, in general, those specified below, with the extent of inspection to be defined by BKI on a case by case basis:

- inspection of base materials for compliance with the requirements 3.4 to 3.6 and for compliance of structures with the approved plans
- inspection of the use and application conditions of welding procedures for compliance with those approved and verification that qualified welders are employed
- visual examination of edge preparations, root chipping and execution of welds in way of structural connections
- examination of radiographs of welded joints (radiographing is to be performed, if necessary, depending on the extent of the examinations), and inspection of performance of execution of the ultrasonic or magnetic particle examinations, which may be required
- inspection of any repairs, to be performed with procedures and inspection methods at the discretion of the Surveyor

.2 The limits for imperfections in welded joints of aluminium alloys are defined in the [Rules for Welding \(Pt.1, Vol.VI\)](#).

.3 Irrespective of the extent of such inspections, it is the responsibility of the builder to ensure that the manufacturing procedures, processes and sequences are in compliance with relevant BKI requirements, approved plans and sound working practice. For this purpose, the shipyard is to have its own quality management system.

3.7.6 General design principles

The following design principles shall be applied:

- transfer of welding seams to low stress areas, like the neutral axis of a girder by using extruded sections for the upper and lower flange
- location of welding seams in such a way, that the thermal load from welding will be led to a far extent to extrusion profiles with big wall thicknesses

- edge preparation, alignment of joints are to be appropriate to the type of joint and welding position, and comply with BKI Rules requirements for the welding procedures adopted
- for correct execution of welded joints, sufficient accessibility is necessary, depending on the welding process adopted and the welding position
- unfavourable welding positions have to be avoided

3.8 Material factor

The material factor k for aluminium alloys is to be determined according to:

$$k_{Al} = \frac{635}{R_{p0,2} + R_m}$$

$R_{p0,2}$ = 0,2 % proof stress of the aluminium alloy [N/mm²]

R_m = tensile strength of the aluminium alloy [N/mm²]

For welded connections the respective values in welded condition are to be taken. Where these figures are not available, the respective values for the soft- annealed condition are to be used.

Note

The material factor to be used in the [Rules for High Speed Craft \(Pt.3, Vol. III\)](#), Sec. 3 is different from the above definition.

3.9 Conversion from steel to aluminium scantlings:

- section modulus: $W_{Al} = W_{St} \cdot k_{Al}$
- plate thickness: $t_{Al} = t_{St} \cdot \sqrt{k_{Al}}$

3.9.1 When determining the buckling strength of structural elements subject to compression, the modulus of elasticity of aluminium must be taken into account. This applies accordingly to structural members for which limited shape imperfections are pre- scribed.

3.9.2 The conversion of the scantlings of the main hull structural elements from steel into aluminium alloy is to be specially considered taking into account the smaller modulus of elasticity, as compared with steel, and the fatigue strength aspects, especially those of the welded connections.

4. Riveting

4.1 The use of rivets for connecting structures shall be specially agreed with BKI. Special applications are to be supported by experimental evidence or good in-service performance.

4.2 The conditions for riveted connection acceptability are to be individually stated in each particular case, depending on the type of members to be connected and the rivet material.

4.3 Whenever riveted connections are to be employed, a detailed plan, illustrating the process, as well as the dimensions and location of rivets and holes, together with the mechanical and metallurgical properties of the rivets, is to be submitted for approval. Specimens of riveted connections constructed under the same conditions as during actual hull construction, to be witnessed by a Surveyor.

4.4 BKI may, at its discretion, require tension, compression and shear tests to be carried out on.

4.5 BKI reserve the right to accept the results of tests performed by recognized bodies or other Classification Societies.

5. Welding transition joints

5.1 General

5.1.1 For welded transitions of the hull structures between steel and aluminium alloys explosion-bonded steel-aluminium transition joints may be used. This use for plates or profiles is subject to BKI's agreement.

5.1.2 Any such jointing system is to be type-approved by BKI.

5.1.3 Qualifications tests for welding procedures are to be carried out for each joint configuration.

5.1.4 A welding booklet giving preparations and various welding parameters for each type of assembly is to be submitted for review.

5.2 Types of explosion-bonded joints

According to the present state of technology and application, the following types of explosion-bonded joints are used:

- butt welds in the welding transition as such
- joints of platings (walls, decks), as a cruciform joint with coaming or a T-joint without coaming
- joints of stiffeners, as a cruciform joint with coaming or a T-joint without coaming
- joints of transverse walls, as cruciform joint with coaming or T-joint without coaming

5.3 Permissible transition stresses

For some widely used steel-aluminium transition joints the permissible stresses to be transmitted are defined in [Table 2.8](#). Owing to the fact, that in general the connection between steel and aluminium is of lower specific strength, a larger surface is therefore required for force transmission.

5.4 Inadmissible heating

For all connections it has to be ensured, that the bond zone between steel and aluminium is not inadmissibly heated above a maximum temperature of 300 °C, as this would cause embrittlement implying the risk of failures.

6. Corrosion protection

6.1 General

For corrosion protection the requirements according to [Guidance for Corrosion Protection \(Pt.1, Vol. G\)](#) have to be met. In addition the requirements below shall be observed. Special solutions concerning material selection, coatings, cathodic protection systems or other methods may be accepted after examination.

6.2 Shop primers

Shop primers are used to provide protection of the steel parts during storage, transport and work processes. Customarily, coatings with a thickness of 15 to 20 µm are applied. This should provide corrosion protection for a period of approx. 6 months.

6.3 Hollow spaces

Hollow spaces, such as those in closed box girders, tube supports and the like, which either can be shown to be air tight or are accepted as such from normal shipbuilding experience, need not have their internal surfaces protected. During assembling, however such hollow spaces must be kept clean and dry.

6.4 Combination of materials

Preventive measures are to be taken to avoid contact corrosion associated with the combination of dissimilar metals with different potentials in an electrolyte solution, such as seawater. In addition to selecting appropriate materials, steps such as suitable insulation, an effective coating and the application of cathodic protection can be taken in order to prevent contact corrosion.

Table 2.8 Material combination and permissible stresses

Type of bonding	Material combination		Permissible tensile stress through thickness [N/mm ²]	Permissible shear stress [N/mm ²]
	Steel	Aluminium alloy		
Explosion-bonded	All types	All types	60	60

6.4.1 Heterogeneous assemblies of steel and aluminium alloys

Connections between aluminium alloy and steel parts, if any, are to be protected against corrosion by means of coatings applied by suitable procedures agreed by BKI.

In any case, any direct contact between steel and aluminium alloy is to be avoided (e.g. by means of zinc or cadmium plating of the steel parts and application of a suitable coating on the corresponding light alloy parts).

6.5 Corrosion protection of ballast water tanks

All seawater ballast tanks having boundaries formed by the vessel's side shell (bottom, outside plating, deck) must be provided with a corrosion protection system consisting of coating and cathodic protection

6.6 Corrosion protection of the underwater hull

6.6.1 Coatings based on epoxy, polyurethane and polyvinyl chloride are considered suitable.

6.6.2 The coating manufacturer's instructions with regard to surface preparation as well as application conditions and processing must be observed.

6.6.3 The coating system without antifouling shall:

- have a minimum dry film thickness of 250 µm
- provide cathodic protection in accordance with recognized standards
- be suitable for being cleaned underwater by mechanical means

6.6.4 The cathodic protection can be provided by means of sacrificial anodes, or by impressed current systems. Under normal conditions for steel, a protection current density of at least 10 mA/m² must be ensured. Hulls or components made of aluminium and aluminium alloys, which are permanently immersed in seawater need to be protected by sacrificial anodes. For hull structures or components of zinc-free aluminium materials which are permanently submerged in seawater, cathodic protection with a protective

potential of less than -0,55 V by sacrificial anodes is required. A cathodic protection is especially needed, if galvanic corrosion is to be expected due to a bimetallic couple between the submerged aluminium alloy structure and other parts, e.g. propulsion components such as stainless steel propeller shafts, bronze propellers or steel hydrojets.

Therefore metallic connection between aluminium alloy structures and other metals should be avoided.

6.6.5 In the case of impressed current systems, overprotection due to inadequately low potential is to be avoided. A screen (dielectric shield) is to be provided in the immediate vicinity of the impressed- current anodes.

6.7 Corrosion protection of austenitic stainless steels

Stainless steels and stainless steel castings exhibit a passive surface state in seawater. Accordingly, coating these types of steel is only recommended under special conditions. In general uncoated stainless steels are not protected by cathodic corrosion protection if they are suitable for withstanding the corrosion stress. Coated stainless steels must be cathodically protected in the submerged zone.

7. Fibre reinforced plastics, sandwich constructions and bonding

Refer to [Rules for Non - Metallic Materials \(Pt.1, Vol.XIV\) Chapter 1 – Fibre Reinforced Plastics and Bondings](#).

7.1 Approval of materials

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 the respective approval procedure is in accordance with BKI requirements.

7.2 Properties of the materials

The basic properties of the different materials shall be verified by test certificate of a recognized testing body. These values shall fulfil the minimum requirements specified in the relevant BKI Rules.

7.3 Processing and surveillance

7.3.1 All manufacturing facilities, store rooms and their operational equipment shall fulfil the requirements of the responsible safety authorities and professional employers liability insurance associations. The manufacturer is exclusively responsible for compliance with these requirements.

7.3.2 BKI reserve the right to carry out inspections without giving prior notice. The manufacturer shall grant BKI Surveyors access to all areas and shall present all documentation concerning records and tests carried out.

8. Cold-moulded wood and glueing

8.1 General

A cold-moulded wood laminate consists of at least three layers of veneer/lamellae.

8.2 Wood

8.2.1 Any of the timbers suitable for boat building may be used.

8.2.2 Timber envisaged for use in this type of construction is to be cut in such a way that the inclination of the annual rings is no less than 30°, i.e. the angle between the chord of the flattest annual ring, and the

face of a lamella or strip of veneer must not be less than 30°. The fibres shall be oriented parallel to the edge of a lamella, if possible. Veneers for making plating may be sliced or sawn.

8.3 Glues and adhesives

Only adhesives and glues tested and approved by BKI may be used. Adhesives and glues shall have passed the tests in accordance with DIN 68141 in Section 3- Testing of glues and adhesive combinations for load bearing wooden components. Relevant confirmation and/or test certificates are to be submitted to BKI.

In accordance with current practice, mixed adhesives will hereinafter also be referred to as glues.

8.4 Works prerequisites and quality assurance

Companies producing wooden hulls and components cold-moulded by glueing shall be qualified for the work to be carried out as regards their workshop equipment, internal quality control, manufacturing process as well as the training and qualification of the personnel carrying 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.

9. Wood and joining of wood materials

The following requirements are an excerpt of the [Rules for Non-Metalic Materials \(Pt.1, Vol.XIV\) Chapter 2 – Wood](#) with the aim of summarizing all aspects directly necessary for the design of Yachts.

9.1 General

9.1.1 Timber selection according to the field of application

Only proven boatbuilding wood shall be used for all timber components exposed to water and weather, i.e. timber with good resistance to water and weather, fungal attack and insect infestation, as well as with good mechanical properties that are also suitable for the particular application. Furthermore, it shall have low swelling and shrinkage properties. For components not exposed to water or weather, and not requiring strength, timber of lower durability may be used.

9.1.2 Quality

The timber used in boatbuilding shall be long-grained and of best quality, i.e. free from sap, shakes, objectionable knots and other defects. Twisted-grown or rough saw cut shall not be used.

9.1.3 Drying

The timber used shall be well seasoned and sufficiently dried in a suitable drying kiln. In case of forced drying, the residual moisture content shall not be more than 10 %. When processing, this content shall not exceed 15 % as a result of hygroscopic behaviour.

9.2 Solid wood

9.2.1 Radially sawn timber shall mainly be used for boatbuilding. The angle of the annual rings to the lower sawn edge shall not be less than 45°.

9.2.2 [Table 2.9](#) shows the number of different types of timber and their most important properties, as well as tensile, compressive and bending strength. Since these properties can vary in the case of timber of the same type, or even within the same trunk, no absolute values are indicated in the table, but rather characteristic values. The timber listed is divided into durability groups from I to V. The timber used in

boatbuilding shall, if exposed to the weather or used for the primary structural components of a boat, belong to at least durability group III.

9.2.3 In place of the timber listed in [Table 2.9](#), other types can be used if the durability and the technological values are verified and are equivalent. The manufacturer shall always be responsible for the correct selection of the quality and type of wood.

9.2.4 The safety factors used in the strength calculation shall be agreed in each case with BKI.

Table 2.9 Timber durability groups and characteristic values in accordance with DIN 68364

Timber type	Durability group ¹	Density	Mean breaking strengths		
	I – V	[g/cm ³]	Tension [N/mm ²]	Compression [N/mm ²]	Bending [N/mm ²]
Coniferous					
Pine	III – IV	0,52	100	45	80
Oregon pine	III	0,54	100	50	80
Larch	III	0,59	105	48	93
Deciduous					
Khaya mahogany	III	0,50	75	43	75
True mahogany	II	0,54	100	45	80
Sapele mahogany	III	0,64	85	57	69
Utile	II	0,59	100	58	100
Meranti, red	III	0,59	129	53	105
Iroko	I – II	0,63	79	55	95
Makore	I – II	0,66	85	53	103
Oak	II	0,67	110	52	95
Teak	I	0,69	115	58	100
Yang	III	0,76	140	70	125
¹ Durability groups: I = very good II = good III = average IV = moderate V = poor					

9.3 Boatbuilding plywood

9.3.1 General

.1 All plywood components exposed to water and weather, or used in primary structural components (such as the deck, shell and bulkheads), shall be produced from boatbuilding plywood that has been tested according to BKI Rules.

.2 The boatbuilding plywood consists of at least three veneers bonded crosswise together by means of curable synthetic-resin adhesives. The resistance of these adhesives to water and weather shall be demonstrated by long-term and outdoor testing.

Table 2.10 Plywood strength and durability groups

Timber type	Botanical name	Durability group ¹	Density	Mean tensile strength of plywood	
		I – V	Approx. [g/cm³]	Longitudinal [N/mm²]	Transverse [N/mm²] Bending [N/mm²]
Strength group F1 (for loadbearing components)					
Teak	Tectona grandis	I	0,64	≥ 40	≥ 30
Makoré	Dumoria hekelii	I	0,62	≥ 40	≥ 30
Douka	Dumoria africana	I	0,62	≥ 40	≥ 30
Utile	Entandro-phragma utile	II	0,57	≥ 40	≥ 30
Sapele mahogany	Entandro-phragma cylindricum	III	0,59	≥ 40	≥ 30
Oak	Querus robur	II	0,63	≥ 40	≥ 30
Strength group: F2					
American mahogany	Swietenia macrophylla	II	0,49	< 40	< 30
African mahogany	Khaya ivorensis	II – III	0,45	< 40	< 30
Okoumé (Gaboon)	Aucoumea klaineana	IV – V	0,41	< 40	< 30
¹ Durability groups: I = very good II = good III = average IV = moderate V = poor					

.3 As plywood can also be destroyed in specific adverse conditions by animal or plant pests, timber shall be used which offers a natural resistance.

9.3.2 Structure

The selection of timber and the structure of the panels (number of veneer layers) shall be appropriate for the field of application. Depending on the application, strong, durable timber - e. g. makoré and the hard, durable mahogany types of strength group F1 (see Table 2.10) - with several thin inner layers of veneer shall be selected for load carrying components subject to high stresses. On the other hand, plywood panels of lighter, less long and less durable timber of strength group F2 e.g. khaya, mahogany, okumé - with thicker and fewer inner layers of veneer and good surface protection are suitable for linings.

9.3.3 Veneer joints

The veneer joints shall be sealed perfectly and shall bond the veneers to each other by butt joints. The joints shall be glued on a suitable joint bonding machine.

Sealed joints between all layers are a precondition for boatbuilding plywood.

9.3.4 Strength groups

.1 With regard to their suitability for the production of boatbuilding plywood, the types of timber listed in [Table 2.10](#) are currently approved. The timber is subdivided into two strength groups. Also shown is the natural durability and weathering resistance of the mentioned types of timber.

.2 Other types of wood may only be used for making plywood panels upon agreement with BKI. The manufacturer shall always remain responsible for the correct selection of quality and type of wood.

9.4 Wood protection

9.4.1 Timber

All timber (with exception of the timber durability group I, [Table 2.10](#)) shall be protected by several coats of suitable protective paint, or by means of impregnation with a proven wood preservative, against fungi and insect infestation. Impregnation is the preferred method for interior surfaces of the yacht's components which are exposed to water or weather (e.g. hull, deck, superstructure) and which have received a coat of paint impervious to vapour pressure.

9.4.2 Plywood

All plywood parts shall be protected by several coats of paint or varnish. Special attention shall be paid to plywood edges and drill-holes by pre-treating them with recognized and proven edge protection coatings.

C. Design Principles

1. General

The following contains definitions and general design guidance for hull structural elements made from metallic materials as well as indications concerning structural details.

2. Required sectional properties

The required section moduli and web areas are related on principle to an axis which is parallel to the connected plating.

For profiles usual in the trade and connected vertically to the plating in general the appertaining sectional properties are given in tables.

Where webs of stiffeners and girders are not fitted vertically to the plating (e.g. frames on the shell in the flaring fore body) the sectional properties (moment of inertia, section modulus and shear area) have to be determined for an axis which is parallel to the plating.

For bulb profiles and flat bars the section modulus of the inclined profile including plating can be calculated simplified by multiplying the corresponding value for the vertically arranged profile by $\sin \alpha$ where α is the smaller angle between web and attached plating.

3. Curved plate panels

The thickness of curved plate panels may be reduced by applying the following correction factor f_c in the formula of [D.4.3](#).

$$f_c = 1,1 - 3 \cdot \frac{h}{s} \quad \text{for} \quad \frac{1}{30} \leq \frac{h}{s} \leq 0,1$$

h = according to Fig. 2.2

s = according to Fig. 2.2

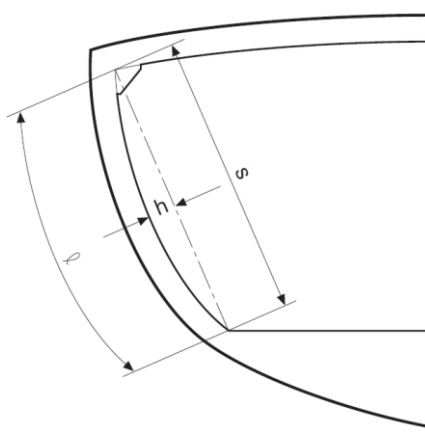


Fig. 2.2 Curved shell plate panels and frames

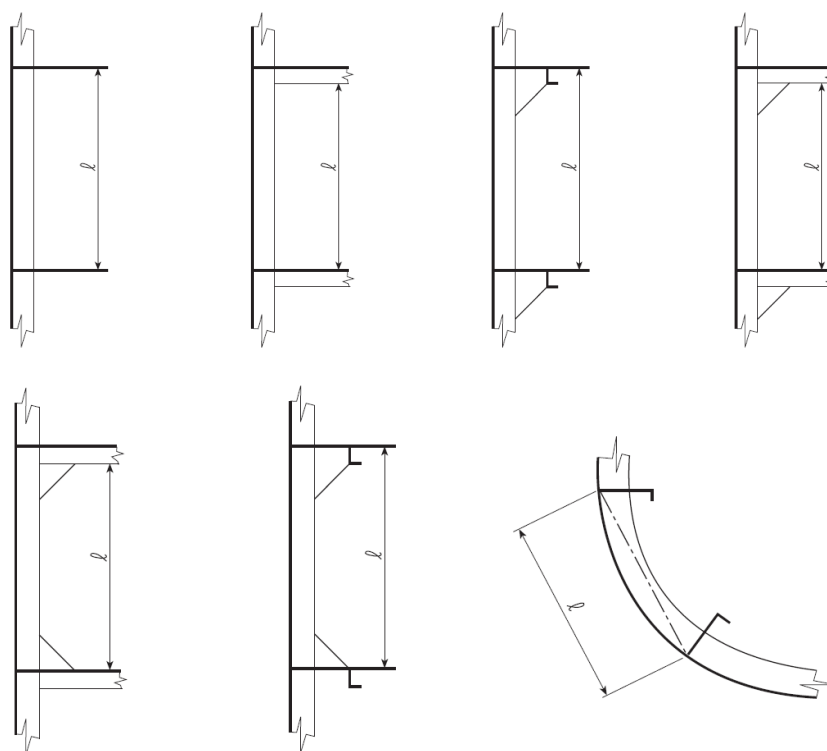


Fig. 2.3 Unsupported span

4. Curved frames and girders

For curved frames and girders, the section modulus may be reduced by applying the factor f_{cs} in the formula of D.4.4.2.

$$f_{cs} = 1,15 - 5 \cdot \frac{h}{s} \quad \text{for } 0,03 \leq \frac{h}{s} \leq 0,1$$

h = according to Fig. 2.2

s = according to Fig. 2.2

5. Unsupported Span

5.1 Stiffeners, frames

The unsupported span ℓ is the true length of the stiffeners between two supporting girders or else their length including end attachments (brackets). See Fig. 2.3.

5.2 Transverses and girders

The unsupported span ℓ of transverses and girders is to be determined according to Fig. 2.4, depending on the type of end attachment.

In special cases, the rigidity of the adjoining girders is to be taken into account when determining the span of girder.

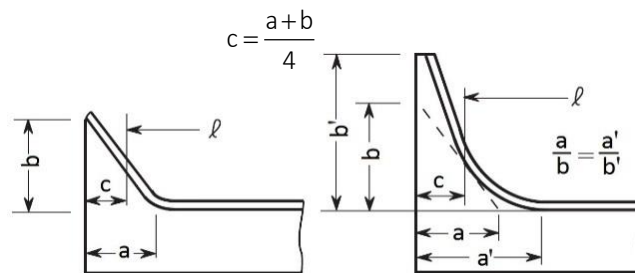


Fig. 2.4 Unsupported span ℓ

6. End Attachments

6.1 Definitions

For determining scantlings of beams, stiffeners and girders the terms "constraint" and "simple support" will be used.

"Constraint" will be assumed where for instance the stiffeners are rigidly connected to other members by means of brackets or are running throughout over supporting girders.

"Simple support" will be assumed where for instance the stiffener ends are sniped or the stiffeners are connected to plating only, see also 6.4.

6.2 Design of details

Structural details are to be so designed and constructed as to minimize hard spots, notches and other structural discontinuities leading to stress concentrations. Therefore sharp corners and abrupt changes in sections are to be avoided. Toes of brackets and ends of members are not to terminate on plating without attachment to an adjacent member, unless specially approved.

6.3 Brackets

6.3.1 For the scantlings of brackets the required section modulus of the section is decisive. Where sections of different section moduli are connected to each other, the scantlings of the brackets are generally governed by the smaller section.

6.3.2 The thickness of brackets is not to be less than :

$$t = c \cdot \sqrt[3]{\frac{W}{k_1}} + t_k \quad [\text{mm}]$$

c = 1,20 for non-flanged brackets

= 0,95 for flanged brackets

k_1 = material factor k for the section according to [Section B.2.2](#)

W = section modulus of smaller section [cm^3]

t_{\min} = 5,5 mm

t_{\max} = web thickness of smaller section.

t_k = corrosion addition according to [D.4.1.2](#)

6.3.3 The arm length of brackets is not to be less than:

$$\ell = 46,2 \cdot \sqrt[3]{\frac{W}{k_1}} \cdot \sqrt{k_2} \cdot c_t \quad [\text{mm}]$$

ℓ_{\min} = 100 mm

W = see [6.3.2](#)

k_1 = see [6.3.2](#)

k_2 = material factor k for the bracket according to [B.2](#)

$$c_t = \sqrt{\frac{t}{t_a}}$$

t_a = "as built" thickness of bracket [mm] $\geq t$ according to [6.3.2](#)

The arm length ℓ is the length of the welded connection.

Note:

For deviating arm length the thickness of brackets is to be estimated by direct calculations considering sufficient safety against buckling.

6.3.4 Where flanged brackets are used the width of flange is to be determined according to the following formulae:

$$b = 40 + \frac{W}{30} \quad [\text{mm}]$$

b is not to be taken less than 50 mm and need not be taken greater than 90 mm.

W = see [6.3.2](#)

6.4 Sniped ends of stiffeners

Stiffeners may be sniped at the ends, if the thickness of the plating supported by stiffeners is not less than:

$$t = c \sqrt{\frac{p \cdot a \cdot (\ell - 0,5 \cdot a)}{R_{eH}}} \quad [\text{mm}]$$

p = design load [kN/m²], [Rules for Hull \(Pt.1, Vol.II\) Sec.4](#)

ℓ = unsupported length of stiffener [m]

a = spacing of stiffeners [m]

R_{eH} = minimum nominal upper yield point of the plating material [N/mm²] according to [Section B.2.2](#)

c = 15,8 for watertight bulkheads and for tank bulkheads when loaded by p_2 according to [Rules for Hull \(Pt.1, Vol.II\) Sec.4](#)
= 19,6 otherwise

7. Effective Breadth of Plating

7.1 Frames and stiffeners

Generally, the spacing of frames and stiffeners may be taken as effective breadth of plating.

7.2 Girders

7.2.1 The effective breadth of plating “ e_m ” of frames and girders may be determined according to [Table 2.11](#) considering the type of loading.

Special calculations may be required for determining the effective breadth of one-sided or non-symmetrical flanges.

Table 2.11 Effective breadth e_m of frames and girders

ℓ/e	0	1	2	3	4	5	6	7	≥ 8
e_{m1}/e	0	0,36	0,64	0,82	0,91	0,96	0,98	1,00	1,00
e_{m2}/e	0	0,20	0,37	0,52	0,65	0,75	0,84	0,89	0,90
<p>e_{m1} is to be applied where girders are loaded by uniformly distributed loads or else by not less than 6 equally spaced single loads.</p> <p>e_{m2} is to be applied where girders are loaded by 3 or less single loads.</p> <p>Intermediate values may be obtained by direct interpolation.</p> <p>ℓ = length between zero-points of bending moment curve, i.e. unsupported span in case of simply supported girders and 0,6 x unsupported span in case of constraint of both ends of girder</p> <p>e = width of plating supported, measured from centre to centre of the adjacent unsupported fields.</p>									

7.2.2 The effective cross sectional area of plates is not to be less than the cross sectional area of the face plate.

7.2.3 The effective width of stiffeners and girders subjected to compressive stresses may be determined by proof of buckling strength, but is in no case to be taken greater than determined by [7.2.1](#).

7.3 Cantilevers

Where cantilevers are fitted at every frame, the effective width of plating may be taken as the frame spacing.

Where cantilevers are fitted at a greater spacing the effective breadth of plating at the respective cross section may approximately be taken as the distance of the cross section from the point on which the load is acting, however, not greater than the spacing of the cantilevers.

8. Rigidity of Transverses and Girders

The moment of inertia of deck transverses and girders, is not to be less than:

$$I = c \cdot W \cdot \ell \quad [\text{cm}^4]$$

$c = 4,0$ if both ends are simply supported

$= 2,0$ if one end is constrained

$= 1,5$ if both ends are constrained

$W =$ section modulus of the structural member considered $[\text{cm}^3]$

$\ell =$ unsupported span of the structural member considered $[\text{m}]$

9. Additional Stresses in Assymetric Sections

The additional stress σ_h occurring in non-symmetric sections may be calculated by the following formulae:

$$\sigma_h = \frac{Q \cdot \ell_f \cdot t_f}{c \cdot W_y \cdot W_z} (b_1^2 - b_2^2) \quad [\text{N/mm}^2]$$

$Q =$ load on section parallel to its web within the unsupported span ℓ_f $[\text{kN}]$

$= p \cdot a \cdot \ell_f$ $[\text{kN}]$ in case of uniformly distributed load p $[\text{kN/m}^2]$

$\ell_f =$ unsupported span of flange $[\text{m}]$

$t_f, b_1, b_2 =$ flange dimensions $[\text{mm}]$ as shown Fig. 2.5 $b_1 \geq b_2$

$W_y =$ Section modulus of section related to the y-y axis including the effective width of plating $[\text{cm}^3]$

$W_z =$ section modulus of the partial section consisting of flange and half of web area related to the z-z axis $[\text{cm}^3]$ (Bulb sections may be converted into a similar L-section)

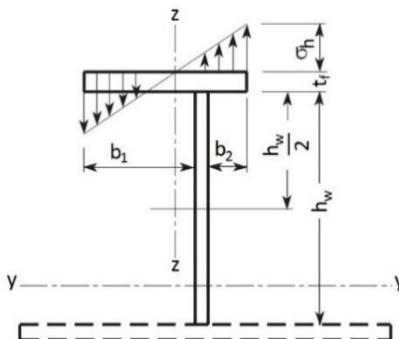


Fig. 2.5 Asymmetrical profile

$c =$ factor depending on kind of load, stiffness of the section's web and length and kind of support of the profile For profiles clamped at both ends and constant area load $c = 80$ can be taken for approximation.

This additional stress σ_h is to be added directly to other stresses such as those resulting from local and hull girder bending.

The total stress according to local bending thus results in:

$$\sigma_{ges} = \frac{Q \cdot \ell_f \cdot 1000}{12 \cdot W_y} \left(1 + \frac{12 \cdot t_f (b_1^2 - b_2^2)}{1000 \cdot c \cdot W_z} \right) \quad [\text{N/mm}^2]$$

Therefore the required section modulus W_y according to 2. must be increased by the factor k_{sp} depending on the type of section and the boundary conditions expressed by c.

$$\sigma_{ges} = \frac{Q \cdot \ell_f \cdot 1000}{12 \cdot W_y} k_{sp} \quad [\text{N/mm}^2]$$

For k_{sp} at least the values given in Table 2.12 are to be taken.

Table 2.12 Factor k_{sp} for asymmetric sections

Type of Profile	k_{sp}
Flat bars and symmetric T-profiles	1,00
Bulb profiles	1,03
Asymmetric T profiles ($\frac{b_2}{b_1} \approx 0.5$)	1,05
Rolled angels (L-profiles)	1,15

10. Proof of Buckling Strength

10.1 General

10.1.1 Principles

The calculation method for buckling strength shown below is based on the standard DIN 18800.

10.1.2 Definitions

a = length of single or partial plate field [mm]

b = breadth of single plate field [mm]

α = aspect ratio of single plate field

$$= \frac{a}{b}$$

n = number of single plate field breadths b within the partial or total plate field

t = nominal plate thickness [mm]

$$= t_a - t_K \quad [\text{mm}]$$

t_a = plate thickness as built [mm]

t_k = corrosion addition according to D.4.1.2. [mm]

σ_x = membrane stress in x-direction [N/mm²]

σ_y = membrane stress in y-direction [N/mm²]

τ = shear stress in the x-y plane [N/mm²]

Compressive and shear stresses are to be taken positive, tension stresses are to be taken negative.

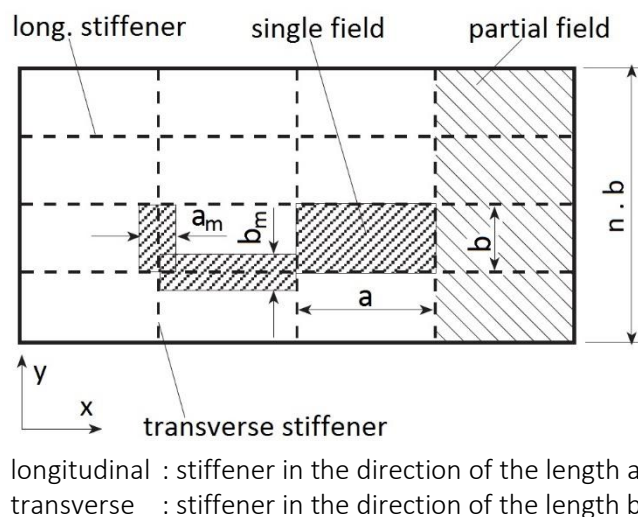


Fig. 2.6 System of longitudinal and transverse

Note:

If the stresses σ_x^* and σ_y^* in the x- and y- direction contain already the Poisson effect, the modified stress values σ_x and σ_y according Table 2.13 may be used for the proof of buckling strength.

Table 2.13 Poisson effect correction

Both σ_x^* and σ_y^* are to be compressive stresses			At least σ_x^* or σ_y^* is tension stress
$\sigma_x^* \geq 0,3 \cdot \sigma_y^*$ or $\sigma_y^* \geq 0,3 \cdot \sigma_x^*$	$\sigma_x^* < 0,3 \cdot \sigma_y^*$	$\sigma_y^* < 0,3 \cdot \sigma_x^*$	
$\sigma_x = \frac{\sigma_x^* - 0,3 \cdot \sigma_y^*}{0,91}$	$\sigma_x = 0$	$\sigma_x = \sigma_x^*$	$\sigma_x = \sigma_x^*$
$\sigma_y = \frac{\sigma_y^* - 0,3 \cdot \sigma_x^*}{0,91}$	$\sigma_y = \sigma_y^*$	$\sigma_y = 0$	$\sigma_y = \sigma_y^*$

ψ = edge stress ratio according to Table 2.16

F_1 = correction factor for boundary condition at the long. stiffeners according to Table 2.14

σ_e = reference stress

$$= 0,9 \cdot E \left(\frac{t}{b} \right)^2 \quad [\text{N/mm}^2]$$

E = Young's modulus
= $2,06 \cdot 10^5$ [N/mm²] for steel
= $0,69 \cdot 10^5$ [N/mm²] for aluminium alloys

Table 2.14 Correction Factor F_1

1,0 for stiffeners sniped at both ends	
Guidance values *:	
1,05	for flat bars
1,10	for bulb sections
1,20	for angle and tee-sections
1,30	for girders of high rigidity (e.g. bottom transverses)
* Exact values may be determined by direct calculations.	

R_{eH} = nominal yield point [N/mm²] for hull structural steels according to [B.2.2](#)
= 0,2 % proof stress [N/mm²] for aluminium alloys
S = safety factor
= 1,1 in general
= 1,2 for structures which are exclusively exposed to local loads
= 1,05 for combinations of statistically independent loads

For constructions of aluminium alloys the safety factors are to be increased in each case by 0,1.

λ = reference degree of slenderness

$$= \sqrt{\frac{R_{eH}}{K \cdot \sigma_e}}$$

K = buckling factor according to [Tables 2.16](#) and [2.17](#)

In general, the ratio plate field breadth to plate thickness shall not exceed $b/t = 100$.

10.2 Proof of single plate fields

10.2.1 Proof is to be provided that the following condition is complied with for the single plate field $a \cdot b$:

$$\left(\frac{|\sigma_x| \cdot S}{\kappa_x \cdot R_{eH}} \right)^{e_1} + \left(\frac{|\sigma_y| \cdot S}{\kappa_y \cdot R_{eH}} \right)^{e_2} - B \left(\frac{\sigma_x \cdot \sigma_y \cdot S^2}{R_{eH}^2} \right) + \left(\frac{|\tau| \cdot S \cdot \sqrt{3}}{\kappa_\tau \cdot R_{eH}} \right)^{e_3} \leq 1,0$$

Each term of the above condition shall not exceed 1,0.

The reduction factors κ_x , κ_y and κ_τ are given in [Table 2.16](#) and/or [2.17](#)

Where $\sigma_x \leq 0$ (tension stress), $\kappa_x = 1,0$.

Where $\sigma_y \leq 0$ (tension stress), $\kappa_y = 1,0$.

The exponents e_1 , e_2 and e_3 as well as the factor B are calculated or set respectively according to [Table 2.15](#):

Table 2.15 Exponent $e_1 - e_3$ and factor B

Exponents $e_1 - e_3$ and factor B	plate field	
	plane	curved
e_1	$1 + \kappa_x^4$	1,25
e_2	$1 + \kappa_y^4$	1,25
e_3	$1 + \kappa_x \cdot \kappa_y \cdot \kappa_t^2$	2,0
B σ_x and σ_y positive (compression stress)	$(\kappa_x \cdot \kappa_y)^5$	0
B σ_x or σ_y negative (tension stress)	1	-

10.2.2 Effective width of plating

The effective width of plating may be determined by the following formulae:

$$b_m = \kappa_x \cdot b \text{ for longitudinal stiffeners}$$

$$a_m = \kappa_y \cdot a \text{ for transverse stiffeners}$$

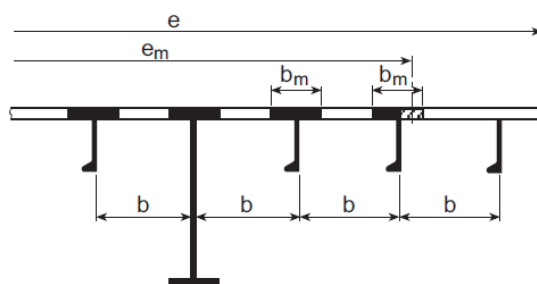
see also [Fig. 2.6](#).

The effective width of plating is not to be taken greater than the value obtained from [7.2.1](#).

Note:

The effective width e'_m of stiffened flange plates of girders may be determined as follows:

Stiffening parallel to web of girder :



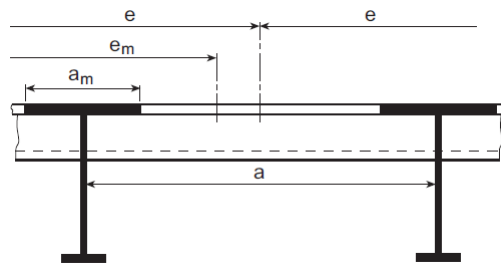
$$b < e_m$$

$$e'_m = n \cdot b_m$$

$$n = \text{integral number of the stiffener spacing } b \text{ inside the effective breadth "e_m" according to Table 2.11}$$

$$= \text{int} \left(\frac{e_m}{b} \right)$$

Stiffening perpendicular to web of girder:



$$a \geq e_m$$

$$e'_m = n \cdot a_m < e_m$$

$$n = 2,7 \cdot \frac{e_m}{a} \leq 1$$

e = width of plating supported according to [7.2.1](#)

For $b \geq e_m$ or $a < e_m$ respectively, b and a have to be exchanged.

Table 2.16 Plane Plate Fields

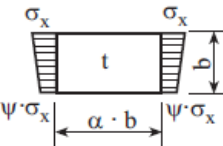
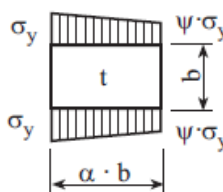
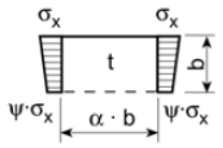
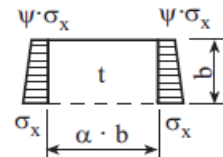
Load case	Edge Stress ratio ψ	Aspect ratio α	Buckling factor K	Reductions factor κ
<p>[1]</p> 	$1 \geq \psi \geq 0$	$\alpha \geq 1$	$K = \frac{8,4}{\psi + 1,1}$	$\kappa_x = 1$ for $\lambda \leq \lambda_c$ $\kappa_x = c \left(\frac{1}{\lambda} - \frac{0,22}{\lambda^2} \right)$ for $\lambda > \lambda_c$ $C = (1,25 - 0,12 \cdot \psi) \leq 1,25$ $\lambda_c = \frac{c}{2} \left(1 + \sqrt{1 - \frac{0,88}{c}} \right)$
	$0 > \psi > -1$		$K = 7,63 - \psi (6,26 - 10 \psi)$	
	$\psi \leq -1$		$K = (1 - \psi)^2 \cdot 5,975$	
<p>[2]</p> 	$1 \geq \psi \geq 0$	$\alpha \geq 1$	$K = F_1 \left(1 + \frac{1}{\alpha^2} \right)^2 \frac{2,1}{(\psi + 1,1)}$	$\kappa_y = c \left(\frac{1}{\lambda} - \frac{R + F^2(H - R)}{\lambda^2} \right)$ $c = (1,25 - 0,12 \cdot \psi) \leq 1,25$ $R = \lambda \left(1 - \frac{\lambda}{C} \right)$ for $\lambda \leq \lambda_c$ $R = 0,22$ for $\lambda \geq \lambda_c$ $F = \left(1 - \frac{\frac{K}{0,91} - 1}{\lambda_p^2} \right) c_1 \geq 0$ $\lambda_c = \frac{c}{2} \left(1 + \sqrt{1 - \frac{0,88}{c}} \right)$ $\lambda_p^2 = \lambda^2 - 0,5 \quad 1 \leq \lambda_p^2 \leq 3$ $c_1 = 1$ for σ_y due to direct loads $c_1 = \left(1 - \frac{F_1}{\alpha} \right) \geq 0$ for σ_y due to bending (in general) $c_1 = 0$ for σ_y due to bending in extreme load cases (e.g. w.t bulkheads) $H = \lambda - \frac{2 \cdot \lambda}{c(T + \sqrt{T^2 - 4})} \geq R$ $T = \lambda + \frac{14}{15 \cdot \lambda} + \frac{1}{3}$
	$0 > \psi > -1$	$1 \leq \alpha \leq 1,5$	$K = F_1 \left[\left(1 + \frac{1}{\alpha^2} \right)^2 \frac{2,1}{1,1} (1 + \psi) - \frac{\psi}{\alpha^2} (13,9 - 10 \cdot \psi) \right]$	
		$\alpha > 1,5$	$K = F_1 \left[\left(1 + \frac{1}{\alpha^2} \right)^2 \frac{2,1}{1,1} (1 + \psi) - \frac{\psi}{\alpha^2} (5,87 + 1,87 \cdot \alpha^2 + \frac{8,6}{\alpha^2} - 10 \cdot \psi) \right]$	
	$\psi \leq -1$	$1 \leq \alpha \leq (1 - \psi) \frac{3}{4}$	$K = F_1 \left(\frac{1 - \psi}{\alpha} \right)^2 \cdot 5,975$	
		$\alpha > (1 - \psi) \frac{3}{4}$	$K = F_1 \left[\left(\frac{1 - \psi}{\alpha} \right)^2 \cdot 3,9675 + 0,5375 \left(\frac{1 - \psi}{\alpha} \right)^4 + 1,87 \right]$	
<p>[3]</p> 	$1 \geq \psi \geq 0$	$\alpha > 0$	$K = \frac{4 \left(0,425 + \frac{1}{\alpha^2} \right)}{3 \cdot \psi + 1}$	$\kappa_x = 1$ for $\lambda \leq 0,7$ $\kappa_x = \frac{1}{\lambda^2 + 0,51}$ for $\lambda > 0,7$
	$0 > \psi \geq -1$		$K = 4 \left(0,425 + \frac{1}{\alpha^2} \right) (1 + \psi) - 5 \cdot \psi (1 - 3,42 \cdot \psi)$	
<p>[4]</p> 	$1 \geq \psi \geq -1$	$\alpha > 0$	$K = \left(0,425 + \frac{1}{\alpha^2} \right) \frac{3 - \psi}{2}$	

Table 2.16 Plane Plate Fields (continued)

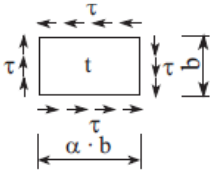
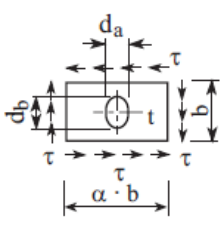
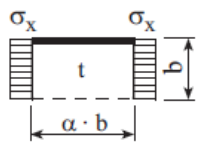
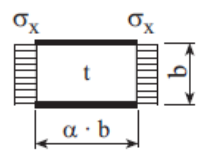
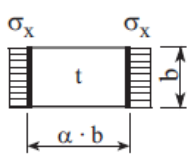
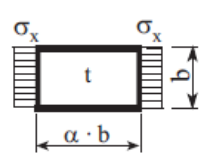
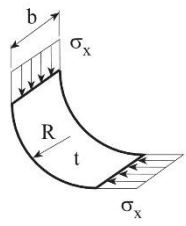
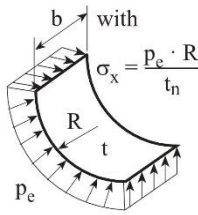
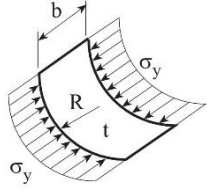
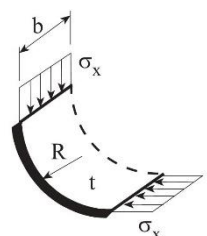
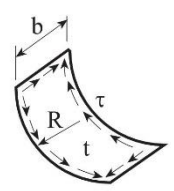
Load case	Edge Stress ratio ψ	Aspect ratio α	Buckling factor K	Reductions factor κ
[5] 	-	$\alpha \geq 1$ $0 < \alpha < 1$	$K = K_{\tau} \cdot \sqrt{3}$	$\kappa_{\tau} = 1$ for $\lambda \leq 0,84$ $\kappa_{\tau} = \frac{0,84}{\lambda}$ for $\lambda > 0,84$
			$K_{\tau} = \left[5,34 + \frac{4}{\alpha^2} \right]$	
			$K_{\tau} = \left[4 + \frac{5,34}{\alpha^2} \right]$	
[6] 	-		$K = K' \cdot r$ $K' = K$ according to line 5 $r =$ Reduction factor $= \left(1 - \frac{d_a}{a} \right) \left(1 - \frac{d_b}{b} \right)$ with $\frac{d_a}{a} \leq 0,7$ and $\frac{d_b}{b} \leq 0,7$	
[7] 	-	$\alpha \geq 1,64$	$K = 1,28$	$\kappa_x = 1$ for $\lambda \leq 0,7$ $\kappa_x = \frac{1}{\lambda^2 + 0,51}$ for $\lambda > 0,7$
		$\alpha < 1,64$	$K = \frac{1}{\alpha^2} + 0,56 + 0,13\alpha^2$	
[8] 	-	$\alpha \geq \frac{2}{3}$	$K = 6,97$	$\kappa_x = 1$ for $\lambda \leq 0,83$ $\kappa_x = 1,13 \left[\frac{1}{\lambda} - \frac{0,22}{\lambda^2} \right]$ for $\lambda > 0,83$
		$\alpha < \frac{2}{3}$	$K = \frac{1}{\alpha^2} + 2,5 + 5 \cdot \alpha^2$	
[9] 	-	$\alpha \geq 4$	$K = 4$	
		$4 > \alpha > 1$	$K = 4 + \left[\frac{4 - \alpha}{3} \right]^4 2,74$	
		$\alpha \leq 1$	$K = \frac{4}{\alpha^2} + 2,07 + 0,67\alpha^2$	
[10] 	-	$\alpha \geq 4$	$K = 6,97$	
		$4 > \alpha > 1$	$K = 6,97 + \left[\frac{4 - \alpha}{3} \right]^4 3,1$	
		$\alpha \leq 1$	$K = \frac{4}{\alpha^2} + 2,07 + 4 \alpha^2$	
Explanations for boundary conditions : ----- plate edge free ————— plate edge simply supported ————— plate edge clamped				

Table 2.17 Curved plate field R/t 2500¹

Load case	Aspect ratio b/R	Buckling factor K	Reduction factor κ
[1a] 	$\frac{b}{R} \leq 1,63 \sqrt{\frac{R}{t}}$	$K = \frac{b}{\sqrt{R \cdot t}} + 3 \frac{(R \cdot t)^{0,175}}{b^{0,35}}$	$\kappa_x = 1^2)$ for $\lambda \leq 0,4$ $\kappa_x = 1,274 - 0,686 \lambda$ for $0,4 < \lambda \leq 1,2$
[1b] 	$\frac{b}{R} > 1,63 \sqrt{\frac{R}{t}}$	$K = 0,3 \frac{b^2}{R^2} + 2,25 \left(\frac{R^2}{b \cdot t} \right)^2$	$\kappa_x = \frac{0,65}{\lambda^2}$ for $\lambda > 1,2$
	$\frac{b}{R} \leq 0,5 \sqrt{\frac{R}{t}}$	$K = 1 + \frac{2 b^2}{3 R \cdot t}$	$\kappa_y = 1^2)$ for $\lambda \leq 0,25$ $\kappa_y = 1,233 - 0,933$ for $0,25 < \lambda \leq 1$
	$\frac{b}{R} > 0,5 \sqrt{\frac{R}{t}}$	$K = 0,267 \frac{b^2}{R \cdot t} \left[3 - \frac{b}{R} \sqrt{\frac{t}{R}} \right]$ $\geq 0,4 \frac{b^2}{R \cdot t}$	$\kappa_y = 0,3/\lambda^3$ for $1 < \lambda \leq 1,5$ $\kappa_y = 0,2/\lambda^2$ for $\lambda > 1,5$
[3] 	$\frac{b}{R} \leq \sqrt{\frac{R}{t}}$	$K = \frac{0,6 \cdot b}{\sqrt{R \cdot t}} + \frac{\sqrt{R \cdot t}}{b} - 0,3 \frac{R \cdot t}{b^2}$	as in load case 1a
	$\frac{b}{R} > \sqrt{\frac{R}{t}}$	$K = 0,3 \frac{b^2}{R^2} + 0,291 \left(\frac{R^2}{b \cdot t} \right)^2$	
[4] 	$\frac{b}{R} \leq 8,7 \sqrt{\frac{R}{t}}$	$K = \kappa_\tau \cdot \sqrt{3}$ $\kappa_\tau = \left[28,3 + \frac{0,67 \cdot b^3}{R^{1,5} \cdot t^{1,5}} \right]^{0,5}$	$\kappa_\tau = 1$ for $\lambda \leq 0,4$ $\kappa_\tau = 1,274 - 0,686 \lambda$ for $0,4 < \lambda \leq 1,2$
	$\frac{b}{R} > 8,7 \sqrt{\frac{R}{t}}$	$K_\tau = 0,28 \frac{b^2}{R \sqrt{R \cdot t}}$	$\kappa_\tau = \frac{0,65}{\lambda^2}$ for $\lambda > 1,2$
<div>Explanations for boundary conditions : ----- plate edge free ————— plate edge simply supported ————— plate edge clamped</div> <div><div><div>¹ For curved plate fields with a very large radius the κ-value need not to be taken less than derived for the expanded plane field.</div><div>² For curved single fields. e.g. the bilge strake, which are located within plane partial or total fields, the reduction factor 6 may be taken as follows: Load case 1b : $\kappa_x = 0,8/\lambda^2 \leq 1,0$; Load case 2: $\kappa_y = 0,65/\lambda^2 \leq 1,0$</div></div></div>			

10.2.3 Webs and flanges

For non-stiffened webs and flanges of sections and girders proof of sufficient buckling strength as for single plate fields is to be provided according to 10.2.1.

Note

Within 0,6L amidships the following guidance values are recommended for the ratio web depth to web thickness and/or flange breadth to flange thickness:

$$\text{flat bars : } \frac{h_w}{t_w} \leq 19,5 \sqrt{k}$$

$$\text{angle-, tee and bulb sections: web : } \frac{h_w}{t_w} \leq 60,0 \sqrt{k}$$

$$\text{flange : } \frac{b_i}{t_f} \leq 19,5 \sqrt{k}$$

b_i = b_1 or b_2 according to Fig. 2.7, the larger value is to be taken.

10.3 Proof of partial and total fields

10.3.1 Longitudinal and transverse stiffeners

Proof is to be provided that the continuous longitudinal and transverse stiffeners of partial and total plate fields comply with the conditions set out in 10.3.2 and 10.3.3.

10.3.2 Lateral buckling

$$\frac{\sigma_a + \sigma_b}{R_{eH}} \leq 1$$

σ_a = uniformly distributed compressive stress in the direction of the stiffener axis [N/mm²]
= σ_x for longitudinal stiffeners
= σ_y for transverse stiffeners

σ_b = bending stress in the stiffeners

$$= \frac{M_0 + M_1}{W_{st} \cdot 10^3} \quad [\text{N/mm}^2]$$

M_0 = bending moment due to deformation w of stiffener

$$= F_{Ki} \frac{p_z \cdot w}{c_f - p_z} \quad [\text{N} \cdot \text{mm}] \quad \text{with } (c_f - p_z) > 0$$

M_1 = bending moment due to the lateral load p for defined as:

$$= \frac{p \cdot b \cdot a^2}{24 \cdot 10^3} \quad [\text{N} \cdot \text{mm}] \quad \text{for longitudinal stiffeners}$$

$$= \frac{p \cdot a (n \cdot b)^2}{c_s \cdot 8 \cdot 10^3} \quad [\text{N} \cdot \text{mm}] \quad \text{for transverse stiffeners}$$

p = lateral load [kN/m²]

F_{Ki} = ideal buckling force of the stiffener [N]

$$F_{Kix} = \frac{\pi^2}{a^2} E \cdot I_x \cdot 10^4 \quad \text{for longitudinal stiffeners}$$

$$F_{Kiy} = \frac{\pi^2}{(n \cdot b)^2} E \cdot I_y \cdot 10^4 \quad \text{for transverse stiffeners}$$

I_x, I_y = moments of inertia of the longitudinal or transverse stiffener including effective width of plating according to 2.2 [cm⁴]

$$I_x \geq \frac{b \cdot t^3}{12 \cdot 10^4}$$

$$I_y \geq \frac{a \cdot t^3}{12 \cdot 10^4}$$

p_z = nominal lateral load of the stiffener due to σ_x , σ_y and τ [N/mm²]

$$p_{zx} = \frac{t_a}{b} \left(\sigma_{x1} \left(\frac{\pi \cdot b}{a} \right)^2 + 2 \cdot c_y \cdot \sigma_y + \sqrt{2} \tau_1 \right) \quad \text{for longitudinal stiffeners}$$

$$p_{zy} = \frac{t_a}{a} \left(2 \cdot c_x \sigma_{x1} \left(\frac{\pi \cdot a}{n \cdot b} \right)^2 + \left[1 + \frac{A_y}{a \cdot t_a} \right] + \sqrt{2} \tau_1 \right) \quad \text{for transverse stiffeners}$$

σ_{x1} = corrected membrane stress in x-direction [N/mm²]

$$= \sigma_x \left(1 + \frac{A_x}{b \cdot t_a} \right) \quad [\text{N/mm}^2]$$

c_x, c_y = factor taking into account the stresses vertical to the stiffener's axis and distributed variable along the stiffener's length

$$= 0,5 (1 + \psi) \quad \text{for } 0 \leq \psi \leq 1$$

$$= \frac{0,5}{1 - \psi} \quad \text{for } \psi < 0$$

ψ = edge stress ratio according to Table 2.16

A_x, A_y = sectional area of the longitudinal or transverse stiffener respectively [mm²]

τ_1 = corrected shear stress [N/mm²] in the x-y plane, defined as:

$$= \left[\tau - t \sqrt{R_{eH} \cdot E \left(\frac{m_1}{a^2} + \frac{m_2}{b^2} \right)} \right] \geq 0$$

for longitudinal stiffeners:

$$\frac{a}{b} \geq 2,0 : \quad m_1 = 1,47 \quad m_2 = 0,49$$

$$\frac{a}{b} < 2,0 : \quad m_1 = 1,96 \quad m_2 = 0,37$$

for transverse stiffeners:

$$\frac{a}{n \cdot b} \geq 0,5 : \quad m_1 = 0,37 \quad m_2 = \frac{1,96}{n^2}$$

$$\frac{a}{n \cdot b} < 0,5 : m_1 = 0,49 \quad m_2 = \frac{1,47}{n^2}$$

$$W = W_0 + W_1$$

$$W_0 = \text{assumed imperfection [mm],}$$

$$\frac{a}{250} \geq w_{0x} \leq \frac{b}{250} \quad \text{for longitudinal stiffeners}$$

$$\frac{n \cdot b}{250} \geq w_{0y} \leq \frac{a}{250} \quad \text{for transverse stiffeners}$$

$$\text{however } w_0 \leq 10 \text{ mm}$$

Note

For stiffeners sniped at both ends w_0 shall not be taken less than the distance from the midpoint of plating to the neutral axis of the profile including effective width of plating.

$$w_1 = \text{deformation of stiffener due to lateral load } p \text{ at midpoint of stiffener span [mm].}$$

In case of uniformly distributed load the following values for w_1 may be used:

$$= \frac{p \cdot b \cdot a^4}{384 \cdot 10^7 \cdot E \cdot I_x} \quad \text{for longitudinal stiffeners}$$

$$= \frac{5 \cdot a \cdot p \cdot (n \cdot b)^4}{384 \cdot 10^7 \cdot E \cdot I_y \cdot c_s^2} \quad \text{for transverse stiffeners}$$

$$c_f = \text{elastic support provided by the stiffener [N/mm}^2\text{]}$$

$$c_{fx} = F_{Kix} \cdot \frac{\pi^2}{a^2} \cdot (1 + c_{px}) \quad \text{for longitudinal stiffeners}$$

$$c_{fy} = c_s \cdot F_{Kiy} \cdot \frac{\pi^2}{(n \cdot b)^2} \cdot (1 + c_{py}) \quad \text{for transverse stiffeners}$$

$$c_{px} = \text{coefficient, defined as:}$$

$$= \frac{1}{1 + \frac{0,91}{c_{x\alpha}} \cdot \left(\frac{12 \cdot 10^4 \cdot I_x}{t^3 \cdot b} - 1 \right)}$$

$$c_{x\alpha} = \text{coefficient, defined as:}$$

$$= \left[\frac{a}{2b} + \frac{2b}{a} \right]^2 \quad \text{for } a \geq 2 \cdot b$$

$$= \left[1 + \left(\frac{a}{2b} \right)^2 \right]^2 \quad \text{for } a < 2 \cdot b$$

$$c_{py} = \text{coefficient, defined as:}$$

$$= \frac{1}{1 + \frac{0,91}{c_{y\alpha}} \cdot \left(\frac{12 \cdot 10^4 \cdot I_y}{t^3 \cdot a} - 1 \right)}$$

$$C_{y\alpha} = \left[\frac{n \cdot b}{2a} + \frac{2a}{n \cdot a} \right]^2 \quad \text{for } n \cdot b \geq 2 \cdot a$$

$$= \left[1 + \left(\frac{n \cdot b}{2a} \right)^2 \right]^2 \quad \text{for } n \cdot b < 2 \cdot a$$

C_s = factor accounting for the boundary conditions of the transverse stiffener

= 1,0 for simply supported stiffeners

= 2,0 for partially constraint stiffeners

W_{st} = section modulus of stiffener (longitudinal or transverse) [cm³] including effective width of plating according to 10.2.2

If no lateral load p is acting the bending stress σ_b is to be calculated at the midpoint of the stiffener span for the fibre which results in the largest stress value. If a lateral load p is acting, the stress calculation is to be carried out for both fibres of the stiffener's cross sectional area (if necessary for the biaxial stress field at the plating side).

Note:

Longitudinal and transverse stiffeners not subjected to lateral load p have sufficient scantlings if their moments of inertia

I_x and I_y are not less than obtained by the following formulae:

$$I_x = \frac{p_{zx} \cdot a^2}{\pi^2 \cdot 10^4} \left(\frac{w_{ox} \cdot h_w}{\frac{R_{eH}}{S} - \sigma_x} + \frac{a^2}{\pi^2 \cdot E} \right) \quad [cm^4]$$

$$I_y = \frac{p_{zy} \cdot (n \cdot b)^2}{\pi^2 \cdot 10^4} \left(\frac{w_{oy} \cdot h_w}{\frac{R_{eH}}{S} - \sigma_y} + \frac{(n \cdot b)^2}{\pi^2 \cdot E} \right) \quad [cm^4]$$

10.3.3 Torsional buckling

.1 Longitudinal stiffeners :

$$\frac{\sigma_x \cdot S}{\kappa_T \cdot R_{eH}} \leq 1,0$$

$$\kappa_T = 1,0 \quad \text{for } \lambda_T \leq 0,2$$

$$= \frac{1}{\phi + \sqrt{\phi^2 - \lambda_T^2}} \quad \text{for } \lambda_T > 0,2$$

$$\phi = 0,5 \left(1 + 0,21 (\lambda_T - 0,2) + \lambda_T^2 \right)$$

λ_T = reference degree of slenderness

$$\lambda_T = \sqrt{\frac{R_{eH}}{\sigma_{KIT}}}$$

$$\sigma_{KiT} = \frac{E}{I_p} \left(\frac{\pi^2 \cdot I_\omega \cdot 10^2}{a^2} \varepsilon + 0,385 \cdot I_T \right) \text{ [N/mm}^2\text{]}$$

For I_p , I_T , I_ω see Fig.2.7 and Table 2.18.

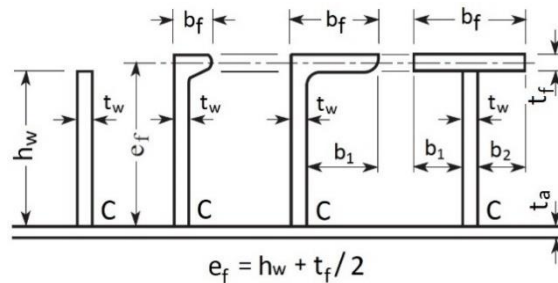


Fig. 2.7 Main dimensions of typical longitudinal stiffeners

- I_p = polar moment of inertia of the stiffener related to the point C [cm⁴]
 I_T = St. Vernet's moment of inertia of the stiffener [cm⁴]
 I_ω = sectorial moment of inertia of the stiffener related to the point C [cm⁶]
 ε = degree of fixation

$$= 1 + 10^{-4} \sqrt{\frac{a^4}{I_\omega \left(\frac{b}{t^3} + \frac{4 \cdot h_w}{3 \cdot t_w^3} \right)}}$$

- h_w = web height [mm]
 t_w = web thickness [mm]
 b_f = flange breadth [mm]
 t_f = flange thickness [mm]
 A_w = web area $h_w \times t_w$
 A_f = flange area $b_f \times t_f$

.2 Transverse stiffeners

For transverse stiffeners loaded by compressive stresses and which are not supported by longitudinal stiffeners, proof is to be provided in accordance with 3.3.1 analogously.

Table 2.18 Formulas for the calculation of moments of inertia I_p , I_T , and I_ω

Profile	I_p	I_T	I_ω
flat bar	$\frac{h_w^3 \cdot t_w}{3 \cdot 10^4}$	$\frac{h_w \cdot t_w^3}{3 \cdot 10^4} \left[1 - 0,63 \frac{t_w}{h_w} \right]$	$\frac{h_w^3 \cdot t_w^3}{36 \cdot 10^6}$
profile with bulb or flange	$\left[\frac{A_w \cdot h_w^2}{3} + A_f \cdot e_f^2 \right] 10^{-4}$	$\frac{h_w \cdot t_w^3}{3 \cdot 10^4} \left[1 - 0,63 \frac{t_w}{h_w} \right] + \frac{b_f \cdot t_f^3}{3 \cdot 10^4} \left[1 - 0,63 \frac{t_f}{b_f} \right]$	for bulb and angle profiles: $\frac{A_f \cdot e_f^2 \cdot b_f^2}{12 \cdot 10^6} \left[\frac{A_f + 2,6 A_w}{A_f \cdot A_w} \right]$ for T - profiles: $\frac{b_f^3 \cdot t_f \cdot e_f^2}{12 \cdot 10^6}$

11. Evaluation of Notch Stresses

11.1 Permissible notch stress

The notch stress σ_K evaluated for linear-elastic material behaviour at free plate edges, e.g. at hatch corners, openings in decks, walls, girders etc., should, in general, fulfill the following criterion:

$$\sigma_K \leq f \cdot R_{eH}$$

f	= 1,1	for normal strength hull structural steel
	= 0,9	for higher strength hull structural steel with $R_{eH} = 315 \text{ N/mm}^2$
	= 0,8	for higher strength hull structural steel with $R_{eH} = 355 \text{ N/mm}^2$.
	= 0,73	for higher strength hull structural steel with $R_{eH} = 390 \text{ N/mm}^2$

For aluminium alloys the permissible notch stress has to be determined individually concerning the respective alloy.

If plate edges are free of notches and corners are rounded-off, a 20 % higher notch stress σ_K may be permitted.

A further increase of stresses may be permitted on the basis of a fatigue strength analysis.

11.2 Notch factors to evaluate actual notch stress

11.2.1 The actual notch stress can be determined by multiplying the nominal stress with the notch factor K_t .

For some types of openings the notch factors are given in [Figs. 2.8](#) and [2.9](#).

Where notch factors for circular holes can be decreased by reinforcement with a coaming, the values for the notch factor K_t have to be specially considered.

Note:

These notch factors can only be used for girders with multiple openings if there is no correlation between the different openings regarding deformations and stresses.

11.3 Openings in decks contributing to longitudinal strength

11.3.1 All openings in the decks contributing to longitudinal strength must have well rounded corners. Circular openings are to be edge-reinforced. The sectional area of the face bar is not to be less than:

$$A_f = 0,25 \cdot d \cdot t \quad [\text{cm}^2]$$

d = diameter of openings [cm]

t = deck thickness [cm]

The reinforcing face bar may be dispensed with, where the diameter is less than 300 mm and the smallest distance from another opening is not less than $5 \times$ diameter of the smaller opening. The distance between the outer edge of openings for pipes etc. and the ship's side is not to be less than the opening diameter.

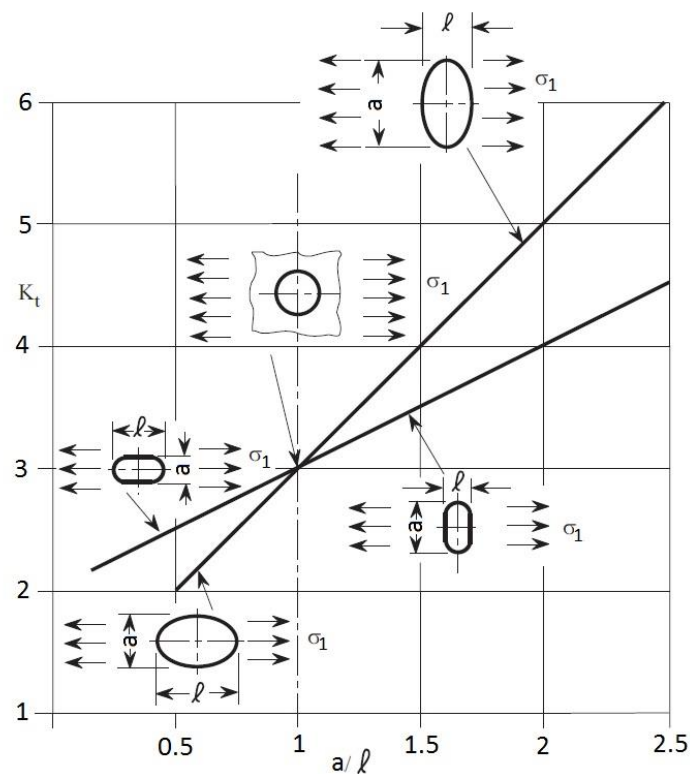


Fig.2.8 Notch faktor K_t for rounded openings

11.3.2 The corners of the opening are to be surrounded by strengthened plates which are to extend over at least one frame spacing fore-and-aft and athwart-ships. Within 0,5 L amidships, the thickness of the strengthened plate is to be equal to the deck thickness abreast the opening plus the deck thickness between the openings. Outside 0,5 L amidships the thickness of the strengthened plated need not exceed 1,6 times the thickness of the deck plating abreast the opening.

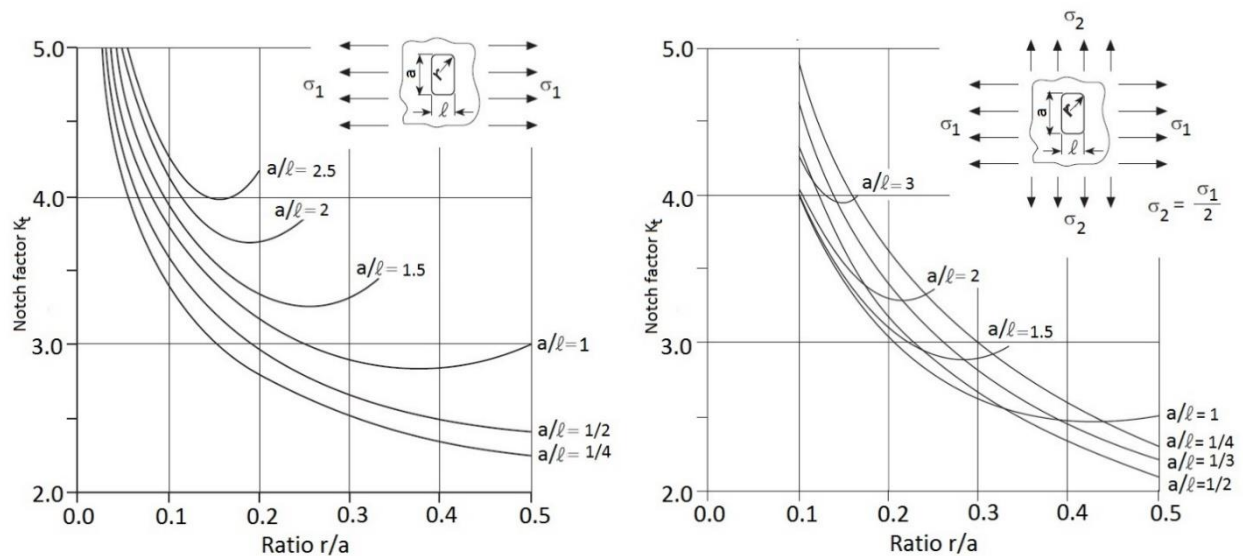


Fig.2.9 Notch faktor K_t for rectangular openings with rounded corners at uniaxial stress condition (left) and at biaxial stress condition (right)

11.3.3 The hatchway corner radius is not to be less than:

$$r = n \cdot b \left(1 - \frac{b}{B} \right)$$

$$r_{\min} = 0,1 \text{ m}$$

$$n_{\min} = \frac{1}{200}$$

$$n_{\max} = 0,25$$

$$\ell = \text{length of opening in [m]}$$

$$b = \text{breadth in [m], of the opening or total breadth of openings in case of more than one. } b/B \text{ need not to be taken smaller than } 0,4.$$

11.3.4 Where the corners of openings are elliptic or parabolic, strengthening according to 11.3.2 is not required. The dimensions of the elliptical and parabolical corners shall be as shown in Fig. 2.10:

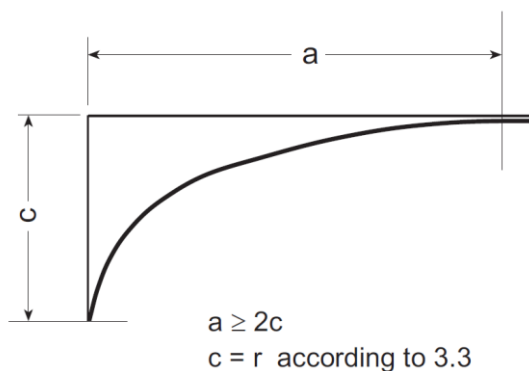


Fig. 2.10 Dimension of elliptical or parabolical corners

Where smaller values are taken for a and c , reinforced insert plates are required which will be considered in each individual case.

11.4 Actual notch stress calculated by FEM methods

An exact distribution of notch stresses can be evaluated by means of finite element calculations. For fatigue investigations the stress increase due to geometry of cut-outs has to be considered.

D. Motor and Sailing Yachts, $24 \text{ m} \leq L \leq 48 \text{ m}$, Steel and Aluminium Structures

1. General

1.1 Scope

The design principles and scantling requirements specified in C apply to the structure of motor and sailing yachts with $24 \text{ m} \leq L \leq 48 \text{ m}$ of normal monohull form made from steel or aluminium alloys. Application of these Rules for special designs or shapes as for fast catamarans, etc., may be agreed upon with BKI.

The following contains definitions and principles for using the scantling formula as well as indications concerning structural details.

1.2 Materials

The requirements for construction materials are defined in [B.2](#). And [B.3](#). Materials with properties deviating from the requirements therein may only be used upon special BKI approval.

1.3 Welding

Welding work is to be in compliance with the [Rules for Welding \(Pt.1, Vol.VI\)](#). An excerpt thereof is given in [B](#).

Shipyards and welding shops, including branches and subcontractors, wishing to perform welding work and to use specific welding procedures covered by these Rules must have been approved for this work by BKI.

2. Principles for structural design

2.1 General

2.1.1 The hull structural arrangement shall consist of an effective strengthening system of bulkheads, web frames, longitudinal girders, etc. as well as transverse frames and/or longitudinal stiffeners. Longitudinal stiffeners are to be supported by transverse web frames or transverse bulkheads. Transverse frames are to be supported by longitudinal girders or other longitudinal structural members, see [Fig. 2.11](#) and [Fig. 2.12](#)

2.1.2 Care is to be taken to ensure structural continuity and to avoid sharp comers. Therefore abrupt discontinuities of longitudinal members are to be avoided and where members having different scantlings are connected with each other, smooth transitions have to be provided. At the end of longitudinal bulkheads or continuous longitudinal walls, suitable scarping brackets are to be provided.

2.1.3 Bottom longitudinals are preferably continuous through the transverse elements. Where longitudinals are interrupted in way of watertight bulkheads or reinforced transverse structures, the continuity of the structure is to be maintained by means of brackets penetrating the transverse element. BKI may allow double brackets welded to the transverse element, provided that special attention is given to the alignment of longitudinals and full penetration welding is used.

In case of continuous longitudinal stiffeners penetrating transverse structural members sufficient effective welding section must be ensured between the two elements.

2.1.4 Floors are to be fitted in line with transverse frames or transverse webs. Alternatively, floors may terminate at longitudinal girders which in tum are supported by transverse bulkheads or deep web rings.

2.1.5 Where frames, beams and stiffeners are intercostal at an intersecting member, the connections have to provide continuity of strength.

2.1.6 Sailing yachts shall have transverse bulk heads or equivalent structures in way of mast(s) in order to achieve adequate transverse rigidity. Bulkheads or deep brackets are to be provided in way of chain plates. Any other arrangement shall be subject to special approval.

2.2 Longitudinal strength

Under certain conditions after consultation with BKI, a check of longitudinal strength is to be carried out.

2.3 Bulkheads

2.3.1 Number and location of watertight bulkheads should be considered in an early design phase to ensure compliance with these Rules and other relevant regulations, if applicable. For the arrangement of bulkheads see also [Section 3, D.8](#).

2.3.2 Collision bulkhead

The collision bulkhead shall extend watertight up to the freeboard deck. Steps or recesses may be permitted.

No doors, manholes, access openings, or ventilation ducts are permitted in the collision bulkhead below the bulkhead deck.

Where pipes are piercing the collision bulkhead, screw down valves are to be fitted directly at the collision bulkhead. Such valves are to be operable from outside the forepeak.

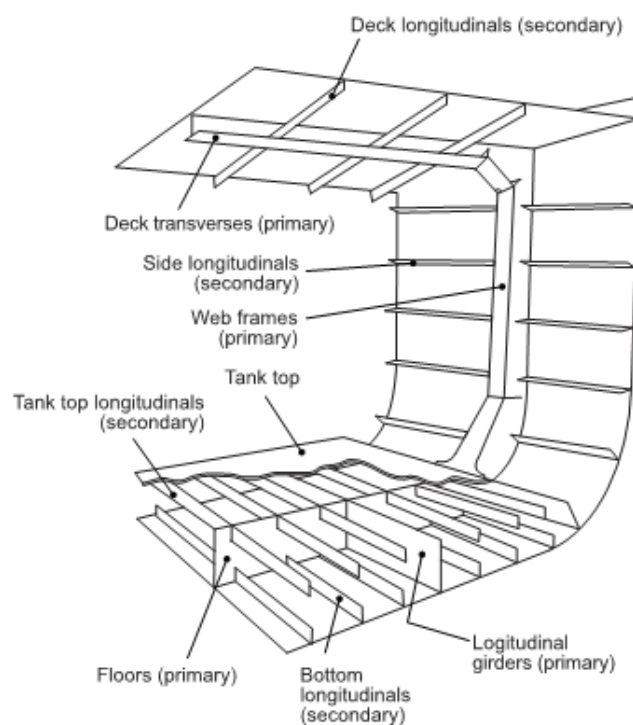


Fig. 2.11 Definition of primary and secondary members of the hull structure (longitudinal framing system)

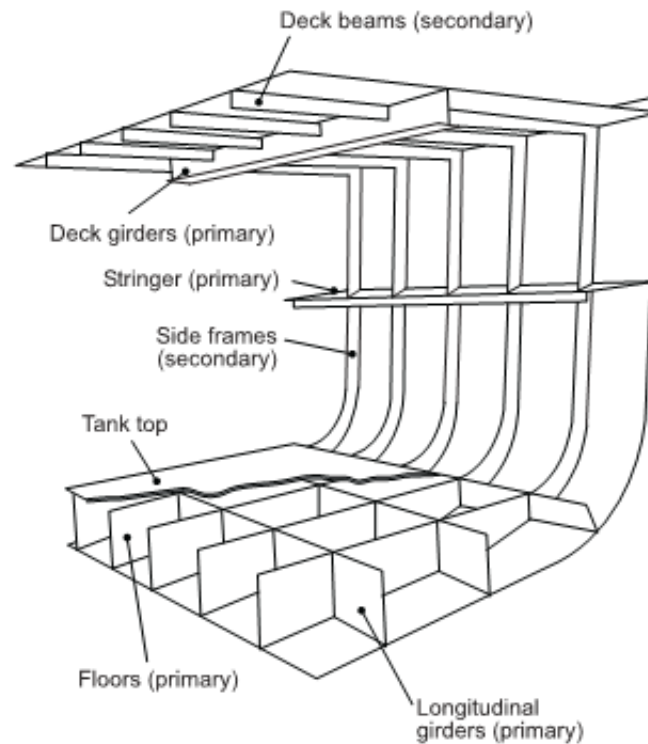


Fig. 2.12 Definition of primary and secondary members of the hull structure (transverse framing system)

2.3.3 Stern tube bulkhead

All yachts are to have a stern tube bulkhead which is, in general, to be so arranged that the stern tube and the rudder trunk are enclosed in a watertight compartment. The stern tube bulkhead shall extend to the freeboard deck or to a watertight platform situated above the load waterline.

Where a complete stern tube bulkhead is not practicable, only watertight void spaces enclosing the stern tube entrance, providing the possibility for a second watertight sealing may be provided after agreement with BKI. The same arrangement can be applied for the rudder trunk.

2.3.4 Remaining watertight bulkheads

Remaining watertight bulkheads are, depending on the type of the yacht and the Classification for damage stability, to extend to the freeboard deck. Wherever practicable, they shall be arranged in one transverse plane, otherwise those portions of decks situated between parts of transverse bulkheads are to be watertight.

It is recommended that bulkheads shall be fitted separating the machinery space from service spaces and accommodation rooms forward and aft and made watertight and gastight up to the freeboard deck.

2.3.5 Bulkhead stiffening

Bulkhead stiffening members are to be located in way of hull and deck longitudinal girders or stiffeners respectively. Where vertical stiffeners are cut in way of watertight doors, reinforced stiffeners are to be fitted on each side of the door opening and crossbars are to be provided to support the cut-off stiffeners.

2.3.6 Openings in watertight bulkheads

.1 Type and arrangement of doors are to be submitted for approval.

In watertight bulkheads other than collision bulkheads, watertight doors may be fitted. Below the deepest load waterline, they are to be constructed as sliding doors, exemptions may be granted on case by case. Above that waterline, hinged doors may be approved.

Watertight doors are to be sufficiently strong and of an approved design. The thickness of plating is not to be less than the minimum thickness according to 4.3.

Openings for watertight doors in the bulkheads are to be effectively framed such as to facilitate proper fitting of the doors and to guarantee watertightness.

.2 Watertight bulkhead doors and their frames, are to be tested before they are fitted on board by a head of water corresponding to the freeboard deck height or the results from damage stability calculation. Alternatively watertight doors may be used which have been type approved in accordance with BKI special acceptance procedure. After having been fitted on board, the doors are to be soap tested for tightness and to be subject to an operational test.

.3 Penetrations through watertight bulkheads

Where bulkhead fittings are penetrating watertight bulkheads, care is to be taken to maintain watertightness. For penetrations through the collision bulkhead 2.3.2 is to be observed.

2.4 Openings

2.4.1 In highly stressed areas openings are to be generally avoided. Bulwark openings shall not be located at ends of superstructures.

2.4.2 Corners of all openings in strength structures are to be well rounded. If necessary, the shape of the openings is to be designed to reduce stress concentrations.

2.5 Side doors

2.5.1 In general, doors in the side shell shall not extend below the load waterline.

2.5.2 Door openings in the shell are to have well rounded corners and adequate compensation of the opening is to be arranged with web frames at sides and stringers above and below. In general the strength of side doors is to be equivalent to the strength of the surrounding structure.

2.5.3 Doors shall preferably be designed to open outwards.

2.6 Bottom structure

2.6.1 Generally, a centreline girder shall be fitted for docking purposes unless sufficient strength and stiffness is already achieved by the external keel or the bottom shape. Additional bottom girders may be appropriate. The centreline and the off-centreline bottom girders are to extend as far forward and aft as practicable. The girders shall be fitted with a continuous face plate.

Lightening holes in girders shall generally not exceed half the depth of the girder and their length shall not exceed half the frame spacing.

2.6.2 Floors or equivalent structural components are to be fitted in the area of the engine foundations, the rudder skeg and the propeller bracket, if applicable. Plating is to be locally increased in way of rudder bearings, propeller brackets and stabilizers by 1,5 times of the adjacent plate thickness.

2.6.3 Manholes and other openings are not to be located at the ends of floor or girder spans, unless shear stress checks are carried out in such areas.

2.6.4 In case of sailing yachts with ballast keel, the bottom structure is to be reinforced due to additional loads transmitted by the keel. Special care is to be taken with the structural support of fin keel's leading and trailing edge.

2.7 Engine foundation

The foundation shall be constructed for the proper transmission of forces in the transverse and longitudinal directions. Longitudinal girders forming seatings of the engine, the gearbox and the thrust block shall therefore extend to the engine room bulkheads and are to be supported transversely by floors, web frames or wing bulkheads. Floors in the engine room are generally to be fitted at every frame. Additional intermediate frames may be appropriate.

2.8 Side structure and bulwarks

2.8.1 Side frames shall be connected to keel floors and deck beams by brackets. Alternatively, a continuous transition between such elements is to be adequately rounded.

Continuity of longitudinal stiffeners is to be ensured, if applicable.

2.8.2 Bulwark plating is to be determined by applying the side design pressure for the relevant vertical height. Bulwark stanchions must be in line with transverse beams or adequate substructure must be provided by other means. Bulwarks are to be provided with freeing ports of sufficient size, see [Section 3, D.5](#).

2.9 Tank structures

2.9.1 The fore peak shall not be used for carrying fuel oil.

2.9.2 Fresh water tanks are to be separated from other tanks such as waste water tanks by cofferdams. The same applies to fuel tanks. Generally, also tanks such as lubricating or hydraulic oil tanks shall be separated from each other by equivalent means.

2.9.3 Each tank is to be fitted with air pipes, over flow and sounding pipes, see [Section 1, C.7.11](#).

2.10 Deck

2.10.1 In case of longitudinal deck stiffeners, deck beams are to be located in way of the vertical web frames of the side shell. Structural continuity of the stiffeners is to be ensured, see [Fig. 2.11](#).

2.10.2 In case of a transversely stiffened deck, deck beams are to be generally fitted at every frame and shall be in line with the side stiffening members, see [Fig. 2.12](#).

2.11 Superstructures and deckhouses

2.11.1 Ends of superstructures and deckhouses are to be sufficiently supported by bulkheads, pillars or other equivalent arrangements. Superstructure front and aft bulkheads are to be aligned with bulkheads in the hull or must be equivalently supported by pillars.

In extension of superstructures and deckhouses, girders shall be arranged under the main deck extending at least three frame spaces beyond the ends of the longitudinal walls. These girders shall overlap the longitudinal walls at least by two frame spaces.

2.11.2 Web frames or partial 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.

As a rule, the spacing of stiffeners on sides of superstructures and deckhouses are to be the same as those of beams on supporting decks.

2.11.3 Structural discontinuities and rigid points are to be avoided. When the strength of a structural element is reduced by the presence of an attachment or an opening, proper compensation is to be provided.

2.12 Pillars

For the structural arrangement of pillars see [4.6](#).

2.13 Further design principles

Further design principles for metallic structures are summarized in [C](#).

3. Design loads

3.1 General

3.1.1 For "high speed" motor yachts which are capable of speeds:

$$v \geq 7,2 \cdot \sqrt[5]{\nabla} \quad [\text{kn}]$$

∇ = moulded volume [m³] according to A.6.6

The relevant design loads and scantling requirements of the [Rules for High Speed Craft \(Pt.3, Vol.III\)](#) apply.

3.1.2 The design loads for sailing and motor yachts not considered as of the "high speed" type are specified in the following. The design loads are to be applied at the following load points:

- for panels: lower edge of the plate
- for structural members: centre of the area supported by the element

3.1.3 Definition of symbols

L_{SC} = Scantling length [mm]

$$= \frac{L_H + L_{WL}}{2}$$

L_H = length of the yacht's hull measured parallel to the design waterline [m], see [Fig. 2.13](#)

L_{WL} = length of the yacht from the foreside of the stem to the after side of the stern or transom, measured at the design waterline [m], see [Fig. 2.13](#)

T_H = see [A.6.2.10](#)

3.2 Loads on hull

3.2.1 The load p_H [kN/m²] on the yacht's hull is to be determined as follows:

$$P_H = 10 \cdot T_H \left(1 - \frac{z}{H} \right) + c_{RY} \cdot c_p \cdot c_L \cdot L_{sc} \left(1 + \frac{v_0}{3 \cdot \sqrt{L_{sc}}} \right) \cdot \cos \left(\frac{\alpha}{1,5} \right) \quad [\text{kN/m}^2]$$

c_p = Panel size factor as a function of f , see also [Fig. 2.14](#)

$$= 0,54 \cdot f^2 - 1,29 \cdot f + 1$$

$$f = \frac{a - 250}{55 \cdot L_{sc} \cdot 550}$$

a = Panel's short span respectively load span of stiffener [mm], not to be taken > 1300 mm

c_L = hull longitudinal distribution factor

for sailing yachts, see [Fig. 2.15](#), c_L is:

$$\text{for } \frac{x}{L_{wl}} < 0 :$$

$$c_L = 0,8 \quad \text{for } L = 24 \text{ m}$$

$$c_L = 0,6 \quad \text{for } L = 48 \text{ m}$$

$$\text{for } 0 \leq \frac{x}{L_{wl}} < 0,65 :$$

$$c_L = 0,8 + 0,615 \cdot \frac{x}{L_{wl}} \quad \text{for } L = 24 \text{ m}$$

$$c_L = 0,6 + 0,538 \cdot \frac{x}{L_{wl}} \quad \text{for } L = 48 \text{ m}$$

$$\text{for } \frac{x}{L_{wl}} \geq 0,65 :$$

$$c_L = 1,2 \quad \text{for } L = 24 \text{ m}$$

$$c_L = 0,95 \quad \text{for } L = 48 \text{ m}$$

for motor yachts see [Fig. 2.16](#) c_L is:

$$\text{for } \frac{x}{L_{wl}} < 0 :$$

$$c_L = 0,85 \quad \text{for } L = 24 \text{ m}$$

$$c_L = 0,65 \quad \text{for } L = 48 \text{ m}$$

$$\text{for } 0 \leq \frac{x}{L_{wl}} < 0,5 :$$

$$c_L = 0,85 + 0,8 \cdot \frac{x}{L_{wl}} \quad \text{for } L = 24 \text{ m}$$

$$c_L = 0,65 + 0,7 \cdot \frac{x}{L_{wl}} \quad \text{for } L = 48 \text{ m}$$

- for $\frac{x}{L_{wl}} \geq 0,5$:

- $c_L = 1,25$ for $L = 24$ m

- $c_L = 1,0$ for $L = 48$ m

z = vertical distance between the load point and the moulded base line [m], see [Fig. 2.13](#)

α = $\beta - 20^\circ$ for sailing yachts (not smaller than 0°)

= $\beta - 5^\circ$ for motor yachts (not smaller than 0°)

β = deadrise angle at the load point, see [Fig. 2.13](#)

c_{RY} = factor considering range of service, see [section 1, A.7.](#)

= 1,0 for unrestricted service

= 0,95 for **P**, restricted service

= 0,90 for **L**, coastal service

= 0,85 for **T**, sheltered water service

3.2.2 In any case the load p_H shall not be smaller than:

$$p_{Hmin} = 10 \cdot H \quad [kN/m^2]$$

for the area of the hull below the full displacement waterline

$$p_{Hmin} = 5 \cdot H \quad [kN/m^2]$$

for the area of the hull above the full displacement waterline

3.2.3 The design load for the ballast keel area of sailing yachts as indicated in [Fig. 2.19](#) shall be taken as:

$$p_{keel} = 2 \cdot p_H$$

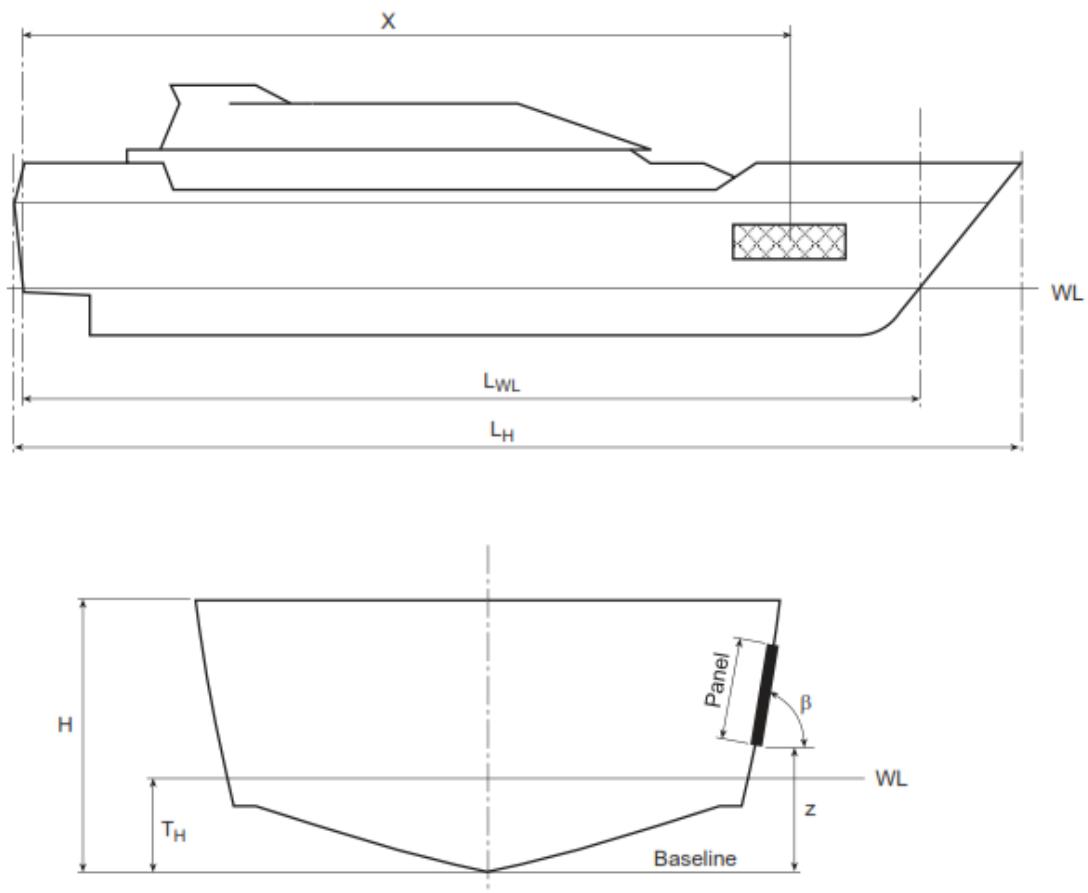


Fig. 2.13 Characteristic parameters for panels of a motor yacht's hull

3.3 Loads on weather decks

3.3.1 The design pressure on weather decks is to be determined according to the following formula:

$$P_D = 2,7 \cdot C_D \cdot \sqrt{\frac{L_{SC}}{T_H + z}}$$

$$P_{D,min} = 6,0 \text{ kN/m}^2$$

z = local height of weather deck above WL [m]

C_D = deck longitudinal distribution factor
= for sailing yachts, see Fig. 2.17, c_D is:

$$\text{for } \frac{x}{L_{WL}} < 0,05: \quad c_D = 1,20$$

$$\text{for } 0,05 \leq \frac{x}{L_{WL}} < 0,25: \quad c_D = 1,25 - \frac{x}{L_{WL}}$$

$$\text{for } 0,25 \leq \frac{x}{L_{WL}} < 0,70: \quad c_D = 1,00$$

$$\text{for } 0,70 \leq \frac{x}{L_{WL}} < 0,90: \quad c_D = 2,5 \cdot \frac{x}{L_{WL}} - 0,75$$

- for $\frac{x}{L_{WL}} \geq 0,90$: $c_D = 1,50$

= for motor yachts, see Fig. 2.18, c_D is:

- for $\frac{x}{L_{WL}} < 0$: $c_D = 1,10$

- for $0 \leq \frac{x}{L_{WL}} < 0,25$: $c_D = 1,10 - 0,4 \cdot \frac{x}{L_{WL}}$

- for $0,25 \leq \frac{x}{L_{WL}} < 0,70$: $c_D = 1,00$

- for $0,70 \leq \frac{x}{L_{WL}} < 1,00$: $c_D = \frac{2}{3} \cdot \frac{x}{L_{WL}} + \frac{8}{15}$

- for $\frac{x}{L_{WL}} \geq 1,00$: $c_D = 1,20$

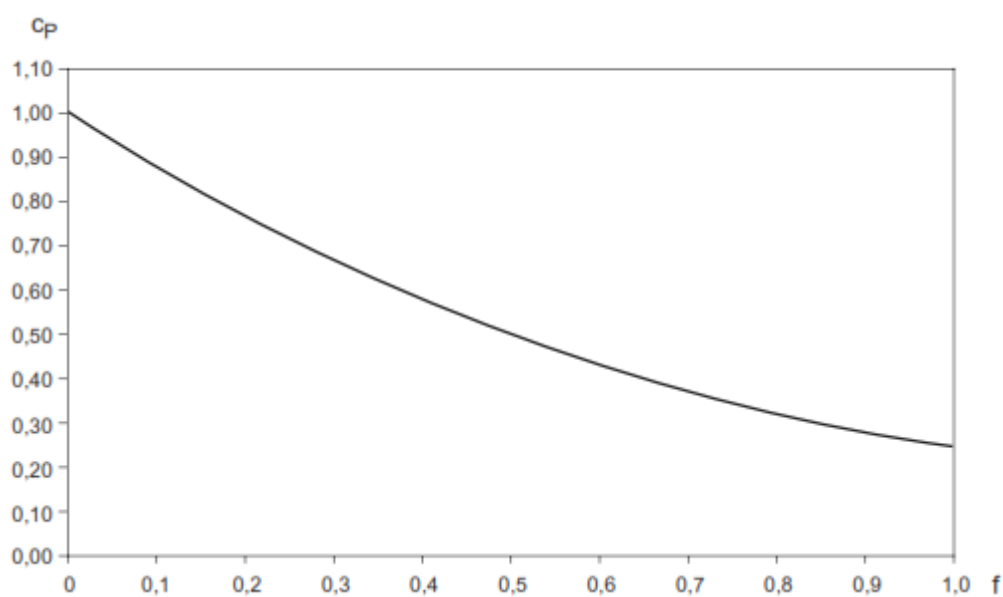


Fig. 2.14 Panel size factor c_p

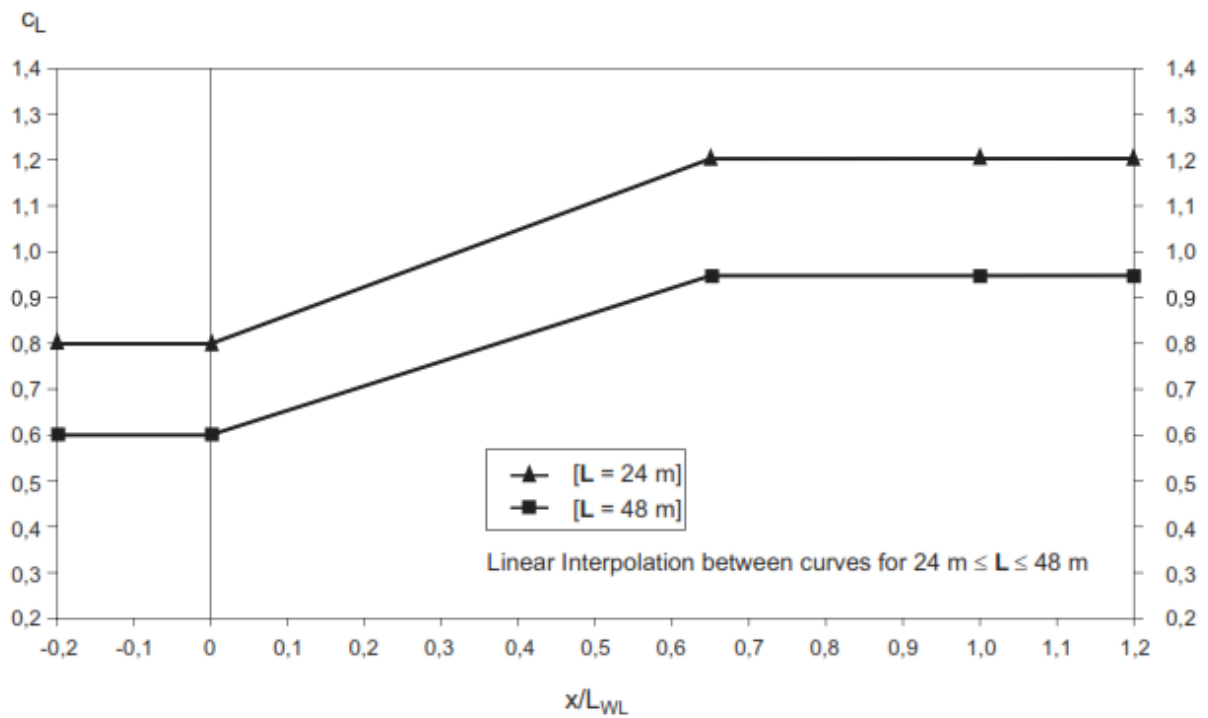


Fig. 2.15 Hull longitudinal distribution factor for sailing yachts c_L

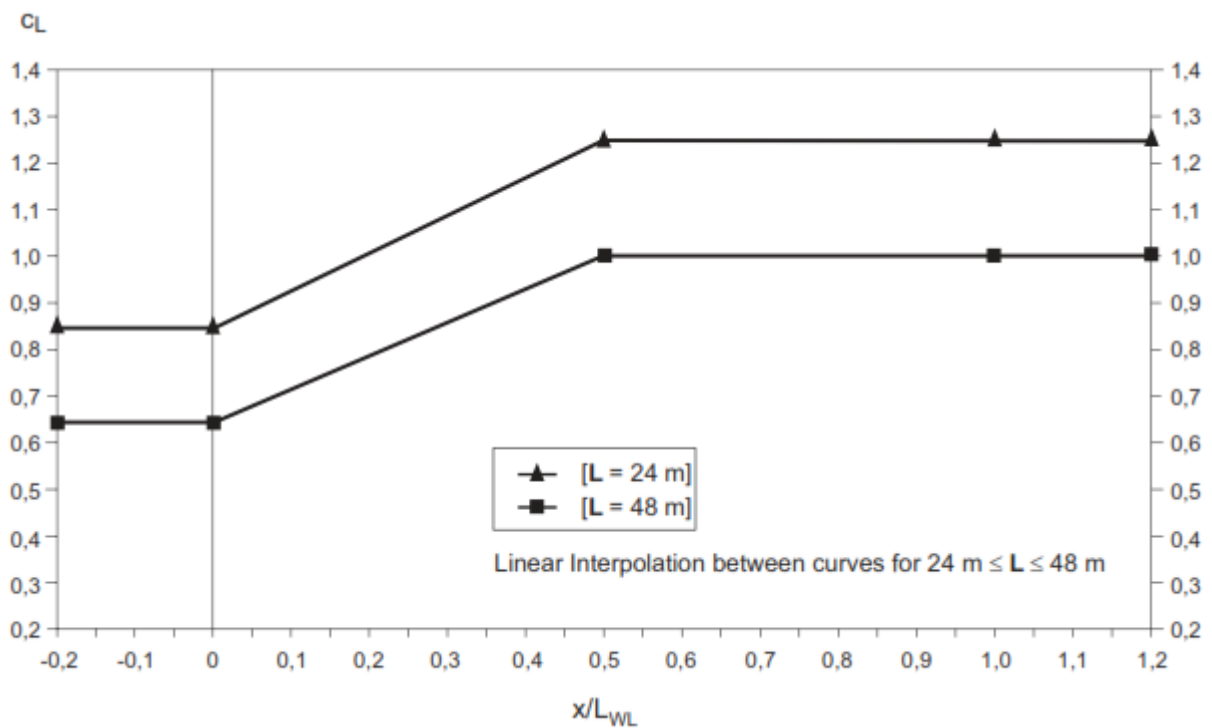


Fig. 2.16 Hull longitudinal distribution factor for motor yachts c_L

3.4 Loads on superstructures and deckhouses

3.4.1 Loads on walls

.1 Front walls

The design load is:

$$P_{AFW} = 1,5 \cdot P_D \quad [\text{kN/m}^2]$$

.2 Side walls

The design load is:

$$P_{AAW} = 1,2 \cdot P_D \quad [\text{kN/m}^2]$$

.3 Aft walls

The design load is:

$$P_{AAW} = 0,8 \cdot P_D \quad [\text{kN/m}^2]$$

3.4.2 Loads on superstructure decks

The load on decks of superstructures and deckhouses is based on the load on the weather deck according to 3.3 and is defined by the following formula:

$$P_{DA} = P_D \cdot n \quad [\text{kN/m}^2]$$

$$P_{DA, \min} = 4,0 \quad [\text{kN/m}^2]$$

$$n = 1 - \frac{Z - H}{10}$$

z = vertical distance of the deck above the base line [m]

3.5 Loads on accommodation decks

The load on accommodation decks can be assumed as:

$$P_L = P_C \cdot C_D \quad [\text{kN/m}^2]$$

P_C = to be defined by the designer in connection with the owner's specification [kN/m²]

$P_{C \min}$ = 3,5 kN/m²

C_D = deck longitudinal distribution factor according to Fig. 2.17 and Fig.2.18

3.6 Loads on bulkheads

3.6.1 Collision bulkhead

The design load is:

$$P_{BH} = 11,5 \cdot z_{BH} \quad [\text{kN/m}^2]$$

z_{BH} = vertical distance from the load centre to the top of the bulkhead [m]

3.6.2 Other bulkhead

The design load is:

$$P_{BH} = 10,0 \cdot z_{BH} \quad [\text{kN/m}^2]$$

3.7 Loads on tank structures

The design load is:

$$P_T = 10,0 \cdot z_T \quad [\text{kN/m}^2]$$

z_T = vertical distance from the load centre to the top of the tank overflow [m]
= not to be taken less than 2,0 m

4. Scantlings

4.1 General

For the scantlings of "high speed" motor yachts see [3.1.1](#).

4.1.1 Rounding-off tolerances

If the determined plate thickness differs from full or half mm they may be rounded off to full or half mm up to 0,2 mm or 0,7 mm; above 0,2 and 0,7 mm they are to be rounded up.

4.1.2 Corrosion allowances

The following, reduced corrosion allowances may be applied for yachts, if special care for maintenance and special attention for measures of corrosion protection can be assumed.

.1 Steel

The scantlings require the following allowances t_k to the theoretical, rounded-off plate thickness:

- t_k = 0,5 mm in general
- t_k = 0,7 mm for lubrication oil, gas oil or equivalent tanks
- t_k = 1,0 mm for water ballast, sewage, sea chests and heavy oil tanks
- t_k = 1.0 mm for deck plating below elastically mounted deckhouses
- t_k = 2.0 mm for chain locker, stern tube
- for special applications t_k shall be agreed with BKI

For all elements of the yacht's structure which are forming a boundary of tanks, the t_k values for tanks have to be considered.

For stainless steel a corrosion addition is not required. A reserve thickness of 0.5 mm is considered within t_k

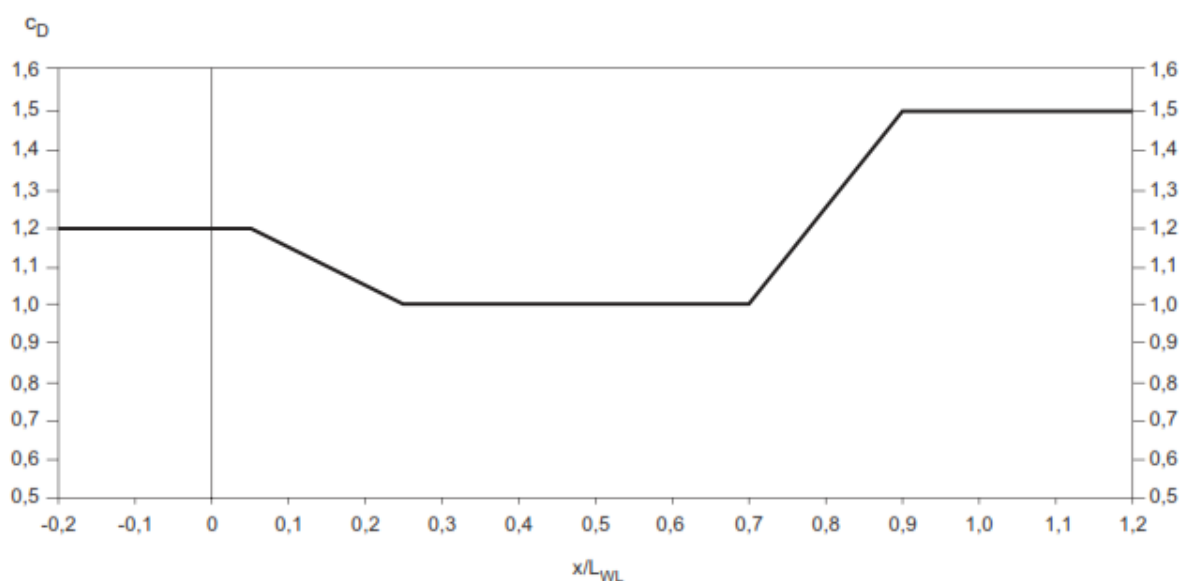


Fig. 2.17 Deck longitudinal distribution factor c_D for sailing yachts

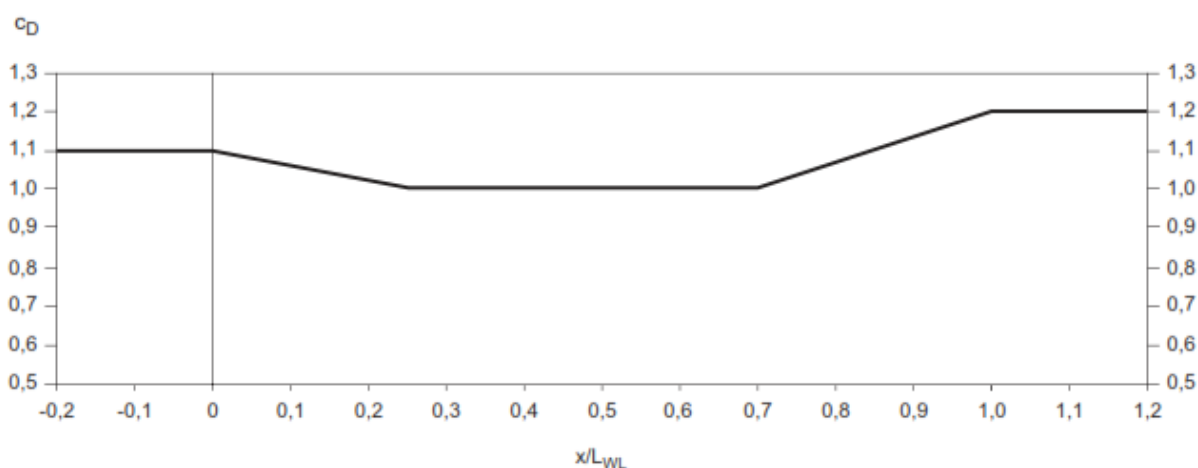


Fig. 2.18 Deck longitudinal distribution factor c_D for motor yachts

.2 Aluminium alloys

If the measures for corrosion protection described in B.6. are fully applied, the corrosion allowance t_k can be assumed as 0 for the types of aluminium alloys defined in B.3.4 and B.3.5. In any way t_k shall not be less than the fabrication tolerances, see Rules for Materials (Pt. 1 Vol.V). A reserve thickness of 0.5 mm is considered within t_k .

In any case, any direct contact between steel and aluminium alloy (e.g. aluminium chain locker and chain cable) shall be avoided.

.3 Minimum plate thickness

In general the minimum plate thicknesses for steel and aluminium alloy structures defined in Table 2.19 shall be met. In exceptional cases other values may be agreed with BKI.

Table 2.19 Minimum plate thickness for steel and aluminium plating

Element	Minimum thickness [mm]
Bottom shell plating	$0,9 \cdot \sqrt{k \cdot L}$
Side shell plating	$0,8 \cdot \sqrt{k \cdot L}$
Deck plating	$0,7 \cdot \sqrt{k \cdot L}$
All other strength relevant plating	3,0
t_k = material factor = for steel according to B.2.1 and B.2.2 = for aluminium = K_{Al} according to B.3.8	

4.2 Keel

4.2.1 Flat plate keel and garboard strake

.1 The width of the flat plate keel b is not to be less than:

$$b = (650 + 5 \cdot L) \cdot \sqrt{k} \quad [\text{mm}]$$

k = material factor for steel materials according to B.2.1 and B.2.2 as well as for aluminium alloys according to B.3.8

.2 The thickness of the flat plate keel is not to be less than:

$$t_{\text{keel}} = t + 2,0 \quad [\text{mm}]$$

t = thickness of the adjacent bottom plating [mm]

Where a single bottom plating is provided, the thickness of the flat plate keel and the garboard strake is to be adequately increased in the machinery space.

These requirements for the flat plate keel are valid for motor yachts. For sailing yachts scantlings of the ballast keel area (refer to Fig.2.19) and the ballast

keel itself are to be determined for a design load of $p_{\text{keel}} = 2 \cdot p_H$ (see 3.2.3)

4.2.2 Bar keel

Where a bar keel is provided, its height h and thickness t are recommended to be determined according to following formulae:

$$h = (1,1 \cdot L + 110) \cdot \sqrt{k} \quad [\text{mm}]$$

$$t = (0,6 \cdot L + 12) \cdot \sqrt{k} \quad [\text{mm}]$$

The adjoining garboard strake shall have the scantlings of a flat plate keel. Minor deviations of the above values are admissible provided the required sectional area is maintained.

4.3 Plating

4.3.1 The thickness of the plating of hull, decks, superstructures, bulkheads and tanks is not to be less than:

$$t = 22,4 \cdot a \cdot \sqrt{\frac{p}{\sigma_{perm}}} \cdot f_a \cdot f_c \cdot t_k \quad [\text{mm}]$$

a = shorter span of panel [m], respectively frame spacing a

b = longer span of panel in [m]

p = applicable design load

= p_H on hull according to 3.2

= p_D on weather deck according to 3.3

= p_A on superstructures and deckhouses according to 3.4

= p_L on accommodation decks according to 3.5

= p_{BH} on watertight bulkheads according to 3.6

= p_T in tanks according to 3.7

$$\sigma_{perm} = \frac{185}{k} \quad [\text{N/mm}^2]$$

k = material factor for steel materials according to B.2.1 and B.2.2 as well as for aluminium alloys according to B.3.8

a = aspect ratio factor

$$= 0,54 + 0,23 \cdot \frac{b}{a} \quad \text{for } \frac{b}{a} \leq 2$$

$$= 1 \quad \text{for } \frac{b}{a} > 2$$

f_c = correction factor for plate panels with simple convex curvature according to C.3.

t_k = corrosion allowance according to 4.1.2

4.3.2 Compliance with minimum thickness requirements according to 4.1.3 is always mandatory.

4.4 Structural members

4.4.1 General

The following formulae to determine the required section modulus and shear area apply to stiffeners, frames, floors, beams and girders. They are valid for stiffening members with webs either perpendicular to the plating or deviating not more than 15° from the perpendicular. In case this angle α exceeds 15°, the required values are obtained by dividing the results of the following formulae by $\cos \alpha$.

4.4.2 Section modulus

The section modulus W of a stiffening member required for support of the plating loaded with the design pressure is not to be less than:

$$W = \frac{c \cdot p \cdot a \cdot \ell^2}{\sigma_{perm}} \cdot f_{cs}$$

c = correction factor for boundary conditions

= 83 for both ends constraint, see C.6.

= 125 for one or both ends simply supported, see C.6.

p = applicable design load [kN/m²] according to 3.

a = load span [m]

ℓ = unsupported length of stiffener [m], see C.5.

f_{cs} = correction factor for plate panels with simple convex curvature according C.4.4

σ_{perm} = permissible stress

$$= \frac{150}{k} \quad [\text{N/mm}^2]$$

k = material factor for steel materials according to B.2.1 and B.2.2 as well as for aluminium alloys according to B.3.8

4.4.3 Shear area

The shear area, i.e. the cross sectional area of the web of the stiffening member A is not to be less than:

$$A = \frac{5 \cdot p \cdot a \cdot \ell}{\tau_{perm}} \cdot f_{cs}$$

p, a, ℓ , k as defined in 4.4.2

τ_{perm} = permissible shear stress

$$= \frac{100}{k} \quad [\text{N/mm}^2]$$

4.4.4 Brackets

Required scantlings for brackets are defined in C.6.3.

4.5 Permissible equivalent stress

4.5.1 The equivalent stress σ_v for hull structural members is to be determined according to:

$$\sigma_v = \sqrt{\sigma_b^2 + 3 \cdot \tau^2} \quad [\text{N/mm}^2]$$

σ_b = bending stress [N/mm²]

τ = shear stress [N/mm²]

4.5.2 The equivalent stress for steel structures is not to exceed the following value:

$$\sigma_v = \frac{190}{k} \quad [\text{N/mm}^2]$$

k = material factor for steel according to B.2.1 and B.2.2

4.5.3 The equivalent stress for aluminium structures is not to exceed the following value:

$$\sigma_v = \frac{190}{k_{Al}} \quad [\text{N/mm}^2]$$

k_{Al} = material factor for aluminium according to B.3.8

4.6 Pillars

4.6.1 General

.1 Structural members at heads and heels of pillars as well as substructures are to be constructed according to the forces they are subject to. Pillars shall rest on girders, floors or other pillars. Openings in webs of floors and girders below pillars are to be avoided. Where pillars on the inner bottom are not in way of intersections of floors and girders, partial floors or other structures are to be provided to support the load transmitted.

.2 At the head and the heel of tubular pillars, plates are generally to be arranged. The connection is to be so dimensioned that at least 1 cm² cross sectional area is available for 10 kN of load.

.3 Where possible, upper deck pillars shall be aligned with pillars below. Stiffeners ensuring efficient load distribution are to be fitted at the ends of pillars.

.4 Pillars in tanks are to be checked for tension. Tubular pillars are not permitted in tanks for flammable liquids.

4.6.2 Definition of loads and geometric parameters

P_s = pillar load [kN]

$$= P_L \cdot A + P_i$$

P_L = Load on deck [kN/m²] according to 3.3 to 3.5 A

A = Load area for one pillar [m²]

P_i = Load from pillars located above the pillar considered [kN]

ℓ_s = Length of the pillar [cm]

$$I_s = A_s \cdot I_s^2$$

= moment inertia of the pillar [cm⁴] considering effective width

A_s = section area of the pillar [cm²]

i_s = radius of gyration of the pillar [cm]

$$= 0,25 \cdot d_s \text{ for solid pillars of circular cross section}$$

$$= 0,25 \cdot \sqrt{d_a^2 + d_i^2}$$

d_a = outside diameter of tubular pillars [cm]

d_i = inside diameter of pillar [cm]

d_s = pillar diameter of solid pillars [cm]

4.6.3 Buckling criterion

The chosen scantlings of a pillar have to meet the following buckling criterion:

$$\frac{1,1 \cdot \sigma_x}{\kappa \cdot R_{eH}} \leq 1$$

In case of aluminium ally pillars R_{eH} is to be substituted by $R_{p0,2}$ (see B.3.8)

σ_x = buckling stress in longitudinal direction of the pillar [N/mm²]

$$\sigma_x = \frac{\nu \cdot P_s \cdot 10}{A_s} \quad [\text{cm}^2]$$

ν = safety factor

$$= 1,50$$

κ = reduction factor

$$\kappa = \frac{1}{\phi + \sqrt{\phi^2 - \lambda^2}}$$

$$\phi = 0,5 \left[1 + n_p (\lambda_s - 0,2) + \lambda_s^2 \right]$$

n_p = 0,34 for pipes and box sections

= 0,49 for open sections

$$\lambda = \sqrt{\frac{R_{eH}}{\sigma_{ki}}}$$

R_{eH} = minimum nominal upper yield stress [N/mm²] according to B.2.1 and B.2.2

σ_{ki} = pillar buckling stress [N/mm]

$$= \frac{\pi^2 \cdot E \cdot I_s}{\ell_s^2 \cdot K_s^2 \cdot A_s}$$

E = modulus of elasticity [N/mm²]

K_s = 1,0 in general. For pillars which end supports can be considered as rigidly fixed, k_s may be reduced accordingly.

4.6.4 Minimum wall thickness

The wall thickness of tubular pillars which may be expected to be damaged during equipment handling, etc. is not to be less than:

$$t_w = 4,5 + 0,015 d_a \quad [\text{mm}]$$

For $d_a \leq 300$ mm

$$t_w = 0,03 d_a \quad [\text{mm}]$$

For $d_a > 300$ mm

4.7 Foundations for main propulsion engines

4.7.1 General

.1 The following requirements apply to diesel engines, gears and generators.

.2 The rigidity of the engine seating and the surrounding bottom structure must be adequate to keep the deformations of the system due to the loads within the permissible limits. In special cases, proof of deformations and stresses may be required.

4.7.2 Due regard is to be paid, at the initial design stage, to a good transmission of forces in transverse and longitudinal direction.

4.7.3 The foundation bolts for fastening the engine at the seating shall be spaced no more than $3 \times d$ apart from the longitudinal foundation girder. Where the distance of the foundation bolts from the longitudinal foundation girder is greater, proof of equivalence is to be provided.

d = diameter of the foundation bolts

4.7.4 In the whole speed range of main propulsion installations for continuous service resonance vibrations with inadmissible vibration amplitudes must not occur; if necessary structural variations have to be provided for avoiding resonance frequencies. Other- wise, a barred speed range has to be fixed. Within a range of -10% to $+5\%$ related to the rated speed no barred speed range is permitted. BKI may require a vibration analysis and, if deemed necessary, vibration measurement.

4.7.5 Longitudinal girders

.1 The thickness of longitudinal girders for internal combustion engines is not to be less than:

$$t = \left(\frac{P}{n \cdot e_1 \cdot c} + \frac{G}{280} \right) \frac{375}{\ell_m} \text{ [mm]}$$

$$c = 1 - \frac{1}{0,025 \cdot \sqrt{P}}$$

$0,2 \leq c \leq 0,5$ for 4-stroke engines

$$= 1 - \frac{1}{0,05 \cdot \sqrt{P}}$$

$\geq 0,3$ for 2-stroke engines

$$t_{\min} = 0,4 \cdot t_p \text{ [mm]}$$

t_p = thickness of top plate, see 4.7.5.3

P = rated driving power of the engine [kW]

n = rated speed at output [1/min]

G = weight of engine [kN]

ℓ_m = bolted length of engine on foundation [m]

e_1 = distance of the longitudinal girder [mm]

The web thickness of longitudinal girders for elastically mounted four-stroke internal combustion engines may be reduced to

$$t' = 0,4 \cdot t$$

If brackets are provided below the mountings, besides each bolt. The web thickness may be reduced to

$$t' = 0,9 \cdot t$$

if two longitudinal girders are provided at each side of an internal combustion engine.

.2 The thickness of the longitudinal girders for gears or generators is not to be less than:

$$t = \frac{P}{n \cdot e_1 \left(\ell_m + \frac{e_1}{3} \right)} \quad [\text{mm}]$$

P = rated output of gear or generator [kW]

e_1, ℓ_m = see 4.7.5.1

.3 The sizes of the top plate (width and thickness) shall be sufficient to attain efficient attachment and seating of the engine and—depending on seating height and type of engine—adequate transverse rigidity.

The thickness of the top plate shall be:

$$t' = 0,9 \cdot d \quad [\text{mm}]$$

d = diameter of the foundation bolts [mm]

The cross sectional area of the top plate is not to be less than:

$$A_T = \frac{P}{15} + 30 \quad [\text{cm}^2] \quad \text{for } P \leq 750 \text{ kW}$$

$$A_T = \frac{P}{75} + 70 \quad [\text{cm}^2] \quad \text{for } P > 750 \text{ kW}$$

P = see 4.7.5.1

Where twin engines are fitted, a continuous top plate is to be arranged in general if the engines are coupled to one propeller shaft.

.4 Top plates are preferably to be connected to longitudinal and transverse girders thicker than approx. 15 mm by means of a double bevel butt joint (K butt joint).

4.8 Transverse support of longitudinal girders

4.8.1 The sectional modulus and the cross sectional area of the floor plates between longitudinal girders are not to be less than:

$$W = \left(\frac{120}{n} + e_1 \cdot G \right) \frac{7 \cdot a}{\ell_m} \quad [\text{cm}^3]$$

$$A_s = \frac{0,35 \cdot a \cdot G}{\ell_m} \quad [\text{cm}^3]$$

a = distance of the floor plates [m]. For all other parameters see 4.7.5.1.

4.8.2 The longitudinal girders of the engine seating are to be supported transversely by means of web frames or wing bulkheads.

4.9 Foundations for deck machinery and mooring equipment

4.9.1 For deck machinery, like anchor windlasses, mooring winches, boat davits, etc. the most critical operational loads have to be considered for an analysis.

4.9.2 For windlasses and chain stoppers the acting forces on the foundation are to be calculated for 100 % of the rated breaking load of the chain cable. The resulting normal stress in the supporting structure shall not exceed the minimum nominal upper yield point R_{eH} . Shear stress is to be within:

$$\frac{R_{eH}}{\sqrt{3}}$$

E. Motor and Sailing Yachts, $24 \text{ m} \leq L \leq 48 \text{ m}$, Composite Structures

1. General

1.1 Scope

1.1.1 The following specifies requirements for design and construction of hulls for motor and sailing yachts with $24 \text{ m} \leq L \leq 48 \text{ m}$, made from composite materials. The term composite refers to fibre reinforced plastic (FRP) materials of the single skin type or to FRP skins in conjunction with lightweight core materials, i.e. sandwich types. For lengths L above 48 m special considerations for the extrapolation of these Rules have to be agreed with BKI. The requirements apply also to hulls of cold-moulded wood construction.

1.1.2 The following may be also used for craft other than yachts, like work boats, patrol boats, etc. For such craft an additional safety factor of 1,2 regarding permissible stresses shall be applied.

1.1.3 Different types of fibres and the multitude of fibre arrangements, as well as different core materials give rise to sophisticated laminate lay-ups of components specifically designed for the loads expected. Strength and stiffness calculations for such structures require careful analysis.

1.2 Materials

1.2.1 Regarding FRP and core materials, the [Rules for Non-Metalic Materials \(Pt.1, Vol.XIV\)](#) apply. An excerpt of these Rules is contained in [B.7](#).

1.2.2 The actual mechanical properties of all FRP layers and the core materials have to be submitted to BKI and are to be verified by tests. The information about the properties shall also include nominal thickness of each ply, specific weight per area and fibre content.

2. Design principles

2.1 General structural arrangement

2.1.1 The hull structural arrangement shall consist of an effective strengthening system of bulkheads, web frames, longitudinal girders, etc. as well as transverse and/or longitudinal frames or stiffeners. Longitudinal stiffeners are to be supported by transverse web frames or transverse bulkheads. Transverse frames are to be supported by longitudinal girders or other longitudinal structural members.

Where bulkheads, bunks, shelves, or other structurally effective interior components are laminated to the hull to provide structural support, they are generally to be bonded by laminate angles on both sides.

bulkheads. Transverse frames are to be supported by longitudinal girders or other longitudinal structural members.

2.1.2 Care is to be taken to ensure structural continuity and to avoid sharp corners and abrupt changes in section and shape.

Where frames, beams and stiffeners are intercostal at an intersecting member, the connections are to provide continuity of strength.

2.1.3 Floors are to be fitted in line with transverse webs or transverse frames. Alternatively, floors may terminate at longitudinal girders which in turn are supported by deep web rings or transverse bulkheads. Floors or equivalent stiffeners are to be fitted in the area of the engine foundations, the rudder skeg and the propeller bracket, if applicable. For sailing yachts with short ballast keels, a reinforced floor at the leading and trailing edge of the keel is to be arranged.

2.1.4 Sailing craft shall have transverse bulkheads or equivalent structures in way of mast(s) in order to achieve adequate transverse rigidity. Transverse bulkheads or deep brackets are to be provided in way of chain plates.

2.2 Longitudinal strength

Under certain conditions after consultation with BKI a check of longitudinal strength is to be carried out.

2.3 Bulkheads

2.3.1 Number and location of watertight bulkheads should be considered in the early design phase to ensure compliance with these Rules and possibly other relevant regulations.

Bulkhead stiffeners, where required, are to be aligned with hull girders. Where vertical stiffeners are cut in way of watertight doors, reinforced stiffeners are to be fitted on each side of the door opening and crossbars are to be provided to support the cut-off stiffeners.

2.3.2 Collision bulkhead

The collision bulkhead shall extend up to the freeboard deck. Steps or recesses may be permitted.

No doors, manholes, access openings, or ventilation ducts are permitted in the collision bulkhead below the bulkhead deck.

Where pipes are penetrating the collision bulkhead, screw down valves are to be fitted directly at the collision bulkhead. Such valves are to be operable from outside the forepeak.

2.3.3 Stern tube bulkhead

All yachts are to have a stern tube bulkhead which is, in general, to be so arranged that the stern tube and rudder trunk are enclosed in a watertight compartment. The stern tube bulkhead shall extend to the freeboard deck or to a watertight platform situated above the load waterline.

Where a complete stern tube bulkhead is not practicable only watertight void spaces enclosing the stern tube entrance, providing the possibility for a second watertight sealing may be provided after agreement with BKI. The same arrangement can be applied for the rudder trunk.

2.3.4 Remaining watertight bulkheads

Remaining watertight bulkheads are, depending on the type of yacht and the Classification for damage stability, to extend to the freeboard deck. Wherever practicable, they shall be situated in one frame plane, otherwise those portions of decks situated between parts of transverse bulkheads are to be watertight.

It is recommended that bulkheads shall be fitted separating the machinery space from service spaces and accommodation rooms forward and aft and made watertight and gastight up to the freeboard deck.

2.3.5 Openings in watertight bulkheads

.1 Type and arrangement of doors are to be submitted for approval.

In watertight bulkheads other than collision bulkheads, watertight doors may be fitted. Below the deepest load waterline, they are to be constructed as sliding doors, exemptions may be granted on case by case. Above that waterline, hinged doors may be approved.

Watertight doors are to be sufficiently strong and of an approved design.

Openings for watertight doors in the bulkheads are to be effectively framed such as to facilitate proper fitting of the doors and to guarantee watertightness.

.2 Watertight bulkhead doors and their frames are to be tested before they are fitted on board by a head of water corresponding to the freeboard deck height or the results from damage stability calculation. Alternatively, watertight doors may be used which have been type approved in accordance with BKI special acceptance procedure. After having been fitted on board, the doors are to be soap-tested for tightness and to be subject to an operational test.

.3 Penetrations through watertight bulkheads

Where bulkhead fittings are penetrating watertight bulkheads, care is to be taken to maintain watertightness. For penetrations through the collision bulkhead 2.3.2 is to be observed.

2.4 Openings

Corners of all openings in strength structures are to be well rounded. If necessary, the shape of openings is to be so designed as to reduce stress concentrations. Structural integrity must be maintained around openings. In highly stressed areas openings should be avoided as far as possible.

2.5 Bottom structure

2.5.1 In general, continuous longitudinal girders are to be provided and shall extend as far aft and forward as practicable. A centreline girder is to be fitted for docking purposes unless sufficient strength and stiffness is already achieved by the external keel or the bottom shape.

2.5.2 Size and location of cut-outs in floors and girders must be appropriately designed for the occurring loads. Particularly at the ends of floors and girders sufficient shear area is required.

2.5.3 A floor or a girder is to be provided under each line of pillars.

2.5.4 In case of a double bottom, manholes must be arranged for access to all parts of the double bottom.

2.5.5 Where solid ballast is fitted, it is to be securely positioned. If necessary, intermediate floors may be fitted for this purpose.

If a ballast keel is fitted, the bottom structure is to be reinforced due to additional loads transmitted by the keel. Special care is to be taken with the structural support of fin keel's leading and trailing edge.

2.6 Engine foundation

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. In way of thrust bearing additional strengthening is to be provided.

2.7 Side structure and bulwarks

2.7.1 Longitudinal stiffeners, if fitted, shall be continuous as far as possible.

2.7.2 Bulwark plating is to be determined by applying the side design pressure for the relevant vertical height. Bulwark stanchions must be in line with transverse beams, or adequate substructure must be provided by other means.

2.8 Tank structures

2.8.1 Fore peak tanks shall not be used for carrying fuel oil.

2.8.2 Fresh water tanks are to be separated from other tanks such as waste water tanks by cofferdams. The same applies to fuel tanks. Generally, also tanks such as lubricating or hydraulic oil tanks shall be separated from each other by equivalent means.

2.8.3 Each tank is to be fitted with air pipes, over- flow and sounding pipes, see [Section 1, C.7.11](#).

2.9 Deck

2.9.1 In case of longitudinal deck stiffeners, deck beams are to be located in way of the vertical web frames of the side shell. Structural continuity of the stiffeners is to be ensured.

2.9.2 In case of transverse deck stiffeners, deck beams are to be, in general, fitted at every frame, in line with side shell stiffeners.

2.10 Superstructures and deckhouses

2.10.1 Superstructure and deckhouse front and aft bulkheads are to be aligned with bulkheads, web frames or pillars in the hull or in the superstructure or deckhouse below.

2.10.2 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.

2.10.3 Ends of superstructures and deckhouses are to be efficiently supported by bulkheads, pillars or other equivalent arrangements

2.10.4 As a rule, the spacing of stiffeners on sides of superstructures and deckhouses is to be the same as those of beams on supporting decks

2.10.5 Structural discontinuities and rigid points are to be avoided. Where structural elements are weakened, e.g. by openings, proper compensation is to be provided.

2.11 Constructional details

2.11.1 Cut-outs for the passage of ordinary stiffeners through primary stiffeners, like girders, etc. are to be as small as possible. As a rule, the depth of cut-outs is not to be greater than half the web height of the primary stiffener.

2.11.2 Changes of thickness for a single-skin laminate are to be made as gradually as possible and over a width which is, in general, not to be less than thirty times the difference in thickness.

The connection between a single-skin laminate and a sandwich laminate is to be carried out as gradually as possible over a width which is, in general, not to be less than three times the thickness of the sandwich core.

2.11.3 Laminate edges and holes are to be sealed.

2.11.4 In way of bolted connections and fittings, the sandwich core is to be replaced by inserts of high density foam or single skin laminate.

3. Design loads

3.1 General

3.1.1 For "high speed" motor yachts which are capable of speeds

$$v \geq 7,2 \cdot \sqrt[6]{\nabla} \quad [\text{kn}]$$

∇ = moulded volume [m³] according to [A.6.6](#)

the relevant design loads of the [Rules for High Speed Craft \(Pt.3, Vol.III\)](#), see [Annex A](#) apply in combination with the scantling requirements of [4](#).

3.1.2 The design loads for sailing and motor yachts not considered as of the "high speed" type are specified in the following. The design loads are to be applied at the following load points:

- for panels: lower edge of panel
- for structural members: centre of the area supported by the element

3.1.3 Definition of symbols

L_{sc} = scantling length [mm]

$$= \frac{L_H + L_{WL}}{2}$$

L_H = length of the yacht's hull measured parallel to the design waterline [m], see [Fig. 2.19](#)

L_{WL} = length of the yacht from the foreside of the stem to the after side of the stern or transom, measured at the design waterline [m], see [Fig. 2.19](#)

T_H = see [A.6.2.10](#)

3.2 Loads on hull

3.2.1 The load p_H [kN/m²] on the yacht's hull is to be determined as follows:

$$p_H = 10 \cdot T_H \left(1 - \frac{z}{H} \right) + c_{RY} \cdot c_p \cdot c_L \cdot L_{sc} \left(1 + \frac{v_0}{3 \cdot \sqrt{L_{sc}}} \right) \cdot \cos \left(\frac{\alpha}{1,5} \right) \quad [\text{kN/m}^2]$$

c_p = Panel size factor as a function of f , see also [Fig. 2.20](#)

$$= 0,54 \cdot f^2 - 1,29 \cdot f + 1$$

$$f = \frac{a-250}{55 \cdot L_{sc} \cdot 550}$$

a = Panel's short span respectively load span of stiffener [mm], not to be taken > 1300 mm

c_L = hull longitudinal distribution factor

= for sailing yachts, see [Fig. 2.21](#), c_L is:

- for $\frac{x}{L_{wl}} < 0$:

$$c_L = 0,8 \text{ for } L = 24 \text{ m}$$

$$c_L = 0,6 \text{ for } L = 48 \text{ m}$$

- for $0 \leq \frac{x}{L_{wl}} < 0,65$:

$$c_L = 0,8 + 0,615 \cdot \frac{x}{L_{wl}} \quad \text{for } L = 24 \text{ m}$$

$$c_L = 0,6 + 0,538 \cdot \frac{x}{L_{wl}} \quad \text{for } L = 48 \text{ m}$$

- for $\frac{x}{L_{wl}} \geq 0,65$:

$$c_L = 1,2 \text{ for } L = 24 \text{ m}$$

$$c_L = 0,95 \text{ for } L = 48 \text{ m}$$

= for motor yachts see [Fig. 2.22](#) c_L is:

- for $\frac{x}{L_{wl}} < 0$:

$$c_L = 0,85 \text{ for } L = 24 \text{ m}$$

$$c_L = 0,65 \text{ for } L = 48 \text{ m}$$

- for $0 \leq \frac{x}{L_{wl}} < 0,5$:

$$c_L = 0,85 + 0,8 \cdot \frac{x}{L_{wl}} \quad \text{for } L = 24 \text{ m}$$

$$c_L = 0,65 + 0,7 \cdot \frac{x}{L_{wl}} \quad \text{for } L = 48 \text{ m}$$

- for $\frac{x}{L_{WL}} \geq 0,5$:

- $c_L = 1,25$ for $L = 24$ m

- $c_L = 1,0$ for $L = 48$ m

z = vertical distance between the load point and the moulded base line [m], see Fig. 2.19

α = $\beta - 20^\circ$ for sailing yachts (not smaller than 0°)

= $\beta - 5^\circ$ for motor yachts (not smaller than 0°)

β = deadrise angle at the load point, see Fig. 2.19

c_{RY} = factor considering range of service, see section 1, A.7.

= 1,0 for unrestricted service

= 0,95 for P, restricted service

= 0,90 for L, coastal service

= 0,85 for T, shelter water service

3.2.2 In any case the load p_H shall not be smaller than:

$$p_{Hmin} = 10 \cdot H \quad [kN/m^2]$$

for the area of the hull below the full displacement waterline

$$p_{Hmin} = 5 \cdot H \quad [kN/m^2]$$

for the area of the hull above the full displacement waterline

3.2.3 The design load for the ballast keel area of sailing yachts as indicated in Fig. 2.19 shall be taken as:

$$P_{keel} = 2 \cdot p_H$$

3.3 Loads on weather decks

3.3.1 The design pressure on weather decks is to be determined according to the following formula:

$$P_D = 2,7 \cdot C_D \cdot \sqrt{\frac{L_{SC}}{T_H + z}}$$

$$P_{D,min} = 6,0 \text{ kN/m}^2$$

z = local height of weather deck above WL [m]

C_D = deck longitudinal distribution factor

= for sailing yachts, see Fig. 2.23, C_D is:

- for $\frac{x}{L_{WL}} < 0,05$: $C_D = 1,20$

- for $0,05 \leq \frac{x}{L_{WL}} < 0,25$: $c_D = 1,25 - \frac{x}{L_{WL}}$
- for $0,25 \leq \frac{x}{L_{WL}} < 0,70$: $c_D = 1,00$
- for $0,70 \leq \frac{x}{L_{WL}} < 0,90$: $c_D = 2,5 \cdot \frac{x}{L_{WL}} - 0,75$
- for $\frac{x}{L_{WL}} \geq 0,90$: $c_D = 1,50$

= for motor yachts, see [Fig. 2.24](#), c_D is:

- for $\frac{x}{L_{WL}} < 0$: $c_D = 1,10$
- for $0 \leq \frac{x}{L_{WL}} < 0,25$: $c_D = 1,10 - 0,4 \cdot \frac{x}{L_{WL}}$
- for $0,25 \leq \frac{x}{L_{WL}} < 0,70$: $c_D = 1,00$
- for $0,70 \leq \frac{x}{L_{WL}} < 1,00$: $c_D = \frac{2}{3} \cdot \frac{x}{L_{WL}} + \frac{8}{15}$
- for $\frac{x}{L_{WL}} \geq 1,00$: $c_D = 1,20$

3.4 Loads on superstructures and deckhouses

3.4.1 Loads on walls

.1 Front walls

The design load is:

$$P_{AFW} = 1,5 \cdot P_D \quad [\text{kN/m}^2]$$

.2 Side walls

The design load is:

$$P_{AAW} = 1,2 \cdot P_D \quad [\text{kN/m}^2]$$

.3 Aft walls

The design load is:

$$P_{AAW} = 0,8 \cdot P_D \quad [\text{kN/m}^2]$$

3.4.2 Loads on superstructure decks

The load on decks of superstructures and deckhouses is based on the load on the weather deck according to [3.3](#) and is defined by the following formula:

$$P_{DA} = P_D \cdot n \quad [\text{kN/m}^2]$$

$$P_{DA, \min} = 4,0 \quad [\text{kN/m}^2]$$

$$n = 1 - \frac{z - H}{10}$$

z = vertical distance of the deck above the base line [m]

3.5 Loads on accommodation decks

The load on accommodation decks can be assumed as:

$$P_L = P_C \cdot C_D \quad [\text{kN/m}^2]$$

p_C = to be defined by the designer in connection with the owner's specification [kN/m^2]

$P_{C \min}$ = 3,5 kN/m^2

C_D = deck longitudinal distribution factor according to [Fig. 2.23](#) and [Fig.2.24](#)

3.6 Loads on bulkheads

3.6.1 Collision bulkhead

The design load is:

$$P_{BH} = 11,5 \cdot z_{BH} \quad [\text{kN/m}^2]$$

z_{BH} = vertical distance from the load centre to the top of the bulkhead [m]

3.6.2 Other bulkhead

The design load is:

$$P_{BH} = 10,0 \cdot z_{BH} \quad [\text{kN/m}^2]$$

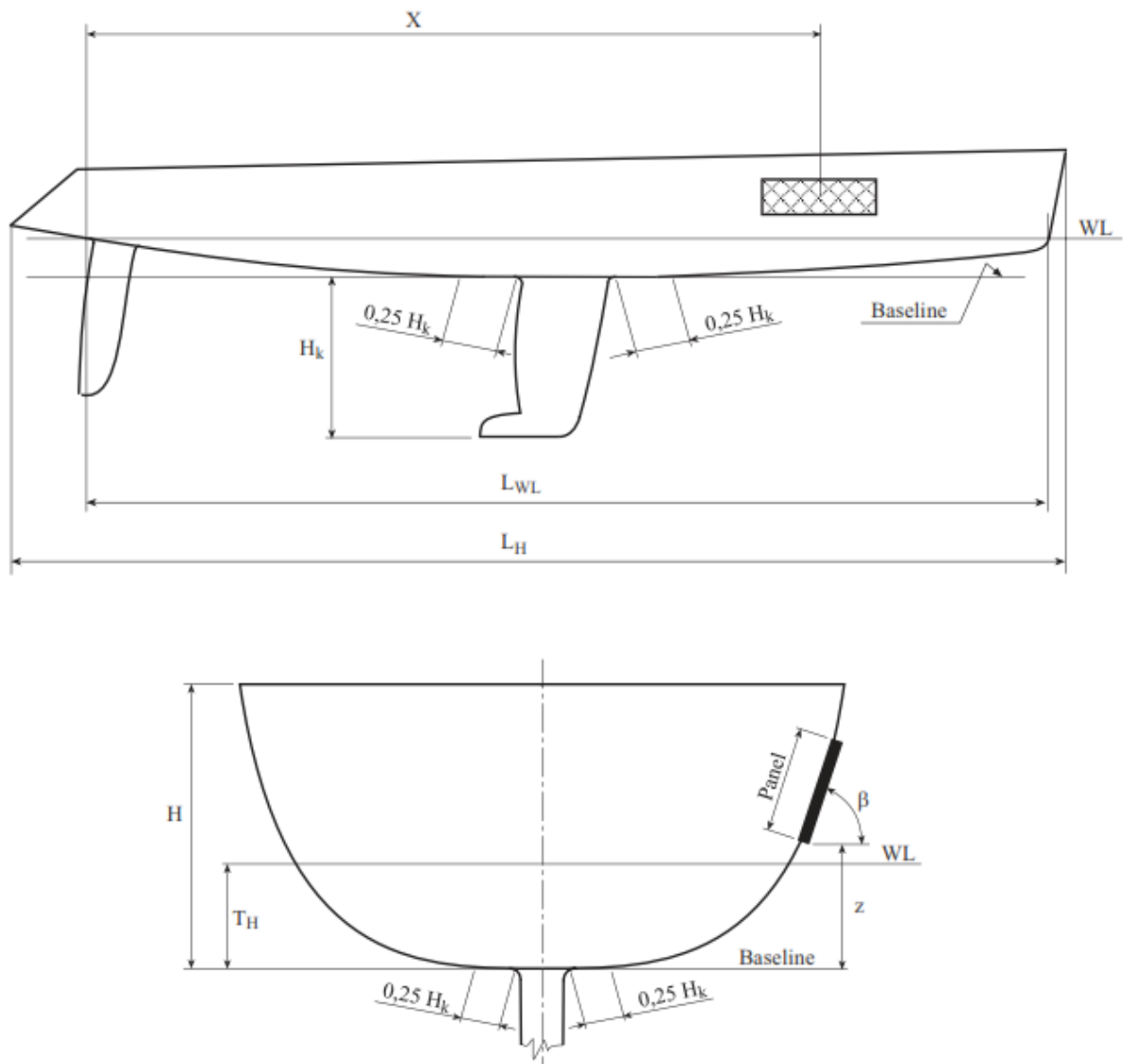


Fig. 2.19 Characteristic parameters for panels of the yacht's hull

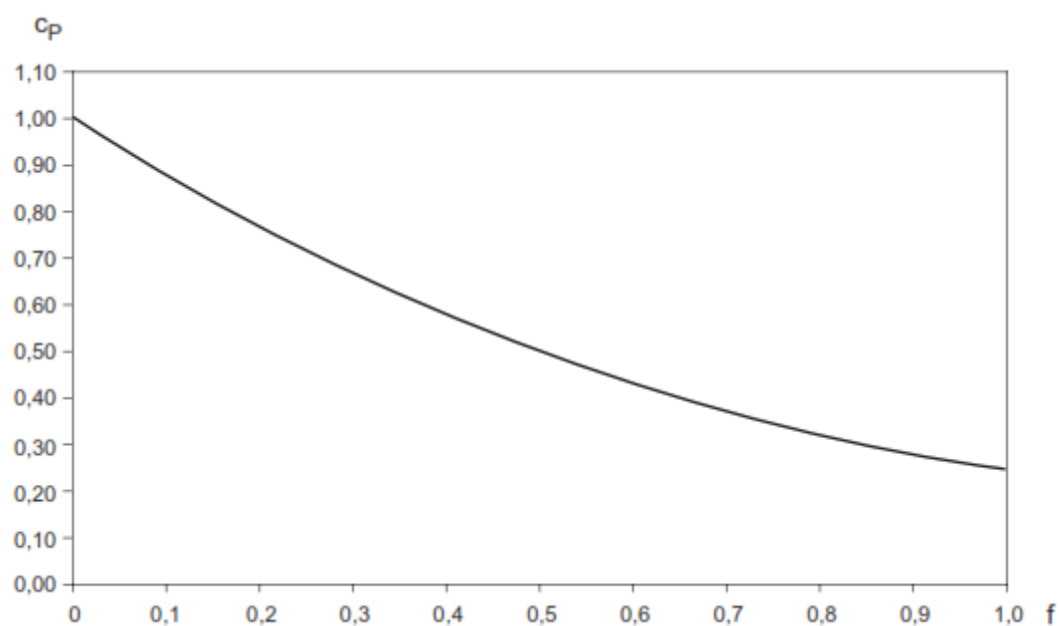


Fig. 2.20 Panel size factor c_p

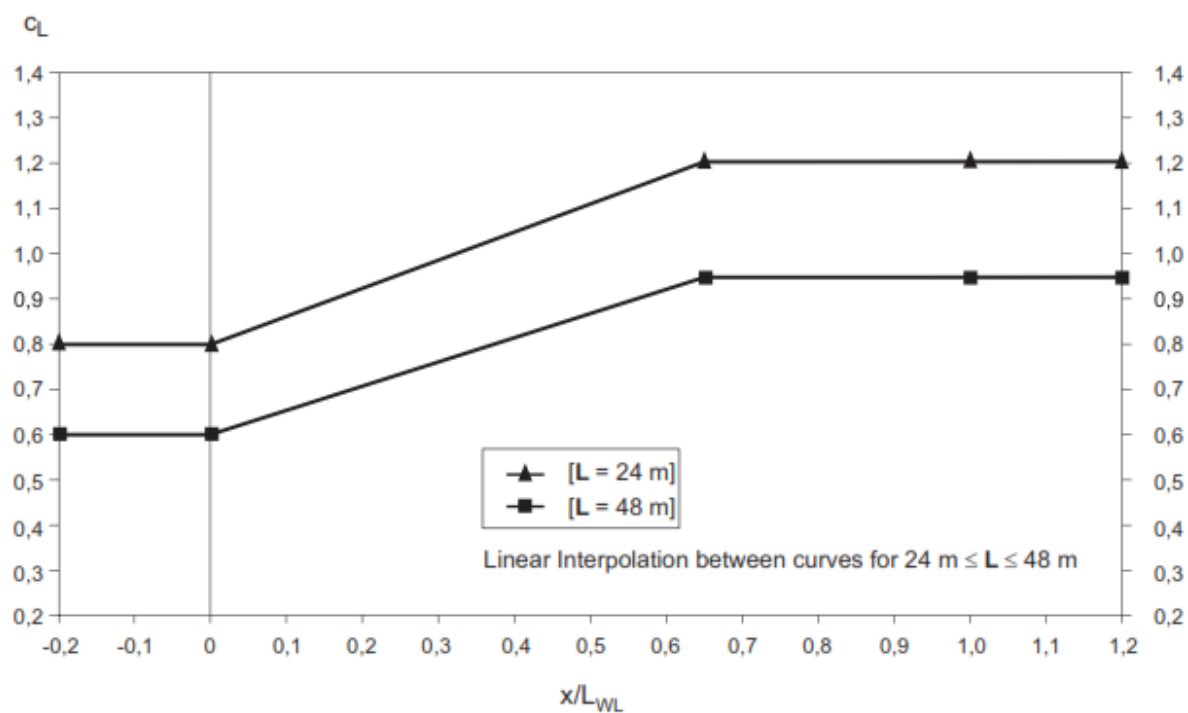


Fig. 2.21 hull longitudinal distribution factor for sailing yachts c_L

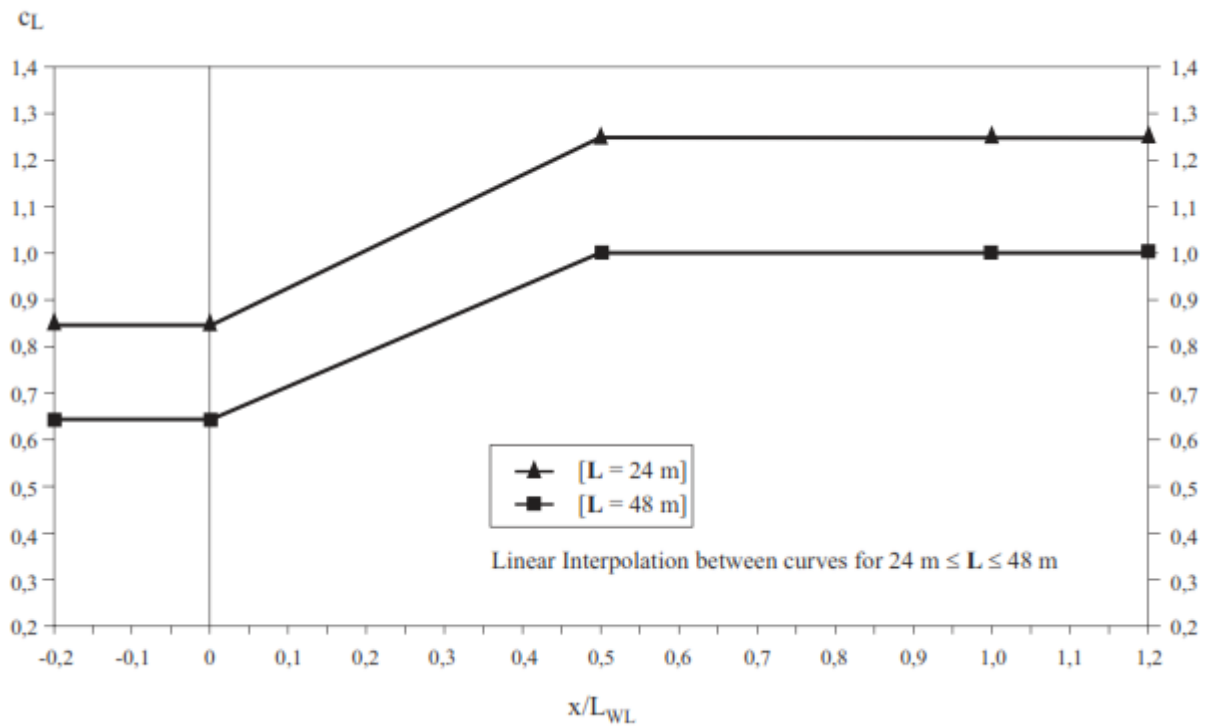


Fig. 2.22 Hull longitudinal distribution factor for motor yachts c_L

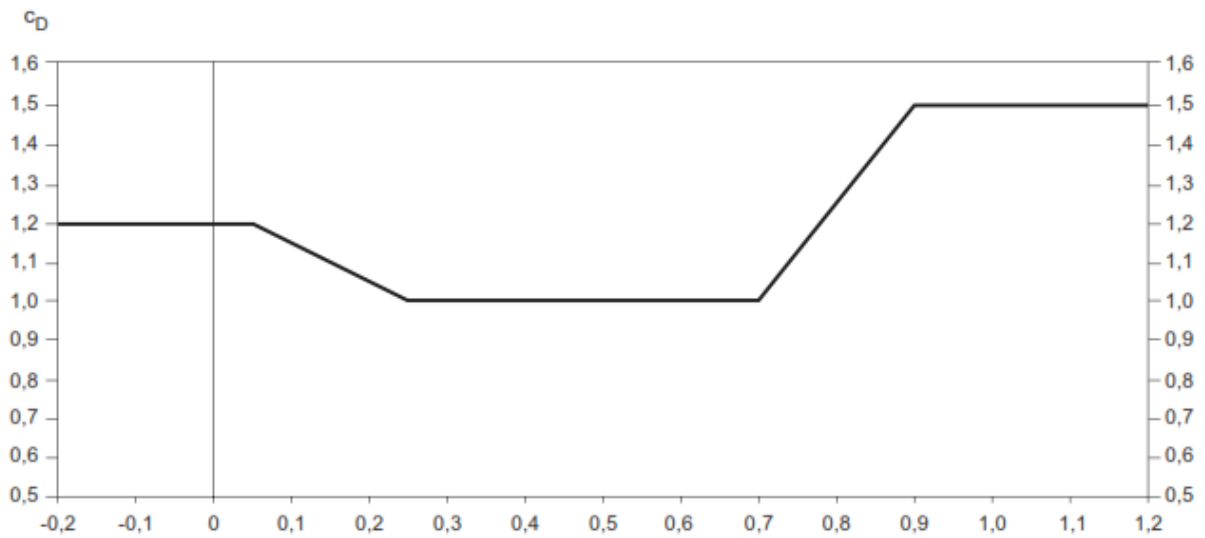


Fig. 2.23 Deck longitudinal distribution factor for sailing yachts c_D

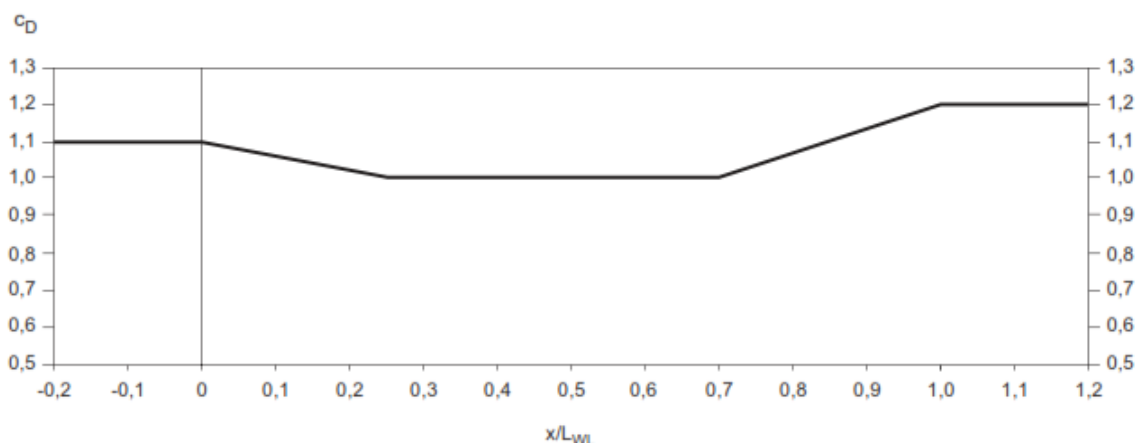


Fig. 2.24 Deck longitudinal distribution factor for motor yachts c_D

3.7 Loads on tank structures

The design load is:

$$P_T = 10 \cdot z_T \quad [\text{kN/m}^2]$$

z_T = vertical distance from the load centre to the top of the tank overflow [m]

= not to be taken less than 2,0 m

4. Scantlings

These scantling requirements have also to be applied for "high speed" motor yachts.

4.1 General

4.1.1 Single skin design

Single skin laminates have to be designed regarding the panel scantling criteria specified below, if applicable. Other kinds of loading and related failure modes of single skin laminates such as buckling must also be considered.

4.1.2 Sandwich design

.1 A sandwich structure generally consists of two FRP skins and a core of lightweight material. In case of flexural loading the skins mainly absorb tension and compression stress, whereas the core mainly absorbs shear stress. In general, the minimum tensile/compressive strength of the outer skin and the inner skin are to be approximately the same.

.2 For sandwich structures, additional failure modes must be considered which can occur before ultimate stress of the skin is attained. Among these are:

- shear failure of the core material
- failure of skin/core bonding
- wrinkling
- core failure under point load
- panel buckling

.3 Sandwich core materials can be:

- rigid foam materials of the closed cell type with a minimum apparent density of 60 kg/m³
- End grained balsa wood
- Honeycomb materials

4.1.3 Transitions from single-skin laminate to sandwich construction

Where sandwich construction changes to single skin laminate, the required single skin laminate is to be determined by the scantlings for the whole panel. A proper core taper ratio shall be provided for.

4.1.4 Single skin construction is recommended in the following areas:

- keel root area of sailing yachts, see [Fig. 2.19](#)
- major penetrations of the hull below the design waterline (WL)

4.2 Panels

4.2.1 Data

The following data have to be specified.

.1 Materials

For all structural composite materials used, the following descriptions shall be provided.

Fibre and resin materials:

- resin system, specific gravity

Cured ply properties for:

- Fibre areal weight
- Fibre orientation
- consolidation method and fibre volume fraction thickness
- defined direction of mechanical properties
- longitudinal and transverse stiffness, in-plane shear stiffness ¹
- longitudinal, transverse ultimate tensile and compressive strength, in-plane ultimate shear strength¹

Core materials:

- type, manufacturer
- nominal density
- thickness
- ultimate shear strength
- compressive stiffness
- shear stiffness

.2 Laminates

For each structural component, the documentation must contain data covering:

¹ In plane shear properties are relevant for layers containing a high percentage of off-axis fibres.

- laminate layup including listing of individual layers and their orientation vs. defined coordinate system
- geometrical data about location, longitudinal and transverse span of panel
- curvature of panel

4.2.2 Applicable design load

Design loads as defined in 3. have to be applied.

4.2.3 Calculation method

The calculation shall be based on classic beam/plate and laminate theory.

4.2.4 Design criteria

The following requirements are to be met:

- a safety factor $SF \geq 4,0$ relative to ultimate stress for each FRP layer
- a safety factor $SF \geq 2,5$ relative to ultimate shear stress for the sandwich core
- 1,5% permissible panel deflection relative to the short span for single skin laminate
- 1,0% permissible panel deflection relative to the short span for sandwich construction

4.3 Stiffeners and girders

4.3.1 Data

The following data have to be specified.

.1 Materials

For all structural composite materials used, the following descriptions shall be provided.

Fibre and resin materials:

- resin system, specific gravity

Cured ply properties for:

- Fibre areal weight
- Fibre orientation
- consolidation method and fibre volume fraction
- thickness
- defined direction of mechanical properties
- longitudinal and transverse stiffness, in-plane shear stiffness ¹
- longitudinal, transverse ultimate tensile and compressive strength in-plane ultimate shear strength ¹

Core materials:

- type, manufacturer
- nominal density
- compressive stress

.2 Laminates

For each structural component the documentation must contain data covering:

- laminate layup including listing of individual layers and their orientation vs. defined coordinate system
- geometrical data about location, span of supported panel, unsupported span of girder/stiffener
- data about section geometry of stiffener/girder
- bonding bendings
- curvature of panel

4.3.2 Applicable design load

Design loads as defined in 3. have to be applied.

4.3.3 Calculation method

The calculation shall be based on classic beam/plate and laminate theory.

4.3.4 Design criteria

The following requirements have to be met:

- A safety factor $SF \geq 4,0$ relative to ultimate stress for bending of each FRP layer
- A safety factor $SF \geq 4,0$ relative to ultimate shear stress in stiffener webs
- 0,5% permissible stiffener deflection relative to the unsupported span of the stiffener
- 0,3% permissible stiffener deflection relative to the unsupported span of engine foundations

F. Motor and Sailing Yachts, $24 \text{ m} \leq L \leq 48 \text{ m}$, Wooden Structures

1. General

1.1 Scope

The following references to rules and requirements applicable for traditionally built wooden hull structures of motor and sailing yachts.

Yacht hulls of cold moulded wood are to be built according to the requirements of E.

1.2 Materials

An excerpt regarding material requirements is given in B.9. Furthermore reference is made to the [Rules for Non-Metalic Materials \(Pt.1, Vol.XIV\) Chapter 2 – Wooden Structures](#)

2. Scantling

The actual determination of scantlings can be carried out according to [Peraturan Kapal Kayu \(Pt.3, Vol.VI\)](#).

Regarding rudder and manoeuvring arrangement and anchor equipment the requirements of J. and K. apply.

G. Motor and Sailing Yachts, L > 48 m, Steel and Aluminium Structures

1. General

1.1 Scope

The following references to BKI Rules applicable for scantling determination of the hull structures of sailing and motor yachts with L > 48 m, see [2](#).

Regarding corrosion allowances and minimum thickness of plating the requirements specified in [2.2.2](#) and [2.2.3](#) are applicable.

1.2 Material

See [B](#).

2. Scantling

2.1 Scantling for high speed yachts

If a yacht is capable of a maximum speed equal to or exceeding

$$v = 7,2 \cdot \sqrt[6]{\nabla} \quad [\text{kn}]$$

$$\nabla = \text{moulded volume [m}^3\text{] according to [A.6.4](#)}$$

[Rules for High Speed Craft \(Pt.3, Vol.III\) Sec.3](#) will be applied.

2.2 Scantlings for moderate speed yachts

2.2.1 For determination of the scantlings of yachts with lower speeds than defined in [2.1](#). The [Rules for Hull \(Pt.1, Vol.II\)](#) have to be applied. The deviations defined in [2.2.2](#) and [2.2.3](#) have to be observed. Upon request further deviations of the scantlings may be granted by BKI after detailed judgement of the actual project.

2.2.2 Corrosion allowances

The following, reduced corrosion allowances may be applied for yachts, if special care for maintenance and special attention for measures of corrosion protection can be assumed.

.1 Steel

The scantlings require the following allowances t_k to the theoretical, rounded-off plate thickness:

- $t_k = 0,5$ mm in general
- $t_k = 0,7$ mm for lubrication oil, gas oil or equivalent tanks
- $t_k = 1,0$ mm for water ballast and heavy oil tanks
- $t_k = 1,0$ mm for deck plating below elastically mounted deckhouses
- $t_k = 2,0$ mm for chain locker, stern tube.
- for special applications t_k shall be agreed with BKI

For all elements of the yacht's structure which form a boundary of tanks, the t_k values for tanks have to be considered.

.2 Aluminium alloys

If the measures for corrosion protection described in B.6. are fully applied, the corrosion allowance t_k can be assumed as 0 for the types of aluminium alloys defined in B.3.4 and B.3.5. In any way t_k shall not be less than the fabrication tolerances, see Rules for Material (Pt.1, Vol.V) Sec.10.

2.2.3 Minimum thickness

The minimum thickness requirements of the plating of different elements of the hull structure are summarized in Table 2.20.

For comparison the table indicates references to the Rules for Hull (Pt.1, Vol.II).

Table 2.20 Minimum thickness of plating

Elements of the hull structure		Minimum thickness t_{min} of plating [mm]
Designation	Reference ¹	Formulae for yachts
Brackets	Section 3, D.2.2	5,5
Bottom	Section 6, B.3	$0,9 \cdot \sqrt{L \cdot k}$
Flat plate keel	Section 6, B.5.1	t_{min} (bottom) + 2,0 mm for 0,7 L midships and in way of engine seating; t_{min} (bottom) otherwise
Side shell	Section 6, C.2	$0,8 \cdot \sqrt{L \cdot k}$
Strength deck for 0,4 L amidships outside line of openings	Section 7, A.6	$(3,5 + 0,05 \cdot L) \sqrt{k}$
Strength deck inside line of openings and 0,1 L from the ends	Section 7, A.7	$(4,5 + 0,02 \cdot L) \sqrt{k}$
Lower decks (2 nd deck)	Section 7, B.1.1	$(4,5 + 0,02 \cdot L) \sqrt{k}$
Other lower decks	Section 7, B.1.1	5,0
Floor plates in the peaks	Section 8, A.1.2.3	5,0 with lightening holes 4,0 without lightening holes
Web of single bottom centre girder	Section 8, A.2.2.1	$(4,5 + 0,07 \cdot L) \sqrt{k}$
Web of single bottom side girder	Section 8, A.2.2.2	$(4,5 + 0,04 \cdot L) \sqrt{k}$
Double bottom longitudinal girders	Section 8, B.7.5.2	$5,0 \cdot \sqrt{k}$
Web frames in machinery spaces	Section 9, A.6.2.1	$8,0 \cdot \sqrt{k}$
Bulkhead plating	Section 11, B.2.1	$5,0 \cdot \sqrt{\frac{235}{R_{eH}}}$
Internal wall plating	—	3,0
Tank structures	Section 12, A.7.1	$(5,5 + 0,02 \cdot L) \sqrt{k}$
Rudder horn plating	Section 13, C.1.5	$2,4 \cdot \sqrt{L \cdot k}$
Webs of rudders	Section 14, E.2.1.3	$8,0 \cdot \sqrt{k}$
Non-effective Superstructure side walls	Section 16, B.1.1	$0,64 \cdot \sqrt{L \cdot k}$
Non-effective superstructure deck	Section 16, B.2.1	$(4,5 + 0,02 \cdot L) \sqrt{k}$
Superstructure end bulkheads and deckhouse walls/lowest tier	Section 16, C.3.2	$(4,0 + 0,01 \cdot L) \sqrt{k}$ and 4,0
Superstructure end bulkheads and deckhouse walls/upper tier	Section 16, C.3.2	$(3,0 + 0,01 \cdot L) \sqrt{k}$ and 3,0
Short deckhouse deck	Section 16, D.1.	4,0

Table 2.19 Minimum thickness of plating (continued)

Elements of the hull structure		Minimum thickness t_{min} of plating [mm]
Designation	Reference ¹	Formulae for yachts
Hatchway coamings	Section 17, C.2.1	7,5
Steel hatch covers	Section 17, B.5.1.1	6,0
¹ in BKI Rules for Hull (Pt.1, Vol.II)		

H. Tank Structures

1. General

1.1 Subdivision of tanks

1.1.1 In tanks which extend over the full breadth of the yacht and are intended to be used for partial filling (e.g. fuel oil and fresh water tanks), at least one longitudinal bulkhead is to be fitted, which may be a swash bulkhead.

1.1.2 Where the forepeak is intended to be used as tank, at least one complete or partial longitudinal swash bulkhead is to be fitted, if the tank breadth exceeds 0,5 **B** or 6,0 m, whichever is the greater.

When the after peak is intended to be used as tank, at least one complete or partial longitudinal swash bulkhead is to be fitted. The largest breadth of the liquid surface should not exceed 0,3 **B** in the aft peak.

1.1.3 Peak tanks exceeding 0,06 **L** or 6,0 m in length, whichever is greater, shall be provided with a transverse swash bulkhead.

1.2 Air, overflow and sounding pipes

1.2.1 Each tank is to be fitted with air pipes, overflow pipes and sounding pipes. The air pipes are to be led to above the exposed deck. The arrangement is to be such as to allow complete filling of the tanks. The height from the deck to the point where seawater may have access is to be at least 760 mm on the freeboard deck and 450 mm on a superstructure deck.

1.2.2 Suitable closing appliances are to be provided for air pipes, overflow pipes and sounding pipes, see also [Section 1, C.7.11](#).

1.2.3 Closely below the inner bottom or the tank top, holes are to be cut into floor plates and side girders as well as into beams, girders, etc., to give the air free access to the air pipes. Besides, all floor plates and side girders are to be provided with limbers to permit the water or oil to reach the pump suction.

1.2.4 Sounding pipes are to be led to the bottom of the tank. The shell plating is to be strengthened by thicker plates or doubling plates under the sounding pipes.

1.3 Forepeak tank

Oil is not to be carried in a forepeak tank, see also [D.2.9.1](#).

1.4 Cross references

1.4.1 Where a tank bulkhead forms part of a watertight bulkhead, its strength is not to be less than required by [C](#). to [G](#). as applicable.

1.4.2 For pumping and piping and fuel oil tanks see [Section 1, C.7](#). For tanks in the double bottom see [C.](#) to [G.](#) as applicable.

1.4.3 For testing of tanks, see [4](#).

1.4.4 Where tanks are provided with cross flooding arrangements the increase of the pressure head is to be taken into consideration.

1.5 Separation of fuel oil tanks from tanks for other liquids

1.5.1 Fuel oil tanks are to be separated from tanks for other liquids by cofferdams. Generally, also tanks such as lubricating or hydraulic oil tanks shall be separated from each other by equivalent means.

1.5.2 Upon special approval, the arrangement of cofferdams between fuel oil and lubricating oil tanks may be dispensed with on relatively small yachts, provided that:

- the common boundary is continuous, i.e. it does not abut at the adjacent tank boundaries, see [Fig. 2.25](#)

Where the common boundary cannot be constructed continuously according to [Fig. 2.25](#), the fillet welds on both sides of the common boundary are to be welded in two layers and the throat thickness is not to be less than $0,5 \cdot t$ (t = plate thickness)

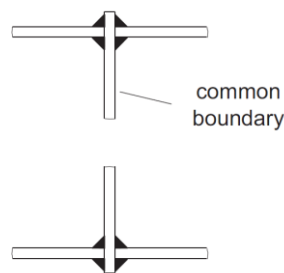


Fig. 2.25 Welding at non-continuous tank boundaries

- stiffeners or pipes do not penetrate the common boundary
- the corrosion allowance t_k for the common boundary is not less than 1,5 mm.

1.5.3 Fuel oil tanks adjacent to lubricating oil circulation tanks are subject to the provisions of [Section 1, C.7](#) in addition to the requirements stipulated in [1.5.2](#) above.

1.6 Potable water tanks

1.6.1 Potable water tanks shall be separated from tanks containing other liquids by cofferdams.

1.6.2 In no case sanitary installations or corresponding piping are to be fitted directly above the potable water tanks.

1.6.3 If pipes carrying liquids other than potable water are to be led through potable water tanks, they are to be fitted in a pipe tunnel.

1.6.4 Air and overflow pipes of potable water tanks are to be separated from pipes of other tanks.

2. Scantlings

2.1 Design loads

The design loads are defined in [D.3.7](#).

2.2 Scantling requirements

Tank plating and stiffener scantlings are to be determined according to [D.4](#).

2.3 The stiffeners of tank bulkheads exceeding 2,0 m length are to be attached at their ends by brackets according to the arrangements defined in [C](#). The scantlings of the brackets are to be determined according to the section modulus of the stiffeners.

The brackets of stiffeners are to extend to the next beam, the next floor, the next frame, or are to be otherwise supported at their ends.

3. Swash bulkheads

3.1 The total area of perforation shall not be less than 5 % and should not exceed 10 % of the total bulkhead area.

3.2 Design loads

For the design pressure for partially filled tanks p_d a direct calculation is required.

3.3 Scantling requirements

The plate thickness shall, in general, be equal to the minimum thickness according to [D.4.1.3](#). Strengthening may be required for load bearing structural parts. The free lower edge of a swash bulkhead is to be adequately stiffened.

4. Testing for tightness

4.1 Testing of fuel oil, ballast, trimming, feed water, fresh water and anti-rolling tanks is to be effected by a combination of a leak test by means of air pressure and an operational test by means of water or the liquid for which the tank is intended to be used. The air pressure is not to exceed 0,2 bar gauge. The increased risk of accident while the tanks are subjected to the air pressure is to be observed.

4.2 Where one tank boundary is formed by the ship's shell, the leak test is to be carried out before launching. For all other tanks leak testing may be carried out after launching. Erection welds as well as welds of assembly openings are to be coated² after the leak test is carried out. This applies also to manually welded connections of bulkheads with other tank boundaries and to collaring arrangements at intersections of tank boundaries and frames, beams, girders, pipes, etc. If it is ensured that in adjacent tanks the same type of liquid is carried, e.g. in adjacent ballast tanks, the above mentioned weld connections may be coated² prior to the leak test.

All other welded connections in tank boundaries may be coated prior to the leak test if it is ensured by suitable means (e.g. by visual examination of the welded connections) that the connections are completely welded and the surfaces of the welds do not exhibit cracks or pores.

4.3 Where the tanks are not subjected to the leak test as per [4.2](#) but are leak tested with water, the bulkheads are, in general, to be tested from one side. The testing should be carried out prior to launching or in the dock. Subject to approval by BKI, the test may also be carried out after launching. Water testing

² Shop primers are not regarded as a coating within the scope of these requirements

may be carried out after application of a coating², provided that during the visual inspection as per 4.2 above deficiencies are not found. The test head must correspond to a head of water of 2,5 m above the top of tank or to the top of overflow or air pipe, whichever is the greater.

4.4 The operational test may be carried out when the ship is afloat or during the trial trip. For all tanks the proper functioning of filling and suction lines and of the valves as well as functioning and tightness of the vent, sounding and overflow pipes is to be tested.

5. Detached tanks

5.1 General

5.1.1 Detached tanks are to be adequately secured against forces due to the ship's motions.

5.1.2 Detached tanks in hold or storage spaces are also to be provided with anti-floatation devices. It is to be assumed that the hold/storage spaces are flooded to the design water line. The stresses in the anti floatation devices caused by the floatation forces are not to exceed the material's yield stress.

5.1.3 Fittings and pipings on detached tanks are to be protected by battens, and gutterways are to be fitted on the outside of tanks for draining any leakage oil.

5.2 Scantlings

5.2.1 Design loads

The design load is:

$$p_{DT} = 10 \cdot h \quad [\text{kN/m}^2]$$

h = head measured from the load point of plate panel or stiffener respectively to the top of overflow. The height of overflow is not to be taken less than 2,0 m.

5.2.2 Scantling requirements

Tank plating and stiffener scantlings are to be determined according to D.4.

I. Chainplates, Ballast Keel, Propeller Brackets

1. General

The following specifies scantling requirements for the above elements and their structural attachment to the yacht's hull.

2. Chainplates and substructures

2.1 Design loads

Where no other indications are available, the dimensioning load will be equal to the breaking load of the attached shrouds and stays. If there are two shrouds attached to a chainplate, the dimensioning load for the chainplate is $F = 1,0$ times the breaking load of the stronger shroud plus 0,5 times the breaking load of the weaker shroud [kN]

2.2 Permissible stresses

For dimensioning of chainplates made of metallic materials the following permissible stresses are to be complied with:

- permissible bearing stress between chain plate and pin

$$\sigma_{LL,perm} = \frac{R_{eH} + R_m}{2} \quad [N/mm^2]$$

- for tension and shear loading:

$$\sigma_{perm} = R_{eH} \quad [N/mm^2]$$

$$\tau = \frac{R_{eH}}{\sqrt{3}} \quad [N/mm^2]$$

R_{eH} is the steel's minimum nominal upper yield point [N/mm²]. In case of aluminium alloys R_{eH} is to be replaced by $R_{p0,2}$, i.e. the 0,2 % proof stress [N/mm²].

2.3 Determination of chainplate geometry

2.3.1 Metallic chainplates

Determination of geometry and thickness of a metallic chainplate according to Fig. 2.26.

$$a_{min} = \frac{F}{2 \cdot t \cdot \sigma_{perm}} + \frac{2}{3} \cdot d_L \quad [mm]$$

$$c_{min} = \frac{F}{2 \cdot t \cdot \sigma_{perm}} + \frac{1}{3} \cdot d_L \quad [mm]$$

d_L = pin hole diameter [mm]

t = thickness of the chainplate [mm]

Thereby it is assumed that the gap between bearing hole and pin is smaller than $0,1 \cdot d_L$. Also the bearing stress limit according to 2.2 must be observed.

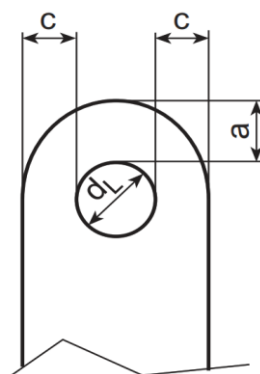


Fig.2.26 Geometry of the chainplate

2.3.2 Metallic chainplate structure

The dimensioning principles, i.e. design load and permissible stress for chainplates of metallic materials as outlined above are to be applied analogously to the metallic chainplate substructure, e.g. tie rods, etc.

2.3.3 Chainplates of composite materials

Regarding chainplate components made of composite materials, e.g. carbon fibre tapes, and composite structures to which chainplates are attached, e.g. FRP bulkheads, dimensioning is to be carried out as follows.

- .1 The relevant stress in the composite component, e.g. tension or shear, is to be calculated applying the design load according to 2.1.
- .2 The permissible stress shall be less than or equal to the ultimate stress of the composite component divided by 1,6.

2.4 Structural members in way of chainplates

Scantlings of structural members in way of chainplates must ensure sufficient strength and rigidity of the hull under the consideration of the design loads defined in 2.1.

3. Structural integration of the ballast keel

The design principles presented in the following are exemplified for a fin ballast keel bolted to the hull. Special ballast keel arrangements of high complexity, e. g. canting or lifting keels, centreboards, etc. are to be considered case by case.

3.1 Design loads

3.1.1 Forces and moments for dimensioning purposes are those caused when the sailing yacht is supposed to heel over 90°, i.e. the keel is not submerged and parallel to the water surface. In addition to bending and shear, torsional loads can become significant if the longitudinal position of the keel's centre of gravity is unusual, e.g. as for L-bulbed fin keels.

3.1.2 The defined basic load case is also valid for other ballast keel arrangements than those described in the following

3.1.3 Each cross section along the fin ballast keel must withstand the forces and moments caused by the basic load case depending on the distance between the considered cross section and the keel's centre of gravity.

3.2 Dimensioning of keel bolts

3.2.1 Keel bolts which are to be strongly and durably anchored to the ballast keel shall be positioned as close as possible to the keel floors of the hull to ensure effective transmission of the loads. The bolt arrangement on the keel root profile is shown in Fig. 2.27

3.2.2 The required keel bolt core diameter is to be determined according to the following formula:

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

W_k = weight of ballast keel [N]

h_k	=	distance between the keel's centre of gravity and the keel root profile [mm], see Fig. 2.27
b_i	=	$0,5 \cdot b_{bi} + 0,4 \cdot b_{ki}$, see Fig 2.27
b_{max}	=	maximum value of b_i
R_{eH}	=	minimum nominal upper yield point of bolt steel [N/mm ²]

3.2.3 Large washers or counter plates are to be arranged to distribute the loads on a wide area. Bolts including washers or counter plates, nuts and locking device are to be made of an approved corrosion resistant material.

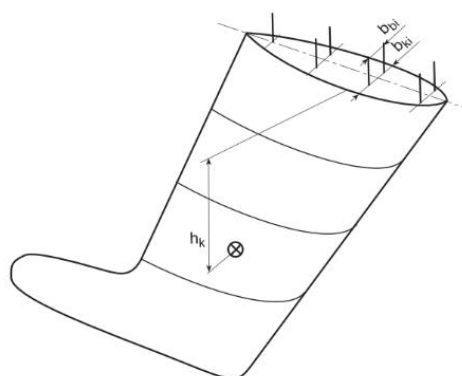


Fig. 2.27 Bolt arrangement on the keel root

3.3 Absorption of forces and moments in the yacht's hull

3.3.1 Bottom structural members in way of the ballast keel must absorb the external design loads defined for the different yacht types and also the forces and moments caused by the ballast keel.

Each floor at the bottom of the hull absorbs a certain percentage of the transverse bending moment. This percentage depends on the width of the keel root at the respective floor; the wider the keel root, the higher the moment which can be absorbed by the floor.

However, in case of grounding the floors (or other structural members) above the leading and trailing edge of the fin ballast keel have to withstand the biggest reaction forces.

3.3.2 In addition to bending moments the keel floors are loaded by shear forces caused by the weight of the ballast keel and possibly other forces caused e.g. in the case of grounding. Therefore the webs of the keel floors are to have sufficient height and thickness.

3.3.3 The keel floors must be supported by other structural members, e.g. longitudinal girders, bulkheads, etc.

4. Propeller brackets

4.1 Arrangement

The strut axes should intersect in the axis of the propeller shaft as far as practicable. The angle between two struts shall be in the range from 50° to 120°. The struts are to be extended through the shell plating and are to be attached in an efficient manner to the frames and plate floors respectively. The construction in way of the shell is to be carried out with special care. In case of welded connection, the struts are to have a weld flange or a thickened part or are to be connected with the shell plating in another suitable manner.

4.2 Strengthening of shell

The strengthening of the shell in way of struts and shaft bossings has to be done in the following way:

- The thickness of the shell plating is to be the same as at 0,4 amidships. In way of struts, the shell is to have a strengthened plate of 1,5 times the midship thickness.
- Where propeller revolutions are exceeding 300 rpm (approx.), particularly in case of flat bottoms intercostal carlings are to be fitted above or forward of the propeller in order to reduce the size of the bottom plate panels.

4.3 Design force

The design force F_u acting on propeller brackets is defined by the following formula:

$$F_u = 7,75 \cdot 10^{-4} \cdot M_p \cdot \frac{z}{z+1} \cdot D \cdot n^2 \quad [\text{kN}]$$

- D = diameter of propeller [m]
n = propeller speed at 100 % performance [min^{-1}]
 M_p = mass of propeller [t]
z = number of propeller blades

4.4 Scantlings

4.4.1 The sectional A of each strut shall not be less than:

$$A = c_1 \cdot F_u \cdot \ell \quad [\text{cm}^2]$$

- c_1 = $4,85 \cdot 10^{-4}$ for steel
= $1,43 \cdot 10^{-3}$ for aluminium alloys
 ℓ = length of strut [mm]

4.4.2 The moment of inertia I of each strut shall not be less than:

$$I = c_2 \cdot F_u \cdot \ell^3 \quad [\text{cm}^4]$$

- c_2 = $1,18 \cdot 10^{-9}$ for steel
= $1,02 \cdot 10^{-8}$ for aluminium alloys

4.4.3 For propeller brackets with one strut the following condition has to be met in addition to 4.4.1 and 4.4.2:

The section modulus W of the strut shall not be less than:

$$W = c_3 \cdot F_u \cdot \ell \quad [\text{cm}^3]$$

- c_3 = 0,011 for steel
= 0,033 for aluminium alloys

For propeller brackets with one strut a vibration and fatigue analysis has to be carried out.

J. Rudder and Manoeuvring Arrangement

1. General

1.1 Manoeuvring arrangement

1.1.1 Yachts have to be provided with a manoeuvring arrangement which will guarantee sufficient manoeuvring capability.

1.1.2 The manoeuvring arrangement includes all parts, from the rudder and steering gear to the steering position necessary for steering of yachts.

1.1.3 Rudder stock, rudder coupling, rudder bearings and rudder body are dealt with in the following. The steering gear is to comply with references given in [Section 1, C](#).

1.1.4 The steering gear compartment shall be readily accessible and, as far as practicable, separated from machinery space.

Note

Concerning use of non-magnetizable material in the wheel house in way of a magnetic compass, the requirements of the national Administration concerned are to be observed.

1.2 Structural details

1.2.1 Effective means are to be provided for supporting the weight of the rudder body without excessive bearing pressure, e.g. by a rudder carrier attached to the upper part of the rudder stock. The hull structure in way of the rudder carrier is to be suitably strengthened.

1.2.2 Suitable arrangements are to be provided to prevent the rudder from lifting.

1.2.3 The rudder stock is to be carried through the hull either enclosed in a watertight trunk, or glands are to be fitted above the deepest load waterline, to prevent water from entering the steering gear compartment and the lubricant from being washed away from the rudder carrier. If the top of rudder trunk is below the deepest waterline, two separate stuffing boxes are to be provided.

1.3 Size of rudder area

In order to achieve sufficient manoeuvring capability, the size of the movable rudder area A is recommended to be not less than obtained from following formula:

$$A = c_1 \cdot c_2 \cdot c_3 \cdot c_4 \frac{1,75 \cdot L \cdot T}{100} \quad [m^2]$$

c_1	= factor for yacht type
	= 1,0 in general
c_2	= factor for rudder type:
	= 1,0 in general
	= 0,9 for semi-spade rudders
	= 0,7 for high lift rudders
c_3	= factor for rudder profile:

- C_4
- = 1,0 for NACA-profiles and plate rudder
 - = 0,8 for hollow profiles and mixed profiles
 - = factor for rudder arrangement:
 - = 1,0 for rudder in propeller jet
 - = 1,5 for rudders outside propeller jet

For semi-spade rudders 50 % of the projected area of the rudder horn may be included into the rudder area A. If several rudders are arranged, the area of each rudder can be reduced by 20 %.

When estimating the rudder area A, 2.1. is to be observed.

1.4 Materials

1.4.1 For materials for rudder stock, pintles, coupling bolts, etc. see [Rules for Materials \(Pt.1, Vol.V\)](#) and [Rules for Welding \(Pt.1, Vol.VI\)](#). Special material requirements are to be observed for ice notations, see [A.1.2](#).

1.4.2 In general, materials having a minimum nominal upper yield point R_{eH} of less than 200 N/mm² and a minimum tensile strength of less than 400 N/mm² or more than 900 N/mm² shall not be used for rudder stocks, pintles, keys and bolts. The requirements of J. are based on a material's minimum nominal upper yield point R_{eH} of 235 N/mm². If materials used having a R_{eH} differing from 235 N/mm², the material factor k_r is to be determined as follows:

$$k_r = \left(\frac{235}{R_{eH}} \right)^{0,75} \quad \text{for } R_{eH} > 235 \quad [\text{N/mm}]$$

$$k_r = \frac{235}{R_{eH}} \quad \text{for } R_{eH} \leq 235 \quad [\text{N/mm}]$$

R_{eH} = minimum nominal upper yield point of the material used [N/mm²]

R_{eH} is not to be taken greater than $0,7 \cdot R_m$ or 450 N/mm², whichever is less. R_m = tensile strength of the material used.

1.4.3 Before significant reductions in rudder stock diameter due to application of steels with R_{eH} exceeding 235 N/mm² are accepted, BKI may require the evaluation of elastic rudder stock deflections. Large deflections should be avoided in order to avoid excessive edge pressures in way of bearings.

1.4.4 Permissible stresses given in 7.1 are applicable for normal strength hull structural steel. When higher strength hull structural steels are used, higher values may be used which will be determined in each individual case.

1.5 Definitions

C_R = rudder force [N]

Q_R = rudder torque [Nm]

A = total movable area of rudder [m²]

A_t = A + area of a rudder horn, if any [m²]

A_f = portion of rudder area located ahead of the rudder stock axis [m²]

- b = mean height of rudder area [m]
c = mean breadth of rudder area [m], see Fig. 2.28

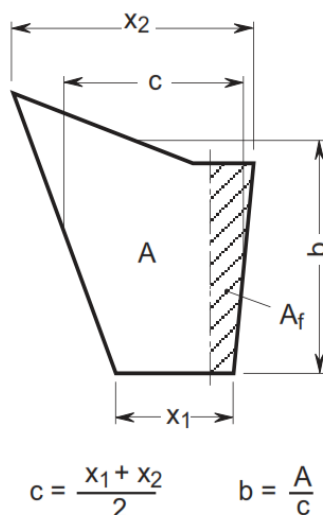


Fig. 2.28 Rudder area

- Λ = aspect ratio of rudder area A_t
 $\Lambda = \frac{b^2}{A^t}$
 v_0 = ahead speed of the yacht in [kn] as defined in A.6.5
If this speed is less than 10 kn, v_0 is to be taken as

$$v_{\min} = \frac{v_0 + 20}{3} \quad [\text{kn}]$$

- v_a = astern speed of the yacht in [kn]; if the astern speed v_a is less than $0,4 \cdot v_0$ or 6 kn, whichever is less, determination of rudder force and torque for astern condition is not required. For greater astern speeds special evaluation of rudder angle may be required. If no limitation for the rudder angle at astern condition is stipulated, the factor κ_2 is not to be taken less than given in Table 2.21 for astern condition.

- k = material factor according to B.

2. Rudder force and torque

2.1 Rudder force and torque for normal rudders

2.1.1 The rudder force is to be determined according to the following formula:

$$C_R = 132 \cdot A \cdot v^2 \cdot \kappa_1 \cdot \kappa_2 \cdot \kappa_3 \cdot \kappa_t \quad [\text{N}]$$

- v = v_0 for ahead condition
= v_a for astern condition

- κ_1 = coefficient, depending on the aspect ratio Λ
= $(\Lambda + 2)/3$, where Λ need not be taken greater than 2
- κ_2 = coefficient, depending on type of rudder and rudder profile according to [Table 2.21](#)
- κ_3 = coefficient, depending on location of the rudder
= 0,8 for rudders outside propeller jet
= 1,0 elsewhere, including also rudders within propeller jet
- κ_t = coefficient, depending on thrust coefficient c_t
= 1,0 normally

In special cases, for propeller thrust coefficients $C_{TH} > 1,0$ determination of κ_t according to following formula may be required:

$$\kappa_t = \frac{C_R(C_{TH})}{C_R(C_{TH}=1,0)}$$

Tables 2.21 Coefficient κ_2 for different types of rudder profiles

Profile / type of rudder	κ_2	
	ahead	Astern
NACA-00 series Göttingen profiles	1,1	1,4
flat side profiles	1,1	1,4
Mixed profiles (e.g. HSVA)	1,21	1,4
Hollow profiles	1,35	1,4
High lift rudders	1,7	To be specially considered; if not known: 1,7

2.1.2 The rudder torque is to be determined by the following formula:

$$Q_R = C_R \cdot r \quad [\text{Nm}]$$

- r = $c(\alpha - k_b)$ [m]
- α = 0,33 for ahead condition
= 0,66 for astern condition (general)
= 0,75 for astern condition (hollow profiles)

For parts of a rudder behind a fixed structure such as a rudder horn:

- α = 0,25 for ahead condition
= 0,55 for astern condition

For high lift rudders α is to be specially considered. If not known, $\alpha = 0,40$ may be used for ahead condition:

- k_b = balance factor as follows:
= $\frac{A_f}{A}$
= 0,08 for unbalanced rudders
- r_{\min} = $0,1 \cdot c$ [m] for ahead condition

2.1.3 Effects of the provided type of rudder/profile on choice and operation of the steering gear are to be observed.

2.2 Rudder force and torque for rudder blades with cut-outs (semi-spade rudders)

2.2.1 The total rudder force C_R is to be calculated according to 2.1.1. The pressure distribution over the rudder area, upon which determination of rudder torque and rudder blade strength is to be based, is to be derived as follows:

The rudder area may be divided into two rectangular or trapezoidal parts with areas A_1 and A_2 , see Fig.2.29.

The resulting force of each part may be taken as:

$$C_{R1} = C_R \frac{A_1}{A} \quad [N]$$

$$C_{R2} = C_R \frac{A_2}{A} \quad [N]$$

2.2.2 The resulting torque of each part may be taken as:

$$Q_{R1} = C_{R1} \cdot r_1 \quad [Nm]$$

$$Q_{R2} = C_{R2} \cdot r_2 \quad [Nm]$$

$$r_1 = c_1 (\alpha - k_{b1}) \quad [m]$$

$$r_2 = c_2 (\alpha - k_{b2}) \quad [m]$$

$$k_{b1} = \frac{A_{1f}}{A_1}$$

$$k_{b2} = \frac{A_{2f}}{A_2}$$

A_{1f} , A_{2f} see Fig. 2.29

$$c_1 = \frac{A_1}{b_1}$$

$$c_2 = \frac{A_2}{b_2}$$

b_1 , b_2 = mean heights of partial rudder areas A_1 and A_2 , see Fig. 2.29.

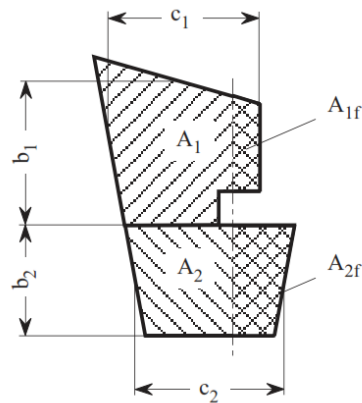


Fig. 2.29 Rudder areas

2.2.3 The total rudder torque is to be determined according to the following formulae:

$$Q_R = Q_{R1} + Q_{R2} \quad [\text{Nm}] \quad \text{or}$$

$$Q_R = C_R \cdot r_{1,2\min} \quad [\text{Nm}]$$

$$r_{1,2\min} = \frac{0,1}{A} (c_1 \cdot A_1 + c_2 \cdot A_2) \quad [\text{m}] \quad \text{for ahead condition}$$

The greater value is to be taken.

3. Scantlings of the rudder stock

3.1 Rudder stock diameter

3.1.1 The diameter of the rudder stock for transmitting the rudder torque is not to be less than:

$$D_t = 4,2 \sqrt[3]{Q_R \cdot k_r} \quad [\text{mm}]$$

$$Q_R = \text{see } 2.1.2, 2.2.2, \text{ and } 2.2.3$$

The related torsional stress is:

$$\tau_t = \frac{68}{k_r} \quad [\text{N/mm}^2]$$

$$k_r = \text{see } 1.4.2$$

3.1.2 The diameter of the rudder stock determined according to 3.1.1 is decisive for steering gear, stopper and locking device.

3.1.3 In case of mechanical steering gear, the diameter of the rudder stock in its upper part, which is only intended for transmission of the torsional moment from the auxiliary steering gear may be 0,9 D. The length of the edge of the quadrangle for the auxiliary tiller must not be less than 0,77 D and the height not less than 0,8 D_t.

3.1.4 The rudder stock is to be secured against axial sliding. The degree of the permissible axial clearance depends on the construction of steering engine and bearing.

3.2 Strengthening of rudder stock

3.2.1 If the rudder is so arranged that additional bending stresses occur in the rudder stock, the stock diameter has to be suitably increased. The increased diameter is, where applicable, decisive for the scantlings of the coupling.

For the increased rudder stock diameter the equivalent stress of bending and torsion is not to exceed the following value:

$$\sigma_v = \sqrt{\sigma_b^2 + 3\tau^2} \leq \frac{118}{k_r} \quad [\text{N/mm}^2]$$

Bending stress:

$$\sigma_b = \frac{10,2 \cdot M_b}{D_1^3} \quad [\text{N/mm}^2]$$

M_b = bending moment at the neck bearing [Nm]

Torsional stress:

$$\tau = \frac{5,1 \cdot Q_R}{D_1^3} \quad [\text{N/mm}^2]$$

D_1 = increased rudder stock diameter [cm]

The increased rudder stock diameter may be determined by the following formula:

$$D_1 = 0,1 \cdot D_t \sqrt[6]{1 + \frac{4}{3} \left(\frac{M_b}{Q_R} \right)^2}$$

Q_R = see 2.1.2, 2.2.2 and 2.2.3

D_t = see 3.1.1

Note

Where a double-piston steering gear is fitted, additional bending moments may be transmitted from the steering gear into the rudder stock. These additional bending moments are to be taken into account for determining the rudder stock diameter.

3.3 Analysis

3.3.1 General

The evaluation of bending moments, shear forces and support forces for the system rudder - rudder stock may be carried out for some basic rudder types as shown in Figs. 2.30 to 2.34 as outlined in 3.3.2 to 3.3.3.

3.3.2 Data for the analysis

$\ell_{10} - \ell_{50}$ = lengths of the individual girders of the system [m]

$I_{10} - I_{50}$ = moments of inertia of these girders [cm⁴]

For rudders supported by a sole piece, the length ℓ_{20} is the distance between lower edge of rudder body and centre of sole piece, and I_{20} is the moment of inertia of the pintle in the sole piece.

ℓ_{50} = effective length of sole piece [m]

I_{50} = moments of inertia of sole piece around z - axis [cm⁴]

Load on rudder body (general):

$$p_R = \frac{C_R}{\ell_{10} \cdot 10^3} \quad [\text{kN/m}]$$

Load on semi-spade rudders:

$$p_{R10} = \frac{C_{R2}}{\ell_{10} \cdot 10^3} \quad [\text{kN/m}]$$

$$p_{R20} = \frac{C_{R1}}{\ell_{20} \cdot 10^3} \quad [\text{kN/m}]$$

C_R, C_{R1}, C_{R2} = see 2.1 and 2.2

Z = spring constant of support in the sole piece or rudder horn respectively

for support in the sole piece (Fig. 2.30):

$$Z = \frac{6,18 \cdot I_{50}}{\ell_{50}^3} \quad [\text{kN/m}]$$

for support in the rudder horn (Fig. 2.31):

$$Z = \frac{1}{f_b + f_t} \quad [\text{kN/m}]$$

f_b = unit displacement of rudder horn [m] due to a unit force of 1 kN acting in the centre of support

$$= 0,21 \frac{d^3}{I_n} \quad [\text{m/kN}] \quad (\text{guidance value for steel})$$

I_n = moment of inertia of rudder horn around the x-axis at $d/2$ [cm⁴], see also Fig.2.31.

f_t = unit displacement due to a torsional moment of the amount $1 \cdot e$ [kN · m]

$$= \frac{d \cdot e^2}{G \cdot J_t}$$

$$= \frac{d \cdot e^2 \cdot \sum u_i / t_i}{3,14 \cdot 10^8 \cdot F_T^2} \quad [\text{m/kN}] \quad \text{for steel}$$

G = modulus of gravity

$$G = 7,92 \cdot 10^7 \quad [\text{kN/m}^2] \quad \text{for steel}$$

J_t = torsional moment of inertia [m⁴]

- F_T = mean sectional area of rudder horn [m²]
- u_i = breadth [mm] of individual plates forming the mean horn sectional area.
- t_i = plate thickness within individual breadth u_i [mm]
- e, d = distances [m] according to Fig. 2.31
- K_{11}, K_{22}, K_{12} = Rudder horn compliance constants calculated for rudder horn with 2-conjugate elastic supports (Fig. 2.34). The 2-conjugate elastic supports are defined in terms of horizontal displacements, y_i , by the following equations :
- y_1 = $-K_{12} B_2 - K_{22} B_1$ at the lower rudder horn bearing
- y_2 = $-K_{11} B_2 - K_{12} B_1$ at the upper rudder horn bearing
- y_1, y_2 = Horizontal displacements [m] at the lower and upper rudder horn bearings, respectively.
- B_1, B_2 = Horizontal support forces [kN] at the lower and upper rudder horn bearings, respectively.
- K_{11}, K_{22}, K_{12} = Obtained [m/kN] from the following formulae:
- $$K_{11} = 1,3 \frac{\lambda^3}{3EJ_{1h}} + \frac{e^2 \lambda}{GJ_{th}}$$
- $$K_{22} = 1,3 \left[\frac{\lambda^3}{3EJ_{1h}} + \frac{\lambda^2 (d\lambda)}{2EJ_{1h}} \right] + \frac{e^2 \lambda}{GJ_{th}}$$
- $$K_{12} = 1,3 \left[\frac{\lambda^3}{3EJ_{1h}} + \frac{\lambda^2 (d\lambda)}{2EJ_{1h}} + \frac{\lambda (d\lambda)^2}{EJ_{1h}} + \frac{(d\lambda)^3}{3EJ_{2h}} \right] + \frac{e^2 d}{GJ_{th}}$$
- d = height if the rudder horn [m] according to Fig. 2.34. This value is to be measured downwards from the upper rudder horn end, at the point of curvature transition, to the mid-line of the lower rudder horn pintle
- λ = Length, in m, as defined in Fig. 2.34. This length is measured downwards from the upper rudder horn end, at the point of curvature transition, to the mid-line of the upper rudder horn bearing. For $\lambda = 0$, the above formulae converge to those of spring constant Z for a rudder horn with 1-elastic support, and assuming a hollow cross section for this part.
- e = Rudder-horn torsion lever [m] as defined in Fig. 2.34 (value taken at $z = d/2$).
- J_{1h} = Moment of inertia of rudder horn about the x axis [m⁴] for the region above the upper rudder horn bearing. Note that J_{1h} is an average value over the length λ (see Fig. 2.34).
- J_{2h} = Moment of inertia of rudder horn about the x axis [m⁴] for the region between the upper and lower rudder horn bearings. Note that J_{2h} is an average value over the length $d - \lambda$ (see Fig. 2.34).
- J_{th} = Torsional stiffness factor of the rudder horn [m⁴] for any thin wall closed section to be calculated from the following formula:

$$= \frac{4F_T^2}{\sum_i \frac{u_i}{t_i}}$$

F_T = Mean of areas enclosed by outer and inner boundaries of the thin walled section of rudder horn [m²].

u_i = Length [mm] of the individual plates forming the mean horn sectional area.

t_i = Thickness [mm] of the individual plates mentioned above.

Note:

That the J_{th} value is taken as an average value, valid over the rudder horn height.

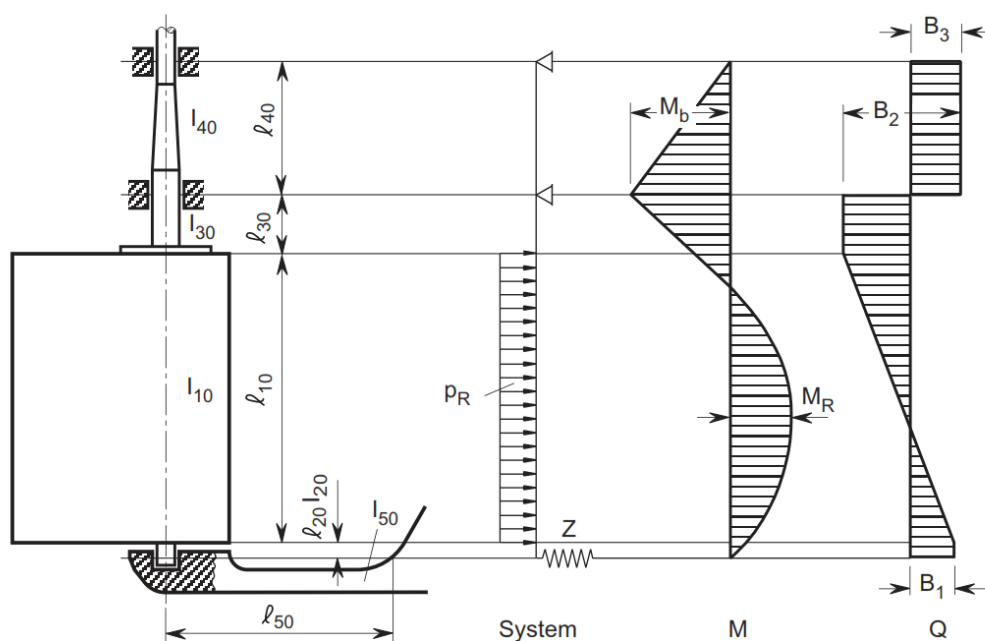


Fig. 2.30 Rudder supported by sole piece

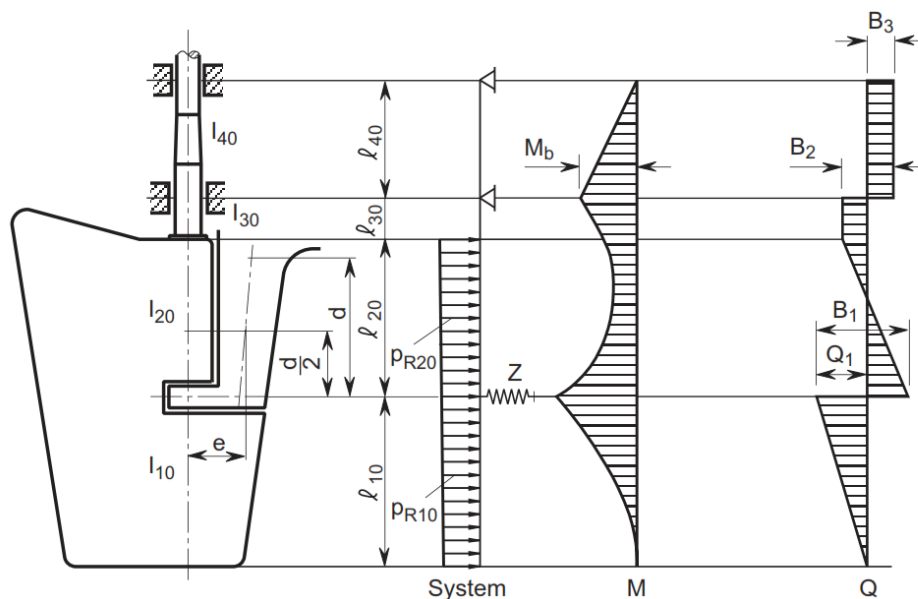


Fig. 2.31 Semi-spade rudder

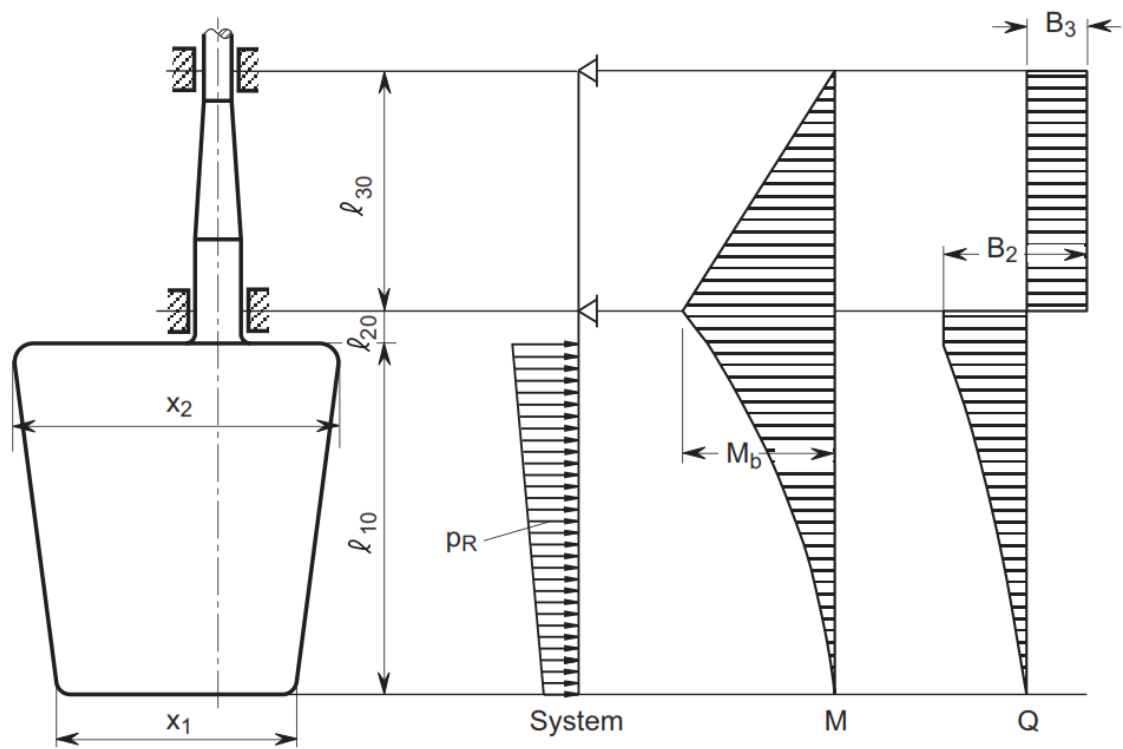


Fig. 2.32 Spade rudder

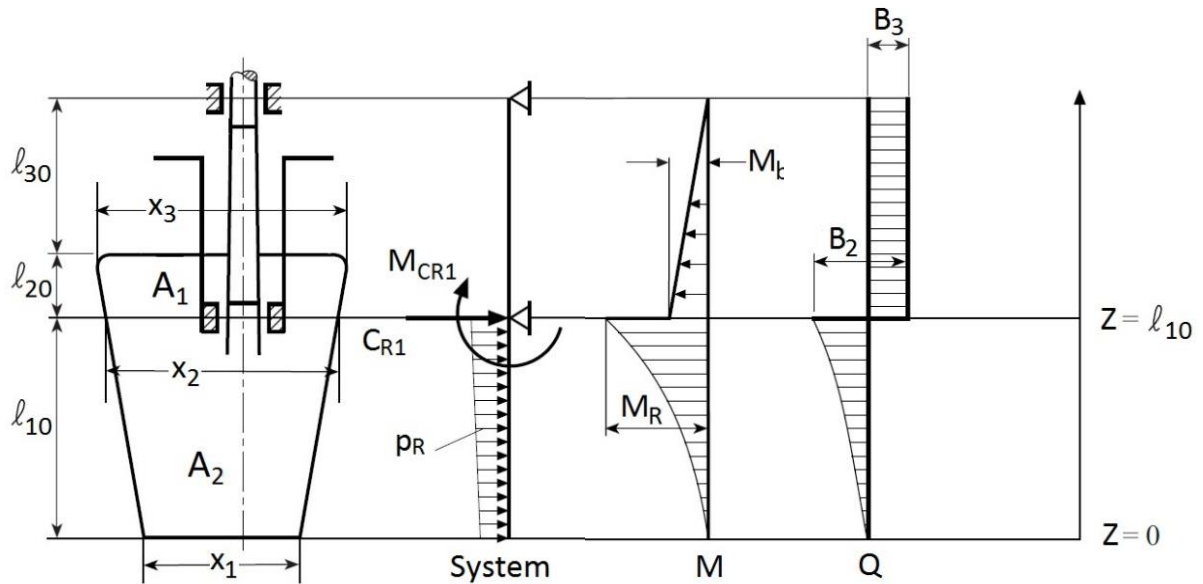


Fig. 2.33 Spade rudders with rudder trunks inside the rudder body

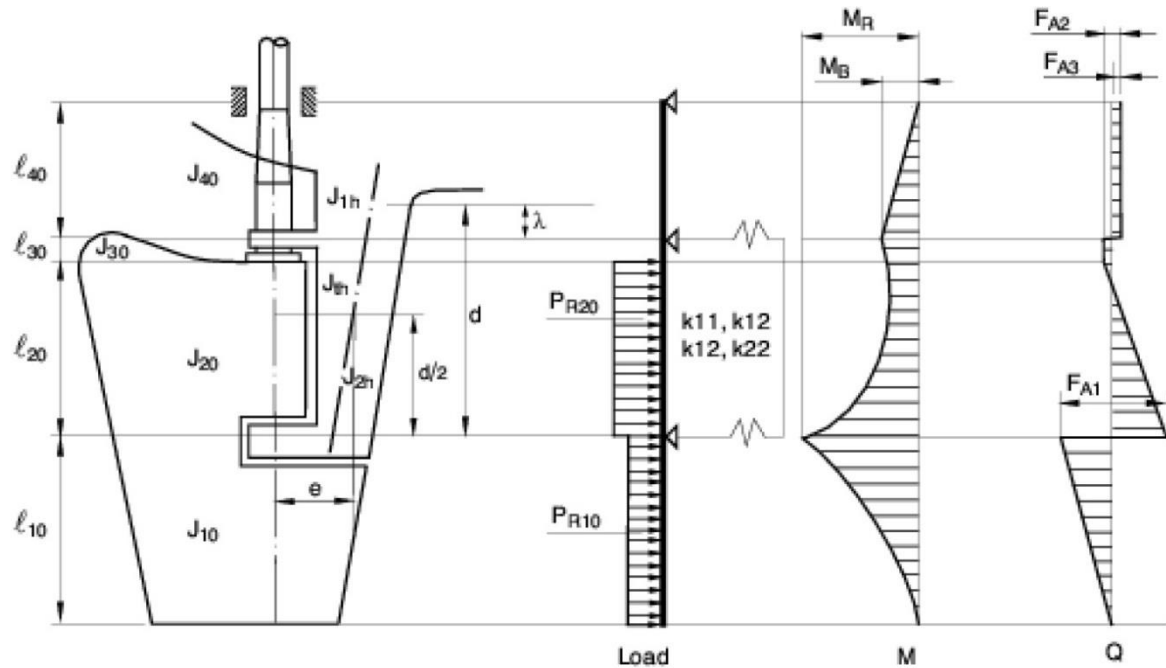


Fig. 2.34 Spade rudders with two supports

3.3.3 Moments and forces to be evaluated

.1 The bending moment M_R and the shear force Q_1 in the rudder body, the bending moment M_b in the neck bearing and the support forces B_1 , B_2 , B_3 are to be evaluated.

The so evaluated moments and forces are to be used for the stress analyses required by 3.2 and 5.1 and for calculation of sole piece and rudder horn.

.2 For spade rudders moments and forces may be determined by the following formulae:

$$M_b = C_R \left(\ell_{20} + \frac{\ell_{10} (2x_1 + x_2)}{3(x_1 + x_2)} \right) \quad [\text{Nm}]$$

$$B_3 = \frac{M_b}{\ell_{30}} \quad [\text{N}]$$

$$B_2 = C_R + B_3 \quad [\text{N}]$$

.3 For spade rudders with rudder trunks (see Fig. 2.33) the moments and forces may be determined by the following formulae :

C_{R1} = rudder force over the partial rudder area A_1 according to B.2.1 [N]

C_{R2} = rudder force over the partial rudder area A_2 according to B.2.1 [N]

$$M_{CR1} = C_{R1} \cdot \ell_{20} \cdot \left[1 - \frac{2 \cdot x_2 + x_3}{3 \cdot (x_2 + x_3)} \right] \quad [\text{Nm}]$$

$$M_{CR2} = C_{R2} \cdot \frac{\ell_{10} \cdot (2 \cdot x_1 + x_2)}{3 \cdot (x_1 + x_2)} \quad [\text{Nm}]$$

$$M_R = \text{Max} (M_{CR1}, M_{CR2}) \quad [\text{Nm}]$$

$$M_b = M_{CR2} - M_{CR1} \quad [\text{Nm}]$$

$$B_3 = \frac{M_b}{\ell_{20} + \ell_{30}} \quad [\text{N}]$$

$$B_2 = C_R + B_3 \quad [\text{N}]$$

.4 Moment and force rudder support by sole piece in [Fig. 2.30](#)

3.4 Rudder trunk

Where the rudder stock is arranged in a trunk in such a way that the trunk is stressed by forces due to rudder action, the scantlings of the trunk are to be such that the equivalent stress due to bending and shear does not exceed $0,35 \cdot R_{eH}$ of the material used.

4. Sole piece

4.1 The section modulus of the sole piece related to z-axis is not to be less than:

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

$$B_1 = \text{see } 5.$$

For rudders with two supports the support force is approximately $B_1 = C_R/2$, when the elasticity of the sole piece is ignored.

x = distance of the respective cross section from the rudder axis [m]

$$x_{\min} = 0,5 \cdot \ell_{50}$$

$$x_{\max} = \ell_{50}$$

$$\ell_{50} = \text{see } \text{Fig 2.35 and } 3.3.2$$

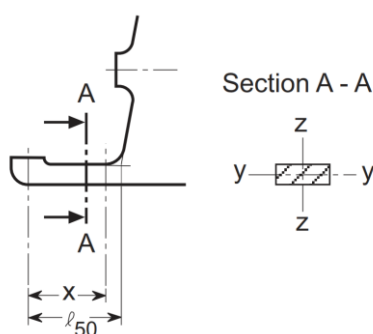


Fig. 2.35 Sole piece parameters

4.2 The section modulus related to y-axis is not to be less than:

– where no rudder post or rudder axle is fitted:

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

- where a rudder post or rudder axle is fitted:

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

4.3 The sectional area at the location $x = \ell_{50}$ is not to be less than:

$$A_s = \frac{B_1}{48} k \quad [\text{mm}^2]$$

4.4 The equivalent stress taking into account bending and shear stresses at any location within length ℓ_{50} is not to exceed:

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

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

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

5. Rudder horn of semi spade rudders

5.1 The distribution of the bending moment, shear force and torsional moment is to be determined according to the following formulae:

- bending moment: $M_b = B_1 \cdot z \quad [Nm]$
- $M_{bmax} = B_1 \cdot d \quad [Nm]$
- shear force: $Q = B_1$
- torsional moment $M_T = B_1 \cdot e(z) \quad [Nm]$

For determining preliminary scantlings flexibility of the rudder horn may be ignored and the supporting force B_1 be calculated according to the following formula:

$$B_1 = C_R \frac{b}{c} \quad [N]$$

b, c, d, e(z) and z see Fig. 2.36 and 2.37

b = results from position of the centre of gravity of the rudder area

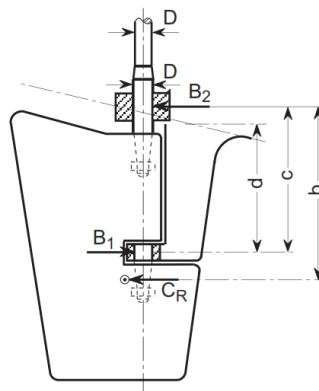


Fig. 2.36 Parameters for semi spade rudders

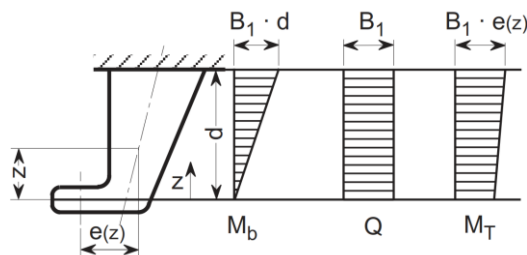


Fig. 2.37 Forces on rudder horn

5.2 The section modulus of the rudder horn in transverse direction related to the horizontal x-axis is at any location z not to be less than:

$$W_x = \frac{M_b \cdot k}{67} \quad [\text{cm}^3]$$

5.3 At no cross section of the rudder horn the shear stress due to the shear force Q is to exceed the value:

$$\tau = \frac{48}{k} \quad [\text{N/mm}^2]$$

The shear stress is to be determined by following formula:

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

A_h = effective shear area of rudder horn in y-direction [mm^2]

5.4 The equivalent stress at any location (z) of the rudder horn shall not exceed following value:

$$\sigma_v = \sqrt{\sigma_b^2 + 3(\tau^2 + \tau_T^2)} = \frac{120}{k} \quad [\text{N/mm}^2]$$

$$\sigma_b = \frac{M_b}{W_x} \quad [\text{N/mm}^2]$$

$$\tau_T = \frac{M_T \cdot 10^3}{2 \cdot A_T \cdot t_h} \quad [\text{N/mm}^2]$$

A_T = sectional area [mm^2] surrounded by the rudder horn at the location examined

t_h = thickness of rudder horn plating in [mm]

5.5 When determining the thickness of rudder horn plating the provisions of 5.2 to 5.4 are to be complied with. The thickness is, however, not to be less than:

$$t_{\min} = 2,4 \sqrt{L \cdot k} \quad [\text{mm}]$$

5.6 The rudder horn plating is to be effectively connected to the aft ship structure, e.g. by connecting the plating to longitudinal girders, in order to achieve a proper transmission of forces, see Fig. 2.38.

Brackets or stringer are to be fitted internally in horn, in line with outside shell plate, as shown in Fig. 2.38.

5.7 Transverse webs of the rudder horn are to be led into the hull up to the next deck in a sufficient number and must be of adequate thickness.

5.8 Strengthened plate floors are to be fitted in line with transverse webs in order to achieve a sufficient connection with the hull structure. The thickness of these plate floors is to be increased by 50 percent above the Rule values as required by D. to G.

5.9 The centre line bulkhead (wash-bulkhead) in the afterpeak is to be connected to the rudder horn.

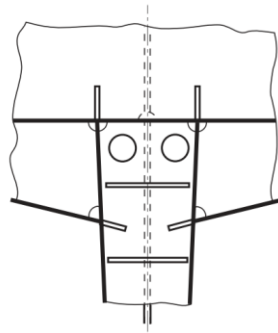


Fig.2.38 Connection of rudder horn to the aft ship structure

5.10 Where the transition between rudder horn and shell is curved, about 50 % of the required total section modulus of the rudder horn is to be formed by webs in a Section A - A located in the centre of the transition zone, i.e. $0,7r$ above beginning of the transition zone. See Fig. 2.39.

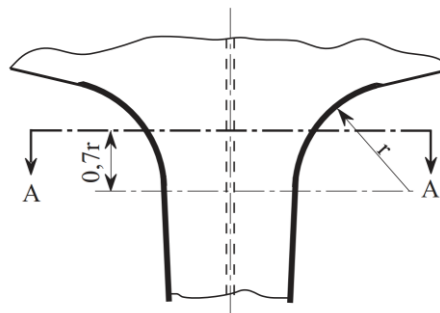


Fig. 2.39 Transition between rudder horn and curved shell

6. Rudder couplings

6.1 General

6.1.1 Couplings are to be designed in such a way as to enable them to transmit the full torque of the rudder stock.

6.1.2 The distance of bolt axis from the edges of the flange is not to be less than 1,2 the diameter of the bolt. In horizontal couplings, at least 2 bolts are to be arranged forward of the rudder stock axis.

6.1.3 Coupling bolts are to be fitted bolts. Bolts and nuts are to be effectively secured against loosening, e.g. according to recognized standards.

6.1.4 For spade rudders horizontal couplings according to 6.2 are permissible only where the required thickness of the coupling flanges t_f is less than 50 mm, otherwise cone couplings according to 6.3 are to be applied. For spade rudders of the high lift type, only cone couplings according to 6.3 are permitted.

6.1.5 If a cone coupling is used between the rudder stock or pintle, as the case can be, and the rudder blade or steering gear (see 6.3), the contact area between the mating surfaces is to be demonstrated to the Surveyor by blue print test and should not be less than 70 % of the theoretical contact area (100 %). Non-contact areas should be distributed widely over the theoretical contact area. Concentrated areas of non-contact in the forward regions of the cone are especially to be avoided. The proof has to be demonstrated using the original components and the assembling of the components has to be done in due time to the creation of blue print to ensure the quality of the surfaces. In case of storing over a longer period, sufficient preservation of the surfaces is to be provided for.

If alternatively a male/female calibre system is used, the contact area between the mating surfaces is to be checked by blue print test and should not be less than 80 % of the theoretical contact area (100 %) and needs to be certified. After ten applications or five years the blue print proof has to be renewed.

6.2 Horizontal couplings

6.2.1 The diameter of coupling bolts is not to be less than:

$$d_b = 0,62 \sqrt{\frac{D^3 \cdot k_b}{k_r \cdot n \cdot e}} \quad [\text{mm}]$$

D = rudder stock diameter according to 3. [mm]

n = total number of bolts, which is not to be less than 6

e = mean distance of bolt axes from centre of bolt system [mm]

k_r = material factor for the rudder stock as given in 1.4.2

b = material factor for bolts analogously to 1.4.2

6.2.2 The thickness of the coupling flanges is not to be less than determined by the following formulae:

$$t_f = 0,62 \sqrt{\frac{D^3 \cdot k_f}{k_r \cdot n \cdot e}} \quad [\text{mm}]$$

$$t_{fmin} = 0,9 \cdot d_b$$

k_f = material factor for the coupling flanges analogously to 1.4.2

The thickness of the coupling flanges clear of the bolt holes is not to be less than $0,65 \cdot t_f$.

The width of material outside the bolt holes is not to be less than $0,67 \cdot d_b$.

6.2.3 Coupling flanges are to be equipped with a fitted key according to DIN 6885 or equivalent standard for relieving the bolts.

The fitted key may be dispensed with if the diameter of the bolts is increased by 10 %.

6.2.4 Horizontal coupling flanges shall either be forged together with the rudder stock or be welded to the rudder stock as outlined in Rules for Hull (Pt.1, Vol.II) Sec. 19, B.4.4.3.

6.2.5 For the connection of the coupling flanges with the rudder body see also [Rules for Hull \(Pt.1, Vol.II\) Sec.19, B.4.4.](#)

6.3 Cone couplings

6.3.1 Cone couplings with key

.1 Cone couplings should have a taper c on diameter of 1 : 8 - 1 : 12.

$$c = (d_0 - d_u)/\ell \quad \text{according to Fig. 2.40}$$

The cone shape should be very exact. The nut is to be carefully secured, e.g. by a securing plate as shown in Fig. 2.40.

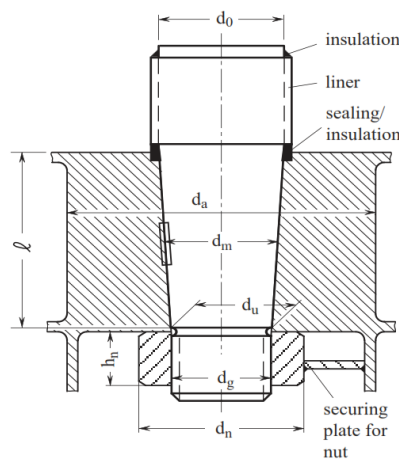


Fig. 2.40 Cone coupling

.2 The coupling length ℓ should, in general, not be less than $1,5 \cdot d_0$.

.3 For couplings between stock and rudder a key is to be provided, the shear area of which is not to be less than:

$$a_s = \frac{16 \cdot Q_F}{d_k \cdot R_{eH1}} \quad [\text{cm}^2]$$

Q_F = design yield moment of rudder stock [Nm] according to 8.

d_k = diameter of the conical part of rudder stock [mm] at the key

R_{eH1} = minimum nominal upper yield point of key material [N/mm²]

.4 The effective surface area of the key (without rounded edges) between key and rudder stock or cone coupling is not to be less than:

$$a_s = \frac{5 \cdot Q_F}{d_k \cdot R_{eH2}} \quad [\text{cm}^2]$$

R_{eH2} = minimum nominal upper yield point of key, stock or coupling material [N/mm²], whichever is less.

.5 The dimensions of the slugging nut are to be as follows, see Fig. 2.40:

- height:

$$h_n = 0,6 \cdot d_g$$

- outer diameter (the greater value to be taken):

$$d_n = 1,2 \cdot d_u \text{ or } d_n = 1,5 \cdot d_g$$

- external thread diameter:

$$d_g = 0,65 \cdot d_o$$

.6 It is to be proved that 50 % of the design yield moment will be solely transmitted by friction in the cone couplings. This can be done by calculating the required push-up pressure and push-up length according to 6.3.2.3 for a torsional moment $Q'_F = 0,5 \cdot Q_F$.

6.3.2 Cone couplings with special arrangements for mounting and dismounting of couplings

.1 Where the stock diameter exceeds 200 mm the press fit is recommended to be effected by a hydraulic pressure connection. In such cases the cone should be more slender, $c \approx 1 : 12$ to $\approx 1 : 20$.

.2 In case of hydraulic pressure connections the nut is to be effectively secured against the rudder stock or the pintle. A securing plate for securing the nut against the rudder body is not to be provided, see Fig. 2.41.

A securing flat bar will be regarded as an effective securing device of the nut, if its shear area is not less than:

$$A_s = \frac{P_s \cdot \sqrt{3}}{R_{eH}} \quad [\text{mm}^2]$$

P_s = shear force as follows

$$= \frac{P_e}{2} \cdot \mu_1 \left[\frac{d_1}{d_g} - 0,6 \right]$$

P_e = push-up force according to 6.3.2.3 [N]

μ_1 = frictional coefficient between nut and rudder body, normally $\mu = 0,3$

d_1 = mean diameter of frictional area between nut and rudder body, see Fig.2.41.

d_g = thread diameter of nut

R_{eH} = yield point [N/mm²] of securing flat bar material.

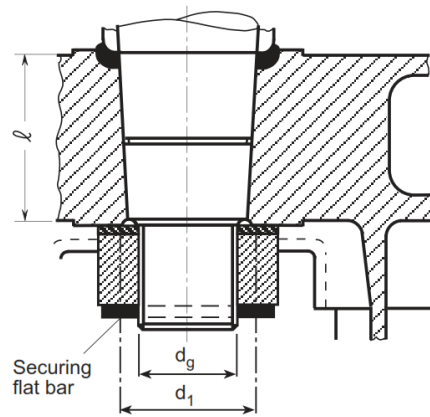


Fig. 2.41 Cone coupling with special arrangements for mounting and dismounting

.3 For safe transmission of the torsional moment by the coupling between rudder stock and rudder body the push-up length and the push-up pressure are to be determined by following formulae.

.3.1 Push-up pressure

The push-up pressure is not to be less than the greater of the two following values:

$$P_{\text{req1}} = \frac{2 \cdot Q_F \cdot 10^3}{d_m^2 \cdot \ell \cdot \pi \cdot \mu_0} \quad [\text{N/mm}^2]$$

or

$$P_{\text{req2}} = \frac{6 \cdot M_b \cdot 10^3}{\ell^2 \cdot d_m} \quad [\text{N/mm}^2]$$

Q_F = design yield moment of rudder stock according to 8. [Nm]

d_m = mean cone diameter [mm]

ℓ = cone length [mm]

μ_0 = 0,15 (frictional coefficient)

M_b = bending moment in cone coupling (e.g. in case of spade rudders) [Nm]

It has to be proved that the push-up pressure does not exceed the permissible surface pressure in the cone. The permissible surface pressure is to be determined by following formula:

$$P_{\text{perm}} = \frac{0,95 \cdot R_{eH} (1 - \alpha^2)}{\sqrt{3 + \alpha^4}} - P_b \quad [\text{N/mm}^2]$$

$$P_b = \frac{3,5 \cdot M_b}{d_m \cdot \ell} \cdot 10^3$$

R_{eH} = yield point [N/mm²] of the material of the gudgeon

$$\alpha = \frac{d_m}{d_a} \quad (\text{see Fig.2.40})$$

The outer diameter of the gudgeon should not be less than:

$$d_a = 1,25 \cdot d_o \text{ [mm]}$$

For d_o , see [Fig. 2.40](#)

.3.2 Push-up length

The push-up length is not to be less than:

$$\Delta \ell_1 = \frac{p_{\text{req}} \cdot d_m}{E \left(\frac{1 - \alpha^2}{2} \right) c} + \frac{0,8 \cdot R_{\text{tm}}}{c} \text{ [mm]}$$

R_{tm} = mean roughness [mm]

$R_{\text{tm}} \approx 0,01 \text{ mm}$

c = taper on diameter according to [6.3.2.1](#)

E = Young's modulus ($2,06 \cdot 10^5 \text{ N/mm}$)

The push-up length is, however, not to be taken greater than:

$$\Delta \ell_2 = \frac{1,6 \cdot R_{\text{eH}} \cdot d_m}{\sqrt{3 + \alpha^4} E \cdot c} + \frac{0,8 \cdot R_{\text{tm}}}{c} \text{ [mm]}$$

Note

In case of hydraulic pressure connections the required push-up force P_e for the cone may be determined by the following formula:

$$P_e = p_{\text{req}} \cdot d_m \cdot \pi \cdot \ell \left(\frac{c}{2} + 0,02 \right) \text{ [N]}$$

Where due to the fitting procedure a partial push-up effect caused by the rudder weight is given, this may be taken into account when fixing the required push-up length, subject to approval by BKI.

.4 The required push-up pressure for pintle bearings is to be determined by following formula:

$$P_{\text{req}} = 0,4 \frac{B_1 \cdot d_o}{d_m^2 \cdot \ell} \text{ [N/mm}^2\text{]}$$

B_1 = supporting force in pintle bearing [N], see also [Fig. 2.31](#)

d_m, ℓ = see [6.3.2.3](#)

d_o = pintle diameter [mm] according to [Fig. 2.40](#)

The push-up length is to be calculated similarly as in [6.3.2.3.1](#) using required push-up pressure and properties for the pintle bearing.

7. Rudder body, rudder bearings

7.1 Strength of rudder body

7.1.1 The rudder body is to be stiffened by horizontal and vertical webs in such a manner that the rudder body will be effective as a beam. The rudder should be additionally stiffened at the aft edge.

7.1.2 The strength of the rudder body is to be proved by direct calculation according to 3.3.

7.1.3 For rudder bodies without cut-outs the permissible stress are limited to:

bending stress due to M_R :

$$\sigma_b \leq \frac{110}{k} \quad [\text{N/mm}^2]$$

shear stress due to Q_1 :

$$\tau \leq \frac{50}{k} \quad [\text{N/mm}^2]$$

equivalent stress due to bending and shear:

$$\sigma_v = \sqrt{\sigma_b^2 + 3\tau^2} \leq \frac{120}{k} \quad [\text{N/mm}^2]$$

M_R , Q_1 see 3.3.3 and Fig. 2.30 and 2.31.

In case of openings in the rudder plating for access to cone coupling or pintle nut the permissible stresses according to 7.1.4 apply. Smaller permissible stress values may be required if the corner radii are less than $0,15 \cdot h_0$, where h_0 = height of opening.

7.1.4 In rudder bodies with cut-outs (semi-spade rudders) the following stress values are not to be exceeded:

bending stress due to M_R :

$$\sigma_b \leq 90 \quad [\text{N/mm}^2]$$

shear stress due to Q_1 :

$$\tau \leq 50 \quad [\text{N/mm}^2]$$

torsional stress due to M_t :

$$\tau_t \leq 50 \quad [\text{N/mm}^2]$$

equivalent stress due to bending and shear and equivalent stress due to bending and torsion:

$$\sigma_{v1} = \sqrt{\sigma_b^2 + 3\tau^2} = 120 \quad [\text{N/mm}^2]$$

$$\sigma_{v2} = \sqrt{\sigma_b^2 + 3\tau_t^2} = 100 \quad [\text{N/mm}^2]$$

$$M_R = C_{R2} \cdot f_1 + B_1 \frac{f_2}{2} \quad [\text{Nm}]$$

$$Q_1 = C_{R2} \quad [\text{N}]$$

f_1, f_2 = see Fig. 2.42

The torsional stress may be calculated in a simplified manner as follows:

$$\tau_t = \frac{M_t}{2 \cdot \ell \cdot h \cdot t} \quad [\text{N/mm}^2]$$

$$M_t = C_{R2} \cdot e \quad [\text{Nm}]$$

C_{R2} = partial rudder force [N] of the partial rudder area A_2 below the cross section under consideration.

$$e = \text{lever for torsional moment} \quad [\text{m}]$$

(horizontal distance between the centroid of area A_2 and centre line a-a of the effective cross sectional area under consideration, see Fig. 2.42. The centroid is to be assumed at $0,33 \cdot c_2$ aft of the forward edge of area A_2 , where c_2 = mean breadth of area A_2).

$$h, \ell, t = \text{in [cm], see Fig. 2.42}$$

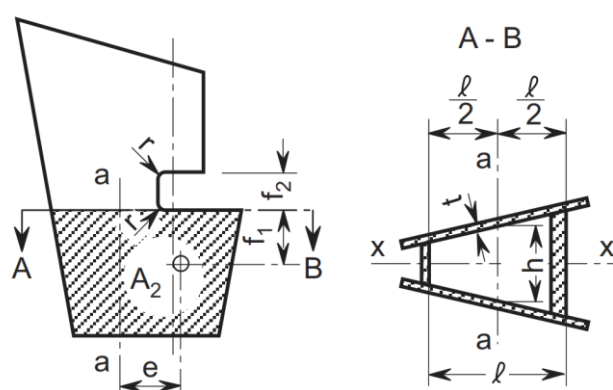


Fig. 2.42 Rudder body

The distance ℓ between vertical webs should not exceed $1,2 \cdot h$.

The radii in the rudder plating are not to be less than 4 – 5 times the plate thickness, but in no case less than 50 mm.

Note :

It is recommended to keep the natural frequency of the fully immersed rudder and of local structural components at least 10 % above the exciting frequency of the propeller (number of revolutions \times number of blades) or if relevant above higher order.

7.2 Rudder plating

7.2.1 The thickness of rudder plating is to be determined according to following formula:

$$t = 1,74 \cdot a \sqrt{p_R \cdot k} + 2,5 \quad [\text{mm}]$$

$$p_R = 10 \cdot T + \frac{C_R}{10^3 \cdot A} \quad [\text{kN/m}^2]$$

$$a = \text{smaller unsupported width of a plate panel} \quad [\text{m}]$$

The influence of the aspect ratio of the plate panels may be taken into account as given in D.4.3. The thickness shall, however, not be less than t according to Table 2.18 for the bottom shell plating.

To avoid resonant vibration of single plate fields the frequency criterion as defined in [Rules for Hull \(Pt.1, Vol.II\) Sec. 12, A.8.3](#) for shell structures applies analogously.

Regarding dimensions and welding for rudder plating in way of coupling flange, [Rules for Hull \(Pt.1, Vol.II\) Sec. 19, B.4.4.1](#) has to be observed in addition.

7.2.2 For connecting the side plating of the rudder to the webs tenon welding is not to be used. Where application of fillet welding is not practicable, the side plating is to be connected by means of slot welding to flat bars which are welded to the webs.

7.2.3 The thickness of the webs is not to be less than 70 % of the thickness of the rudder plating according to [7.2.1](#), but not less than:

$$t_{\min} = 8 \sqrt{k} \quad [\text{mm}]$$

Webs exposed to seawater must be dimensioned according to [7.2.1](#).

7.3 Transmitting of rudder torque

7.3.1 For transmitting the rudder torque, the rudder plating according to [7.2.1](#) is to be increased by 25% in way of the coupling. A sufficient number of vertical webs is to be fitted in way of the coupling.

7.3.2 If the torque is transmitted by a prolonged shaft extended into the rudder, the latter must have the diameter D_t or D_1 , whichever is greater, at the upper 10 % of the intersection length. Downwards it may be tapered to 0,6 D_t , in spade rudders to 0,4 times the strengthened diameter, if sufficient support is provided for.

7.4 Rudder bearings

7.4.1 In way of bearings liners and bushes are to be fitted. Where in case of small ships bushes are not fitted, the rudder stock is to be suitably increased in diameter in way of bearings enabling the stock to be re-machined later.

7.4.2 An adequate lubrication is to be provided.

7.4.3 The bearing forces result from the direct calculation mentioned in [3.3](#). As a first approximation the bearing force may be determined without taking account of the elastic supports. This can be done as follows:

- normal rudder with two supports:
- The rudder force C_R is to be distributed to the supports according to their vertical distances from the centre of gravity of the rudder area.
- semi-spade rudders:
- support force in the rudder horn:

$$B_1 = C_R \cdot \frac{b}{c} \quad [\text{N}]$$

- support force in the neck bearing:

$$B_2 = C_R - B_1 \quad [\text{N}]$$

For b and c see [Fig.2.36](#)

7.4.4 The projected bearing surface A_b (bearing height \times external diameter of liner) is not to be less than:

$$A_b = \frac{B}{q} \quad [\text{mm}^2]$$

B = support force [N]

q = permissible surface pressure according to [Table 2.22](#)

7.4.5 Stainless and wear resistant steels, bronze and hot-pressed bronze-graphite materials have a considerable difference in potential to non-alloyed steel. Respective preventive measures are required.

7.4.6 The bearing height shall be equal to bearing diameter, however, is not to exceed 1,2 times the bearing diameter. Where bearing depth is less than bearing diameter, higher specific surface pressures may be allowed.

7.4.7 The wall thickness of pintle bearings in sole piece and rudder horn shall be approximately $\frac{1}{4}$ of pintle diameter.

Table 2.22 Permissible surface pressure for bearing materials

Bearing material	q [N/mm ²]
lignum vitae	2,5
white metal, oil lubricated	4,5
synthetic material ¹	5,5
steel ² , bronze and hot-pressed bronze-graphite materials	7,0
¹ Synthetic materials to be of approved type. Surface pressures exceeding 5,5 N/mm ² may be accepted in accordance with bearing manufacturer's specification and tests, but in no case more than 10 N/mm ² . ² Stainless and wear resistant steel in an approved combination with stock liner. Higher surface pressures than 7 N/mm ² may be accepted if verified by tests.	

7.5 Pintles

7.5.1 Pintles are to have scantlings complying with conditions given in [7.4.4](#) and [7.4.6](#). The pintle diameter is not to be less than:

$$d = 0,35 \sqrt{B_1 \cdot k_r} \quad [\text{mm}]$$

B_1 = support force [N]

k_r = see [1.4.2](#)

7.5.2 The thickness of any liner or bush shall not be less than:

$$t = 0,01 \sqrt{B_1} \quad [\text{mm}]$$

$t_{\min} = 8 \quad \text{mm}$ for metallic materials and synthetic material

$= 22 \quad \text{mm}$ for lignum material

7.5.3 Where pintles are of conical shape, they are to comply with the following:

taper on diameter 1 : 8 to 1 : 12 if keyed by slugging nut

taper on diameter 1 : 12 to 1 : 20 if mounted with oil injection and hydraulic nut

7.5.4 Pintles are to be arranged in such a manner as to prevent unintentional loosening and falling out. For nuts and threads the requirements of 6.3.1.5 and 6.3.2.2 apply accordingly.

7.6 Guidance values for bearing clearances

7.6.1 For metallic bearing material the bearing clearance should generally not be less than:

$$\frac{d_b}{1000} + 1,0 \quad [\text{mm}]$$

d_b = inner diameter of bush [mm]

7.6.2 If non-metallic bearing material is applied, the bearing clearance is to be specially determined considering the material's swelling and thermal expansion properties.

7.6.3 Clearance is in no way to be taken less than 1,5 mm on diameter. In case of self lubricating bushes going down below this value can be agreed to on the basis of the manufacturer's specification.

8. Design yield moment of rudder stock

The design yield moment of the rudder stock is to be determined by the following formula:

$$Q_F = 0,02664 \frac{D_t^3}{k_r} \quad [\text{Nm}]$$

D_t = stock diameter [mm] according to 3.1

Where the actual diameter D_{ta} is greater than the calculated diameter D_t , diameter D_{ta} is to be used. However, D_{ta} need not be taken greater than $1,145 \cdot D_t$.

9. Stopper, locking device

9.1 Stopper

The motions of quadrants or tillers are to be limited on either side by stoppers. The stoppers and their foundations connected to the ship's hull are to be of strong construction so that the yield point of the applied materials is not exceeded at the design yield moment of the rudder stock.

9.2 Locking device

Each steering gear is to be provided with a locking device in order to keep the rudder fixed at any position. This device as well as the foundation in the ship's hull are to be of strong construction so that the yield point of the applied materials is not exceeding the design yield moment of the rudder stock as specified in 8. Where the ship's speed exceeds 12 knot, the design yield moment need only be calculated for a stock diameter based on a speed $v_0 = 12$ knot.

10. Fin stabilizers

The structural integration of fin stabilizer systems into the hull is subject to approval.

If non-retractable fins extend over the maximum breadth of the ship their location shall be marked on the shell's side.

K. Anchor and Mooring Equipment

1. General

1.1 The equipment of anchors, chain cables, wires and ropes is to be determined from [Table 2.23](#) in accordance with the equipment numeral EN.

Note

Anchoring equipment as required hereinafter is intended for temporary mooring of a yacht within a harbour or sheltered area when the yacht is awaiting berth, tide, etc.

The equipment is, therefore, not designed to hold a yacht off fully exposed coasts in rough weather or to stop a yacht which is moving or drifting. In this condition the loads on the anchoring equipment increase to such a degree that its components may be damaged or lost owing to the high energy forces generated, particularly in sailing yachts.

Anchoring equipment as required hereinafter is designed to hold a yacht in good holding ground in conditions such as to avoid dragging of the anchor. In poor holding ground the holding power of the anchors will be significantly reduced.

The equipment numeral formula for anchoring equipment is based on an assumed current speed of 2,5 m/s, wind speed of 25 m/sec and a scope of chain cable between 6 and 10, the scope being the ratio between length of chain paid out and water depth.

It is assumed that under normal circumstances a yacht will use only one bow anchor and chain cable at a time.

1.2 Every yacht is to be equipped with at least one anchor windlass.

Windlass and chain stopper, if fitted, are to comply with the [Rules for Machinery Installations \(Pt.1, Vol.III\), Sec. 14, D](#).

1.3 For yachts having a navigation notation **L** (coastal service) affixed to their Character of Classification, the equipment may be determined as for one numeral range lower than required in accordance with the equipment numeral EN.

1.4 When determining the equipment for yachts having a navigation notation **T** (shelter water service) affixed to their Character of Classification, the anchor mass may be 60 % of the value required by [Table 2.23](#). The chain diameter may be determined according to the reduced anchor mass. The length of the ropes is recommended to be 50 % of the length given in [Table 2.23](#).

1.5 Yachts built under survey of BKI and which are to have the mark **✠** stated in their Certificate and in the Register Book, must be equipped with anchors and chain cables complying with the [Rules for Materials \(Pt.1, Vol.V\) Sec. 12 and 13](#) and have to be tested on approved machines in presence of a BKI Surveyor.

2. Equipment numeral

2.1 For monohull yachts the equipment numeral is to be calculated as follows:

$$EN = \sqrt[3]{\Delta^2} + 2(a \cdot B + \sum b_i \cdot h_i \cdot \sin \Theta_i) + 0,1 \cdot A$$

- Δ = moulded displacement [t] to design waterline in sea water with a density of 1,025t/m³
- a = distance [m], from design waterline, amidships, to upper deck at side, as show in [Fig. 2.43](#)
- B = greatest moulded breadth [m]

- b_i = actual breadth of deckhouses with a breadth greater $B/4$
- h_i = height [m] on centreline of each tier of superstructures and deckhouses corresponding to b_i (deck sheer, if any, is to be ignored)
- Θ_i = the angle of inclination aft of each front bulk-head, as shown in [Fig. 2.43](#)
- A = area [m²], in profile view of the hull, superstructures and houses, having a breadth greater than $B/4$, above the design waterline within the length L and up to the height $a + \sum h_i$

For sailing yachts the rig has to be appropriately considered when determining area A .

Note

The influence of windage effects on masts and rigging for square rigged sailing yachts on the equipment numeral be assumed as follows:

- for yachts with $L < 48$ m, typically 50 % increase in relation to a motor yacht having the same total longitudinal profile area of hull and superstructure
- for yachts with $L \geq 100$ m, typically 30 % increase in relation to a motor yacht having the same total longitudinal profile area of hull and superstructure
- for yachts with a length in between linear interpolation may be used

Where a deckhouse having a breadth greater than $B/4$ is located above a deckhouse having a breadth of $B/4$ or less, the wide house is to be included and the narrow house ignored.

Windscreens or bulwarks 1,5 m or more in height above deck at side are to be regarded as parts of houses when determining h and A , e.g. the areas specially marked in [Fig. 2.43](#) are to be included in A (area).

2.2 For multihull yachts the equipment numeral has to be defined in analogous way, details are given in [Rules for High Speed Craft \(Pt.3, Vol.III\), Sec. 6](#).

3. Anchors

3.1 Number and arrangement of bower anchors

3.1.1 Normally two bower anchors according to [Table 2.23](#) have to be provided.

3.1.2 For yachts with a length $L \leq 48$ m having at least two independent propulsion systems and an adequate steering system the following reductions may be granted:

- reduction of the number of bower anchors to one, and/or
- reduction of weight of the bower anchors and chain cables

according to a decision of BKI Head Office. In this case sails are not considered as a propulsion system.

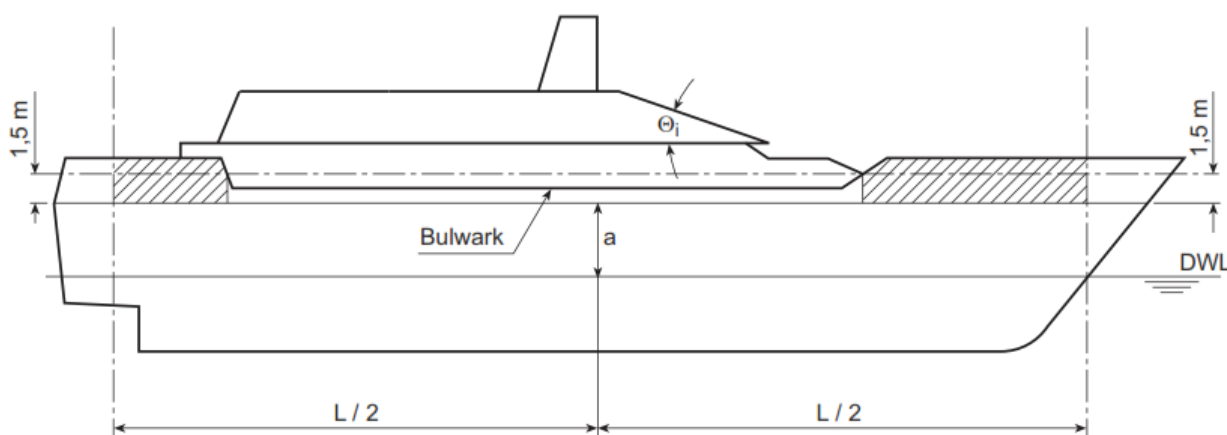


Fig. 2.41 Profile view of hull, superstructure and deckhouses relevant for equipment numeral

3.1.3 Bower anchors are to be connected to their chain cables and positioned on board ready for use. A third, spare anchor is not required for yachts.

It is to be ensured that each anchor can be stowed in hawse and hawse pipe in such a way that it remains firmly secured in seagoing conditions.

Note

National Regulations concerning provision of a spare anchor, stream anchor or a stern anchor may need to be observed.

3.1.4 For yachts of new design special requirements may be agreed with BKI.

3.2 Anchor design

3.2.1 Anchors must be of approved design. The mass of the heads of patent (ordinary stockless) anchors, including pins and fittings, is not to be less than 60 per cent of the total mass of the anchor.

3.2.2 For stock anchors, the total mass of the anchor, including stock, shall comply with the values in [Table 2.23](#). The mass of the stock shall be 20 percent of this total mass.

3.2.3 The mass of each individual bower anchor may vary by up to 7 per cent above or below required individual mass provided that the total mass of all the bower anchors is not less than the sum of the required individual masses.

3.3 High holding power anchors

3.3.1 Where special anchors are approved by BKI as "High Holding Power Anchors" (HHP), the anchor mass may be 75 per cent of anchor mass as per [Table 2.23](#).

"High Holding Power Anchors" are anchors which are suitable for the yacht's use at any time and which do not require prior adjustment or special placement on sea bed.

3.3.2 For approval as a "High Holding Power Anchor", satisfactory tests are to be made on various types of bottom and the anchor is to have a holding power at least twice that of a patent anchor ("Admiralty Standard Stockless") of the same mass. Tests have to be approved by BKI.

3.3.3 Dimensioning of chain cable and windlass is to be based on the undiminished anchor mass according to [Table 2.23](#).

3.4 Very high holding power anchors

Where special anchors are approved by BKI as "Very High Holding Power Anchors" (VHHP), anchor mass may be not less than 2/3 of the mass required for the HHP anchor it replaces.

3.5 Stern anchors

Where stern anchor equipment is fitted, such equipment is to comply in all respects with the rules for anchor equipment. The mass of each stern anchor shall be at least 35 per cent of that of bower anchors. The diameter of chain cables is to be determined from [Table 2.23](#) in accordance with anchor mass. Where a stern anchor windlass is fitted, the requirements of the [Rules Machinery Installations, \(Pt.1, Vol.III\) Sec. 14, D.](#), are to be observed.

4. Chain cables

4.1 Chain cable diameters given in [Table 2.23](#) apply to chain cables made of chain cable materials specified in the requirements of the [Rules Materials, \(Pt.1, Vol.V\) Sec. 13](#) for following grades:

- Grade KI-K1 (ordinary quality)
- Grade KI-K2 (special quality)
- Grade KI-K3 (extra special quality)

4.2 Grade KI-K1 material used for chain cables in conjunction with "High Holding Power Anchors" must have a tensile strength R_m of not less than 400 N/mm².

4.3 Grade KI-K2 and KI-K3 chain cables must be purchased from and re-heat treated by recognized manufacturers only.

4.4 The total length of chain given in [Table 2.23](#) is to be divided in approximately equal parts between two bower anchors.

4.5 For connection of the anchor with the chain cable approved Kenter-type anchor shackles may be chosen in lieu of the common Dee-shackles. A forerunner with swivel is to be fitted between anchor and chain cable. In lieu of a forerunner with swivel an approved swivel shackle may be used. However, swivel shackles are not to be connected to the anchor shank unless specially approved.

4.6 Steel wire and synthetic wire ropes may be used as an alternative to stud link chain cables defined in [Table 2.23](#) for yachts upon request and agreement with BKI.

4.7 The attachment of the inboard ends of chain cables to the yacht's structure is to be provided with means suitable to permit, in case of emergency, an easy slipping of chain cables to sea operable from an accessible position outside of chain locker.

Inboard ends of the chain cables are to be secured to the hull structures by a fastening able to withstand a force not less than 15 % nor more than 30 % of rated breaking load of the chain cable.

5. Chain locker

5.1 The chain locker is to be of capacity and depth adequate to provide an easy direct lead of the cables through the chain pipes and self-stowing of the cables.

The minimum required stowage capacity without mud box for the two bow anchor chains is as follows:

$$S = 1,1 \cdot d^2 \cdot \frac{\ell}{10^5} [\text{m}^3]$$

d = chain diameter [mm] according to [Table 2.23](#)

ℓ = total length of stud link chain cable according to [Table 2.23](#)

The total stowage capacity is to be distributed on two chain lockers of equal size for port and starboard chain cables. The shape of the base areas shall, as far as possible, be quadratic with the maximum edge length of $33 \cdot d$. As an alternative, circular base areas may be selected, the diameter of which shall not exceed $30 - 35 d$.

Above the stowage of each chain locker in addition a free depth of at least

$h = 750 \text{ mm}$ for $L = 24 \text{ m}$

$h = 1500 \text{ mm}$ for $L \geq 48 \text{ m}$

is to be provided; if the size of the yacht enables this. For intermediate lengths L linear interpolation is to be applied for the depth h .

5.2 The chain locker boundaries and their access openings are to be watertight as necessary to prevent accidental flooding of the chain locker from damaging essential auxiliaries or equipment or affecting the proper operation of the yacht.

5.3 Adequate drainage facilities of chain locker are to be provided.

5.4 Where chain locker boundaries are also tank boundaries, their scantlings of stiffeners and plating are to be determined as for tanks in accordance with [H.2](#).

Where this is not the case, plate thickness and section modulus of stiffening are also to be determined according to [H.2](#), using the pressure p_2 only. The distance from the load centre to the top of chain locker pipe is to be taken for calculating the load. A corrosion allowance of 2,0 mm has to be applied.

6. Mooring equipment

6.1 Ropes

6.1.1 The tow lines and mooring ropes specified in [Table 2.23](#) and the content of the following up to 6.1.3 are recommendations only, a compliance with them is not a condition of Class.

6.1.2 Breaking load

For tow lines and mooring lines, steel wire ropes as well as fibre ropes made of natural or synthetic fibres or wire ropes consisting of steel wire and fibre cores may be used. Nominal breaking loads specified in [Table 2.23](#) are valid for wire ropes only. Where ropes of synthetic fibre are used, the breaking load is to be increased above the table values. The extent of increase depends on the material quality.

The required diameters of synthetic fibre ropes used in lieu of steel wire ropes may be taken from [Table 2.24](#).

Regardless of the breaking load, recommended in [Table 2.23](#), the diameter of the fibre roped should not be less than 20 mm.

6.1.3 Length

The length of the individual mooring ropes may be up to 7 per cent less than that given in [Table 2.23](#), provided that the total length of all the wires and ropes is not less than the sum of the individual lengths.

6.2 Mooring winches, bollards, hawses

6.2.1 Mooring winches are to be designed taking into account the actual mooring lines and 80 % of their nominal breaking loads.

6.2.2 Hawses, bollards and cleats shall be so designed as to protect the ropes against excessive wear. They are to be of proved construction and shall comply with relevant standards.

Note

Attention is drawn to relevant National Standards.

6.2.3 Hawses, bollards, cleats and their substructure are to be strengthened, if they are intended to be belayed by multiple lines. In this case 80 % of the nominal breaking load of the individual lines has to be used as pulling forces.

Table 2.23 Anchor, chain cables and ropes

Equipment numeral EN	2 stockless bower anchors Mass per anchor [kg]	Stud link chain cables				Recommended ropes				
		Bower anchors				Towline		Mooring ropes		
		Total length [m]	Diameter ¹			Length [m]	Break. Load ² [kN]	Number	Length [m]	Break. Load ² [kN]
			d ₁ [mm]	d ₂ [mm]	d ₃ [mm]					
1	2	3	4	5	6	7	8	9	10	11
– 50	120	165	12,5	12,5	12,5	180	100	3	80	35
50 – 70	180	220	14	12,5	12,5	180	100	3	80	35
70 – 90	240	220	16	14	14	180	100	3	100	40
90 – 110	300	247,5	17,5	16	16	180	100	3	110	40
110 – 130	360	247,5	19	17,5	17,5	180	100	3	110	45
130 – 150	420	275	20,5	17,5	17,5	180	100	3	120	50
150 – 175	480	275	22	19	19	180	100	3	120	55
175 – 205	570	302,5	24	20,5	20,5	180	110	3	120	60
205 – 240	660	302,5	26	22	20,5	180	130	4	120	65
240 – 280	780	330	28	24	22	180	150	4	120	70
280 – 320	900	357,5	30	26	24	180	175	4	140	80
320 – 360	1020	357,5	32	28	24	180	200	4	140	85
360 – 400	1140	385	34	30	26	180	225	4	140	95
400 – 450	1290	385	36	32	28	180	250	4	140	100
450 – 500	1440	412,5	38	34	30	190	275	4	140	110
500 – 550	1590	412,5	40	34	30	190	305	4	160	120
550 – 600	1740	440	42	36	32	190	340	4	160	130
600 – 660	1920	440	44	38	34	190	370	4	160	145
660 – 720	2100	440	46	40	36	190	405	4	160	160
720 – 780	2280	467,5	48	42	36	190	440	4	170	170
780 – 840	2460	467,5	50	44	38	190	480	4	170	185
840 – 910	2640	467,5	52	46	40	190	520	4	170	200
910 – 980	2850	495	54	48	42	200	560	4	170	215
980 – 1060	3060	495	56	50	44	200	600	4	180	230
1060 – 1140	3300	495	58	50	46	200	645	4	180	250
1140 – 1220	3540	522,5	60	52	46	200	690	4	180	270
1220 – 1300	3780	522,5	64	54	48	200	740	4	180	285
1300 – 1390	4050	522,5	64	65	50	200	785	4	180	305

Table 2.23 Anchor, chain cables and ropes (continued)

Equipment numeral EN	2 stockless bower anchors Mass per anchor [kg]	Stud link chain cables				Recommended ropes				
		Bower anchors				Towline		Mooring ropes		
		Total length [m]	Diameter ¹			Length [m]	Break. Load ² [kN]	Number	Length [m]	Break. Load ² [kN]
			d ₁ [mm]	d ₂ [mm]	d ₃ [mm]					
1	2	3	4	5	6	7	8	9	10	11
1390 – 1480	4320	550	66	58	50	220	835	4	180	325
1480 – 1570	4590	550	68	60	52	220	890	5	190	325
1570 – 1670	4890	550	70	62	54	220	940	5	190	335
1670 – 1790	5250	577,5	73	64	56	220	1025	5	190	350
1790 – 1930	5610	577,5	76	66	58	220	1110	5	190	375
¹ d ₁ = Chain diameter Grade K1 (Ordinary quality) d ₂ = Chain diameter Grade K2 (Special quality) d ₃ = Chain diameter Grade K3 (Extra special quality)										
² See 6.1.2.										

See also 4.1

Table 2.24 Equivalent diameters of synthetic wire and fibre ropes

Steel wire ropes ¹	Synthetic wire ropes	Fibre ropes		
	Polyamide ²	Polyamide	Polyester	Polypropylene
Diameter [mm]	Diameter [mm]	Diameter [mm]	Diameter [mm]	Diameter [mm]
12	30	30	30	30
13	32	32	32	32
14	36	36	36	36
16	40	40	40	40
18	44	44	44	44
20	48	48	48	48
22	48	48	48	52
24	52	52	52	56
26	56	60	60	64
¹ according to DIN 3068 or similar ² Regular laid ropes of refined polyamide monofilaments and filament fibres				

L. Masts and Rigging

1. General

1.1 The requirements stated below generally apply to large motor and sailing yachts, under the condition that the yacht is handled correctly in terms of good seamanship.

1.2 The principles presented are to be seen as a general guidance. Any detailed analysis which is leading to different reserve or reduction factors can be submitted on the basis of an equivalent safety.

1.3 During the standard Classification procedure only the dimensions of the masts and the standing rigging will be checked and approved. For an extended examination of the complete rigging application for a "Rig Design Certificate" has to be made.

2. Bermudian Rigging

For Bermudian rigging the [Guidelines for Rigging Technology](#) are applicable for yachts.

Scope of these guidelines is the structural dimensioning of standing rigging, mast and boom sections as well as local design in way of attached structural fittings.

3. Traditional rigging

BKI has developed Rules for the following types of sailing ships, respectively yachts with traditional rigging:

- yachts with square rigs or fore and aft rigging
- two masted yachts, like brigs, schooner brigs, schooners
- three masted yachts, like barks, topsail schooners and full rigged yachts
- four and five masts yachts, like barks and full rigged yachts.

The details for the rigging of such type are contained in the [Guidelines for Rigging Technology](#), which can fully be applied to yachts.

4. Signal and radar masts

4.1 General

4.1.1 Drawings of masts, mast substructures and hull connections are to be submitted for approval.

4.1.2 Loose component parts are to comply with the [Guidelines for Certification of Lifting Appliances \(Pt.7, Vol.1\)](#) .

4.1.3 Other masts than covered by [4.2](#) and [4.3](#) as well as special designs must, as regards dimensions and construction, in each case be individually agreed with BKI.

4.2 Single tubular masts

The following requirements apply to tubular or equivalent rectangular sections made of steel with an ultimate tensile strength of 400 N/mm², which are designed to carry only signals (navigation lanterns, flag and day signals).

4.2.1 Stayed masts

.1 Stayed masts may be constructed as simply supported masts (rocker masts) or may be supported by one or more decks (constrained masts).

.2 The diameter of stayed steel masts in the uppermost support is to be at least 18 mm for each 1m length of mast (l_w) from the uppermost support to the fixing point of shrouds. The length of the mast top above the fixing point is not to exceed $1/3 l_w$.

.3 Masts according to [4.2.1.2](#) may be gradually tapered towards the fixing point of shrouds to 75 per cent of the diameter at the uppermost support. The plate thickness is not to less than $1/70$ of the diameter at the uppermost support or at least 3,6 mm, see [4.4.1](#).

.4 Wire ropes for shrouds are to be thickly galvanized. It is recommended to use wire ropes composition of a minimum number of thick wires, as for instance a rope composition 6 x 7 with a tensile breaking strength of 1570 N/mm² or more on which Table 2.25 is based. Other rope compositions shall be of equivalent stiffness.

.5 Where masts are stayed forward and aft by two shrouds on each side of the yacht, steel wire ropes are to be used according to Table 2.25.

Table 2.25 Definition of ropes for stays

h [m]	4	6	8	10
Rope diameter [mm]	12	14	16	18
Nominal size of shackle, rigging screw, rope socket	1,6	1,6	2	2,5
h = height of shroud fixing point above shroud foot point				

.6 Where steel ropes according to Table 2.25 are used, the following conditions apply:

$$b \geq 0,3 \cdot h$$

$$0,15 \cdot h \leq a \leq b$$

a = the longitudinal distance from a shroud's foot point to its fixing point

b = the transverse distance from a shroud's foot point to its fixing point

Alternative arrangements of stayings are to be of equivalent stiffness.

4.2.2 Unstayed masts

.1 Unstayed masts may be completely constrained in the uppermost deck or to be supported by two or more decks. (In general the fastenings of masts to the hull of a yacht should extend over at least one deck height.

.2 The scantlings of unstayed steel masts are given in Table 2.26.

Table 2.26 Scantlings of unstayed steel masts

Length of mast ℓ_m [m]	4	6	8	10
D · t [mm]	127 · 3, 6	168 · 3, 6	216 · 3, 6	267 · 3, 6
ℓ_m = length of mast from uppermost support to the top D = diameter of mast at uppermost support t = plate thickness of mast				

.3 The diameter of masts may be gradually tapered to D/2 at the height of 0,75 ℓ_m .

4.3 Box girder and frame work masts

4.3.1 For dimensioning the dead loads, acceleration forces and wind loads are to be considered.

4.3.2 Where necessary, additional loads, e.g. loads caused by tension wires are also to be considered.

4.3.3 The design loads for [4.3.1](#) and [4.3.2](#) as well as the allowable stresses can be taken from the [Guidelines for Certification of Lifting Appliances \(Pt.7, Vol. 1\)](#) as defined in [4.1.2](#).

4.3.4 Single tubular masts mounted on the top of box girder or frame work masts may be dimensioned according to [4.2](#).

4.3.5 In case of thin walled box girder masts stiffeners and additional buckling stiffeners may be necessary.

4.4 Structural details

4.4.1 Steel masts closed all-round must have a wall thickness of at least 3,6 mm.

For masts not closed all-round the minimum wall thickness is 5 mm.

For masts used as funnels a corrosion addition of at least 1 mm is required.

4.4.2 The mast's foundations are to be dimensioned in accordance with the acting forces.

4.4.3 Doubling plates at mast feet are permissible only for the transmission of compressive forces since they are generally not suitable for the transmission of tensile forces or bending moments.

4.4.4 In case of tubular constructions, all welds for fastenings and connections must be of full penetration weld type.

4.4.5 If necessary, slim tubular structures are to be additionally braced in order to avoid vibrations.

4.4.6 The dimensioning normally does not require a calculation of vibrations. However, in case of undue vibrations occurring during the yacht's trials a respective calculation will be required.

4.4.7 For determining scantlings of masts made from aluminium, the requirements of [B.3](#) apply.

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Section 3 Safety Requirements

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A. Safety Appliances and Provisions

1. General

This Section summarizes various safety aspects relevant for the safe operation of a yacht.

2. Guard-Rails

2.1 Location

Efficient guard rails or bulwarks are to be fitted on all exposed parts of the freeboard and superstructure decks.

2.2 Heights

The height is to be at least 1,0 m from the deck (in exceptional cases for yachts of a length $L \leq 48$ m at least 600 mm from the deck).

It is recommended that on each side of the yacht a toe rail at least 20 mm high is provided along the deck edge.

The height below the lowest course of the guardrails is not to exceed 230 mm. The other courses are not to be spaced more than 380 mm apart.

2.3 Wires

Guard-rails shall consist of multi strand steel wire provided with a relevant plastic cover and equipped with a device to control their tension in an easy way. The minimum thickness of the top rail shall be at least 10 mm. The thickness of the lower rails may be reduced by 40 %, but must be not less than 6 mm dia.

2.4 Stanchions

Guard-rail stanchions must not be more than 2,15 m apart. In case of yachts with rounded gunwales, the guard-rail supports are to be placed on the flat part of the deck. Stanchion feet must be bolted through or welded down, but may not be welded on the shell plating.

2.4.1 For Yacht with $24 \text{ m} \leq L \leq 48 \text{ m}$ stanchions shall have the following minimum section modulus at the foot:

$$W = h \cdot \frac{300 \cdot a + 100}{R_{eH}}$$

- a = stanchion spacing [m]
h = stanchion height [m]
 R_{eH} = upper yield strength of material [N/mm²]

2.4.2 For yachts with $L > 48$ m reference is made to the [Rules for Hull \(Pt.1, Vol.II\)](#), [Sec.21.Q](#). regarding requirements of guard rails

3. Access to the rig and bowsprit

Special measures are to be taken for safe access to rig and bowsprit and also for safe working thereon regarding operation, maintenance, surveys, etc.

4. Lifting appliances

4.1 The determination of scantlings and checking of lifting gear is not part of Classification.

4.2 Approval of the hull structure in way of the lifting gear taking into account the forces from the gear is part of Classification.

Note:

In all cases where BKI is entrusted with the judgement of lifting gears of yachts, the [Guidelines for the Construction and the Survey of Lifting Appliances \(Pt.6, Vol.IV\)](#) will apply.

B. Structural Fire Protection

1. General

1.1 Purpose

The purpose of these Rules is to recommend design criteria, construction standards and other safety measures concerning the structural fire protection of yachts with a length $L \geq 24$ m.

1.2 Equivalence

Ships deviating partly from the requirements of these Rules may be assigned Class if the arrangements, material or equipment which have been applied are considered equivalent to those of the Rules.

1.3 Definitions

The meaning of terms and phrases used in these Rules corresponds with the definitions as stated in the relevant chapters of SOLAS 74 as amended.

2. Yachts under 500 GT and $L \leq 48$ m

2.1 Structural integrity

2.1.1 Machinery spaces, galleys and store rooms containing inflammable substances shall be surrounded by divisions of steel or shall be protected by other equivalent methods.

2.1.2 Boundaries of control stations and of machinery spaces containing internal combustion machinery or other oil-burning, heating or pumping units shall be equal to an "A-60" standard, but may be

reduced to "A-30" or "A-0" if the ship operates in restricted or protected waters respectively. In case the adjacent spaces are of negligible fire risk, the fire integrity of the divisions needs not to exceed the "A-0" standard.

2.1.3 Escape routes shall be separated from adjacent spaces by at least class B divisions.

2.2 Fire protection materials and details of construction

2.2.1 In general insulating materials shall be non-combustible. Where combustible insulation material is used in accessible spaces in which a fire might occur, it shall be covered with materials having at least approved low-flame spread characteristics.

2.2.2 In spaces where the penetration of oil products is possible, the surface of insulation shall be impervious to oil or oil vapors.

2.2.3 Combustible material if used for partitions, ceilings or linings requires adequate alternative measures of fire protection. Alternative measures might be for example the installation of a fixed fire detection and fire alarm system or of an automatic sprinkler, fire detection and fire alarm system.

2.2.4 Paints, varnishes and other finishes used on exposed interior surfaces are to be of an approved low flame-spread type and shall not be capable of producing excessive quantities of smoke and toxic products.

2.3 Ventilations

As far as practicable ventilation systems shall meet the requirements of [3.10](#). In any case the standard of the [Rules for Small Vessels up to 24 m \(Pt.3, Vol.VII\)](#) shall be met at last.

2.4 Means of Escape

2.4.1 As far as practicable the means of escape shall meet the requirements in [3.11](#). In any case the standard of the provisions in [2.4.2](#) to [2.4.4](#) shall be met at least.

2.4.2 Stairways and ladders shall be arranged to provide ready means of escape to the open deck and then to the survival craft from all accommodation, service and other spaces which may normally be occupied.

2.4.3 As far as practicable not less than two means of escape shall be provided. Dead-end situations exceeding 7 m in length shall be avoided in any case. Accommodation spaces or groups of spaces shall have two means of escape unless there is a means of escape that leads directly to the open deck.

2.4.4 Below the lowest open deck at least one means of escape shall be independent of watertight doors.

3. Yachts of 500 GT and L > 48 m

3.1 General

The requirements of [3.](#) are additional to those of [2.](#) The requirements of [3.](#) take precedence over [2.](#)

3.2 Structural integrity

3.2.1 The hull, superstructures, structural bulk-heads, decks and deckhouses shall be constructed of steel or other equivalent material. Special fire protection precautions are required if parts or all of the aforementioned structural elements are consisting of materials other than steel or other equivalent material.

3.2.2 Unless otherwise specified in [2.2.1](#), in cases where any part of the structure is of aluminium alloy, the following shall apply:

- A) The insulation of aluminium alloy components of "A" or "B" class divisions, except structure which, in the opinion of BKI, is nonloadbearing, shall be such that the temperature of the structural core does not rise more than 200 °C above the ambient temperature at any time during the applicable fire exposure to the standard fire test.
- B) Special attention shall be given to the insulation of aluminium alloy components of columns, stanchions and other structural members required to support lifeboat and liferaft stowage, launching and embarkation areas, and A and B class divisions to ensure:
 - that for such members supporting lifeboat and liferaft areas and "A" class divisions, the temperature rise limitation specified in above shall apply at the end of one hour
 - that for such members required to support B class divisions, the temperature rise limitation specified in above shall apply at the end of half an hour.

3.2.3 Crowns and casings of machinery spaces of category A shall be of steel construction and shall be insulated as required by [Table 3.1](#), as appropriate. For vessels under 1000 GT the steel construction is not required provided the relevant divisions are of "A-60" standard and an approved method for boundary cooling is available that operates also under emergency power supply.

3.2.4 The floor plating of normal passageways in machinery spaces of category A shall be made of steel.

3.2.5 Materials readily rendered ineffective by heat shall not be used for overboard scuppers, sanitary discharges, and other outlets which are close to the waterline and where the failure of the material in the event of fire would give rise to danger of flooding.

3.3 Main vertical zones and horizontal zones

3.3.1 The hull, superstructure and deckhouses in way of accommodation and service spaces shall be subdivided into main vertical zones by "A" class divisions, the mean length and width of which on any deck does not in general exceed 40 m. These divisions shall have insulation values in accordance with [Tables 3.1](#) and [3.2](#).

3.3.2 As far as practicable, the bulkheads forming the boundaries of the main vertical zones above the bulkhead deck shall be in line with watertight subdivision bulkheads situated immediately below the bulkhead deck. The length and width of main vertical zones may be extended to a maximum of 48 m in order to bring the ends of main vertical zones to coincide with watertight subdivision bulkheads or in order to accommodate a large public space extending for the whole length of the main vertical zone provided that the total area of the main vertical zone is not greater than 1600 m² on any deck. The length or width of a main vertical zone is the maximum distance between the furthestmost points of the bulkheads bounding it.

3.3.3 Such bulkheads shall extend from deck to deck and to the shell or other boundaries.

3.3.4 Where a main vertical zone is subdivided by horizontal "A" class divisions into horizontal zones for the purpose of providing an appropriate barrier between a zone with sprinklers and a zone without sprinklers, the divisions shall extend between adjacent main vertical zone bulkheads and to the shell or exterior boundaries of the ship and shall be insulated in accordance with the fire insulation and integrity values given in [Table 3.2](#).

3.4 Fire integrity of bulkheads and decks

3.4.1 Yachts shall be subdivided into spaces by thermal and structural divisions having regard to the fire risk of the space.

3.4.2 Bulkheads required to be "B" class divisions shall extend from deck to deck and to the shell or other boundaries. However, where a continuous "B" class ceiling or lining is fitted on both sides of the bulkhead, the bulkhead may terminate at the continuous ceiling or lining.

3.4.3 Bulkheads not required to be "A" or "B" class divisions, shall be at least "C" class construction.

3.4.4 In addition to complying with the specific provisions for the fire integrity of bulkheads and decks, the minimum fire integrity of bulkheads and decks shall be as described in [Tables 3.1](#) and [3.2](#).

Table 3.1 Bulkhead separating adjacent spaces

Space above Space below		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Control stations	(1)	A-0 _c	A-0	A-60	A-15	A-0	A-60	A-15 _g	A-60	A-60	*
Corridors	(2)		C _c	B-0 _c	A-0 _a	B-0 _c	A-60	A-0	A-0 _d	B-0 _{d, f}	*
Accommodation spaces	(3)			C _c	A-0 _a	B-0 _c	A-60	A-0	A-0 _d	B-0 _{d, f}	*
Stairways	(4)				A-0 _a	A-0 _a	A-60	A-0	A-0 _d	A-30	*
Service space (low risk)	(5)					C _c	A-60	A-0	A-0	B-0 _{d, f}	*
Machinery space of category A	(6)						*	A-0	A-60	A-60	*
Other machinery spaces	(7)							A-0 _b	A-0	A-0 _{d, g}	*
Service space (high risk)	(8)								A-0 _b	A-0 _d	*
Special outfit areas	(9)									d, f	*
Open decks	(10)										-

Table 3.2 Decks separating adjacent spaces

Space above Space below		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Control stations	(1)	A-0	A-0	A-0	A-0	A-0	A-60	A-0	A-0	A-30	*
Corridors	(2)	A-0	*	*	A-0	*	A-60	A-0	A-0	A-30	*
Accommodation spaces	(3)	A-60	A-0	*	A-0	*	A-60	A-0	A-0	A-30	*
Stairways	(4)	A-0	A-0	A-0	*	A-0	A-60	A-0	A-0	A-30	*
Service space (low risk)	(5)	A-0	A-0	A-0	A-0	*	A-60	A-0	A-0	A-30	*
Machinery space of category A	(6)	A-60	A-60	A-60	A-60	A-60	*	A-60 _g	A-60	A-60	*
Other machinery spaces	(7)	A-15 _g	A-0	A-0	A-0	A-0	A-0	*	A-0	A-30 _g	*
Service space (high risk)	(8)	A-60	A-0 _d	A-0 _d	A-0 _d	A-0	A-60	A-0	A-0	A-30	*
Special outfit areas	(9)	A-60	A-30	A-30	A-30	A-30	A-60	A-30 _g	A-30	A-30	*
Open decks	(10)	*	*	*	*	*	*	*	*	*	-

- a. For boundaries of stairways connecting only two decks and being not part of a main vertical zone division "A-0" may be reduced to B-0.
- b. Where spaces are of the same numerical category and subscript b appears, a bulkhead or a deck of the rating shown in the tables is only required when the adjacent spaces are of a different purpose, e.g. in category (8). A galley next to a galley does not require a bulkhead but a galley next to a point room requires an "A-0" bulkhead.
- c. Bulkheads separating the wheelhouse and the chartroom from each other may be of "B-0" rating.
- d. For main vertical zone divisions "A-0", "B-0" and the dash, where appearing in the tables, shall be read as "A-30".
- e. For main vertical zone divisions "B-0" and "C", where appearing in the tables, shall be read as "A-0".
- f. In case of deck opening enclosures for stairways, lifts, trunks, etc. being part of special outfit areas "B-0" and the dash, where appearing in the tables, shall be read as "A-30".
- g. Fire insulation need not be fitted if, in the opinion of BKI, the machinery space of category [7] has little or no fire risk.
- * Where an asterisk appears in the tables, the division is required to be of steel or other equivalent material but is not required to be of "A" class standard. However, where a deck, except an open deck, is penetrated for the passage of electric cables, pipes and vent ducts, such penetrations should be made tight to prevent the passage of flame and smoke. Divisions between control stations (emergency generators) and open decks may have air intake openings without means for closure, unless a fixed gas fire-fighting system is fitted.
- For decks being part of a main vertical zone division an asterisk, where appearing in the tables, shall be read as "A-0". Special fire protection precautions are to be taken in case relevant boundaries are not of steel or other equivalent material.

In the [Tables 3.1](#) and [3.2](#) the classification of space use is defined using the following numbers for different types of spaces:

1) Control stations

Spaces containing emergency sources of power and lighting, wheelhouse and chartroom, spaces containing the ship's radio equipment, fire control stations, control room for propulsion machinery when located outside the machinery space, spaces containing centralized fire alarm equipment.

2) Corridors

Corridors and lobbies

3) Accommodation spaces

Spaces used for public spaces, lavatories, cabins, offices, hospitals, cinemas, game and hobby rooms, barber shops, pantries containing no cooking appliances and similar spaces.

4) Stairways

Interior stairway, lifts, totally enclosed emergency escape trunks, and escalators (other than those wholly contained within the machinery spaces) and enclosures thereto. In this connection, a stairway which is enclosed only at one level shall be regarded as part of the space from which it is not separated by a fire door

5) Service spaces (low risk)

Lockers and store-rooms not having provisions for the storage of flammable liquids and having areas less than 4 m² and drying rooms and laundries

6) Machinery spaces of category A

Machinery spaces of category A are those spaces and trunks to such spaces which contain either:

- internal combustion machinery used for main propulsion
- internal combustion machinery used for purposes other than main propulsion where such machinery has in the aggregate a total power output of not less than 375 kW; or
- any oil-fired boiler or oil fuel unit, or any oil-fired equipment other than boilers, such as inert gas generators, incinerators, etc.

7) Other machinery spaces

Machinery spaces containing propulsion machinery, boilers, oil fuel units, steam and internal combustion engines, generators and major electrical machinery, oil filling stations, refrigerating, stabilizing, ventilation and air conditioning machinery, and similar spaces, and trunks to such spaces.

Electrical equipment rooms (auto-telephone exchange, air-conditioning duct spaces)

8) Service spaces (high risk)

Galleys, pantries containing cooking appliances, saunas, paint lockers and store-rooms having areas of 4 m² or more, spaces for the storage of flammable liquids, and workshops other than those forming part of the machinery spaces.

9) Special outfit spaces

Spaces as per [3.9](#)

10) Open decks

Open deck spaces and enclosed promenades having little or no fire risk. To be considered in this category, enclosed promenades shall have no significant fire risk, meaning that furnishings shall be

restricted to deck furniture. In addition, such spaces shall be naturally ventilated by permanent openings.

Air spaces (the space outside superstructures and deckhouses).

3.4.5 Continuous "B" class ceilings or linings, in association with the relevant decks or bulkheads, may be accepted as contributing, wholly or in part, to the required insulation and integrity of a division.

3.4.6 External boundaries which are required to be of steel or other equivalent material may be pierced for the fitting of windows and side scuttles. Similarly, in such boundaries which are not required to have "A" class integrity, doors may be constructed of approved materials other than steel.

3.4.7 Saunas shall comply with the following:

- The perimeter of the sauna shall be of "A" class boundaries and may include changing rooms, showers and toilets. The sauna shall be insulated to "A-60" standard against other spaces except those insides of the perimeter and open deck spaces, sanitary spaces and machinery spaces having little or no fire risk.
- Bathrooms with direct access to saunas may be considered as part of them. In such cases, the door between sauna and the bathroom need not comply with fire safety requirements.
- The traditional wooden lining on the bulkheads and ceiling are permitted in the sauna. The ceiling above the oven shall be lined with a non-combustible plate with an air gap of at least 30 mm. The distance from the hot surfaces to combustible materials shall be at least 500 mm or the combustible materials shall be protected (e.g. non-combustible plate with an air gap of at least 30 mm).
- The traditional wooden benches are permitted to be used in the sauna.
- The sauna door shall open outwards by pushing.
- Electrically heated ovens shall be provided with a timer.

3.4.8 Stairways which penetrate only a single deck shall be protected, at a minimum, at one level by at least "B-0" class divisions and self-closing doors. Lifts which penetrate only a single deck shall be surrounded by "A-0" class divisions with steel doors at both levels. Stairways and lift trunks which penetrate more than a single deck shall be surrounded by at least "A-0" class divisions and be protected by self-closing doors at all levels.

3.4.9 On yachts having accommodation for 12 persons or less, where stairways penetrate more than a single deck and where there are at least two escape routes direct to the open deck at every accommodation level, the "A-0" requirements of 3.4.8 may be reduced to "B-0".

3.5 Penetration in fire-resisting divisions and prevention of heat transmission

3.5.1 Where "A" class divisions are penetrated, such penetrations shall be of an approved type. In case of ventilation ducts 3.10.2 and 3.10.5 apply. However, pipe penetrations made of steel or equivalent material having a thickness of 3 mm or greater and a length of not less than 900 mm (preferably 450 mm on each side of the division), and no openings, is considered as an approved type. Such penetrations shall be suitably insulated by extension of the insulation at the same level as the division.

3.5.2 Where "B" class divisions are penetrated for the passage of electric cables, pipes, trunks, ducts, etc., or for the fitting of ventilation terminals, lighting fixtures and similar devices, arrangements shall be made to ensure that the fire resistance is not impaired, subject to the provisions of 3.10.6. Pipes other than steel or copper that penetrate "B" class divisions shall be protected by either:

- an approved penetration device, suitable for the fire resistance of the division pierced and the type of pipe used; or

- a steel sleeve, having a thickness of not less than 1,8 mm and a length of not less than 900 mm for pipe diameters of 150 mm or more and not less than 600 mm for pipe diameters of less than 150 mm (preferably equally divided to each side of the division). The pipe shall be connected to the ends of the sleeve by flanges or couplings; or the clearance between the sleeve and the pipe shall not exceed 2,5 mm; or any clearance between pipe and sleeve shall be made tight by means of non-combustible or other suitable material.

3.5.3 Un-insulated metallic pipes penetrating "A" or "B" class divisions shall be of materials having a melting temperature which exceeds 950 °C for "A-0" and 850 °C for "B-0" divisions.

3.5.4 With regard to the risk of heat transmission at intersections and terminal points of required thermal barriers, the insulation of a deck or bulkhead shall be carried past the penetration, intersection or terminal point for a distance of at least 450 mm in the case of steel and aluminium structures. If a space is divided with a deck or bulkhead of "A" class standard having insulation of different values, the insulation with the higher value shall continue on the deck or bulkhead with the insulation of the lesser value for a distance of at least 450 mm.

3.6 Doors in fire-resisting divisions

3.6.1 The fire resistance of doors shall be equivalent to that of the division in which they are fitted, this being proved by using doors of an approved type. Doors and door frames in "A" class divisions shall be constructed of steel or other equivalent material. Doors in "B" class divisions shall be non-combustible. Doors fitted in boundary bulkheads of machinery spaces of category A shall be reasonable gas-tight and self-closing. The use of combustible materials in doors separating cabins from individual interior sanitary accommodation, such as showers, may be permitted.

3.6.2 Fire doors in main vertical zone bulkheads and stairway enclosures other than power-operated watertight doors and those which are normally locked shall be self-closing.

3.6.3 Doors required to be self-closing shall not be fitted with hold-back hooks. However, hold-back arrangements as well as power-operated drive facilities fitted with remote release devices of the fail-safe type may be utilized.

3.6.4 In corridor bulkheads ventilation openings may be permitted in and under doors of cabins and public spaces. Ventilation openings are also permitted in B class doors leading to lavatories, offices, pantries, lockers and store rooms. Except as permitted below, the openings shall be provided only in the lower half of the door. Where such an opening is under a door the total net area of any such opening or openings shall not exceed 0,05 m². Alternatively, a non-combustible air balance duct routed between the cabin and the corridor, and located below the sanitary unit is permitted where the cross-sectional area of the duct does not exceed 0,05 m². Ventilation openings, except those under the door, shall be fitted with a grille made of non-combustible material.

3.6.5 Watertight doors need not be insulated.

3.7 Fire protection materials and details of construction

3.7.1 Insulating materials shall be non-combustible, except in baggage rooms and refrigerated compartments of service spaces. Vapor barriers and adhesives used in conjunction with insulation, as well as the insulation of pipe fittings for cold service systems, need not be of non-combustible materials, but they shall be kept to the minimum quantity practicable and their exposed surfaces shall have approved low flame spread characteristics.

3.7.2 In spaces where penetration of oil products is possible, the surface of insulation shall be impervious to oil or oil vapors.

3.7.3 In accommodation and service spaces and control stations all linings, ceilings, draught stops and their associated grounds shall be of non-combustible materials.

3.7.4 Non-combustible bulkheads, ceilings and linings fitted in accommodation and service spaces may be faced with combustible materials, facings, mouldings, decorations and veneers in accordance with the provisions of 3.7.5 to 3.7.8. However, traditional wooden benches and wooden linings on bulkheads and ceilings are permitted in saunas and such materials need not be subject to the calculations prescribed in 3.7.5 and 3.7.6.

3.7.5 Combustible materials used on the surfaces and linings specified in 3.7.4 shall have a calorific value not exceeding 45 MJ/m² of the area for the thickness used. The requirements of this paragraph are not applicable to the surfaces of furniture fixed to linings or bulkheads.

3.7.6 Where combustible materials are used in accordance with 3.7.4, they shall comply with the following requirements:

- The total volume of combustible facings, mouldings, decorations and veneers in any accommodation and service space not protected by an approved automatic sprinkler, fire detection and fire alarm system shall not exceed a volume equivalent to 2,5 mm veneer on the combined area of the walls and ceiling linings. Furniture fixed to linings, bulkheads or decks need not be included in the calculation of the total volume of combustible materials.
- In the case of yachts fitted with an approved automatic sprinkler, fire detection and fire alarm system, the above volume may include some combustible material used for erection of "C" class divisions.

3.7.7 The following surfaces shall have approved low flame-spread characteristics:

- exposed surfaces in corridors and stairway enclosures and of ceilings in accommodation and service spaces (except saunas) and control stations.
- surfaces and grounds in concealed or inaccessible spaces in accommodation and service spaces and control stations

3.7.8 Paints, varnishes and other finishes used on exposed interior surfaces shall not be capable of producing excessive quantities of smoke and toxic products, this being determined in accordance with approved procedures.

3.7.9 Primary deck coverings, if applied within accommodation and service spaces and control stations, shall be of approved material which will not give rise to smoke or toxic or explosive hazards at elevated temperatures, this being determined in accordance with approved procedures.

3.7.10 Primary deck coverings, if applied within accommodation and service spaces and control stations, shall be of approved material which will not readily ignite, this being determined in accordance with approved procedures.

3.7.11 Air spaces enclosed behind ceilings, panelling or linings shall be divided by close-fitting draught stops spaced not more than 14 m apart. In the vertical direction, such enclosed air spaces, including those behind linings of stairways, trunks, etc., shall be closed at each deck.

3.8 Fire detection and alarm

A fixed fire detection and fire alarm system of an approved type shall be so installed and arranged as to provide smoke detection in all corridors, stairways and escape routes within accommodation spaces, see [Rules for Electrical Installations \(Pt.1, Vol.IV\), Sec.9.D.3.](#)

3.9 Alternative approach to the structural fire protection of accommodation and service spaces with special outfit

3.9.1 In lieu of complying with the requirements of 3.4.3 and 3.7.3 to 3.7.7, the following regulations may apply to restricted areas of accommodation and service spaces with special outfit.

3.9.2 There may be no restriction on the construction of bulkheads not required by this or other regulations to be "A", "B" or "C" class divisions, except in individual cases where fire-rated bulkheads are required in accordance with Table 3.1.

3.9.3 The boundary decks of special outfit spaces shall be of "A-30" standard, unless 3.4 requires a higher standard. Enclosures of deck openings for stairways, lifts, trunks, etc. are to be protected to the same standard.

3.9.4 Main vertical zone divisions shall be of "A-30" standard if special outfit spaces are adjacent, unless 3.4 requires a higher standard.

3.9.5 Corridors and stairway enclosures serving accommodation and service spaces must not be part of the special outfit areas, unless there are means of escape from those spaces that lead directly to the open deck.

3.9.6 In addition to complying with the specific provisions for the fire integrity of bulkheads and decks, the minimum fire integrity of bulkheads and decks shall be as described in Tables 3.1 and 3.2.

3.9.7 Areas with special outfit spaces shall be readily accessible for fire-fighting purposes.

3.9.8 An automatic sprinkler, fire detection and fire alarm system of an approved type shall be so installed and arranged as to protect all special outfit spaces, except spaces which afford no substantial fire risk such as void spaces, sanitary spaces, etc. In addition, an approved fixed fire detection and fire alarm system shall be so installed and arranged as to provide smoke detection in the same spaces.

3.9.9 Provided that the area of the special outfit space or spaces is bounded by a continuous "A" or "B" class division not exceeding 50 m², in lieu of complying with the requirements of 3.9.8, a fixed fire detection and fire alarm system of an approved type shall be so installed and arranged as to detect the presence of fire in all special outfit spaces, providing smoke detection in such spaces, except spaces which afford no substantial fire risk such as void spaces, sanitary spaces, etc.

3.10 Ventilation systems

3.10.1 Ventilation ducts shall be of non-combustible material. However, short ducts, not generally exceeding 2 m in length and with a free cross-sectional area not exceeding 0,02 m², need not be non-combustible subject to the following conditions:

- The ducts are made of a material which has low flame-spread characteristics.
- The ducts are only used at the end of the ventilation device.
- The ducts are not situated less than 600 mm, measured along the duct, from an opening in an "A" or "B" class division including continuous "B" class ceiling.

3.10.2 The following arrangements shall be tested in accordance with approved methods:

- fire dampers, including their relevant means of operation
- duct penetrations through "A" class divisions. However, the test is not required where steel sleeves are directly joined to ventilation ducts by means of riveted or screwed flanges or by welding.

3.10.3 The ventilation systems for machinery spaces of category A and galleys shall, in general, be separated from each other and from the ventilation systems serving other spaces. Except that the galley ventilation systems on ships of less than 4000 gross tonnage, need not be completely separated, but may be served by separate ducts from a ventilation unit serving other spaces. In any case, an automatic fire damper shall be fitted in the galley ventilation duct near the ventilation unit. Ducts provided for the ventilation of machinery spaces of category A or galleys shall not pass through accommodation spaces, service spaces or control stations unless they comply with the conditions specified as follows:

- The ducts are constructed of steel having a thickness of at least 3 mm and 5 mm for ducts the widths or diameters of which are up to and including 300 mm and 760 mm and over respectively and, in the case of such ducts, the widths or diameters of which are between 300 mm and 760 mm having a thickness obtained by interpolation.
- The ducts are to be suitably supported and stiffened.
- The ducts are fitted with automatic fire dampers close to the boundaries penetrated.
- The ducts are insulated to "A-60" class standard from the machinery spaces or galleys to a point at least 5 m beyond each fire damper.

Alternatively:

- The ducts are constructed of steel in accordance with the first and second item of [3.10.3](#).
- The ducts are insulated to "A-60" class standard throughout the accommodation spaces, service spaces or control stations; except that penetrations of main zone divisions shall also comply with the requirements of [3.8](#).

3.10.4 Ducts provided for ventilation to accommodation spaces, service spaces or control stations shall not pass through machinery spaces of category A and galleys unless they comply with the conditions specified as follows:

- The ducts where they pass through a machinery space of category A or galley are constructed of steel in accordance with the first and second item of [3.10.3](#).
- Automatic fire dampers are fitted close to the boundaries penetrated.
- The integrity of the machinery space or galley boundaries is maintained at the penetrations.

Alternatively:

- The ducts where they pass through a machinery space of category A or galley are constructed of steel in accordance with the first and second item of [3.10.3](#).
- The ducts are insulated to "A-60" standard within the machinery space or galley; except that penetrations of main zone divisions shall also comply with the requirements of [3.8](#).

3.10.5 Where a thin plated duct with a free cross-sectional area equal to, or less than, 0,02 m passes through "A" class bulkheads or decks, the opening shall be lined with a steel sheet sleeve having a thickness of at least 3 mm and a length of at least 200 mm, divided preferably into 100 mm on each side of the bulkhead or, in the case of the deck, wholly laid on the lower side of the decks pierced.

Where ventilation ducts with a free cross-sectional area exceeding 0,02 m pass through "A" class bulkheads or decks, the opening shall be lined with a steel sheet sleeve. However, where such ducts are of steel construction and pass through a deck or bulkhead, the ducts and sleeves shall comply with the following:

- The sleeves shall have a thickness of at least 3 mm and a length of at least 900 mm. When passing through bulkheads, this length shall be divided preferably into 450 mm on each side of the bulkhead. These ducts, or sleeves lining such ducts, shall be provided with fire insulation. The insulation shall have at least the same fire integrity as the bulkhead or deck through which the duct passes.

- Ducts with a free cross-sectional area exceeding 0,075 m² shall be fitted with a fire damper in addition to the requirements of the above item. The fire damper shall operate automatically, but shall also be capable of being closed manually from both sides of the bulkhead or deck. The damper shall be provided with an indicator which shows whether the damper is open or closed. Fire dampers are not required, however, where ducts pass through spaces surrounded by "A" class divisions, without serving those spaces, provided those ducts have the same fire integrity as the divisions which they pierce. Fire dampers shall be easily accessible. Where they are placed behind ceilings or linings, these ceilings or linings shall be provided with an inspection door on which a plate reporting the identification number of the fire damper is provided. The fire damper identification number shall also be placed on any remote controls required.

3.10.6 Ventilation ducts with a free cross-sectional area exceeding 0,02 m passing through "B" class bulkheads shall be lined with steel sheet sleeves of 900 mm in length divided preferably into 450 mm on each side of the bulkhead, unless the duct is of steel for this length.

3.10.7 In general, the ventilation fans shall be so disposed that the ducts reaching the various spaces remain within the same main vertical zone.

3.10.8 Where it is necessary that a ventilation duct passes through a main vertical zone division, a fail-safe automatic closing fire damper shall be fitted adjacent to the division. The damper shall also be capable of being manually closed from each side of the division. The operating position shall be readily accessible and be marked in red light-reflecting color. The duct between the division and the damper shall be of steel or other equivalent material and, if necessary, insulated to comply with the requirements of 3.5.1. The damper shall be fitted on at least one side of the division with a visible indicator showing whether the damper is in the open position.

3.10.9 Where ventilation systems penetrate decks, precautions shall be taken, in addition to those relating to the fire integrity of the deck required by 3.5.1, to reduce the likelihood of smoke and hot gases passing from one 'tween-deck space to another through the system. In addition to insulation requirements contained in this paragraph, vertical ducts shall, if necessary, be insulated as required by Table 3.1 or 3.2 as appropriate.

3.10.10 Practicable measures shall be taken for control stations outside machinery spaces in order to ensure that ventilation, visibility and freedom from smoke are maintained so that, in the event of fire, the machinery and equipment contained therein may be supervised and continue to function effectively. Alternative and separate means of air supply shall be provided and air inlets of the two sources of supply shall be so disposed that the risk of both inlets drawing in smoke simultaneously is minimized. Such requirements need not apply to control stations situated on, and opening on to, an open deck or where local closing arrangements would be equally effective.

3.10.11 Exhaust ducts shall be provided with hatches for inspection and cleaning. The hatches shall be located near the fire dampers.

3.10.12 Where they pass through accommodation spaces or spaces containing combustible materials, the exhaust ducts from galley ranges shall be constructed of "A" class divisions. Each exhaust duct shall be fitted with:

- a grease trap readily removable for cleaning
- arrangements, operable from within the galley, for shutting off the exhaust fans
- fixed means for extinguishing a fire within the duct

3.10.13 The main inlets and outlets of all ventilation systems shall be capable of being closed from outside the spaces being ventilated. The means of closing shall be easily accessible as well as prominently and permanently marked and shall indicate whether the shutoff is open or closed.

3.10.14 Power ventilation of accommodation spaces, service spaces, control stations and machinery spaces shall be capable of being stopped from an easily accessible position outside the space being served. This position shall not be readily cut off in the event of a fire in the spaces served.

3.11 Means of escape

3.11.1 General requirements

.1 Unless expressly provided otherwise in this regulation, at least two widely separated and ready means of escape shall be provided from all spaces or group of spaces.

.2 Lifts shall not be considered as forming one of the means of escape as required by this regulation.

3.11.2 Means of escape from control stations, accommodation and service spaces

.1 Stairways and ladders shall be so arranged as to provide ready means of escape to the lifeboat and liferaft embarkation deck from passenger and crew accommodation spaces and from spaces in which the crew is normally employed, other than machinery spaces.

.2 All stairways in accommodation and service spaces and control stations shall be of steel frame construction except where BKI sanctions the use of other equivalent material.

.3 Doors in escape routes shall, in general, open in way of the direction of escape, except that:

- individual cabin doors may open into the cabins in order to avoid injury to persons in the corridor when the door is opened
- doors in vertical emergency escape trunks may open out of the trunk in order to permit the trunk to be used both for escape and for access

.4 At all levels of accommodation there shall be provided at least two widely separated means of escape from each restricted space or group of spaces.

.5 Below the lowest open deck the means of escape shall be stairways, ladders, or watertight doors. At least one of the means of escape, from each watertight compartment or similarly restricted space or group of spaces shall be independent of watertight doors.

.6 Above the lowest open deck the means of escape shall be corridors, stairways or doors to an open deck or a combination thereof. There shall be at least two means of escape from each main vertical zone or similarly restricted space or group of spaces.

.7 No dead-end corridors having a length of more than 7 m shall be accepted.

.8 Stairways and corridors used as means of escape shall be not less than 700 mm in clear width and shall have a handrail on one side. Stairways and corridors with a clear width of 1800 mm and over shall have handrails on both sides. "Clear width" is considered the distance between the handrail and the bulkhead on the other side or between the handrails. The angle of inclination of stairways should be, in general 45°, but not greater than 50°, in small spaces not more than 60°. Doorways which give access to a stairway shall be of the same size as the stairway.

.9 Exceptionally, BKI may dispense with one of the means of escape, for crew spaces that are entered only occasionally, if the required escape route is independent of watertight doors.

3.11.3 Means of escape from machinery spaces

.1 Except as provided in [3.11.3.2](#), two means of escape shall be provided from each machinery space of category A. In particular, one of the following provisions shall be complied with:

- Two sets of steel ladders as widely separated as possible leading to doors in the upper part of the space similarly separated and from which access is provided to the open deck. One of these ladders shall be located within a protected enclosure that satisfies the category (4) requirements of [Table 3.1](#) and [3.2](#), from the lower part of the space it serves to a safe position outside the space. Self-closing fire doors of the same fire integrity standards shall be fitted in the enclosure. The ladder shall be fixed in such a way that heat is not transferred into the enclosure through non-insulated fixing points. The enclosure shall have minimum internal dimensions of at least 800 mm × 800 mm, and shall have emergency lighting provisions; or
- one steel ladder leading to a door in the upper part of the space from which access is provided to the open deck and, additionally, in the lower part of the space and in a position well separated from the ladder referred to, a steel door capable of being operated from each side and which provides access to a safe escape route from the lower part of the space to the open deck.

.2 For a yacht of less than 1000 gross tonnage, BKI may dispense with one of the means of escape required under [3.11.3.1](#), due regard being paid to the dimension and disposition of the upper part of the space. In addition, the means of escape from machinery spaces of category A need not comply with the requirement for a protected enclosure listed in the first item of [3.11.3.1](#).

In the steering gear space, a second means of escape shall be provided when the emergency steering position is located in that space unless there is direct access to the open deck.

.3 From machinery spaces other than those of category A, two escape routes shall be provided except that a single escape route may be accepted for spaces that are entered only occasionally, and for spaces where the maximum travel distance to the door is 5 m or less.

.4 The angle of inclination of stairways in machinery spaces should be not more than 60°.

3.12 Helicopter decks

3.12.1 Structural integrity

.1 In general, the construction of the helidecks shall be of steel or other equivalent materials. If the helideck forms the deckhead of a deckhouse or super-structure, it shall be insulated to "A-60" class standard.

.2 If BKI permits aluminium or other low melting point metal construction that is not made equivalent to steel, the following provisions shall be satisfied:

- A) If the platform is cantilevered over the side of the ship, after each fire on the ship or on the platform, the platform shall undergo a structural analysis to determine its suitability for further use.
- B) If the platform is located above the ship's deckhouse or similar structure, the following conditions shall be satisfied:
 - The deckhouse top and bulkheads under the platform shall have no openings.
 - Windows under the platform shall be provided with steel shutters.
 - After each fire on the platform or in close proximity, the platform shall undergo a structural analysis to determine its suitability for further use.

.3 Drainage facilities in way of helidecks shall be constructed of steel and shall lead directly overboard independent of any other system and shall be designed so that drainage does not fall onto any part of the ship.

3.12.2 Means of escape

A helideck shall be provided with both a main and an emergency means of escape and access for firefighting and rescue personnel. These shall be located as far apart from each other as is practicable and preferably on opposite sides of the helideck.

C. Fire Protection and Fire Extinguishing

1. Fire protection measures

1.1 General

1.1.1 To prevent a fire from starting as well as from spreading, preventive measures shall be taken in the area where a fire hazard may exist.

Possible sources of fire are:

- Machinery
- electrical installations and appliances
- heating and cooking appliances, etc

1.1.2 The requirements defined in the following are to be observed in addition to the other relevant parts of these Rules.

1.1.3 Installation of the machinery and the electrical gear in accordance with [Section 1, C.](#) and [D.](#) already provides a certain basic level of required fire protection measures.

1.1.4 All requirements on escape routes and emergency exits are contained in [B.](#)

1.1.5 Compliance with the requirements defined in [C.](#), preventive maintenance of the appliances and installations by the owner and/or the operator of the yacht, plus the latter's prudent behaviour and regular checks will contribute to fire prevention.

1.2 Open flame appliances

1.2.1 General

.1 Galley stoves or cookers operating with liquid fuel shall be provided with savealls of non-combustible materials. Measures are to be taken to prevent any leaking fuel to spread through the yacht.

.2 Stoves, cookers and heating appliances are to be so installed that undue heating of adjacent structures will not occur.

.3 For the operation of galley stoves and cookers using liquid fuels or gas, there shall be adequately sized ventilation openings. If such openings are closable, a notice shall be fitted at the appliance:

"Ventilation openings are to be kept open during the use of stove/cooker!"

1.2.2 Heaters burning liquid fuel

.1 Only fuels with a flash point ≥ 55 °C may be used, unless specifically approved otherwise by BKI.

.2 Only heaters with closed combustion chamber and air supply and exhaust gas lines tight against the interior of the yacht are permitted.

.3 Heaters which do not fully meet the requirements regarding safety time margin of a Standard recognized by BKI may be approved, if safety of operation is proved in some other way, e.g. by explosion-proof design of the combustion chamber and the exhaust gas ducts.

1.2.3 Liquefied petroleum gas systems

Cooking and heating appliances using liquefied petroleum gas (e.g. propane, butane) shall comply with the following:

- The systems have been manufactured and installed in accordance with ISO 10239.
- At intervals of not more than 2 years a survey has to be done by an approved expert.

1.2.4 Materials and surfaces in vicinity of open flame cooking appliances

.1 Materials and surfaces of components in the vicinity of an open flame cooking appliance must meet the requirements shown in Fig.3.1. On the right side the requirements for liquid fuels are defined, on the left side the requirements for gaseous fuels.

Area I : Non-combustible material to be provided

Area II : Approved surface material with low flame spread to be provided

Unit : (mm)

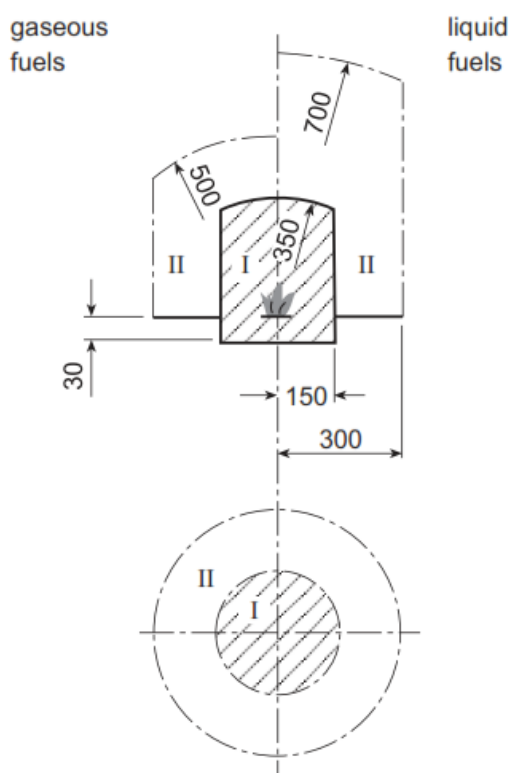


Fig. 3.1 Materials and surfaces of components in the vicinity of an open flame cooking appliance

.2 Not readily ignitable materials are to be used for textile draperies.

1.3 Shielding of fuel pipes

Regardless of the intended use and location of any internal combustion engine, all internal fuel injection lines (high pressure lines between injection pumps and injection valves) are to be shielded in such a way that any leaking fuel is:

- Safely collected
- Drained away unpressurised
- Effective monitored

2. Fire extinguishing arrangements

2.1 General scope of fire extinguishing arrangements

Any yacht is to be equipped with a general water fire extinguishing system and with portable and mobile extinguishers.

2.2 Extinguishing systems

2.2.1 Selection of systems

In addition, depending on their nature, size and the propulsion power installed, spaces subject to a fire hazard are to be provided with fire extinguishing systems according to [Table 3.3](#).

Unless specified otherwise, these systems are normally to be located outside the spaces and areas to be protected and must be capable of being actuated from a readily accessible location not likely to be cut off in the event of a fire in the protected space or area.

Table 3.3 Fixed fire extinguishing systems

Spaces and areas to be protected	Motor yachts	Sailing yachts
Machinery spaces containing internal combustion engines ¹ or oil-fired boilers	CO ₂ system ²	
Paint lockers and flammable liquid lockers	CO ₂ , dry powder extinguishing or pressure water spraying system	
Helicopter landing deck	Low expansion foam	-
¹ installed aggregate power ≥ 375 kW ² alternatively an approved gas fire extinguishing system other than CO ₂ or a pressure water spraying system according to MSC / Circ. 1165 will be accepted		

2.2.2 General water fire extinguishing systems

.1 Minimum capacity and number of fire pumps

The minimum capacity and the number of fire pumps shall be as specified in [Table 3.4](#).

Table 3.4 Minimum number and capacity of fire pumps

Number/ capacity of fire pumps	Yachts of length L ≤ 48 m	Yachts of length L > 48 m
Number of power-driven pumps	2	2
Minimum capacity Q of one pump	20 m ³ /h	$Q = 3,8 \cdot 10^{-3} \cdot d_H^{2,1}$ But not less than 25 m ³ /h
¹ d _H [mm] = theoretical diameter of the bilge main according to Section 1, 7.6.1.1		

.2 Emergency fire pumps

On yachts of a length $L > 48$ m an emergency fire pump is to be provided if a fire in any one compartment can put all the fire pumps out of action.

.3 Water from two sea chests

For yachts it is sufficient that provision is made for supplying water for fire pumps from one sea chest only.

.4 Remote starting arrangement for fire pumps

On yachts of a length $L > 48$ m at least one fire pump is to be provided with remote starting arrangements from the bridge. The associated shut-off valves from the sea water inlet to the fire main must be capable of being controlled from the above mentioned position. Alternatively locally operated valves may be used; these are to be kept open permanently and provided with appropriate signs, e.g.:

"Valve always to be kept open!"

.5 Conditions for emergency fire pumps

The capacity of an emergency fire pump needs not be more than $20 \text{ m}^3/\text{h}$

The emergency fire pumps shall fulfil the following conditions:

- installation outside of the space where the main fire pumps are located
- energy supply independent of the space containing the main fire pumps
- self-priming type

.6 International shore connection

An international shore connection need not be provided.

.7 Arrangement of fire mains

For yachts of a length $L > 48$ m the [Rules for Machinery Installations \(Pt.1, Vol.III\)](#), [Sec. 12](#) is to be applied. However, for the shut-off valves at branch pipes for haws pipe flushing local operation will be accepted.

.8 Pressure at nozzles

For yachts of a length $L \leq 48$ m the system shall be designed for delivering at least one effective jet of water (length of throw approx. 10 m) from any hydrant.

.9 Position of hydrants

On yachts of a length $L \leq 48$ m hydrants are to be so positioned that any part of the yacht normally accessible can be reached with water from at least one nozzle with not more than 1 standard hose length (for $L \leq 48$ m standard hose length on deck: 15 m, in machinery spaces: 10 m; for $L > 48$ m standard hose length on deck: 20 m, in machinery spaces: 15 m).

.10 Hydrants in machinery spaces

For yachts of a length $L \leq 48$ m hydrants in machinery spaces need not be provided.

.11 Number of hoses and nozzles

For yachts of a length $L \leq 48$ m at least 2 hoses and nozzles and for yachts of a length $L > 48$ m at least 5 hoses and nozzles have to be provided.

.12 Nozzle sizes

- 9 mm or as near thereto as possible for yachts of a length $L \leq 48$ m

- 12 mm or as near thereto as possible for yachts of a length $L > 48$ m

2.2.3 High-pressure CO₂ fire extinguishing systems / rooms for CO₂ cylinders

.1 Accessible CO₂ rooms:

All requirements as defined in the [Rules for Machinery Installations \(Pt.1, Vol. III\) Sec.12.G](#)

.2 Non accessible CO₂ rooms:

Such rooms are only suitable for a limited number of cylinders, the arrangement of the cylinders must be suitable for efficient operation. Mechanical ventilation is not required.

2.2.4 Automatic pressure water spraying systems (sprinkler systems)

The system is to meet the [Rules for Machinery Installations \(Pt.1, Vol. III\) Sec.12.L](#). However, the capacity of the system need not be higher than that required for the total area to be protected.

2.3 Portable and mobile fire extinguishers

2.3.1 General

.1 CO₂ fire extinguishers may not be located in accommodation areas and water fire extinguishers not in machinery spaces.

.2 The charge in portable dry powder and gas extinguishers should be at least 5 kg and the content of foam and water extinguishers should be not less than 9 litres.

.3 A portable foam applicator unit comprises two portable tanks, each containing 20 litres of foaming agent, an air-foam jet pipe and ejector unit. The nozzle should be capable of producing at least 1,5 m³/min of foam

2.3.2 Accommodation

In accommodation decks of yachts portable fire extinguishers are to be arranged not more than 20 m apart at a readily accessible location.

At least one portable fire extinguisher is to be provided on each deck and in each main vertical zone, but the total number shall not be less than:

- 3 for yachts of a length $L \leq 48$ m, or
- 5 for yachts of a length $L > 48$ m

2.3.3 Machinery spaces

.1 For yachts of a length $L \leq 48$ m portable dry powder fire extinguishers are to be provided as follows:

- up to 100 kW installed power: a minimum weight of 6 kg extinguishing agent
- for each further 100 kW or part thereof: 2 kg extinguishing agent in addition

.2 For yachts of a length $L > 48$ m the following is to be provided:

- portable dry powder fire extinguishers so located that from any point in the space an extinguisher can be reached within 10 m walking distance

- mobile fire extinguishers of 50 kg dry powder or 45 litre foam which shall be so located that any part of the fuel and lubricating oil pressure systems, gearing and other fire hazards can be reached

2.3.4 Other spaces and life boats

Paint lockers, flammable liquid lockers, radio rooms (if any), galleys and motor life boats are each to be equipped with at least one portable fire extinguisher. In motor life boats portable dry powder extinguishers of 2 kg will be accepted.

2.4 Special arrangements for spaces for the carriage of automobiles and other craft

For these spaces the following items have to be provided:

- a pressure water spraying system with a capacity of 5 litres per square meter and minute
- an independent forced ventilation for at least 10 air changes per hour
- electrical equipment with grade of protection IP 55 at least and maximum surface temperature 200 °C

All installations less than 450 mm above a deck shall be approved for use in an explosive petrol/air atmosphere.

D. Closure Conditions, Buoyancy and Stability

1. General

1.1 Classification

Yachts will be assigned Class only after it has been demonstrated that the closure conditions, subdivision, buoyancy and their intact stability is adequate for the service intended.

1.2 Closure conditions

1.2.1 General

The measures for achieving weathertight integrity shall comply with the International Load Line Convention ILLC 66 as far as reasonable and practicable.

1.2.2 Closure report

A closure plan report in accordance with BKI Form for yachts of a length $L > 48$ m, showing all openings, cut-outs, passages, etc. in deck and shell "as built", will be established by Surveyor and sent for approval to the BKI Head Office.

1.3 Stability
1.3.1 Adequate intact stability means compliance with standards laid down by the relevant Administration. BKI reserve the right to deviate therefrom, if required for special reasons, taking into account the yacht's size and type. The level of intact stability for yachts of all sizes should in any case be not less than that provided by IMO-Resolution A.749(18), excluding Chapter 3 (3.2 weather criterion), unless special operational restrictions reflected in the Class Notation render this impossible.

1.3.2 Evidence of approval by the competent Administration concerned may be accepted for the purpose of Classification.

1.3.3 The above provisions do not affect any intact stability requirements resulting from damage stability calculations, e.g. for yachts which are assigned the symbol \square in the Character of Classification.

1.3.4 Yachts with proven damage stability will be assigned the symbol \square . In the Register book and in an appendix to the Certificate the proof of damage stability will be specified by a five digit code as detailed in the [Guidances for Class Notations \(Pt.0, Vol.B\)](#).

1.3.5 The compliance with the requirements of [D](#). is to be checked by calculation and/or trials with the prototype, if any, or with the actual yacht itself in the fully loaded, ready for use condition. Trials are to be carried out under the supervision of a BKI Surveyor.

1.4 Documents to be submitted for approval

For the condition of drawings and documents which are necessary for approval see [Section 1, E](#).

1.5 Definitions

1.5.1 Down flooding point

Down flooding point means any opening through which flooding of the spaces which comprise the reserve buoyancy could take place while the yacht is in the intact or damaged condition, and heels to an angle past the angle of equilibrium.

1.5.2 Permeability

The permeability μ of a space is the proportion of the immersed volume of that space which can be occupied by water.

1.5.3 Watertight

Watertight in relation to a structural element means capable of preventing the passage of water through the structure in any direction under the head of water likely to occur in the intact or damaged condition.

1.5.4 Weathertight

Weathertight means that water will not penetrate into the yacht in any wind and wave conditions up to those specified as critical design condition.

1.5.5 Weathertight for heeling

Weathertight for heeling means that all openings liable to become submerged over a certain heeling range shall, if the situation requires, be made weathertight to ensure a stability range up to a certain heeling angle.

Angle of maximum heeling:

- Motor yacht : 50°
- Sailing yacht, motor sailers : 90°

1.5.6 Angle of heel

ϕ = angle of heel relative to the y-axis [°], see also [Section 2, Fig. 2.1](#)

1.5.7 Sprayproof

Sprayproof means that no major quantities of water can penetrate into the yacht as a result of short-time immersion.

1.5.8 No unauthorized opening

If openings are accessible during the voyage, they shall be fitted with a device which prevents unauthorized opening.

1.5.9 Positions

The positions for the arrangement of hatches, doors, manholes are:

Position 1:

- on exposed freeboard decks
- on raised quarter decks
- on exposed superstructure decks within the forward quarter of L

Position 2:

- on exposed superstructure decks aft of the forward quarter of L

1.6 Anti-heeling devices

1.6.1 If tanks are used as heeling devices, effects of maximum possible tank moments on intact stability are to be checked. A respective proof has to be carried out for several draughts and taking maximum allowable centres of gravity resulting from the stability limit curve as a basis.

1.6.2 If a yacht is equipped with anti-heeling arrangements which may counteract heeling angles of more than 10°, the [Rules for Machinery Installations \(Pt.1, Vol. III\), Sec. 11, P.1.4](#) have to be observed.

1.6.3 All devices have to comply with [Rules for Electrical Installations \(Pt.1, Vol. IV\), Sec. 7, G](#).

2. Openings and closures in hull, deck, cockpit and superstructures

2.1 Decks

2.1.1 Coaming heights for deck openings leading below the freeboard deck, to enclosed superstructures or to spaces considered buoyant in the stability calculation are in general to be in accordance with ICLL 66, as far as reasonable and practicable.

2.1.2 Where applicable, sill or coaming heights should comply with National Administration requirements.

2.2 Doors and hatches

2.2.1 Doors, hatches and ventilation ducts including their covers, lock tumblers and securing arrangements must be adequately dimensioned. Details are to be submitted for approval.

2.2.2 All doors and escape hatches must be operable from both sides, see also [B](#).

2.3 Ventilation systems

2.3.1 General

.1 The thickness of the coaming plates is to be 7,5 mm where the clear opening sectional area of the ventilator coaming is 300 cm² or less, and 10 mm where the clear opening sectional areas exceeds 1600 cm³. Intermediate values are to be determined by direct interpolation. A thickness of 6 mm will generally be considered sufficient within not permanently closed structures.

.2 The thickness of ventilator posts should be at least equal to the thickness of coaming as per [2.3.1.1](#).

.3 Generally the coamings and posts shall pass through the deck and shall be welded to the plating from above and below.

2.3.2 Closing appliances

.1 Inlet and exhaust openings of ventilation systems are to be provided with easily accessible closing appliances, which can be closed weathertight against wash of the sea. In yachts with the length $L \leq 100$ m, the closing appliances are to be permanently attached. In yachts with length $L > 100$ m, they may be conveniently stowed near the openings to which they belong.

.2 The measures necessary for fire protection are defined in [B](#).

2.4 Hull

2.4.1 Openings in the hull shall comply with SOLAS Regulation II – 1 / 25-10: "External openings in cargo ships".

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

2.4.3 Regarding inlet and outlet fittings on the shell for the cooling and bilge water as well as sewage lines, see [Section 1, C](#).

2.5 Summary of requirements

The general requirements, which are to be applied as a minimum, are summarized in [Table 3.5](#). The relevant coaming heights are defined in [Table 3.6](#).

Table 3.5 Requirements for openings and closures

Closure components	Requirements	
	Range of service	
	Unrestricted, P, L	T
Shell openings (e.g. windows, shell doors)	Watertight ¹ and no unauthorized opening	
Deck hatches	Weathertight	Sprayproof and weathertight for heeling
Cockpit hatches	Weathertight	Sprayproof and weathertight for heeling

Table 3.5 Requirements for openings and closures (continued)

Closure components		Requirements	
		Range of service	
		Unrestricted, P, L	T
Doors to enclosed spaces and accesses	Pos.1 and 2	Weathertight	
	all others	Sprayproof	
Ventilation ducts for accommodation		Weathertight	Sprayproof and weathertight for heeling
Ventilation ducts for machinery spaces		Weathertight	
Air pipes		Weathertight	Sprayproof and weathertight for heeling
¹ Weathertight, if situated above the freeboard deck.			

Table 3.6 Minimum coaming heights for sailing and motor yachts in [mm]

Closure components	Requirements				
	Position 1	Position 2	No direct access leading below	Normally closed at sea (regardless of position)	Sheltered water T
Shell openings (e.g. windows, shell doors)	500 above waterline				50
Deck hatches	600	450	Flush	Flush	50 ²
Cockpit hatches	-	-	-	Flush	Flush
Sliding covers	Only on top of a superstructure or deckhouse within the forward quarter of the yacht's length: 150, behind this point: flush				
Door and accesses to enclosed spaces	600	450	150	50	50
Ventilation ducts for accommodation	900	760	150	-	150
Ventilation ducts for machinery spaces	900	760	760	-	760
	4500 ¹	2300 ¹			
¹ height without weathertight covers					
² when used at sea. When closed at sea: flush					

3. Windows, skylights and side scuttles

3.1 Windows and side scuttles

3.1.1 Closure condition

In any case, windows opening into enclosed spaces shall be watertight and adequately dimensioned for the intended range of service.

Note:

The respective ISO-Standards (e.g. DIN ISO 1751 and ISO 3903) are to be considered as guidance. Other types are to be submitted for approval.

3.1.2 Windows in the hull

Windows in the hull which can be opened must be kept closed when at sea. 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.

3.1.3 Deadlights

Deadlights are to be carried on board for all windows in the hull in accordance with the ICLL 66 Regulations as amended or where required from stability point of view.

Windows and side scuttles in deckhouses on the freeboard deck forming the only protection of openings giving access to a space below, are in general to be provided with permanently attached deadlights.

Special constructions with equivalent safety standards may be used on request and after special examination/testing and with the consent of the competent Flag State Administration.

3.1.4 Window framing

Panes of PMMA or PC sheet material are to be fixed by frames. They may also be bolted, 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 may be permitted. The strength is to be proven by tests and/or calculation.

Note:

If bonding is used, it shall only be executed with materials approved by BKI, by personnel certified by BKI and considering the requirements of the [Rules for Materials \(Pt.1, Vol.V\)](#)

3.1.5 Glass thickness

The window glass thickness has to be determined in accordance with the respective ISO 21005 or with equivalent regulations.

3.2 Skylights

3.2.1 All skylights shall be of efficient weathertight construction and shall be located on or as near to the centreline of the yacht as practicable. If they are of the opening type they shall be provided with efficient means whereby they can be secured in the closed position.

3.2.2 Skylights which are provided as a means of escape shall be operable from both sides. An escape skylight shall be readily identified and easy and safe to use, having due regard to its position and access to and from the skylight.

3.2.3 For glass and framing of skylights see [3.1.4](#), [3.1.5](#) and [3.1.6](#). A minimum of one portable cover for each size of glazed opening should be provided, which can be accessed rapidly and efficiently secured in the event of a breakage of the skylight.

3.2.4 Skylights shall not be fitted in way of the machinery space.

4. Cockpit

Especially for sailing yachts a cockpit may be provided. Its lay-out has to consider the following criteria.

4.1 Structure

The cockpit floor plus longitudinal and transverse walls are to be considered as primary structural members, the scantlings of which shall be in accordance with the requirements of [Section 2](#).

Cockpits shall be watertight to the inside of the yacht.

4.2 Closure condition

Regarding closures and coaming heights of hatches and doors of adjoining storage and living spaces, [see 2.](#) and [3.](#)

4.3 Cockpit floor

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

4.4 Drain pipes

4.4.1 Cross section

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

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

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

Minimum total cross section for different ranges of service:

- unrestricted : 30,0 cm^2
- P and L : 20,5 cm^2
- T : 15,0 cm^2

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

Cockpits extending all the way across the yacht must have clearing ports or drain pipe cross sections in accordance with [6.](#)

4.4.2 Design details

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

4.4.3 Short hose sleeves

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 yacht heeled 15°.
- The hose used shall be in accordance with National/International Standard.
- Two corrosion resistant clips are to be fitted at each end of the sleeve.

5. Deck drainage

5.1 Closure condition

Where bulwarks on exposed portions of freeboard and/or superstructure decks form wells, ample provision is to be made for rapidly freeing the deck of water. Therefore, an adequate number of freeing ports or drain pipes of adequate size shall be fitted.

5.2 Freeing

5.2.1 The minimum area of openings on one side of the yacht A is to be determined in accordance with the following formula:

$$A = 0,07 \cdot \ell$$

ℓ = length of bulwark [m]

$$\ell_{\max} = 0,7 L$$

5.2.2 The opening area for each well in a super-structure deck shall not be less than 50 % of A.

If the bulwark is more than 1,2 m in average height, A is to be increased by 0,004 m² per metre of length of well for each 0,1 m difference in height. If the bulwark is less than 0,9 m in average height, A may be decreased accordingly.

For yachts with no sheer A has to be increased by 50 %. Where the sheer is less than the standard, the percentage shall be obtained by linear interpolation.

5.2.3 Two thirds of the freeing port area required shall be provided in the half of the well nearest to the lowest point of the shear curve.

The lower edges of the freeing ports shall be as near to the deck as practicable.

All openings shall be protected by rails or bars spaced approximately 230 mm apart.

If shutters are fitted, ample clearance shall be provided to prevent jamming.

Hinges shall have pins or bearings of non-corrodible material.

5.3 Scuppers

5.3.1 Scuppers sufficient in number and size to provide effective drainage of water are to be fitted in the weather deck and in the freeboard deck within weathertight closed superstructures and deckhouses. Decks within closed superstructures are to be drained to the bilge. Scuppers from superstructures and deck-houses which are not closed weathertight are to be led outside.

5.3.2 Scupper draining spaces below the design waterline are to be led to the bilges.

Where scupper pipes are led outside from spaces below the freeboard deck and from weathertight closed superstructures and deckhouses, they are to be fitted with screw-down non-return valves (SDNR), which can be closed from a position always accessible and above the freeboard deck. Means showing whether the valves are open or closed are to be provided at the control position.

5.3.3 Scuppers and other discharges should not be fitted in way of life boat launching positions or means for preventing any discharge of water into the life boats are to be provided for. The location of scuppers and other discharges is also to be taken into account when arranging gangways and pilot lifts.

5.4 Drain Pipe

5.4.1 Deck drain pipes shall match the surrounding hull in strength.

5.4.2 Valves are not permitted in deck drain pipes.

5.4.3 Deck drain pipes may only be replaced by hoses with special permission of BKI.

7. Intact buoyancy and stability

7.1 Intact buoyancy

7.1.1 All yachts shall have a sufficient reserve of buoyancy at the design waterline to meet the intact stability requirements of 7. This reserve of buoyancy shall be calculated by including only those compartments which are:

- watertight
- accepted as having scantlings and arrangements adequate to maintain their watertight integrity
- situated in locations below a boundary, which may be a watertight deck or an equivalent structure of a non-watertight deck covered by a weathertight structure as defined in 7.1.3

7.1.2 Arrangements shall be provided for checking the watertight integrity of those compartments taken into account in 7.1.1.

7.1.3 Where entry of water into structures above the boundary as defined in 7.1.1, third item would significantly influence the stability and buoyancy of the yacht, such structure shall be:

- of adequate strength to maintain the weathertight integrity and fitted with weathertight closing appliances; or
- provided with adequate drainage arrangements; or
- an equivalent combination of both measures

7.1.4 The means of closing openings in the boundaries of weathertight structures shall be such as to maintain weathertight integrity in all operational conditions.

7.2 Intact stability

7.2.1 Adequate stability of the yacht shall be proven. Insofar as rig, yacht type and propulsive installation do not demonstrate any unusual characteristics, the criteria listed below are used for determining stability.

Legal national regulations beyond these may also have to be complied with.

The yacht shall have its proof of stability based on an inclining experiment; the test is to be supervised by Surveyor.

Note:

Compliance with the stability criteria does not ensure immunity against capsizing. Good seamanship is therefore an essential prerequisite for a stability-safe yacht.

7.2.2 Criteria for motor yachts

.1 The following criteria have to be fulfilled:

- The area under the righting lever curve (GZ curve) shall not be less than 0,055 metre-radian up to $\varphi = 30^\circ$.
- The area under the righting lever curve shall not be less than 0,09 metre-radian up to $\varphi = 40^\circ$ or the angle of flooding (angle of heel at which non-weathertight openings immerse).
- Additionally the area under the righting lever curve (GZ curve) between the angles of heel 30° and 40° or between 30° and the angle of flooding, if this angle is less than 40° , shall not be less than 0,03 metre-radian.
- The righting lever GZ should be at least 0,20 m at an angle of heel equal to or greater than 30° .

- The maximum righting arm shall occur at an angle of heel preferably exceeding 30° but not less than 25° .
- The initial metacentric height GM, should be not less than 0,35 m.
- The turning circle an angle of heel is to be determined by trials and shall not exceed 12° at maximum speed. During trials the speed is to be increased in steps. If the turning circle angle of heel exceeds 12° before maximum speed is attained the test has been failed.

If any of these criteria are not complied with, this may be accepted by BKI if proof of equivalent safety is provided.

.2 The proof of adequate stability shall be provided for at least the following conditions:

- yacht in the fully loaded departure condition, with full stores and fuel and with the full number of crew and guests with their luggage
- yacht in the fully loaded arrival condition, with the full number of crew and guests with their luggage, but with only residual stores and fuel remaining

.3 BKI reserve the right to deviate from the above regulations when particular circumstances warrant this.

7.2.3 Criteria for sailing yachts

.1 The following criteria have to be fulfilled:

- The areas B, C shall be not less than $1,4 (A + B)$, see Fig. 3.3.
- The righting lever at the maximum of the lever arm curve shall be not less than 0,30 m.
- The stability range shall be not less than 60° for yachts without ballast keel.
- The stability range shall be not less than 90° for yachts with ballast keel.
- The initial metacentric height GM0 shall not be less than 0,60 m.
- The static angle of heel under sail shall not exceed 20° , but in any way shall not be more than the angle of deck immersion.

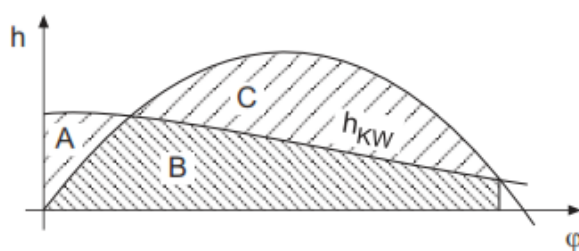


Fig. 3.3 Lever arm curve

h_{KW} = curve of heeling levers due to lateral wind pressure

.2 If any of these criteria are not complied with, this may be accepted by BKI, if proof of equivalent safety is provided.

For multi hull sailing craft, stability ranges smaller than 60° may be permitted.

.3 The proof of adequate stability shall be provided for the yacht at least under the following conditions:

- all sails set

- half the sail area
- storm sails
- sails struck

In each case the permissible wind speed or force shall be determined at which the limit of stability set by the criteria is reached. With the sails struck, a lateral wind pressure equivalent to Beaufort Force 12 (32,7 – 36,9 m/s = 63,6 – 71,7 kn) must be tolerable.

7.2.4 Ice Class

The effect of icing has to be considered in the stability calculation if a Class Notation for ice has been requested.

8. Subdivision and damage stability

8.1 Bulkheads

8.1.1 At least the following watertight bulkheads are to be fitted in all yachts:

- one collision bulkhead
- one afterpeak bulkhead
- one bulkhead at each end of the machinery space

8.1.2 The distance [m] of the collision bulkhead shall be located at a distance from the forward perpendicular not less than 0,05 L or 10 m, whichever is the less except as may be permitted by administration, not more than 0,08 L or 0,05 L + 3 m whichever the greater.

8.1.3 Where any part of the yacht below the waterline extends forward of the forward perpendicular, e.g., a bulbous bow, the distances stipulated in this paragraph shall be measured from a point either:

- at the mid length of such extension,
- at a distance 0,015 L forward of the forward perpendicular, or
- at a distance 3,0 m forward of the forward perpendicular, whichever gives the smallest measurement.

If collision bulkhead is located outside and more forward than the permissible range, the requirement may be substituted by proof of survivability of simultaneous two compartment damage of both foremost compartments according to the criteria defined in [8.3.3](#).

8.1.4 In yachts having continuous or long superstructures, the collision bulkhead shall extend to the first deck above the bulkhead deck. The extension need not be fitted directly in line with the bulkhead below, the requirements for hull local scantling are fulfilled and the scantlings of the part of the bulkhead deck which forms the step or recess are not less than required for a collision bulkhead. Openings with weather tight closing appliances may be fitted above the bulkhead deck in the collision bulkhead and in the aforementioned step and recess. However the number of openings shall be reduced to the minimum compatible with the design and proper working of the yacht.

8.1.5 Where a readily accessible space which is not a hold space is located directly adjacent to the forepeak, e.g., a bow-thruster space, the screw down valves may be fitted within this space directly at the collision bulkhead and need not be operable from a remote position. For different space layouts alternative solutions with the safety level may be agreed by BKI.

8.2 Double bottom

8.2.1 At least for yachts with a length L exceeding 48 m a double bottom should be fitted extending from the collision bulkhead to the after peak bulkhead, as far as practicable and compatible with the design and proper operation of the ship. In any case, a double bottom must be fitted in areas prescribed in Regulation II-1/9 of SOLAS 74.

8.2.2 The double bottom has to protect the yacht's bottom up to the turn of the bilge. For this purpose, the intersecting line of the outer edge of the margin plate with the shell plating is not to be lower at any part than a horizontal plane, passing through the point of intersection with the frame line amidships of a transverse diagonal line inclined 25 degrees to the baseline and cutting the base line at $B/2$ from the centreline of the yacht (see Fig.3.4).

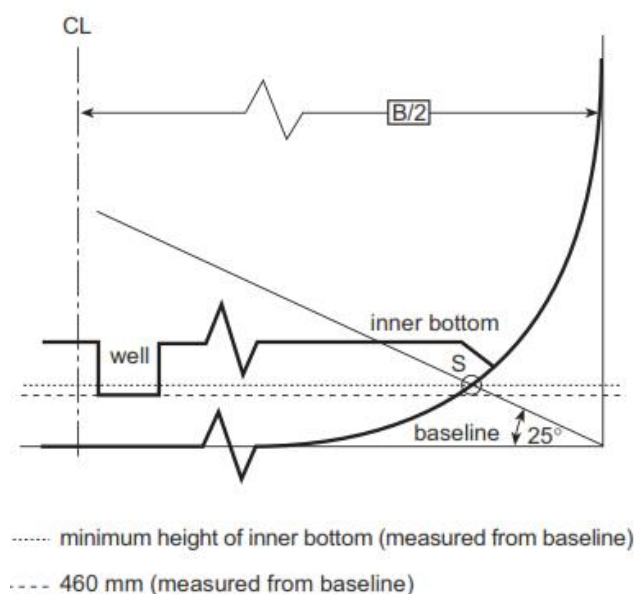


Fig. 3.4 Double bottom with drain sumps location

8.2.3 The double bottom need not be fitted in way of deep tanks, provided that the efficiency of the watertight subdivision is not impaired by such an arrangement.

8.2.4 The bottoms of drain sumps are to be situated at a distance of at least 460 mm from the base line. Only above the horizontal plane determined from 8.2.2, the bottoms of drain wells may be led to the shell plating. Exemptions for the depth of drain wells may also be granted in shaft tunnels and pipe tunnels.

8.3 Damage Stability

8.3.1 General

For yachts with a length L exceeding 48 m a damage stability investigation is required.

For yachts with a length L between 48 m and 85 m sufficient damage stability has to be shown by calculating one compartment damages. For yachts with a length L exceeding 85 m a calculation of two compartment damages is required additionally.

8.3.2 Damage Stability Calculation

.1 General

Compliance with the damage stability criteria has to be shown in all permitted conditions of loading to withstand all stages of flooding of the main compartments.

.2 Assumption

The damage stability calculation shall be based on the following assumptions:

- A) The assumed extent of damage shall be as follows:
 - longitudinal extent: 3 m plus 3 % of the length L of the yacht or 11 m, whichever is less
 - transverse extent (to be measured inboard from the ship's side, at right angles to the centre line at the level of the deepest subdivision load line): a distance of one fifth of the breadth of the yacht
 - vertical extent: from the base line upwards without limit
 - If any damage of lesser extent than that indicated above would result in a more severe condition regarding heel or loss of metacentric height, such damage shall be assumed in the calculations.
- B) For damage stability calculations, the permeability for each space or part of a space shall be used as set out in [Table 3.7](#).
- C) Direct calculation of permeability shall be used where a more onerous condition results, and may be used where a less onerous condition results, if compared with the second item.

Table 3.7 Values of permeability

Definition of spaces	Permeability [%]
Control stations, accommodation rooms, kitchens, pantries	95
Machinery and ventilation rooms	85
Storage rooms, refrigerating rooms	60
Garages for automobiles and other craft	90
Tanks, bunkers, cells	0 or 95 ¹
Void spaces	95
¹ whichever results in more severe requirements	

8.3.3 Stability criteria

.1 The stability required in the final condition after damage, and after equalization where provided, shall be determined as follows:

- The positive residual righting lever curve shall have a minimum range of 15° beyond the angle of equilibrium.
- The area under the righting lever curve shall be at least 0,015 metre-radians, measured from the angle of equilibrium to the angle at which progressive flooding occurs.
- A residual righting lever is to be obtained within the range of the positive stability of at least 0,1 m.

.2 Unsymmetrical flooding has to be kept to a minimum. Efficient cross flooding arrangements should correct large angles of heel preferably in a self-acting way. If the cross-flooding system is not self-acting the required time of equalization shall not exceed 15 minutes. Sufficient time of equalization has to be demonstrated by calculation.

8.3.4 Final condition of yacht

The final conditions of the yacht after damage and, in case of unsymmetrical flooding, after equalization measures have been taken, shall be as follows:

- In case of symmetrical flooding there shall be a positive residual metacentric height of at least 50 mm as calculated by the constant displacement method.
- In case of unsymmetrical flooding, the angle of heel for one-compartment flooding shall not exceed 7°, for the simultaneous flooding of two or more adjacent compartments, a heel of 12° may be permitted by BKI.
- In no case shall the final waterline be less than 300 mm below the level of any opening through which further flooding could take place.

8.3.5 Use of low-density foam

Use of low-density foam or other media to provide buoyancy in void spaces may be permitted, provided that satisfactory evidence is provided that any such proposed medium is the most suitable alternative and is:

- of closed cell form, or otherwise impervious to water absorption
- structurally stable under service conditions
- chemically inert in relation to structural materials with which it is in contact or to other substances with which the medium is likely to be in contact
- properly secured in place and easily removable for inspection of the void spaces

8.4 Damage control plan

8.4.1 There shall be permanently exhibited or readily available on the navigating bridge, for the guidance of the officer in charge of the yacht, a plan showing clearly:

- for each deck and compartment the boundaries of the watertight compartments, the openings therein with the means of closure and position of any controls thereof
- for doors, a description of degree of tightness, operating mode, normal position, operating circumstances (opened while at sea, not normally used while at sea, not used while at sea)
- arrangements for the correction of any list due to flooding

8.4.2 General precautions shall consist of a listing of equipment, conditions and operational procedures, considered to be necessary to maintain watertight integrity under normal yacht operations.

8.4.3 Specific precautions shall consist of a listing of elements (i.e. closures, securing of equipment/loads, sounding of alarm, etc.) considered to be vital to the survival of the yacht and its crew.

9. Inclining and stability information

9.1 Every yacht on completion of build shall undergo an inclination test and the elements of its stability determined. If an accurate inclining is not practical, the lightship displacement and centre of gravity should be determined by a lightweight survey and accurate calculation.

9.2 The master shall be supplied by the owner with reliable information relating to the stability of the yacht in accordance with the provisions of [D](#). The information relating to stability shall, before issue to the master, be submitted to BKI for approval and shall incorporate such additions and amendments as BKI may require in any particular case.

9.3 Where any alterations are made to a yacht so as to materially affect the stability information supplied to the master, amended stability information should be provided. If necessary, the yacht shall be re-inclined.

9.4 A report of each inclination test carried out in accordance with [D](#). or of each calculation of the lightship condition particulars shall be submitted to BKI for approval. The approved report shall be placed

on board of the yacht in the custody of the master/owner and should incorporate such additions and amendments as BKI may require in any particular case.

E. Requirements for Hydraulically-Operated Equipment

1. General

1.1 Scope

The requirements contained in this sub-section apply to hydraulically-operated systems used, for example, to move deck/hatch covers, closing appliances in the yacht's shell and at bulkheads, hoists and stabilizers. The requirements are to be applied in analogous manner to the yacht's other hydraulic systems.

1.2 Documents for approval The diagram of the hydraulic system together with drawings of the cylinders containing all the data necessary for assessing and checking the system, e.g. operating data, descriptions, materials used, etc. are to be submitted in electronic format for approval.

1.3 Dimensional design

For the design of pressure vessels and for dimensions of pipes and hose assemblies see references defined in [Section 1, C](#).

1.4 Materials

1.4.1 Approved materials

.1 Components fulfilling a major function in the power transmission system shall normally be made of steel or cast steel in accordance with the [Rules for Materials \(Pt.1, Vol.V\)](#). The use of other materials is subject to special agreement with BKI.

Cylinders are preferably to be made of steel, cast steel or nodular cast iron (with a predominantly ferritic matrix).

.2 Pipes are to be made of seamless or longitudinal welded steel tubes.

.3 The pressure-loaded walls of valves, fittings, pumps, motors, etc. are subject to the requirements of the references defined in [Section 1, C](#).

1.4.2 Testing of materials

The following components are to be tested under supervision of BKI in accordance with the [Rules for Materials \(Pt.1, Vol.V\)](#):

- pressure pipes with nominal diameter $D_N > 32$
- cylinders, where the product of the pressure times the diameter is:

$$p \cdot D_i > 20000$$

p = maximum allowable working pressure [bar]

D_i = inside diameter of tube [mm]

- hydraulic accumulators

Testing of materials may be dispensed with in case of cylinders for secondary applications, provided that evidence in the form of a works test certificate (e.g. EN 10204-2.3) is supplied.

2. Covers for deck openings

2.1 Scope

The following requirements apply to hydraulic power equipment for opening and closing of covers for deck openings and hatches.

2.2 Design and construction

2.2.1 Hydraulic operating equipment for deck openings and hatch covers may be served either by one common power station for all openings or several power stations individually assigned to a single cover. Where a common power station is used, at least two pump units are to be fitted. Where the systems are supplied individually, change-over valves or fittings are required so that operation can be maintained should one pump unit fail.

2.2.2 Movement of the covers may not be initiated by the starting of the pumps. Special control stations are to be provided for controlling the opening and the closing of the covers. The controls are to be so designed, that as soon as they are released, movement of the cover stops immediately.

The openings/hatches should normally be visible from the control station. Should this, in exceptional cases, be impossible, opening and closing of the covers is to be signalled by an audible alarm. In addition, the control station must then be equipped with indicators for monitoring the movement of the covers.

2.2.3 Suitable equipment must be fitted in, or immediately adjacent to, each power unit (cylinder or similar) used to operate covers to enable the openings to be closed slowly in the event of a power failure, e.g. due to pipe rupture.

2.3 Pipes

2.3.1 Pipes are to be installed and secured in such a way as to protect them from damage while enabling them to be properly maintained from outside. Pipes may be led through tanks in pipe tunnels only. The piping system is to be fitted with relief valves to limit the pressure to the maximum allowable working pressure.

2.3.2 The piping system is to be fitted with filters for cleaning the hydraulic fluid. Equipment is to be provided to enable the hydraulic system to be vented.

2.3.3 The accumulator space of the hydraulic accumulator must have permanent access to the relief valve of the connected system. The gas chamber of the accumulator may be filled only with inert gases. Gas and operating medium are to be separated by accumulator bags, diaphragms or similar.

2.3.4 Connection between the hydraulic system used for operation of covers for deck openings and other hydraulic systems is permitted only with the consent of BKI.

2.3.5 Tanks forming part of the hydraulic system are to be fitted with oil level indicators.

2.3.6 The hydraulic fluids must be suitable for the intended ambient and service temperatures.

2.4 Hose assemblies

The construction of hose assemblies shall conform to the references given in [Section 1, C](#). The requirement that hose assemblies should be of flame-resistant construction may be set aside for hose lines in spaces not subject to a fire hazard and in systems not important to the safety of the ship.

2.5 Emergency operations

It is recommended that devices be fitted which are independent of the main system and which enable the covers to be opened and closed in the event of failure of the main system. Such devices may, for example, take the form of loose rings enabling covers to be moved by warping winches, etc.

3. Closing appliances in the yacht's shell

3.1 Scope

The following requirements apply to power equipment of hydraulically operated closing appliances in the yacht's shell such as shell doors and platforms at the yacht's side and stern.

3.2 Design and construction

3.2.1 The movement of the shell doors, etc. may not be initiated merely by starting of the pumps at the power station.

3.2.2 Local control, inaccessible to unauthorized persons, is to be provided for every closing appliance in the yacht's shell. As soon as the controls (pushbuttons, levers or similar) are released, movement of the appliance must stop immediately.

3.2.3 Closing appliances in the yacht's shell should normally be visible from the control station. If the movement cannot be observed, audible alarms are to be fitted. In addition, the control station is then to be equipped with indicators enabling the execution of the movement to be monitored.

3.2.4 Closing appliances in the yacht's shell are to be fitted with devices which prevent them from moving into their end positions at excessive speed. Such devices are not to cause the power unit to be switched off.

As far as is required, mechanical means must be provided for locking closing appliances in the open position.

3.2.5 Every power unit driving horizontally hinged or vertically operated closing appliances is to be fitted with throttle valves or similar devices to prevent sudden dropping of the closing appliance.

3.2.6 It is recommended that the driving power be shared between at least two mutually independent pump sets.

3.3 Pipes, hose assemblies

[2.3](#) and [2.4](#) are to be applied in analogous manner to the pipes and hose lines of hydraulically operated appliances in the yacht's shell.

4. Bulkhead closures

4.1 Scope

4.1.1 The following requirements apply to the power equipment of hydraulically-operated watertight bulkhead doors.

4.1.2 For the arrangement of bulkheads see [D.8](#).

4.2 Design

Bulkhead doors shall be power-driven sliding doors moving horizontally. Other designs require the approval of BKI and the provision of additional safety measures where necessary.

4.3 Piping

4.3.1 Where applicable, the pipes in hydraulic bulkhead closing systems are governed in 2.3, with the restriction that the use of flexible hoses is not permitted.

4.3.2 The hydraulic fluids must be suitable for the intended ambient and service temperatures.

4.4 Drive unit

4.4.1 A selector switch with the switch positions "local control" and "close all doors" is to be provided at the central control station on the bridge. Under normal conditions this switch should be set to "local control". In this position, the doors may be locally opened and closed without automatic closure.

In the "close all doors" position, all doors are closed automatically. They may be reopened by means of the local control device but must close again automatically as soon as the local door controls are released. It shall not be possible to open closed doors from the bridge.

4.4.2 Closed or open bulkhead doors shall not be set in motion automatically in the event of a power failure.

4.4.3 The control system is to be designed in such a way that an individual fault inside the control system, including the piping, does not have any adverse effect on the operation of the bulkhead doors.

4.4.4 The controls for the power drive are to be located at least 1,6 m above the floor on both sides of the bulkhead close to the doors. The controls are to be installed in such a way that a person passing through the door is able to hold both controls in the open condition.

The controls must return to their original position automatically when released.

4.4.5 The direction of movement of the controls is to be clearly marked and must be the same as the direction of the movement of the door.

4.4.6 In the event that an individual element fails inside the control system for the power drive, including the piping, but excluding the closing cylinders on the door or similar components, the operational ability of the manually-operated control system must not be impaired.

4.4.7 The movement of the power-driven bulkhead doors may not be initiated simply by switching on the drive units but only by actuating additional devices.

4.4.8 The control and monitoring equipment for the drive units is to be housed in the central control station on the bridge.

4.5 Manual control

4.5.1 Each door must have a manual control system which is independent of the power drive.

4.5.2 The manual control must be capable of being operated at the door from both sides of the bulkhead.

4.5.3 The controls must allow the door to be opened and closed.

4.6 Indicators

Visual indicators to show whether each bulkhead door is fully open or closed are to be installed at the central control station on the bridge.

4.7 Electrical equipment

For electrical equipment see [Section 1, D](#).

4.8 Alarms

Whilst all doors are being closed from the central control station, an audible alarm must be sounded.

5. Hoists

5.1 Scope

For the purpose of these requirements, hoists include hydraulically-operated appliances such as lifts and similar equipment.

5.2 Design and construction

5.2.1 Hoists may be supplied either by a combined power station or individually by several power stations.

In case of a combined power supply and of hydraulic drives whose piping system is connected to other hydraulic systems, a second pump unit is to be fitted.

5.2.2 The movement of hoists shall not be capable of being initiated merely by starting the pumps. The movement of the hoists is to be controlled from a special operating station. The controls are to be so arranged that, as soon as they are released, the movement of the hoist ceases immediately.

5.2.3 Local controls, inaccessible to unauthorized persons, are to be fitted. The movement of hoists should normally be visible from the operating station.

If the movement cannot be observed, audible and/or visual warning devices are to be fitted. In addition, the operating station is then to be equipped with indicators for monitoring the movement of the hoist.

5.2.4 Devices are to be fitted which prevent the hoist from reaching its end position at excessive speed. The devices are not to cause the power unit to be switched off. As far as necessary, mechanical means must be provided for locking the hoist in its end position.

If the locking devices cannot be observed from the operating station, a visual indicator is to be installed at the operating station to show the locking status.

5.2.5 [2.2.3](#) is to be applied in analogous manner to those devices which, if the power unit fails or a pipe ruptures, ensure that the hoist is slowly lowered.

6. Stabilizers

6.1 Scope

The following requirements apply to stabilizer drive units suitable for reducing the roll movement and for securing the safety of the ship.

6.2 Design and construction

6.2.1 Pipes of the hydraulic system are to be made of seamless or longitudinally welded steel tubes. The use of cold drawn, unannealed tubes is not permitted. At points where they are exposed to danger, copper pipes for control lines are to be provided with protective shielding and are safeguarded against hardening due to vibration by use of suitable fastenings.

6.2.2 High pressure hose assemblies may be used for short pipe connections subject to compliance with the references of [Section 1, C](#), if this is necessary due to vibrations or flexible mounting units.

6.2.3 The materials used for pressurized components including the seals must be suitable for the hydraulic oil in use.

6.2.4 The sealing arrangement at the penetration of the fin shaft through the yacht's shell has to be submitted for approval.

6.2.5 For retractable stabilizer fins the actual position has to be indicated at the bridge.

7. Tests and trials

7.1 Tests in the manufacturer's factory

7.1.1 Testing of power units

The power units are required to undergo testing on a test bed. Factory test certificates for this testing are to be presented at the final inspection of the hydraulic system.

7.1.2 Pressure and tightness tests

Pressure components are to undergo a pressure test.

The test pressures

$$p_c = 1,5 \cdot p$$

p = the maximum allowable working pressure [bar] or the pressure at which the relieve valves open. However, for working pressures above 200 bar the test pressure need not exceed $p + 100$ bar.

For pressure testing of pipes their valves and fittings, see references in [Section 1, C](#).

Tightness tests are to be performed on components to which this is appropriate at the discretion of Surveyor.

7.2 Shipboard trials

7.2.1 After installation on board, the equipment is to undergo an operational test.

7.2.2 The operational test of watertight doors has to include the emergency operating system and determination of closing time.

7.2.3 The operational efficiency of the stabilizer equipment is to be demonstrated during the sea trials.

F. Requirements for Helicopter Facilities

1. General

1.1 Scope

1.1.1 The following describes the requirements for the arrangement and the structures of helicopter landing deck, the arrangement of aviation fuel tanks and the necessary safety measures including fire extinguishing.

1.1.2 It is assumed that only one helicopter will be operated at a time. The landing deck is to be dimensioned for the largest helicopter type expected for helicopter operation. The characteristics of this helicopter type have to be defined clearly in the documents submitted for approval. It is assumed that the helicopter is parking on the open landing deck being safely lashed to the deck.

1.2 Hangar

If a helicopter hangar is provided, the additional requirements have to be defined case by case on the basis of other BKI Rules.

1.3 Operation manual

Each helicopter facility shall have an operation manual, including a description and a checklist of safety precautions, procedures and equipment requirements.

2. Arrangement of helicopter landing decks

2.1 Positioning of the landing deck

A helicopter landing deck shall be situated on an upper deck. If the helicopter deck is situated at the stern of the yacht with superstructures/deckhouses beforehand it is recommended that the angle of possible approaches should be at least 90° at each side of the yacht's longitudinal axis.

A location of permanently occupied spaces, like accommodation, messes, service spaces under the helicopter deck shall be avoided because of safety reasons. If this is not possible, then the landing deck has to be designed completely as a crash zone, see [3.2](#), load case LC 3.

2.2 Size of a landing deck

In establishing a landing area it is essential to ensure a safe correlation between:

- The sizes of helicopters expected to use the landing deck
- The dimensions of the aiming circle, clear zone and maneuvering zone and the permitted height of obstructions in these zones, see [Fig. 3.5](#)

The following three zones can be defined for a landing area:

– Aiming circle/touch down zone:

The aiming circle is an area concentric to the Centre of the clear zone and has a diameter half that of the clear zone itself. The circle shall accommodate with safety the landing gear of helicopters for which it is intended and shall therefore be completely obstruction free. If this is not possible, obstructions not higher than 0,1 m may be permissible.

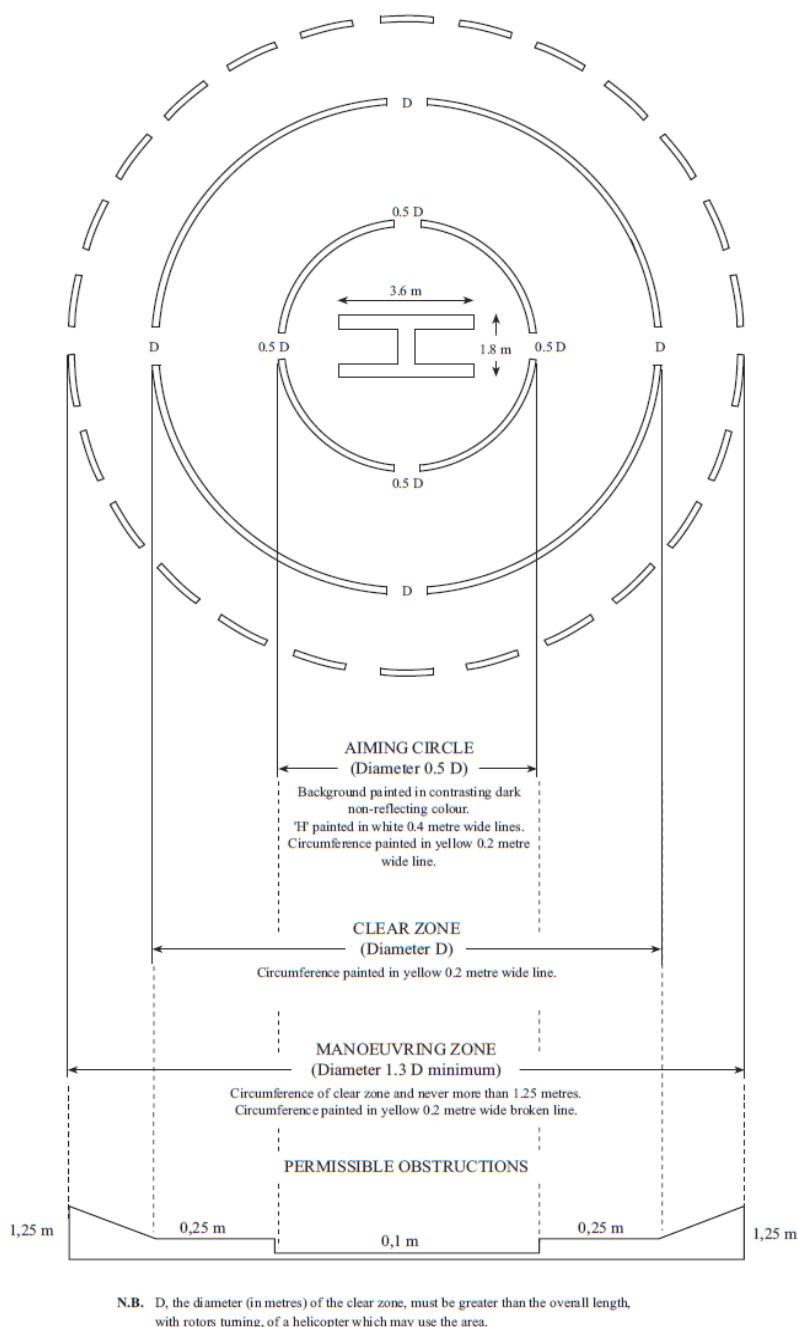


Fig. 3.5 Definition of a helicopter landing area

– **Clear zone:**

The clear zone shall be as large as possible recognising that its diameter D must be greater than the overall length with rotors turning, of a helicopter planned to use the landing area. There shall be no obstacles in the clear zone higher than 0,25 m.

– **Manoeuvring zone:**

The manoeuvring zone of the landing area extends the area in which the helicopter may manoeuvre with safety by enlarging, to a diameter of at least 1,3 D, the area over which the rotors of the helicopter may overhang without danger from high obstructions. If it is impossible to remove all obstacles from the manoeuvring zone, a graduated increase in permitted height of obstructions is defined in [Fig. 3.5](#).

Note

For the convenience of the users of these Rules reference is made to the "Guide to Helicopter/Ship Operations" published by the International Chamber of Shipping (ICS).

3. Landing deck structures

3.1 Design loads

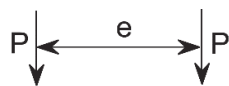
The following design load cases (LC) are to be considered:

3.1.1 LC 1

Helicopter lashed on deck, with the following vertical forces acting simultaneously:

- Wheel and/or skid force P acting at the points resulting from the lashing position and distribution of the wheels and/or supports according to helicopter construction.

$$P = 0,5 \cdot G (1 + a_v) \quad [\text{kN}]$$



G = maximum permissible take-off weight [kN]

P = evenly distributed force over the contact area $f = 30 \times 30$ cm for single wheel or according to data supplied by helicopter manufacturers; for dual wheels or skids to be determined individually in accordance with given dimensions.

e = wheel or skid distance according to helicopter types to be expected

a_v = $F \cdot m$

$$F = 0,11 \frac{v_0}{\sqrt{L}}$$

$$m = m_0 - 5(m_0 - 1) \frac{x}{L} \quad \text{for } 0 \leq \frac{x}{L} \leq 0,2$$

$$= 1 \quad \text{for } 0,2 < \frac{x}{L} \leq 0,7$$

$$= 1 + \frac{m_0 + 1}{0,3} \left(\frac{x}{L} - 0,7 \right) \quad \text{for } 0,7 < \frac{x}{L} \leq 1,0$$

$$m_0 = 1,5 + F$$

v_0 = see [Section 2, A.6.5](#)

- force due to weight of helicopter deck M_e as follows:

$$M_e (1 + a_v) \quad [\text{kN}]$$

- load $p = 2,0 \text{ kN/m}^2$ evenly distributed over the entire landing deck

3.1.2 LC 2

Helicopter lashed on deck, with the following horizontal and vertical forces acting simultaneously:

- Forces acting horizontally:

$$H = 0,6 (G + M_e) + W \quad [\text{Kn}]$$

W = Wind load, taking into account the lashed helicopter;
wind velocity $v_w = 50 \text{ m/s}$.

- Forces acting vertically:

$$V = G + M_e \quad [\text{kN}]$$

3.1.3 LC 3

Normal landing impact, with the following forces acting simultaneously:

- Wheel and/or skid load P at two points simultaneously, at an arbitrary (most unfavourable) point of the helicopter deck (landing zone + safety zone)

$$P = 0,75 G \quad [\text{kN}]$$

- Load $p = 0,5 \text{ kN/m}^2$ evenly distributed

(for taking into account snow or other environmental loads)

- Weight of the helicopter deck

- Wind load in accordance with the wind velocity admitted for helicopter operation (v_w), where no data are available, $v_w = 25 \text{ m/s}$ may be used.

3.2 Scantlings of structural members

3.2.1 Stresses and forces in the supporting structure are to be evaluated by means of direct calculations.

3.2.2 Permissible stresses for stiffeners, girders and substructure:

$$\sigma_{zul} = \frac{235}{k \cdot \lambda_f}$$

γ_f = Safety factors according to [Table 3.8](#).

Table 3.8 - Safety facto for heli deck structures γ_f

Structural element	γ_f	
	LC1, LC2	LC 3
Stiffeners (deck beam)	1,25	1,1
main girders (deck girder)	1,45	1,45
load-bearing structure (pillar system)	1,7	2,0

3.2.3 The thickness of deck plating for wheel loading is to be determined by the following formulae:

$$t = c \sqrt{P \cdot k} + t_K \quad [\text{mm}]$$

k = material factor, see [Section 2, B](#)

t_K = corrosion allowance, see [Section 2, G.2.2.2](#)

c = factor according to the following formulae:

- For the aspect ratio $b/a = 1$ and for the range $0 < \frac{f}{F} \leq 0,3$ (refer to Fig. 3.6) :

$$c = 1,87 - \sqrt{\frac{f}{F} \left[3,4 - 4,4 \frac{f}{F} \right]}$$

- For the aspect ratio $b/a = 1$ and the range $0,3 \leq \frac{f}{F} \leq 1,0$:

$$c = 1,2 - 0,4 \frac{f}{F}$$

- For the aspect ratio $b/a \geq 2,5$ and the range $0 < \frac{f}{F} < 0,3$:

$$c = 2,0 - \sqrt{\frac{f}{F} \left[5,12 - 7,2 \frac{f}{F} \right]}$$

- For the aspect ratio $b/a \geq 2,5$ and the range $0,3 < \frac{f}{F} < 1,0$:

$$c = 1,2 - 0,517 \frac{f}{F}$$

For intermediate values of b/a , the factor c is to be obtained by direct interpolation.

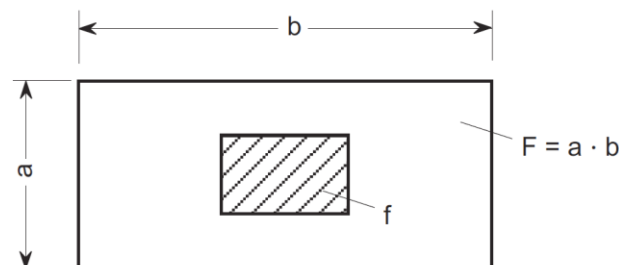


Fig. 3.6 Print area of wheel within plate panel

3.3 Materials

3.3.1 Helicopter landing decks shall be of steel or steel equivalent fire-resistant construction. If the space below the helicopter landing deck is a high fire risk space, adequate insulation has to be provided, see B.

3.3.2 If aluminium or other low melting metal construction that is not made equivalent to steel are permitted, the following provisions for helicopter decks above a deckhouse or similar structure shall be satisfied:

- The deckhouse top and the bulkheads under the platform shall have no openings.
- All windows under the platform shall be provided with steel shutters.
- The required fire-fighting equipment shall be provided according to 5. and be to satisfaction of the Administration.

- After each fire on the deck or in close proximity, the helicopter landing deck shall undergo a structural analysis to determine its suitability for further use.

4. Landing deck equipment

4.1 Landing deck sheathing

The landing deck sheathing has to comply with the following requirements:

- Resistant against increased mechanical impact at starting and landing procedure
- Resistant against aircraft fuel, hydraulic and lubricating oils
- Resistant against dry fire extinguishing powder and foams
- Resistant against defrosting expedient and salt
- Friction coefficient $\mu = 0,6$ at minimum

4.2 Helicopter fastenings

In the parking zone means have to be provided for lashing of the helicopter. It is recommended to provide one lashing point for about 2 m² of the landing deck. The lashing points have to be flush with the deck.

4.3 Personnel safety measures

4.3.1 Two means of escape have to be provided from the landing deck. They shall be situated at the maximum possible distance from each other.

4.3.2 A collapsible railing has to be provided at the perimeter of the landing deck. The railing shall follow the requirements for guardrails according to [A.2](#). The design shall be based on an outreach of 1,5 m at the folded down position, a mesh size of about 80 mm and a design load of at least 2,0 kN/m².

5. Fire extinguishing systems

5.1 In close proximity to the helicopter landing deck there shall be provided and stored near the means of access to that deck:

5.1.1 At least two dry powder extinguishers having a total capacity of not less than 45 kg;

5.1.2 CO₂-extinguishers of a total capacity of not less than 18 kg or equivalent;

5.1.3 A fixed low expansion foam system with monitors or foam making branch pipes capable of delivering foam to all parts of the helideck in all weather conditions in which helicopters can operate. The system shall be capable of delivering a discharge rate as required in [Table 3.9](#) for at least five minutes.

Table 3.9 Discharge rate of foam solution

Helicopter category	Overall length of helicopter l [m]	Discharge rate of foam solution [l/min]
H1	$l < 15$	250
H2	$15 \leq l < 24$	500

The foam agent shall meet the performance standards of ICAO 24 and be suitable for use with salt water.

5.1.4 At least two nozzles of dual-purpose type and hoses sufficient to reach any part of the helideck.

5.1.5 Two firemen's outfits in addition to those required by SOLAS or national regulations.

5.1.6 At least the following equipment, stored in a manner that provides for immediate use and protection from the elements:

- adjustable wrench
- blanket, fire resistant
- cutters bolt 600 mm
- hook, grab or salving
- hacksaw, heavy duty complete with 6 spare blades
- ladder
- life line 5 mm diameter × 15 m in length
- pliers, side cutting
- set of assorted screwdrivers
- harness knife complete with sheath

5.2 Drainage of the helicopter landing deck

Drainage facilities in way of helicopter landing decks shall be constructed of flame proof material/steel and lead directly overboard independent of any other system and designed so that drainage does not fall on to any part of the yacht.

6. Aviation fuel arrangement

6.1 General

The following requirements apply to aviation fuel with a flash point above or below 60 °C.

6.2 Storage

6.2.1 General

.1 For the storage of aviation fuel the general safety measures for fuel tanks are to be applied analogously, see [Section 1, C](#).

.2 The aviation fuel has to be stored in dedicated tank(s).

6.2.2 Arrangement of tanks

The arrangement of aviation fuel tanks has to comply with the following requirements:

- Tanks have to be located as remote as practicable from accommodation spaces, escape routes, embarkation stations and machinery spaces.
- Tanks have to be isolated by cofferdams from areas containing sources of ignition.
- No fuel tanks are to be arranged forward of the collision bulkhead.
- Aviation fuel tanks may not be arranged directly at the shell. They shall not have common boundaries with tanks not containing aviation fuel.

- The fuel storage area should be provided with arrangements whereby fuel spillage may be collected and drained to a safe location.

6.2.3 Tank equipment

- .1 The filling and outlet pipes, the sounding equipment, the mounting of devices and fittings as well as the ventilation and overflow equipment has to be provided in accordance with [Section 1, C](#).
- .2 If the flash point of the fuel is below 60 ° C the following requirements have to be complied with:
 - Venting pipes have to be provided with pressure vacuum valves and flame arrestors of approved type. The openings to the atmosphere have to be located at least 3 m away from any source of ignition, openings to accommodation, ventilation inlets and outlets.
 - Electrical equipment has to be explosion protected.

6.3 Fuel transfer system

6.3.1 General

- .1 For the handling of aviation fuel on board, separate piping systems are to be provided, which are not connected to other fuel systems. It is assumed that the refuelling is done on the helicopter landing deck.
- .2 The following functions are required:
 - filling of the yacht's aviation fuel tank(s)
 - discharging from any of the tanks via the connections, with the fuel transfer pump
 - transfer of fuel between any of the aviation fuel tanks, using the transfer pump, if applicable
 - refuelling of the helicopter from the aviation fuel tank, using the refuelling pump
 - flushing of the refuelling hoses to the aviation fuel tank

6.3.2 Piping and pumping arrangements

- .1 The tank outlet valve has to be directly at the tank. It has to be a quick-closing valve capable of being closed remote-controlled.
- .2 The piping and the valves have to be made of steel or equivalent material.

Piping connections have to be of approved type.
- .3 Compensators and hoses have to be of steel or have to be flame-resistant and have to be of approved type.
- .4 Piping and pumping arrangements have to be firmly connected with the hull structure.
- .5 The pump has to be able to be controlled from the refuelling station.
- .6 A relief device has to be provided which prevents over-pressure in the refuelling hose.
- .7 The following items have to be provided in the system:
 - fuel metering
 - fuel sampling
 - filters
 - water traps

6.4 Requirements for the room containing the pump and filter unit (pump room)

The following requirements have to be met:

- The bulkheads and decks have to be of steel and have to be insulated to "A 60" standard towards adjoining spaces.
- Access to the room is only permitted from the open deck. There is no access permitted to other spaces from this room.
- The room has to be provided with a fire detection system and a fixed fire extinguishing system which can be released from outside the room.
- The room has to be provided with a mechanical ventilation of the extraction type which is separate from any other ventilation system. The fans have to be of non-sparking design. The capacity of the ventilation has to be sufficient for 20 air changes per hour, based on the gross volume of the room.
- Inside the room only explosion protected equipment is permitted (IIA, T3).
- Drip trays have to be provided below components where leakages can occur.
- Outside the room, up to a distance of 3 m from openings to the room, possible sources of ignition and openings to other rooms containing possible sources of ignition are not permitted.
- An emergency shutdown of the pumps and release of the quick-closing valves have to be provided from a position located outside the pump room close to the refuelling station.

G. Systems for Breathing Gases and Diving

1. General rules and instructions

1.1 General

1.1.1 Especially the requirements for systems for breathing gases will be defined in the following.

1.1.2 The requirements defined in [G.](#) are valid for diving systems and systems for production, bottling and storage of breathing gases if they are to be classified by BKI.

1.1.3 If fixed diving systems are to be installed on board, such systems have to be manufactured and installed according to the [Rules for Underwater Technology](#)

1.1.4 For the installation of diving compression chambers the [Rules for Underwater Technology](#).

1.1.5 For the manufacturing and operating of underwater equipment the [Rules for Underwater Technology](#)

1.1.6 Designs differing from these Rules may be permitted provided their suitability has been verified by BKI and they have been recognized as equivalent. In these cases BKI is entitled to require the submission of additional documentation and the performance of special tests.

1.1.7 National regulations existing alongside the BKI Rules are unaffected.

1.2 Definitions

1.2.1 Breathing gases, breathing gas mixture

Breathing gases and breathing gas mixtures are all gases and gas mixtures which are used during diving missions respectively during use of breathing apparatus.

1.2.2 Bottles, gas cylinders

Bottles and gas cylinders are pressure vessels for the storage and transport of breathing gases under pressure.

1.2.3 Bottling plant

Bottling plants are used for filling of pressure vessels for breathing gases. This plant includes the complete equipment to fill the bottles. The plant begins immediately behind the closing valve at the pipeline for the gas to be bottled or at the suction socket of the transfer system.

1.2.4 Nitrox

Nitrox is a mixture of breathing gases from compressed air and oxygen with an oxygen content of above 22%.

1.3 Documents for approval

1.3.1 Before the start of manufacture, plans and drawings of all components subject to compulsory inspection, to the extent specified below, are to be submitted to BKI in electronic format:

- Piping diagrams, block diagrams and descriptions are to be furnished for the entire gas supply system and/or bottling plant.
- Description of compressors and compressor drives including longitudinal and transverse sectional drawings of the compressors.
- Drawings of pressure vessels and apparatus giving full details for appraising the safety of the equipment. Approvals of other institutions may be taken into consideration.

1.3.2 The drawings must contain all data necessary to check the equipment's design including information such as pressure ranges, set pressures of safety valves, etc. Wherever necessary, calculations relating to components and descriptions of the system are to be submitted.

1.4 Marking

1.4.1 Permanently installed gas bottles, gas containers and gas piping systems are, in addition, to be marked with a permanent colour code in accordance with [Table 3.10](#) and with the chemical symbol designating the type of gas concerned. The marking of gas bottles must be visible from the valve side.

1.4.2 Gas bottles, gas containers and gas piping systems for nitrox have to be marked separately with a colour code and have to be provided with the designation "Nitrox".

Table 3.10 Marking of gas systems

Type of gas	Chemical symbol	Colour code
Oxygen	O ₂	white
Nitrogen	N ₂	Black
Air	- - -	White & black

1.4.3 Manometers for oxygen and/or nitrox have to be marked as free of oil and grease.

2. Principles for the design and construction of systems for breathing gases

2.1 General principles

2.1.1 Bottling plants are to be constructed and operated in a way that the operating, control and maintenance personnel or other persons in the proximity of the plant are not endangered.

2.1.2 Pipe connections between pressured air bottling plants for the production of breathing gases and other compressed air systems on board are only to be established with special approval of BKI and under consideration of additional protection measures.

2.1.3 Pipelines carrying gas or oxygen under high pressure shall not be routed through accommodation spaces, engine rooms or similar compartments.

2.1.4 Pipelines for mixed gases containing more than 25 % oxygen are to be treated as pure oxygen lines.

2.1.5 Filling pipes and intermediate or coupling pieces of filling pipes must be suitable to be released of pressure without danger.

2.1.6 Filling connections are to be constructed or marked in a way that confusion of the gases to be filled is safely avoided and a correct connection can be established.

2.1.7 At the gas draw-off position the bottling plant has to be equipped with a manometer which shows the supply pressure.

2.2 Pressure vessels and apparatus

Pressure vessels and apparatus under pressure are to be designed and manufactured according to the reference in [Section 1, C](#).

2.3 Compressors

2.3.1 The compressors must be suitable for an operation on board of seagoing yachts and are to be operable under the actual operating and ambient conditions of the yacht.

2.3.2 Compressors are to be designed for the required delivery rates, types of gas and delivery pressures.

2.3.3 Compressors are to be so designed that no lubricating oil can penetrate the gas circuit.

2.3.4 Compressors are to be so installed that no harmful gases can be sucked in.

2.3.5 Oxygen compressors are to be installed in separate spaces with adequate ventilation.

2.3.6 Compressors must be equipped with adequately designed suction filters, coolers and water separators.

2.3.7 The breathing air produced by the compressors must fulfil the requirements of EN 12021. National regulations are unaffected from this.

2.3.8 Each compressor stage must be equipped with a pressure relief valve or rupture disc, neither of which can be disabled. This safety device must be designed and set in such a way that the specified pressure in the compressor stage concerned cannot be exceeded by more than 10 %. The setting must be safeguarded against unauthorized alteration.

2.3.9 Each compressor stage must be provided with a suitable pressure gauge indicating clearly the final pressure of that stage.

2.3.10 where a compressor stage comprises more than one cylinder and each cylinder can be closed off individually, a pressure relief valve and a pressure gauge must be provided for each cylinder.

2.3.11 Dry-running reciprocating compressors must be equipped at each stage with a device which activates a warning signal and shuts down the drive motor if the final compression temperature stated in the operating instructions is exceeded.

2.3.12 Diaphragm-type compressors must be equipped at each stage with a diaphragm rupture indicator which shuts down the compressor as soon as damage occurs to the drive or compressor diaphragm.

2.3.13 Marking

A manufacturer's data plate containing the following details must be permanently fixed to each compressor:

- type designation
- manufacturer's name
- serial number
- year of manufacture
- flow mass
- delivery pressure
- revolutions per minute

2.4 Piping systems

2.4.1 Piping systems are to be constructed and manufactured on the basis of standards generally used in shipbuilding.

As far as it is not defined in detail in the following, pipelines of bottling plants have to fulfil the requirements according to the reference in [Section 1, C](#).

2.4.2 Expansion in piping systems is to be compensated by pipe bends or compensators. Attention is to be given to the suitable location of fixed points.

2.4.3 Means must be provided for the complete evacuation, drainage and venting of pipelines.

2.4.4 Pipelines which in service may be subject to pressures higher than the design pressure must be fitted with overpressure protection.

2.4.5 The use of hoses is to be restricted to a minimum and only short length have to be installed.

2.5 Pipe connections

2.5.1 Wherever possible, pipes should be joined by full-penetration butt welds.

2.5.2 Screwed pipe connections may only be made using bite joints approved by BKI.

2.5.3 Flanged connections may be used provided that the flanges and flange bolts conform to a recognized standard.

2.6 Valves and fittings

2.6.1 Shut-off devices must conform to a recognized standard. Valves with screw-down bonnets or spindles are to be protected against unintentional unscrewing of the bonnet.

2.6.2 Manually operated shut-off devices are to be closed by turning in the clockwise direction.

2.6.3 Oxygen lines may only be fitted with screw down valves, although ball valves may be used for emergency shut-off purposes.

2.6.4 Hose fittings are to be made of corrosion resistant material and are to be so designed that they cannot be disconnected accidentally.

2.7 Materials

2.7.1 Materials must be suitable for the proposed application and must conform to [Rules for Materials \(Pt.1, Vol.V\)](#)

2.7.2 Welds are to conform to [Rules for Welding \(Pt.1, Vol.VI\)](#).

2.7.3 Materials for breathing gas systems shall not form any toxic or combustible products.

2.7.4 In oxygen systems, only those materials may be used which are approved for use with oxygen and which are suitable for the proposed operating conditions.

2.8 Electrical installation

The electrical installation has to meet the requirements of [Section 1, D](#). Systems for breathing gases are to be provided with a sufficient compensation of electrical potential.

2.9 Control and monitoring

Bottling plants for breathing gases have to be operated and monitored manually.

2.10 Additional requirements for breathing gas systems for nitrox and oxygen

2.10.1 Fittings for oxygen are to be constructed to avoid a burn-off or are to be so arranged or protected that the personnel can not be hurt in case of a burnoff.

2.10.2 Spindle valves for oxygen have to be constructed for a nominal diameter above 15 mm and operating pressures of more than 40 bar in a way that the spindle thread is outside of the gas space.

2.10.3 Tighting materials containing combustible elements and which come into contact with compressed gases with oxidizable effects are only approved for fittings if the suitability for the pressures, temperatures and type of installation is proven.

2.10.4 For oxygen armatures and fittings only lubricants are allowed which are approved for the actual operating conditions.

2.10.5 Hoses must be suitable for oxygen.

3. Fire protection and safety

3.1 Arrangement of systems for breathing gases

3.1.1 Production and bottling plants for breathing gases are not to be installed in areas where internal combustion engines or boilers are operated.

3.1.2 Production and bottling plants for breathing gases have to be installed with sufficient space for operation, maintenance and cleaning, for escape and safety routes as well as for fire-fighting.

3.1.3 Closed spaces for bottling plants are to be provided with a mechanical ventilation of at least 8 air changes per hour. The air must be sucked from an area which is not endangered by explosion.

3.1.4 Spaces where breathing gas systems for oxygen and/or nitrox are installed have to be provided with fire warning devices. Floor drainage has to be avoided.

3.1.5 Compressed gas from pressure release and safety devices has to be carried off safely.

3.2 Gas storage

3.2.1 The breathing gases have to be stored in a fixed gas storage or at a suitable place for gas cylinders.

3.2.2 Oxygen gas cylinders are to be stored at well ventilated locations, preferably in suitable cabinets at the open deck and shall not be stored near combustible materials.

3.2.3 Spaces in which oxygen is stored must be separated from the adjoining spaces by bulkheads and decks of an "A 60" class standard and must be arranged to facilitate speedy exit in case of danger.

Spaces where oxygen can penetrate are to be equipped with an oxygen monitoring device. The oxygen sensor has to be installed near the floor. As an alternative a monitored suction of the space air may be provided near the floor.

4. Tests and trials

4.1 General

Systems for breathing gases are subject to constructional and material tests as well as to pressure and tightness tests and trials. All the tests called for in the following are to be performed under BKI supervision.

4.2 Pressure vessels and apparatuses

Vessels and apparatuses under pressure are to be checked and tested according to the reference in [Section 1, C](#).

4.3 Compressors

4.3.1 Compressor components subject to pressure are to undergo a hydraulic pressure test at a test pressure equal to 1,5 times the delivery pressure of the compressor stage concerned.

4.3.2 On completion, compressors are to be subject to a tightness test at their maximum working pressure. In addition, a performance test is to be carried out in which the final moisture content and any possible contamination of the compressed gas are to be determined.

4.3.3 Compressor plants have to undergo a functional test after their completion, which has to include a check of the control, monitoring and safety equipment.

4.4 Pipes and fittings

4.4.1 After completion, but before insulation and painting all pipes and fittings have to undergo a pressure test with 1,5 times the design pressure.

4.4.2 Pipes and fittings for breathing gases and oxygen have to be cleaned before putting into operation and have to undergo a cleanness test.

4.4.3 For fittings in oxygen and/or nitrox lines the oxygen suitability has to be proven.

4.5 Hoses

4.5.1 The bursting pressure of each hose type has to be proven to BKI, whereby for gases at least 5 times the maximum permissible working pressure has to be endured.

4.5.2 Each hose is to be subjected to a hydraulic pressure test at least 2 times the maximum permissible working pressure.

4.6 Electrical equipment

Electrical machines, components, cables and lines as well as the electrical protection equipment are to be tested in the manufacturer's works in accordance with [Section 1, E](#).

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