RULES
FOR THE CLASSIFICATION OF SHIPS

Part 35 – YACHTS

January 2022

CROATIAN REGISTER OF SHIPPING

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By the decision of the General Committee of Croatian Register of Shipping,

RULES FOR THE CLASSIFICATION OF SHIPS
Part 1 – GENERAL REQUIREMENTS

have been adopted on 20th December 2021 and shall enter into force on 1st January 2022

This Part of the Rules includes the requirements of the following international Organisations:

International Maritime Organization (IMO)

Resolutions: A.654(16), A.951(23), A.952(23), A.1116(30), MSC.81(70), MSC.98(73) and MSC.307(88)

Circulars: MSC/Circ.1050, MSC/Circ.1176, MSC.1/Circ.1200, MSC.1/Circ.1276, MSC.1/Circ.1431 and MSC.1/Circ.1515.

Contents:

1 GENERAL

1.1 GENERAL REQUIREMENTS

1.1.1 This Part of the Rules for the classification of ships (hereinafter referred to as: the Rules) of CROATIAN REGISTER OF SHIPPING (hereinafter referred to as: the *Register*) applies to yachts of 24 meters in length and over and is specifying classification requirements for such vessels.

1.1.2 General provisions related to the classification with regard to classification survey, class notations, and classification procedure, as stipulated in the *Rules for the classification of ships, Part 1 – General requirements, Chapter 1 – General information, Sections 2, 3 and 4* respectively, shall be complied with, as far as applicable.

The classification of a yacht according to this Part of the Rules, and pertinent decisions and acts of the *Register*, do not absolve the client from compliance with any different, additional and/or more stringent statutory requirements, issued by the Flag State, and/or of the State of the base port from which the yachts operates.

In the case of discrepancy between the specific regulations of the Flag State (if available) and this Part of the Rules, the former shall apply.

1.1.3 The yacht complying with the classification requirements of this Part of the Rules will be assigned with the class notation **Charter yacht** or **Pleasure yacht**, as defined in the *Rules for the classification of ships, Part 1 – General requirements, Chapter 1 General information, Section 4*.

With regard to descriptive notation to be assigned to yachts intended to operate exclusively within 60 nautical from the nearest coast, land, island, with a port of refuge, or safe sheltered anchorage refer to the *Rules for the classification of ships, Part 1 – General requirements, Chapter 1 General information, Section 4*

1.2 APPLICATION

1.2.1 The requirements in this Part of the Rules apply for the classification of yachts, in commercial use (charter yachts) or used for pleasure, having length 24 meters and above.

If not stated otherwise, the requirements in this Part of the Rules apply to yachts in commercial use.

Relaxation of requirements for **Pleasure yachts** are explicitly specified, where applicable, within this Part of the Rules.

For yachts of less than 24 m in length refer to the *Rules for the classification of ships, Part 34 – Rules for the classification of vessels of less than 24 m in length.*

1.2.2 The application of this Part of the Rules to yachts with reinforced plastic hull, or thermoplastic, or wooden hull is generally limited to yachts of less than 500 GT. Yachts with GT above 500 may be considered by the *Register* on a case-by-case basis, depending on their specific operation and construction characteristics.

1.2.3 Vessel falling under the scope of HSC Code shall be reviewed under requirements of HSC Code.

1.2.4 Where necessary, in various Sections of the Rules, specific conditions relevant to the field of application of the requirements are given.

1.2.5 For the purpose of the assignment of additional class notations, the requirements of the *Rules for the classification of ships, Part 1 – General requirements, Chapter 1 – General information, Section 4* and *Chapter 6* shall be complied with, as far as practicable, at the discretion of the *Register*, concerning the navigation area, vessel type notation, vessel size, and hull structure material.

1.2.6 Where reference is made in this Part of the Rules to a paragraph, all the provisions of the subparagraphs of that designation shall apply.

1.2.7 Items not specified within the Rules are subject to special consideration by the *Register* in each particular case.

1.2.8 The *Register* may consider the classification of yachts based on or applying novel design principles or features, to which the Rules are not directly applicable, based on the experiments, calculations, or other supporting information provided to the *Register*. Any such specific restrictions or limitations may be indicated in the Certificate of class.

1.2.9 The *Register* may consider the use of other equivalent Rules or standards, subject to special consideration on a case-by-case basis.

1.3 DEFINITIONS

1.3.1 Definitions and explanations relating to the general terminology of the Rules are given in the *Rules, Part 1 – General requirements, Chapter 1 – General information, Section 2*.

For other definitions and explanations see other relevant Parts of the Rules.

1.3.2 For the purpose of this Part of the Rules the following definitions should apply unless expressly provided otherwise (in individual Sections of this Part of the Rules, or other applicable Parts of the Rules, and especially in the *Rules for the classification of ships, Part 2 – Hull, 1.2* and in the *Rules for the classification of ships, Part 4 – Stability*):

The definitions of the following terms are applicable throughout the Rules and as a rule, are not repeated in the different Sections of the Rules. Definitions applicable only to certain paragraphs are specified therein.

.1 **Aft perpendicular** (AP) - is the perpendicular at the intersection of the full load waterline with the after side of the rudder post or to the centre of the rudder stock for yachts without a rudder post. In yachts with unusual stern arrangements or without a rudder, the position of **AP** and the relevant L_{PP} will be specially considered.

.2 **Bulkhead deck** – is the complete deck:
- to which the main bulkheads and the yacht’s shell are made watertight, and
- whose the deck line at any point of the yacht length should not be submerged at the equilibrium in any stage of flooding for damage case defined in item 20.1.4 of this Part of the *Rules*.

A bulkhead deck may be a stepped deck. Normally, it is the uppermost complete deck exposed to weather and sea.

.3 **Deckhouse -** the deckhouse is a decked structure located above the main deck, with lateral walls inboard of the side of more than 4 per cent of the local breadth. Structure located on the main deck and whose walls are not in the same longitudinal plane as the underside shell may be regarded as a deckhouse.

.4 **Displacement** (Δ), in t, of the yacht at draught T.

.5 **Depth** (D), in metres, measured vertically on the transverse section at the middle of length L, from moulded base line to the top of the deck beam at side on the weather deck.

.6 **Depth** (D_1), in metres, measured vertically on the transverse section at the middle of length L, from the lower side of the bar keel, if any, or of the fixed ballast keel, if any, or of the drop keel, to the top of the deck beam at side on the weather deck.

.7 **Draught** (T), in metres, measured at the middle of length L, in metres, between the full load waterline and the lower side of the keel. In the case of hulls with a drop or ballast keel, the lower side of the keel is intended to mean the intersection of the longitudinal plane of symmetry with the continuation of the external surface of the hull.

.8 **Draught** (T_1), in metres, measured to the lower side - theoretically extended, if necessary, to the middle of length L - of the fixed ballast keel, where fitted, or the drop keel.

.9 **Fore perpendicular** (FP) - is the perpendicular at the intersection of the full load waterline with the fore side of the stem.

.10 **Hull -** the hull is the outer boundary of the enclosed spaces of the vessel, except for the deckhouses.

.11 **Length** (*L*) - means 96% of the total length on a waterline at 85% of the least moulded depth measured from the top of the keel, or the length from the foreside of the stem to the axis of the rudder stock on that waterline, if that be greater. In ships designed with a rake of keel, the waterline on which this length is measured shall be parallel to the designed waterline. The length (*L*) shall be measured in metres.

.12 **Length between perpendiculars** (L_{PP}) - is the distance, in m, measured on the full load waterline from **FP** to **AP**.

.13 **Lightship** - is the displacement of a fully equipped yacht in metric tonnes [t], but without any fuel, lubricating oil, ballast water, fresh water and feedwater in tanks, and without consumable stores, passengers and crew and their effects. Machinery and piping fluids, such as lubricants and hydraulics, at operating levels, shall be included in lightship.

.14 **Main deck -** the main deck is the uppermost complete deck of the hull. It may be stepped.

.15 **Maximum design speed** (V), in knots, of the yacht at displacement Δ.

.16 **Maximum outside breadth** (B), in metres.

.17 **Moulded base line** - the line parallel to the summer load waterline, crossing the upper side of keel plate or the top of skeg at the middle of length.

.18 **Recognized standards** - applicable international or national standards acceptable to the *Register*.

1.4 REQUIREMENTS FOR CERTIFICATION OF SHIPYARDS, MATERIALS AND EQUIPMENT

1.4.1 Vessel shall generally be produced by manufacturer who is approved by the *Register*. In case that manufacturer is not approved by the *Register*, acceptance of manufacturer is subject to special consideration, on case by case basis.

1.4.2 Materials and equipment shall be provided with the certificates deemed suitable by the *Register*, being either:

.1 product (unit) certificates and/or type approval certificates; or

.2 works certificates,

depending on the type of the vessel and type of materials and equipment.

Product (unit) certificate (or 3.2 certificate according to EN 10204) is generally required for the following materials and products:

- All materials to be used in hull and superstructure, including appendages and masts.
- Fixed fire extinguishing system.
- Rudder and rudder stock (if fitted).
- Watertight doors (if fitted).
- Anchors.
- Anchor chains
- Anchoring/mooring winch.
- Diesel engines with output power more than 130 [kW].
- Shell valves.
- Propeller shaft.
- Other main propelling, essential auxiliary machinery and the electrical equipment will be considered by the *Register* on a case by case basis, depending on equipment and vessel specific operation and construction characteristics.

Type approval is generally required for the following materials and products:

- welding electrodes (if applicable),
- weathertight doors,
- windows and portholes,
- hatch covers,
- fire divisions,
- materials having low flame spread characteristics,
- fire doors,
- fire dampers,
- fire detection system,

- fire pump,
- fire hydrants,
- fire hoses and nozzles,
- portable fire extinguishers,
- Diesel engines with output power more than 130 kW,
- Type approval for other main propelling, essential auxiliary machinery and the electrical equipment will be considered by the *Register* on a case by case basis, depending on equipment and vessel specific operation and construction characteristics.

Works certificate (3.1 according to EN 10204) is generally required for the following materials and products:

- bollards,
- anodes for cathodic protection,
- sails and riggings (if fitted),
- mooring ropes.

For each vessel, list of required certificates will be specified and agreed with the *Register* at the contractual phase.

*NOTE: * Not required for* ***Pleasure yachts****.*

Detail requirements for certification of materials and equipment may be specified at the beginning of each Section.

1.5 TECHNICAL DOCUMENTATION

1.5.1 Technical documentation is to enable understanding of the design and construction of the vessel and is to confirm compliance with the requirements given in this Part of the Rules.

The following technical data and documents shall be submitted to the *Register*, what is applicable:

General

- General arrangement plan.
- Lines plan.
- Tank arrangements.
- Capacity plan.

Hull, superstructure, and deckhouses

- Strength calculation of structural elements.
- Technology.
- Midship section (including main particulars, speed, materials and associated mechanical properties).
- Profile and decks.
- Longitudinal and transverse sections.
- Watertight bulkheads.
- Shell expansion.
- Lamination plan.
- Welding plan.
- Testing plan.
- Tanks structure.
- Tank testing plan.
- Machinery foundations.
- Deck equipment foundations.
- Superstructures and deckhouses including openings with sill heights, and their closing appliances.
- Bilge keel.
- Masts and riggings plan.
- Sails plan.

Hull equipment

- Hull appendages with their attachments to the hull, including material, and dimensions.
- Bottom plugs.
- Side fender.
- Rudder calculation
- Rudder and rudder stock.
- Hatchways, hatch covers and manholes including securing and tightening appliances.
- Equipment number calculation
- Anchoring and mooring equipment.
- Doors plan.
- Windows and portholes plan.
- Shell doors.
- Cathodic protection plan.

Stability and freeboard

- Trim and Stability Book.
- Inclining test report.
- Freeboard data.
- Damage stability calculation

Machinery

- Engine room arrangement.
- Bilge and ballast system diagram.
- Air, sounding, and overflow systems diagram.
- Cooling systems diagram.
- Fuel oil system diagram.
- Lubricating oil system diagram.
- Propeller.
- Gearing.
- Shaft line arrangement.
- Steering gear.
- Exhaust gas system.
- Ventilation system in machinery spaces.
- Compressed air system.
- Hydraulic and pneumatic control piping system.
- Fresh and drinking water piping system.
- Sanitary piping and discharges system.
- Ship side valves and fittings.
- Scheme of remote control of quick-closing valves.
- Waste water treatment system.

Electrical and automation

- Overall single line diagram.
- General arrangement plan of major electrical equipment.
- Control and monitoring system documentation.

Fire protection

- Structural fire protection, including means of escape.
- Ventilation.
- Fire detection.
- Fixed fire extinguishing system.
- Fire control plan.
- Penetrations plan.

Additional documentation which may be required for some vessel types are specified within relevant Sections. The *Register* reserves the right to require additional documentation if such documentation is deemed necessary.

General provisions related to submission and review of technical documentation, as stated in the *Rules for the classification of ships, Part 1 – General requirements,* *Chapter 2 – Survey during construction and initial survey, Section 1*, should be followed also, as far as applicable.

1.6 ARRANGEMENT PRINCIPLES

1.6.1 Accommodation and protection of persons on board

1.6.1.1 An adequate standard of accommodation for all persons on board should be provided, with primary concern directed towards ensuring the health and safety aspects of persons e.g. ventilation, lighting, noise, water services, galley services, sleeping accommodation, toilet facilities, stowage facilities, escape and access arrangements.

Controls and items to be operated in the emergency should be located in the accommodation area.

In addition to the above special attention should be paid to the means for the protection of persons on board related to fire hazards, hot surfaces, vessels under pressure, moving or rotating mechanical parts, carriage of dangerous and flammable goods, use of deck cranes, and other lifting appliances.

In some cases, and if available specific requirements of the Flag State should be observed.

1.6.1.2 Effective means of ventilation shall be provided to all enclosed spaces which are entered by persons.

In case of the air conditioning system is not fitted, mechanical ventilation should be provided to accommodation spaces, especially to passenger cabins and those situated below the main deck. As far as practicable, such ventilation arrangement should be designed to provide at least six changes of air per hour when access openings to spaces are closed.

Galleys and other spaces containing flammable liquids shall be vented independently from other spaces.

Ventilation inlets and outlets shall be as far as practicable from the engine exhaust.

Specific requirements of the Flag State, if available, should be taken into account.

1.6.1.3 Adequate sanitary toilet facilities shall be provided onboard.

Specific requirements of the Flag State should apply for the number and disposition of toilet facilities for passengers and crew.

Additional requirements regarding sewage pollution prevention should be taken into account (i.e. prohibition of direct overboard discharge, installation of sewage holding tanks, pumps, associated piping, and standard shore connection).

1.6.1.4 The installation of furniture shall be such as to allow adequate access to any part of the accommodation space. In particular, they shall not obstruct access to, or use of, any essential emergency equipment or means of escape. Additionally, furniture along escape routes shall be secured in place to prevent shifting if the yacht rolls or lists.

Seats and other furniture, and the structure in the proximity of the furniture, shall be of a form and design, and so arranged, such as to minimize the possibility of injury and to avoid trapping of the passengers. Dangerous projections and hard edges shall be eliminated or padded.

Specific requirements of the Flag State, if available, regarding accommodation outfitting shall be taken into account.

1.6.2 Steering position

1.6.2.1 The design and the layout of the steering position should be suitable for the intended use and not used for other purposes.

Disposition of the steering position, under normal conditions of use (speed and load), must ensure good all-round visibility.

Crew members at the steering position shall be provided with separate seats.

The steering position shall be equipped with the instrument and the equipment required by the Flag State.

1.7 SAFETY OF PERSONNEL

1.7.1 All areas above and below deck intended accessible to persons shall be equipped either with railings, bulwark, handholds of substantial design, or other means of safe grip.

External decks are normally to be surrounded by railing or bulwark having following characteristics:

- minimum 1000 [mm] height
- distance between vertical stanchions not more than 1.5 [m],
- vertical distance between the lowest course and the deck normally shall not exceed 230 [mm] and 380 [mm] elsewhere on decks other than external decks,
- the top rail shall have an ergonomic shape.

On **Pleasure yachts**, the height of bulwarks or rails (or combination of both) can be reduced to 900 [mm].

Also, in some cases of specific location and in the event that there is no danger to persons on board the *Register* may allow a lower height of bulwarks or rails.

1.7.2 The *Register* should be satisfied that the safety and stability of the vessel are not endangered with the disposition of lifting appliances and with lifting operations in general.

In general, lifting appliances should be designed, installed, and used in a way that prevents accidents and injuries, especially from rotating and moving parts.

All powered equipment, that upon use represents a danger to the operator if he is dragged towards or into the equipment during working operations, should be fitted with emergency stop safety devices activated by a single person.

Safety rules and operating instructions for lifting equipment shall be provided.

1.8 EQUIVALENT RULES AND STANDARDS

1.8.1 The *Register* may consider the use of other equivalent Rules or standards, subject to special consideration on a case-by-case basis.

1.8.2 Additional equivalent Rules and standards may be specified within each item.

1.9 FIELD SURVEY AT THE PREMISES OF THE SHIPBUILDER

1.9.1 General requirements for survey during construction, as stated in the *Rules for the classification of ships, Part 1 – General requirements, Chapter 2 – Survey during construction and initial survey, Section 1* shall apply, as far as applicable, but by taking into account any specific requirement contained in this Part of the Rules.

1.9.2 Stages of the construction to be attended by the *Register* (including any specific stages depending on the type of the hull structure material) shall be agreed with *Register* at the contractual phase.

1.10 ADMISSION TO CLASS OF EXISTING YACHTS

1.10.1 For existing yachts applying for admission to class of the *Register* provisions of the *Rules for the classification of ships, Part 1 – General requirements, Chapter 2 – Survey during construction and initial survey, Section 2* should apply.

1.11 PERIODICAL CLASS SURVEYS OF VESSELS IN SERVICE

1.11.1 Requirements stated in the *Rules for the classification of ships, Part 1 – General requirements, Chapter 5 – Survey of ships in service*, related to the scope and periodicity of periodical class surveys, including dry-docking survey, shall be complied with.

2 MATERIALS

2.1 GENERAL REQUIREMENTS

2.1.1 Metallic materials

2.1.1.1 Steel

2.1.1.1.1 All structural steel materials to be used in hull and superstructure shall be delivered with a 3.2 certificate (according to EN 10204).

2.1.1.1.2 Structural steel materials shall be weldable.

2.1.1.1.3 Structural steel materials shall have a yield point of not less than 235 MPa.

2.1.1.2 Aluminium alloys

2.1.1.2.1 All structural aluminium materials to be used in hull and superstructure shall be delivered with a 3.2 certificate (according to EN 10204).

2.1.1.2.2 Structural aluminium materials shall be weldable.

2.1.1.2.3 Structural aluminium material shall be resistant to corrosion in marine environments.

Acceptable alloy grades are: 5052, 5083, 5086, 5154A, 5383, 5454, 5754; 6005A,6060, 6061, 6063 and 6082.

The use of 6000-series aluminium alloys in direct contact with sea water may be restricted depending on application and corrosion protection system.

2.1.1.2.3 Aluminium alloys are generally not acceptable for forgings and castings. For these products, suitable materials according to recognized standards may be used.

2.1.2 Non-metallic materials

2.1.2.1 FRP

2.1.2.1.1 Raw materials for FRP structures shall be delivered under a certification scheme recognized by the *Register* or certified by an institution recognized by the *Register*. The following materials shall be certified:

- fibre reinforcements,
- resin products,
- sandwich core materials,
- sandwich adhesives and cement,
- adhesives (for adhesive bonding).

2.1.2.1.2 Each lot shall be marked with the manufacturers name, type designation, approval certificate reference, batch number and date of manufacture.

Products lacking the marking may be accepted, on case by case basis, only upon satisfactorily completion of product control testing acceptable to the *Register*.

2.1.2.2 Wood

2.1.2.2.1 Constructional timber and plywood shall be suitable for the marine environment.

Timber shall be free from sapwood, resin, cortex, splits, loose knots, insect attacks, rot or other imperfections that will have effect on the quality of the material.

2.1.2.3 Other structural materials

2.1.2.3.1 Other materials can be considered, based on a case by case evaluation.

2.2 JOINING OF METALLIC MATERIALS

2.2.1 Aluminium alloy materials

2.2.1.1 Joining of different materials shall not lead to galvanic corrosion. In joints, aluminium to another metal, the materials shall be galvanically insulated.

2.2.1.2 All welding shall take place under dry conditions and at a minimum temperature of 5 °C. The welding area shall be protected against drafts.

2.2.1.3 Welding of construction parts shall be done by a welder or supervised by a welder with approved certificate for the actual or similar alloy and method of welding. Welding procedures shall be approved by the *Register*.

2.2.1.4 Welding consumables shall be kept clean and dry and otherwise be stored and handled in accordance with the maker's recommendations.

2.2.1.5 Other type of joints, such as riveting and adhesive bonding, could be applied, subject to special approval by the *Register*.

2.2.1.6 Requirements of the *Rules for the classification of ships, Part 26 – Welding* and of the *Rules for the classification of ships, Part 2 – Hull, Section 15* generally applies, to the extent deemed necessary by the *Register*.

2.2.2 Steel materials

2.2.2.1 Shop primer used shall be of a type that is possible to weld without leaving any damaging effect to the strength of the welding.

2.2.2.2 Welding of construction parts shall be done by a welder or supervised by a welder with approved certificate for the actual or similar alloy and method of welding. Welding procedures shall be approved by the *Register*.

2.2.2.3 Welding consumables shall be kept clean and dry and otherwise be stored and handled in accordance with the maker's recommendations.

2.2.2.4 Other type of joints, such as riveting, could be applied, subject to special approval by the *Register*.

2.2.2.5 Requirements of the *Rules for the classification of ships, Part 26 – Welding* and of the *Rules for the classification of ships, Part 2 – Hull, Section 15* generally applies, to the extent deemed necessary by the *Register*.

2.3 FIBRE REINFORCED PLASTICS

2.3.1 Definitions

2.3.1.1 Laminate (reinforced plastic) is a composite material consisting mainly of two components, a matrix of thermosetting resin and of reinforcements.

2.3.1.2 Reinforcement (fibre) is a material which is encapsulated in the resin to increase its strength.

2.3.1.3 A single skin construction is considered to be a structure consisting of a FRP laminate supported and stiffened locally by a system of adequately spaced FRP stiffeners.

2.3.1.4 A sandwich construction is considered to be structural element consisting of a FRP skin laminate on each side of a low-density sandwich core.

2.3.2 Symbols

2.3.2.1 The following symbols are applied:

σ_{nu} = breaking strength of FRP laminate in tension or compression in MPa

E_n = modulus of elasticity of FRP laminate in tension or compression in MPa

σ_{bu} = breaking strength in bending of FRP laminate in MPa

E_b = modulus of elasticity in bending of FRP laminate in MPa

τ_u = breaking strength in shear of sandwich core material in MPa

$f_n = 80/\ \sigma_{nu}$ correction factor for strength

$f_b = 80/\ \sigma_{bu}$ correction factor for strength, bending

t = laminate thickness in mm, either for a single skin plate or a sandwich skin laminate

s = shortest panel edge for single skin and sandwich panels

b = load breadth for stiffening members in metres

l = span length of stiffening members in metres.

2.3.3 Materials for FRP structures

Fibre reinforcements other than glass fibre, carbon fibre and aramid fibre, resins other than polyester, vinyl ester and epoxy, and coatings other than gelcoat and topcoat, may be accepted based upon testing and approval in each individual case.

2.3.3.1 Resins

Resins may be used for laminating or for surface coating (gelcoat); the latter shall be compatible with the former, having mainly the purpose of protecting the laminate from external agents.

Polyester-orthophthalic type gelcoat and skincoat resins are not permitted.

The resins used are in general of the polyester, polyestervinylester or epoxide type; in any case, the resin is to have an ultimate elongation of not less than 3,0% if on the surface and 2,5% if in the laminate.

2.3.3.2 Additives

Resin additives (catalysts, accelerators, fillers, wax additives and colour pigments) shall be compatible with the resins and suitable for their curing process.

The Manufacturer's recommendations for the level of catalyst and accelerator to be mixed into the resins shall be followed.

The inert fillers are not to significantly alter the properties of the resin, with particular regard to the viscosity, and shall be carefully distributed in the resin itself in such a way that the laminates have the minimum mechanical properties stated in these requirements.

2.3.3.3 Reinforcements

The reinforcements taken into consideration in these requirements are mainly of fibres of three types: glass fibre, aramid type fibre and carbon type fibre.

2.3.3.3.1 Glass fibre

The glass generally used for the manufacture of reinforcements is that called type "E". Reinforcements manufactured in "S" type glass may also be used.

2.3.3.3.2 Aramid fibre

Reinforcements in aramid type fibres are generally used in

the form of roving or cloth of different weights (g/m^2). Such reinforcements can be used in the manufacture of hulls either alone or alternated with layers of mat or roving of "E" type glass.

2.3.3.3.3 Carbon-graphite fibres

Carbon-graphite type fibres means those which are at present

called "carbon" type, used in the form of products suitable to be incorporated as reinforcements by themselves or together with other materials like glass fibres or aramid type fibres, in resin matrices for the construction of structural laminates.

2.3.3.4 Core materials for sandwich laminates

The materials considered in these requirements are rigid expanded foam plastics polyurethane (PUR) and polyvinyl chloride (PVC) and balsa wood. The use of other materials will be taken into consideration on a case-by-case basis by *Register*.

2.3.3.5 Plywood

Plywood for structural applications shall be marine plywood type approved by the *Register*. Where it is used for the core of reinforcements or sandwich structures, the surfaces shall be suitably treated to enable the absorption of the resin and the adhesion of the laminate.

2.3.3.6 Timber

The use of timber is subject to special consideration by the *Register*. In general, the submitted drawings shall be amended with characteristics such as strength and density.

2.3.4 Mechanical properties of laminate

2.3.4.1 The requirements for structural laminates are based on the following minimum mechanical properties:

Tensile strength, σ_{nu} = 80 MPa

Tensile modulus, E_n = 7000 MPa

Bending strength, σ_{bu} = 130 Mpa

Bending modulus, E_b = 6000 Mpa.

2.3.4.2 The mechanical properties used for the scantling determination shall normally be derived from tests, these tests shall be conducted in accordance with the International Standards given below.

2.3.4.3 The test specimen shall be representative of the product as manufactured.

2.3.4.4 The mean value of the results from the tests shall comply with the requirements given in 5.1.7.1. No single value shall be less than 80% of the value used as basis for determination of scantlings.

2.3.4.5 The mechanical properties used in the calculations shall be:

- for strength, 90% of the mean ultimate strength,
- for elastic modulus, the mean value.

2.3.4.6 The fibre content by mass shall be at least 27% measured in accordance with ISO 1172. All individual test result values are to comply with the specified requirements.

2.3.4.7 Tensile strength, σn, and modulus, E_n, is determined in accordance with ISO 527. The test specimens should be taken in both directions.

2.3.4.8 Flexural strength, σb, and modulus, E_b, is determined in accordance with ISO 178. The test specimens should be taken in both directions.

2.3.5 Mechanical properties of sandwich core materials

2.3.5.1 For hull structural applications core material of Grade 1 is required. For the other applications Grade 2 may be accepted.

2.3.5.2 It shall be verified by shear testing in accordance with ISO 1922 or ASTM C 273 that the bonds between skin and core and between individual core elements have at least the same shear strength as specified for the core material in question.

2.3.5.3 The shear strength and modulus of core materials shall be specified and verified by testing in accordance with the above standards.

2.3.5.4 It shall be verified by four-point sandwich beam bending tests in accordance with ASTM C 393 that the applied sandwich adhesive does not crack or de-bond at a lower load level than the core materials itself.

2.3.5.5 The testing is normally to be carried out at 20°C, if considered necessary the testing may be required to be carried out at other representative operating temperatures.

2.4 WOOD

2.4.1 General

2.4.1.1 All exposed timber and plywood shall be given weathertight protection, such as paint, varnish or preservative, suitable for a marine environment.

2.4.1.2 Moisture content in constructional timber shall not be higher than 20%. Timber to be bonded by adhesive shall not have higher moisture content than 15 %.

Constructional timber to be used in hull- and deck- planking and for lamination of frames shall have straight grains and be quarter sawn.

2.4.1.3 Plywood to be used in hull and deck structure shall comply with BS 1088, BS 4079 or the other equivalent standard. The facing veneers shall have a good, solid surface free from visible defects.

Plywood to be used for non-structural application may be of a lesser quality than stated above, but the adhesive used shall comply with BS 1203 or equivalent standard.

2.4.1.4 Adhesives for timber and plywood shall comply with BS 1204 or the other equivalent standard.

2.4.2 Suitable timber species

2.4.2.1 The species of timber suitable for construction are listed in Table 1 together with the following details:

- commercial and scientific denomination;
- natural durability and ease of impregnation;
- average physical-mechanical characteristics at 12% moisture content.

The durability classes are relative to the solid timber's resistance to moulds.

The suitability for use in the various hull structures is given in Table 2.

The same species are suitable for the fabrication of marine plywood and lamellar structures in accordance with the provisions of Section 2.4.3 below.

The use of timber species other than those stated in Table 1 may be accepted provided that the characteristics of the species proposed are as similar as possible to those of one of the species listed.

2.4.3 Timber quality

2.4.3.1 Planking

2.4.3.1.1 The timber shall be well-seasoned, free from sapwood and any noxious organisms (moulds, insects, larvae, bacteria, etc.) which might impair its durability and structural efficiency.

The moisture content at the time of use shall be not greater than 20 % (according to the method UNI 8939 Planking - Check of batch moisture content).

Knots may be tolerated when they are intergrown, provided that their diameter is less than 1/5 of the dimension parallel to such diameter, measured on the section of the knot. The grain shall be straight (the maximum admissible inclination in relation to the longitudinal axis of the piece is equal to a ratio of 1:10).

NOTE 1: Timber with the above characteristics corresponds roughly to Class 1 of UNI 8198 (Conifer planking - Classification on the basis of mechanical resistance).

2.4.3.2 Marine plywood and lamellar structures

2.4.3.2.1 The suitable timber species and criteria for the use of alternative species are listed in Table 1.

For marine plywood, the elevated temperatures reached during drying and pressing rule out the possibility of survival of insects and larvae in the finished panels. Moreover, this factor contributes in enabling the marine plywood to have a lower moisture content than that of solid timber of the same species in the same ambient conditions, rendering it less prone to attacks of mould.

Therefore, assuming the same species of timber, the durability of marine plywood is greater than that of solid timber.

In any case, the thickness of the individual layers constituting the plywood or the lamellar structure shall be reduced in direct proportion to the durability of the species used; the maximum recommended thicknesses are listed in Table 1.

The minimum number of plywood layers used in the construction is 3 for thicknesses not greater than 6 mm and 5 for greater thicknesses.

The marine plywood adopted for hull construction and structural parts in general shall be type tested by the *Register* in accordance with the relevant regulations.

2.4.3.3 Certification and checks of timber quality

2.4.3.3.1 The quality of timber, plywood and lamellar structures shall be certified as complying with the provisions of 2.4.3.1 and 2.4.3.2 by the builder to the *Register's* Surveyor, who, in the event of doubts or objections, will verify the circumstances by performing appropriate checks.

Such certification is to refer to the checks carried out during building survey in the yard, relative to the following characteristics:

a) for solid timber: mass density and moisture content;
b) for plywood and lamellar structures: glueing test.

Such checks are not required for Quality Assurance material certified by the *Register* in pursuance of the relevant regulations.

2.4.3.4 Mechanical characteristics and structural scantlings

2.4.3.4.1 The structural scantlings indicated in Section 16 apply to timber with the following density δ, in kg/m^3, at a moisture content not exceeding 20%:

- bent frames: δ = 720
- non-bent frames keel and stem: δ = 640
- shell and deck planking, shelves and clamps, stringers and beams: δ = 560.

The scantlings given in Section 16 may be modified as a function of the density of the timber employed and its moisture content, in accordance with the relationship:

$$S1 = S / K$$

$$K = (\delta_e / \delta) + (U - U_e) * 0{,}02$$

S1 - corrected section (or linear dimension)

S - Rule section (or linear dimension), obtained in accordance with Section 16

δ - density of the timber species (or plywood) used;

δe - standard density of the timber species of reference;

U - standard moisture content percentage (20% for solid timber, 15% for plywood or lamellar structures);

δe - standard density of the timber species of reference;

U - standard moisture content percentage (20% for solid timber, 15% for plywood or lamellar structures);

Ue - maximum expected moisture content balance for the part considered, in service conditions.

Reductions in scantlings exceeding those obtained using the formulae above may be accepted on the basis of the mechanical base characteristics of the timber, plywood or lamellar structures actually employed.

Table 1: Basic physical/mechanical characteristics of timbers for construction

Commercial name	Origin (1)	Botanical name (2)	Mass density (kg/m^3)	Natural durability (3)	Ease of impregnation (3)	Mechanical characteristics (4)			
						Rf (N/mm^2)	Ef (N/mm^2)	Rc (N/mm^2)	Rt (N/mm^2)
DOUSSIE	Africa	Afzelia spp	800	A	4	114	16000	62	14,0
IROKO	Africa	Chlorophora excelsa	650	A/B	4	85	10000	52	12,0
KHAYA	Africa	Khaya spp	520	C	4	74	9600	44	10,0
MAKORE’	Africa	Tieghemella spp	660	A	4	86	9300	50	11,0
MAHOGANY	America	Swietenia spp	550	B	4	79	10300	46	8,5
OKOUME’	Africa	Aucoumea Kleineana	440	D	3	51	7800	27	6,7
ELM	Europe	Ulmus spp	650	D	2/3	89	10200	43	11,0
OAK	Europe	Quercus robur e Q. petraea	710	B	4	125	15600	68	13,0
SAPELE	Africa	Entandrophragma cylindricum	650	C	3	105	12500	56	15,7
SIPO	Africa	Entandrophragma utile	640	B/C	3/4	100	12000	53	15,0
TECK	Asia	Tectona grandis	680	A	4	100	10600	58	13,0
WHITE OAK	America	Quercus spp.	730	B/C	4	120	15000	65	12,6
CHESTNUT	Europe	Castanea spp.	600	B	4	59	8500	37	7,4
CEDAR (Western Red)	America	Thuja plicata	380	B/C	3	51	7600	31	6,8
DOUGLAS FIR	America	Pseudotsuga menziesil	500	C/D	3/4	85	13400	50	7,8
LARCH	Europe	Larix decidua	550	C/D	3/4	89	12800	52	9,4

Abbreviations:

Natural durability
- A = very durable
- B = durable (maximum permissible thickness for the fabrication of marine plywood 5 mm)
- C = not very durable (maximum permissible thickness for the fabrication of marine plywood 2,5 mm)
- D = not durable (maximum permissible thickness for the fabrication of marine plywood 2 mm)

Ease of treatment for impregnation
- 1 = permeable
- 2 = not very resistant
- 3 = resistant
- 4 = very resistant

NOTE:

(1) Area of natural growth

(2) Unified botanical name (spp. = different species)

(3) Level of natural durability and ease of treatment for impregnation according to Standard EN 350/2

(4) Mechanical characteristics with 12% moisture content, source: Wood Handbook: wood as an engineering material - 1987, USDA
- Ultimate flexural strength Rf (strength concentrated amidships)
- Bending modulus of elasticity Ef (strength concentrated amidships)
- Ultimate compression strength Rc (parallel to the grain)
- Ultimate shear strength Rt (parallel to the grain).

Table 2: Guide for selections of construction timbers

	SPECIES OF TIMBER										
STRUCTURAL ITEM	**Douglas**	**Cedar (red)**	**Iroko**	**Larch**	**Makore**	**Mahogany**	**Elm English**	**White oak**	**Oak**	**Sapeli**	**Teak**
Keel, hog, sternpost, deadwoods			II		II	II	II	II	II	III	I
Stern					II	II	II	II	II	III	I
Bilge stringer	III			II				II		III	I
Beam shelves, clamps waterways	III		II	II				II	II	III	I
Floors					II	II	II	II	II		I
Frames grown or web frames				II **(2)**	II			II **(1)**	II **(1)**	III	I
Frames, bent frames								II **(1)**	II **(1)**		
Planking below waterline	III		II	II		II		II	II	III	I
Planking above water-line	III		II	III		II		II		III	I
Deck planking	II	III	II								I
Beams, bottom girders	II			II	II **(2)**	II **(2)**		II **(1)**	II **(1)**		I
Brackets vertical				II				II **(1)**	II		
Bracket horizontal				II				I	I		
Gunwale margin planks			II			II		II	II		

NOTE:
(1) The timber concerned may be employed either in natural or laminated form.
(2) The timber may be employed only in laminated form. Suitability of timber for use:
I = very suitable
II = fairly suitable
III = hardly suitable

2.5 COMBINATION OF THE STRUCTURAL MATERIALS

2.5.1 Yachts built using a combination of the materials specified in this Section, i.e. when hull and superstructure are made of different materials, are subject to the applicable requirements of all relevant Sections.

Connections between different materials are subject of special consideration by the *Register*.

2.6 OTHER MATERIALS

2.6.1 Buoyancy materials

2.6.1.1 Buoyancy material is a low-density material, e.g. foam with a specific gravity of less than 1.0, which provides buoyancy to the vessel when flooded.

2.6.1.2 The water absorption of buoyancy materials shall not exceed 8 % by volume after being submerged for 8 days according to ISO 2896 or other equivalent standard, such as IMO Resolution MSC.81(70).

2.6.1.3 Buoyancy materials shall be resistant to liquids, e.g. petrol fuel. The requirement may be omitted if the material is totally encapsulated when fitted.

2.6.2 Other materials

2.6.2.1 Requirements of the *Rules for the classification of ships, Part 24 – Non-metallic materials*, *Part 25- Metallic materials* and *Part 26 – Welding* may be applied, to the extent deemed necessary by the *Register*.

3 DESIGN PRINCIPLES AND DESIGN LOADS

3.1 DESIGN PRINCIPLES

3.1.1 Strength calculations shall be submitted, in order to demonstrate that stresses are within required limits.

See 1.6.1 for required documentation for hull, superstructure and deckhouses.

The *Register* may require direct calculations to be carried out, if deemed necessary. Direct calculations (such as FEM analysis) are generally acceptable for compliance with requirements of this Section.

Such calculations shall be carried out based on structural modelling, loading and checking criteria accepted by the *Register*.

Longitudinal strength calculations shall be submitted for yachts of length of 65 m and greater, following requirements in *Rules for the classification of ships, Part 2 – Hull, Section 4*.

Strenghtening for navigation in ice shall be in compliance with requirements of *Rules for the classification of ships, Part 29 - Rules for classification of Polar Class ships and Ice Class ships.*

3.1.2 Equivalency

In lieu of complying with requirements of Section, the *Register* may accept compliance with other equivalent Rules, subject to special consideration by the *Register* in each particular case.

3.1.3 Units

Unless otherwise specified, the following units are used in the Rules:

- thickness of plating, in mm,
- section modulus of stiffeners, in cm^3,
- shear area of stiffeners, in cm^2,
- span and spacing of stiffeners, in m,
- stresses, in N/mm^2,
- concentrated loads, in kN,
- distributed loads, in kN/m or kN/m^2.

3.1.4 Local reinforcements

Structure with local loads from deck-gears, foundations, fenders, etc. shall be reinforced for the actual loads.

Forces from cranes shall be multiplied by a factor 1.4.

Glass reinforced plastics and wooden vessels shall be reinforced in areas of local wear.

3.1.5 For additional design principles for yachts made of steel and/or aluminium alloy see also *Rules for the classification of ships, Part 2 – Hull,* 2.1 to 2.8.

3.2 DESIGN LOADS

3.2.1 General

3.2.1.1 This item provides data regarding design loads for determining the scantlings of the hull structural elements by means of the design formulae given in the following Sections or by means of direct calculations. Guidelines for direct calculations of ship structure are given in *Rules for the classification of ships, Part 2 – Hull, Annex D*.

3.2.1.2 Definitions

3.2.1.2.1 Load centre:

a) For plates:
   - vertical stiffening system: 0,5 x stiffener spacing above the lower support of plate field, or lower edge of plate when the thickness changes within the plate field;
   - horizontal stiffening system:
   - midpoint of plate field.

b) For stiffeners and girders:
   - centre of span l.

3.2.1.2.2 Definition of symbols:

v = ship's speed [knots], at summer water line in

calm water;

ρ = density of liquids, [t/m^3];

ρ = 1,025 t/m^3 for fresh and sea water;

z = vertical distance of the structure's load centre above base line, [m];

x = distance from aft end of length L, in [m];

C_b = block coefficient;

p_o = $2{,}1\,(C_b + 0{,}7) \cdot C_w \cdot C_L \cdot f$, [kN/m^2], basic external load for;

$$C_w = \frac{L}{25} + 4{,}1, \text{ for } L < 90 \text{ [m]}$$

$$C_w = 10{,}75 - \left(\frac{300 - L}{100}\right)^{1{,}5}, \text{ for } 90 \le L \le 300 \text{ m}$$

$$C_L = \sqrt{\frac{L}{90}}, \text{ for } L < 90 \text{ m};$$

C_L = 1,0, for $L \ge 90$ m;

f = 1 for shell plating and weather deck;

f = 0,75 for frames and deck beams;

f = 0,60 for web frames, stringers and grillage systems.

NOTE: For restricted service areas these values p_o may be decrease, as follows:

10% for service range 2;

25% for service range 3.

3.2.2 External sea loads

3.2.2.1 Load on weather deck

3.2.2.1.1 The load on weather decks shall be determined according to the following formula:

$$p_D = p_o \frac{20 \cdot d}{(10 + z - d) \cdot D} \cdot C_a, \quad [\text{kN/m}^2]$$

where:

C_a = factor depending of the longitudinal position according to Table 3.2.2.1.1.

Table 3.2.2.1.1

Range	Coefficient C_a
$0 \leq \frac{x}{L} < 0{,}2$	$1{,}2 - \frac{x}{L}$
$0{,}2 \leq \frac{x}{L} \leq 0{,}7$	1,0
$0{,}7 \leq \frac{x}{L} \leq 1{,}0$	$1{,}0 + \frac{C}{3}\left(\frac{x}{L} - 0{,}7\right)$ $C = 0{,}15 \cdot L - 10$ $100 \text{ m} \leq L \leq 250 \text{ m}$

3.2.2.1.2 For strength deck which shall be treated as weather decks as well as for forecastle decks the load is not to be less than the greater of the following two values:

p_{Dmin} = $12 \cdot f$, [kN/m²];

or

p_{Dmin} = $0{,}7 \cdot p_o$, [kN/m²]

f = according to 3.2.1.2.2.

3.2.2.2 Load on ship's sides and of bow structures

3.2.2.2.1 Load on ship's sides

The external load on the ship's sides shall be determined according to the following formulae:

a) For elements the load centre of which is located below load waterline:

$$p_s = 10\,(d - z) + p_o \cdot C_F \left(1 + \frac{z}{d}\right), [\text{kN/m}^2];$$

b) For elements the load centre of which is located above load waterline:

$$p_s = p_o \cdot C_F \frac{20}{10 + z - d}, \quad [\text{kN/m}^2];$$

C_F = factor depending of the longitudinal position according to Table 3.2.2.2.1;

Table 3.2.2.2.1

Range	Coefficient C_F
$0 \leq \frac{x}{L} < 0{,}2$ 1)	$1{,}0 + \frac{5}{C_b}\left(0{,}2 - \frac{x}{L}\right)$
$0{,}2 \leq \frac{x}{L} < 07$	1,0
$0{,}7 \leq \frac{x}{L} \leq 1{,}0$ 2)	$1{,}0 + \frac{20}{C_b}\left(\frac{x}{L} - 0{,}7\right)^2$

1) $\frac{x}{L}$ need not be taken less than 0,1

2) $\frac{x}{L}$ need not be taken greater than 0,93

3.2.2.2.2 Load on bow structures

The design load for bow structures from forward to $0{,}1 \cdot L$ behind **F.P.** and above the ballast waterline in accordance with the draft d_b in 3.2.2.4 shall be determined according to the following formula:

p_e = $c\,(0{,}2 \cdot v + 0{,}6 \cdot \sqrt{L}\,)^2$ [kN/m²]

L_{max} = 200 m

c = 0,8 in general.

$c = \frac{0{,}45}{1{,}2 - 1{,}09 \cdot \sin\alpha}$, for extremely flared sides

where the flare angle α is larger than 40°.

The flare angle at the load centre shall be measured in the plane of frame between a vertical line and the tangent to the side shell plating, see Fig. 3.2.2.2.2.

For unusual bow shapes p_e can be specially considered.

p_e must not be smaller than p_s according to 3.2.2.2.1.

Aft of $0{,}1 \cdot L$ from **F.P.** up to $0{,}15 \cdot L$ from **F.P.** the pressure between p_e and p_s shall be graded steadily.

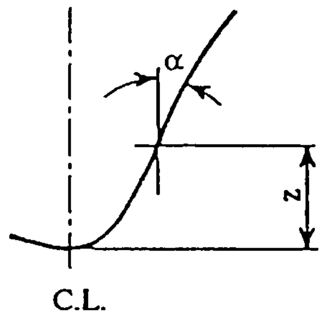


Figure 3.2.2.2.2

3.2.2.2.3 Load on stern structure

The design load for stern structures from the aft end to 0,1 L forward of the aft end of L and above the smallest design ballast draught at **A.P.** up to $d + C_w/2$ shall be determined according to the following formula:

p_e = $c_A \cdot L$ [kN/m²]

c_A = $0{,}3 \cdot c \geq 0{,}36$

c = see 3.2.2.2

L_{max} = 200 m.

p_e must not be smaller than p_s according to 3.2.2.2.1.

3.2.2.3 Load on the ship's bottom

The external load p_B of the ship's bottom shall be determined according to the following formula:

$p_B = 10 \cdot d + p_o \cdot C_F$ [kN/m²],

where:

C_F = see Table 3.2.2.2.1

3.2.2.4 Design slamming pressure

The design slamming pressure may be determined by the following formulae:

$p_{SL} = 162\sqrt{L} \cdot C_1 \cdot C_2 \cdot C_{SL}$, [kN/m²], for $L \leq 150$ [m];

$p_{SL} = 1984\ (1{,}3 - 0{,}002\ L)\ C_1 \cdot C_2 \cdot C_{SL}$, [kN/m²], for $L > 150$ [m]

where:

$$C_1 = 3{,}6 - 6{,}5 \left(\frac{d_b}{L}\right)^{0{,}2}$$

C_{1max} = 1,0

d_b = the smallest design ballast draught at F.P for normal ballast conditions, in [m];

Where the sequential method for ballast water exchange is intended to be applied, d_b shall be considered for the sequence of exchange.

$C_2 = 10/A$

A = loaded area between the supports of the structure considered, in [m²];

C_2 = 1,0, for plate panels and stiffeners;
$0{,}3 \leq C_2 \leq 1{,}0$ generally;

C_{SL} = distribution factor, see Figure 3.2.2.4.

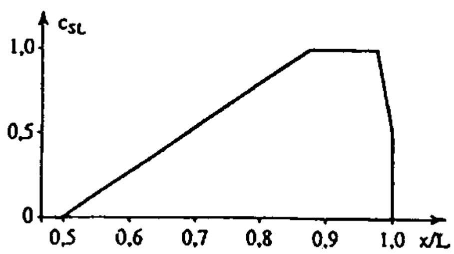


Figure 3.2.2.4

$$C_{SL} = 0, \text{ for } \frac{x}{L} \leq 0{,}5$$

$$C_{SL} = \frac{\frac{x}{L} - 0.5}{C_3}, \text{ for } 0{,}5 \leq \frac{x}{L} \leq 0{,}5 + C_3$$

$$C_{SL} = 1{,}0 \text{ for } 0{,}5 + C_3 \leq \frac{x}{L} \leq 0{,}65 + C_3$$

$$C_{SL} = 0{,}5 \cdot \left[1 + \frac{1 - \frac{x}{L}}{0{,}35 - C_3}\right], \text{for } \frac{x}{L} > 0{,}65 + C_3$$

$$C_3 = 0{,}33 \cdot C_b + \frac{L}{2500}$$

C_{3max} = 0,35

NOTE: For restricted service areas these values p_{SL} may be decrease, as follows:

5% for service range 2

12,5% for service range 3, 4

3.2.2.5 Load on decks of superstructures and deckhouses

3.2.2.5.1 The load on exposed decks and parts of superstructure and deckhouse decks, which are not to be treated as strength deck, shall be determined as follows:

$p_{DA} = p_D \cdot n$, in [kN/m²]

where:

p_D = according to 3.2.2.1.1;

$$n = 1 - \frac{z - D}{10};$$

n_{min} = 0,5;

n = 1,0 for the forecastle deck.

For deckhouses the value so determined may be multiplied by the factor:

$$\left(0{,}7\ \frac{b'}{B'} + 0{,}3\right)$$

b' = breadth of deckhouse;

B' = largest breadth of ship at the position considered.

Except for the forecastle deck the minimum load is:

p_{DAmin} = 4 kN/m².

For exposed wheel house tops the load is not to be taken less than:

p = 2,5 kN/m².

3.2.3 Load on accommodation decks

3.2.3.1 Loads on accommodation and machinery decks

The deck load in accommodation and service spaces is:

$p = 3{,}5\ (1 + a_v)$, [kN/m²]

The deck load of machinery decks is:

$p = 8\ (1 + a_v)$, [kN/m²]

3.2.3.2 Significant single forces are also to be considered, if necessary.

3.2.4 Load on tank structures

3.2.4.1 Design pressure for filled tanks

3.2.4.1.1 The design pressure for service conditions is the greater of the following values:

$p_1 = 9{,}81 \cdot h_1 \cdot \rho + 100 \cdot p_v$ [kN/m^2],

or

$p_1 = 9{,}81 \cdot \rho \cdot [h_1 \cdot \cos\varphi + (0{,}3 \cdot b + y) \cdot \sin\varphi] + 100 \cdot p_v$ [kN/m^2]

where:

h_1 = distance of load centre from tank top, in [m];

φ = design heeling angle, [°], for tanks;

= $\arctan\left(f_{bk} \cdot \frac{D}{B}\right)$, in general;

f_{bk} = 0,5 for yachts with bilge keel

= 0,6 for yachts without bilge keel

$\varphi \geq 20°$ for hatch covers of holds carrying liquids

b = upper breadth of tank, [m];

y = distance of load centre from the vertical longitudinal central plane of tank, [m];

p_v = set pressure of pressure relief valve, [bar], (if a pressure relief valve is fitted);

p_{vmin} = 0,1 bar (1,0 mSV), during ballast water exchange for both, the sequential method as well as the flow-through method;

mSV = metre of head water.

3.2.4.1.2 The maximum static design pressure is:

$p_2 = 9{,}81 \cdot h_2$, [kN/m^2]

h_2 = distance of load centre from top of overflow or from a point 2,5 m above tank top, whichever is the greater.

For tanks equipped with pressure relief valves and/or for tanks intended to carry liquids of a density greater than 1 t/m^3, the head h_2 is at least to be measured to a level at the following distance h_p above tank top:

$h_p = 2{,}5 \cdot \rho$ [mSV], head of water, [m], or

$h_p = 9{,}81 \cdot p_v$ [mSV], where $p_v > 0{,}25 \cdot \rho$.

Regarding the design pressure of fuel tanks and ballast tanks which are connected to an overflow system, the dynamic pressure increase due to the overflowing shall be taken into account in addition to the static pressure height up to the highest point of the overflow system.

3.2.4.2 Design pressure for partially filled tanks

3.2.4.2.1 For tanks which may be partially filled between 20% and 90% of their height, the design pressure is not to be taken less than given by the following formulae:

a) For structures located within $l_t/4$ from the bulkheads limiting the free liquid surface in the ship's longitudinal direction:

$$p_d = \left[4 - \frac{L}{150}\right] l_t \cdot \rho \cdot n_x + 100 \cdot p_v \text{[kN/m}^2\text{];}$$

b) For structures located within $b_t/4$ from the bulkheads limiting the free liquid surface in the ship's transverse direction:

$$p_d = \left[5{,}5 - \frac{B}{20}\right] b_t \cdot \rho \cdot n_y + 100 \cdot p_v \quad \text{[k/Nm}^2\text{],}$$

where:

l_t = distance, in [m], between transverse bulkheads or effective transverse wash bulkheads at the height where the structure is located;

b_t = distance in, [m], between tank sides or effective longitudinal wash bulkhead at the height where the structure is located;

$$n_x = 1 - \frac{4}{l_t} \cdot x_1$$

$$n_y = 1 - \frac{4}{b_t} \cdot y_1$$

x_1 = distance of structural element from the tank's ends in the ship's longitudinal direction, in [m];

y_1 = distance of structural element from the tank's sides in the ship's transverse direction, in [m].

3.2.4.2.2 For tanks with ratios $l_t/L > 0{,}1$ or $b_t/B > 0{,}6$ a direct calculation of the pressure p_d may be required.

3.2.5 Design values of acceleration components

3.2.5.1 Acceleration components

The following formulae may be taken when calculating the acceleration components owing to ship's motions:

- Vertical acceleration (vertical to the base line) due to heave and pitch:

$$a_z = \pm a_o \sqrt{1 + \left[5{,}3 - \frac{45}{L}\right]^2 \left[\frac{x}{L} - 0{,}45\right]^2 \left[\frac{0{,}6}{C_b}\right]^{1{,}5}}$$

- Transverse acceleration (vertical to the ship's side) due to sway, yaw and roll including gravity component of roll:

$$a_y = \pm a_o \sqrt{0{,}6 + 2{,}5 \left[\frac{x}{L} - 0{,}45\right]^2 + k\left[1 + 0{,}6 \cdot k\,\frac{z - d}{B}\right]^2}$$

- Longitudinal acceleration (in longitudinal direction) due to surge and pitch including gravity component of pitch:

$$a_x = \pm a_o \sqrt{0{,}06 + A^2 - 0{,}25\,A}$$

where:

a_x, a_y, a_z = maximum dimensionless accelerations (i.e., relative to the acceleration of gravity g) in the related directions x, y and z.

$$A = \left[0{,}7 - \frac{L}{1200} + 5\,\frac{z - d}{L}\right] \frac{0{,}6}{C_b};$$

$$a_o = \left[0{,}2 \ \frac{v}{\sqrt{L}} + \frac{3 \cdot C_w \cdot C_L}{L} \right] \cdot f \ ;$$

$$k = 13 \ \frac{\overline{GM}}{B} \ ;$$

$\overline{G}\overline{M}$ = metacentric height, in [m];

k_{min} = 1,0;

C_w = wave coefficient, see 3.2.1.2.2;

C_L = length coefficient, see 3.2.1.2.2

f = factor depending on probability level Q as outlined in Table 3.2.5.1;

L = not to be taken less than 100 m.

Table 3.2.5.1

Q	***f***
10^{-8}	1,000
10^{-7}	0,875
10^{-6}	0,750
10^{-5}	0,625
10^{-4}	0,500

4 STEEL AND ALUMINIUM ALLOY STRUCTURES

4.1 GENERAL

4.1.1 The materials used for hull structures regulated by this Section are to comply with the *Rules for the classification of ships, Part 25 - Metallic materials* and *Part 26 - Welding*.

Manufacturing of the materials has to be supervised by the *Register*.

4.1.2 Requirements for the dimensioning of steel and aluminium alloy structural elements are given in Sections 5 to 13.

4.2 HULL STRUCTURAL STEEL

4.2.1 Material factor, *k*,

For normal hull structural steel with yield strength R_{eH} = 235 N/mm^2 and a tensile strength R_m of 400 – 520 N/mm^2, the material factor, *k*, in the formulae of the following Sections shall be taken 1,0.

The material factor, *k*, for groups of higher tensile hull structural steel is defined as follows:

k = 0,78, for steel with R_{eH} = 315 N/mm^2,

k = 0,72, for steel with R_{eH} = 355 N/mm^2,

k =0,66, for steel with R_{eH} = 390 N/mm^2 provided that a fatigue assessment of the structure is performed to verify compliance with the requirements of the *Register*,

k =0,68, for steel with R_{eH} = 390 N/mm^2 in other cases.

For higher tensile hull structural steel with other nominal yield strength (235 < R_{eH} < 390 N/mm^2 and $R_{eH} \neq$ 315 or 355 N/mm^2), the material factor *k* may be determined by the following formula:

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

4.2.2 Forged steel and cast steel

Forged steel and cast steel for stem, stern frame, rudder post as well as other structural components, which are subject of this Rule, are to comply with the *Rules for the classification of ships, Part 25 - Metallic materials*.

The tensile strength of forged steel and of cast steel is not to be less than 400 N/mm^2. While selecting forged steel and cast steel toughness requirements and weldability shall be considered beside the strength properties.

4.3 ALUMINIUM ALLOY

4.3.1 Use of seawater resisting aluminium alloys is permitted for hull, superstructure and deckhouses.

4.3.2 The conversion of the structural elements from steel into aluminium alloy shall be specially considered taking into account the smaller modulus of elasticity *E*, as compared with steel, and the fatigue strength aspects, specifically those of the welded connections.

4.3.3 The smaller modulus of elasticity *E* shall be taken into account when determining the buckling strength of structural elements subjected to compression. This shall be applied accordingly to structural elements for which maximum allowable deflections have to be adhered to.

4.3.4 The conversion from steel to aluminium scantlings shall be carried out by using the material factor:

$$k_{Al} = \frac{635}{Rp_{0,2} + R_m}$$

where:

$Rp_{0,2}$ = 0,2% proof stress of the aluminium alloy, in [N/mm^2];

R_m = tensile strength of the aluminium alloy, in [N/mm^2].

Method of conversion:

section modulus: $W_{AL} = W_{st} \cdot k_{AL}$

plate thickness: $t_{AL} = t_{st} \cdot \sqrt{k_{AL}}$

W_{st}, t_{st} = section modulus and plate thickness of steel, respectively.

5 STEEL AND ALUMINIUM ALLOY SHELL PLATING

5.1 GENERAL

5.1.1 Application

The application of the design formulae given in 5.2.1.2 to yachts of less than 90 m in length may be accepted by the *Register* when a proof of longitudinal strength has been carried out.

5.1.2 Definitions

Following definitions are used in this Section:

k = material factor according to 4.2.1;

p_B = load on bottom, in [kN/m²], according to 3.2.2.3;

p_s= load on sides, in [kN/m²], according to 3.2.2.2.1;

p_e = design pressure for the bow area, in [kN/m²], according to 3.2.2.2.2;

p_{SL} = design slamming pressure, in [kN/m²], according to 3.2.2.4;

n_1 = 1,0 for transverse framing;

n_1 = 0,83 for longitudinal framing;

σ_L = maximum hull girder bending stress in [N/mm²] for calculating stress and for fatigue analysis at the considered station is given by the following formula:

$$\sigma_L = \frac{|M_s| + 0{,}75\ |M_w| + |M_{SL}|}{W} \cdot 10^3, \quad \text{[N/mm}^2\text{]}$$

where:

W = W_d, ili W_b section modulus at deck or bottom, in [cm³];

τ_L = maximum design shear stress due to longitudinal hull girder bending, in [N/mm²], where the wave shear force may be taken as 0,75 F_w;

σ_{dop} = permissible design stress in [N/mm²];

$$\sigma_{dop} = \left[0{,}8 + \frac{L}{450}\right] \cdot \frac{230}{k}, \text{ [N/mm}^2\text{], for } L < 90 \text{ m};$$

σ_{dop} = 230/k,[N/mm²], for $L \geq 90$ m;

t_k = corrosion addition, 0,5 mm.

5.2 BOTTOM PLATING

5.2.1 Plating within 0,4 L amidships

5.2.1.1 The thickness of the bottom plating of yachts up to 90 m in length is not to be less than:

$$t_1 = 1{,}9\ n_1 \cdot s \cdot \sqrt{p_B \cdot k} + t_k \quad \text{[mm]}$$

5.2.1.2 The thickness of the bottom plating for yachts of 90 m in length and more is not to be less than the following two values:

$$t_1 = 18{,}3 \cdot n_1 \cdot s \cdot \sqrt{\frac{P_B}{\sigma_a}} + t_k \quad \text{[mm]}$$

$$t_2 = 1{,}21 \cdot s \cdot \sqrt{p_B \cdot k} + t_k \quad \text{[mm]};$$

$$\sigma_a = \sqrt{\sigma_{dop}^2 - 3 \cdot \tau_L^2} - 0{,}89 \cdot \sigma_L \quad \text{[N/mm}^2\text{]};$$

As a first approximation σ_L may be taken as follows:

$$\sigma_L = \frac{12{,}6 \cdot \sqrt{L}}{k}, \text{ [N/mm}^2\text{], for } L < 90 \text{ m};$$

$$\sigma_L = \frac{120}{k}, \text{ [N/mm}^2\text{], for } L \geq 90 \text{ m};$$

τ_L = 0;

s = stifferner's spacing, [m], spacing measured from moulding edge to moulding edge adjacent frames.

5.2.2 Critical plate thickness

5.2.2.1 For yachts, for which proof of longitudinal strength is carried out, the thickness is not to be less than thickness according to the following formula:

$$t_{krit} = c_1 \cdot 1{,}6 \cdot s \cdot \sqrt{\sigma_L} + t_k, \quad \text{[mm]}$$

where:

c_1= 0,5, for longitudinal framing;

$c_1 = \frac{1}{(1+\alpha^2)\cdot\sqrt{c}}$, for transverse framing;

α= aspect ratio of plate panel considered, $\frac{s}{l}$;

c = correction factor;

c = 1,0 for stiffeners sniped at both ends;

c = 1,3 when plating stiffened by floors or deep girders;

c = 1,21 when stiffeners are angles or T-sections;

c = 1,10 when stiffeners are bulb bars;

c = 1,05 when stiffeners are flat bars;

c = 1,0 for longitudinal framing;

σ_L = according to 5.1.2;

s = stiffener's spacing [m], spacing measured from moulding edge to moulding edge adja-cent frames;

l = larger side of panel, [m].

5.2.2.2 The values obtained from 5.2.2.1 shall be verified according to *Rules for the classification of ships, Part 2 – Hull*, Section 4.6. For this purpose, the stresses due to hull girder bending and the stresses to local loads of the bottom structure shall be considered.

5.2.3 Bottom plating outside 0,4 L amidships

5.2.3.1 The thickness at the ends for 0,1 L from aft end of the length L and for 0,05 L from F.P. respectively is not to be less than the value t_2 obtained according to 5.2.1.2.

5.2.3.2 The thicknesses shall be gradually tapered from the midship thicknesses to the thicknesses at the ends.

Gradual taper is also to be effected between the thicknesses required for strengthening of the bottom forward and the adjacent thicknesses.

5.2.4 Bilge strake

5.2.4.1 The thickness of the bilge strake shall be determined as required for the bottom plating according to 5.2.1. The thickness so determined shall be verified for sufficient buckling strength according to *Rules for the classification of ships, Part 2 – Hull*, Section 4.6, see Table 4.6.2.1-3, load cases 1a, 1b, 2 and 4.

5.2.4.2 If a higher steel grade than A/AH is required for the bilge strake, the width of the bilge strake is not to be less than:

$b = 600 + 5 \cdot L$, [mm]

5.2.5 Flat plate keel and garboard strake

5.2.5.1 The width of the flat plate keel is not to be less than:

$b = 600 + 5\,L$, [mm]

and need not be greater than:

$b_{max} = 1500$ mm.

The thickness of the flat plate keel within 0,7 L amidships is not to be less than:

$t_{KB} = t + 2{,}0$, [mm]

where:

t = thickness of the adjacent bottom plating, in [mm].

5.2.5.2 Where a bar keel is arranged, the adjacent garboard strake is to have the scantling of a flat plate keel.

5.2.6 Minimum thickness

At no point the thickness of the bottom shell plating shall be less than:

$t_{min} = (1{,}5 - 0{,}01 \cdot L) \cdot \sqrt{L \cdot k}$ [mm], for $L <$ 50 m

$t_{min} = \sqrt{L \cdot k}$ [mm], for $L \geq 50$ m

or 16,0 mm, whichever is less.

5.3 SIDE SHELL PLATING

5.3.1 Side shell plating within 0,4 L amidships

5.3.1.1 The thickness of the side shell plating for yachts up of 90 m in length is not to be less than:

$$t_s = 1{,}9 \cdot n_1 \cdot s \cdot \sqrt{p_s \cdot k} + t_k \text{ [mm]}$$

5.3.1.2 The thickness of the side shell plating for yachts of 90 m in length and more is not to be less than the greater of the two following values:

$$t_{s1} = 18{,}3 \cdot n_1 \cdot s \cdot \sqrt{\frac{p_s}{\sigma_a}} + t_k, \text{ [mm]}$$

$$t_{s2} = 1{,}21 \cdot s \cdot \sqrt{p_s \cdot k} + t_k, \text{ [mm]}$$

$$\sigma_a = \sqrt{\sigma_{dop}^2 - 3\tau_L^2} - 0{,}89 \cdot \sigma_{LS}, \text{ [N/mm}^2\text{]}$$

As first approximation σ_{Ls} *and* τ_L may be taken as follows:

$\sigma_{LS} = 0{,}76 \cdot \sigma_L$

σ_L = according to 5.2.1.2

$\tau_L = \frac{55}{k}$, [N/mm^2].

5.3.1.3 In way of large shear forces, the shear stresses shall be checked in accordance with *Rules for the classification of ships, Part 2 – Hull*, Section 4.4.

5.3.2 Plating outside 0,4 *L* amidships

5.3.2.1 The plate thickness at the ends for 0,1 L from aft end of the length L and for 0,05 L from forward perpendicular is not to be less than t_{s2} according to 5.3.1.2.:

5.3.2.2 The plate thicknesses may be tapered from 0,4 L amidship the ends.

5.3.3 Minimum thickness

For the minimum thickness of the side shell plating 5.2.6 applies accordingly.

Above a level $d + C_w/2$ above base line smaller thicknesses than t_{min} may be accepted if the stress level permits such reduction.

C_w = according to *Rules for the classification of ships, Part 2 – Hull*, 4.2.2.

5.3.4 Sheerstrake

5.3.4.1 The width of the sheerstrake is not to be less than:

$b = 600 + 5\,L$, [mm],

and need not be greater than:

$b_{max} = 1500$ mm.

5.3.4.2 The thickness of the sheer strake within 0,4 L amidships, in general, not to be less than the greater of the following values:

$t = 0{,}5\,(t_d + t_s)$ [mm];

$t = t_s$ [mm];

t_d = required thickness of strength deck;

t_s = required thickness of side shell.

5.3.4.3 Where the connection of the deck stringer with the sheerstrake is rounded, the radius shall be at least 15 times the plate thickness.

5.3.4.4 In yachts exceeding 60 m in length, in principle welding is not allowed on the upper edge of the sheerstrake within 0,5 *L* amidships.

5.3.5 Buckling strength

For yachts for which proof of longitudinal strength is required or carried out proof of buckling strength of the side shell shall be provided in accordance with the requirements of *Rules for the classification of ships, Part 2 – Hull*, Section 4.6.

5.3.6 Side plating of superstructures

The side plating of effective superstructures shall be determined according to 5.3.

The side plating of non-effective superstructures shall be determined according to Section 13. For the definition of effective and non-effective superstructures see Section 13.

5.3.7 Strengthenings for harbour and tug manoeuvres

5.3.7.1 In those zones of the side shell which may be exposed to concentrated loads due to harbour manoeuvres the plate thickness is not to be less than required by 5.3.7.2. These zones are mainly the plates in way of the ship's fore and aft shoulder and in addition amidships. The exact locations where the tugs shall push shall be defined in the building specification. They shall be identified in the shell expansion plan. The length of the strengthened areas shall not be less than approximately 5 m. The height of the strengthened areas shall extend from about 0,5 m above ballast draught to about 4,0 m above scantling draught. Where the side shell thickness so determined exceeds the thickness required by 5.3.1 to 5.3.4 it is recommended to specially mark these areas.

5.3.7.2 The plate thickness in the strengthened areas shall be determined by the following formula:

$$t = 0{,}60 \cdot \sqrt{P_{fl} \cdot k} + t_k, \text{ [mm]}$$

where:

P_{fl} = local design impact force, [kN]

= $D/100$, [kN] with a minimum of 200 kN and a maximum of 1000 kN

D = displacement of the ship, [t].

Any reductions in thickness for restricted service are not permissible.

5.3.7.3 In the strengthened areas the section modulus of side longitudinals is not to be less than:

$$W = 0{,}35 \cdot P_{fl} \cdot l \cdot k \quad \text{[cm}^3\text{]}$$

l = unsupported span of longitudinal, [m].

5.3.7.4 Tween decks, transverse bulkheads, stringer and transverse walls shall be investigated for sufficient buckling strength against loads acting in the ship's transverse direction.

5.4 STRENGTHENING OF BOTTOM FORWARD

5.4.1 Arrangement of floors and girders

5.4.1.1 In case of transverse framing, plate floors shall be fitted at every frame. Where the longitudinal framing system or the longitudinal girder system is adopted the spacing of plate floors may be equal to three transverse frame spaces.

5.4.1.2 In case of transverse framing, the spacing of side girders is not to exceed $L/250 + 0{,}9$ (m), up to a maximum of 1,4 m.

In case of longitudinal framing, the side girders shall be fitted every two longitudinal frame spacings apart.

5.4.1.3 Spacing stated in 5.4.1.1 and 5.4.1.2 are:

- forward of $\frac{x}{L} = 0{,}7$, for $L \le 100$ m
- forward of $\frac{x}{L} = 0{,}6 + 0{,}001\,L$, for $100 < L \le 150$ m
- forward of $\frac{x}{L} = 0{,}75$, for $L > 150$ m

5.4.2 Bottom plating forward of $\frac{x}{L} = 0{,}5$

5.4.2.1 The thickness of the bottom plating of the flat part of the ship's bottom up to a height of 0,05 d_{min} or 0,3 m above base line, whichever is the smaller value, is not to be less than:

$$t = 0{,}9 \cdot f_2 \cdot s \cdot \sqrt{p_{sl} \cdot k} + t_k \quad \text{, [mm]}$$

where:

f_2 = see *Rules for the classification of ships, Part 2 – Hull*, 2.1.3;

s = stiffeners spacing, in [m];

p_{sl} = according to Section 3.2.2.4;

t_k = 0,5 mm.

5.4.2.2 Above 0,05 d_{min} or 0,3 m above base line the plate thickness may gradually be tapered to the rule thickness determined according to 5.2.

5.4.3 Stiffeners forward of $\frac{x}{L} = 0{,}5$

5.4.3.1 The section modulus of transverse or longitudinal stiffeners is not to be less than:

$$W = 0{,}155 \cdot p_{sl} \cdot s \cdot l^2 \cdot k, \text{ [cm}^3\text{]}$$

5.4.3.2 The shear area and the cross-sectional area of the welded connection is not to be less than:

$$A = 0{,}028 \cdot p_{sl} \cdot s\,(l - 0{,}5 \cdot s) \cdot k \quad \text{[cm}^2\text{]}$$

l = unsupported span of stiffener, in [m];

k = material factor according 4.2.1.

5.4.4 Strengthening in way of propellers and propeller brackets

5.4.4.1 In way of propeller bracket and shaft bossings, the thickness of the shell plating shall be the same as required for 0,4 *L* amidships. in way of the struts, the shell plating is to have a strengthened plate of 1,5 times the midship thickness.

5.4.4.2 Where propeller revolution is exceeding 300 rpm (approx.) particularly in case of that bottoms intercostal carlings shall be fitted above or forward of the propeller in order to reduce the size of the bottom plate panels (see also 7.1.1.2.3).

5.5 BILGE KEEL

5.5.1.1 Where bilge keels are provided, they shall be continuous over their full length. the bilge keels shall be welded to continuous flat bars which are welded to the shell plating with their flat side.

5.5.1.2 The ends of the bilge keels are to have soft transition zones according to Fig. 5.5.1.2, and they shall terminate above an internal stiffening element.

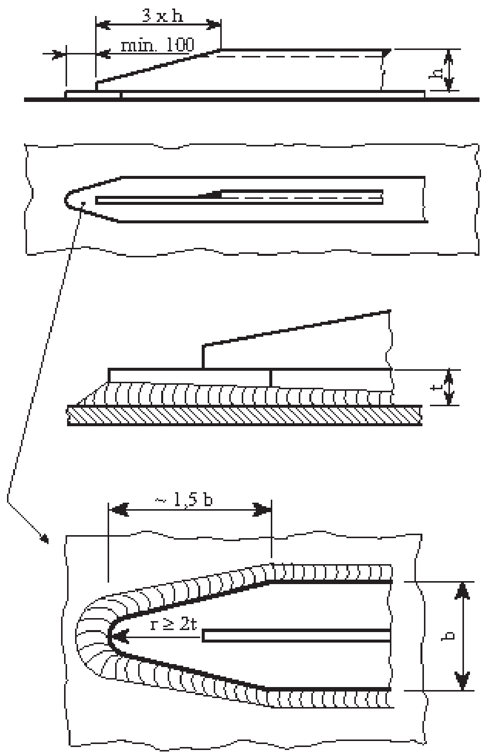


Figure 5.5.1.2

5.5.1.3 Any scallops or cut-outs in the bilge keels shall be avoided.

5.6 BULWARK

5.6.1 The thickness of bulwark plating is not to be less than:

$$t = \left[0{,}75 - \frac{L}{1000}\right]\sqrt{L}\text{ , [mm], for } L \le 100 \text{ m}$$

$$t = 0{,}65\sqrt{L}\text{ , [mm], for } L > 100 \text{ m}$$

L need not be taken greater than 200 m. The thickness of bulwark plating forward particularly exposed to wash of sea shall be equal to the thickness of the forecastle side plating according to 1.3.2.1.

In way of superstructures above the freeboard deck abaft 0,25 *L* from F.P. the thickness of the bulwark plating may be reduced by 0,5 mm.

The bulwark height or height of guard rails is not to be less than 1,0 m.

Plate bulwarks shall be stiffened at the upper edge by bulb section or other similar.

5.6.2 The bulwark shall be supported by bulwark stays fitted at every alternate frame and at every frame on this with respectively bow flare.

Where the stays are designed as per Fig. 5.6.2, the section modulus of their cross section effectively attached to the deck is not to be less than:

$W = 4 \cdot p_s \cdot e \cdot l^2$ [cm^3]

where:

p_s= load, in [kN/m^2], as per 3.2.2.2.1;

p_{smin} = 1,0 kN/m^2;

e = spacing of stays, in [m];

l = length of stay, in [m].

The stays shall be fitted above deck beams, or other transversal members. Where deck is longitudinally framed, ends of stayes have to finish above longitudinal members.

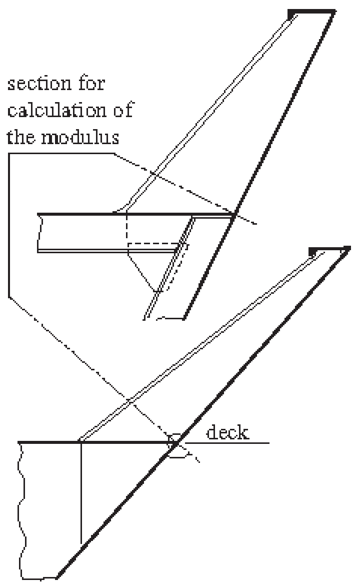


Figure 5.6.2

5.6.3 An adequate number of expansion joints shall be provided in the bulwark.

The number of expansion joints for yachts exceeding 60 m in length should not be less than:

$n = L/40$,

but need not be greater than $n = 5$.

5.6.4 Openings in the bulwarks shall have sufficient distance from the end bulkheads of superstructures. Connection of bulwarks to superstructure sides shall be constructed carefully.

5.7 OPENINGS IN THE SHELL PLATING

5.7.1 General

5.7.1.1 Where openings are cut in the shell plating for windows or side scuttles, hawses, scuppers, sea valves etc., they are to have well rounded corners. If they exceed 500 mm in width in yachts up to L = 70 metres, and 700 mm in yachts having a length L of more than 70 metres, the openings shall be surrounded by framing, a thicker plate or a doubling.

5.7.1.2 Above openings in the sheer strake within 0,4 L amidships, generally a strengthened plate or a continuous doubling shall be provided compensating the omitted plate sectional area. For shell doors and similar large openings see *Rules for the classification of ships*, *Part 3 – Hull Equipment*, 7.4. Special strengthening is required in the range of openings at ends of superstructures.

5.7.1.3 The shell plating in way of the hawse pipes shall be reinforced.

5.7.2 Pipe connections at the shell plating

Scupper pipes and valves shall be connected to the shell by weld flanges. Instead of weld flanges short-flanged sockets of adequate thickness may be used if they are welded to the shell in an appropriate manner. Reference is made to *Rules for the classification of ships, Part 3 – Hull equipment*, 7.4 and *Part 8 – Piping*, 1.5.

Construction drawings shall be submitted for approval.

6 STEEL AND ALUMINIUM ALLOY DECKS

6.1 STRENGTH DECK

6.1.1 General, definitions

6.1.1.1 The strenght deck is:

- the uppermost continuous deck which is forming the upper flange of the hull structure,
- a superstructure deck which extends into 0,4 *L* amidships and the length of which exceeds 0,15 *L*.
- a quarter deck or the deck of a sunk superstructure which extends into 0,4 *L* amidships.

6.1.1.2 In way of a superstructure deck which shall be considered as a strength deck, the deck below the superstructure deck is to have the same scantlings as a 2nd deck, and the deck below this deck the same scantlings as a 3rd deck. The thicknesses of a strength deck plating shall be extended into the superstructure for a distance equal to the width of the deck plating abreast the hatchway. For strengthening of the stringer plate in the breaks, see Section 13.

6.1.1.3 If the strength deck is protected by sheathing a corrosion addition t_k is not needed. Where a sheathing other than wood is used, attention shall be paid that the sheathing does not affect the steel. The sheathing shall be effectively fitted to the deck.

6.1.1.4 For yachts with a speed $v = 1{,}6\ \sqrt{L}$, [kn], additional strengthening of the strength deck and the sheerstrake may be required.

6.1.1.5 The following definitions apply throughout this Section:

k = material factor according to 4.2.1

p_D = load according to 3.2.2.1.1

t_k = corrosion addition 0,5 mm.

6.1.2 Connection between strength deck and sheerstrake

6.1.2.1 The welded connection between strength deck and sheerstrake may be effected by fillet welds according to Section 15.

Where the plate thickness exceeds approximately 20 mm, a fully welded connection according to Section 15 shall be carried out instead fillet welds.

In special cases a fully welded connections may also be required, where the plate thickness is less than 25 mm.

6.1.2.2 Where the connection of deck stringer to sheerstrake is rounded, the requirements of 5.3.3 shall be observed.

6.1.3 Openings in the strength deck

6.1.3.1 All openings in the strength deck are to have well rounded corners. Circular openings shall be edge-reinforced. The sectional area of the face bar is not to be less than:

$A = 0{,}25 \cdot d_o \cdot t$ [cm^2]

d_o = diameter of opening, in [cm],

t = deck thickness, in [cm].

The distance between the outer edge of opening and the ship's side is not to be less than the opening diameter.

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 x diameter of the smaller opening.

6.1.3.2 The hatchway corners shall be surrounded by strengthened plates which are to extend over at least one frame spacing fore-and-aft and athwartships. Within 0,5 *L* amidships, the thickness of the strengthened plate shall be equal to the deck thickness abreast the hatchway plus the deck thickness between the hatchways. Outside 0,5 *L* amidships the thickness of the strengthened plates need not exceed 1,6 times the thickness of the deck plating abreast the hatchway.

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

$r = n \cdot b\ (1 - b/B)$, [m]

r_{min}= 0,1 m

where:

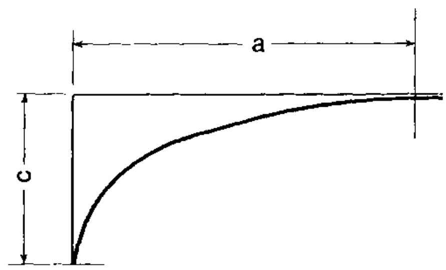
$n = l/200$, but not lesser than 0,1 and not greater than 0,25;

l = length of hatchway, in [m];

b = breadth in [m], of hatchway or total breadth of hatchways in case of more than one hatchway;

b/B = need not be taken smaller than 0,4.

6.1.3.4 Where the hatchway corners are elliptic or parabolic, strengthening according to 6.1.3.2 is not required. The dimensions of the elliptical and parabolical corners shall be as shown in Fig. 6.1.3.4.



$a \geq 2c$
c = r according to 6.1.3.3

Figure 6.1.3.4

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

6.1.3.5 For yachts with large deck openings the design of the hatch corners will be specially considered on the basis of the stresses due to longitudinal hull girder bending, torsion and transverse loads.

6.1.3.6 At the corners of the engine room casings, strengthenings according to 6.1.3.2 may also be required, depending on the position and the dimensions of the casing.

6.1.4 Scantlings of strength deck of yachts up to 65 m length

The scantlings of the strength deck for yachts, for which proof of longitudinal strength is not required, i.e. in general for yachts with length $L \leq 65$ [m], the sectional area of the strength deck within 0,4 L amidships shall be determined such that the requirements for the minimum midship section modulus according to *Rules for the classification of ships, Part 2 – Hull*, 4.3.4 are complied with.

The thickness within 0,4 L amidships is not to be less than the minimum thickness according to 6.1.7. For the ranges 0,1 L from ends the requirements of 6.1.7 apply.

6.1.5 Scantlings of strength deck of yachts of more than 65 m in length

6.1.5.1 Deck sectional area

The deck sectional area abreast the hatchways, if any, shall be so determined that the section moduli of the cross sections are in accordance with the requirements of *Rules for the classification of ships, Part 2 – Hull*, Section 4.3.

6.1.5.2 Critical plate thickness, buckling strength

6.1.5.2.1 The critical plate thickness shall be determined according to Section 5.2.2 analogously.

6.1.5.2.2 In regard to buckling strength the requirements of Section 5.2.2 apply analogously.

6.1.5.3 Deck stringer

If the thickness of the strength deck plating is less than that of the side shell plating, a stringer plate shall be fitted having the width of the sheerstrake and the thickness of the side shell plating.

6.1.6 Minimum thickness

The thickness of deck plating for 0,4 L amidships outside line of hatchways is not to be less than the greater of the two following values:

$t_{min} = (4{,}0 + 0{,}05\,L) \cdot \sqrt{k}$ [mm]

or

$t_{0,1L}$ according to 6.1.7.1.

L need not be taken greater than 200 m.

6.1.7 Thickness at ship's ends and between hatchways

6.1.7.1 The thickness of strength deck plating for 0,1 L from the ends and between hatchways is not to be less than:

$t_{0,1L} = 1{,}21 \cdot s \cdot \sqrt{p_D \cdot k} + t_k$ [mm]

$t_{0,1L2} = 1{,}1 \cdot s \cdot \sqrt{p_L \cdot k} + t_k$ [mm]

$t_{0,1Lmin} = (4{,}5 + 0{,}02 \cdot L)\sqrt{k}$ [mm]

L need not be taken greater than 200 m.

6.1.7.2 Between the midship thickness and the end thickness, the thicknesses shall be tapered gradually.

6.1.7.3 The strength of deck structure between hatch openings has to withstand compressive transversely acting loads. Proof of buckling strength shall be provided according to *Rules for the classification of ships, Part 2 – Hull*, 4.6.

6.2 LOWER DECKS

6.2.1 Thickness of decks for cargo loads

6.2.1.1 The plate thickness of decks loaded with cargo is not to be less than:

$t = 1{,}1 \cdot s \cdot \sqrt{p_L \cdot k} + t_k$ [mm]

but not less than:

$t_{min} = (4 + 0{,}02\,L)\sqrt{k}$, [mm], for the 2nd deck;

$t_{min} = 5{,}0$ mm, for other lower decks.

L need not be taken greater than 200 mm.

6.2.2 Machinery decks and accommodation decks

6.2.2.1 The scantlings of machinery decks and other accommodation decks have to be based on the loads given in Section 3.3.3.

6.2.2.2 The thickness of the plates is not to be less than:

$t = 1{,}1 \cdot s \cdot \sqrt{p \cdot k} + t_k$, [mm]

$t_{min} = 5$ mm.

6.2.2.3 At the corners of the engine room casings, strengthenings according to 6.1.3 may also be required depending on the position and the dimensions of the casing.

6.3 HELICOPTER DECKS

6.3.1 General

The starting/landing zone shall be dimensioned for the largest helicopter type expected to use the helicopter deck.

Where the conditions of operation are not known, the data in 6.3.2 may be used as a basis.

6.3.2 Load assumptions

6.3.2.1 For helicopter lashed on deck (LH1), with the following vertical forces acting simultaneously:

a) Wheel and/or ski force P acting at the points resulting from the lashing position and distribution of the wheels and/or supports according to helicopter construction:

$P = 0{,}5 \cdot G\,(1 + a_v)$ [kN]

where:

G = maximum permissible take-off weight, in [kN];

a_v = according to 3.2.5.1;

P = evenly distributed force over the contact area a = 30 x 30 cm for single wheel or according to data supplied by helicopter manufacturers; for dual wheels or skies to be determined individually in accordance with given dimensions.

b) Force due to weight of helicopter deck M_{hd} as follows:

$M_{hd}\,(1 + a_v)$ kN

c) Evenly distributed load over the entire landing deck determined as follows:

p = 2,0 kN/m^2

6.3.2.2 Helicopter lashed on deck (LH_2), with the following horizontal and vertical forces acting simultaneously:

a) Forces acting horizontally:

$P_H = 0{,}6\,(G + M_{hd}) + W$ [kN],

where:

W = wind load, taking into account the lashed helicopter;

wind velocity v_w = 30 m/s.

b) Forces acting vertically:

$P_v = G + M_{hd}$ [kN]

6.3.2.3 Normal landing impact (LH3), with forces acting simultaneously:

a) Wheel and/or ski load P at two points simultaneously, at an arbitrary point of the helicopter deck (landing zone + safety zone):

P = 0,75 G, [kN]

b) Evenly distributed load for taking into account snow or other environmental loads:

p = 0,5 kN/m^2

c) Weight of the helicopter deck

d) Wind load in accordance with the wind velocity admitted for helicopter operation(v_w). Where no data are available, v_w = 25 m/s may be used.

6.3.3 Scantlings of structural members

6.3.3.1 Stresses and forces in the supporting structure shall be evaluated by means of direct calculations.

6.3.3.2 Permissible stresses for stiffeners, girders and substructure:

$$\sigma_p = \frac{235}{k \cdot v_s} \quad \text{N/mm}^2$$

where

v_s = safety factors according to Table 6.3.3.2.

Table 6.3.3.2

Structural element	v_s	
	LH_1, LH_2	LH_3
stiffeners (beams, deck longitudinals)	1,25	1,1
main girders (deck girders)	1,45	1,45
load-bearing structure (pillar system)	1,7	2,0

6.3.3.3 The thickness of the plating shall be determined according to 6.2.2 where the coefficient c may be reduced by 5%.

6.3.3.4 Proof of sufficient buckling strength shall be carried out in accordance with *Rules for the classification of ships, Part 2 – Hull*, 4.6 for structures subjected to compressive stresses.

7 STEEL AND ALUMINIUM ALLOY BOTTOM STRUCTURES

7.1 SINGLE BOTTOM

7.1.1 Floor plates

7.1.1.1 General

Floor plates shall be fitted at every frame.

Deep floors, particularly in the after peak, shall be provided with buckling stiffeners.

The floor plates shall be provided with limbers to permit the water to reach the pump suctions.

7.1.1.2 Scantlings

7.1.1.2.1 Floor plates in the cargo hold area

On yachts without double bottom or outside any double bottom the scantlings of floor plates fitted between afterpeak bulkhead and collision bulkhead shall be determined according to the following formulae:

a) The section modulus is not to be less than:

$W = k_2 \cdot d \cdot s \cdot l^2$ [cm^3],

where:

s = spacing of plate floors, [m];

l = unsupported span, [m], generally measured on upper edge of floor from side shell to side shell;

l_{min} = 0,7 B, if the floors are not supported at longitudinal bulkheads;

k_2= 7,5 for spaces which may be empty at full draught, e.g. machinery spaces, storerooms, etc.

k_2= 4,5 elsewhere.

For the conversion from steel to aluminium scantlings see Section 4.3.

b) The depth of the floor plates is not to be less than:

$h = 50 \cdot B - 40$ [mm],

but not less than:

h_{min} = 150 mm.

In yachts having rise of floor, at $0,1 \cdot l$ from the ends of the length l where possible, the depth of the floor plate webs is not to be less than half the required depth.

In yachts having a considerable rise of floor, the depth of the floor plate webs at the beginning of the turn of bilge is not to be less than the depth of the frame.

c) The web thickness is not to be less than

$$t = \frac{h}{100} + 3 \quad \text{[mm]}$$

The web sectional area shall be determined according to 7.2.6.2.2. analogously.

7.1.1.2.2 The face plates of the floor plates shall be continuous over the span l. If they are interrupted at the centre keelson, they shall be connected to the centre keelson by means of full penetration welding.

7.1.1.2.3 Floor plates in the peaks

The thickness of the floor plates in the peaks is not to be less than:

$t = 0{,}035L + 4{,}0$ [mm]

The thickness, however, need not be greater than required by 7.2.6.2.1.

The floor plate height in the fore peak is not to be less than:

$h = 0{,}06 \cdot D + 0{,}5$ [m]

The floor plates in the afterpeak are to extend over the stern tube.

7.1.2 Longitudinal girders

7.1.2.1 All single bottom yachts are to have a centre girder keelson. Where the breadth measured on top of floors does not exceed 8 m one additional side girder shall be fitted, and two side girders where the breadth exceeds 8 m. Side girders are not required where the breadth does not exceed 6 m.

7.1.2.2 For the spacing of side girders from each other and from the centre girder in way of bottom strengthening forward see Section 5.4

7.1.2.3 The centre and side girders are to extend as far forward and aft as practicable. They shall be connected to the girders of a non-continuous double bottom or shall be scarped into the double bottom by two frame spacings.

7.1.2.4 Centre girder

The web thickness within 0,7 L amidships is not to be less than:

$t = 0{,}06\,L + 5{,}0$ [mm]

The sectional area of the face plate within 0,7 L amidships is not to be less than:

$A_f = 0{,}6L + 10$ [cm^2]

Towards the ends the thickness of the web plate as well as the sectional area of the top plate may be reduced by 10%. Lightening holes shall be avoided.

7.1.2.5 Side girder

The web thickness within 0,7 L amidships is not to be less than:

$t = 0{,}04\,L + 5$ [mm]

The sectional area of the face plate within 0,7 L amidships is not to be less than:

$A_f = 0{,}2L + 6$ [cm^2]

Towards the ends, the thickness of the web plate and the sectional area of the face plate may be reduced by 10%.

7.2 DOUBLE BOTTOM

7.2.1 General

7.2.1.1 On yachts of 500 GT and upwards a double bottom shall be fitted extending from the collision bulkhead to the afterpeak bulkhead, as far as this is compatible with service of the ship.

For yachts of less than 500 GT double bottom are not required.

7.2.1.2 In single hull yachts the inner bottom shall be continued out to the ship's side as to protect the bottom to the turn of the bilge. In double hull yachts the inner bottom shall be extended to the inner hull.

7.2.1.3 Small wells for hold drainage may be arranged in the double bottom, their depth, however, shall be as small as practicable. A well extending to the outer bottom, may, however, be permitted at the after end of the shaft tunnel.

7.2.1.4 Other wells may be permitted if their arrangement does not reduce the level of protection equivalent to that afforded by a double bottom complying with this Section.

7.2.1.5 In fore-and afterpeak a double bottom need not to be arranged.

7.2.1.6 If the double bottom is not subdivided by watertight side girders, the centre girder should be watertight at least for 0,5 · *L* amidships.

7.2.1.7 For bottom strengthening forward, see Section 5.4.

7.2.2 Centre girder

7.2.2.1 Centre girder shall be extended as far as possible toward the aft and forward and to be connected with the stem.

Lightening holes in the centre girder are generally permitted only outside 0,75 *L* amidships. Their depth is not to exceed half the depth of the centre girder and their lengths are not to exceed half the frame spacing.

7.2.2.2 Scantlings

Depth and thickness of the centre girder are determined as follows:

a) The depth of the centre girder is not to be less than:

$h_{db} = 350 + 45 \cdot B$ [mm]

$h_{min} = 600$ [mm]:

where longitudinal wing bulkheads are fitted, the distance between the bulkheads may be taken instead of *B*, not less than 0,8 · *B*.

b) The thickness of the centre girder is not be less than:

- within 0,7 *L* amidships:

$$t = \frac{h_{db}}{h_a}\left[\frac{h_{db}}{100} + 1{,}0\right]\sqrt{k}\ , \quad \text{[mm], for } h_{db} \le 1200 \text{ mm}$$

$$t = \frac{h_{db}}{h_a}\left[\frac{h_{db}}{120} + 3{,}0\right]\sqrt{k}\ , \quad \text{[mm], for } h_{db} > 1200 \text{ mm}$$

where:

h_a = depth of centre girder as built, in [mm], where h_a is larger than h_{db}:

$$\frac{h_{db}}{h_a} \le 1{,}0$$

- 0,15 · *L* at the ends:

$t_1 = 0{,}9 \cdot t$

t = thickness within 0,7·*L* amidships, [mm].

7.2.3 Side girders

7.2.3.1 Arrangement

At least one side girder shall be fitted in the engine room and in way of 0,25 *L* aft of F.P. In the other parts of the double bottom, one side girder shall be fitted where the horizontal distance between ship's side and centre girder exceeds 4,5 m. Two side girders shall be fitted where the distance exceeds 8 m, and three side girders where it exceeds 10,5 m. The distance of the side girders from each other and from centre girder and ship's side respectively shall not be greater than:

- 1,6 m in the engine room within the breadth of engine seatings,
- 3,5 m where one side girder is fitted in the other parts of double bottom,
- 3,0 m where two side girders are fitted in the other parts of double bottom,
- 2,5 m where three side girders are fitted in the other parts of double bottom.

7.2.3.2 Scantlings

7.2.3.2.1 The thickness of the side girders is not to be less than:

$$t = \frac{h_{db}^{\ 2}}{120 \cdot h_a}\sqrt{k} \quad \text{[mm]},$$

h_{db} = depth of the centre girder, in [mm] according to 7.2.2.2.

h_a = depth of side girder as built, in [mm], where h_a is larger than h_{db}.

The scantlings of watertight side girders are also to be in accordance with the requirements given under 7.2.6.3.

Lightening holes in the side girders shall be of such size as to level a remainder of web plate around the hole not less than 0,2 of the height of side girder or of frame spacing. Where the holes are fitted with flat bars, the above value may be reduced to 0,15 of the height of side girder.

For strenghtenings under the engine seatings, see 7.3.2.3.

7.2.4 Inner bottom

7.2.4.1 The thickness of the inner bottom plating is not to be less than:

$t = 1{,}1 \cdot s\ \sqrt{p \cdot k} + t_k$ [mm],

where:

p = design pressure in [kN/m²].

p is the greater of the following values:

p_1 = $10\ (d - h_{db})$

p_2 = $10 \cdot h$, where the inner bottom forms a tank boundary

h = distance from top of overflow pipe to inner bottom, in [m];

h_{db} = double bottom height, in [m].

7.2.4.2 For strengthening of inner bottom in machinery spaces, see 7.3.

7.2.5 Double bottom tanks

7.2.5.1 Fuel and lubricating oil tanks

7.2.5.1.1 In double bottom tanks, oil fuel may be carried, the flash point of which exceeds 60ºC.

7.2.5.1.2 Where practicable, lubricating oil discharge tanks or circulating tanks shall be separated from the shell.

7.2.5.1.3 For the separation of oil fuel tanks from tanks for other liquids, see Section 11.1.4.

7.2.5.1.4 Requirements for air, overflow, and sounding pipes, are stated in *Rules for the classification of ships, Part 8 – Piping*, Section 5.

7.2.5.1.5 Where tanks are intended to carry heated liquids thermal stress calculations may be required.

7.2.5.1.6 The thickness of structures is not be less than the minimum thickness according to Section 11.

7.2.5.2 See chests

7.2.5.2.1 The plate thickness of sea chests is not to be less than:

$$t = 10 \cdot s \sqrt{p \cdot k} + t_k \quad \text{[mm]}$$

where:

s = spacing of stiffeners, in [m];

p = blow out pressure at the safety valve, in [bar], but not to be less than 2 bar.

7.2.5.2.2 The section modulus of sea chest stiffeners is not to be less than:

$$W = 50 \cdot s \cdot p \cdot l^2 \cdot k \quad \text{[cm}^3\text{]},$$

where:

l = unsupported span of stiffeners, in [m],

s, p = see 7.2.5.2.1.

7.2.5.2.3 The sea-water inlet openings in the shell shall be protected by gratings.

7.2.5.2.4 A cathodic corrosion protection with galvanic anodes made of zinc or aluminium shall be provided in sea chests. For the suitably coated plates a current density of 30 $\mu A/m^2$ shall be provided and for the cooling area a current density of 180 $\mu A/m^2$.

7.2.6 Double bottom, transverse framing system

7.2.6.1 Plate floors

7.2.6.1.1 It is recommended to fit plate floors at every frame in the double bottom if transverse framing is adopted.

7.2.6.1.2 Plate floors shall be fitted at every frame:
- in way of strengthening of the bottom forward according to Section 5.4;
- in the engine room;
- under the boiler bearers;

7.2.6.1.3 Plate floors shall be fitted:
- under bulkheads;
- under corrugated bulkheads.

7.2.6.1.4 For the remaining part of the double bottom, the spacing of plate floors shall not exceed approximately 3 m.

7.2.6.2 Scantlings

7.2.6.2.1 The thickness of plate floors is not to be less than:

$$t_p = t - 2{,}0\sqrt{k} \quad \text{[mm]}$$

t = thickness of centre girder according to 7.2.2.2

t_{pmax} = 12,0 mm

If the floor depth exceeds the height h_{db} according to 7.2.2.2., the thickness may be reduced, provided that the buckling strength is considered according to *Rules for the classification of ships, Part 2 – Hull,* 4.6.

7.2.6.2.2 The sectional area of the plate floors is not to be less than:

$$A_w = f_1 \cdot d \cdot l \cdot s\,(1 - 2\,b_1/l) \cdot k \quad \text{[cm}^2\text{]}$$

where:

s = spacing of plate floors, in [m];

l = span between longitudinal bulkheads, if any, in [m];

l = B, if longitudinal bulkheads are not fitted;

b_1 = distance between supporting point of the plate floor (ship's side, longitudinal bulkhead) and the section considered, in [m]. The distance b_1 is not to be taken greater than $0.4 \cdot l$;

f_1 = 0,5 for spaces which may be empty at full draught, e.g. machinery spaces, storerooms, etc.;

f_1 = 0,3 elsewhere;

k = material factor according to 4.2.1.

7.2.6.2.3 Where in small yachts side girders are not required, at least one vertical stiffener shall be fitted at every plate floor; its thickness shall be equal to that of the floors and its depth of web at least 1/15 of the height of centre girder.

7.2.6.2.4 The thickness of watertight floors is not to be less than that required for tank bulkheads according to 11.2.2. In no case their thickness shall be less than required for plate floors according to 7.2.6.2.1.

7.2.6.2.5 The scantlings of stiffeners at watertight floors shall be determined according to 11.2.3.

7.2.6.2.6 In way of strengthening of bottom forward according to 5.4, the plate floors shall be connected to the shell plating and inner bottom by continuous fillet welding.

7.2.6.3 Bracket floors

7.2.6.3.1 Where plate floors are not required according to 7.2.6.1 bracket floors may be fitted.

7.2.6.3.2 Bracket floors consist of bottom frames at the shell plating and reversed frames at the inner bottom, attached to centre girder, side girders and ship's side bilge by means of brackets.

7.2.6.3.3 The section modulus of bottom and inner bottom frames is not to be less than:

$$W = e \cdot f_2 \cdot s \cdot l^2 \cdot p \cdot k \quad \text{[cm}^3\text{]},$$

where:

p = design load, in [kN/m^2] as follows:

- for bottom frames

  $p = p_B$ (according to 3.2.3)

- for inner bottom frames (the greater value shall be used)

  $p = p_1$ or p_2 (according to 3.4.1),

  $p = 10 \cdot (d - h_{db})$,

h_{db} = double bottom height in [m],

e = 0,44, if $p = p_2$,

e = 0,55, if $p = p_{DB}$ or p_1,

e = 0,70, if $p = p_B$,

f_2 = 0,60 where struts according to 7.2.6.4.5 are provided at $l/2$, otherwise $f_2 = 1,0$

l = unsupported span, in [m], disregarding struts, if any.

7.2.6.4 Brackets

7.2.6.4.1 The brackets are, in general, to be of the same thickness as the plate floors, and breadth shall be 0,75 of the depth of the centre girder. The brackets shall be flanged at their free edges, where the unsupported span of bottom frames exceeds 1 m or where the depth of floors exceeds 750 mm.

7.2.6.4.2 As the side girders, bottom frames and inner bottom frames shall be supported by flat bars having the same depth as the inner bottom frames.

7.2.6.5 Struts

The cross-sectional area of the struts shall be determined according to 9.3.2. The design force shall be taken as the following value:

$$P = 0,5 \cdot p \cdot s \cdot l \quad \text{[kN]},$$

p and l as stated in 7.2.6.3.3.

7.2.7 Double bottom, longitudinal framing system

7.2.7.1 General

Where the longitudinal framing system changes to the transverse framing system, structural continuity shall be provided for.

7.2.7.2 Bottom and inner bottom longitudinals

7.2.7.2.1 The scantlings shall be calculated according to 8.2.

7.2.7.2.2 Where bottom and inner bottom longitudinals are coupled by struts in the centre of their unsupported span l, their section moduli may be reduced to 60% of the values required by 8.2.

The scantlings of the struts shall be determined in accordance with 7.2.6.5.

7.2.7.3 Plate floors

7.2.7.3.1 The floor spacing shall, in general, not exceed 5 times the transverse frame spacing.

7.2.7.3.2 Plate floors shall be fitted under transversal bulkheads and corrugated bulkheads. Floors shall be fitted at every frame in the machinery space under the main engine. In the remaining part of the machinery space, floors shall be fitted at every alternate frame.

7.2.7.3.3 Regarding floors in way of the strengthening of the bottom forward, 5.4 shall be observed.

7.2.7.3.4 The scantlings of floors shall be determined according to 7.2.6.2.

7.2.7.3.5 The plate floors shall be stiffened at every longitudinal by a vertical stiffener having the same scantlings as the inner bottom longitudinals. The depth of the stiffener need not exceed 150 mm.

7.2.7.4 Brackets

7.2.7.4.1 Where the ship's sides are framed transversally frame flanged brackets having a thickness of the floors shall be fitted between the plate floors at every transverse frame, extending to the outer longitudinals at the bottom and inner bottom.

7.2.7.4.2 One bracket shall be fitted at each side of the centre girder between the plate floors where the plate floors are spaced not more than 2,5 m apart. Where the floor spacing is greater, two brackets shall be fitted.

7.2.7.5 Longitudinal girder system

7.2.7.5.1 Where longitudinal girders are fitted instead of bottom longitudinals, the spacing of floors may be greater than permitted by 7.3.1, provided that adequate strength of the structure is proved.

7.2.7.5.2 The plate thickness of the longitudinal girders is not to be less than:

$$t = (4,0 + 0,03\ L) \sqrt{k} \quad \text{[mm]},$$

but not less than:

$$t_{min} = 5,0 \sqrt{k} \quad \text{[mm]}$$

7.2.7.5.3 The longitudinals girders shall be examined for sufficient safety against buckling according to *Rules for the classification of ships, Part 2 – Hull*, 4.6.

7.2.8 Design loads, permissible stresses for direct calculations

7.2.8.1 Design Loads

$p = p_{DB} - p_a$ [kN/m^2], for loaded holds

$p = p_a$ [kN/m^2], for empty holds

where:

P_{DB} = load on inner bottom;

p_a = $10 \cdot d - p_o \cdot C_F$, sagging conditions;

p_a = $10 \cdot d + p_o \cdot C_F$, hogging conditions;

p_o, C_F = according to 3.2.2.

Where single loads are acting (e.g. loads of containers), such loads shall be used instead of the load P_{DB}.

7.2.8.2 Permissible stresses

7.2.8.2.1 Equivalent permissible stress, σ_{ekv}

The equivalent stress is not to exceed the following value:

$$\sigma_{ekv} = \frac{230}{k} \quad [\mathrm{N/mm^2}]$$

$$\sigma_{ekv} = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x \cdot \sigma_y + 3 \cdot \tau^2}$$

where:

σ_x = stress in the ship's longitudinal direction;

σ_x = $\sigma_L + \sigma_l$;

σ_L = design hull girder bending stress, in [N/mm^2], according to *Rules for the classification of ships, Part 2 – Hull*, Section 4;

σ_l = bending stress, in [N/mm^2], due to the load p, in longitudinal direction, in longitudinal girders;

σ_x = 0, for webs of transverse girders;

σ_y = stress in the ship's transverse direction;

σ_y = σ_t

σ_t = bending stress, in [N/mm^2], due to load p, in transverse direction, in transverse girders;

σ_y = 0, for webs of longitudinal girders;

τ = shear stress in the longitudinal girders or transverse girders due to load p, in [N/mm^2].

For direct calculation of bottom grillage may be used the following stress definitions:

σ_x = $\sigma_L + \sigma_l + 0{,}3 \cdot \sigma_t$

σ_y = $\sigma_t + 0{,}3 \cdot (\sigma_L + \sigma_l)$

7.2.8.3 Maximum permissible values of stresses

The stresses σ_l, σ_t and τ are not exceed the following values:

$$\sigma_l,\ \sigma_t = \frac{150}{k} \quad [\mathrm{N/mm^2}]$$

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

7.2.8.4 Buckling strength

The buckling strength of the bottom structures shall be examined according to *Rules for the classification of ships, Part 2 – Hull*, 4.6. For this purpose, the design stresses according to *Rules for the classification of ships, Part 2 – Hull*, 4.5.3 and the stresses due to local loads shall be considered.

7.3 BOTTOM STRUCTURE IN WAY OF THE MAIN PROPULSION PLANT

7.3.1 Single bottom

7.3.1.1 The scantlings of floors shall be determined according to 7.1.1.2 for the greatest span measured in the engine room.

7.3.1.2 The web depth of the plate floors in way of the engine foundation should be as large as possible. The depth of plate floors connected to web frames shall be similar to the depth of the longitudinal foundation girders. In way of the crank case, the depth shall not be less than 0,5. h. The web thickness is not to be less than:

$$t = \frac{h}{100} + 4 \quad [\mathrm{mm}],$$

where:

h = according to 7.1.1.2.1.

7.3.1.3 The thickness of the longitudinal foundation girders shall be determined according to 7.2.3.2.

7.3.1.4 No centre girder need be fitted in way of longitudinal foundation girders. Intercostal docking profiles shall be fitted instead. The sectional area of the docking profiles is not to be less than:

$$A_w = 10 + 0{,}2L \ [\mathrm{cm^2}]$$

7.3.2 Double bottom

7.3.2.1 Lightening holes in way of the engine foundation shall be kept as small as possible with due regard, however, to accessibility. Where necessary, the edges of lightening holes shall be strengthened by means of face bars or the plate panels shall be stiffened.

7.3.2.2 Plate floors

Plate floors shall be fitted at every frame. The floor thickness according to 7.2.6.2.1 shall be increased for percentage as follows:

$$3{,}6 + \frac{P}{500} \quad [\%]$$

but not less 5 %, and not greater than 15 %.

where:

P = single engine output, [kW].

7.3.2.3 Side girders

7.3.2.3.1 The thickness of side girders under an engine foundation top plate inserted into the inner bottom shall be similar to the thickness of side girders above the inner bottom according to 7.3.3.2.

7.3.2.3.2 Side girders under foundation girders shall be extended into the adjacent spaces and to be connected to the bottom structure. This extension abaft and forward of the engine room bulkheads shall be two to four frame spacings if practicable.

7.3.2.3.3 Between the foundation girders, the thickness of the inner bottom plating required according to 7.2.4.1 shall be increased by 2 mm. The strengthened plate shall be extended beyond the engine seating by three to five frame spacings.

7.3.2.3.4 No centre girder is required in way of the engine seating (see 7.3.1.4).

7.3.3 Engine seating

7.3.3.1 General

The following regulations apply to low speed engines. Seating for medium and high-speed engines as well as for turbines will be specially considered.

7.3.3.2 Longitudinal girders

a) The thickness of the longitudinal girders above the inner bottom is not to be less than:

$$t = \sqrt{\frac{P}{15}} + 5 \quad \text{[mm], for } P < 1500 \text{ kW}$$

$$t = \sqrt{\frac{P}{750}} + 12 \text{ [mm]}, \quad \text{for } 1500 \le P \le 7500 \text{ kW}$$

$$t = \sqrt{\frac{P}{1875}} + 18 \text{ [mm], for } P > 7500 \text{ kW}$$

P = see 7.3.2.2

b) Where two longitudinal girders are fitted on either side of the engine, their thickness may be reduced by 4 mm.

c) The cross-sectional area of the top plate is not to be less than:

$$A = \frac{P}{15} + 20 \quad \text{[cm}^2\text{], for } P \le 750 \text{ kW}$$

$$A = \frac{P}{75} + 50 \quad \text{[cm}^2\text{], for } P > 750 \text{ kW}$$

The longitudinal girders of the engine seating shall be supported transversely by means of web frames or wing bulkheads. The scantlings of web frames shall be determined according to Section 8.1.6.

7.4 DOCKING CALCULATION

7.4.1 General

For yachts exceeding 120 m in length, particularly in the aft body and for yachts with a docking load of more than 700 kN/m a special calculation of the docking forces is required. The maximum permissible cargo load to remain onboard during docking and the load distribution shall be specified. The proof of sufficient strength can be performed either by a simplified docking calculation or by a direct docking calculation. The number and arrangement of the keel blocks shall agree with the submitted docking plan. Direct calculations are required for yachts with unusual overhangs at the ends.

7.4.2 Direct docking calculation

If the docking block forces are determined by direct calculation, e.g. by a finite element calculation, considering the stiffness of the ship's body and the weight distribution, the ship has to be assumed as elastically bedded at the keel blocks. The stiffness of the keel blocks has to be determined including the wood layers.

If a floating dock is used, the stiffness of the floating dock shall be taken into consideration.

Transitory docking conditions need also to be considered.

7.4.3 Permissible stresses

The permissible equivalent stress σ_{ekv} is:

$$\sigma_{ekv} = \frac{R_{eH}}{1{,}05}$$

7.4.4 Buckling strength

The bottom structures shall be examined according to *Rules for the classification of ships, Part 2 – Hull*, 4.6.

8 STEEL AND ALUMINIUM ALLOY FRAMING SYSTEM

8.1 TRANSVERSE FRAMING

8.1.1 General

8.1.1.1 Forward of the collision bulkhead and aft of the afterpeak bulkhead, the frame spacing shall in general not exceed 600 mm.

8.1.1.2 Definitions

S = spacing of web frames, [m];

s = spacing of frames, in [m];

l = unsupported span of web frames, in [m];

l_{min} = 2,0 [m];

l_{k1},l_{k2} = length of lower / upper bracket connection at main frames within the lenght l in [m], see Fig. 8.1.2;

p_s= load on ship's sides, in [kN/m^2], according to 3.2.2;

p_e = load on bow structures, in [kN/m^2], according to 3.2.2.2;

p_L = 'tween deck load, in [kN/m^2];

p_1 = pressure, in [kN/m^2], according to Section 3.4.1;

f = factor for curved frames;

f = 1,0 - 2 · e/l;

f_{min} = 0,75;

e = max. height of curve, in [m].

For the conversion from steel to aluminium scantlings see Section 4.3.

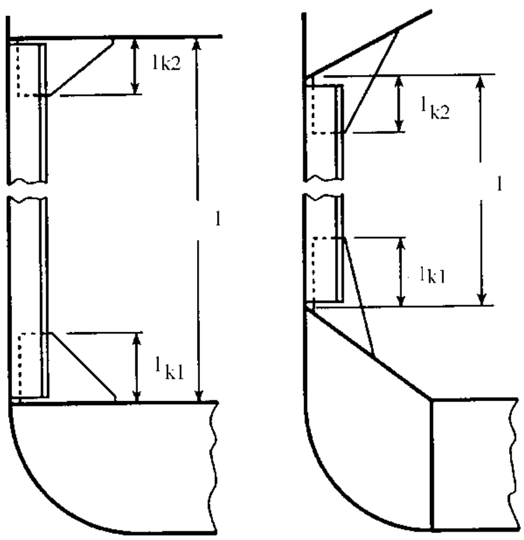


Figure 8.1.2

8.1.2 Main frames

8.1.2.1 Scantlings

8.1.2.1.1 The section modulus of the main frames including end attachments is not to be less than:

$$W = n \cdot c \cdot s \cdot l^2 \cdot p_s \cdot f \cdot k \text{ [cm}^3\text{]}$$

where:

n = 0,9 - 0,0035 · L, for $L < 100$ [m]

n = 0,55, for $L \geq 100$ [m]

c = 1,0 - (l_{k1} + 0,45 ·l_{k2})

c_{min} = 0,65

Within the lower bracket connection, the section modulus is not to be less than the value obtained for c = 1,0.

8.1.2.1.2 In yachts with more than 3 decks the main frames are to extend at least to the deck above the lowest deck.

8.1.2.1.3 The scantlings, of the main frames are not to be less than those of the 'tween deck frames above.

8.1.2.1.4 Where the scantlings of the main frames are determined by strength calculations, the following permissible stresses shall be observed:

- bending stress:

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

- shear stress:

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

- equivalent stress:

$$\sigma_{ekv} = \sqrt{\sigma + 3\tau^2} = 180/k \quad \text{[N/mm}^2\text{]}$$

8.1.2.2 Frames in tanks

The section modulus of frames in tanks or in hold spaces for ballast water is not to be less than the greater of the following values:

W_1 = $n \cdot c \cdot s \cdot l^2 \cdot p_1 \cdot f \cdot k$ [cm^3]

or

W_2 = according to 11.2.3.1

n, c = see 8.1.2.1.1.

8.1.2.3 End attachment

8.1.2.3.1 The lower bracket attachment to the bottom structure shall be determined on the basis of the main frame section modulus.

8.1.2.3.2 The upper bracket attachment to the deck structure and/or to the 'tween deck frames shall be determined on the basis of the section modulus of the deck beams or 'tween deck frames whichever is the greater.

8.1.2.3.3 Where frames are supported by a longitudinally stiffened deck, the frames fitted between web frames shall be connected to the adjacent longitudinals by brackets. The scantlings of the brackets shall be determined on the basis of the section modulus of the frames.

8.1.3 Tween deck and superstructure frames

8.1.3.1 General

8.1.3.1.1 In yachts having a speed exceeding v = 1,6 $\sqrt{L}$ [kN], the forecastle frames forward of 0,1 *L* are to have at least the same scantlings as the frames located between the first and the second deck.

For 'tween deck frames in tanks, the requirements for the section moduli W_1 and W_2 according to 8.1.2.2 shall be observed.

8.1.3.2 Scantlings

8.1.3.2.1 The section modulus of the 'tween deck and superstructure frames are not to be less than:

$$W = 0{,}55 \cdot s \cdot l^2 \cdot p \cdot f \cdot k, \quad [\text{cm}^3]$$

p is not to be taken less than:

$$p_{min} = 0{,}4 \cdot p_L \cdot (b/l)^2, \quad [\text{kN/m}^2]$$

b = unsupported span of the deck beam below the respective 'tween deck frame, in [m].

For 'tween deck frames connected at their lower ends to the deck transverses, p_{min} shall be multiplied by the factor:

$$f_1 = 0{,}75 + 0{,}25 \cdot S/s \geq 1{,}0.$$

8.1.3.3 End attachment

'Tween deck and superstructure frames shall be connected to the main frames below, or to the deck. The end attachment may be carried out in accordance with Fig. 8.1.3.3.

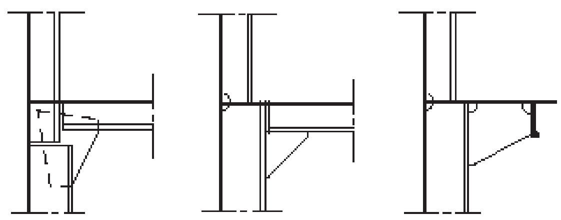


Figure 8.1.3.3

8.1.4 Peak frames and frames in way of the stern

8.1.4.1 Peak frames

8.1.4.1.1 The section modulus of the peak frames is not to be less than:

$$W = 0{,}8 \cdot s \cdot l^2 \cdot p_s \cdot f \cdot k \qquad [\text{cm}^3]$$

$p = p_s$ or p_e whichever is applicable.

8.1.4.1.2 Where the length of the forepeak does not exceed 0,06 *L* the section modulus required at half forepeak length may be maintained throughout the entire forepeak.

8.1.4.1.3 The peak frames shall be connected to the stringer plates to ensure sufficient transmission of shear forces.

8.1.4.1.4 Where peaks shall be used as tanks, the section modulus of the peak frames is not to be less than required by 11.2.31 for W_2.

An additional stringer may be required in the aft body outside the afterpeak where frames are inclined considerable and not fitted vertically to the shell.

8.1.5 Strengthenings in fore-and aft body

8.1.5.1 General

As far as practicable and possible, tiers of beams or web frames and stringers shall be fitted in the fore-and afterpeak.

8.1.5.2 Tiers of beams

8.1.5.2.1 Forward of the collision bulkhead, tiers of beams, at every other frame, generally spaced not more than 2,6 [m] apart, measured vertically, shall be arranged below the lowest deck within the forepeak. Stringer plates shall be fitted on the tiers of beams which shall be connected by continuous welding to the shell plating and by a bracket to each frame. The scantlings of the stringer plates shall be determined from the following formulae:

width: $b = 75\sqrt{L}$ [mm]

thickness: $t = 5{,}0 + L/40$ [mm].

8.1.5.2.2 The cross-sectional area of each beam shall be determined according to 9.3.2. for a load

$P = A \cdot p$ [kN]

where:

A = load area of a beam, in [m^2];

p = p_s or p_e whichever is applicable.

8.1.5.2.3 In the afterpeak, tiers of beams, with stringer plates generally spaced 2,6 m apart, measured vertically, shall be arranged as required under 8.1.5.2.1 as far as practicable with regard to the ship's shape.

8.1.5.2.4 Intermittent welding at the stringers in the afterpeak shall be avoided.

8.1.5.2.5 Where peaks are used as tanks, stringer plates shall be flanged or face bars shall be fitted at their inner edges. Stringers shall be effectively fitted to the collision bulkhead so that the forces can be properly transmitted.

8.1.5.2.6 Where perforated decks are fitted instead of tiers of beams, their scantlings shall be determined as for wash bulkheads according to 11.5. the requirements regarding cross sectional area stipulated in 8.1.5.2.2 are, however, to be complied with.

8.1.5.3 Web frames and stringers

8.1.5.3.1 Where web frames and supporting stringers are fitted instead of tiers of beams, their scantlings shall be determined as follows:

- for section modulus:

$$W = 0{,}55 \cdot S \cdot l^2 \cdot p_s \cdot c \cdot k \ [\text{cm}^2]$$

- for web sectional area at the supports:

$$A_w = 0{,}05 \cdot S \cdot l_1 \, p_s \cdot \text{k} \ [\text{cm}^2]$$

where:

l = unsupported span, in [m], without consideration of cross ties, if any;

l_1 = similar to l, however, considering cross ties, if any;

c = coefficient according to the Table 8.1.5.3.1.

Table 8.1.5.3.1

Number of cross ties	*c*
0	1,0
1	0,5
2	0,3
≥ 3	0,2

8.1.5.3.2 Vertical transverses shall be interconnected by cross ties the cross-sectional area of which shall be determined according to 8.1.5.2.2.

8.1.5.4 Web frames and stringers in 'tween decks and superstructure decks

Where the speed of the ship exceeds v = 1,6 $\sqrt{L}$, [kn], or in yachts with a considerable bow flare respectively, stringers and transverses according to 8.1.5.3 shall be fitted within 0,1 L from forward perpendicular in 'tween deck spaces and superstructures.

The spacing of the stringers and transverses shall be less than 2,8 m. A considerable bow flare exists, if the flare angel exceeds 40°, measured in the ship's transverse direction and related to the vertical plane.

8.1.5.5 Tripping brackets

8.1.5.5.1 Between the point of greatest breadth of the ship at maximum draft and the collision bulkhead tripping brackets spaced not more than 2,6 m, measured vertically. The arrangement of tripping brackets is shown at Fig. 8.1.5.5.1. Where proof of safety against tripping is provided tripping brackets may partly or completely be dispensed with.

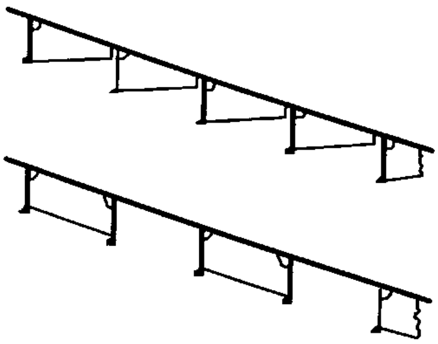


Figure 8.1.5.5.1

8.1.5.5.2 In the same range, in 'tween deck spaces and superstructures of 3 m and more in height, tripping brackets according to 8.1.5.5.1 shall be fitted.

8.1.5.5.3 Where peaks or other spaces forward of the collision bulkhead are intended to be used as tanks, tripping brackets according to 8.1.5.5.1 shall be fitted between tiers of beams or stringers.

8.1.6 Web frames in machinery spaces

8.1.6.1 Arrangement

8.1.6.1.1 In the engine and boiler room, web frames shall be fitted. Generally, they should extend up to the uppermost continuous deck. They shall be spaced not more than 5 times the frame spacing in the engine room.

8.1.6.1.2 For combustion engines, web frames shall generally be fitted at the forward and aft ends of the engine. The web frames shall be evenly distributed along the length of the engine.

8.1.6.1.3 Where combustion engines are fitted aft, stringers spaced 2,6 m apart shall be fitted in the engine room, in alignment with the stringers in the after peak, if any. Otherwise the main frames shall be adequately strengthened. The scantlings of the stringers shall be similar to those of the web frames. At least one stringer is required where the depth up to the lowest deck is less than 4 m.

8.1.6.1.4 For the bottom structure in machinery spaces, see Section 7.3.

8.1.6.2 Scantlings

8.1.6.2.1 The section modulus of web frames is not to be less than:

$W = 0{,}8 \cdot S \cdot \cdot l^2 \cdot p_s \cdot k$ [cm^3]

The moment of inertia of web frames is not to be less than:

$I = D\,(4{,}5\,D - 3{,}75) \cdot c \cdot 10^2$ [cm^4],

for 3 m ≤ D ≤ 10 m

$I = D\,(7{,}25\,D - 31) \cdot c \cdot 10^2$ [cm^4],

for D > 10 m

where:

c = $1 + (H_u - 4) \cdot 0{,}07$

H_u = depth up to the lowest deck, in [m].

The scantlings of the webs shall be calculated as follows:

depth: h = $50 \cdot D$ [mm],

h_{min} = 200 mm

thickness: t = $h / (32 + 0{,}03\,h)$ [mm]

t_{min} = 7,0 mm

8.1.6.2.2 Yachts with a depth of less than 3 m are to have web frames with web scantlings not less than 200 x 7 mm and a minimum face sectional area of 10 cm^2.

8.2 BOTTOM, SIDE, AND DECK LONGITUDINALS, SIDE TRANSVERSES

8.2.1 General

8.2.1.1 Longitudinals shall preferable be continuous through floor plates and transverses. Attachments of their webs to the webs of floor plates and transverses shall be such that the reaction forces of support will be transmitted. The permissible shear stress of $100/k$ [N/mm^2] is not to be exceeded.

8.2.1.2 Where longitudinals abut at transverse bulkheads or webs, brackets shall be fitted. These longitudinals shall be attached to the transverse webs or bulkhead by brackets with the thickness of the stiffeners web thickness, and with a length of weld at the longitudinals equal to 2 x depth of the longitudinals.

8.2.1.3 Where longitudinals are sniped at watertight floors and bulkheads, they shall be attached to the floors by brackets of the thickness of plate floors, and with a length of weld at the longitudinals equal to 2 x depth of the bottom longitudinals.

8.2.1.4 Outside the upper and the lower hull flange, the cross sectional areas stipulated in 8.2.1.2 may be reduced by 20 per cent.

8.2.1.5 For buckling strength of longitudinals see Section 4.6.

8.2.2 Definitions

p = load, in [kN/m^2];

= p_B according to 3.2.3 for bottom longitudinals.

= p_s according to 3.2.2 for side longitudinals

= p_1 according to 3.4.1, for longitudinals at decks and at ship's sides, at longitudinal bulkheads and inner bottom in way of tanks.

For bottom longitudinals in way of tanks p is not to be taken less than:

p_1 - [10 · d_{min} - p_o · C_F] [kN/m^2]

For side longitudinals below d_{min} p need not to be taken larger than:

$$p_1 - \left[10 \cdot (d_{\min} - z) - p_o \cdot C_F \left(1 + \frac{z}{d_{\min}}\right)\right] \left[\text{kN/m}^2\right]$$

= p_d according to 3.4.2 for side and deck longitudinals as well as for horizontal stiffeners of longitudinal bulkheads in tanks which may be partially filled;

= p_D according to 3.2.1 for deck longitudinals of the strength deck;

σ_D = maximum normal stress σ_L due to longitudinal hull girder bending, in [N/mm^2], in the strength deck level at side;

σ_B = maximum normal stress σ_L due to longitudinal hull girder bending, in [N/mm^2], in the bottom;

σ_L = according to 4.5.3.

Where σ_D and σ_B are not known the following values may be taken:

σ_D = σ_{Lmax}

σ_B = 0,8 · σ_{Lmax}

z = distance, in [m], above base line;

$m = (m_1^2 - m_2^2)$

$$m_1 = 1 - \Sigma\left(\frac{l_k}{l} \sin^2 \alpha_k\right)$$

l_k = according to Fig. 8.2.2, in [m]

α_k = according to Fig. 8.2.2, in [°]

$$m_2 = 0{,}204 \frac{s}{l}\left[4 - \left(\frac{s}{l}\right)^2\right]$$

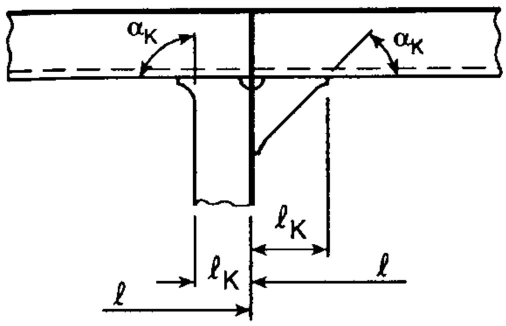


Figure 8.2.2

8.2.3 Scantlings

8.2.3.1 The section modulus and shear area of longitudinals and longitudinal beams of the strength deck is not to be less than:

$W_l = 83{,}3/\sigma_{dop} \cdot m \cdot s \cdot l^2 \cdot p$ [cm^3]

$A_l = (1 - 0{,}817 \cdot m_2) \cdot 0{,}05 \cdot s \cdot l \cdot p \cdot k$ [cm^2]

The permissible stress σ_{dop} shall be determined according to the following formulae.

- below the neutral axis of the respective cross section:

$$\sigma_{dop} = \sigma_l - \sigma_B + z\,\frac{\sigma_B + \sigma_D}{D} \text{ [N/mm}^2\text{]}$$

- above the neutral axis of the respective cross section:

$$\sigma_{dop} = \sigma_l + \sigma_B - z\,\frac{\sigma_B + \sigma_D}{D} \text{ [N/mm}^2\text{]}$$

$\sigma_{dop} \leq 150/k$ [N/mm^2]

σ_l = (0,8 + L/450) · 230/k [N/mm^2]

$$\sigma_{lmax} = \frac{230}{k} \text{ [N/mm}^2\text{]}$$

For calculation purpose the absolute stress values shall be taken for σ_B and σ_D.

8.2.3.2 In tanks, the section modulus is not to be less than W_2 according to 11.2.3.1.

8.2.3.3 For determining the section modulus of longitudinals located adjacent to a bilge strake which is not stiffened longitudinally, the width.

$$\frac{R}{3} + \frac{s}{2}$$

for R see Fig. 8.2.3.3

shall be inserted, in lieu of s, into the formula as per 8.2.3.1.

For safety against tripping, the spacing of transverses shall be less than 12 x width of the longitudinal face. Otherwise, an additional bracket shall be fitted at half transverse's spacing.

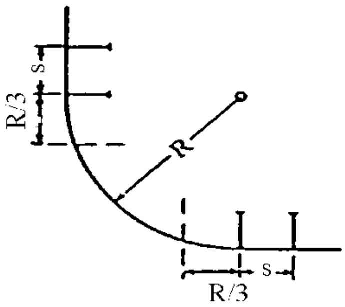


Figure 8.2.3.3

8.2.3.4 Where the scantlings of longitudinals are determined by strength calculations, the total equivalent stress comprising local bending and shear stresses and normal stresses due to longitudinal hull girder bending is not to exceed the total stress value σ_t as defined in 8.2.3.1.

8.2.4 Side transverses

8.2.4.1 The section modulus of side transverses supporting side longitudinals is not to be less than:

$W = 0{,}55 \cdot S \cdot l^2 \cdot p \cdot k$ [cm³]

Minimum cross-sectional area of the web:

$A_w = 0{,}05 \cdot S \cdot l \cdot p \cdot k$ [cm²]

8.2.4.2 Where the side transverses are designed on the basis of strength calculations the following stresses are not to be exceeded:

σ_b = 150/k [N/mm²]

τ = 100/k [N/mm²]

$$\sigma_{ekv} = \sqrt{\sigma_b^2 + 3\tau^2} \leq 180/k \text{ [N/mm}^2\text{]}$$

8.2.4.3 In tanks, the section modulus and the cross-sectional area shall be in accordance with 11.2.3, W_2 and A_{w2} respectively.

8.2.4.4 The webs of side transverses in those areas, where concentrated loads due to ship manoeuvres at terminals may be expected, shall be examined for sufficient buckling strength according to *Rules for the classification of ships, Part 2 – Hull*, 4.6. The force induced by a fender into the web frame may approximately be determined by the following formula:

$$P_g = \frac{\Delta \cdot v^2}{2 \cdot f} \quad \text{[kN]}$$

where:

Δ = displacement of the ship, in [t];

Δ_{max} = 100 000 t

f = displacement of fender, in [m], guidance values for f are given in Table 8.2.4.4-1

v = manoeuvring speed of the ship, in [m/s], guidance values are given in Table 8.2.4.4.

Table 8.2.4.4

Δ [t]	f [m]	v [m/s]
≤ 1000	0,25	0,2
> 1000 ≤ 10000	$0{,}22 + 2{,}8 \cdot \Delta \cdot 10^{-5}$	$0{,}21 - 1{,}1\ \Delta \cdot 10^{-5}$
> 10000	0,5	0,10

8.2.4.5 The compressive stress in the web of the transverse due to the action of the force P_g may be determined by the following formula:

$$\sigma_D = \frac{P_g \cdot 10^3}{h \cdot t_w} \text{ [N/mm}^2\text{]}$$

where:

h = vertical length of application of the force P_g if h is not known, h = 300 mm may be used as a guidance value;

t_w= web thickness, in [mm].

9 STEEL AND ALUMINIUM ALLOY SUPPORTING DECK STRUCTURES

9.1 GENERAL

9.1.1 Definitions

k = material factor (according to 4.2.1);

l = unsupported span, in [m];

b = width of deck supported, in [m];

p = deck load p_D, p_{DA} or p_L, in [kN/m²] (according to 3.2.1, 3.2.5);

f = 0,55;

f = 0,75 for beams, girder and transverses which are simply supported on one or both ends;

P_u = pillar load;

P_u = $p \cdot A + P_i$, [kN];

A = load area for one pillar, in [m²];

P_i = load from pillars located above the pillar considered, in [kN];

λ_u = degree of slenderness of the pillar;

λ_u = l_u/i_u;

l_u = length of the pillar, in [cm];

i_u = radius of gyration of the pillar;

$i_u = \sqrt{I_u / A_u}$ [cm];

I_u = moment of inertia of the pillar, in [cm⁴];

A_u = sectional area of the pillar, in [cm²];

i_u = $0,25 \cdot d_u$ for solid pillars of circular cross section;

$i_u = 0,25\sqrt{d_{uv}^2 + d_{uu}^2}$ for tubular pillars;

d_u = pillar diameter in [cm];

d_{uv} = outside diameter of pillar, in [cm];

d_{uu} = inside diameter of pillar, in [cm];

m_2 = factor according to Section 8.2.2.

For the conversion from steel to aluminium scantlings see Section 4.3.

9.1.2 Permissible stresses

Where the scantlings of girders not forming part of the longitudinal hull structure, or of transverses, deck beams, etc. are determined by means of strength calculations the following stresses are not to be exceeded:

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

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

$$\sigma_{ekv} = \sqrt{\sigma^2 + 3\tau^2} = 180/k \text{ [N/mm}^2\text{]}$$

9.1.3 Buckling strength

The buckling strength of the deck structures shall be examined according to *Rules for the classification of ships, Part 2 – Hull*, 4.6. For this purpose to design stresses according to *Rules for the classification of ships, Part 2 – Hull,* 4.5.3 and the stresses due to local loads shall be considered.

9.2 DECK BEAMS, LONGITUDINALS AND GIRDERS

9.2.1 Transverse deck beams and deck longitudinals

The section modulus and shear area of transverse deck beams and of deck longitudinals not contributing to the longitudinal strength shall be determined by the following formula:

$$W_d = f \cdot s \cdot p \cdot l^2 \cdot k \quad \text{[cm}^3\text{]}$$

$$A_d = (1 - 0{,}817 \cdot m_2) \cdot 0{,}05 \cdot s \cdot l \cdot p \cdot k \quad \text{[cm}^2\text{]}$$

9.2.2 Deck longitudinals in way of the upper and lower hull flange

9.2.2.1 The section modulus of deck longitudinals contributing to the longitudinal strength shall be calculated according to 8.2.3.

9.2.3 Attachment

9.2.3.1 Transverse deck beams shall be connected to the frames by brackets according to 7.2.6.

9.2.3.2 Deck beams crossing longitudinal walls and girders may be attached to the stiffeners of longitudinal walls and the webs of girders respectively by welding without brackets.

9.2.3.3 Where deck beams shall be attached to hatchway coamings and girders of considerable rigidity brackets shall be provided.

9.2.3.4 Within 0,6 L amidships, the arm lengths of the beam brackets in single deck yachts shall be increased by 20%.

9.2.3.5 For the connection of deck longitudinals to transverses and bulkheads, see also Section 8.2.3.

9.2.4 Girders and transverses

9.2.4.1 The section modulus W is not to be less than:

$$W = f \cdot b \cdot l^2 \cdot p \cdot k \text{ [cm}^3\text{]}$$

9.2.4.2 The shear area A_w is not to be less than:

$$A_w = 0{,}05 \cdot p \cdot b \cdot l \cdot k \text{ [cm}^2\text{]}$$

9.2.4.3 The depth of girders is not to be less than 1/25 of the unsupported span. The web depth of girders scalloped for continuous deck beams shall be at least 1,5 times the depth of the deck beams.

Scantlings of girders of tank decks shall be determined according to Section 11.2.3.

9.2.4.4 End attachments of girders at bulkheads shall be so dimensioned that the bending moments and shear forces can be transferred. Bulkhead stiffeners under girders shall be sufficiently dimensioned to support the girders.

9.2.4.5 Face plates shall be stiffened by tripping brackets. At girders of symmetrical section, they shall be arranged alternately on both sides of the web.

9.2.4.6 Where a girder does not have the same section modulus throughout all girder fields, the greater scantlings shall be maintained above the supports and shall be reduced gradually to the smaller scantlings.

9.2.4.7 For girders forming part of the longitudinal hull structure and for hatchway girders see 9.5.

9.2.5 Supporting structure of windlasses and chain stoppers

9.2.5.1 For the supporting structure under windlasses and chain stoppers, the following permissible stresses shall be observed:

$$\sigma_b = 200/k \text{ [N/mm}^2\text{]}$$

$$\tau = 120/k \text{ [N/mm2]}$$

$$\sigma_{ekv} = \sqrt{\sigma^2 + 3\tau^2} = 220/k \text{ [N/mm}^2\text{]}$$

9.2.5.2 The acting forces shall be calculated for 80% and 45% respectively of the rated breaking load of the chain cable, i.e.:

- for chain stoppers 80%;
- for windlasses 80%, where chain stoppers are not fitted;
- for windlasses 45%, where chain stoppers are fitted.

9.3 PILLARS

9.3.1 General

9.3.1.1 Structural members at heads and heels of pillars as well as substructures shall be constructed according to the forces they are subjected to. The connection shall be so dimensioned that at least 1 cm^2 cross sectional area is available for 10 kN of load.

Where pillars are affected by tension loads doublings are not permitted.

9.3.1.2 Pillar in tanks shall be checked for tension. Tubular pillars are not permitted in tanks for flammable liquids.

9.3.1.3 For structural elements of the pillars' transverse section, sufficient buckling strength according to *Rules for the classification of ships, Part 2 – Hull,* 4.6. has to be verified. The wall thickness of tubular pillars which may be expected to be damaged during loading and unloading operations is not to be less than:

$t_u = 4{,}5 + 0{,}015 \cdot d_{uv}$ [mm], for $d_{uv} \le 300$ mm

$t_u = 0{,}03\ d_{uv}$ [mm], for $d_{uv} > 300$ mm

where:

d_{uv} = outside diameter of tubular pillar, in [mm].

9.3.1.4 Pillars also loaded by bending moments have to be specially considered.

9.3.2 Scantlings

The sectional area of pillars is not to be less than:

$A_u = 10 \cdot P_u / \sigma_t$ [cm^2]

where:

σ_t= permissible compressive stress according to Table 9.3.2, in [N/mm$_2$].

Table 9.3.2.-1

Degree of slenderness (λ_u)	Permissible compressive stress [N/mm^2]	
	Pillars within accommodation	Elsewhere
≤ 100	$140 - 0{,}0067 \cdot \lambda^2_u$	$117 - 0{,}0056 \cdot \lambda^2_u$
> 100	$7{,}3 \cdot 10^5/\lambda^2_u$	$6{,}1 \cdot 10^5/\lambda^2_u$

9.4 CANTILEVERS

9.4.1 General

9.4.1.1 Cantilevers for supporting girders, hatchway coamings, engine casings and unsupported parts of decks shall be connected to transverses, web frames, reinforced main frames, or walls in order to withstand the bending moment arising from the load *P*.

9.4.1.2 Face plates shall be secured against tilting by tripping brackets fitted to the webs at suitable distances.

9.4.2 Permissible stresses

9.4.2.1 When determining the cantilever scantlings, the following permissible stresses shall be observed:

a) Where single cantilevers are fitted at greater distances:

$$\sigma_b = 125/k \text{ [N/mm}^2\text{]}$$

$$\tau = 80/k \text{ [N/mm2]}$$

b) Where several cantilevers are fitted at smaller distances (e.g. at every frame):

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

$$\tau = 80/k \text{ [N/mm2]}$$

$$\sigma_{ekv} = \sqrt{\sigma^2 + \tau^2} = 180/k \text{ [N/mm}^2\text{]}$$

The stresses in web frames are not exceed the values specified above.

9.5 HATCHWAY GIRDERS AND GIRDERS FORMING PART OF THE LONGITUDINAL HULL STRUCTURE

9.5.1 The scantlings of longitudinal and transverse hatchway girders shall be determined on the basis of strength calculations. The calculations shall be based upon the deck loads according to 3.2.2.

9.5.2 The hatchway girders shall be so dimensioned that the stress values given in Table 9.5.2 will not be exceeded.

Table 9.5.2

Longitudinal coaming and girders of the strength deck		**All other hatchway girders**
upper and lower flanges	$150/k$ [N/mm^2]	$150/k$ [N/mm^2]
deck level	$70/k$ [N/mm^2]	

9.5.2.3 For continuous longitudinal coamings the combined stress resulting from longitudinal hull girder bending and local bending of the longitudinal coaming is not to exceed the following value:

$\sigma_L + \sigma_l \leq 200/k$ [N/mm^2],

where:

σ_l = local bending stress in the ship's longitudinal direction (permissible stress values are given in Table 9.5.2);

σ_L = design longitudinal hull girder bending stress according to 4.5.3;

9.5.2.4 The equivalent stress is not to exceed the following value:

$$\sigma_{ekv} = \left[0,8 + \frac{L}{450}\right] \cdot \frac{230}{k} \quad \text{[N/mm}^2\text{], for } L < 90 \text{ m}$$

$$\sigma_{ekv} = 230/k \text{ [N/mm}^2\text{], for } L \geq 90 \text{ m}$$

$$\sigma_{ekv} = \sqrt{\sigma_x^2 - \sigma_x \cdot \sigma_y + \sigma_y^2 + 3\tau^2}\ ,$$

where:

σ_x = $\sigma_L + \sigma_l$;

σ_y = stress in the ship's transverse direction;

τ = shear stress;

τ_{max} = $90/k$ [N/mm^2]

The individual stresses σ_l and σ_y are not to exceed $150/k$ [N/mm^2].

9.5.2.5 The requirements regarding buckling strength according to Section 9.1.3 shall be observed.

10 STEEL AND ALUMINIUM ALLOY WATERTIGHT BULKHEADS

10.1 GENERAL

10.1.1 All yachts have to be structurally subdivided, according to the requirements stated in Sec. 21.

10.2 SCANTLINGS

10.2.1 General

10.2.1.1 Where holds are intended to be filled with ballast water, their bulkheads are to comply with the requirements of Section 11.

10.2.1.2 Definitions:

t_k = corrosion addition, 0,5 mm;

s = spacing of stiffeners in [m];

l = unsupported span, in [m];

p = $9{,}81 \cdot h$ [kN/m^2];

h = distance from the load centre of the structure to a point 1 m above the bulkhead deck, at the ship's side, for the collision bulkhead to a point 1 m above the collision bulkhead at the ship's side.

C_p, C_s = coefficients according to Table 10.2.1.3;

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

R_{eH} = minimum nominal upper yield point, in [N/mm^2], according to 4.2.1.

For the conversion from steel to aluminium scantlings see Section 4.3.

Table 10.2.1.3

Coefficient C_p and C_s		Collision bulkhead	Other bulkheads
Plating	C_p	$1{,}1\sqrt{k}$	$0{,}9\sqrt{k}$
Stiffeners and corrugated bulkhead elements	C_s: in case of constraint of both ends	$0{,}33\,k$	$0{,}265\,k$
	C_s: in case of simple support of one end and constraint at the other end	$0{,}45 \cdot k$	$0{,}36 \cdot k$
	C_s: both ends simply supported	$0{,}66 \cdot k$	$0{,}53 \cdot k$

10.2.2 Bulkhead plating

10.2.2.1 The thickness of the bulkhead plating is not to be less than:

$$t = C_p \cdot s\sqrt{p} + t_k \text{ [mm]},$$

but not less than:

$$t_{min} = 5{,}0\sqrt{k} \text{ [mm]}$$

10.2.2.2 In small yachts, the thickness of the bulkhead plating need not exceed the thickness of the shell plating for a frame spacing corresponding to the stiffener spacing.

10.2.2.3 The stern tube bulkhead shall be provided with a strengthened plate in way of the stern tube.

10.2.3 Stiffeners

10.2.3.1 The section modulus of bulkhead stiffeners is not to be less than:

$$W = C_s \cdot s \cdot l^2 \cdot p \text{ [cm}^3\text{]}$$

10.2.3.2 In horizontal part of bulkheads, the stiffeners are also to comply with the rules for deck beams according to 9.2.1.

10.2.3.3 The scantlings of the brackets shall be determined in dependence of the section modulus of the stiffeners. If the length of the stiffener is 3,5 m and over, the brackets are to extend to the next beam or the next floor.

10.2.3.4 Unbracketed bulkhead stiffeners shall be connected to the decks by welding. The length of welds shall be at least 0,6 x depth of the section.

10.2.3.5 Bulkhead stiffeners which cut in way of watertight doors shall be supported by carlings or stiffeners.

10.2.4 Corrugated bulkheads

10.2.4.1 The plate thickness of corrugated bulkheads is not to be less than required according to 10.2.2.1. For the spacing s, the greater one of the values b or c, in [m], according to 10.2.4.3 shall be taken.

10.2.4.2 The section modulus of a corrugated bulkhead element shall be determined according to 10.2.3.1. For the spacing s, the width of an element a, in [m], according to 10.2.4.3 shall be taken.

10.2.4.3 The actual section modulus of a corrugated bulkhead element shall be assessed according to the following formula:

$$W = t \cdot h \cdot \left(b + \frac{c}{3}\right) \text{ [cm}^3\text{]},$$

where:

a = width of element, in [cm];

b = breadth of face plate, in [cm];

c = breadth of web plate, in [cm];

h = distance between face plates, in [cm];

t = plate thickness, in [cm];

$\alpha \geq 45^\circ$

See Fig. 10.2.4.3

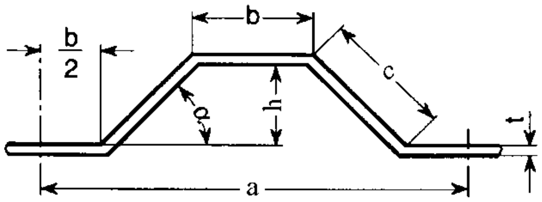


Figure 10.2.4.3

10.3 SHAFT TUNNELS

10.3.1 General

10.3.1.1 Where one or more compartments are situated between stern tube bulkhead and engine room, a watertight shaft tunnels shall be arranged. The size of the shaft tunnels shall be adequate for service and maintenance purposes.

10.3.1.2 The access opening between engine room and shaft tunnel shall be closed by a watertight sliding door. For extremely short shaft tunnels watertight doors between tunnel and engine room may be dispensed with, subject to special approval by the *Register*.

10.3.1.3 Tunnel ventilators and the emergency exit shall be constructed watertight up to the freeboard deck.

10.3.2 Scantlings

10.3.2.1 The plating of the shaft tunnel shall be dimensioned as for a bulkhead according to 10.2.2.1.

10.3.2.2 The plating of the round part of tunnel tops may be 10 per cent less in thickness.

10.3.2.3 The section modulus of shaft tunnel stiffeners shall be determined according to 10.2.3.1.

10.3.2.4 Shaft tunnels in tanks are to comply with the requirements of Section 11.

10.3.2.5 Horizontal parts of the tunnel shall be treated as horizontal parts of bulkheads.

10.3.2.6 The tunnel shall be suitably strengthened under pillars.

11 STEEL AND ALUMINIUM ALLOY TANK STRUCTURES

11.1 GENERAL

11.1.1 Subdivision of tanks

11.1.1.1 In tanks extending over the full breadth of the ship intended to be used for partial filling, at least one longitudinal bulkhead shall be fitted, which may be a swash bulkhead.

11.1.1.2 Where the forepeak is intended to be used as tank, at least one complete or partial longitudinal swash bulkhead shall be fitted, if the tank breadth exceeds 0,5 B or 6 m, whichever is the greater.

When the afterpeak is intended to be used as tank, at least one complete or partial longitudinal swash bulkhead shall be fitted. The largest breadth of the liquid surface should not exceed $0{,}3 \cdot B$ in the aft peak.

11.1.1.3 Peak tanks exceeding 0,06 L or 6 m in length, whichever is greater, shall be provided with a transverse swash bulkhead.

11.1.2 Air, overflow and sounding pipes

Each tank shall be fitted with air pipes, overflow pipes and sounding pipes. See also *Rules for the classification of ships, Part 8 - Piping*, Section 5.

11.1.3 Forepeak tank

Oil is not to be carried in a forepeak tank or a tank forward of the collision bulkhead.

11.1.4 Separation of oil fuel tanks from tanks for other liquids

11.1.4.1 Oil fuel tanks shall be separated from tanks for lubricating oil, hydraulic oil, vegetable oil, feedwater, condensate water and potable water by cofferdams.

11.1.4.2 Fuel oil tanks adjacent to lubricating oil circulation tanks are not permitted.

11.1.5 Tanks for heated liquids

11.1.5.1 Where heated liquids are intended to be carried in tanks, a calculation of thermal stresses is required, if the carriage temperature of the liquid exceeds the following values:

T = 65 °C in case of longitudinal framing,

T = 80 °C in case of transverse framing.

11.1.5.2 The calculations shall be carried out for both temperatures, the actual carriage temperature, and the limit temperature T according to 11.1.5.

The calculations are to give the resultant stresses in the hull structure based on a sea water temperature of 0 °C and an air temperature of 5 °C.

Constructional measures and/or strengthening will be required on the basis of the results of the calculation for both temperatures.

11.1.6 Cross references

11.1.6.1 Where a tank bulkhead forms part of a watertight bulkhead, its strength is not to be less than required by Section 10.

11.1.6.2 For oil fuel tanks, see also *Rules for the classification of ships, Part 8 - Piping*, Section 8. For tanks in the double bottom, see Section 7.2.

11.1.6.3 For testing of tanks, see 11.6.

11.1.6.4 For corrosion protection and cathodic protection see *Rules for the classification of ships, Part 1 - General requirements*, *Chapter 5* and *Part 24 - Non- metallic materials*, *Section 4*.

11.1.7 Minimum thickness

11.1.7.1 The thickness of all structures in tanks is not to be less than the following minimum value:

$$t_{min} = 4{,}5 + 0{,}02 \cdot L \text{ [mm]}$$

11.1.7.2 For fuel oil, lubrication oil and freshwater tanks t_{min} need not be taken greater than 6,5 mm.

11.2 SCANTLINGS

11.2.1 Definitions

k = material factor according to 4.2.1;

s = spacing of stiffeners or load width, in [m];

l = unsupported span, in [m];

p = load p_1 or p_d, in [kN/m²], according to 3.2.4 (the greater load to be taken);

p_2 = load, in [kN/m²], according to 3.2.4;

t_k = corrosion addition, in [mm];

h = filling height of tank, in [m];

l_t = tank length, in [m];

b_t = tank breadth, in [m];

$$\sigma_a = \sqrt{\left(\frac{235}{k}\right)^2 - 3 \cdot \tau_L^2} - 0{,}89 \cdot \sigma_L \text{ [N/mm}^2\text{]}$$

σ_L, τ_L = design hull girder bending or shear stress respectively, in [N/mm²], within the plate field considered as defined in *Rules, Part 2 – Hull,* 4.5.3;

C = 1,0, for transverse stiffening;

C = 0,83, for longitudinal stiffening.

For the conversion from steel to aluminium scantlings see Section 4.3.

11.2.2 Plating

11.2.2.1 The plate thickness is not to be less than:

$$t_1 = 1{,}1 \cdot s \cdot \sqrt{p \cdot k} + t_k \text{ [mm]},$$

$$t_2 = 0{,}9 \cdot s \cdot \sqrt{p_2 \cdot k} + t_k \text{ [mm]},$$

11.2.2.2 The thickness of tank boundaries (including deck and inner bottom) carrying also normal and shear stresses due to longitudinal hull girder bending is not to be less than:

$$t = 16{,}8 \cdot C \cdot s \sqrt{\frac{p}{\sigma_a}} + t_k \text{ [mm]}$$

11.2.2.3 The buckling strength of longitudinal and transverse bulkheads exposed to compressive stresses shall be carried out according to *Rules for the classification of ships, Part 2 – Hull,* 4.6. for longitudinal bulkheads the design stresses according to *Rules for the classification of ships, Part 2 – Hull,* 4.5.3 and the stresses due to local shall be considered.

11.2.3 Stiffeners and girders

11.2.3.1 Stiffeners and girders, which are not considered as longitudinal strength members

11.2.3.1.1 The section modulus of stiffeners and girders constrained at their ends, which are not considered as longitudinal strength members, is not to be less than:

$$W_1 = 0{,}55 \cdot s \cdot l^2 \cdot p \cdot k \text{ [cm}^3\text{]}$$

$$W_2 = 0{,}44 \cdot s \cdot l^2 \cdot p_2 \cdot k \text{ [cm}^3\text{]}$$

Where one or both ends are simply supported, the section moduli shall be increased by 50 per cent.

The cross-sectional area of the girder webs is not to be less than:

$$A_{w1} = 0{,}05 \cdot s \cdot l \cdot p \cdot k \text{ [cm}^2\text{]}$$

$$A_{w2} = 0{,}04 \cdot s \cdot l \cdot p_2 \cdot k \text{ [cm}^2\text{]}$$

A_{w2} shall be increased by 50 per cent at the position of constraint for a length of $0{,}1 \cdot l$.

The buckling strength of the webs shall be examined according to *Rules for the classification of ships, Part 2 – Hull,* 4.6.

11.2.3.1.2 Where the scantlings of stiffeners and girders, which are not considered as longitudinal strength members, the following permissible stress values apply:

- if subjected to load p:

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

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

$$\sigma_{ekv} = \sqrt{\sigma_b^2 + 3\tau^2} = 180/k \text{ [N/mm}^2\text{]}$$

- if subjected to load p_2:

$$\sigma_b = 180/k \text{ [N/mm}^2\text{]}$$

$$\tau = 120/k \text{ [N/mm}^2\text{]}$$

$$\sigma_{ekv} = \sqrt{\sigma_b^2 + 3\tau^2} = 200/k \text{ [N/mm}^2\text{]}$$

11.2.3.2 Stiffeners and girders, which shall be considered as longitudinal strength members

11.2.3.2.1 The section moduli and shear areas of horizontal stiffeners and griders, which shall be considered as longitudinal strength members, shall be determined according to 8.2.3 as for longitudinals. In this case for girders supporting transverse stiffeners the factors $m = 1$ and $m_2 = 0$ shall be used.

11.2.3.2.2 The scantlings of beams and girders of tank decks are also to comply with the requirements of Section 9.

11.2.3.2.3 For frames in tanks, see 8.1.2.2.

11.2.3.2.4 The stiffeners of tank bulkheads shall be attached at their ends by brackets according to Section 7.2.6. The scantlings of the brackets shall be determined according to the section modulus of the stiffeners. Brackets must be fitted where the length of the stiffeners exceeds 2 m.

The brackets of stiffeners are to extend to the next beam, the next floor, the next frame, or shall be otherwise supported at their ends.

11.2.3.2.5 Regarding buckling strength of girders the requirements of 11.2.2.3 shall be observed.

11.2.3.2.5 Where stringers of transverse bulkheads are supported at longitudinal bulkheads or at the side shell, the supporting forces of these stringers shall be considered when determining the shear stress in the longitudinal bulkheads. Likewise, where vertical girders of transverse bulkheads are supported at deck or inner bottom, the supporting forces of these vertical girders shall be considered when determining the shear stresses in the deck or inner bottom respectively.

The shear stress introduced by the stringer into the longitudinal bulkhead or side shell may be determined by the following formula:

$$\tau_{St} = \frac{P_{St}}{2 \cdot b_{St} \cdot t} \quad \text{[N/mm}^2\text{]}$$

where:

P_{St} = supporting force of stringer or vertical girder, in [kN];

b_{St} = breadth of stringer or depth of vertical girder including end bracket (if any) at the supporting point, in [m;

t = see 11.2.2.1.

The additional shear stress σ_{St} shall be added to the shear stress τ_L due to longitudinal bending according to *Rules for the classification of ships, Part 2 – Hull,* 4.5.3 in the following area:

- 0,5 m on both sides of the stringer in the ship's longitudinal direction
- $0{,}25 \cdot b_{St}$ above and below the stringer

Thereby the following requirement shall be satisfied:

$$\frac{110}{k} \geq \tau_{St} = \frac{P_{St}}{2 \cdot b_{St} \cdot t} + \tau_L$$

11.2.4 Corrugated bulkheads

11.2.4.1 The plate thicknesses of corrugated bulkheads as well as the required section moduli of corrugated bulkhead elements shall be determined according to 11.2.2 and 11.2.3, proceeding analogously to 10.2.4.

The minimum plate thickness shall be in accordance with 11.1.7 or as follows:

- if subjected to load p_1:

$$t_{min} = \frac{b}{905}\sqrt{\sigma_D} + t_k \text{ [mm]};$$

- if subjected to load p_2:

$$t_{min} = \frac{b}{960}\sqrt{\sigma_D} + t_k \text{ [mm]};$$

where:

σ_D = compressive stress, [N/mm^2];

b = breadth of face plate strip, in [mm], see Fig. 10.2.4.3.

11.3 TANKS WITH LARGE LENGTHS OR BREADTHS

11.3.1 General

Tanks with lengths $l_t > 0{,}1 \cdot L$ or breadths $b_t > 0{,}6 \cdot B$ (e.g. hold spaces for ballast water) which are intended to be partially filled, shall be investigated to avoid resonance between the liquid motion and motion of the ship.

If necessary, critical tank filling ratios shall be avoided. The ship's periods of pitch and roll motion as well as the natural periods of the liquid in the tank may be determined by the following formulae:

- natural period of liquid in tank:

$$T_{l,b} = 1{,}132\sqrt{\frac{e_t}{f}} \text{ [s]},$$

where:

f = tanh ($\pi \cdot h/e_t$) hyperbolic function;

- period of pitch motion

$$T_s = 1{,}8\sqrt{\frac{L}{g}} \text{ [s]};$$

- period of roll motion

$$T_r = \frac{C_r \cdot B}{\sqrt{\overline{GM}}} \text{ [s]},$$

where:

C_r = 0,78 in general;

$\overline{GM}$ ≈ 0,07 · B in general;

e_t = characteristic tank dimension l_t or b_t, in [m].

11.4 DETACHABLE TANKS

11.4.1 General

11.4.1.1 Detached tanks shall be adequately secured against forces due to the ship's motions.

11.4.1.2 Fittings and pipings on detached tanks shall be protected by battens, and gutterways shall be fitted on the outside of tanks for draining any leakage oil.

11.4.2 Scantlings

11.4.2.1 The thickness of plating of detached tanks shall be determined according to 11.2.2.1 using the formula for t_1 and the pressure p as defined in 11.4.2.2.

11.4.2.2 The section modulus of stiffeners of detached tanks is not to be less than:

$$W = C_1 \cdot s \cdot l^2 \cdot p \cdot k \text{ [cm}^3\text{]},$$

where:

C_1 = 0,36 if stiffeners are constrained at both ends;

C_1 = 0,54 if one or both ends are simply supported;

p = 9,81 ·h [kN/m^2];

h = head measured from the load centre of plate panel or stiffener respectively to the top of overflow; the height of overflow is not to be taken less than 2,5 m.

11.4.2.3 For minimum thickness the requirements of 11.1.7 apply in general.

11.5 SWASH BULKHEADS

11.5.1 The total area of performation is not to be less than 5% and are not to exceed 10% of the total bulkhead area.

11.5.2 The plate thickness is, in general, to be equal to the minimum thickness according to 11.1.7. Strengthenings may be required for load bearing structural parts.

The free lower edge of a wash bulkhead shall be adequately stiffened.

11.5.3 The section modulus of the stiffeners and girders is not to be less than W_1 as per 11.2.3.1, however, the load p_d according to 3.2.4.2 shall be taken in lieu of p.

11.6 TESTING PROCEDURES OF WATERTIGHT COMPARTMENTS

11.6.1 Application

Revision of this Section shall be complied with in respect of the testing of watertight compartments in accordance with notes 1, 2, 3 and 4.

11.6.2 General

11.6.2.1 The testing procedures of watertight compartments shall be carried out in accordance with Head 11.7 and Head 11.8.

11.6.2.2 Testing procedures of watertight compartments for yachts of 500 GT and upwards shall be carried out in accordance with Section 11.7, unless:

a) the shipyard provides documentary evidence of equivalent testing provisions, subject to *Register's* acceptance on case by case basis; and

b) the above-mentioned exemption / equivalency has been granted by the responsible Flag State.

11.6.2.3 Testing procedures of watertight compartments shall be carried out in accordance with Section 11.8 for yachts of less than 500 GT.

11.7 PROCEDURES FOR TESTING TANKS AND TIGHT BOUNDARIES (FOR YACHTS OF 500 GT AND UPWARDS)

11.7.1 General

11.7.1.1 These test procedures are to confirm the watertightness of tanks and watertight boundaries and the structural adequacy of tanks which consist of the watertight subdivisions of yachts. These procedures may also be applied to verify the weathertightness of structures and shipboard outfitting. The tightness of all tanks and watertight boundaries of yachts during new construction and those relevant to major conversions or major repairs shall be confirmed by these test procedures prior to the delivery of the ship.

11.7.1.2 Testing procedures of watertight compartments shall be carried out in accordance with this Section, unless:

1. the shipyard provides documentary evidence of the shipowner's agreement to a request to the Flag State for an exemption from the application of *SOLAS Chapter II-1, Regulation 11*, or for an equivalency agreeing that the content of Section 11.7 is equivalent to *SOLAS Chapter II-1, Regulation 11*; and
2. the above-mentioned exemption / equivalency has been granted by the responsible Flag State.

11.7.2 Application

11.7.2.1 All gravity tanks and other boundaries required to be watertight or weathertight shall be tested in accordance with this Procedure and proven to be tight and structurally adequate as follows:

1. gravity tanks for their tightness and structural adequacy,
2. watertight boundaries other than tank boundaries for their watertightness, and
3. weathertight boundaries for their weathertightness.

11.7.2.2 Testing of structures not listed in Table 11.7.1 or 11.7.2 shall be specially considered.

11.7.3 Test types and definitions

11.7.3.1 The following two types of test are specified in this requirement:

Structural test: A test to verify the structural adequacy of tank construction. This may be a hydrostatic test or, where the situation warrants, a hydro-pneumatic test.

Leak test: A test to verify the tightness of a boundary. Unless a specific test is indicated, this may be a hydrostatic/hydro-pneumatic test or an air test. A hose test may be considered an acceptable form of leak test for certain boundaries, as indicated by footnote 3 of Table 11.7.1.

11.7.3.2 The definition of each test type is as follows:

Hydrostatic test: (Leak and structural)	A test wherein a space is filled with a liquid to a specified head.
Hydro-pneumatic test: (Leak and structural)	A test combining a hydrostatic test and an air test, wherein a space is partially filled with a liquid and pressurized with air.
Hose test: (Leak)	A test to verify the tightness of a joint by a jet of water with the joint visible from the opposite side.
Air Tests: (Leak)	A test to verify tightness by means of air pressure differential and leak indicating solution. It includes tank air tests and joint air tests, such as a *compressed air fillet weld tests* and *vacuum box tests*.
Compressed air fillet weld test: (Leak)	An air test of a fillet welded tee joint wherein leak indicating solution is applied on fillet welds.
Vacuum box test: (Leak)	A box over a joint with leak indicating solution applied on the welds. A vacuum is created inside the box to detect any leaks.
Ultrasonic test: (Leak)	A test to verify the tightness of the sealing of closing devices such as hatch covers by means of ultrasonic detection techniques.
Penetration test: (Leak)	A test to verify that no visual dye penetrant indications of potential continuous leakages exist in the boundaries of a compartment by means of low surface tension liquids (i.e. dye penetrant test).

11.7.4 Test procedures

11.7.4.1 General

Tests shall be carried out in the presence of a Surveyor at a stage sufficiently close to the completion of work with all hatches, doors, windows, etc. installed and all penetrations including pipe connections fitted, and before any ceiling and cement work is applied over the joints. Specific test requirements are given in 11.7.4.4 and Table 11.7.1. For the timing of the application of coating and the provision of safe access to joints, see 11.7.4.5, 11.7.4.6 and Table 11.7.3.

11.7.4.2 Structural test procedures

11.7.4.2.1 Type and time of test

Where a structural test is specified in Table 11.7.1 or Table 11.7.2, a hydrostatic test in accordance with 11.7.4.4.1 will be acceptable. Where practical limitations (strength of building berth, light density of liquid, etc.) prevent the performance of a hydrostatic test, a hydro-pneumatic test in accordance with 11.7.4.4.2 may be accepted instead.

A hydrostatic test or hydro-pneumatic test for the confirmation of structural adequacy may be carried out while the vessel is afloat, provided the results of a leak test are confirmed to be satisfactory before the vessel is afloat.

11.7.4.2.2 Testing schedule for new construction or major structural conversion

11.74.2.2.1 Tanks which are intended to hold liquids, and which form part of the watertight subdivision of the ship[1)], shall be tested for tightness and structural strength as indicated in Table 11.7.1 and Table 11.7.2.

11.7.4.2.2.2 The tank boundaries shall be tested from at least one side. The tanks for structural test shall be selected so that all representative structural members are tested for the expected tension and compression.

11.7.4.2.2.3 The watertight boundaries of spaces other than tanks for structural testing may be exempted, provided that the watertightness of boundaries of exempted spaces is verified by leak tests and inspections. Structural testing may not be exempted and the requirements for structural testing of tanks in 11.7.4.2.2.1 to 11.7.4.2.2.2 shall apply, for ballast holds and chain lockers.

11.7.4.2.2.4 Tanks which do not form part of the watertight subdivision of the ship [1)], may be exempted from structural testing provided that the water-tightness of boundaries of exempted spaces is verified by leak tests and inspections.

11.7.4.3 Leak test procedures

For the leak test specified in Table 11.7.1, tank air tests, compressed air fillet weld tests, vacuum box tests in accordance with 11.7.4.4.4 through 11.7.4.4.6, or their combination will be acceptable. Hydrostatic or hydro-pneumatic tests may also be accepted as leak tests provided that 11.7.4.5, 11.7.4.6 and 11.7.4.7 are complied with. Hose tests will also be acceptable for such locations as specified in Table 11.7.1, footnote 3, in accordance with 11.7.4.4.3.

The application of the leak test for each type of welded joint is specified in Table 11.7.3.

Air test of joints may be carried out in the block stage provided that all work on the block that may affect the tightness of a joint is completed before the test. See also 11.7.4.5.1 for the application of final coatings and 11.7.4.6 for the safe access to joints and the summary in Table 11.7.3.

11.7.4.4 Test methods

11.7.4.4.1 Hydrostatic test

Unless another liquid is approved, hydrostatic tests are to consist of filling the space with fresh water or sea water, whichever is appropriate for testing, to the level specified in Table 11.7.1 or Table 11.7.2. See also 11.7.4.7.

All external surfaces of the tested space shall be examined for structural distortion, bulging, and buckling, other related damage and leaks.

11.7.4.4.2 Hydro-pneumatic test

Hydro-pneumatic tests where approved shall be such that the test condition in conjunction with the approved liquid level and supplemental air pressure will simulate the actual loading as far as practicable. The requirements and recommendations for tank air tests in 11.7.4.4.4 will also apply to hydro-pneumatic tests. See also 11.7.4.7.

All external surfaces of the tested space shall be examined for structural distortion, bulging and buckling, other related damage and leaks.

11.7.4.4.3 Hose test

Hose tests shall be carried out with the pressure in the hose nozzle maintained at least at $2\cdot10^5$ Pa during the test. The nozzle is to have a minimum inside diameter of 12 mm and be at a perpendicular distance from the joint not exceeding 1,5 m. The water jet shall be impinge directly upon the weld.

Where a hose test is not practical because of possible damage to machinery, electrical equipment insulation or outfitting items, it may be replaced by a careful visual examination of welded connections, supported where necessary by means such as a dye penetrant test or ultrasonic leak test or the equivalent.

11.7.4.4.4 Tank air test

All boundary welds, erection joints and penetrations including pipe connections shall be examined in accordance with approved procedure and under a stabilized pressure differential above atmospheric pressure not less than $0.15\cdot10^5$ Pa with a leak indicating solution such as soapy water/detergent or a proprietary brand applied.

A U-tube with a height sufficient to hold a head of water corresponding to the required test pressure shall be arranged. The cross-sectional area of the U-tube is not to be less than that of the pipe supplying air to the tank. Arrangements involving the use of two calibrated pressure gauges to verify the required test pressure may be accepted taking into account the provisions in F5.1 and F7.4 of *IACS Recommendation 140, "Recommendation for Safe Precautions during Survey and Testing of Pressurized Systems"*.

A double inspection shall be made of tested welds. The first shall be immediately upon applying the leak indication solution; the second shall be after approximately four or five minutes in order to detect those smaller leaks which may take time to appear.

---

1) Watertight subdivision means the main transverse and longitudinal subdivisions of the ship required to satisfy the subdivision requirements of *SOLAS Chapter II-I.*

11.7.4.4.5 Compressed air fillet weld test

In this air test, compressed air is injected from one end of a fillet welded joint and the pressure verified at the other end of the joint by a pressure gauge. Pressure gauges shall be arranged so that an air pressure of at least $0.15 \cdot 10^5$ Pa can be verified at each end of all passages within the portion being tested.

NOTE: Where a leak test is required for fabrication involving partial penetration welds, a compressed air test is also to be applied in the same manner as to fillet weld where the root face is large, i.e. 6-8 mm.

11.7.4.4.6 Vacuum box test

A box (vacuum testing box) with air connections, gauges and an inspection window is placed over the joint with a leak indicating solution applied to the weld cap vicinity. The air within the box is removed by an ejector to create a vacuum of $0.20 \cdot 10^5 - 0.26 \cdot 10^5$ Pa inside the box.

11.7.4.4.7 Ultrasonic test

An ultrasonic echo transmitter shall be arranged inside of a compartment and a receiver shall be arranged on the outside. The watertight/weathertight boundaries of the compartment are scanned with the receiver in order to detect an ultrasonic leak indication. A location where sound is detectable by the receiver indicates leakage in the sealing of the compartment.

11.7.4.4.8 Penetration test

A test of butt welds or other weld joints uses the application of a low surface tension liquid at one side of a compartment boundary or structural arrangement. If no liquid is detected on the opposite sides of the boundaries after the expiration of a defined period of time, this indicates tightness of the boundaries. In certain cases, a developer solution may be painted or sprayed on the other side of the weld to aid leak detection.

11.7.4.4.9 Other test

Other methods of testing may be considered by the *Register* upon submission of full particulars prior to the commencement of testing.

11.7.4.5 Application of coating

11.7.4.5.1 Final coating

For butt joints welded by an automatic process, the final coating may be applied any time before the completion of a leak test of spaces bounded by the joints, provided that the welds have been carefully inspected visually to the satisfaction of the Surveyor.

Surveyors reserve the right to require a leak test prior to the application of final coating over automatic erection butt welds.

For all other joints, the final coating shall be applied after the completion of the leak test of the joint. See also Table 11.7.3.

11.7.4.5.2 Temporary coating

Any temporary coating which may conceal defects or leaks shall be applied at the time as specified for the final coating (see 11.7.4.5.1). This requirement does not apply to shop primer.

11.7.4.6 Safe access to joints

For leak tests, a safe access to all joints under examination shall be provided. See also Table 11.7.3.

11.7.4.7 Hydrostatic or hydro-pneumatic tightness test

In cases where the hydrostatic or hydro-pneumatic tests are applied instead of a specific leak test, examined boundaries must be dew-free, otherwise small leaks are not visible.

Table 11.7.1
Test requirements for tanks and boundaries

	Tank or boundary to be tested	Test type	Test head or pressure	Remarks
1	Double bottom tanks [4)]	Leak and structural [1)]	The greater of: - top of the overflow, - to 2,4 m above top of tank [2)], or - to bulkhead deck	
2	Double bottom voids [5)]	Leak	See 11.7.4.4.4 through 11.7.4.4.6, as applicable	Including pump room double bottom and bunker tank protection double hull required by MARPOL, Annex I
3	Double side tanks	Leak and structural [1)]	The greater of: - top of the overflow, - to 2,4 m above top of tank [2)], or - to bulkhead deck	
4	Double side voids	Leak	See 11.7.4.4.4 through 11.7.4.4.6, as applicable	
5	Deep tanks other than those listed elsewhere in this table	Leak and structural [1)]	The greater of: - top of the overflow, or - to 2,4 m above top of tank [2)]	
6	Deleted			
7	Deleted			
8	Peak tanks	Leak and structural [1)]	The greater of: - top of the overflow, or - to 2.4 m above top of tank [2)]	After peak to be tested after installation of stern tube
9	.1 Fore peak spaces with equipment	Leak	See 11.7.4.4.3 through 11.7.4.4.6, as applicable	
	.2 Fore peak voids	Leak	See 11.7.4.4.4 through 11.7.4.4.6, as applicable	
	.3 Aft peak spaces with equipment	Leak	See 11.7.4.4.3 through 11.7.4.4.6, as applicable	
	.4 Aft peak voids	Leak	See 11.7.4.4.4 through 11.7.4.4.6, as applicable	After peak to be tested after installation of stern tube
10	Cofferdams	Leak	See 11.7.4.4.4 through 11.7.4.4.6, as applicable	
11	.1 Watertight bulkheads	Leak [8)]	See 11.7.4.4.3 through 11.7.4.4.6, as applicable [7)]	
	.2 Superstructure end bulkheads	Leak	See 11.7.4.4.3 through 11.7.4.4.6, as applicable	
12	Watertight doors below freeboard or bulkhead deck	Leak [6), 7)]	See 11.7.4.4.3 through 11.7.4.4.6, as applicable	
13	Double plate rudder blades	Leak	See 11.7.4.4.4 through 11.7.4.4.6, as applicable	
14	Shaft tunnels clear of deep tanks	Leak [3)]	See 11.7.4.4.3 through 11.7.4.4.6, as applicable	
15	Shell doors	Leak [3)]	See 11.7.4.4.3 through 11.7.4.4.6, as applicable	
16	Weathertight hatch covers and closing appliances	Leak [3), 7)]	See 11.7.4.4.3 through 11.7.4.4.6, as applicable	Hatch covers closed by tarpaulins and battens excluded
17	Deleted	Leak [3), 7)]	See 11.7.4.4.3 through 11.7.4.4.6, as applicable	In addition to structural test in item 6 or 7
18	Chain lockers	Leak and structural [1)]	Top of chain pipe	

	Tank or boundary to be tested	Test type	Test head or pressure	Remarks
19	L.O. sump. tanks and other similar tanks/spaces under main engines	Leak 9)	See 11.7.4.4.3 through 11.7.4.4.6, as applicable	
20	Ballast ducts	Leak and structural 1)	The greater of: - ballast pump maximum pressure, or - setting of any pressure relief valve	
21	Fuel oil tanks	Leak and structural 1)	The greater of: - top of the overflow, - to 2,4m above top of tank 2), or - to top of tank 2) plus setting of any pressure relief valve, or - to bulkhead deck	

NOTES:

1) Refer to section 11.7.4.2.2.
2) The top of a tank is the deck forming the top of the tank excluding any hatchways.
3) Hose Test may also be considered as a medium of the test. See 11.7.3.2.
4) Including tanks arranged in accordance with the provisions of SOLAS Regulation II-1/9.4.
5) Including duct keels and dry compartments arranged in accordance with the provisions of SOLAS regulation II-1/11.2 and II-1/9.4 respectively, and/or oil fuel tank protection and pump room bottom protection arranged in accordance with the provisions of MARPOL Annex I, Chapter 3, Part A Regulation 12A and Chapter 4, Part A, Regulation 22 respectively.
6) Where water tightness of watertight door has not been confirmed by prototype test, testing by filling watertight spaces with water shall be carried out. See SOLAS Regulation II-1/16.2 and MSC/Circ.1176.
7) As an alternative to the hose testing, other testing methods listed in 11.7.4.4.7 through 11.7.4.4.9 may be applicable subject to adequacy of such testing methods being verified. See SOLAS Regulation II-1/11.1. For watertight bulkheads (item 11.1) alternatives to the hose testing may only be used where a hose test is not practicable.
8) Deleted.
9) Where L.O. sump tanks and other similar spaces under main engines intended to hold liquid form part of the watertight subdivision of the ship, they shall be tested as per the requirements of Item 5, Deep tanks other than those listed elsewhere in this table.

Table 11.7.3
Application of leak test, coating, and provision of safe access for type of welded joints

Type of welded joints		Leak test	Coating 1)		Safe Access 2)	
			Before leak test	After leak test but before structural test	Leak test	Structural test
Butt	Automatic	Not required	Allowed 3)	N/A	Not required	Not required
	Manual or semi-automatic 4)	Required	Not allowed	Allowed	Required	Not required
Fillet	Boundary including penetrations	Required	Not allowed	Allowed	Required	Not required

NOTES:

1) Coating refers to internal (tank/hold coating), where applied, and external (shell/deck) painting. It does not refer to shop primer.
2) Temporary means of access for verification of the leak test.
3) The condition applies provided that the welds have been carefully inspected visually to the satisfaction of the *Register's* surveyor.
4) Flux Core Arc Welding (FCAW) semiautomatic butt welds need not be tested provided that careful visual inspections show continuous uniform weld profile shape, free from repairs, and the results of NDE testing show no significant defects.

11.8 PROCEDURES FOR TESTING TANKS AND TIGHT BOUNDARIES (FOR YACHT OF LESS THAN 500 GT)

11.8.1 General

11.8.1.1 These test procedures are to confirm the watertightness of tanks and watertight boundaries and the structural adequacy of tanks which consist of the watertight subdivisions of yachts._These procedures may also be applied to verify the weathertightness of structures and_shipboard outfitting. The tightness of all tanks and watertight boundaries of yachts during new construction and those relevant to major conversions or major repairs shall be confirmed by these test procedures prior to the delivery of the ship.

11.8.2 Application

11.8.2.1 Testing procedures shall be carried out in accordance with the requirements of Head 11.7 in association with the following alternative procedures for 11.7.4.2.2 of 11.7 “Testing schedule for new construction or major structural conversion” and alternative test requirements for 11.7, Table 11.7.1.

11.8.2.2 The tank boundaries shall be tested from at least one side. The tanks for structural test shall be selected so that all representative structural members are tested for the expected tension and compression.

11.8.2.3 Structural tests shall be carried out for at least one tank of a group of tanks having structural similarity (i.e. same design conditions, alike structural configurations with only minor localised differences determined to be acceptable by the attending *Register's* surveyor) on each vessel provided all other tanks are tested for leaks by an air test.

11.8.2.4 Additional tanks may require structural testing if found necessary after the structural testing of the first tank.

11.8.2.5 Where the structural adequacy of the tanks of a vessel were verified by the structural testing required in 11.7, Table 11.7.1, subsequent vessels in the series (i.e. sister ships built from the same plans at the same shipyard) may be exempted from structural testing of tanks, provided that:

1. water-tightness of boundaries of all tanks is verified by leak tests and thorough inspections are carried out.
2. structural testing is carried out for at least one tank of each type among all tanks of each sister vessel.
3. additional tanks may require structural testing if found necessary after the structural testing of the first tank or if deemed necessary by the attending *Register's* surveyor.

11.8.2.6 Sister ships built (i.e. keel laid) two years or more after the delivery of the last ship of the series, may be tested in accordance with 11.8.2.5 at the discretion of the *Register*, provided that:

1. general workmanship has been maintained (i.e. there has been no discontinuity of shipbuilding or significant changes in the construction methodology or technology at the yard, shipyard personnel are appropriately qualified and demonstrate an adequate level of workmanship as determined by the *Register*) and:
2. an NDT plan is implemented and evaluated by the *Register* for the tanks not subject to structural tests. Shipbuilding quality standards for the hull structure during new construction shall be reviewed and agreed during the kick-off meeting. Structural fabrication shall be carried out in accordance with *IACS Recommendation 47, “Shipbuilding and Repair Quality Standard”*, or a recognised fabrication standard which has been accepted by the *Register* prior to the commencement of fabrication/construction. The work shall be carried out in accordance with the Rules and under survey of the *Register*.

11.9 CONSTRUCTION AND INITIAL TESTS OF WATERTIGHT DECKS, TRUNKS, ETC.

11.9.1 Watertight decks, trunks, tunnels, duct keels and ventilators shall be of the same strength as watertight bulkheads at corresponding levels. The means used for making them watertight, and the arrangements adopted for closing openings in them, shall be to the satisfaction of the *Register*. Watertight ventilators and trunks shall be carried at least up to the freeboard deck in yachts of 500 GT and upwards.

11.9.2 Where a ventilation trunk passing through a structure penetrates the bulkhead deck, the trunk shall be capable of withstanding the water pressure that may be present within the trunk, after having taken into account the maximum heel angle allowable during intermediate stages of flooding, in accordance with requirements of the *Rules for the classification of ships, Part 5 – Subdivision, 2.7*.

11.9.3 Where all or part of the penetration of the bulkhead deck is on the main ro-ro deck, the trunk shall be capable of withstanding impact pressure due to internal water motions (sloshing) of water trapped on the ro-ro deck.

11.9.4 After completion, a hose or flooding test shall be applied to watertight decks and a hose test to watertight trunks, tunnels and ventilators.

12 STEEL AND ALUMINIUM ALLOY STEM AND STERNFRAME

12.1 DEFINITIONS

12.1.1 Definitions stated in this section are as follows:

p_e = design pressure, in [kN/m^2], according to 3.2.2.2.2;

R_{eH} = minimum nominal upper yield point, in [N/mm^2];

k = material factor according to 4.2.1, for cast steel, see *Rules for the classification of ships, Part 25 - Metallic materials,* 3.12;

C_R = rudder force, in [N], according to *Rules for the classification of ships, Part 3 - Hull equipment*, 2.3;

B_1 = support force, in [N], according to *Rules for the classification of ships, Part 3 - Hull equipment*, 2.4;

t_k = corrosion addition.

For the conversion from steel to aluminium scantlings see Section 4.3.

12.2 STEM

12.2.1 Bar stem

12.2.1.1 The cross sectional area of a bar stem below the load waterline is not to be less than:

$$A_s = 1{,}25\ L\ [\text{cm}^2]$$

12.2.1.2 Starting from the load waterline, the sectional area of the bar stem may be reduced towards the upper end to 0,75 A_s.

12.2.2 Plate stem

12.2.2.1 The thickness of welded plate stem is not to be less than:

$$t = (0{,}6 + 0{,}4 \cdot S_B) \cdot (0{,}08 \cdot L + 6) \cdot \sqrt{k}\ , \quad [\text{mm}]$$

$$t_{max} = 20 \cdot \sqrt{k}\ , \quad [\text{mm}]$$

where:

S_B = spacing, in [m], between horizontal stringers, breasthooks / diaphragm, or equivalent horizontal stiffening members.

12.2.2.2 Starting from 600 mm above the load waterline up to d+C_w, the thickness may gradually be reduced to $0{,}8 \cdot t$.

12.2.2.3 Plate stems and bulbous bows shall be stiffened by diaphragm plates and/or cant frames.

12.2.2.4 Where the spacing of the diaphragm plates is reduced to 0,5 m the thickness of the plate stem may be reduced by 20 %.

12.2.2.5 The plate thickness of a bulbous bow shall in general not be less than required according to 12.2.2.1.

12.2.2.6 The scantlings of the stiffening shall be done according to Section 8.

12.3 STERNFRAME

12.3.1 General

12.3.1.1 Propeller post and rudder post shall be led into the hull in their upper parts and connected to it in a suitable and efficient manner. In way of the rudder post the shell shall be strengthened according to 5.4.3. Due regard shall be paid to the design of the aft body, rudder and propeller well in order to minimize the forces excited by the propeller.

12.3.1.2 The following value is recommended for the propeller clearance from shell (sternframe) related to 0,9 R (see Fig. 12.3.1.2-1):

$$d_{0,9} \geq 0{,}004 \cdot n \cdot d_p^3 \cdot \sqrt{\frac{v\ \left[1 - \sin\ (0{,}75\gamma)\right]\ \left(0{,}5 + \dfrac{Z_B}{x_F}\right)}{\Delta}}\quad [\text{m}],$$

where:

R = propeller radius, in [m];

v = ship's speed, in [kn];

n = number of propeller revolutions [min^{-1}];

Δ = maximum displacement of ship, in [t];

d_p = propeller diameter in [m];

γ = skew angle of the propeller, in [o], see Fig. 12.3.1.2-2;

Z_B = height of wheelhouse deck above weather deck, in [m], see Fig. 12.3.1.2-1;

X_F = distance of deckhouse front bulkhead from aft edge of stern, in [m], see Fig. 12.3.1.2-1.

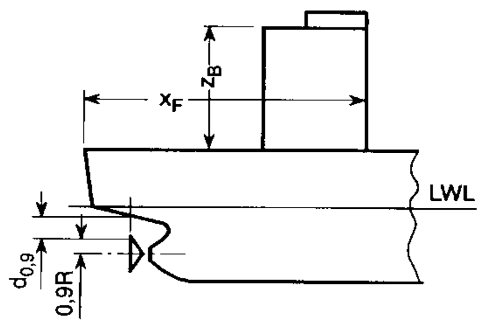


Figure 12.3.1.2-1

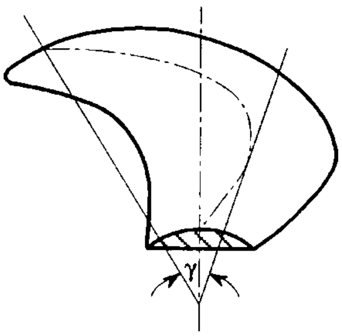


Figure 12.3.1.2-2

12.3.1.3 For single screw yachts, the lower part of the sternframe shall be extended forward by at least 3 times the frame spacing from fore edge of the boss, for all other yachts by 2 times the frame spacing from after edge of the sternframe (rudder post).

12.3.1.4 The stern tube shall be surrounded by the floor plates and connected with welding.

12.3.1.5 The plate thickness of sterns of welded construction for twin screw vessels is not to be less than:

$$t = (0{,}07\, L + 5{,}0) \cdot \sqrt{k} \quad [\text{mm}]$$

$$t_{max} = 20{,}0\, \sqrt{k} \quad [\text{mm}]$$

12.3.2 Propeller post

12.3.2.1 The scantlings of rectangular, solid propeller posts shall be determined according to the following formulae:

$$l = 1{,}4\, L + 90 \quad [\text{mm}]$$

$$b = 1{,}6\, L + 15 \quad [\text{mm}]$$

Where other sections than rectangular ones are used, their section modulus is not to be less than that resulting from rectangular section.

12.3.2.2 The scantlings of propeller posts of welded construction shall be determined according to the following formulae:

$$l = 50\, \sqrt{L} \quad [\text{mm}]$$

$$b = 36\, \sqrt{L} \quad [\text{mm}]$$

$$t = 2{,}4 \cdot \sqrt{L \cdot k} \quad [\text{mm}]$$

for l, b and t see Fig. 12.3.2.2.

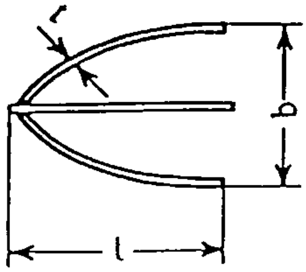


Figure 12.3.2.2

12.3.2.3 Where the cross-sectional configuration is deviating from Fig. 12.3.2.2 and for cast steel propeller posts the section modulus of the cross section related to the longitudinal axis is not to be less than:

$$W_x = 1{,}2 \cdot L^{1{,}5} \cdot k \quad [\text{cm}^3]$$

12.3.2.4 The wall thickness of the boss in the propeller post in its finished condition shall be not less:

$$t_{sc} = 0{,}1\, d_v + 56 \quad [\text{mm}],$$

$$t_{scmin} = 0{,}6 \cdot b \quad [\text{mm}]$$

where:

d_v = diameter of tail propeller shaft (see Fig. 12.3.2.4);

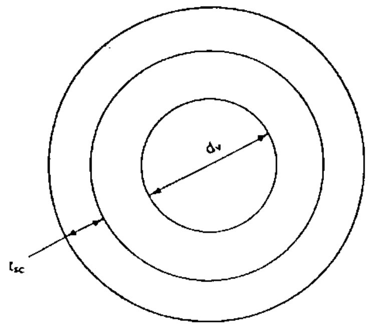


Figure 12.3.2.4

All welded connections between sternframe and propeller post shall be full penetrated.

12.3.3 Rudder post

12.3.3.1 The section modulus of the rudder post related to longitudinal axis of the ship is not to be less than:

$$W = C_R \cdot l \cdot k \cdot 10^{-3} \quad [\text{cm}^3],$$

where:

l = unsupported span of the rudder post, in [m].

Strength calculations for the rudder post, taking into account the flexibility of the sole piece, may be required, by the *Register*, due to its low rigidity in y-direction.

The bending stress is not to exceed:

$$\sigma_b = 85, \quad [\text{N/mm}^2]$$

12.3.4 Sole pieces

12.3.4.1 The section modulus of the sole piece around the vertical z-axis is not to be less than:

$$W_Z = \frac{M_b \cdot k}{80}, \quad [\text{cm}^3]$$

12.3.4.2 The section modulus of the sole piece around the transverse y-axis is not to be less than:

$$W_y = \frac{W_z}{2}, \quad [\text{cm}^3]$$

12.3.4.3 The sectional area is not to be less than:

$$A_s = \frac{B_1}{48} \cdot k, \quad [\text{mm}^2]$$

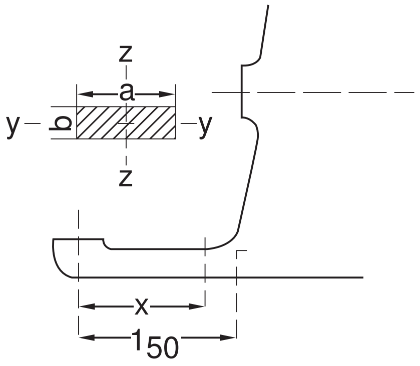


Figure 12.3.4.1
Sole piece

12.3.4.4 Equivalent stress

At no section within the length ℓ_{50} is the equivalent stress to exceed 115/k N/mm². The equivalent stress shall be determined by the following formula:

$$\sigma_{ekv} = \sqrt{\sigma_b^2 + 3\tau^2}, \quad [\text{N/mm}^2]$$

where:

$$\sigma_b = \frac{M_b}{W_z(x)} \quad [\text{N/mm}^2]$$

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

M_b = bending moment at the section considered, in [Nm];

$M_b = B_1 \cdot x$

$M_{bmax} = B_1 \cdot \ell_{50}$

B_1 = supporting force in the pintle bearing, in [N], (normally $B_1 = C_R / 2$)

ℓ_{50} = see Fig. 12.3.4.1

For B_1, C_R, k = see *Rules for the classification of ships, Part 3 – Hull Equipment,* Section 2.

12.3.5 Rudder horn

12.3.5.1 When the connection between the rudder horn and the hull structure is designed as a curved transition into the hull plating, special consideration shall be given to the effectiveness of the rudder horn plate in bending and to the stresses in the transverse web plates.

The bending moments and shear forces shall be determined by a direct calculation or in line with the guidelines given in the *Rules for the classification of ships, Part 3 – Hull Equipment,* Section 2 for semi spade rudder with one elastic support and semi spade rudder with 2-conjugate elastic support respectively.

12.3.5.2 The section modulus of the rudder horn around the horizontal x-axis is not to be less than:

$$W_x = \frac{M_b \cdot k}{67}, \quad [\text{cm}^3]$$

12.3.5.3 The shear stress due is not to be larger than:

$$\tau = \frac{48}{k}, \quad [\text{N/mm}^2]$$

where:

k = material factor as given in the *Rules for the classification of ships, Part 3 – Hull Equipment,* Section 2.

12.3.5.4 The equivalent stress

At no section within the height of the rudder horn is the equivalent stress to exceed 120 kN/mm². The equivalent stress shall be determined by the following formula:

$$\sigma_{ekv} = \sqrt{\sigma_b^2 + 3\left(\tau^2 + \tau_T^2\right)}, \quad [\text{N/mm}^2]$$

where:

$$\sigma_b = \frac{M_b}{W_x} \quad [\text{N/mm}^2];$$

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

B_1 = supporting force in the pintle bearing, in [N],

A_h = effective shear area of the rudder horn in y-direction, in [mm²].

$$\tau_T = \frac{M_T \cdot 10^3}{2 \cdot A_T \cdot t_h} \quad [\text{N/mm}^2];$$

M_T = torsional moment as given in the *Rules for the classification of ships, Part 3 – Hull Equipment,* Section 2, in [Nm];

A_T = area in the horizontal section enclosed by the rudder horn, in [mm²];

t_h = plate thickness of rudder horn, [mm].

k = material factor as given in the *Rules for the classification of ships, Part 3 – Hull Equipment,* Section 2.

12.3.5.5 Rudder horn plating

The thickness of the rudder horn side plating is not to be less than:

$$t_{min} = 2{,}4 \cdot \sqrt{L \cdot k}, \quad [\text{mm}]$$

where:

L = rule length as defined in *Rules for the classification of ships, Part 2 – Hull,* 1.2.3.1.

k = material factor as given in the Rules for the classification of ships, Part 3 – Hull Equipment, Section 2.

12.3.5.6 Welding and connection to hull structure

12.3.5.6.1 The rudder horn plating shall be effectively connected to the aft ship structure, e.g. by connecting the plating to side shell and transverse/longitudinal girders, in order to achieve a proper transmission of forces, see Fig. 12.3.5.6.1.

Brackets or stringer shall be fitted internally in horn, in line with outside shell plate, as shown in Fig. 12.3.5.6.1.

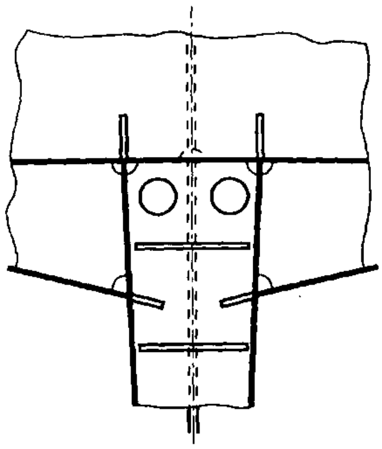


Figure 12.3.5.6.1
Connection of rudder horn to aft ship structure

12.3.5.6.2 Transverse webs of the rudder horn shall be led into the hull up to the next deck in a sufficient number.

Strengthened plate floors shall be fitted in line with the transverse webs in order to achieve a sufficient connection with the hull.

12.3.5.6.3 The centre line bulkhead (wash-plate) in the afterpeak shall be connected to the rudder horn.

12.3.5.6.4 Scallops shall be avoided in way of the connection between transverse webs and shell plating.

The weld at the connection between the rudder horn plating and the side shell shall be full penetration. The welding radius shall be as large as practicable and may be obtained by grinding.

12.3.6 Rudder trunk

12.3.6.1 Materials, welding and connection to hull

12.3.6.1.1 The requirements in this section apply to trunk configurations which are extended below stern frame and arranged in such a way that the trunk is stressed by forces due to rudder action.

12.3.6.1.2 The steel used for the rudder trunk shall be of weldable quality, with a carbon content not exceeding 0.23% on ladle analysis and a carbon equivalent C_{EQ} not exceeding 0.41%.

Plating materials for rudder trunks are in general not to be of lower grades than corresponding to class II as defined in *Rules for the classification of ships, Part 2 – Hull,* 1.4.2.

12.3.6.1.3 The weld at the connection between the rudder trunk and the shell or the bottom of the skeg shall be full penetration.

12.3.6.1.4 The fillet shoulder radius r, in [mm] (see Fig. 12.3.6.1.4) shall be as large as practicable and to comply with the following formulae:

$r = 0.1d_c$, without being less than

$r = 60$ mm, when $\sigma \geq 40 / k$, [N/mm²]

$r = 30$ mm, when $\sigma < 40 / k$ [N/mm²]

where:

d_c = rudder stock diameter as defined in the *Rules for the classification of ships, Part 3 – Hull Equipment,* Section 2.

σ= bending stress in the rudder trunk, in [N/mm²].

k = material factor as given in the *Rules for the classification of ships, Part 3 – Hull Equipment,* Section 2.

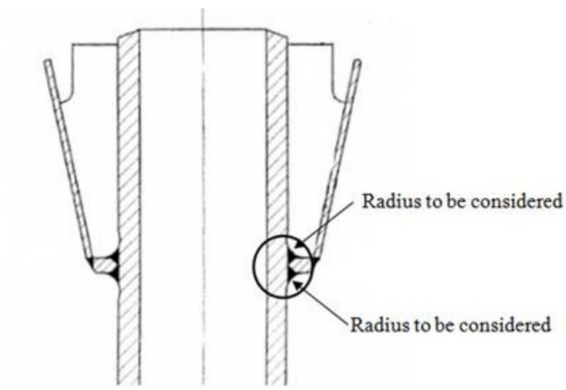


Figure 12.3.6.1.4
Fillet shoulder radius

The radius may be obtained by grinding. If disk grinding is carried out, score marks shall be avoided in the direction of the weld. The radius shall be checked with a template for accuracy. Four profiles at least shall be checked. A report shall be submitted to the *Register`s* surveyor.

12.3.6.1.5 Rudder trunks comprising of materials other than steel shall be specially considered by the *Register*.

12.3.6.2 Scantlings

12.3.6.2.1 The scantlings of the trunk shall be such that:

- the equivalent stress due to bending and shear does not exceed 0.35 R_{eH},
- the bending stress on welded rudder trunk shall be in compliance with the following formula:

$\sigma \leq 80/k$, in [N/mm²].

with:

σ= bending stress in the rudder trunk, as defined in 12.3.6.1;

k = material factor for the rudder trunk as given in the *Rules for the classification of ships, Part 3 – Hull Equipment,* Section 2, not to be taken less than 0.7;

R_{eH} = specified minimum yield stress, in [N/mm^2], of the material used.

12.3.6.2.2 For calculation of bending stress, the span to be considered is the distance between the mid-height of the lower rudder stock bearing and the point where the trunk is clamped into the shell or the bottom of the skeg.

13 STEEL AND ALUMINIUM ALLOY SUPERSTRUCTURES AND DECKHOUSES

13.1 GENERAL

13.1.1 Explanation

13.1.1.1 For definitions of superstructure and deckhouse see 1.2.5.

13.1.1.2 A long deckhouse is a deckhouse the length of which within 0,4 L amidships exceeds 0,2 L or 12 m. The strength of a long deckhouse shall be specially considered.

13.1.1.3 Superstructures extending into the range of 0,4 L amidships and the length of which exceeds 0,15 L are defined as effective superstructures. Their side plating shall be treated as shell plating and their deck as strength deck.

All superstructures being located beyond 0,4 L amidships or having a length of less than 0,15 L or less than 12 m are, for the purpose of this Section, considered as non-effective superstructures.

13.1.1.4 For deckhouses of aluminium, see the *Rules for the classification of ships, Part 2 – Hull,* 1.4.4. For the use of non-magnetic material in way of the wheelhouse, the requirements of the Flag State concerned shall be observed.

13.1.2 Definitions

Throughout this Section the following definitions apply:

k = material factor according to 4.2.1.

p_D = load according to 3.2.2.1.1.

p_s= load according to 3.2.2.2.1.

p_e = load according to 3.2.2.2.2.

p_{DA} = load according to 3.2.2.5.

t_k = corrosion addition, 0,5 mm.

For the conversion from steel to aluminium scantlings see Section 4.3.

13.1.3 Strengthening at the ends of superstructures

13.1.3.1 At the ends of superstructures one or both end bulkheads of which are located within 0,4 L amidships, the thickness of the shear strake, the strength deck in a breadth of 0,1 B from the shell, as well as the thickness of the superstructure side plating shall be strengthened as specified in Table 13.1.3.1. The strengthening shall be extend over a region from 4 frame spacings abaft the end bulkhead to 4 frame spacings forward of the end bulkheads.

Table 13.1.3.1-1

Type of superstructure	Strengthening, in [%]	
	Strength deck and shear strake	Side plating of superstructure
Effective, according to 13.1.1.3	30	20
Non-effective	20	10

13.1.3.2 Under strength decks in way of 0,6 L amidships, girders shall be fitted in alignment with longitudinal walls, which are to extend at least over three frame spacings beyond the end points of the longitudinal walls. The girders are to overlap with the longitudinal walls by at least two frame spacings.

13.1.4 Transverse structure of superstructures and deckhouses

The transverse structure of superstructures and deckhouses shall be sufficiently dimensioned by a suitable arrangement of end bulkheads, web frames, steel walls of cabins and casings, or by other measures.

13.1.5 Openings in closed superstructures and deckhouses

For openings in closed superstructures and deckhouses see the *Rules for the classification of ships, Part 3 - Hull equipment*, 7.5.

13.2 SIDE PLATING AND DECKS OF NON-EFFECTIVE SUPERSTRUCTURES

13.2.1 Side plating

13.2.1.1 The thickness of the side plating is not to be less than the grater of the following values:

$$t = 1{,}21 \cdot s \cdot \sqrt{p \cdot k} + t_k \quad \text{[mm]},$$

or

$$t = 0{,}8 \cdot t_{min} \quad \text{[mm]},$$

where:

p = p_s or p_e as the case may be

t_{min} = according to Section 5.2.6.

13.2.1.2 The thickness of the side plating of upper tier superstructures may be reduced by 0,5 mm.

13.2.2 Deck plating

13.2.2.1 The thickness of deck plating is not to be less than the greater of the following values:

$$t = 1{,}21 \cdot s \cdot \sqrt{p \cdot k} + t_k \text{ [mm]};$$

$$t = (4{,}5 + 0{,}02\, L) \cdot \sqrt{k} \quad \text{[mm]},$$

where:

p = p_{DA} or p_L, (the greater value shall be taken)

L - need not be taken greater than 200 m.

13.2.2.2 Where additional superstructure is arranged on non-effective superstructures located on the strength deck, the thickness required by 13.2.2.1 may be reduced by 10%.

13.2.2.3 Where plated decks are protected by sheathing, the thickness of the deck plating according to 13.2.2.1 and 13.2.2.2 may be reduced by t_k, however, it is not to be less than 5 mm.

Attention shall be paid that the sheathing does not affect the steel. The sheathing shall be effectively fitted to the deck.

13.2.3 Deck beams, supporting deck structure and frames

13.2.3.1 The scantling of the deck beams and the supporting deck structure shall be determined in accordance with Section 9.2.

13.2.3.2 The scantlings of superstructure frames are given in Section 8.1.3.

13.3 SUPERSTRUCTURE END BULKHEADS AND DECKHOUSE WALLS

13.3.1 General

The following requirements apply to bulkheads forming the only protection for openings as per *Regulation 18 of LLC 1966* and for accommodations. These requirements define minimum scantlings based upon local lateral loads and it may be required that they be increased in individual cases.

13.3.2 Definitions

The design load for determining the scantlings is:

$p_A = n \cdot c \cdot (b \cdot f - z)$ [kN/m²]

where:

$n = 20 + \frac{L}{12}$, for the lowest tier of unprotected fronts. The lowest tier is normally that tier which is directly situated above the uppermost continuous deck to which the rule depth D shall be measured;

$n = 10 + \frac{L}{12}$, for 2nd tier unprotected fronts;

$n = 5 + \frac{L}{15}$, for 3rd tier of sides and protected fronts;

$n = 7 + \frac{L}{100} - 8\frac{x}{L}$, for aft ends abaft amidship;

$n = 5 + \frac{L}{100} - 4\frac{x}{L}$, for aft ends forward of amidship.

L need not be taken greater than 300 m.

$$b = 1{,}0 + \left[\frac{\frac{x}{L} - 0{,}45}{C_b + 0{,}2}\right]^2, \text{ for } \frac{x}{L} < 0{,}45;$$

$$b = 1{,}0 + 1{,}5\left[\frac{\frac{x}{L} - 0{,}45}{C_b + 0{,}2}\right]^2, \text{ for } \frac{x}{L} \geq 0{,}45;$$

$0{,}60 \leq C_b \leq 0{,}8$ when determining scantlings of aft ends forward of amidships, C_b need not be taken less than 0,8.

x = distance, in [m], between the bulkhead considered and aft end of the length L.

When determining sides of a deckhouse, the deckhouse shall be subdivided into parts of approximately equal length, not exceeding 0,15 L each, and x shall be taken as the distance between aft end of the length L and the centre of each part considered.

$$f = 0{,}1\,L \cdot e^{-\frac{L}{300}} - \left[1 - \left(\frac{L}{150}\right)^2\right], \text{ for } L < 150 \text{ m};$$

$f = 0{,}1\,L \cdot e^{-\frac{L}{300}}$, for 150 m $\leq L \leq$ 300 m;

f = 11,0, for L > 300 m;

z = vertical distance, in [m], from the summer load line to the midpoint of stiffener span, or to the middle of the plate field.

$$c = 0{,}3 + 0{,}7\,\frac{b'}{B};$$

b' = breadth of deckhouse at the position considered, in [m];

B' = actual maximum breadth of ship on the exposed weather deck at the position considered, in [m].

b'/B' is not to be taken less than 0,25.

For exposed parts of machinery casings, c is not to be taken less than 1,0.

The design load p_A is not to be taken less than the minimum values given in Table 13.3.2.

Table 13.3.2

L [m]	**p_{Amin} [kN/m²]**	
	Lowest tier of unprotected fronts	**Elsewhere**
≤ 50	30	15
> 50 ≤ 250	$25 + \frac{L}{10}$	$12{,}5 + \frac{L}{20}$
> 250	50	25

13.3.3 Scantlings

13.3.3.1 Stiffeners

The section modulus of the stiffeners shall be determined according to the following formula:

$W = 0{,}35 \cdot s \cdot l^2 \cdot p_A \cdot k$ [cm³]

where:

W = stiffener modulus, in [cm^3];

l = unsupported span, in [m]; l shall be taken as the superstructure height or deckhouse height respectively, however, not less than 2,0 m;

s = spacing of stiffeners, in [m].

These requirements assume the webs of lower tier stiffeners to be efficiently welded to the decks. Scantlings for other types of end connections may be specially considered.

The section modulus of house side stiffeners need not be greater than that of side frames on the deck situated directly below, taking account of spacings and unsupported span l.

13.3.3.2 Plate thickness

The thickness of the plating shall be determined according to the following formula:

$$t = 0{,}95 \cdot s \cdot \sqrt{p_A \cdot k} + t_k \quad \text{[mm]}$$

but not less than:

$$t_{min} = \left(5{,}0 + \frac{L}{100}\right) \cdot \sqrt{k}$$, for the lowest tier;

$$t_{min} = \left(4{,}0 + \frac{L}{100}\right) \cdot \sqrt{k}$$, for the upper tiers,

however, not less than 5,0 mm

where:

s and p_A are as defined above.

When determining p_A, z shall be measured to the middle of the plate field.

13.4 DECKS OF SHORT DECKHOUSES

13.4.1 Plating

The thickness of deck plating exposed to weather but not protected by sheathing is not to be less than:

$$t = 7 \cdot s \cdot \sqrt{k} + t_k \quad \text{[mm]}$$

For decks exposed to weather protected by sheathing and for decks within deckhouses the thickness may be reduced by t_k.

In no case the thickness shall be less than the minimum thickness of 5,0 mm.

13.4.2 Deck beams

The deck beams and the supporting deck structure shall be determined according to Section 9.

14 SAILING MASTS AND RIGGINGS

14.1 GENERAL

14.1.1 This Section generally applies to sailing yachts of 24 m in length and upwards, under the condition that the yacht is handled correctly in terms of good seamanship.

14.1.2 This Section is generally applicable for Bermudian rigs with spars made of carbon fibre reinforced plastics or aluminium alloy.

14.1.3 The calculation methodology according to this Section is also considered applicable to masts made of steel, since both materials (aluminium alloys and steel) belong to ductile and isotropic materials.

Since the methodology according to this Section does not imply the influence of plasticity in the structural analysis, steel materials could be used upon defining Young's modulus of elasticity, Poisson's ratio, material density and appropriate mechanical properties.

14.1.4 The principles presented in this Section shall be used 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.

14.1.5 Scope of this Section is the structural integrity of one or multiple-masted, Bermudian rigged monohull or multihull sailing yachts including the dimensioning of standing rigging, mast and boom sections as well as local construction in way of fittings structurally attached to the spars.

14.2 DESIGN AND CONSTRUCTION PRINCIPLES

14.2.1 The basic value for all following evaluations is, generally, the static righting moment (RM) of the yacht at full displacement with a heel angle corresponding to Safe Working Angle.

14.2.2 The "Safe Working Angle" (SWA in further text) generally represents a heeling angle of 30°. However, other angles may be defined as SWA in agreement with the *Register*. The *Register* reserves the right to assess the SWA according to the relevant characteristics of the yacht under sail according to Table 1.1 or special characteristics such as canting keel.

14.2.3 Large Cruising Catamarans require a different approach in defining basic design parameters. Where the righting moment is a very common value for monohulls, this is not so for "heavy" cruising catamarans. These vessels often provide excessive stability which makes it impractical to work from. Rather a more direct, yet conservative, approach is taken by using the wind pressure directly.

14.3 LOAD CASES

14.3.1 Ordinary sailing conditions

Upwind beating, reaching and broad reaching under appropriate sail configurations for light, moderate, strong, and stormy wind conditions, such as:

- full main, working jib, genoa or reacher;
- several reef stages main, working jib, reefed jib, stay sail;
- spinnaker only;
- others and special configurations for special rigs.

Table 14.3.1
Yacht characteristics

Category	Displacement characteristics	Typical purpose characteristics	Typical handling characteristics
I	Motor Sailer / Heavy Cruiser	Ocean Going	Handled by owner / crew
II	Mid Displacement	Offshore	Short-handed
III	Light Displacement	Coastal pleasure cruises / Club Racing	Short-handed or handled by crew

14.3.2 Extreme conditions

Extreme conditions may need to be defined in special cases, depending on the boat size and type and other configurations.

14.4 DETERMINATION OF RIG LOADS

14.4.1 Pre-tensioning of rig

The pre-tensioning of the rigging shall be specified by the designer, otherwise pre-tensioning is set to avoid slack leeward cap shrouds with an appropriate reserve, when sailing at heeling angles at or below the "SWA".

14.4.2 Transverse sail forces

14.4.2.1 Monohulls

Transverse forces are determined from righting moment:

Each sail's contribution to the resultant heeling moment is assumed to be proportional to the sail's area and the distance of its centre of effort above the underwater body's centre of lateral resistance, see Fig. 14.4.2.1. The sum of these heeling moments is set equal to the vessel's righting moment under the conditions and specific sail configurations being evaluated:

Transverse force from mainsail:

$$F_{tm} = \frac{\mathrm{RM}_{design}}{\overline{CoE_m CLR} + \frac{A_F \cdot SFC_f}{A_m \cdot SFC_m} \cdot \overline{CoE_f CLR}} [N]$$

Transverse force from foresail:

$$F_{tf} = \frac{A_f \cdot SCF_f}{A_m \cdot SCF_m} \cdot F_{tm} [N]$$

Transverse force from spinnaker when "broaching".

$$F_{ts} = \frac{\mathrm{RM}_{design}}{\overline{CoE_s CLR}} \quad [N]$$

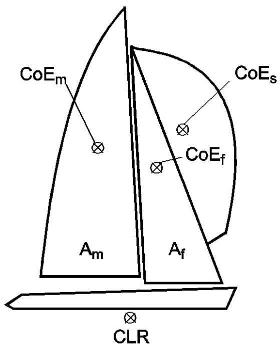


Figure 14.4.2.1
Centres of effort

RM_{Design} = righting moment as defined in B.1. [Nm]

$\mathrm{CoE}_{m/f/s}$ = centre of effort of respective sail:

CoE_m = 0,39 P above gooseneck [m] (default)

CoE_f = 0,39 I above foot [m] (default)

CoE_s = 0,59 I above deck [m] (default)

CLR = The centre of lateral resistance of the underwater body (including appendages) [m]

A_m = mainsail area, projected laterally [m^2]

A_f = foresail area, projected laterally [m^2]

P = mainsail hoist [m]

E = foot of mainsail [m]

I = height of fore triangle [m]

SFC_m = side force coefficient mainsail = 0,9

SFC_f = side force coefficient foresail = 1,1

14.4.2.2 Estimation of corresponding apparent wind speed for upwind cases

$$v_a = \sqrt{\frac{F_{t(m/f)}}{SFC_{f/m} \cdot A_{m/f} \cdot 0{,}5 \cdot \rho}} \quad \left[\frac{m}{s}\right]$$

ρ = density of air [kg/m3]

14.4.3 Multiple-mast rig

For a multiple-mast rig a conservative assumption of the proportioning of righting moment shall be made:

For all relevant sail configurations, the fractions of sail area moments (SAM) for each mast from the total SAM have to be determined to find the design righting moment for each mast.

The sail area moment is defined as:

$$SAM = \mathrm{A} \cdot \overline{CoE\ CLR} \quad [m^3]$$

A = projected sail area

The sail area moment for each mast is defined as:

$$SAM_I = \sum_{j=l}^{n} \left(A_j \cdot \overline{CoE_j\ CLR}\right) \quad [m^3]$$

i = index for specific mast

j = index for specific sail on specific mast

The fraction of each mast from the total sail area moment is defined as:

$$f_i = \sum_{j=l}^{n} \frac{SAM_i}{SAM_i}$$

The design righting moment RMdesign for each mast shall be taken the lower of:

- RMdesign = 1,0 (RM at SWA)
- RMdesign = 1,56 f (RM at SWA)

Windage of masts and rigging (and equipment) and therewith contribution to (each) SAM and/or (OTM) may be taken into account.

OTM = overturning moment, see 14.4.4.

14.4.4 Multihulls

The relevant apparent wind speed, resulting from the true wind speed and the predicted boat speed is used to calculate the pressure forces for a rig.

$$AWS_O = TWS + \cos(TWA) \cdot BS$$

TWS = True Wind Speed

TWA = True Wind Angle

BS = Boat Speed

This operational wind speed AWS0 is defining the safe operational limits for the vessel, equivalent to a safe working heel angle on monohulls, which may not be exceeded. The operational limits of a rig need to be defined precisely and followed diligently.

The design wind speed, which a rig is designed to, needs to be determined conservatively. As a catamaran does not "heel away" from wind forces, a gust factor is introduced as a buffer, which acts as a multiplier on TWS (True Wind Speed).

The design wind speed is calculated using the above equation with the true wind speed multiplied by factor of 1,25:

$$AWS_D = 1{,}25 \cdot \mathrm{TWS} + \cos(TWA) \cdot BS$$

From this wind speed the sail pressure forces are calculated using the equation:

$$F = \frac{\rho}{2} \mathrm{TWS} + AWS_D\ AWS_D{}^2 \cdot A \ \cdot c_s$$

ρ = density of air

The side force coefficient cs for a mainsail is generally 0,9, for a jib 1,1. These pressure forces are supposed to act at the sails centre of effort, where the assumptions for the locations are:

Mainsail 45% of mean height for sails with "normal roach".

Headsail 39% of mean height of triangular sail.

Looking at a different angle of this approach, these sail pressure forces calculated from the design wind speed result in an "overturning moment" (OTM). If really required for reference, the OTM shall be calculated about the vessel's longitudinal axis, at an elevation which can be called "platform" of the rig, mostly deck or sheerline level.

What has been found from studies is that obviously the AWS is a conservative value to work with. While bearing away from upwind the allowable TWS gets higher and also the AWS gets slightly higher. But the OTMs stay rather constant or even get marginally smaller. So actually, for all "upwind sail" configurations, an AWS limit is conservative and serves well for dimensioning purposes. Downwind cases need to be looked at separately, at a certain OTM (Rules: similar to upwind) and a wind pressure due to an AWS of 25 kn.

14.4.5 Distribution of transverse sail forces of the mainsail

A set of point loads shall be calculated from F_{tm} acting on the mast as shown in Fig. 14.4.5. The point load distribution shall be appropriate for the specified sail configuration and has to reproduce the equilibrium of moments. Table 14.4.5 shows examples of such point load distributions.

Table 14.4.5
Possible approaches for mainsail load distribution, unreefed

	Distribution factor c_{im}		
	3-spreader-rig	4-spreader-rig	5-spreader-rig
clew [1)]	(0,25)	(0,25)	(0,25)
gooseneck, tack	0,0	0,0	0,0
spreader 1	0,05	0,0	0,0
spreader 2	0,15	0,05	0,0
spreader 3	0,25	0,15	0,05
spreader 4	-	0,25	0,15
spreader 5	-	-	0,25
main headboard	0,30	0,30	0,30
[1)] not applied on rig explicitly			

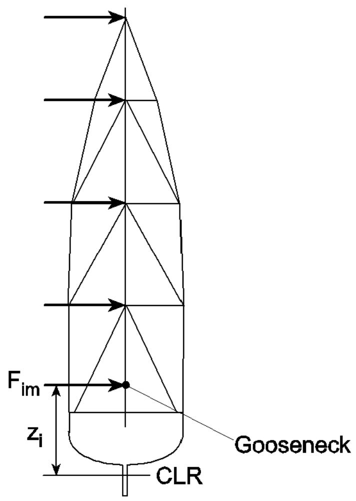


Figure 14.4.5
Mainsail load distribution

$$F_{im} = c_{im} \cdot F_{tm}\ [N], where$$

$$\frac{\overline{(CoE\ _{m}CLR)}}{\sum_{i=1}^{n}(c_{im} \cdot z_i)} = 1$$

F_{tm} = transverse force mainsail according to 14.4.2

c_{im} = distribution factor with:

$$\sum_{i=1}^{n} c_{im} = 1$$

z_i according to Fig. 14.4.5

14.4.6 Distribution of transverse sail forces of the foresail

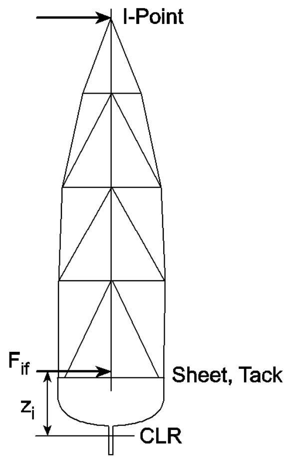


Figure 14.4.6
Foresail point loads

$$F_{if} = c_{if} \cdot F_{tf}\ [N], where$$

$$\frac{\overline{(CoE_{f}CLR)}}{\sum_{i=1}^{3}(c_{if} \cdot z_i)} = 1$$

F_{tf} = transverse force foresail according to 14.4.2

c_{if} = distribution factor with:

$$\sum_{i=1}^{n} c_{if} = 1$$

z_i according to Fig. 14.4.6

Table 14.4.6 showing an example of the foresail load distribution.

Table 14.4.6
Approach for foresail load distribution

	c_{if}
tack[1]	(0,3)
clew[1]	(0,3)
head	0,4
[1] not applied on rig explicitly	

14.4.7 Distribution of transverse sail forces of the spinnaker

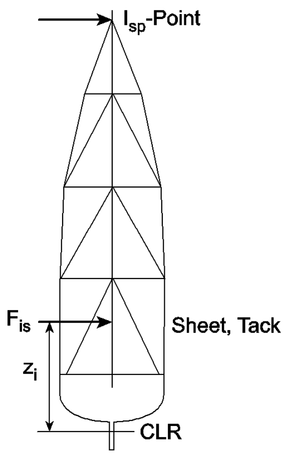


Fig. 14.4.7 Spinnaker point loads

$$F_{is} = c_{is} \cdot F_{ts}\ [N], where$$

$$\frac{\overline{(CoE_s CLR)}}{\sum_{i=1}^{3}(c_{is} \cdot z_i)} = 1$$

F_{ts} = transverse force spinnaker according to 14.4.2

c_{is} = distribution factor with:

$$\sum_{i=1}^{n} c_{is} = 1$$

z_i according to Fig. 14.4.7

Table 14.4.7 shows an example of the foresail load distribution.

Table 14.4.7
Approach for spinnaker load distribution

	c_{is}
tack [1)]	(0,3)
clew[1]	(0,3)
head	0,4
[1)] not applied on rig explicitly	

14.5 SELF-WEIGHT FORCES

The self-weight of a rig induces additional internal forces in the rig, especially when a rig is heeled; the occurring forces are often of mentionable magnitude and need to be considered and applied to computational rig models aside the forces derived from righting moment or wind pressure.

14.6 EXTREME LOADS

Extreme loads can be defined in each separate case depending on special configurations.

14.7 DETERMINATION OF WORKING LOADS OF RUNNING AND STANDING RIGGING

14.7.1 Running rigging

The following approaches shall be seen as a general estimation of an initial calculation value. Care has to be taken, when configurations require modified approaches.

14.7.2 Halyards

The working load of a halyard is generally generated by membrane forces in a sail. Its magnitude depends on the amount of sag of the leech including a preload due to hoisting. Determination of the halyard load shall be based on design righting moment and the following sail configuration:

Full main and 100 % foresail (i.e. the foresail foot length equals J).

J = base of fore triangle [m]

14.7.2.1 Mainsail and/or mizzensail halyards:

$$F_{mhy} = 1{,}08 \cdot F_{ml} \quad [N]$$

F_{ml} = mainsail leech load

$$F_{ml} = \frac{F_{tm}}{8 \cdot s} \cdot f_r \quad [N]$$

f_r = roach factor

$$f_r = \frac{A_m}{0{,}5 \cdot P \cdot E}$$

F_{tm} = according to 14.4.2

s = sag fraction

= 0,065 [–], (6,5 % of leech length) for all categories

14.7.2.2 Foresails (genoa, jib, staysail, etc.) halyards

$$F_{fhy} = 1{,}02 \frac{F_{ft}}{8 \cdot s} \quad [N]$$

F_{tf} = according to 14.4.2

s = sag fraction

= 0,045 [–], (4,5 % of leech length)

14.7.3 Boom outhaul

The force of the outhaul is generated by the horizontal component of the leech load and a force resultant from the sag of the sail foot.

$$F_{oh} = cos\left(arctan\left(\frac{P}{E}\right)\right) \cdot F_{ml} + F_{tm} \cdot \frac{E}{P \cdot 8 \cdot 0{,}05} \quad [N]$$

F_{ml} = according to 14.7.2.1

F_{tm} = transverse force from mainsail according to 14.4.2

For P and E see 14.4.2.

14.7.4 Mainsheet

The working load of the mainsheet is estimated by a given sag of the leech. Its vertical component F_{msv} is calculated by the formula:

$$F_{msv} = \frac{E}{X_{ms}} \cdot F_{ml} \quad [N]$$

X_{ms} = sheet attachment point on boom aft of goose neck [m]

F_{ml} = according to 14.7.2.1

14.7.5 Vang

The maximum vang loads normally occur when reaching or running downwind. Base value for calculating the vang load is again the leech load of the mainsail which in turn is determined by the sag fraction specified below. By omitting the mainsheet load contribution, the following formula for the vang load Fv results from force equilibrium according to Fig. 14.7.5.

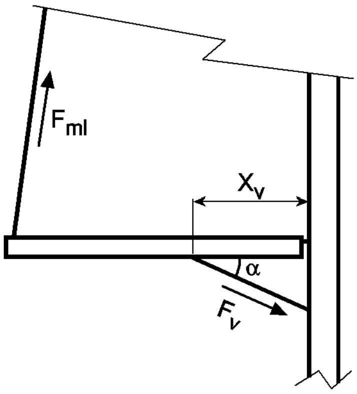


Fig. 14.7.5
Vang load determination

$$F_V = sin\left(arctan\left(\frac{P}{E}\right)\right) \cdot F_{ml} \cdot \frac{E}{x_V sin\ \alpha} \quad [N]$$

F_{ml} = according to 14.7.2.1

x_V = distance from gooseneck to boom vang fitting [m]

α = angle between vang and boom

s = sag fraction

= 0,25 [–], (25%of leech length) for category I, II

= 0,20 [–], (20%of leech length) for category III

= 0,15 [–], (15%of leech length) for category IV

14.7.6 Spinnaker pole

Normally, the maximum working compression of the spinnaker pole occurs under tight reaching condition, when the spinnaker pole points straight forward. The load induced is assumed to be generated by an interaction between after guy and pole according to Fig. 14.7.6.

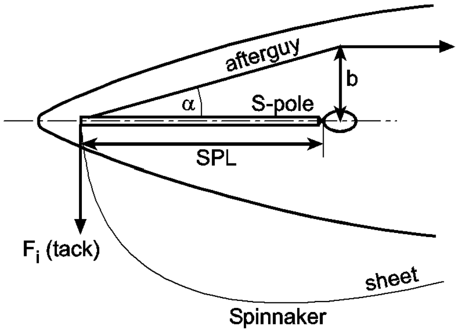


Fig. 14.7.6
Spinnaker pole force

Maximum working compression of spinnaker pole:

$$F_{sp} = \frac{F_i\,(tack)}{\tan\alpha} \quad [N]$$

F_i (tack) = relevant F_{is} according to 14.4.7

$$\alpha = \arctan\left(\frac{b}{SPL}\right)$$

b = distance of deflection sheave from centre line or length of jockey pole [m]

It shall be considered whether a supplement has to be made due to sheet loads (for rather flat spinnakers or gennakers).

14.8 STANDING RIGGING

The *Register* examines standing rigging sizes by calculating tensile forces and correlate them with the reserve factors according to 14.9. Calculation method is geometric non-linear finite element analysis. The tensile forces determined this way are also called maximum working loads (MWL) under the conditions of this Rules.

NOTE: Working loads of longitudinal stays can be determined analytically (see 14.8.2).

14.8.1 Shrouds

Calculation of shroud working loads shall be based on the input specified in 14.4.

14.8.2 Headstays

The working load is the resultant axial force due to sag of a sail-carrying headstay.

The sag is the maximum transverse deflection of a line under a lateral uniform load between its end points.

The values specified below are relevant for the load case of a full main combined with a jib of 100 % forestay-triangle area or reefed main combined with staysail at SWA. The lateral load q is a uniform load equivalent to the force F_{tf} defined in 14.4.2, see Fig. 14.8.2.

Headstay working load F_{hs}:

$$F_{hs} = \frac{q \cdot l_0}{8 \cdot s} \quad [N]$$

$$q = \frac{F_{tf}}{l_0} \quad [N/m]$$

l_0 = stay length [m]

s = the magnitude of sag "s" as a fraction of the stay length is not to be taken more than according to Table 14.8.2:

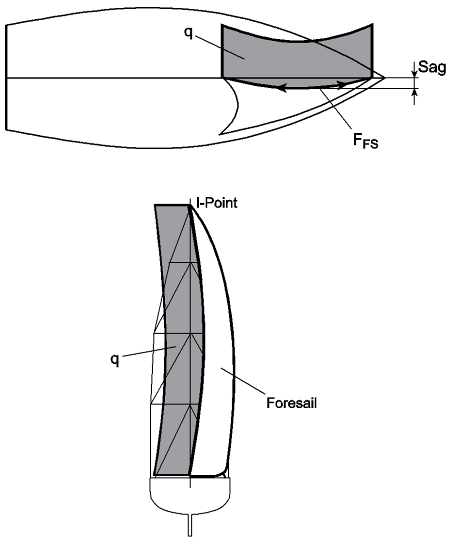


Fig. 14.8.2
Headstay load

Table 14.8.2
Headstay sag

	sag			
	Cat. IV	**Cat. III**	**Cat. II**	**Cat. I**
Primary headstay	0,7 %	1,0 %	1,5 %	2,0 %
Secondary headstay(s)	1,5 %	2,5 %	3,0 %	5,0 %

Deviations from these indexes can only be considered in well-founded cases, resulting from exceptional sail and/or design characteristics.

Working loads for non-sail-carrying headstays (inner forestays, baby stays) are not explicitly specified here.

In this case, design criterion is the rig's required longitudinal stiffness dealt with in 14.10.

14.8.3 Backstay(s)

For masthead rigs, backstay design load is obtained by opposing the forestay design load under equilibrium of moments about the mast base. In case of swept spreaders a contribution of cap shrouds may be considered.

14.8.4 Runners, check stays, etc.

Runner and/or check stay design loads are obtained by opposing the forward longitudinal stays design loads under equilibrium of moments about the mast base.

Besides, runners may be necessary not only to control but also to support and stabilise the rig, see 14.10.

14.9 GLOBAL ANALYSIS

14.9.1 Standing rigging

14.9.1.1 General

Diagonal shrouds shall generally have a minimum angle to the mast centreline of 9°. If spreaders are swept, they shall be swept evenly, so that all shrouds are in plane on either side, when rig is unstressed.

Spreader sweep angles between 5° and 9° are not advisable.

While dimensioning of standing rigging, global rig stiffness characteristics have to be considered, since in case of swept spreaders the "system stiffness" of the rig is also influenced by the dimensions and geometric arrangement of transverse rigging.

14.9.1.2 Dimensioning of standing rigging made of steel rod

The following reserve factors (RF) are valid provided working loads in standing rigging have been calculated by static, geometric non-linear analysis. They are related to the ultimate break load specified by the manufacturer. If not explicitly mentioned, the following reserve factors are valid for Nitronic 50 Rod rigging.

14.9.1.3 Transverse rigging and jumper

RF ≥ 2,5 on working loads determined according to 14.8

14.9.1.4 Fore and aft rigging, others

RF ≥ 2,0 on design load according to 14.8

RF ≥ 2,5 on design load according to 14.8 for soft aramid rigging and generally for Category I yachts

14.9.2 Dimensioning of standing rigging made of polymer fibre cables

For fibre rigging elements, such as PBO or carbon strand cables, the working load determined by static, geometric non-linear analysis using the approaches offered in this Rules so far may not exceed the cable's maximum working load specified by the cable supplier. This maximum cable working load may be a *Register*-certified value and thus/or be determined by the approach offered in Rules of the *Register*. In lack of such proof, the following reserve factors shall be used:

14.9.2.1 Transverse rigging and jumper

RF ≥ 4,5 on working loads determined according to 14.8 including the self-weight effect

14.9.2.2 Fore and aft rigging, others

RF ≥ 3,6 on design load according to 14.8

RF ≥ 4,5 on design load according to 14.8 for Category I yachts

14.10 STABILITY ANALYSIS

The following stability evaluations are based on the determination of buckling modes. The reserve factors versus buckling do not necessarily represent a safety against the occurrence of this failure mode, because the applied method assumes ideal straightness of the mast and its alignment with the forces which is not the case in the realistic situation. Yet, the method provides a measure for assessing the rig's stiffness.

14.10.1 Global stability and stiffness

Global buckling is called the longitudinal buckling of the whole rig-system fore and aft. The following reserve factors are applicable for an evaluation according to the "Euler Eigenmode" method. The determination of mast compression levels is based on static, non-linear analysis.

RF ≥ 3,1 on each set of mast panel compressions (resulting from all relevant working loads according to 14.7)

Global stiffness shall also be considered in case the yacht is driven with no mainsail, e.g. under engine, against heavy seaways.

14.10.2 Local stability and stiffness

Local transverse buckling of the mast normally occurs as "panel-buckling" between transverse supports.

Reserve factors are again applicable for an evaluation according to the "Euler Eigenmode" method.

RF ≥ 2,6 on each set of mast panel compressions resulting from all relevant working loads according to 14.7.

14.10.3 Shear stiffness of CRP-mast tubes

25 % (by weight) of the mast's basic laminate layup shall have ± 45° fibre orientation to achieve a minimum shear and torsional stiffness. A stiffness correction of this content shall be taken into account in case of dissimilar moduli of fibres running in 0° and 45°.

Also refer to 14.20 for minimum elastic properties of tubes.

However special considerations are required for furling masts with open sections.

14.10.4 Thin wall buckling of the tube

Tube wall buckling has to be considered.

RF ≥ 3,0 on ultimate buckling stress or strain according to max. working compression in each wall panel resulting from load cases acc. to 14.3.1 (reserve factors are applicable for Roark and Young's theory of skin buckling under compression loads for curved, non-isotropic plates). Load concentrations shall be considered particularly in way of:

- mast step, especially when the mast cannot be pitched
- D-tangs
- slots or halyard exits

14.11 SPREADER CONSTRUCTION

Spreaders are subjected to axial, bending and shear loads. Each of the following scenarios described in 14.11.1 to 14.11.3 shall be considered. Proof of sufficient safety is based on "first principles" of engineering. In Figures 14.11.1-1 and 14.11.1-2 relevant arrangements and coordinates are shown. Relevant allowable strains and stresses are defined in 14.15.2, 14.15.3 and 14.15.4. The design loads shall be determined as follows:

14.11.1 Loading on windward side

F_x = load in x-direction, resulting from relevant components of 2,5 times the calculated shroud working loads [N]

M_{by} = bending moment resulting from 2,5 times the calculated working loads of V_{n+1} with an offset of h (tip cup offset) [Nm]:

- for Navtec 528 Standard:
- Tip cup offset = 0,6 · diam. V_{n+1}
- for Navtec 534/834: 0,5 · diam V_{n+1}
- for others: to be specified

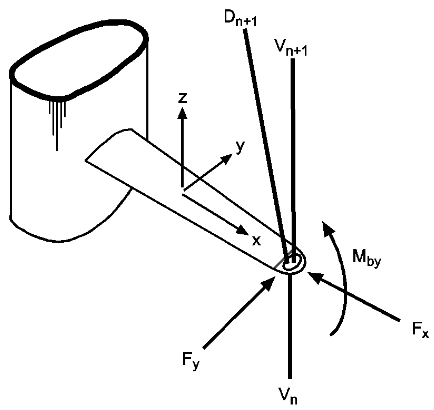


Fig. 14.11.1-1
Forces on a spreader

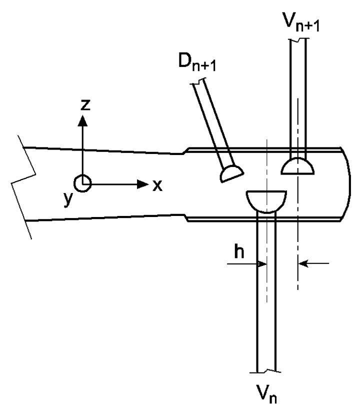


Fig. 14.11.1-2
Spreader end detail

Tip cup moments else from this approach may be considered if a variation of load cases has been calculated and the most conservative value resulting from combination of V_n, V_{n+1} und D_{n+1}. This moment shall be multiplied by 2,5 for subsequent spreader calculations.

F_{ya} = load in y-direction at spreader tip generated by mast bent ($F_{ya\,max}$ on windward side):

= V1· 0,0055 · $k_1 \cdot k_2$ [N]

V_1 = nominal break load or 2,5 times the calculated working load from V1 [N]

k_1 = 0,7 for non-swept spreaders

= 1,0 for 20° spreader-rake, interpolate in-between

k_2 = distribution factor according to Table 14.11.1

or

F_{yb} = sectional loads in y-direction F_y at spreader tips obtained from finite element analysis (FEA)

= 2,5 · F_y [N]

The sectional loads in the spreaders are combinations from design loads listed above.

Table 14.11.1
Distribution factors

k_2	3-spreader-rig	4-spreader-rig	5-spreader-rig
Spreader 1	0,7	0,6	0,6
Spreader 2	1,0	0,9	0,8
Spreader 3	0,95	1,0	1,0
Spreader 4	-	0,96	0,95
Spreader 5	-	-	0,85

14.11.2 Loading on leeward side

F_{yc} = loads from mainsail pushing against each leeward spreader

$$F_{yc} = l_p \cdot E \cdot c_1 \cdot c_2 \cdot c_3 \cdot \frac{\rho}{2} \cdot v_{aws}^2 \quad [N]$$

$$l_p = \frac{P}{n+1} \ [m]$$

n = number of spreaders

P = mainsail hoist, see 14.4.2.1

= density of air [kg/m3]

v_{aws} = apparent wind speed for design purpose = 19 m/s

c_1 = sail girth factor, refer to Table 14.12-1

c_2= distribution factor, refer to Table 14.12-2

c_3 = overload factor = 2,0

E = foot of mainsail, see 14.4.2.1

Choosing this method, all other design loads (F_x, F_{ya} and M_{by}) are assumed to be zero.

Table 14.12-1
Girth factors

c_1	3-spreader-rig	4-spreader rig	5- spreader rig
Spreader 1	0,75	0,8	0,83
Spreader 2	0,5	0,6	067
Spreader 3	0,25	0,4	0,5
Spreader 4	-	0,2	0,33
Spreader 5	-	-	0,17

Table 14.12-2
Distribution factors

c_2	3-spreader rig	4-spreader rig	5-spreader rig
Spreader 1	0,5	0,5	0,4
Spreader 2	0,8	0,7	0,6
Spreader 3	1,0	0,9	0,8
Spreader 4	-	1,0	0,9
Spreader 5	-	-	1,0

14.11.3 Spreader buckling

RF ≥ 1,1 for Euler-Buckling of spreader versus relevant design loads specified in 14.11.1

14.11.4 Spreader wall buckling

RF ε 1,1 for thin wall buckling of spreader versus relevant design loads specified in 14.11.1

14.12 BOOMS

Booms are subjected to compression, bending, shear and torsion primarily through the loads from sheet, leech, outhaul and vang, see Fig. 14.12-1.

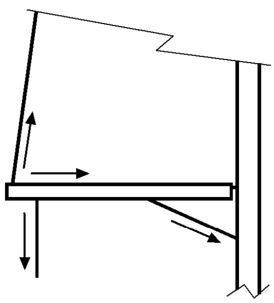


Fig. 14.12-1
Forces on boom

Design Loads:

1,5 × release load for max. possible relief valve setting [N]

1,0 × max. working loads of all relevant sheets, lines, outhauls etc. [N]

1,0 × M_t (resulting torsional moment), see Fig. 14.12-3

$M_t = F_{sh} \cdot h + F_{sail} \cdot k$ [Nm]

F_{sh} = horizontal component of mainsheet load [N], see Fig. 14.12-2

F_{sail} = component of mainsail load acting at mainsail clew [N], see Fig. 14.12-2

$$F_{sh} = F_{sail} = \frac{1}{3} \cdot \frac{\rho}{2} \cdot A \cdot v^2 = 75 \cdot A \quad [N]$$

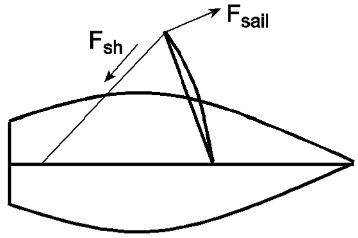


Fig. 14.12-2
Mainsail clew

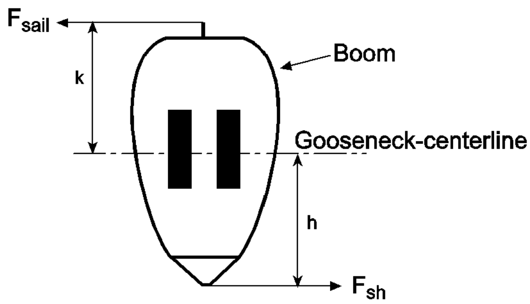


Fig. 14.12-3
Boom section

v = apparent wind speed for design purpose
= 19 m/s (35 kn)

A = mainsail area [m^2]

ρ = density of air [kg/m^3]

An appropriate combination of the above loads shall be assumed for the strength calculation.

It is strongly recommended to provide the vang with an overload relief valve. Otherwise the design load for the boom in respect of forces due to the vang has to be replaced by:

1,0 × breaking load of vang [N]

The requirements for allowable strains and stresses as defined in 14.5.3, 14.5.4 and 14.5.5 shall be met when applying the design loads. Also, wall buckling of the boom shall be considered.

14.13 MAST STEP

A mast step is subjected to compression and shear forces. Especially for keel-stepped masts, shear is mainly generated by boom compression.

14.14 MAST-PANEL BETWEEN MASTSTEP AND UPPERMOST SPINNAKER POLE POSITION "(PANEL 0)"

If the loading of Panel 0 due to vang, spinnaker/ jockey pole and boom has not been part of the global analysis, these loads have to be taken into account additionally when designing Panel 0. The resultant loads due to the following design loads shall be considered then:

Vang: resultant loads due to 1,5 × max. vang working load according to 14.7.5 (for hydraulic device:

vang load = release load at max. eased mainsheet).

Poles: 2 x resultant loads due to pole compression according to 14.7.6.

Gooseneck: resultant loads due to 1,5 x max. vang load (for hydraulic device: vang load = release load at max. eased mainsheet plus other relevant contributions (outhaul, mainsheet etc.)).

14.15 LOCAL ANALYSIS

14.15.1 Local analysis of components made of multi-axial-carbon fibre laminate or aluminium alloy

The reduction factors and allowable material strains and stresses in this Rules are applicable for the following general engineering approaches (according to the "Classic Laminate Theory (CLT)" for carbon fibre reinforced plastic). For 3-D finite element analysis the reduction factors have to be defined separately.

Pin seating:

- bearing stress/strain [MPa]:

$$\sigma_b = \frac{F}{t \cdot d} \qquad \varepsilon_b = \frac{\sigma_b}{E}$$

- shear-out stress (for CRP) [MPa]:

$$\tau_{st} = \frac{F}{2 \cdot t \cdot \left(e - \frac{d}{4}\right)} \qquad \varepsilon_{st} = \frac{\tau_{st}}{G}$$

Shear-out stress has to be considered for bolt-fastenings with an edge distance lower than 2d. In any case, when plate material is not quasi-isotropic.

- tensile (hoop) stress [MPa]:

$$\sigma_{hs} = \frac{F}{t \cdot (b - d)} \qquad \varepsilon_{hs} = \frac{\sigma_{hs}}{E}$$

where:

F = design load according to 14.15.1 [N]

t = plate thickness [mm]

d = pin hole diameter/bushing diameter [mm]

e = distance from pin centre to edge of component in direction of load [mm]

b = width of component perpendicular to direction of load [mm]

E = mean compressive modulus [MPa]

G = mean shear modulus [MPa]

This implies, that the construction allows for such simplifications, otherwise stress concentration factors (SCF) have to be incorporated. Index values for SCF are:

- SCF = 3,0 for holes around loaded pins
- SCF = 1,7 for holes in loaded isotropic or quasi-isotropic laminates

Furthermore:

- Bending in bolt-connections shall be kept small by choosing an appropriate arrangement.
- Where pins introduce an un-symmetrical loading in a plate due to additional transverse loading (e.g. at forestay attachment), holes shall have a bushing and be clamped. (A clamped laminate is supported by a steel bushing inside a hole and at its cheeks with washers or plates connected to the bushing.)
- An efficient load transfer for local load introductions through bolt-connections in flat CRP-plates can be provided with a quasi-isotropic plate laminate with the following fractions of fibre-directions:

0°: 30 % – 50 %

± 45°: 40 % – 60 %

90°: ≥ 10 %

For minimum elastic off-axis properties, relate also to 14.20.

14.15.2 Design loads for structural joints, fittings attachments and connections:

1,0 x breaking load of the relevant shroud or stay (usually used for steel rod rigging components)

or

2,5 × calculated working load of the relevant stay or shroud (usually used for fibre rigging components)

If more than one of the following design loads is relevant, the highest resulting value has to be chosen.

1,0 x release load of halyard tensioners / winches and sheet winches etc.

0,8 x breaking load of running rigging

2,0 x max. working load of running rigging

1,5 x max. vang load (hydraulic device: release load)

Others to be specified in detail.

If more than one design load is relevant, the highest resulting value has to be chosen.

14.15.3 Allowable strains for carbon fibre laminates under design loads

εb all = 0,25 % allowable bearing strain of carbon laminate with circular holes

εbc all = 0,35 % allowable bearing strain of clamped carbon laminate with circular holes

εct all = 0,25 % allowable compression and tensile strain

εis all = 0,45 % allowable in-plane shear strain

14.15.4 Applicable reduction factors for carbon fibre laminate strength under design loads on the basis of appropriate and approved material test data, refer to 14.20

γb = 2,0 on ultimate bearing strength (compressive test)

γbc = 1,5 on ultimate bearing strength of clamped laminates (compressive test)

γct = 2,0 on ultimate compression and tensile strength

γs = 2,0 on ultimate in-plane shear strength

14.15.5 Applicable reduction factors for aluminium alloys under design loads

γb = 1,1 on ultimate bearing strength

γct = 1,1 on ultimate compression and tensile strength

γs = 1,1 on ultimate shear strength

For welded components the modified material properties in the heat affected zone have to be taken into account.

14.16 LOCAL STRENGTH OF METALLIC PINS AND OTHER ATTACHMENTS MADE OF STAINLESS STEEL OR ALUMINIUM ALLOY

γy = 1,1 on yield strength under design-loads according to 14.15.1

14.17 BONDED JOINTS

Bonded joints are normally in-plane shear loaded.

γgjb = 2,0 on ultimate shear strength of adhesive in connection with bolts/rivets

γgj = 2,5 on ultimate shear strength of adhesive without bolts/rivets

- cleavage shall be avoided
- joints of mast, boom or spreader shells shall be located in one of the neutral axes
- structural threads are not allowed in laminates

14.18 MATERIALS AND FABRICATION

14.18.1 Materials

14.18.1.1 CRP in General

A solid laminate lay-up shall have well-balanced mechanical properties, i.e. off-axis fibres evenly distributed, unless special configurations are required in well-founded exceptional cases.

In a laminate a batch of plies with fibres aligned solely in one direction may not exceed a thickness of 1,5 mm or a fibre weight of 1500 g/m2 respectively. Generally, grouping of 90° plies shall be avoided.

For polymer matrix composites the reinforcement fibre will be the primary load carrying element, because it is stronger and stiffer than the matrix. The mechanism for transferring load throughout the reinforcement is the shearing stress developed in the matrix. Thus, a fibre dominated laminate characteristic is desired wherever possible. A (0°/ ± 45°/ 90°) lay-up is recommended, a minimum of 10 % of the fibres should be aligned in each of those directions (see also 19.1).

In any case the transverse Young's modulus in compression shall exceed a minimum of 20 % of the value in longitudinal direction. The polar graph of the in-plane Young's modulus shall not have major concave areas see Fig. 14.18.1.1.

The minimum shear modulus in shell plane shall be not less than 11 % of the Young's modulus in compression.

Conditions, where peel stresses occur due to abrupt steps or bonded structures with significantly different stiffnesses shall be avoided.

The taper of a laminate, for example reduction of section thickness or a reinforcement patch, has to be carried out according to a proper taper ratio.

When drilling holes in CRP, measures shall be taken to prevent fibres from breaking out of the back face.

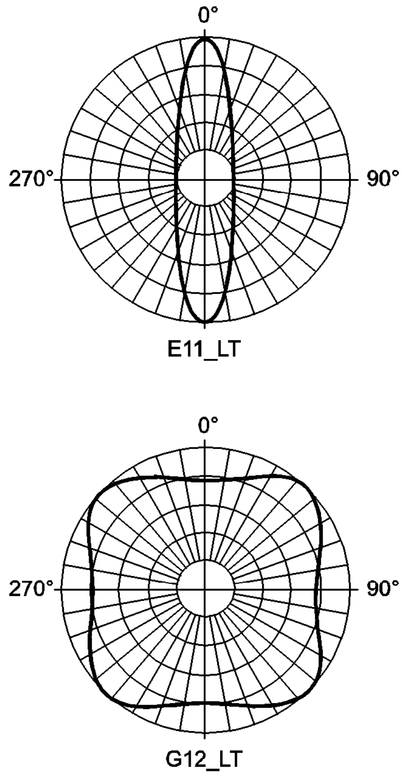


Fig. 14.18.1.1
Polar diagrams

14.19 CRP SAMPLES

CRP samples of the fabricated tube have to be submitted to the *Register*. Samples can be:

- spar shell ends close behind cut-offs
- pieces from cut-outs, e.g. from:
- spreaders, tang fittings
- halyard slots
- others, if available, with designation of their location

Pieces will be stored.

Some of the CRP samples shall be representative of the 0° (longitudinal) direction of the tube with a minimum size of 100 × 10 × t [mm] for a possible compression test.

14.20 MATERIAL TESTS (CRP)

Analysis of local details may be performed in a more exact and less conservative way, when reliable test data of the relevant laminate properties are available.

However, before applying test data values it shall always be considered whether the test data in question are (really) significant for the particular design problem.

Tests have to be carried out according to appropriate standards at an independent, accredited institute.

The specimen shall be supplied by the mastbuilder and be fabricated under realistic conditions corresponding to the component-construction.

14.21 DESIGN VALUES

For each mechanical property of a laminate a min. number of tests shall be carried out. A statistical average is then to be taken as outlined in the following, to obtain the characteristic value, which will be taken as design value.

A "normal distribution" is assumed for the test values of the mechanical properties. A 5 % fractile for a probability of P = 95 % (confidence interval) shall be applied here. The relevant formula for the characteristic value R_k is:

$$R_k\,(\alpha, P, s, n) = x - s\,\cdot\,\left(u_\alpha \frac{u_p}{\sqrt{n}}\right)$$

$u_{\alpha/P}$ = α %/P % fractile (percentile value) of a normal distribution for defining a minimum value

= 1,654 for the above condition (α = 5 %, P = 95 %)

x = arithmetic mean value from test results

$$x = \frac{\sum_{i=1}^{n} x_i}{n}$$

s = standard deviation

$$s = \sqrt{\frac{1}{n-1}\cdot\sum_{i=1}^{n}(x_i - x)^2}$$

x_i = individual test value i of set of n tests

n = number of tests for one mechanical property

Elastic properties for a laminate with off-axis content can be calculated if the properties for the pure unidirectional laminate are known according to the "classic laminate theory". An analogous conclusion for strength properties is unfortunately not possible.

A simplified approach to derive strength properties of multiaxial laminates from properties of unidirectional laminates is given here with the "strain to failure" consideration:

It is assumed that the strength properties of a laminate are "fibredominated" (see also provisions in 14.21).

The strain to failure values are similar for multiaxials and unidirectionals. This is because for a multiaxial laminate the ultimate strain in compression or tension is governed by the ultimate strain of the 0° plies contained therein. This allows to obtain the ultimate strain values from a 100 % 0° laminate as to represent design values when statistically assured. Further, it will be assumed that the in-plane shear strain is governed by tensile/compression properties of fibres running under ± 45°.

To obtain allowable values, the design values for strength and strain properties have to be combined with the reduction factors (refer to 14.15.4). Fig. 14.23 illustrates the path and links between load application and load absorption accordingly.

The tests according to Table 14.24 are considered appropriate for the investigation of material properties for CRP.

The *Register* reserves the right to interpret the test data due to different test methods.

14.22 MATERIAL CERTIFICATES FOR ALUMINIUM ALLOYS

Valid material properties of specific aluminium alloy verified by a "14.4.1 material certificate" according to DIN EN 10204 or similar can be submitted to the *Register*. Otherwise, the *Register* will base the calculations on general minimum properties for the aluminium alloy in question.

14.23 QUALITY ASSURANCE

An internal quality assurance of the production facility shall be guaranteed, e.g. be in compliance with the ISO 9000 series or be suitable for the facilities and comprise inspection of incoming goods, storage of material, responsibilities and the process of fabrication.

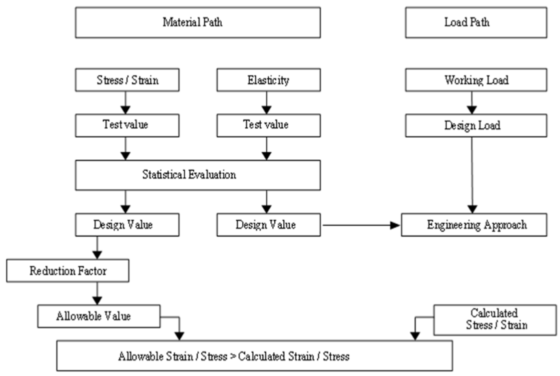


Fig. 14.23
Engineering flow chart

14.24 FABRICATION

Table 14.24
Material tests

(Tensile strength), tensile modulus, elongation at break	ASTM D3039, SACMA SRM4 or DIN EN ISO 527-4, Test specimen III, 5 samples
(Compressive strength), compressive modulus, elongation at break	ASTM D3410, SACMA SRM1 or Draft DIN EN 2850, specimen A1 with free edge of 8 mm, 5 samples
Flexural strength, flexural modulus (if applicable)	ASTM D790, EN 63-ISO 178, 5 samples
Interlaminate shear strength	ASTM D2344, 5 samples

The fabrication of polymer matrix composites shall in general be in compliance with the material supplier's recommendations and/or requirements and the Rules of the *Register*.

14.25 MISCELLANEOUS

14.25.1 Fittings, equipment

Rigging parts like terminals, turnbuckles, toggles, shackles, eyes, jaws, tip cups are not within the scope of this Rules but shall nevertheless be state of the art equipment and of good common marine quality.

Relief valve settings and/or max. pull or max. holding power of non-manual driven devices, that act on standing rigging, shall be adjusted to

- 66% of the breaking load of the respective stay for rod and wire
- 50% of the breaking load of the respective stay for aramid rigging.

14.25.2 Rigging

14.25.2.1 Solid rod rigging

Rod rigging shall be made of an established metallurgical high strength steel alloy of sufficient toughness (e.g. "Nitronic 50" cold drawn wire with appropriate cold reduction treatment). It shall be self-aligning under changing lead to avoid bending. The best common fitting for alignment under load is the marine eye combined with a toggle. For transverse rigging, ball-type fittings are also acceptable (stemball fittings), but not so for head stays due to the magnitude of lead change under load.

14.25.2.2 Soft (flexible) aramid rigging

Soft aramid rigging is generally acceptable for aft longitudinal rigging (backstays, running backstays, checkstays), but not recommended for Category I yachts.

Spliced terminals are not allowed due to the possibility of chafe.

Soft aramid rigging shall be proof tested to at least 25 % of the rated strength of the stay prior to installation.

Terminals shall have a sufficient bend and strain relief and transition towards the cable and shall provide a good isolation from salt water, humidity, and UV-radiation.

For maintenance recommendations/requirements refer to 14.25.2.

14.25.2.3 PBO, carbon rigging

It is generally recommended to provide a *Register* type approval for cables made of PBO or carbon fibres. This will be carried out in accordance with Rules of the *Register*.

Apart from the required proof and testing defined therein, the following shall be considered in general:

- If cables are intended for components other than for diagonal shrouds, aft stays and "secondary" headstays, particular considerations shall be given to special features such as additional chafe protection, special arrangements for the case a cable is being central part of a furling headsail, etc.
- Terminals shall be free of bending moment introduction.
- Terminals shall have a sufficient strain and bend relief.
- Fibres shall be totally protected from ingress of humidity and UV radiation.
- Cables shall be proof-tested prior to installation.

For general maintenance recommendations / requirements refer to 14.25.2.3.

14.26 MAINTENANCE

Rigging and other highly loaded components of the rig shall be inspected in appropriate intervals, depending on the proportion of usage with non-destructive testing methods, especially at terminals, fittings and ball-heads.

Suppliers recommendations have to be considered.

14.26.1 Rigging and attached fittings

14.26.1.1 General

Rod rigging should be replaced, when:

- any kind of crack appears (typically at "cold heads")
- in case of a permanent bent caused by mishandling

A first disassembly and inspection of the rigging should be carried out latest after 2 years (1 year for category III and IV rigs) or 40 000 miles (10 000 miles for category III and IV rigs) or according to suppliers schedules.

14.26.1.2 Soft aramid rigging

Soft aramid cable shall be replaced when the cover is damaged such that the break penetrates to the fibre core.

Rigging should be inspected at least every year (every 1/2 year for category III or IV rigs) or after 10 000 miles (5 000 miles for category III or IV rigs), whichever comes first or according to supplier's schedules.

The terminals should be inspected according to supplier's recommendations.

14.26.1.3 PBO and carbon rigging

In general, maintenance and replacement schedule of the cable supplier shall be followed.

14.27 COATING

All carbon parts that are subjected to direct sunlight shall be protected by a non-transparent, light colour. The thickness shall be sufficient to protect from UV radiation.

14.28 CORROSION PROTECTION

Metallic parts have to be insulated from carbon fibres by using an adhesive layer or a thin glass fibre ply, which shall ensure sufficient protection against conductive connection. The reason is that carbon fibres do not only conduct electrical current but are also sensitive to cathodic corrosion.

It is generally recommended to wrap carbon-spars in a resin-rich layer of glass woven roving laminate to prevent splintering of carbon fibres in case of damage and to provide a certain protection against local impact.

For spars made of aluminium-alloy, austenitic metals have to be insulated from aluminium alloy components.

14.29 GENERAL RECOMMENDATIONS FOR LIGHTNING PROTECTION

14.29.1 An aluminium mast itself is a good conductor with enough cross-sectional area to conduct a lightning strike.

14.29.2 Carbon fibres are not to be used as a conductor.

14.29.3 For mast heights over 15 m above water line, the protection zone is based on the striking distance of the lightning stroke. Since the lightning stroke may strike any grounded object within the striking distance of the point from which final breakdown to ground occurs, the zone is defined by a circular arc. The radius of the arc is the striking distance (30 m). The arc passes through the top of the mast and is tangent to the water. If more than one mast is used, the zone of protection is defined by arcs to all masts.

The protection zone formed by any configuration of masts or other elevated, conductive and grounded objects can readily by determined graphically. All components inside the protection zone shall be lightning grounded to earth.

14.29.4 The entire circuit from the top of the mast to the ground shall have a mechanical strength and conductivity not less than that of a 25 mm^2 copper conductor. The path to ground followed by the conductor shall be essentially straight and on the shortest way possible. Corners or sharp edges shall be avoided in conductors.

14.29.5 For carbon masts it is recommended to protect other cables against (strong) magnetic fields occurring, when passing the conductor through the mast.

14.29.6 The top of the lightning spike should at least be 300 mm above anything that is susceptible in this context (structure, antenna, instruments), see also definition of "protection zone" in 14.29.

14.29.7 The lightning spike should have a metallic diameter of not less than 8 mm.

Also refer to ISO 10134 and/or Rules of the *Register*.

14.30 STEPPING AND RIGGING OF MASTS

The stepping and rigging of a mast has to be performed by experts according to the designers/manufacturers specifications.

14.31 VISUAL PRE-DELIVERY INSPECTION

It is strongly recommended to carry out a shakedown cruise of at least 7 days offshore. Wind speeds of at least 25 – 30 knots have to be experienced over a period of at least 24 hours.

A visual inspection of the rig will in any case be carried out prior to delivery.

15 FRP STRUCTURES

15.1 GENERAL

15.1.1 Application

15.1.1.1 The requirements in this section apply to fibre reinforced plastic (FRP) single skin and sandwich constructions.

15.1.1.2 Additional or modified requirements may be given in association with the various type and service notations.

15.1.1.3 Alternative scantling determination methods may be accepted upon consideration in each individual case.

15.1.2 Calculation methods

15.1.2.1 To determine stresses and deflections in FRP single skin and sandwich constructions either direct calculations using the full stiffness and strength properties of the laminate in all directions or a simplified method in accordance with 5.3, 5.4 and 5.5 will be accepted.

15.1.2.2 The simplified method may be employed on the following conditions:

- the principal directions of the laminate reinforcement are parallel to the panel edges
- the difference in elastic modulus in the two principal directions is not more than 20%
- the skin laminates of sandwich panels are thin, i.e.
- $d/t > 5.77$.

15.1.2.3 Direct calculations (such as FEM analysis) based on the full strength and stiffness properties in all directions are generally acceptable for compliance with requirements of this Section.

15.1.3 Structural design in general

15.1.3.1 Attention is drawn to the importance of structural continuity in general.

15.1.3.2 The vessel structure shall generally be arranged to ensure continuity of longitudinal strength, including horizontal shear area to carry a strength deck along. Structure shall include:

- transverse bulkheads or strong webs
- web/pillar rings in engine room
- superstructures and deckhouses
- direct support
- transitions
- deck equipment support
- multi-deck pillars, in line, as practicable
- external attachments, inboard connections.

15.1.3.3 Corners and dimensional transitions shall be well rounded to avoid stress concentrations.

15.1.3.4 Tensile loads perpendicular to the plan of the laminate should be avoided.

15.1.3.5 Thickness differences in laminates should be tapered over a length of at least 20 × thickness difference.

15.1.3.6 Overlap between layers of reinforcement shall be such that the in-plane shear strength of the joint is at least equal to the axial strength of the reinforcement. For most standard reinforcements this is achieved with an overlap of 40 mm.

15.1.3.7 In bolt and rivet connections the distance from the laminate edge to the centre of the hole shall be 3.0 × and 2.5 × hole diameter respectively.

15.1.3.8 Distance between rivets shall be at least 2.5 × hole diameter and for bolts at least 3.0 × hole diameter. Bolts and rivets shall normally be fitted with washers with diameter 2.0 × hole diameter in both ends.

15.1.4 Materials

15.1.4.1 Structural materials shall comply with the requirements of subsection 2.3.

15.2 STRUCTURAL ARRANGEMENT

15.2.1 Bottom structures

15.2.1.1 The bottom single skin or sandwich panels shall comply with the requirements given in 5.3 and 5.4. The local strength of the keel shall be sufficient to withstand loads in connection with docking attachment of external ballast keel, etc.

15.2.1.2 Bottom structures may be longitudinally or transversely stiffened.

15.2.1.3 In planning vessel single bottom as well as double bottoms shall normally be longitudinally stiffened in single skin constructions. In vessel with sandwich construction transverse stiffening may be accepted.

15.2.1.4 The longitudinal should preferably be continuous through transverse members. At their ends longitudinal shall be fitted with brackets or to be tapered out beyond the point of support.

15.2.1.5 Longitudinal stiffeners shall be supported by bulkheads and/or web frames.

15.2.1.6 Displacement vessels with single bottom and transverse frames shall have floors at each frame. The floors shall be continuous from side to side. The scantlings of the floors may be taken in accordance to Table 5-1, with notes. The table values are applicable when the distance between transverse bulkheads or other equivalent support for the longitudinal girders does not exceed the breadth of the vessel. If the girder span is greater than the breadth of the vessel, the floors web plate height and flange area shall be increased as stated in the table's note. Alternatively, the scantlings of the floors shall be established in accordance with 5.5.

15.2.1.7 Longitudinal girders shall be carried continuously through bulkheads. In vessel built in sandwich construction longitudinal girders may be fitted to support the bottom panels.

15.2.1.8 A centre girder shall be fitted for docking purpose if the external keel or bottom shape does not give sufficient strength and stiffness.

15.2.1.9 Openings should not be located at ends of girders without due consideration being taken to shear loadings.

15.2.1.10 The scantlings of longitudinal girders may be taken in accordance with Table 5-2 or alternatively according to 15.5.

15.2.1.11 Main engines shall be supported by longitudinal girders with suitable local reinforcement to take the engine and gear mounting bolts. Rigid sandwich core materials to be applied in all through bolt connections.

15.2.1.12 Web frames shall be continuous around the cross section of the vessel, i.e. web- and flange laminates of floors, side webs and deck beams shall be efficiently connected together. If intermediate floors are fitted, their ends should be well tapered or connected to local panel stiffening.

15.2.1.13 In the engine room, floors shall be fitted at every frame. The floors are preferably to be carried continuously through the engine girders. In way of thrust bearings additional strengthening must be provided.

15.2.1.14 In double bottoms manholes shall be made in the inner bottom, floors, and longitudinal girders to provide access to all parts of the double bottom. The vertical extension of openings shall not exceed one half of the girder height. Exposed edges of openings in sandwich constructions shall be sealed with resin impregnated mat. All openings shall have well rounded corners.

15.2.1.15 Vessels built in sandwich construction and with:

$$V/\sqrt{L} > 4.5$$

shall have the fore stem designed so that a local impact at or below the waterline will not result in skin laminate peeling due to hydraulic pressure. The vertical extension of the collision protection shall be from the keel to a point 0.03 L (m) above the waterline at operating speed.

15.2.2 Side structures

15.2.2.1 The hull sides may be longitudinally or vertically stiffened. The continuity of longitudinal shall be as required for bottom and deck longitudinal respectively.

15.2.2.2 The single skin or sandwich panels of the hull sides shall comply with the requirements of 15.3 and 15.4.

15.2.2.3 Vertical side frames shall normally be connected to floors and deck beams with well-rounded transitions and a continuous flange laminate.

15.2.3 Transom structure

15.2.3.1 The scantlings of transom not subjected to loads from engine or rudder installations shall comply with the requirements of 15.3 and 15.4.

5.2.3.2 Trust-bearing transom for outboard engine or stern drive mounting is preferable to be built as a sandwich panel with a sandwich core of waterproof plywood or equivalent material. The thickness of the transom for engine power specified by the manufacturer, should not be less than given in the Table 15-1.

Table 5-1
Thrust-bearing transom

Engine power (kW)	Total thickness of transom (mm)	
	Outboard mounting	Stern drive mounting
< 3	12	17
3 - 7	15	20
7 - 18	25	30
18 - 30	30	35
30 - 60	35	40
60 - 95	40	45
> 95	Scantlings to be specially considered in each individual case.	

15.2.3.3 The inner laminate on the sandwich core is normally to have a thickness not less than 0.7 times the thickness of the side laminate, and the outer laminate a thickness not less than 0.7 of the bottom laminate. The inner laminate shall extend forward along the sides and the bottom of the vessel and shall be gradually tapered in thickness.

15.2.4 Deck structure

15.2.4.1 Decks may be longitudinally or transversely stiffened.

15.2.4.2 Deck panels of single skin or sandwich construction shall comply with the requirements of 15.3 and 15.4.

15.2.4.3 Longitudinal should preferably be continuous through transverse members. At their ends longitudinal shall be fitted with brackets or be tapered out beyond the point of support.

15.2.4.4 Bulwark sides are considered to be a part of the hull side and shall have scantlings accordingly. A strong flange shall be made along the upper edge of the bulwark. Bulwark stays shall be arranged in line with transverse beams or local stiffening. The stays are to have sufficient width at deck level. If the deck is of sandwich construction, solid sandwich core inserts shall be fitted at the foot of the bulwark stays. Stays of increased strength shall be fitted at ends of bulwark openings. Openings in bulwarks should not be situated near the ends of superstructures.

15.2.5 Bulkhead structures

15.2.5.1 The scantlings of bulkhead structures shall comply with the requirements of 15.3 and 15.4.

15.2.5.2 Number and location of transverse watertight bulkheads shall be in accordance with the requirements given for the vessel types.

15.2.5.3 Bulkheads supporting decks shall be regarded as pillars. The buckling strength will be considered in each individual case.

15.2.6 Superstructures and deckhouses

15.2.6.1 The scantlings of superstructures and deckhouses shall comply with the requirements of subsections 15.3 and 15.4.

15.2.6.2 Superstructure is defined as a decked structure on the freeboard deck, extending from side to side of the ship of with the side plating not inboard of the shell plating more than 4% of the breadth (B).

15.2.6.3 Deckhouse is defined as a decked structure above the strength deck with the side plating being inboard of the shell plating more than 4% of the breadth (B).

15.2.6.4 Long deckhouse - deckhouse having more than 0.2 *L* of its length within 0.4 *L* amidships.

15.2.6.5 Short deckhouse is a deckhouse not defined as a long deckhouse.

15.2.6.6 In superstructures and deckhouses, the front bulkhead shall be in line with a transverse bulkhead in the hull below or be supported by a combination of girders and pillars. The after end bulkhead is also to be effectively supported. As far as practicable, exposed sides and internal longitudinal and transverse bulkheads shall be located above girders and frames in the hull structure and shall be in line in the various tiers of accommodation. Where such structural arrangement in line is not possible, there shall be other effective support.

15.2.6.7 Sufficient transverse strength shall be provided by means of transverse bulkheads or girder structures.

15.2.6.8 At the break of superstructures, which have not set-in from the ship's side, the side plating is to extend beyond the ends of the superstructure and be gradually reduced in height down to the deck or bulwark. The transition shall be smooth and without local discontinuities.

15.2.6.9 In long deckhouses, openings in the sides shall have well rounded corners. In deckhouses of single skin construction horizontal stiffeners shall be fitted along the upper and lower edge of large openings for windows. Openings for doors in the sides shall be substantially stiffened along the edges.

15.2.6.10 Casings supporting one or more decks above shall be adequately strengthened.

Table 15-2
Floors in single bottom

Height of floor at vessel's centreline × web thickness (mm × mm) Flange area (cm^2)					
Bd	**2**	**3**	**4**	**5**	**6**
0.5	120 × 6 1.5	150 × 6 2			
1.0	120 × 7 2	170 × 7 2	230 × 7 4		
1.5	140 × 8 3	190 × 8 3.5	250 × 8 5	295 × 8.7 9	
2.0		210 × 9.7 4	270 × 9.5 6	320 × 10.5 10	345 × 12.3 14
2.5		230 × 11 5	290 × 11 7.5	340 × 12 11.0	375 × 13.5 15
3.0			310 × 12 9	360 × 13.5 12	400 × 15 16
3.5				385 × 14.8 13	425 × 16.5 17.5
Basic frame spacing s in mm					
	350	350	350	360	380
B = breadth of vessel in metres *d* = draught in metres to lower side of bottom laminate (measured at centreline)					

NOTES:

[1] For frame spacings differing from those indicated in the table, the table values for web thickness and flange area are corrected in proportion to the frame spacings.

[2] In vessels with rise of floor amidships greater than half the rule height of the floor, the flange area may be reduced by 40 H/d %.
H/d = rise of floor amidships/draught to lower side of bottom laminate at centre.

3) When the span l_s of centre girder is greater than the breadth B of the vessel, the table values for flange area and web thickness of floors are multiplied by a factor f_l taken from the following table.

4) Web thickness ts is measured as shown in Figure 15-12.

Centre girder

l_s / B	1.10	1.25	1.50	2.00
f_l	1.13	1.25	1.37	1.50

Table 15-3
Longitudinal bottom girders

Flange area in cm² / web thickness in mm					
Bd	***2.5***	***3***	***4***	***5***	***6***
0.5	3.0/6.0	3.0/5.0			
1.0	3.5/6.0	3.6/8.3	8.0/10.0		
1.5	5.0/8.0	5.0/11.0	11.9/12.2	18.0/13.0	
2.0		6.1/13.3	14.0/15.0	23.0/15.2	35.0/16.3
2.5		7.0/15.2	15.5/17.5	27.0/18.0	41.0/18.7
3.0			18.4/19.6	31.0/20.4	46.0/21.0
3.5				35.0/22.3	51.0/23.0
B = breadth of vessel in metres *d* = draught in metres to lower side of bottom laminate					

NOTE: For girder spans greater than vessel's breadth, the table values for flange area and web thickness of the girder are multiplied by the factor f1 given in note 3 to Table 15-2.

Side girder

	Vessel's breadth *B* in metres		
	4	***5***	***6***
f_2	0.40	0.47	0.50

For side girders:

Flange area = f2 × flange area of centre girder

Web thickness = 0.9 × web thickness of centre girder.

15.3 SINGLE SKIN CONSTRUCTIONS

15.3.1 General

15.3.1.1 In this item the general requirements for the local strength of stiffened single skin constructions are specified.

15.3.1.2 Buckling strength of single skin panels subjected to longitudinal hull girder or local compression loads will be individually considered.

15.3.2 Laminate thicknesses

15.3.2.1 The thickness of structural laminates, excluding topcoat and gelcoat, shall not be less than the largest value found from the following formulas:

$$t_{min} = (t_0 + k \cdot L)\sqrt{f_b} \text{ (mm)}$$

$$t_p = k_p \cdot f_p \cdot s \cdot \sqrt{P} \text{ (mm)}$$

t_0 and k are taken from the Table 15.4

f_p is taken from the formulae in 15.3.2.2.

k_p= 3.82 for bottom panels

= 4.73 for side panels

= 4.11 for panels elsewhere and for all stiffening members.

Table 15-4
Laminate thickness

Item	$L \le 15$ (m)		$L > 15$ (m)	
	t_0	k	t_0	k
Hull bottom	2.5	0.58 x kv	8.6	0.17
Hull side	2.0	0.58	8.1	0.17
Transom, not supporting en-	2.0	0.58	8.1	0.17
Exposed deck	1.7	0.42	6.8	0.08
Cargo deck	$1.7 + q$	0.42	7.3	0.08
Accommoda-tion deck	1.7	0.42	6.8	0.08
Superstruc-tures and	1.7	0.42	6.8	0.08
Structural/wa-tertight bulk-	1.1	0.42	6.2	0.08
Tanks (except freestanding)	1.1	0.45	6.2	0.11

$k_v = 0.86 + 0.014 \cdot V$

q = deck cargo in t/m^2

15.3.2.2 The combined correction factor, f_p, is given by:

$$f_p = f_{p1} \cdot f_{p2} \cdot \sqrt{f_b}$$

The aspect ratio correction, f_{p1}, shall be taken from the Figure 15-1.

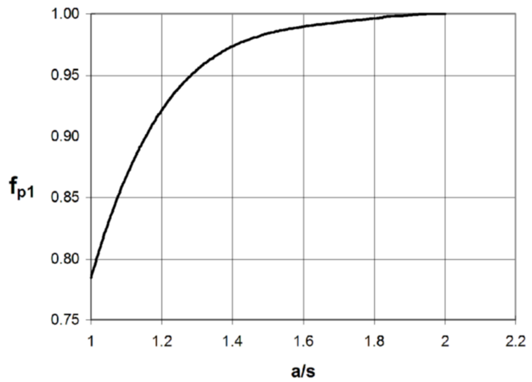


Figure 15-1

a and s are the longest and shortest panel edge respectively.

The panel curvature correction, f_{p2}, shall be taken as:

$f_{p2} = 1 - h/s$

$f_{p2\,min} = 0.8$

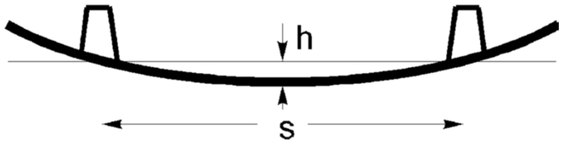


Figure 15-2

15.3.2.3 Reduced thicknesses may be accepted provided equivalent impact resistance can be documented.

15.3.3 Local laminate reinforcement

5.3.3.1 The structural laminates shall locally be reinforced to a thickness not less than:

$$t_{l\,min} = (t_0 + k \cdot L) \cdot \sqrt{f_b} \text{ (mm)}$$

t_0 and k are given in the Table 15-5.

Table 15-5
Laminate reinforcement

Item	L ≤ 5 m		L > 15 m	
	t_0	k	t_0	k
Keel type 1 and 2	2.9	0.9 x k_v	14.5	0.14
Keel type 3	3.5	1.1 x k_v	17.5	0.17
Fore and aft stem	2.9	0.9	14.5	0.14
Chine and transom corners *)	2.4	0.7 x k_v	12.0	0.11
Bottom laminate in way of rud-der stock, shaft brackets, etc.	3.5	1.1 x k_v	17.5	0.17
*) Breadth to each side shall be min. 25 B (mm), but not less than 100 mm				

Extension of keel laminate is shown below.

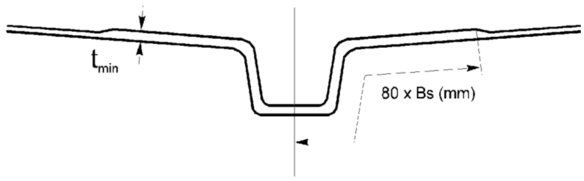


Figure 15-3
Keel type 1

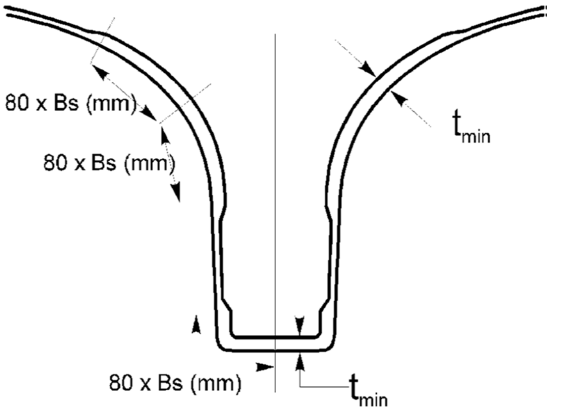


Figure 15-4
Keel type 2

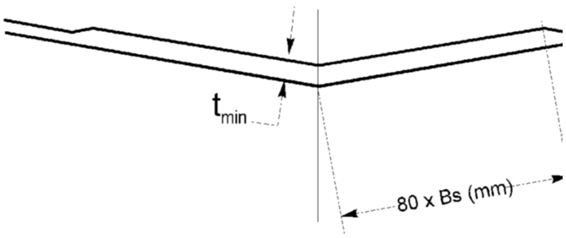


Figure 15-5
Keel type 3

15.4 SANDWICH CONSTRUCTIONS

15.4.1 General

15.4.1.1 In this section the general requirements for the local strength of sandwich constructions are given.

15.4.1.2 Buckling strength of sandwich constructions subjected to longitudinal hull girder or local compression loads will be individually considered.

15.4.2 Panel requirements

15.4.2.1 The thickness of skin laminates of sandwich panels shall not be less than:

$t_{s\,min} = k \cdot t_{1min}/f_c$ (mm)

$t_{l\,min}$ = minimum thickness found from 15.3.2.1

$f_c = 0.94 + 0.12 \cdot \sigma_c$

σ_c = compressive strength of the core material in N/mm^2

k is defined in Table 15-6.

Table 15-6
Panel requirements

Structural member	*k*	
	Exposed [1]	Protected [2]
Hull bottom	0.40	0.30
Hull side and transom*)	0.42	0.31
Cargo deck	0.63	0.48
Exposed deck	0.63	0.48
Accommodation deck	0.40	0.30
Superstructures and deckhouses	0.40	0.30
Structural/watertight bulkheads	0.40	0.30

NOTES:

[1] The term exposed means a side of a panel which is subject to permanent liquid submergence or which can be exposed to local mechanical abrasive or impact loads.

[2] The term protected means a side of a panel which is not subject to loads as described above.

*) Transom not thrust bearing

15.4.2.2 The section modulus and moment of inertia of a 1 cm wide panel strip shall be not less than:

$W = 0.04 \cdot f_w \cdot P \cdot s^2$ (cm^3)

$f_w = f_{w1} \cdot f_n$

$I = 0.0364 \cdot f_i \cdot p \cdot s^3$ (cm^4)

$f_i = f_{i1} \cdot f_{i2} \cdot f_{i3}$

The correction factors for panel aspect ratio, f_{w1} and f_{i1}, are defined in the Figure 15-6.

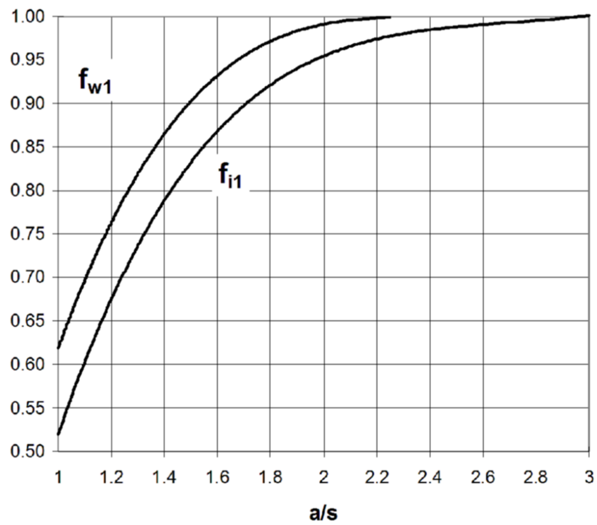


Figure 15-6
Correction factor

a and s: longest and shortest panel side, respectively.

The correction factor for laminate strength, fn, is given in 2.3.

The correction factor for laminate stiffness, fi2, shall be taken as:

fi2 = 7000/En

The stiffness factor, f_{i3}, shall be taken as:

f_{i3} = 1.0 for decks and floor panels

f_{i3} = 0.5 elsewhere.

If the stiffness of the panel is increased due to curvature, a lower moment of inertia may be accepted. W and I properties for panels with skin laminates of equal thicknesses are given in 15.4.2.5.

15.4.2.3 The shear strength of the core material shall be not less than:

$\tau_u = 1{,}5 \cdot f_{T1} \cdot P_s/d$ (MPa)

For core materials in bottom panels of planning vessel documentation of dynamic properties of the material may be required.

The shear strength of bottom panels shall not be less than: 0.04 V (MPa), minimum 0.7 MPa.

The shear strength of other panels shall not be less than: 0.4 MPa.

The thickness of the core shall not be less than: 10 · s (mm).

d = panel thickness in (mm) measured as the distance between the centreline of the laminates, as shown in 15.4.2.5.

The correction factor for panel aspect ratio, f_{T1}, is defined in the Figure 15-7.

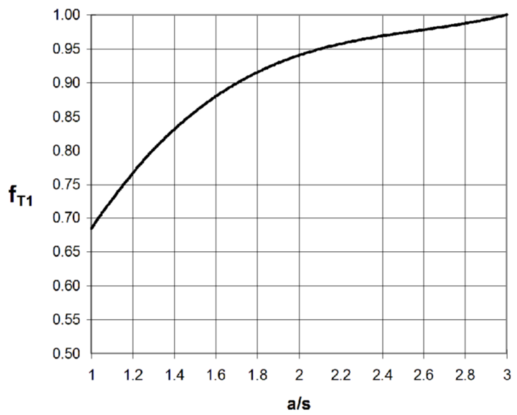
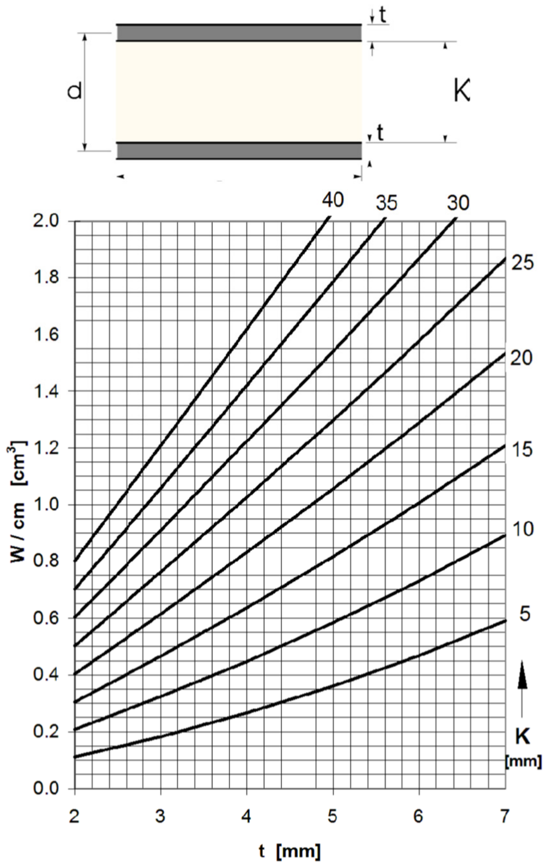


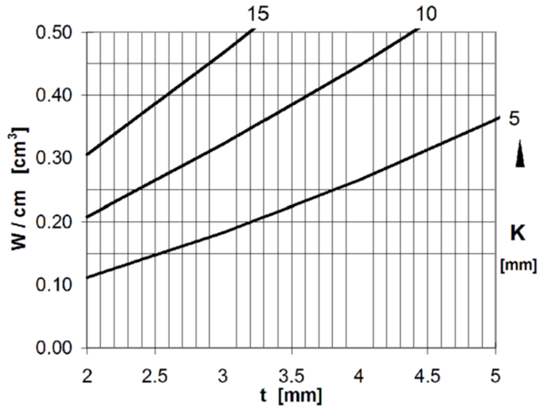
Figure 15-7

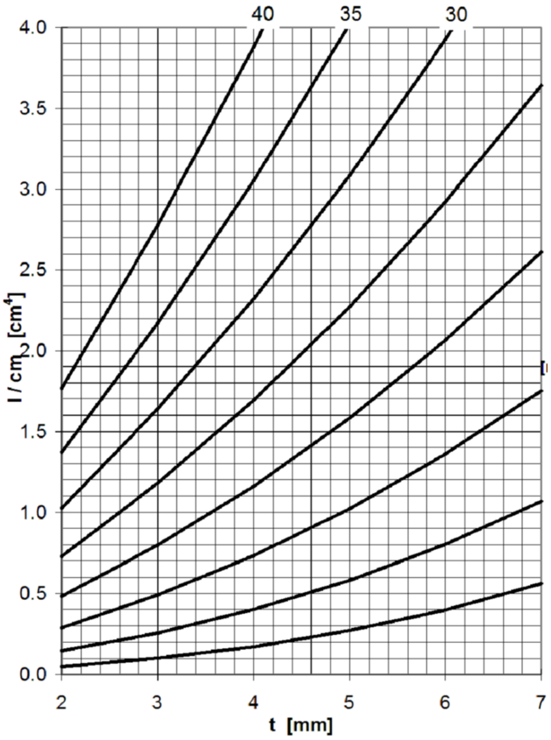
a and s: longest and shortest panel side, respectively.

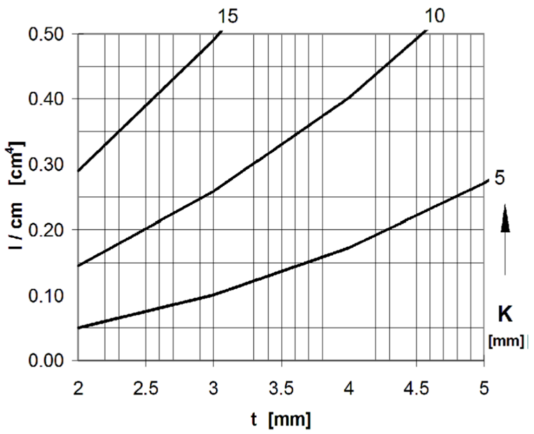
15.4.2.4 Reduced thicknesses may be accepted provided equivalent impact resistance can be documented.

15.4.2.5 Section modulus (W) and moment of inertia (I) of a 1 cm wide sandwich panel with skin laminate of equal thickness, are given in the figures below as a function of core thickness K and skin laminate thickness t.









15.4.3 Local panel reinforcements

15.4.3.1 The sandwich panel skin laminates shall locally be reinforced to a thickness not less than:

$t_{s\,min} = k \cdot T_{1min}/f_c$ (mm)

$t_{l\,min}$ = minimum thickness according to 15.3.2.1

$f_c = 0.94 + 0.12 \cdot \sigma_c$

where σ_c is compressive strength of the core material in MPa.

k is found from the table below:

Table 15-7
Local panel reinforcement

Structural member	k	
	Exposed [1)]	Protected [2)]
Keel type 1 and 2	0.4	0.3
Keel type 3	0.6	0.3
Fore and aft stem	0.4	0.3
Chine and transom corners [*)]	0.4	0.3
Bottom laminate in way of rudder stock, shaft brackets, etc.	0.4	0.3

NOTES:

[1)] The term exposed means a side of a panel which is subject to permanent liquid submergence or which can be exposed to local mechanical abrasive or impact loads.

[2)] The term protected means a side of a panel that is not subject to loads as described above.

[*)] Breadth to each side shall be min. 25 B (mm), but not less than 100 mm.

15.5 FRAMES, GIRDER AND STIFFENERS

15.5.1 General

15.5.1.1 In this section the general requirements for the strength of laterally loaded frames, beams and other stiffeners in single skin and sandwich constructions are given.

15.5.1.2 Stiffening profiles are normally to be attached to the base panel by secondary bonding.

15.5.1.3 Where continuous stiffening profiles of the same height and built with a weak sandwich core material, are crossing each other load bearing core inserts may be required to provide sufficient shear strength.

15.5.2 Stiffening member requirements

15.5.2.1 The section modulus of stiffening members is not to be less than:

$W = 4.0 \cdot m \cdot f_n \cdot P \cdot b \cdot l^2$ (cm³)

$I = 36.4 \cdot d \cdot f_i \cdot P \cdot b \cdot l^3$ (cm⁴)

b = load breadth in metres

l = stiffener span in metres, for curved frames see 15.5.2.2.

m- and d- values for the most common structural members are found from the table in 15.5.2.3.

f_n and fi are given in 15.5.2.4.

15.5.2.2 For curved frames the length l which determines the scantlings is given by:

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

l_0 = length in metres of the straight part of the frame in bottom.

When the bilge radius is constant, l_0 is measured as shown in Figure 15-8. When the radius varies, l_0 is measured as shown in Figure 15-9.

R = bilge radius in metres.

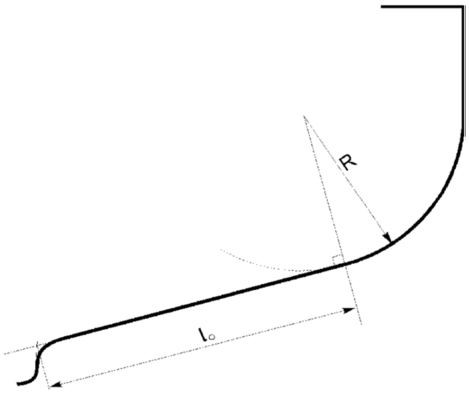


Figure 15-8

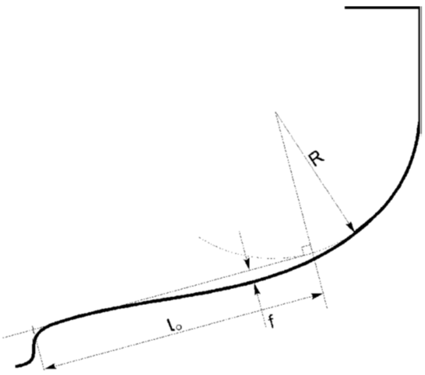


Figure 15-9

For S-shaped frames the length which determines scantlings is measured as shown in Figure 15-10 and Figure 15-11.

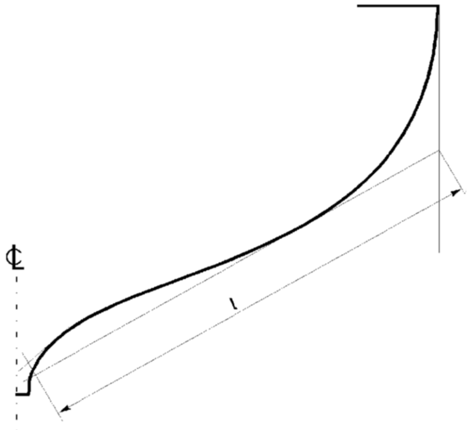


Figure 15-10

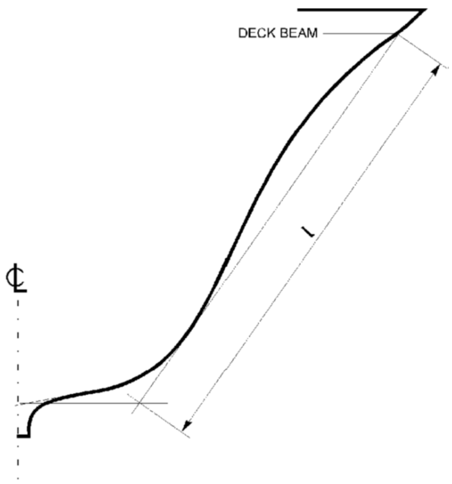


Figure 15-11

15.5.2.3 The m- and d-values for the various structural members are specified in Table 15-8.

Table 15-8
Section modulus parameters

Item	m	d
Continuous longitudinals	0.85	0.4
Non-continuous longitudinals	1.00	1.0
Transverse	1.00	1.0
Vertical members, ends fixed	1.00	1.0
Vertical members, simply supported	1.35	2.0
Bottom longitudinal	0.85	0.4
Bottom transverse	1.00	1.0
Side longitudinal	0.85	0.4
Side vertical	1.00	1.0
Deck longitudinal	0.85	0.4

Item	m	d
Deck transverse	1.00	1.0
W.T. bulkhead, fixed ends	0.65	
W.T. bulkhead, fixed one end	0.85	
W.T. bulkhead, simply supported ends	1.25	
Tank and cargo bulkheads, fixed ends	1.00	1.0
Tanks and cargo bulkheads, simply supported ends	1.35	2.0
Deckhouse stiffener	1.00	1.0
Casings	1.00	1.0

15.5.2.4 The correction factors for laminate properties shall be taken as follows:

$f_n = 80 / \sigma_{nu}$

$f_n = 7000 / E_a$

If the various parts of the stiffener, including the plate flange, have different strength and stiffness "equivalent sectional areas" shall be used when calculating the section modulus of the stiffener.

The "equivalent sectional area" is found by multiplying the actual area with the stiffness ratio Ea/Er. A condition for employing this method is that the strength ratio σa/σr is not less than the stiffness ratio above.

Ea, σa = tensile modulus and strength respectively of the laminate considered

Er, σr = tensile modulus and strength respectively of the reference laminate for which the section modulus requirement is calculated.

15.5.2.5 Section modulus W for profiles with panel as function of flange area A_{fl} sandwich core height H and web thickness t_s is given in the following Figures.

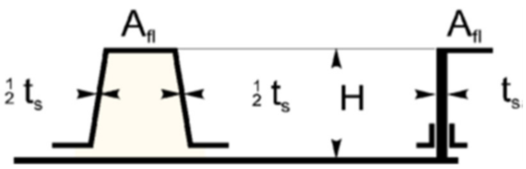


Figure 15-12
Definition of A_{fl}, H and t_s

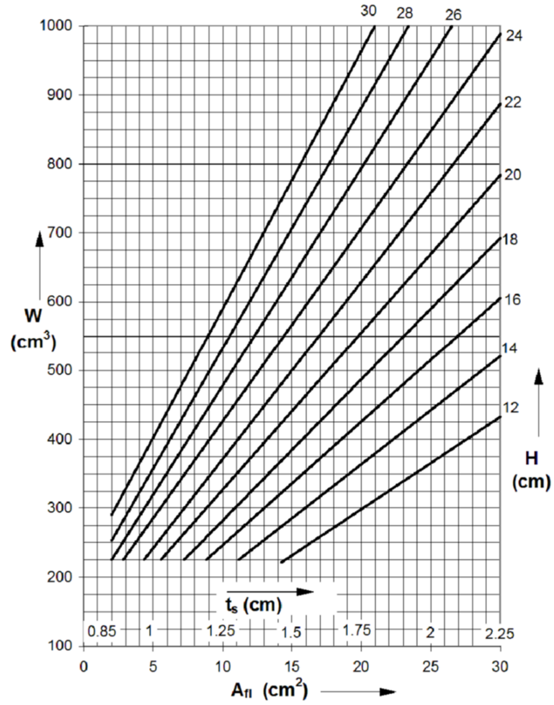


Figure 15-13 Section modulus W of profiles

15.5.2.6 Section modulus W of skin laminate steps as function of step height and laminate thickness t.

Figure 15-14

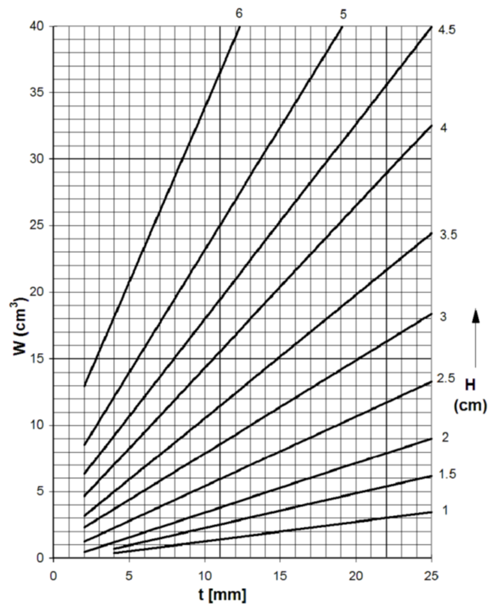


Figure 15-15

16 WOODEN STRUCTURES

16.1 GENERAL

16.1.1 Scope

This section applies to sailing and motor yachts whose hull is constructed of wood similar materials.

In lieu of compliance with requirements of this Section, the *Register* may accept compliance with other recognized standard, subject to special consideration on case by case basis.

Wood quality and type shall be to the satisfaction of the *Register*.

16.1.2 Supervision during construction

16.1.2.1 All structural elements named in this section of the Rules are subject to the supervision of the *Register* during construction. For that purpose, shipyards, workshops, and manufacturers (hereinafter referred to as manufacturers) must provide access to the structures and parts of the structure of the ship being surveyed.

16.1.2.2 Prior to the start of construction, the relevant technical documentation must be submitted to the *Register* for approval (see item 16.1.2.5).

16.1.2.3 The manufacturer must provide appropriate conditions for the performance of the work concerned, where this is necessary due to the specific nature of the work technology.

16.1.2.4 During the preparation or production, the basic material for shipbuilding (wood, laminated wood) and additional material (metal connecting elements, glues, and other artificial materials) are subject to the survey of the *Register*.

16.1.2.5 **S**ubmit technical documentation for the approval (see section 1.5) additionally with the following:

- ship dimensions, displacement coefficient at constructive draft, ship speed, type and wood characteristics and
- longitudinal section and details of the structure (keel, hog, stempost, sternpost, etc.) with key details, fastenings, and clogging data.

16.1.3 Building place

16.1.3.1 It is recommended to build wooden boats in proven workshop, in controlled atmospheric conditions. If the ship is being built outdoors, the duration of construction should be as short as possible.

16.1.3.2 Ships whose hull, deck, and superstructure are of wood that needs to be bent and / or glued must be made in workshop where the temperature is not lower than + 10 °C, and where the ambient temperature can be controlled during shipbuilding.

16.1.3.2 Storage of building material

16.1.3.2.1 The wood must be stored in a dry and well-ventilated area premises, protected from direct sunlight and other sources, harmful effects, and shocks.

16.1.3.2.2 The wood must be stored flat, each row separately, with narrow wooden inserts, to ensure good air circulation around each piece. Laminated wood must be stored horizontally, with washers at the ends and in the middle.

16.1.3.2.2 The adhesive must be stored in accordance with the manufacturer's instructions.

16.2 FASTENINGS WORKING AND PROTECTION OF TIMBER

16.2.1 Fastenings

16.2.1.1 Glues for timber fastenings shall be of resorcinolic or phenolic type, i.e. durable and water-resistant in particular.

Urea formaldehyde glues may only be used in well-ventilated parts of the hull not subject to humidity.

Glues shall be used according to the Manufacturer's instructions on timber with moisture content not exceeding 15 - 18% or, for urea-type glues, 12,5 - 15%.

The parts to be glued shall be carefully prepared and cleaned and, in particular, all traces of grease shall be removed.

Where rivets, screws and bolts are not made of material recognized as suitable for resisting corrosion from the marine environment, they shall be hot galvanized in accordance with a recognized standard. In the absence of such standard, after rivets, screws and bolts have been hot galvanized and subsequently machine finished, the protective zinc coating on their surfaces is to remain intact.

Through bolts shall be clinched on washers, or tightened by a nut, also on washers. Nuts and washers shall be of the same material as that of the bolts.

Where connecting bolts go through shell planking or keel, they are to have heads packed with cotton or other suitable material.

Where screw fastenings are used for planking, the threading is to penetrate the support frame for a distance equal to the planking thickness.

16.2.1.2 The use of suitable glues in place of mechanical connections will be the subject of special consideration by the *Register*.

In general, such replacement of fastening methods will be accepted subject to the satisfactory outcome of tests, on representative samples of the joints, conducted with procedures stipulated based on type of glue, the type of connection and any previous documented applications.

In any event, the *Register* reserves the right to require a minimum number of mechanical connections.

16.2.2 Timber working

16.2.2.1 Timber working shall be appropriate to the species and hardness of the timber, as well as to the type of hull construction, e.g. grown or web frames, lamellar structures, board or plywood planking.

Lamellar structure is generally employed for bent structural parts, with lamellas as continuous as possible or with scarf joints and normally glued before bending.

The lamellas are generally to be made using the same species of timber.

The lamellas shall be arranged with their fibers parallel to the length of the element to be constructed.

16.2.3 Protection

16.2.3.1 Inaccessible surfaces of internal hull structures shall be treated with a suitable wood preservative according to the Manufacturer's instructions and compatible with the glues, varnishes and paints employed. The timber of the internal bottom of the hull shall be smeared with oil or varnish; any synthetic resins used as coating shall be applied to dry timber with the utmost care.

All cut edges of plywood shall be sealed with glue, paint, or other suitable products such as to prevent the penetration of moisture along the end-grain.

16.3 BUILDING METHODS FOR PLANKING

16.3.1 Shell planking

16.3.1.1 Simple skin

16.3.1.1.1 Planks shall be arranged such that strake butts are at least 1,20 meters apart from those of adjacent strakes and at least three continuous strakes separate two butts arranged on the same frame.

The butts of garboards shall be arranged clear of those in the keel, and the butts of the sheerstrake shall be arranged clear of those of the waterway.

Butts may be strapped or scarfed, and wooden straps are to have thickness equal to that of the planking, width so as to overlap adjacent strakes by at least 12 mm and length as necessary for the connection while leaving a space for water drainage between the strap edge and the frame.

Scarfs are to have length not less than 5 times the planking thickness, to be centered on the frames and to be connected by means of gluing and pivoting.

16.3.1.2 Double diagonal skin

16.3.1.2.1 This consists of an inner skin of thickness not exceeding 0,4 of the total thickness and an outer skin arranged longitudinally.

16.3.1.3 Double longitudinal skin

16.3.1.3.1 This consists of an inner and outer skin, arranged such that the seams of the outer skin fall on the middle of the planks of the inner skin.

The inner skin is to have thickness not exceeding 0,4 of the total thickness and to be connected to the frames by means of screws or nails and to the outer skin by means of screws or through bolts. The outer skin is, in turn, to be connected to the frames by means of through bolts. When frames other than laminated frames are employed, the use of screws is permitted. A suitable elastic compound layer shall be arranged between the two skins.

16.3.1.4 Laminated planking in several cold glued layers

16.3.1.4.1 The construction of cold moulded laminated planking shall be effected in location at a constant temperature.

It is therefore of the utmost importance that the Manufacturer should be equipped with adequate facilities for this type of construction.

The planks forming the laminate shall be of width and thickness adequate for the shape of the hull; the width is generally not to exceed 125 mm.

The number of layers shall be such as to obtain the required thickness.

16.3.1.5 Plywood planking

16.3.1.5.1 Plywood planking consists of panels as large as practicable in relation to the shape of the hull. The butts shall be suitably staggered from each other and from machinery foundations.

The connection of seams shall be achieved by means of glue and bolts; the connection of butts shall be effected by means of scarfs or straps. Scarfs are to have length not less than 8 times the thickness and, where effected in situ, to be backed by straps, at least 10 times as wide as the thickness, glued and fastened.

The strap connection shall be effected using straps of the same plywood.

16.3.1.6 Double skin with inner plywood and outer longitudinal strakes

16.3.1.6.1 This consists of two layers: one internal of plywood, arranged as described in 16.3.1.5, the other external, formed by planks in longitudinal strakes arranged as described in 16.3.1.3. The plywood thickness shall be not less than 0,4 of the total thickness.

16.3.1.7 Fastenings and caulking

16.3.1.7.1 Butt-straps on shell planking (see Figure 1) shall be connected by means of through bolts of the scantlings given in Tab 1 for the connection of planking to frames, and shall be proportionate in number to the width a of panels, as follows:

- $a < 100$ mm
  3 bolts at each end of plank
- $100 \leq a < 100$ mm
  4 bolts at each end of plank
- $200 \leq a < 250$ mm
  3 bolts at each end of plank.

The number and scantlings of bolts to be used for connection of planking to frames are given in Table 1.

The following types of connection shall be adopted:

- Type I framing: all through fastenings;
- Type II framing with grown or laminated frames: through bolts in way of bilge stringers or side longitudinals, wood screws for other connections;
- Type II framing with metal frames: all connections formed by through bolts with nuts;
- Type III framing: connections as above depending on whether bent, grown, laminated or steel frames are concerned.

All fastenings for strengthened frames in way of masts shall be through fastenings.

When plywood planking is adopted, it shall be connected to frames by means of nails or screws spaced 75 mm apart and with diameters as given in Table 2.

Planks of shell planking, if not glued, are to have caulked seams and butts

16.3.1.8 Sheathing of planking

16.3.1.8.1 When use is made of reinforced plastic or synthetic resin sheathing, the hull shall be prepared by carefully levelling every joint and filling every bolt hole with suitable compounds after adequate sinking of the bolts. The protective sheathing is to cover keel, false keel and deadwood as far as practicable, prior to the fitting of external ballast in the keel, where envisaged.

When sheathing is applied, the moisture content of the timber shall be as low as possible.

16.3.2 Deck planking

16.3.2.1 Planking

16.3.2.1.1 The butts of planks of two contiguous strakes shall be spaced at least 1,20 metres apart; two plank butts on the same beam shall be separated by at least three strakes of continuous planking.

Butts shall be set onto a beam and may be simple or scarfed.

16.3.2.2 Plywood

16.3.2.2.1 Plywood panels shall be as long as possible. The butts shall be arranged clear of those of adjacent panels and shall be strapped or otherwise set onto a strong beam. Longitudinal joints shall be set onto longitudinal structures of sufficient width for the connection. All joints shall be sealed watertight.

16.3.2.3 Plywood sheathed with laid deck

16.3.2.3.1 The butts of plywood panels shall be in accordance with the specifications given in 16.3.2.2.1, while the distribution of plank butts is to comply with the provisions of 16.3.2.1.1.

16.3.2.4 Longitudinal planking

16.3.2.4.1 When longitudinal planking is adopted, each plank shall be fastened to beams by means of a wood screw or lateral nail. In addition, each plank may be connected to that adjacent by means of a glued, sunk-in strip.

Plywood planking shall be glued and riveted to beams, or otherwise fastened by means of screws with pitch not less than 75 mm and diameter in accordance with that shown in Table 1.

16.3.2.5 Caulking

16.3.2.5.1 Wood planking shall be caulked or made watertight by the application of a suitable elastic compound.

Wooden dowels used to cover bolt holes shall be glued.

Table 1: Connections of shell and deck planking - scantlings of fastenings

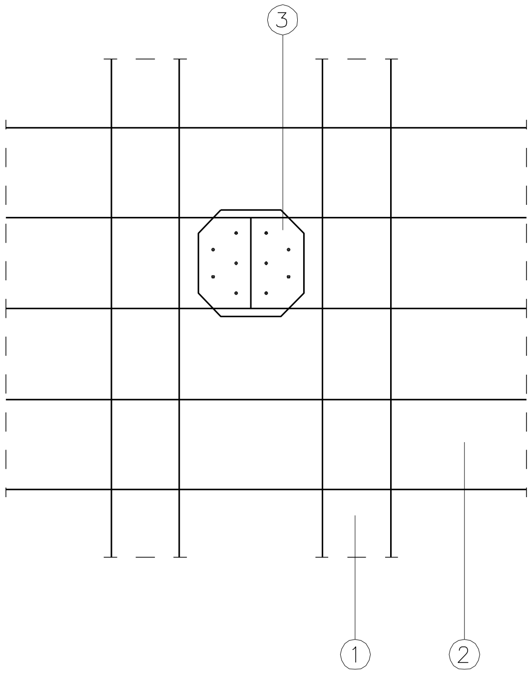
Thickness of planking (mm)	SHELL PLANKING				DECK PLANKING		NUMBER OF FASTENINGS PER PLANK				
	Grown frame: laminated, or steel frames			Bent frames	Wood screws diameter (mm)	Bolts with nuts diameter (mm)	Width a of plank "a" (mm)				
	Diameter			Diameter							
	bolts with nuts (mm)	wood screws (mm)	copper nails (mm)	copper nails (mm)			a < 100	100 ≤ a < 150	150 ≤ a < 180	180 ≤ a < 205	205 ≤ a < 225
18	4,5	5	4,5	2,5	4,5	4,5	2	2	3	3	3
20	4,5	5	5	3	5	4,5	2	2	3	3	3
22	6	5	6,5	3,5	5	6	2	2	3	3	3
24	6	5	6,5	3,5	5,5	6	2	2	3	3	3
26	7	5,5	6,5	3,5	5,5	6	1	2	2	3	3
28	7	5,5	6,5	4,5	5,5	6	1	2	2	3	3
30	7	5,5	6,5	4,5	5,5	6	1	2	2	3	3
32	8	6,5	7,5	5	6,5	8	1	2	2	3	3
34	8	6,5	7,5	5,5	6,5	8	1	2	2	3	3
36	8	7	7,5	5,5	6,5	8	1	2	2	2	3
38	8	7	7,5	5,5	7	8	1	2	2	2	3
40	9	8	9,5	6	7	8	1	2	2	2	3
42	9	8	9,5	6	7	9	1	2	2	2	3
44	10	8	9,5	-	8	9	1	2	2	2	3
46	12	8,5	11	-	8	10	1	2	2	2	3
48	12	8,5	11	-	8	10	1	2	2	2	3
50	14	10	12,5	-	8,5	12	1	2	2	2	3
52	14	10	12,5	-	8,5	12	1	2	2	2	3

Table 2: Connections of shell and deck planking in plywood

Thickness of plywood (mm)	OVERLAP OF SEAMS		Width of butt-straps (mm)		DIAMETER OF FASTENINGS	
	shell and deck planking, on keel, stringers, shelves, or carlings (mm)				wood screws (mm)	copper nails (mm)
6	25	single fastening	150	single fastening	4,5	3,5
8	28		175		5	3,5
10	32		200		5	4,5
12	35		225		5,5	4,5
14	35		250		5,5	5
16	45		280		5,5	5
18	45	double fastenings	350	double fastenings	6,5	5
20	50		350		6,5	5,5
22	50		350		6,5	6
24	60		380		7	6,5
26	60		380		7	6,5

Figure 1: Butt-straps on shell planking

a) Metal butt addition plate (overlap min.12mm)

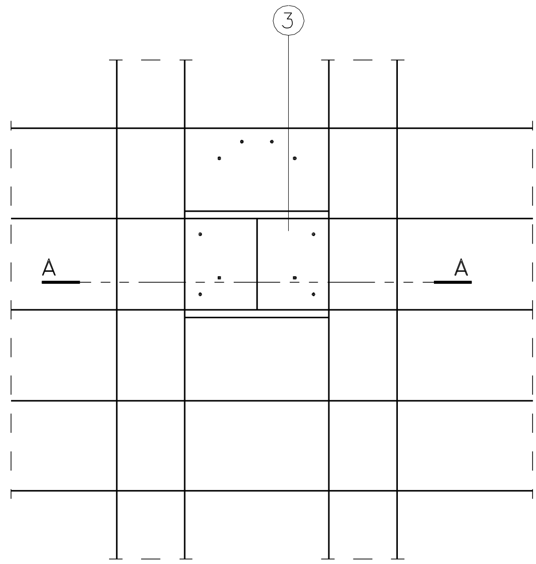


1 - Frame

2 - Shell planking

3 - Butt - strap

b) Wooden butt addition plate



A-A

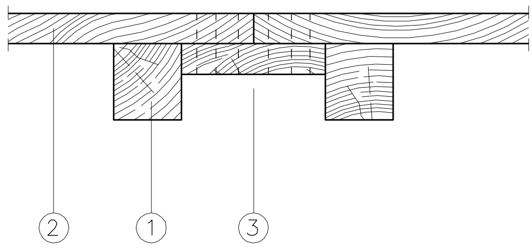
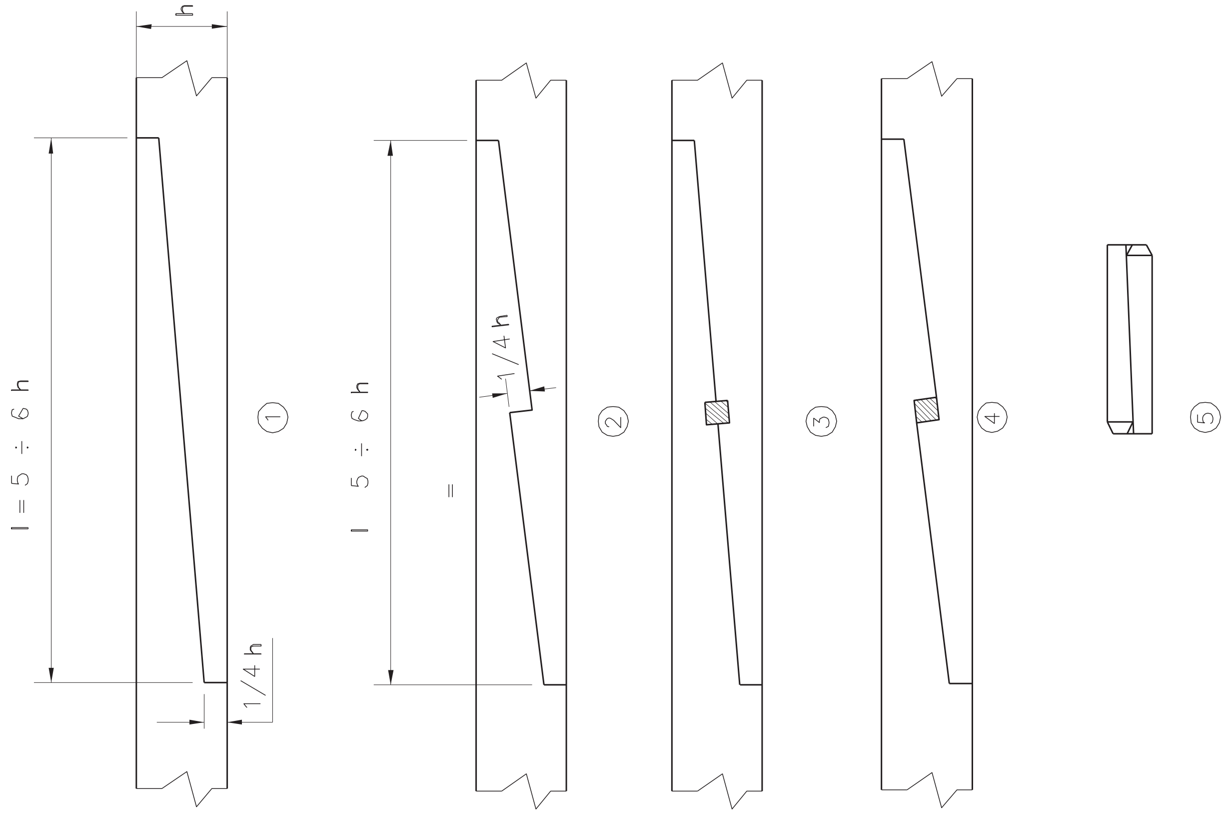


Figure 2: Usual types of scarf-joints



1 - Plan scarf

2 - Hooked scarf

3 - Tabled scarf

4 - Tabled hooked scarf

5 - Double wedges

16.4 STRUCTURAL SCANTLINGS OF SAILING YACHTS WITH OR WITHOUT AUXILIARY ENGINES

16.4.1 General

16.4.1.1 The scantlings in this Section apply to hulls of length **L** not exceeding 30 metres with round bottom of shape similar to that shown in Fig. 1 and Fig. 2 and fitted with fixed ballast or drop keel. Subject to the *Register* authorisation the value of the structural scantlings for yachts more than 30 metres but not more than 40 metres in length may be calculated by linear interpolation of the results for yachts not more than 30 metres, given in this Section.

Yachts of length **L** exceeding 30 metres or hull shapes other than the above will be considered in each case on the basis of equivalence criteria.

16.4.2 Keel

16.4.2.1 The scantlings of wooden keels are given in Table 1.

The keel thickness shall be maintained throughout the length, while the width may be gradually tapered at the ends so as to be faired to the stem and the sternpost.

The breadth of the rabbet on the keel for the first plating strake shall be at least twice the thickness and not less than 25 mm.

The wooden keel shall be made of a minimum number of pieces; scarf joints may be permitted with scarf 6 times as long as the thickness and tip 1/4 to 1/7 of the thickness of the hooked or tabled type, if bolted, or of the plain type, if glued. It is recommended that scarfs should not be arranged near mast steps or ends of engine foundation girders.

Where the keel is cut for the passage of a drop keel, the width shall be increased.

Where the mast is stepped on the keel, it shall be arranged aft of the forward end of the ballast keel. Where this is not practicable, effective longitudinal stiffeners shall be arranged extending well forward and aft of the mast step and effectively connected to the keel.

Bolted scarfs shall be made watertight by means of soft- wood stopwaters.

16.4.3 Stempost and sternpost

16.4.3.1 The stempost shall be adequately scarfed to the keel and increased in width at the heel as necessary so as to fit the keel fairing.

Stempost scantlings are given in Table 1.

The sternframe is shown in Fig. 3 and sternpost scantlings are given in Tab 1.

The lower portion of the sternpost shall be tenoned or other- wise attached to the keel. The connection is completed by a stern deadwood and a large bracket fastening together false keel, keel, and post by means of through bolts.

The counter stern shall be effectively connected to the stern- post; where practicable, such connection shall be effected by scarfs with through bolts.

The cross-sectional area of the counter stern at the connection with the sternpost shall be not less than that of the latter; such area may be reduced at the upper end by 25%.

16.4.4 Frames

16.4.4.1 Types of frames

16.4.4.1.1 Bent frames

Bent frames consist of steam warped listels. Their width and thickness shall be uniform over the whole length; the frames shall be in one piece from keel to gunwale and, where practicable, from gunwale to gunwale, running continuous above the keel.

Table 1: Keel, Stempost, Sternpost

Length L (m)	Keel		Stempost				Sternpost	
			at heel		at head			
	Width (mm)	Depth (mm)	Width (mm)	Depth (mm)	Width (mm)	Depth (mm)	Depth (mm)	Depth (mm)
24	435	240	240	240	190	190	190	190
26	455	255	255	255	200	200	200	200
28	470	270	270	270	215	215	215	215
30	480	290	290	290	230	230	230	230

16.4.4.1.2 Grown frames

Grown frames consist of naturally curved timbers connected by means of scarfs or butted and strapped. Their width shall be uniform, while their depth shall be gradually tapered from heel to head.

The length of scarfs shall be not less than 6 times the width, and they shall be glued.

16.4.4.1.3 Laminated frames

Laminated frames consist of glued wooden layers. The glueing may take place before forming where the latter is slight; otherwise it should be carried out in situ or be prefabricated by means of suitable strong moulds.

16.4.4.1.4 Metal frames

Steel frames consist of angles properly curved and bevelled such that the flange to planking is closely fayed to the same planking.

16.4.4.2 Framing systems and scantlings

16.4.4.2.1 The admissible framing systems and the frame scantlings are indicated in Tables 2 and 3:

- Type I: all equal frames, of the bent type;
- Type II: all equal frames, of grown, laminated or steel angle type;
- Type III: frames of scantlings as required for Type II, but alternated with one, two or three bent frames.

These types are hereafter referred to, respectively, as Type III1, Type III2, Type III3.

When a frame spacing other than that specified in the Table is adopted, the section modulus of the frame shall be modified proportionally. For wooden rectangular sections, a being the width and b the height of the Rule section for the spacing s, a1 and b2 the actual values for the assumed spacing s_1, it follows that:

$$a_1 \times b_1^2 = a \times b^2 \times (s_1/s)$$

When internal ballast supported by the frames is arranged, the latter shall be increased in scantlings.

Frames adjacent to masts shall be strengthened on each side as follows, or equivalent arrangements shall be provided.

Type I framing

Three grown frames shall be fitted, with scantlings as required for Type II framing, but with constant depth equal to that indicated in Tab 3 for the heel. Such frames shall be arranged instead of alternate bent frames. Otherwise, six consecutive bent frames with a cross-section increased by 60% in respect of that shown in the above-mentioned table may be fitted.

Type II framing

Three grown frames shall be fitted, with a cross-section increased by 50% in respect of that required for the heel in the above-mentioned table and constant depth. Such frames shall be alternated with ordinary grown frames. If alternate frames are adopted, they shall be stiffened by reverse frames of scantlings as prescribed for the reverse frames of plate floors.

Type III framing

Three grown frames with a cross-section increased by 50% in respect of that required for the heel in the above-mentioned table, and constant depth, shall be arranged at Rule spacing, with one or two intermediate bent frames. If steel frames are adopted, three shall be stiffened by reverse frames with scantlings as required for the frames of plate floors and arranged with one or two intermediate bent frames.

Where, in way of the mast, a sufficiently strong bulkhead is provided, such increased frames may be reduced in number to two.

The width of frames shall be not less than that necessary for the fastening; their depth is in any case to be assumed as not less than 2/3 of the width, except where increased width is required for local strengthening in way of masts.

The table scantlings, duly modified where necessary for the specific gravity of the timber and for the frame spacing, shall be maintained for 0,6 of the hull length amidships; outside such zone, the following reductions may be applied:

- for bent or laminated frames: 10% in width,
- for grown frames: 20% in width throughout the length of the frame, and 20% in depth of the head,
- metal frames: 10% in thickness.

Frames may have a reduction in strength of 25% where cold laminated planking is adopted in situ, in accordance with the provisions of 16.4.8.

Frames shall be properly shaped so as to fit the planking perfectly.

Where no floors are arranged, the frames shall be wedged into and fastened at the heels of the centreline structural member of the hull.

16.4.5. Floors

16.4.5.1 General

16.4.5.1. Floors may be made of wood or metal (steel or aluminium alloy).

- Wooden floors, as a rule, may only be employed in association with grown frames and shall be flanked by them.
- Metal floors are employed in association with either bent, grown or laminated frames, and are arranged on the internal profile of the frames.
- Angle floors may be employed with either bent, grown or laminated frames, and may be arranged as shown in Tab 1. When they are arranged with a flange inside, an angle lug shall be fitted in way of the throat, for the connection to the wooden keel (see the above table).
- Plate floors may be employed in association with either grown or angle frames (see the above-mentioned table). The internal edge shall be provided with a reverse angle or a flange; in the latter case, the thickness shall be increased by 10%.

16.4.5.2 Arrangement of floors

16.4.5.2.1 Where Type I framing with bent frames is adopted (see Tables 2 and 3), floors shall be fitted inside 0,6 L amid- ships as follows.

- on every second frame if the hull depth does not exceed 2,75 metres and on every frame in hulls of greater depth;
- on every second frame inside 0,6 L amid- ships, and out- side such area over an extent corresponding to the length on the water- line;
- on every third frame elsewhere.

Where Type III framing is adopted, a floor shall be fitted in way of every grown, laminated or angle frame. Where one or two intermediate bent frames are arranged, and the depth D exceeds 2,40 metres, floors shall be fitted on bent frames located inside 0,6 L amidships.

Where three intermediate bent frames are ar- ranged, a floor shall be fitted on the central frame.

16.4.5.3 Scantlings and fastenings

16.4.5.3.1 The scantlings of floors are given in Tables 4 and 5. At the hull ends, the length of arms need not exceed one third of the frame span.

Wooden floors shall be made of suitably grained or laminated timber, and their height at the ends shall be not less than half the height of the throat.

Where the ballast keel bolts cross wooden floors, the width of the latter at the throat shall be locally increased, if necessary, so as to be not less than three and a half times the diameter of the bolt.

Table 2: Frames

Depth D1 (mm) (1)	TYPE I Bent frames only			TYPE II Grown frames, or laminated frames, or steel frames only							
				Spacing (mm)	Grown frames			Laminated frames		Steel frames	
	Spacing (mm)	Width (mm)	Depth (mm)		width (mm)	depth (mm) at heel	depth (mm) at head	width (mm)	depth (mm)	section modulus (cm^3)	scantlings (mm) (2)
3,00	215	57	40	305	61	74	53	81	52	3,1	50 x 50 x 5
3,20	225	62	43	322	68	83	58	93	59	4,4	60 x 30 x 6
3,40	235	67	46	340	75	91	68	103	66	6	65 x 50 x 7
3,60	245	72	49	355	81	100	80	117	74	7,9	75 x 50 x 6
3,80	255	77	52	375	87	112	92	122	84	10,2	80 x 60 x 7
4,00	265	82	55	390	94	124	100	131	94	12,5	90 x 60 x 7
4,20	-	-	-	408	100	140	117	143	102	14,5	90 x 60 x 8

(1) For hulls fitted with external ballast in the keel, 0,75 D1, may be assumed in place of 0,75 D1, where the ballast/light displacement ratio is less than approximately 0,25. For yachts with a drop keel, the value 1,15 D is taken in lieu of D1.
(2) The scantlings of bars are given for guidance purposes. Solution I s only applicable where D1 does not exceed 3,60 metres. The frame spacing is intended as that measured amidships of the frame widths.

Table 3: Frames

Depth D1 (mm) (1)	TYPE III Main frames (grown or laminated) alternated with bent frames				
	Spacing between main frames and intermediate frames			Bent frames	
	1 bent frame (mm)	2 bent frames (mm)	3 bent frames (mm)	Length (mm)	Depth (mm)
3,00	515	620	695	43	33
3,20	560	650	730	45	35
3,40	590	690	770	48	39
3,60	620	725	800	50	43
3,80	650	765	840	53	47
4,00	680	800	870	56	51
4,20	-	-	-	-	-

(1) For hulls fitted with external ballast in the keel, 0,75 D1, may be assumed in place of 0,75 D1, where the ballast/light displacement ratio is less than approximately 0,25. For yachts with a drop keel, the value 1,15 D is taken in lieu of D1.
Solution I is only applicable where D1, does not exceed 3,60 metres.
The frame spacing is intended as that measured amidships of the frame widths.

Table 4: Frames

Depth D1 (mm) (1)	FLOORS ON BENT FRAMES					Plate floors on grown or steel floors	
	Length of arms (mm)	forged		steel angle floors (2)			
		at throat (mm)	at the ends (mm)	section modulus (cm^3)	scantlings (mm)	for 2/3 L amidships (mm)	outside 2/3 L amidships (mm)
3,00	430	29 x 15	24x6	1,4	40 x 40 x 4	300 x 5	200 x 4
3,20	465	31 x 16	25x6	1,4	40 x 40 x 4	320 x 5	220 x 4
3,40	495	33 x 17	27x6	1,5	40 x 40 x 4	330 x 5	230 x 4
3,60	530	35 x 17	28x6	1,5	40 x 40 x 4	340 x 6	240 x 4
3,80	-	-	-	-	-	345 x 6	245 x 4
4,00	-	-	-	-	-	350 x 6	250 x 4
4,20	-	-	-	-	-	360 x 6	260 x 4

(1) For hulls fitted with external ballast in the keel, 0,75 D1 may be assumed in place of D1, where the ballast/light displacement ratio is less than approximately 0,25. For yachts with a drop keel, the value 1,15 D is taken in lieu of D1.

(2) The scantlings of angle floors are given for guidance purposes.

Table 5: Frames

Depth D1 (mm) (1)	FLOORS ON GROWN OR LAMINATED FRAMES							
	Length of arms		Forged floors		Wooden floors		Steel angle floors (2)	
	for 3/5 L amidships (mm)	outside 3/5 L amidships (mm)	at throat (mm)	at the ends (mm)	width (mm)	depth (mm)	section modulus (cm^3)	scantlings (mm)
3,00	580	430	56 x 22	50 x 12	51	135	2,40	45 x 45 x 5
3,20	610	460	60 x 24	52 x 13	56	148	3,60	50 x 50 x 6
3,40	650	500	64 x 26	54 x 14	60	160	5,70	55 x 55 x 8
3,60	680	530	69 x 28	56 x 16	64	170	6,90	60 x 60 x 8
3,80	720	560	73 x 30	58 x 17	70	180	6,90	60 x 60 x 8
4,00	750	590	77 x 31	61 x 18	75	190	9,00	65 x 65 x 9
4,20	780	620	80 x 31	63 x 20	80	200	10,0	70 x 70 x 9

(1) For hulls fitted with external ballast in the keel, 0,75 D1, may be assumed in place of 0,25 circa. where the ballast/light displacement ratio is less than approximately 0,25. For yachts with a drop keel, the value 1,15 D is taken in lieu of D1.

(2) The scantlings of angle floors are given for guidance purposes.

Lugs for the connection of angle or plate floors to the wooden keel, if penetrated by the ballast keel bolts, are to have a flange width at least three times the diameter of the bolt and thickness equal to that of the plate floor plus 2,5 mm.

At the end of the hull, when frames are continuous through the centre structure, floors need not be fitted; whenever practicable, however, the frames shall be attached to the centre structure by means of three through bolts.

Floors shall be connected to frames by at least three bolts for arms with length l < 250 mm and at least 6 bolts for greater l; for diameters of bolts, see Table 10.

16.4.6 Beam shelves, beam clamps in way of masts, bilge stringers

16.4.6.1 Beam shelves

16.4.6.1.1 The cross-sectional area of beam shelves through 0,6 L amidships shall be not less than that indicated in Table 6. Outside such zone, the cross-section may be gradually decreased to reach, at the end, a value equal to 75% of that shown.

The cross-section to be considered shall be inclusive of the dappings for fixing of beams.

Where beam shelves are made of two or more pieces, the connection shall be effected by means of glued scarfs adequately arranged so as to be staggered in respect of the sheerstrake, waterway and bracket joints.

Scarfs are generally arranged vertically.

When the weather deck is not continuous owing to the presence of raised decks, the shelf is to extend to the hull end or, alternatively, stiffeners shall be fitted to prevent excessive discontinuity due to the interruption of the deck. The scantlings of frames may be required to be increased.

Where angle frames are employed, reverse lugs shall be fit- ted in order to allow connection to the beam shelf. When Type III framing is adopted, the shelf is to rest on the bent frames with interposition of suitable chocks.

The shelves shall be connected to each frame by a through bolt for heights ≤ 180 mm and by two through bolts for greater heights. If metal frames are adopted, bolting of the shelf shall be effected on a reverse lug. For bolt scantlings, see Table 10.

16.4.6.2 Beam clamps in way of masts

16.4.6.2.1 In way of masts, a beam clamp shall be arranged, of length approximately equal to the hull breadth in the same position.

Such clamp, with cross-section equal to approximately 75% of that required for shelves, may be arranged so that its wider side is faying to the beams and leaning against the shelf or, alternatively, it may be arranged below the shelf.

16.4.6.3 Bilge stringers

16.4.6.3.1 In hulls with Type I or Type III framing, a bilge stringer shall be arranged, having cross-section for 0,6 L amidships not less than that given in Table 6. Outside such zone, the cross-section may be decreased to reach, at the ends, a value equal to 75% of that required.

The greater dimension of the stringer shall be arranged against the frames.

When the stringer is built of two or more pieces, these shall be connected by means of glued scarfs parallel to the planking. Such scarfs shall be properly staggered in the port and starboard stringers and arranged clear of the joints of other longitudinal elements.

Where angle frames are adopted, these shall be connected to the stringer by means of a reverse lug.

When Type III framing is adopted, chocks shall be fitted for the connection between stringer and intermediate bent frames.

In lieu of a bilge stringer, two side stringers having cross- section equal to 60% of that required for the bilge stringer may be fitted.

16.4.6.4 End breasthooks

16.4.6.4.1 The beam shelves and the stringers shall be connected to each other at the hull ends, and with the centreline structure, by means of suitable breasthooks or brackets.

In hulls with exceptionally raked ends, such breasthooks shall be given adequate attention.

16.4.7 Beams

16.4.7.1 Scantlings of beams

16.4.7.1.1 The scantlings of beams are given in Table 7. Where the spacing adopted is other than that shown in the table, the scantlings, following correction as necessary for the weight of the timber employed, shall be modified in accordance with the following relationship:

$$a_1 \times b_1^2 = a \times b^2$$

where a and b are the width and height of the Rule cross-section, a1 and b2 are the width and height of the modified section, s is the Rule spacing, and s1 the assumed spacing

Laminated beams may be reduced in width by 15%.

Strong beams shall be fitted in way of openings which cause more than two beams to be cut and in way of masts, when deemed necessary by the *Register*.

Table 6: Beam shelves and bilge stringers

Length L (m)	Cross-sectional area of beam shelves (cm^2)	Cross-sectional area of bilge stringers (cm^2)
24	190	140
26	220	160
28	250	175
30	280	190

Table 7: Beams

Length of beam (m)	Spacing (mm)	ORDINARY BEAMS FOR 3/5 L AMIDSHIPS			ORDINARY BEAMS OUTSIDE 3/5 L AMIDSHIPS, HALF BEAMS			STRONG BEAMS		
		Width (mm)	Depth		Width (mm)	Depth		Width (mm)	Depth	
			at mid-beam (mm)	at beam ends (mm)		at mid-beam (mm)	at beam ends (mm)		at mid-beam (mm)	at beam ends (mm)
3,00	350	45	72	50	39	54	43	61	81	61
3,50	390	51	80	57	47	61	48	72	91	72
4,00	430	57	90	63	48	67	53	78	101	78
4,50	480	62	99	69	52	74	57	85	111	85
5,00	520	68	106	75	57	80	62	93	120	93
5,50	560	72	114	80	59	87	65	98	128	98
6,00	600	78	121	86	62	95	69	107	136	107
6,50	640	83	129	92	64	103	71	116	144	116
7,00	680	86	132	96	67	113	74	128	156	128
7,50	720	95	146	105	69	125	76	140	168	140

Table 8: Vertical knees of beams

Length of beams (m)	Number (1) of knees on each side	LENGTH OF ARMS		FORGED KNEES		STEEL ANGLE KNEES		PLATE KNEES thickness (mm)
		for 3/5 L amidships (mm)	outside 3/5 L amidships (mm)	at throat (mm)	at the ends (mm)	scantlings (2) (mm)	section modulus (cm^3)	
3,00	5	400	320	34 x 17	30 x 7	40 x 40 x 5	1,70	4
3,50	6	440	350	41 x 20	37 x 7	50 x 50 x 5	3,00	4
4,00	7	490	390	48 x 23	42 x 8	55 x 55 x 5	4,30	4
4,50	8	530	420	53 x 26	46 x 9	60 x 60 x 6	5,90	5
5,00	9	570	450	57 x 28	49 x 10	75 x 50 x 6	7,50	5
5,50	10	610	490	62 x 30	52 x 11	75 x 50 x 7	9,30	5
6,00	10	650	520	67 x 32	54 x 12	90 x 60 x 7	11,50	6
6,50	11	700	560	72 x 34	55 x 14	90 x 60 x 8	14,00	6
7,00	12	740	590	78 x 35	57 x 16	100 x 65 x 7	16,00	6
7,50	12	780	620	81 x 37	58 x 17	100 x 65 x 8	19,00	7

(1) The number of knees is given on the basis of the maximum breadth B of the hull, using the column for the length of beam.
(2) The scantlings of angles are only given as indications.

16.4.7.2 End attachments of beams

16.4.7.2.1 Beams shall be dovetailed on the shelf. When ply- wood deck planking is employed, in place of the dovetail a simple dapping may be adopted, having depth not less than 1/4 of the beam depth; in this case, the beam shall be fastened to the shelf by means of a screw or pin.

Vertical knees shall be fitted, to the extent required in Table 8, to strong beams and to suitably distributed ordinary beams. Each arm of the knees shall be connected to the shelf and the frame by means of 4 bolts, which need not go through the planking, with a diameter as shown in Table 10.

Bulkheads of adequate scantlings, connected to the beam and frame, can be considered as substitutes for knees.

At the ends of the hull, the length of knee arms may be not more than one third of the span of the beam or frame.

In the above-mentioned table, the scantlings of forged plate knees are given; the depth at the throat shall be not less than 1,6 h for naturally curved wooden knees and not less than 1,4 h for laminated wooden knees, h being the depth at heel of a grown frame.

Horizontal knees shall be fitted in way of hatch-end beams and beams adjacent to mast wedgings. These knees need not be arranged when plywood deck planking is adopted.

16.4.7.3 Local strengthening

16.4.7.3.1 The beams and decks shall be locally strengthened at the attachments of halyards, bollards and cleats, at skylight ends, and in way of foundations of winches.

In way of mast weldings, four strong beams shall be fitted, with scantlings as prescribed in Table 7, but constant section equal to that indicated for amidships. The beams shall be arranged, as far as practicable, in proximity of the web frames dealt with in 16.4.4.2.

All openings on deck shall be properly framed so as to constitute an effective support for half beams.

16.4.7.4 Lower deck and associated beams

16.4.7.4.1 In hulls with depth measured from the upper side of the wooden keel to the weather deck beam at side $\geq$ 3, metres, a lower deck or cabin deck shall be arranged and fit- ted with beams having scantlings not less than 60% of those of the weather deck.

When the depth, measured as specified above, exceeds 4,3 metres, vertical knees shall be arranged no smaller in scantlings than prescribed in Table 8 as a function of the beam span, and in number equal to half of those required for the weather deck.

16.4.8 Planking

16.4.8.1 Shell planking

16.4.8.1.1 The basic thickness of shell planking is given in Table 9. Such thickness shall be modified as follows.

If the frame spacing is other than that indicated in Table 2, the thickness shall be increased where there is greater spacing, or may be reduced where there is smaller spacing, by:

- 6 mm for every 100 mm of difference if Type I framing is adopted;
- 4 mm for every 100 mm of difference if Type II or III framing is adopted.

After correction for spacing as indicated above, and for the weight of the timber, where necessary, the planking thick- ness may be reduced: by 10% if arranged in diagonal or longitudinal double skin; by 10% if laminated and cold moulded in situ, when the frames are reduced in scantlings by 25% in respect of the value given in Table 2; the thickness may be decreased by 25% where the frames have not been reduced in respect of the requirements of the table.

When plywood is employed, the thickness may be reduced in relation to the type of framing adopted; the maximum reduction permitted is 25%.

Sheathing of the hull is not required; where envisaged, e.g. in copper or reinforced plastics, it will be considered by the *Register* on a case-by-case basis.

16.4.8.2 Deck planking

16.4.8.2.1 Deck planking may be:

- constituted by planks parallel to the gunwale limited by a stringer board at side and by a kingplank at the centreline;
- plywood;
- plywood with associated planks as above.

The thickness of the deck is given in Table 9 and is subject to the following modifications:

- if the beam spacing is other than that indicated in Table 7, the thickness shall be modified by 3 mm for every 100 mm of variation in spacing;
- if plywood is employed, the thickness may be reduced by 30%;
- if plywood is adopted in association with planking, the specific mass of the plywood/planking assembly shall be not less than 430 kg/m^3, and the combined thickness may be reduced by 30%. In addition, the plywood thickness shall be not less than 30% of the combined thickness, or less than 6,5 mm; when the planking thickness is less than 19 mm, the seams shall be made watertight by the application of a suitable elastic compound approved by the *Register*.

A further reduction of 1,5 mm may be applied to the deck thickness when the deck is sheathed with nylon, reinforced plastics or other approved coverings.

The fixed fittings on deck, in particular winches, windlasses, bollards and fairleads, shall be well secured on suitable basements and isolated by means of coatings of appropriate materials. Before applying such insulating materials to the basements, the timber shall be protected by suitable preservative solutions or paints.

Guardrail stanchions shall be fastened by at least two pins, one of which shall be a through pin.

Table 9: Planking - basic thickness

Length L (m)	Shell and deck planking (mm)	Deck planking in deckhouses and coachroofs (mm)	Coamings of coachroofs (mm)
24	45,5	26	36
26	47,5	27	36
28	50	28	36
30	52	29	36

Table 10: Floor fastenings

Depth of yacht D (m)	Diameter of bolts			
	at throat		in the arms	
	Grown, or laminated, or steel frames (mm)	Bent frames (mm)	Grown, or laminated, or steel frames (mm)	Bent frames (mm)
≤ 2, 4 2,6	12	8	8	8
2,8	12	9	9	8
3	14	10	10	8
3,2	14	12	12	8
3,4	16	12	12	9
3,6	18	14	14	9
3,8	20	14	14	9
4	20	-	14	-
4,2	20	-	16	-
	22	-	16	-

FASTENINGS OF LONGITUDINAL STRUCTURES

Length of yacht L (m)	Diameter of bolts		
	Centreline structures of yachts (mm)	Scarfs and breasthook arms (mm)	Beam shelves and beam knees (mm)
24	20	14	11
26	20	14	11
28	22	16	12
30	22	18	14

16.4.8.3 Superstructures - Skylights

16.4.8.3.1 When coachroofs are adopted, the opening on deck shall be well framed and the coaming on the weather deck shall be not less in thickness than that required in Table 9.

The coachroof deck is to have sheathing as prescribed in Table 9, though such sheathing may be reduced in thickness in accordance with the specifications in 16.4.8.2 for the weather deck. If the beam spacing is other than that indicated in Table 5, the thickness shall be modified by 3 mm for every 100 mm of difference in spacing.

When deckhouses are adopted, they are to have a coaming fastened to the beams and carlings by means of through bolts.

The structure of deckhouses shall be similar to that required for coachroofs. Depending on their size, deckhouses shall be adequately stiffened to the satisfaction of the *Register*.

Deck openings for skylights shall be well framed and provided with shutters of adequate thickness.

16.4.8.4 Masts and rigging

16.4.8.4.1 Each yacht shall be provided with masts, rigging and sails sufficient in number and in good condition. The scantlings of masts and rigging are left to the experience of builders and shipowners. Care will be taken by the *Register's* Surveyor, however, in verifying that the attachments of shrouds and stays to the hull are such as to withstand at least twice the load expected on such rigging.

The mast step shall be of strong construction and shall be extended so as not to be connected to the transverse and longitudinal framing of the bottom of the hull. The wedging on deck shall be provided with watertight means.

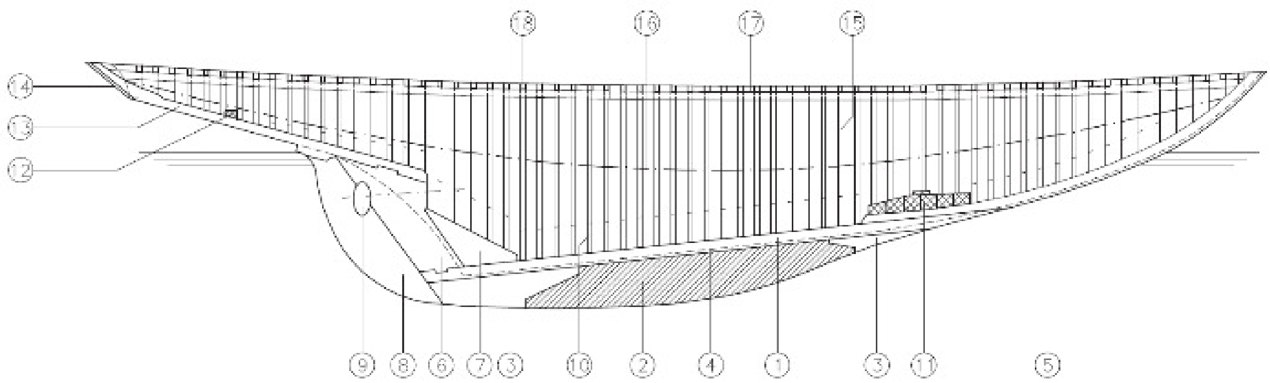
When the mast rests on deck, the underlying structure shall be strengthened in way such as to avoid giving way. If the mast rests on a coachroof, the hull shall be strengthened in way by means of a bulkhead or a stiffened frame.

For shrouds and stays in wire and not in rod, the breaking loads of wires in galvanised steel 160 UNI 4434, in spiral shape, 1 x 19 wires (col. 1) and in stainless steel AISI 316 18/10 (ASTM-A 368-55), in spiral shape, 1 x 19 wires (col. 2) are included below for information purposes.

Table 11

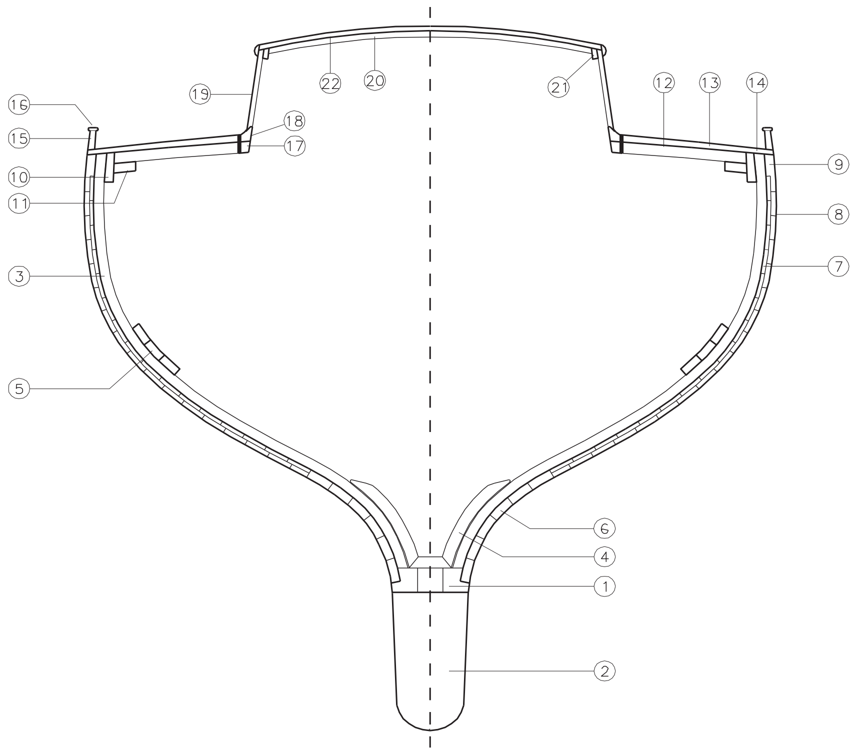
Diameter (mm)	**Metallic cross-section (mm^2)**	**Breaking load (kN)**	
		col. 1	**col. 2**
3	5,37	7,75	7,36
4	9,55	13,73	13,73
5	14,2	21,10	20,60
6	21,5	30,90	29,43
7	29,2	41,60	40,22
8	38,2	54,94	52,97
10	59,7	65,73	83,39
12	86,0	122,63	117,72

Figure 1: Sailing yachts - Constructional profile



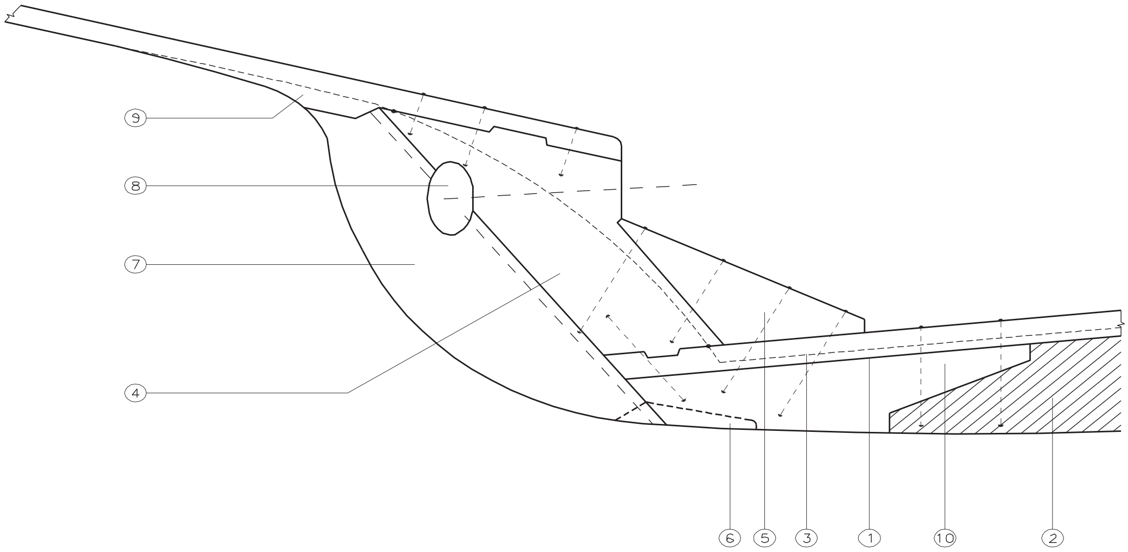
1 - Wood keel	7 - Knee	13 - Stern counter
2 - External ballast	8 - Rudder	14 - Upper stern
3 - Hog	9 - Propeller aperture	15 - Frames
4 - Rabbet	10 - Floors	16 - Stringers
5 - Stempost	11 - Mainmast step	17 - Shelves
6 - Sternpost	12 - Mizzen step	18 - Beams

Figure 2: Midship section



1 - Wood keel	9 - Sheerstrake	17 - Carling
2 - Ballast	10 - Shelf	18 - Coaming "Coachroof"
3 - Frame	11 - Beam clamp	19 - Side planking "Coachroof"
4 - Floor	12 - Half beams	20 - Beam "Coachroof"
5 - Stringers	13 - Deck planking	21 - Shelf "Coachroof"
6 - Bottom simple planking	14 - Waterway	22 - Top "Coachroof"
7 - Planking inner skin	15 - Seam	
8 - Planking outer skin	16 - Stay seam	

Figure 3: Sternframe

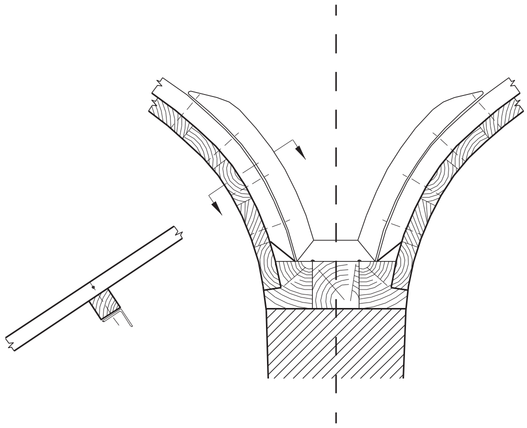


1 - Wood keel
2 - External ballast
3 - Rabbet
4 - Sternpost
5 - Knee
6 - Heel piecedl
7 - Rudder
8 - Propeller aperture
9 - Stern counter
10 - Hog

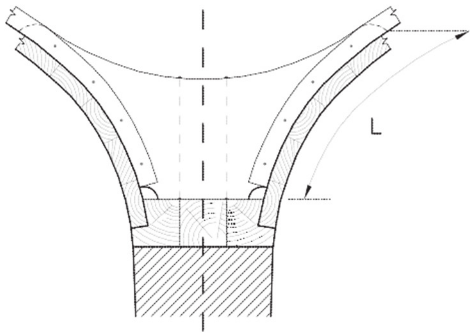
1 - Wood keel
2 - External ballast
3 - Rabbet
4 - Sternpost
5 - Knee
6 - Heel piecedl
7 - Rudder
8 - Propeller aperture
9 - Stern counter
10 - Hog

Figure 4: Typical floors

L = length of arms

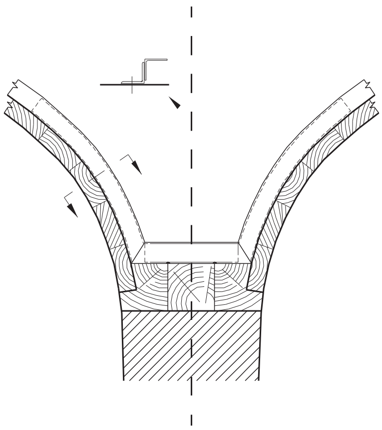


ANGLE FLOOR



WOOD FLOOR

h = height of floor



ANGLE FLOOR

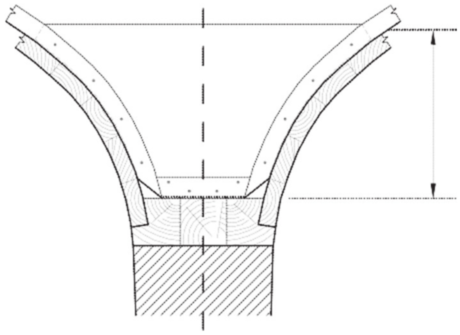


PLATE FLOOR

16.5 STRUCTURAL SCANTLINGS OF MOTOR YACHTS

16.5.1 General

16.5.1.1 The scantlings in this Section apply to yachts of length L ≤ 35 metres with chine hulls of the type shown in Figures 1 and 2 and speed not exceeding 40 knots. Subject to the *Register's* authorisation the value of the structural scantlings for yachts more than 35 metres but not more than 45 metres in length may be calculated by linear interpolation of the results for yachts not more than 35 metres, given in this Section.

For yacht which differ substantially from the above as regards dimensions and/or speed, or yachts with round keels, the scantlings are determined by equivalence criteria.

16.5.2 Keel - stempost

16.5.2.1 The minimum breadth of the keel and the aggregate cross-sectional area of keel and hog frame are given in Table 1.

Such scantlings shall be maintained up to the stem end, while they may be reduced by 30 % at the stern end.

Where they are made from a number of pieces, the keel and hog frame shall be scarfed. The scarfs shall be 6 times the thickness and of hooked or tabled type, if bolted, or of plain type, if glued; the length may be reduced to not less than 4 times the thickness where the scarf is bolted and glued.

The keel scarfs shall be spaced not less than 1,5 metres apart from those of the hog frame.

Stempost scantlings are given in Table 1 and a typical stern- frame is shown in Fig. 3.

16.5.3 Transom

16.5.3.1 In chine hulls, the sternpost is replaced by a transom. The transom structure consists of a frame having profile parts with a cross-section not less than 120% of bottom frames, side frames or beams; moreover, the structure's vertical stiffeners, arranged in way of keel and bottom girders, are to have a cross-section with a height equal to that of the side frames and width increased by 50%.

The stiffeners above are generally to be spaced not more than 600 mm apart.

The thickness of transom planking shall be equal to that given in Table 2 (col. 2), with any modifications required in accordance with those specified for shell planking.

16.5.4 Floors and frames

16.5.4.1 General

16.5.4.1.1 The ordinary framing of the hull is divided into three parts:

- bottom frames, comprising those between the keel and the chine stringers;
- side frames, comprising those between the chine stringers and the waterways;
- beams.

The bottom frames, generally made of two pieces, one port and one starboard of the keel, are butted in way of the centreline and connected by means of a double plywood floor.

The side frames are in one piece connected to the bottom frames by means of double plywood brackets.

The beams are connected to the side frames by means of double plywood brackets.

Table 1: Keel and stempost

Length (m)	KEEL		STEMPOST		
	Minimum breadth (mm)	Cross-section of keel or keel and hog (1) (cm^2	Width at heel and at head (mm)	Cross-section at heel (cm^2)	Cross-section at head (cm^2)
1	2	3	4	5	6
24	230	413	230	413	289
26	245	462	245	462	324
28	260	516	260	516	361
30	280	570	280	570	399

(1) Where there is no hog frame, a reduction in keel area of 10% in respect of that prescribed may be permitted. A keel cross-section reduced such as to be not less than 0,85 of that given in col. 3 may be accepted provided that the difference is compensated by an increased cross-section of girders.

16.5.4.2 Bottom and side frames

16.5.4.2.1 Frame scantlings are given in Tables 3, 4 and 5, where three different types of frames are considered:

- Type I: solid or laminated frames, of constant scantlings throughout the length of the hull;
- Type II: solid or laminated frames, alternated with one or two bent frames. Only the former is connected by means of floors and brackets; the scantlings are as prescribed for Type I frames;
- Type III: solid or laminated frames, associated with bent longitudinals; this type of framing shall be associated with double-skin cross planking or cold moulded laminated multi-layer planking or, alternatively, with plywood planking.

16.5.4.3 Floors

16.5.4.3.1 The floors connecting bottom frames (see 16.4.4.1) are to have thickness equal to half that required for the latter, extend at the yacht's centreline to a height not less than twice that prescribed for the heel of such frames and overlap the frames by a distance not less than 2,5 times their depth so as to constitute an effective connection by means of glue and clenched bolts. The space between the two floors above the frames shall be fitted with a chock; alternatively, the frames may be shaped so as to have, at the centreline, a depth above the keel equal to that required for the heel of the frames. For floors, see Fig 4.

16.5.4.4 Frame and beam brackets

16.5.4.4.1 The connection of bottom frames to side frames and of the latter to beams shall be achieved be means of double brackets similar to those described for floors, but overlapping both frames and beams by a distance not less than twice their respective depths (see Figures 5 and 6).

In lieu of the brackets above, the frame-beam connection may be effected by simply overlapping, preferably dovetailing the beam on the shelf (with glueing and pivoting), and provided that transverse bulkheads are arranged, with spacing not exceeding approximately 2 metres, so as to constitute main transverse strengthening elements of the hull, and that no superstructure is arranged on the weather deck.

Table 2: Shell and deck planking

Length L (m)	SHELL PLANKING		Weather deck planking (mm)	Deck of superstructures (quarterdeck, deckhouses, coachroofs, trunks) (mm)
	Type I and II framing (mm)	Type III framing (mm)		
1	2	3	4	5
24	32	28,5	32	21
26	34	30	34	21
28	36	32	36	21
30	37,5	33,5	37,5	21

Table 3: Frames

<table>
<tr><th rowspan="5">Depth D (m)</th><th colspan="11">TYPE I FRAMING (EITHER GROWN OR LAMINATED FRAMES ONLY)</th></tr>
<tr><th rowspan="4">Spacing of web (mm)</th><th colspan="5">BETWEEN KEEL AND CHINE</th><th colspan="5">BETWEEN CHINE AND DECK</th></tr>
<tr><th colspan="3">Grown frames</th><th colspan="2">Laminated frames</th><th colspan="3">Grown frames</th><th colspan="2">Laminated frames</th></tr>
<tr><th rowspan="2">width (mm)</th><th colspan="2">depth</th><th rowspan="2">width (mm)</th><th rowspan="2">depth (mm)</th><th rowspan="2">width (mm)</th><th colspan="2">depth</th><th rowspan="2">width (mm)</th><th rowspan="2">depth (mm)</th></tr>
<tr><th>at heel (mm)</th><th>at head (mm)</th><th>at heel (mm)</th><th>at head (mm)</th></tr>
<tr><td>3,0</td><td>322</td><td>35</td><td>127</td><td>116</td><td>35</td><td>93</td><td>35</td><td>103</td><td>90</td><td>35</td><td>85</td></tr>
<tr><td>3,1</td><td>340</td><td>39</td><td>140</td><td>127</td><td>39</td><td>104</td><td>39</td><td>117</td><td>108</td><td>39</td><td>94</td></tr>
<tr><td>3,3</td><td>355</td><td>44</td><td>148</td><td>135</td><td>44</td><td>113</td><td>44</td><td>122</td><td>110</td><td>44</td><td>103</td></tr>
<tr><td>3,5</td><td>375</td><td>50</td><td>162</td><td>148</td><td>50</td><td>125</td><td>50</td><td>131</td><td>115</td><td>50</td><td>114</td></tr>
<tr><td>3,7</td><td>390</td><td>55</td><td>178</td><td>162</td><td>55</td><td>135</td><td>55</td><td>143</td><td>123</td><td>55</td><td>125</td></tr>
<tr><td>3,9</td><td>408</td><td>60</td><td>200</td><td>182</td><td>60</td><td>157</td><td>60</td><td>156</td><td>130</td><td>60</td><td>143</td></tr>
</table>

Table 4: Frames

Depth D (mm)	TYPE II FRAMING (EITHER GROWN OR LAMINATED FRAMES WITH BENT FRAMES IN BETWEEN)				
	Spacing between main frames and alternate frames			Bent frames	
	one bent frame (mm)	two bent frames (mm)	three bent frames (mm)	width (mm)	depth (mm)
3,0	560	650	730	36	25
3,1	590	690	770	38	27
3,3	620	725	800	40	30
3,5	-	-	-	-	-
3,7	-	-	-	-	-
3,9	-	-	-	-	-

16.5.5 Side girders and longitudinals

16.5.5.1 On bottom frames, at least two continuous girders shall be fitted each side, with a cross-section not less than 90 cm^2.

Such girders, continuous over bottom frames, shall be connected to the bottom planking by means of chocks between frames, set on a bent longitudinal continuous through the floors and connected to the planking. The chocks and the bent longitudinal may be omitted, but in such case the bot- tom planking thickness given in Table 2 shall be augmented such as to achieve a cross-section throughout the bottom increased by at least half that of the longitudinals.

A similar longitudinal, but with a cross-section reduced to 0,65 of those described above and not fastened to the planking, shall be fitted on side frames.

Such longitudinal may be omitted where Type III framing is adopted.

Table 5: Frames

Depth D (m)	TYPE III FRAMING (GROWN OR LAMINATED FRAMES OR BENTWOOD LONGITUDINALS)										
	Spacing of web (mm)	BETWEEN KEEL AND CHINE					BETWEEN CHINE AND DECK				
		Grown frames			Laminated frames		Grown frames			Laminated frames	
		width (mm)	depth		width (mm)	depth (mm)	width (mm)	depth		width (mm)	depth (mm)
			at heel (mm)	at head (mm)				at heel (mm)	at head (mm)		
3,0	640	37	148	126	37	92	37	104	94	37	84
3,1	680	41	160	136	41	103	41	112	106	41	93
3,3	710	46	176	150	46	112	46	122	110	46	103
3,5	750	52	192	163	52	124	52	135	115	52	113
3,7	780	58	208	176	58	135	58	146	122	58	123
3,9	820	62	232	197	62	156	62	160	129	62	142

Table 6: Frames

Depth D (m)	TYPE III FRAMING (GROWN OR LAMINATED FRAMES OR BENTWOOD LONGITUDINALS)				
	BENTWOOD LONGITUDINALS				
	spacing (mm)	between keel and chine		between chine and deck	
		width (mm)	depth (mm)	width (mm)	depth (mm)
3,0	285	45	30	45	25
3,1	300	48	33	48	27
3,3	315	50	36	50	30
3,5	330	53	39	53	33
3,7	345	55	42	55	36
3,9	360	58	45	58	39

16.5.6 Beams

16.5.6.1 The arrangement of beams is generally to be carried out as follows:

- for hulls with Type I framing: beams on every frame;
- for hulls with Type II or III framing: beams in way of solid or laminated frames, with bracket connection and intermediate beams, without brackets, let into the shelf.

Beams are to have width equal to that of the frames to which they are connected and section modulus, in cm^3, not less than:

$Z_1 = K_1 \times a \times s$

At the ends of large openings, beams shall be fitted having a section modulus, in cm^3, not less than:

$Z_2 = K_2 \times a \times s$

where:

Z_1, Z_2 : section modulus of beams without planking contribution, in cm^3

a : width of beams, in cm

s : beam spacing, in m

K_1, K_2 : coefficient given by Tab 7 as a function of the beam span.

Where laminated beams are arranged, the section moduli Z_1 and Z_2 may be reduced to 0,85 of those indicated above.

Table 7

Beam span (m)	Coefficients for calculation of beam section modulus			
	K_1		K_2	
	At the centreline	At the ends	At the centreline	At the ends
≤2	14,3	6,43	23	11,4
2,5	18	8,5	31	15,1
3	22,2	10,7	38,6	17,7
3,5	24,7	12,5	43,6	22,2
4	28,3	13,9	48,7	23,6
4,5	30,6	14,9	52,5	25,2
5	32,4	16,3	56,8	27,7
5,5	35,1	17,1	60	28,7
6	36,9	18,1	63,5	31,8
6,5	38,7	19,5	70	35
7	39,6	20,5	73,5	40,2
7,5	40,5	23	81	45,4

16.5.7 Beam shelves and chine stringers

16.5.7.1 The cross-sectional area of beam shelves and chine stringers shall be not less than that given by Tab 8 below as a function of L and to have the ratio $h/t < 3$, where h is the depth and t the thickness of the bar.

The cross-section of shelves and stringers shall be considered as inclusive of the dappings for beam and frame ends.

Table 8

Length L of the hull (m)	Cross-sectional area of beam shelves (cm^2)	Cross-sectional area of chine stringers (cm^2)
24	95	112
26	110	128
28	125	140
30	140	152
32	155	164
35	177	182

16.5.8 Shell planking

16.5.8.1 Thickness of shell planking

16.5.8.1.1 The basic thickness of shell planking is given in Table 2.

If the frame spacing is other than that shown in Table 3, the planking thickness shall be increased or may be reduced, accordingly, by 10% for every 100 mm of difference.

After correction for spacing, the planking thickness may be reduced:

- by 10% if a diagonal or longitudinal double-skin planking is adopted;
- by 15% if composite planking constituted by inner plywood skin and one or two outer longitudinal diagonal strakes is adopted;
- by 25% if laminated planking (i.e. at least three cold- moulded layers) or plywood is adopted.

Moreover, the plywood thickness shall be not less than 30% of the total thickness or less than 6 mm.

Yachts with speed > 25 knots are to have bottom frames (floors and longitudinals) stiffened in respect of the scant- lings in this Section and planking thickness increased as follows (for deadrise = 25°) in respect of the values in Table 2:

- speed from 26 to 30 knots: 5%
- speed from 31 to 35 knots: 10%
- speed from 36 to 40 knots: 15%.

When the deadrise is between 25° and 30° and outer longitudinal strakes are fitted on the bottom planking, the above increase in thickness may be reduced but is generally to be no less than half of the percentage values above.

16.5.9 Deck planking

16.5.9.1 Weather deck

16.5.9.1.1 Deck planking may be constituted by planks flanked by a stringer board at side and by a kingplank at the centreline. Such planking may be solely plywood or plywood with associated planking arranged as described above.

The thickness of deck planking is given in Table 2. If the beam spacing is other than that prescribed in 16.5.4.2, the planking thickness shall be increased or may be reduced, accordingly, by 10% for every 100 mm of difference.

After correction for spacing, the planking thickness may be reduced by 30% if plywood or plywood associated with planking is employed.

Moreover, the plywood thickness shall be not less than 30% of the total thickness or less than 6 mm.

16.5.9.2 Superstructure decks

16.5.9.2.1 The thickness of planking of superstructure decks is given in Table 2.

Such thickness is subject to the reductions and increases for weather deck planking as provided for in 16.5.9.1.

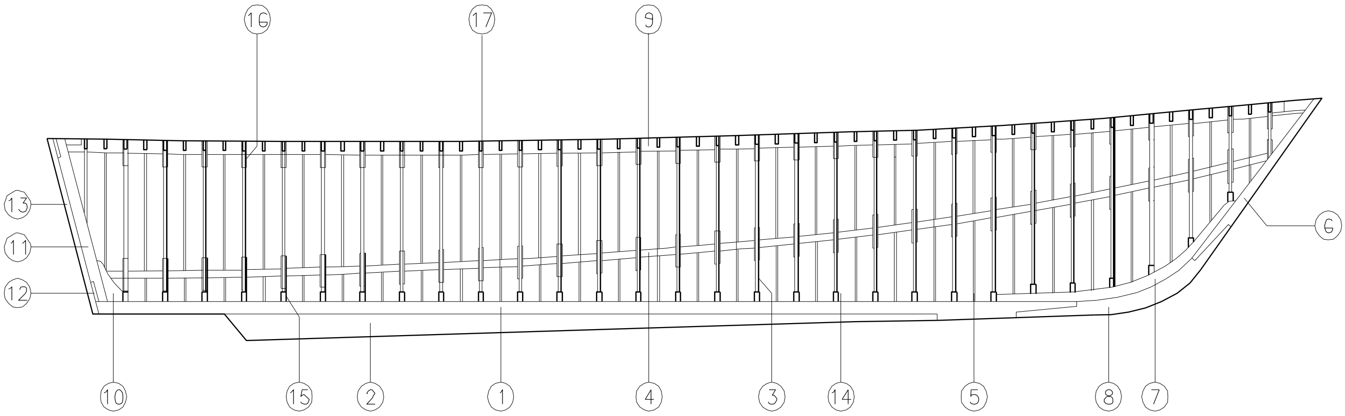
16.5.9.3 Lower deck

16.5.9.3.1 In hulls with depth, measured between the upper keel side and the weather deck beam, greater than or equal to 3,10 metres, a lower or cabin deck shall be arranged, with beams having a section modulus not less than 60% of that prescribed in 16.5.6 for weather deck beams and effectively fastened to the sides by means of a shelf with a ross sectional area not less than 2/3 of that required in Table 8.

When the depth, as measured above, exceeds 4,30 metres, the fastening of beams to side shall be completed by means of plywood brackets arranged at least at every second beam and having scantlings as prescribed in 16.5.4.4.

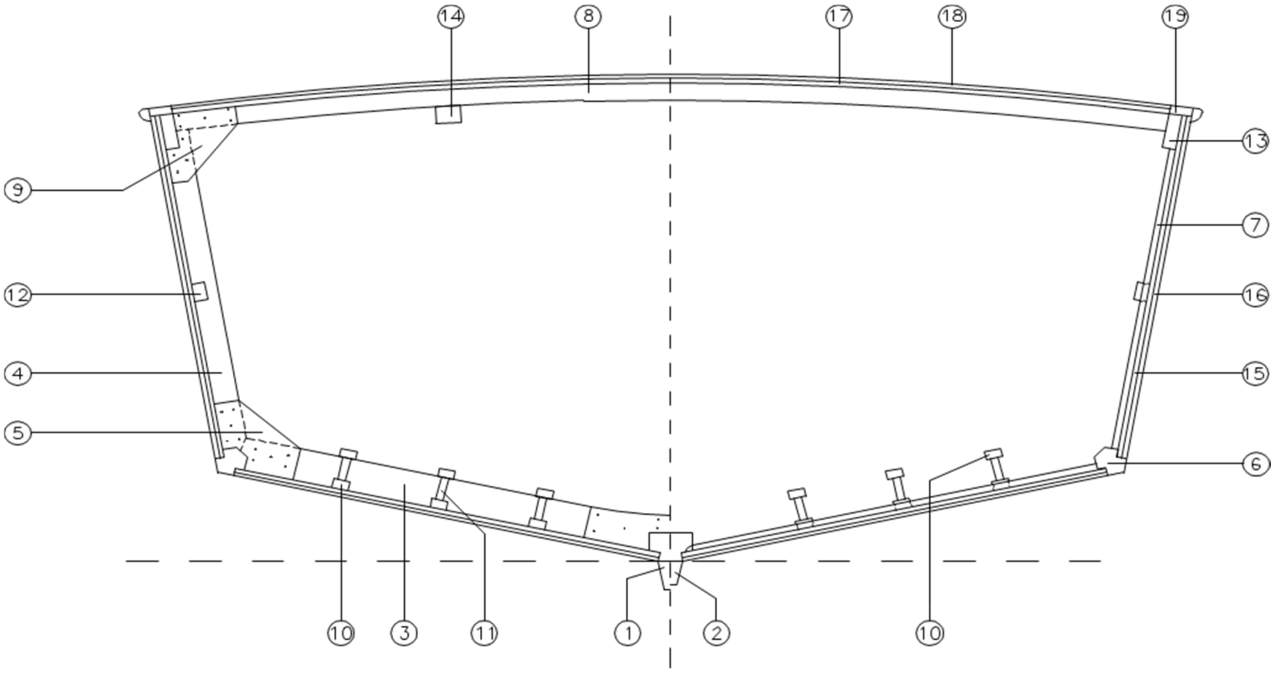
The scantlings of the deck planking shall be not less than those required in 16.5.9.2.

Figure 1: Motor yachts - Constructional profile



1 - Keel
2 - Hog
3 - Grown frame
4 - Chine stringer
5 - Bent frame
6 - Stempost
7 - Apron
8 - Stem
9 - Shelf
10 - Knee
11 - Transom stiffeners
12 - Transom frame
13 - Transom frame
14 - Chine knees
15 - Floors
16 - Beam knees
17 - Beam

Figure 2: Midship section



1 - Keel
2 - Hog
3 - Bottom frame
4 - Side frame
5 - Double knee
6 - Chine
7 - Bent frame
8 - Beam
9 - Double knee
10- Bottom stringers
11 - Deadwood
12 - Side stringers
13 - Shelf
14 - Carling
15 - Bottom and side planking - Inner skin
16 - Bottom and side planking - Outer skin
17 - Deck planking - Inner skin
18 - Deck planking - Outer skin
19 - Waterway

Figure 3: Stem

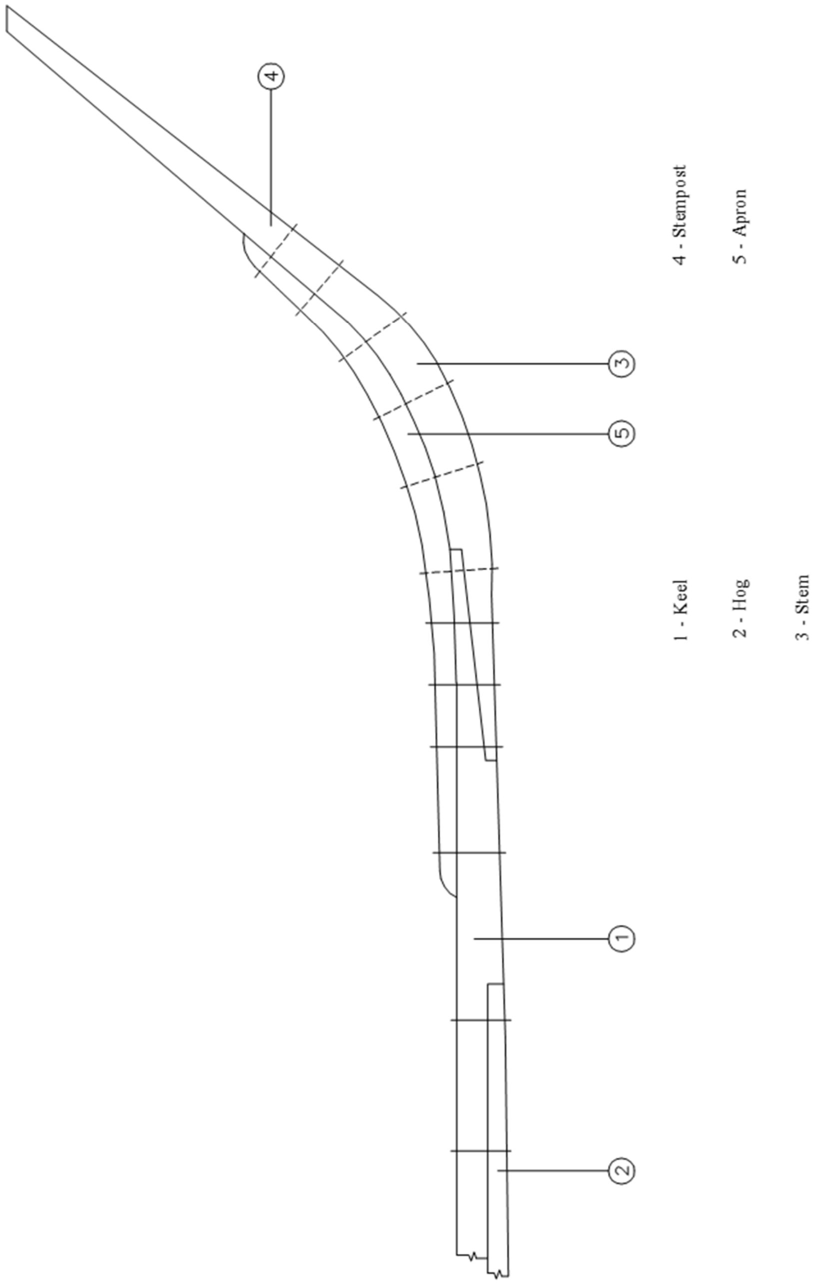
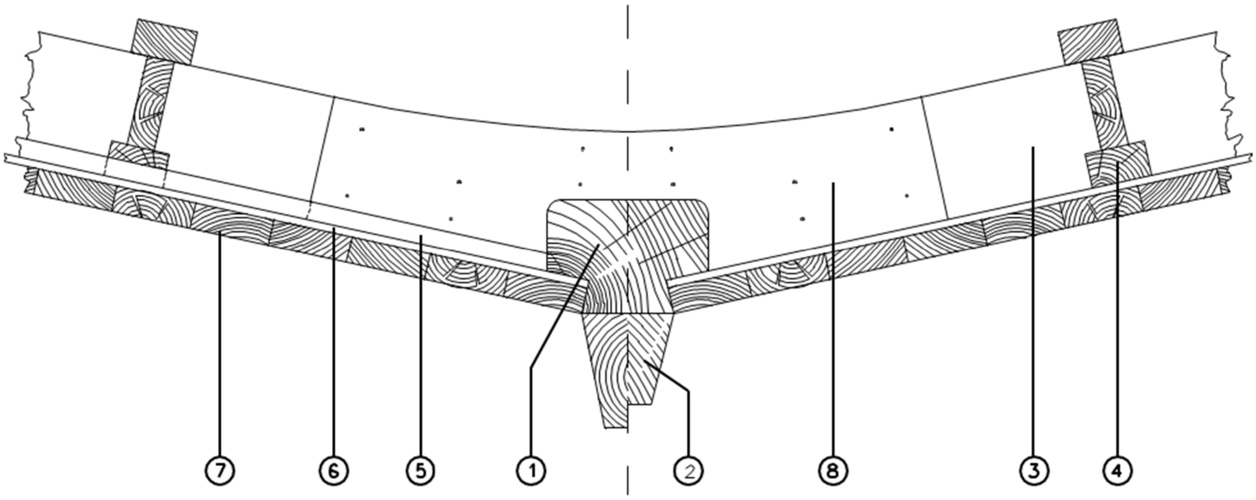
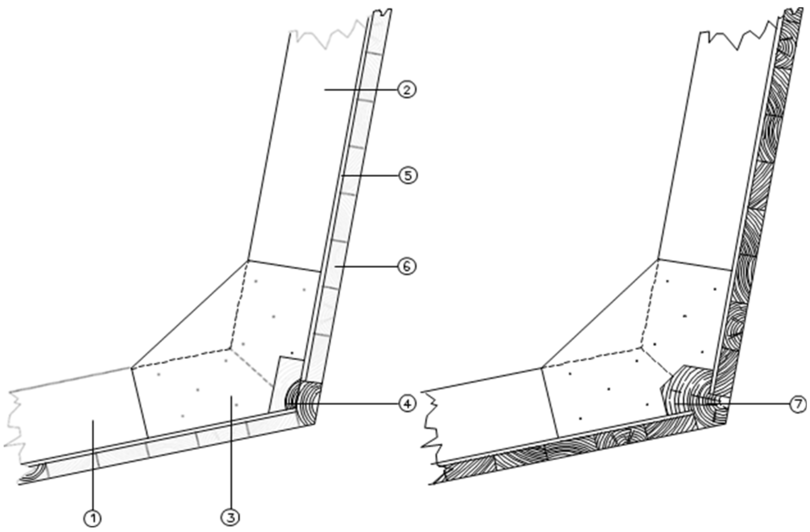


Figure 4 Detail of floor



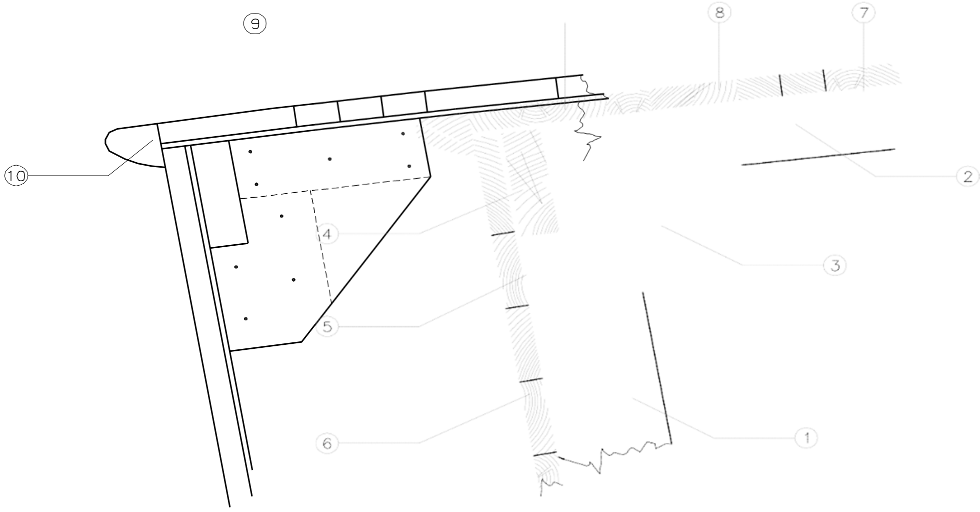
1 - Keel	4 - Bottom stringer	7 - Planking - Outer skin
2 - Hog	5 - Bent frame	8 - Double floor
3 - Bottom frame	6 - Planking - Inner skin	

Figure 5: Detail of floor



1 - Bottom frame	5 - Planking - Inner skin
2 - Side frame	6 - Planking - Outer skin
3 - Double knees	7 - Chine
4 - Chine stringer	

Figure 6: Detail of gunwale connection



1 - Side frame	6 - Hull planking - Outer skin
2 - Beam	7 - Deck planking - Inner skin
3 - Double knees	8 - Deck planking - Outer skin
4 - Shelf	9 - Waterway
5 - Hull planking - Inner skin	10 - Rubbing piece

16.6 WATERTIGHT BULKHEADS, LINING, MACHINERY SPACE

16.6.1 Wooden bulkheads

16.6.1.1 Wooden watertight bulkheads normally consist of plywood boards of adequate thickness in relation to the hull size and the spacing and strength of stiffeners. Glues for timber fastenings shall be of resorcinolic or phenolic type, i.e. durable and water-resistant in particular.

As regards the number of watertight bulkheads, attention is drawn to the provisions of 1.7.

The plywood, normally arranged in vertical panels, shall be scarfed or strapped in way of vertical stiffeners.

Connection to the hull shall be effected by means of a grown or laminated frame and made watertight by packing where necessary.

16.6.2 Steel bulkheads

16.6.2.1 Steel watertight bulkheads shall be of thickness as shown in Table 1 as a function of the spacing of stiffeners and the height of the bulkhead.

The scantlings are given on the assumption that the lowest strake is horizontal and subsequent strakes vertical. When all strakes are horizontal, the thickness of the third and higher strakes may be decreased by a maximum of 0,5 mm per strake so as to reach a reduction of 25 %, in respect of the table thickness, for the highest strake.

If the spacing is other than that shown in the table, the thickness shall be modified by 0,5 mm for every 100 mm of difference in spacing. The spacing of vertical stiffeners is not to exceed 600 mm for the collision bulkhead.

The scantlings of vertical stiffeners, in cm^3, without end connections shall be not less than:

$$Z = (4{,}2 + 4 \times h) \times s \times S^2$$

where:

Z : section modulus of vertical stiffener with associated strip of plating one spacing wide, in cm^3

H : distance from midpoint of stiffener to top of bulkhead, in m

S : spacing of vertical stiffeners, in m

S : aggregate span of vertical stiffeners.

The connection of the bulkhead to planking shall be effected on grown or laminated frames, and provided with watertight packing where necessary.

Bulkheads shall be caulked or made watertight by means of suitable gaskets. On completion, any watertight bulkheads and doors shall be tested using a strong jet of water.

16.6.3 Internal lining of hull and drainage

16.6.3.1 Where ceilings or internal linings are arranged, they shall be fitted so as to be, as far as practicable, easily removable for maintenance and painting of the underlying structures. Linings are to allow sufficient ventilation of air spaces between them and planking.

Limber holes shall be provided in the bottom structures such as to allow the drainage of bilge liquids into suction wells.

16.6.4 Machinery space structures

16.6.4.1 The scantlings of floors, web frames and foundation girders shall be adequate for the weight, power and type of machinery; their suitability and that of associated connections shall be satisfactory with particular regard to engine running and navigation tests when required by this Rules.

Table 1: Watertight steel bulkheads

Height of bulkhead (mm)	Spacing of vertical stiffeners (mm)	Thickness of lower strake (mm)	Thickness of other strakes (mm)
≤ 2,40	375	4	3,5
2,60	390	5	4,5
2,80	410	5	4,5
3,00	425	5,5	5
3,20	440	5,5	5
3,40	460	5,5	5
3,60	475	6	5,5
3,80	490	6	5,5
4,00	510	6	5,5
4,20	525	6	5,5
4,40	540	6,5	6
4,60	560	6,5	6
4,80	575	6,5	6
5,00	590	6,5	6

17 HULL OUTFITTING

17.1 RUDDERS

17.1.1 Section 2 of the *Rules for the classification of ships, Part 3 - Hull equipment* shall be compiled with.

17.2 PROPELLER SHAFT BRACKETS

17.2.1 Propeller shafting could be enclosed in bossing or independent of the main hull and supported by shaft brackets.

17.2.2 The arrangement and scantlings of bracket arms shall be as follows.

Bracket arms shall be attached to deep floors or girders of increased thickness, and the shell plating shall be increased in thickness and suitably stiffened, at the discretion of the *Register*.

The thickness of the palm connecting the arms to the hull, if any, shall be not less than 0,2 · dS, where:

dS : Rule diameter, in mm, of the propeller shaft, calculated with the actual mechanical characteristics.

The arm shall be connected to the hull by means of through bolts, fitted with nut and lock nut, in way of the internal hull structures suitably stiffened at the discretion of the *Register*.

The arms of V-shaft brackets shall be perpendicular, as far as practicable.

The bearing length of the shaft bracket boss, in mm, shall be not less than 3 · dS.

The thickness, in mm, of the shaft bracket boss after boring operation shall be not less than:

$t_b = 0{,}2 \cdot d_s \cdot (k_1 + 0{,}25)$

where:

K1 = Rms/Rmb,

Rms = minimum tensile strength, in N/mm^2, of the propeller shaft,

Rmb = minimum tensile strength, in N/mm^2, of the shaft bracket boss, with appropriate metallurgical temper.

Each arm of V-shaft brackets is to have a cross-sectional area, in mm^2, of not less than:

$S = 87{,}5 \cdot 10^3 \cdot d^2_{SO} \cdot (1600 + Rma) / Rma$

where:

d_{SO} = Rule diameter, in mm, of the propeller shaft, for carbon steel material,

Rma = minimum tensile strength, in N/mm^2, of arms, with ap-propriate metallurgical temper.

Single-arm shaft brackets are to have a section modulus at ves-sel plating level, in cm^3, of not less than:

$W = 3 \cdot 10^2 \cdot l \cdot d^2_{SO} \cdot (n \cdot d_{SO})^{0,5} / Rma$

where:

l = length of the arm, in m, measured from the shell plating to the centreline of the shaft boss,

n = shaft revolutions per minute.

Moreover, the cross-sectional area of the arm at the boss is not to be less than 60% of the cross-sectional area at shell plating.

17.2.3 Plated bossing

Where the propeller shafting is enclosed within a plated bossing, the aft end of the bossing shall be adequately supported.

The scantlings of end supports shall be individually considered. Supports shall be designed to transmit loads to the main structure.

End supports shall be connected to at least two deep floors of increased thickness or connected to each other within the vessel.

Stiffening of the boss plating shall be individually considered. At the aft end, transverse diaphragms shall be fitted at every frame and connected to floors of increased scantlings. At the fore end, web frames spaced not more than four frames apart shall be fitted.

17.3 SUPPORTING STRUCTURE OF WATERJETS

17.3.1.1 The supporting structures of waterjets shall be able to withstand the loads thereby generated in the following conditions:

- maximum ahead thrust;
- maximum thrust at maximum lateral inclination;
- maximum reversed thrust (going astern).

Information on the above loads shall be given by the waterjet Manufacturer, supported by documents.

The shell thickness in way of nozzles, as well as the shell thickness of the tunnel, shall be individually considered. In general, such thicknesses shall be not less than 1,5 times the thickness of the adjacent bottom plating.

17.4 STABILIZER ARRANGEMENTS

17.4.1 General

The scantlings, arrangement and efficiency of stabiliser arrangements do not fall within the scope of the *Register*, nevertheless, the bedplates of the various components, the supporting structures and the watertight integrity shall be examined.

17.4.2 Stabiliser arrangements

17.4.2.1 The stabiliser fin machinery shall be supported by adequately reinforced structures. Drawings shall be submitted for approval showing the position, the supporting structures and the loads transmitted.

17.4.2.2 The shell plating in way of stabilizer fins shall be adequately reinforced. In the case of fixed type stabiliser fins, the passage to the hull and the components necessary for the operation of the system, supported by adequately reinforced structures shall be arranged in a watertight box with an inspection opening fitted with a watertight cover.

In metal structures, the watertight box shall be at least of the same thickness as the adjacent shell plating. The box shall be well stiffened. For GRP vessels, the scantling of the watertight boxes and their stiffeners will be considered case by case. Where it is not practical to provide a watertight box, particularly because of the restricted inside spaces, the arrangement will be specially considered by the Register.

17.4.3 Stabilising tanks

The tank structures are to comply with the requirements for tank bulkheads, taking into account the maximum head that may arise in service. Where sloshing is foreseeable the scantlings will be the subject of special consideration.

17.5 THRUSTER TUNNELS

17.5.1 Tunnel wall thickness

17.5.1.1 The thickness of the tunnel shall be in accordance with the Manufacturer's specifications; in general, the thickness shall be not less than:

- For steel tunnels: the Rule thickness of the adjacent plating increased by 10% (but at least 2 mm), and in any case not less than 7 mm.
- For light alloy tunnels: the Rule thickness of the adjacent plating increased by 10% (but at least 1 mm), and in any case not less than 8 mm.
- For composite tunnels: the Rule thickness of the adjacent plating increased by 25%; in any case the thickness shall be not less than 8 mm. For tunnels having an inside diameter not more than 300 mm, the *Register* may accept a tunnel thickness equal to that of the adjacent plating provided that in any case the thickness is not less than 8 mm.

17.5.2 Tunnel arrangement details

17.5.2.1 The system for connecting the tunnel to the hull depends on the material used for the construction.

17.5.2.2 The tunnel shall be arranged between two floors of increased height or in a separate watertight compartment.

17.5.2.3 The thickness of the plating shall be locally increased at least 50%.

17.5.2.4 The tunnel shall be connected to the plating by

means of full penetration welding.

17.5.2.5 For tunnels in composite material, the weight of the connecting laminate stiffener shall be equal to the weight of the bottom plating stiffener. The stiffener shall be arranged on both sides of the plating laminate.

Prior to the connecting lamination, the surfaces of the tunnel and the plating concerned shall be suitably cleaned and prepared and the edges of the cuts shall be sealed with resin.

17.6 CRANE SUPPORTS ARRANGEMENTS

Crane foundations shall be designed considering the worst combinations of the following loadings:

- maximum load capacity
- the weight of the crane itself;
- wind;
- crane accelerations resulting from the vessel's heel and trim.

Insert plates shall be provided in the deck in way of the crane foundation; in order to avoid concentration of forces, these insert plates are to have suitable dimensions (in respect of the dimensions of the foundation), be suitably prepared and have round corners. The thickness of these inserts shall be in accordance with the Designer's calculations.

A drawing of this arrangement with all the forces acting and the detail of the connection to the deck shall be sent for approval.

17.7 SAILING YACHT APPENDAGES AND COMPONENT FASTENINGS

17.7.1 Keel connection

The typical ratio of the weight of external ballast to light displacement is generally 0,4- 0,5.

The ballast may be internal or external to the hull.

In the first case, the ballast shall be permanently secured, by clips or equivalent means, to the resistant structures of the hull (floors, frames, etc) but in no case to the plating, on which it is never to bear, so as not to shift even during rolling or pitching.

In the second case, the connection to the hull shall be effected by means of bolts long enough to incorporate the height of the ballast, either wholly or in part; such bolts are to pass through the hull, with a head (or nut and lock nut) at one end and a nut and lock nut at the other, towards the inside of the hull. The surface of the ballast keel head shall be flush with the surface of the hull, the bolt holes shall be fashioned with equipment designed to achieve an almost complete absence of play between bolt and hole, and the locking of the nuts shall be uniform. The nuts are to rest on plates or large washers and to be left uncovered so that they may be easily examined.

The diameter d, in mm, at the bottom of the thread of each keel bolt is given by the following formula:

where:

$$d = 1{,}60 \cdot \left[\frac{W \cdot h_G}{\sum li \cdot \delta_R}\right]$$

W is the total weight of the ballast in N;

h_G is the distance in mm, from the centroid of the ballast, to the plane attachment of the ballast to the hull;

δ_R is the minimum yield strength of the bolt material, N/mm^2;

Σli is summation of the distances from the centre of the bolts on side of the keel to the edge of the keel on the other side, in mm.

If there are fewer bolts on one side of the keel, Σli shall be measured from the centroid of the bolts on that side to the edge of the keel on the other side.

Where are fitted bolts on the longitudinal axis of the keel, Σli should be measured from the centre of the bolts to the edge of the keel.

It shall be verified that the arrangement is strong enough to withstand the grounding loads. It is assumed that the conventional grounding loads are the following:

a) Longitudinal grounding loads acting in the aft direction and parallel to the longitudinal hull axis. The load shall be applied to the bottom edge of the keel

$L_{GL} = 3,1\ \Delta$ (if $Lwl \geq 20$ m)

$L_{GL} = 1,60\ \Delta$ (if $Lwl \geq 10$ m)

b) Vertical grounding load V_{GL}, in tons, acting upward on the bottom of the keel

$V_{GL} = 1,60\ \Delta$

It shall be verified that shear stress and primary stress due to the load as indicated in a and b are not more than the value given from the following formula:

shear stress $\leq 0,70\ \eta_B$

primary stress $\leq 0,70\ \eta_B$

where:

Δ : the maximum displacement of the vessel, in tonnes.

η_B : minimum shear yield stress of the bolt material, in N/mm^2.

Where direct calculations are carried out to determine the diameter of bolts, the degree of locking shall be taken into account and a safety factor ≥ 3,5 in relation to the ultimate tensile strength and ≥ 2 in relation to the yield stress of the bolt material shall be applied.

17.7.2 Chain plates

The plates should be ample in size and well fastened to the structure to distribute the loads.

Many arrangements may be adopted according to the design philosophy.

Basically, the following arrangement could be adopted:

a) Single strap design:
in this case the chainplates may be fitted internally or externally and by means of bolts. In the case of internal fittings, the bolts are to have large heads; on account of their appearance, washers are not normally fitted on the outside of the hull;

b) Bracket connection in this case the chainplate is connected to a plywood bracket by means an angle or flat bar chainplate.

The chainplate shall be bolted to the bracket. Where possible, the chainplates shall be bolted directly to the bulkhead. Where the chainplate and bolts penetrate, the hull or deck shall be made watertight with a flexible sealant rather than a rigid resin, which may crack under the strain and result in annoying leakage.

Chainplates shall be generally of mild steel, stainless steel, monel or aluminium. Bolts shall be galvanically compatible with the other materials and shall be sea corrosion-resistant. Adequately hull reinforcement shall be provided in way of the chainplates.

17.7.3 Component fastenings

Components can be satisfactorily fastened with bolts, screws or rivets. These fasteners shall be of a corrosion-resistant metal. Bolts, washers, backing plates and fittings shall be of a compatible material. Where chemically incompatible, adequately insulation shall be provided. If the components shall be fitted to a hull structure in sandwich construction with low density core materials, the local hull area shall be replaced with structurally effective inserts in way of bolted connections and fittings. The inserts shall be adequately bonded to the laminate skins and to the adjacent low-density core.

Alternatively, the local area can be replaced with monolithic laminate of the same thickness as the sandwich laminate.

18 EQUIPMENT

18.1 EQUIPEMENT NUMBER

18.1.1 All yachts shall be provided with anchors, chain cables and ropes based on their Equipment Number EN, as shown in Table 18-1.

The equipment Number EN shall be calculated as follows:

$$EN = \Delta^{2/3} + 2h \cdot B + 0{,}1A$$

where:

Δ = yacht displacement, in [t],

B = moulded breadth, in [m],

h = effective height, in [m], from the summer load waterline to the top of the uppermost house; for the lowest tier "h" shall be measured at centreline from the upper deck or from a notional deck line where there is local discontinuity in the upper deck. for an example.

$h = a + \sum h_n$

a = the distance from the summer load waterline amidships to the upper deck, in [m],

h_n = height, in [m], on the centreline of each tier of houses having a breadth greater than B/4.

A = area, in [m^2], in profile view, of the hull, superstructures and houses above the summer load waterline which are within the Equipment length of the yacht and also have a breadth greater than B/4.

For yachts that have superstructures with the front bulkhead with an angle of inclination aft, the equipment number can be calculated as follows:

$$EN = \Delta^{2/3} + 2\left(aB + \sum b_n h_n \sin\theta_n\right) + 0{,}1A$$

Theta n: angle of inclination with the horizontal axis aft of each front bulkhead

b_n = greatest breadth, in m, of each tier n of superstructures or deckhouses having a breadth greater than B/4.

For EN > 1060 the anchors, chain cables and ropes will be fixed by the *Register* depending on the case.

18.1.2 When calculating h, sheer and trim shall be disregarded, i.e. h shall be taken equal to the sum of freeboard amidships plus the height h_n (at the centreline) of each tier of superstructures and deckhouses having a breadth greater than B/4.

Where a deckhouse having a breadth greater than B/4 is above another deckhouse with a breadth of B/4 or less, the upper deckhouse shall be included and the lower ignored. Screens or bulwarks 1,5 metres or more in height shall be regarded as parts of deck-houses when determining h and A.

In determining the area A, when a bulwark is more than 1,5 metres in height the area above such height shall be included.

18.1.3 A drawing relevant to the equipment number to be sent for approval; the drawing is to contain also information on:

- geometrical elements for calculation
- list of equipment;
- construction and breaking load of steel wires;
- material, construction, breaking load and relevant elongation of synthetic ropes.

18.2 ANCHORS

18.2.1 Anchors shall be manufactured in accordance with the *Rules* for *the classification of ships, Part 25 – Metallic materials*, Sec 6 and 7.

The bower anchors shall be connected to their chain cables and positioned on board ready for use.

The stream anchor should be ready to be connected with its cable.

Ships with Equipment Number of 205 and less may have the second bower anchor as spare one on condition that provision is made for its quick getting ready for use.

Unmanned barges and pontoons where length is less than 30 m the anchor may be dispensed with and where length is greater than 30 m may have only one bower anchor.

18.2.2 The mass, per anchor, given in Table 1 applies to "high holding power" anchors. When use is made of normal type anchors, the mass shown in the table shall be multiplied by 1,33.

When "very high holding power" anchors are used, the mass of the anchors may be equal to 70% of that shown in Table 1 for stockless anchors.

The actual mass of each anchor may vary by + or - 7% with respect to that shown in Table 1, provided that the total mass of the two anchors is at least equal to the sum of the masses given in the table.

When 2 anchors are required:

The second anchor is intended as a spare and it is not necessary to carry it as a bower anchor provided that, in the event of the loss of the first anchor, the spare anchor can be readily removed from its position and arranged as a bower anchor.

In this case, the first anchor shall be equipped with at least 70% of the length of chain indicated in table, and the spare anchor with at least 70% of the required length.

When only 1 anchor is required (EN less than 110) and a second is foreseen as a spare, this spare anchor has to have a mass of at least 70% of the main anchor; in this case the chain length shall be at least 65% for EN < 70 and 70% for EN < 110 of the required chain length for the main anchor and also of the spare anchor.

For EN < 280 a maximum of a 90% of the chain length fitted on the spare anchor may be replaced by wire or fibre rope.

Possibility of replacing a mass required for 1 anchor fit in place with 2 anchors both fixed in place and used simultaneously:

a) When 2 anchors are required (EN more than 110) Each anchor is to have a mass equal at least 60% of the of the requested mass of each anchor and the length of each chain line shall not be less than 75% of the total length indicated in the table.

In this case the spare anchor may have a mass equal at least 60% of the of the requested mass of each anchor and the length of each chain line shall not be less than 75% of the total length indicated in the table.
A maximum of 90% of the chain length fitted on the spare anchor may be replaced by wire or fibre rope.

b) When only 1 anchor is required (EN less than 110) The mass required for each anchor can be replaced with two anchors having a total mass not less than the mass of the anchor required. In this case the two anchors shall be in place, to be used simultaneously. Where the requested mass for each anchor is divided in two anchors, each one having a mass equal to least 60% of the requested mass, the length of each chain line shall not be less than 65% for EN < 70 and 70% for EN < 110 of the total length indicated in the table.

18.2.3 The diameters refer to Grade Q1 steel chain cables; where Grade Q2 or Q3 steel studless chain cables are used, the diameters may be reduced guaranteeing the same breaking load as the chain cable corresponding to Grade Q1.); where Grade Q2 or Q3 steel with stud chain cables are used, the diameters may be reduced guaranteeing as per Tab 18.1.

For HHP and VHHP anchors, grade Q1 chain cables are not allowed and Grade Q2 or Q3 chain cables shall be used; in this case the reduction of chain diameter for VHHP may be possible only for chain with stud as per Tab 18.1.

For yacht of more than 500GT studless chain cables are not allowed.

18.2.4 Test for high holding power anchors approval.

For approval and/or acceptance as a HHP anchor, comparative tests shall be performed on various types of sea bottom.

Such tests are to show that the holding power of the HHP anchor is at least twice the holding power of an ordinary stockless anchor of the same mass.

For approval and/or acceptance as a HHP anchor of a whole range of mass, such tests shall be carried out on anchors whose sizes are, as far as possible, representative of the full range of masses proposed. In this case, at least two anchors of different sizes shall be tested. The mass of the maximum size to be approved shall be not greater than 10 times the maximum size tested. The mass of the smallest shall be not less than 0,1 times the minimum size tested.

18.2.5 Test for very high holding power anchors approval

For approval and/or acceptance as a VHHP anchor, comparative tests shall be performed at least on three types of sea bottom: soft mud or silt, sand or gravel and hard clay or similar compounded material. Such tests are to show that the holding power of the VHHP anchor shall be at least four times the holding power of an ordinary stockless anchor of the same mass or at least twice the holding power of a previously approved HHP anchor of the same mass.

The holding power test load shall be less than or equal to the proof load of the anchor.

For approval and/or acceptance as a VHHP anchor of a whole range of mass, such tests shall be carried out on anchors whose sizes are, as far as possible, representative of the full range of masses proposed. In this case, at least three anchors of different sizes shall be tested. relevant to the bottom, middle and top of the mass range.

18.2.6 Specification for test on high holding power and super high holding power anchors

Tests are generally to be carried out from a tug. Shore based tests may be accepted by the *Register* on a case-by- case basis.

Alternatively, sea trials by comparison with a previous approved anchor of the same type (HHP or VHHP) of the one to be tested may be accepted by the *Register* on a case by-case basis.

For each series of sizes, the two anchors selected for testing (ordinary stockless and HHP anchors for testing HHP anchors, ordinary stockless and VHHP anchors or, when ordinary stockless anchors are not available, HHP and SHHP anchors for testing VHHP anchors) are to have approximately the same mass.

The length of chain cable connected to each anchor, having a diameter appropriate to its mass, shall be such that the pull on the shank remains practically horizontal. For this purpose, a value of the ratio between the length of the chain cable paid out and the water depth equal to 10 is considered normal. A lower value of this ratio may be accepted by the *Register* on a case-by-case basis.

Three tests shall be carried out for each anchor and type of sea bottom.

The pull shall be measured by dynamometer; measurements based on the RPM/bollard pull curve of tug may, however, be accepted instead of dynamometer readings.

Note shall be taken where possible of the stability of the anchor and its ease of breaking out. For approval and/or acceptance as a VHHP anchor, comparative tests shall be performed at least on three types of sea bottom: soft mud or silt, sand or gravel and hard clay or similar compounded material. Such tests are to show that the holding power of the VHHP anchor shall be at least four times the holding power of an ordinary stockless anchor of the same mass or at least twice the holding power of a previously approved HHP anchor of the same mass.

For approval and/or acceptance as a VHHP anchor of a whole range of mass, such tests shall be carried out on anchors whose sizes are, as far as possible, representative of the full range of masses proposed. In this case, at least three anchors of different sizes shall be tested. relevant to the bottom, middle and top of the mass range.

18.2.6 Specification for test on high holding power and super high holding power anchors.

Tests are generally to be carried out from a tug. Shore based tests may be accepted by the *Register* on a case-by- case basis.

Alternatively, sea trials by comparison with a previous approved anchor of the same type (HHP or VHHP) of the one to be tested may be accepted by the *Register* on a case by-case basis.

For each series of sizes, the two anchors selected for testing (ordinary stockless and HHP anchors for testing HHP anchors, ordinary stockless and VHHP anchors or, when ordinary stockless anchors are not available, HHP and SHHP anchors for testing VHHP anchors) are to have approximately the same mass.

The length of chain cable connected to each anchor, having a diameter appropriate to its mass, shall be such that the pull on the shank remains practically horizontal. For this purpose, a value of the ratio between the length of the chain cable paid out and the water depth equal to 10 is considered normal. A lower value of this ratio may be accepted by the *Register* on a case-by-case basis.

Three tests shall be carried out for each anchor and type of sea bottom.

The pull shall be measured by dynamometer; measurements based on the RPM/bollard pull curve of tug may, however, be accepted instead of dynamometer readings.

Note shall be taken where possible of the stability of the anchor and its ease of breaking out.

18.3 CHAIN CABLES FOR ANCHORS

18.3.1 Chain cables are to have proportions in accordance with recognised unified standards and to be of the steel grade given in Table 1.

Grade 1 chain cables are generally not to be used in association with "high holding power" anchors; chain cables of at least Grade 2 shall be used with "very high holding power anchors.

18.4 MOORING LINES

18.4.1 Mooring lines may be of wire, natural or synthetic fibre, or a mixture of wire and fibre.

Where steel wires are used, they shall be of the flexible type.

Steel wires to be used with mooring winches, where the wire is wound on the winch drum, may be constructed with an independent metal core instead of a fibre core.

The breaking loads shown in Table 18.1 refer to steel wires or natural fibre ropes.

Where synthetic fibre ropes are adopted, their size will be determined taking into account the type of material used and the manufacturing characteristics of the rope, as well as the different properties of such ropes in comparison with natural fibre ropes.

The equivalence between synthetic fibre ropes and natural fibre ropes may be assessed by the following formula:

$$CR_S = 7{,}4 \cdot \frac{\delta \cdot CR_M}{CR_M^{1/9}}$$

where:

δ : elongation to breaking of the synthetic fibre rope, to be assumed not less than 30%;

CR_S = breaking load of the synthetic fibre rope, in kN;

CR_M = breaking load of the natural fibre rope, in kN;

Where synthetic fibre ropes are used, rope diameters under 20 mm are not permitted, even though a smaller diameter could be adopted in relation to the required breaking load**.**

18.5 SAILING YACHTS

18.5.1 For sailing yachts (with or without auxiliary engine), the value of EN shall be calculated using the formula given in 18.2.

18.6 NON-STRUCTURAL FUEL TANKS

18.6.1 General

Tanks for liquid fuel shall be designed and constructed so as to withstand, without leakage, the dynamic stresses to which they will be subjected. They shall be fitted with internal diaphragms, where necessary, in order to reduce the movement of liquid.

Tanks shall be arranged on special supports on the hull and securely fastened to them so as to withstand the stresses induced by movement of the yacht.

Tanks shall be arranged so as to be accessible at least for external inspection and check of piping.

Where their dimensions permit, tanks are to include openings allowing at least the visual inspection of the interior.

In tanks intended to contain fuel with a flashpoint below 55°C determined using the closed cup test (petrol, kerosene and similar), the above openings shall be arranged on the top of the tank.

Such tanks shall be separated from accommodation spaces by integral gastight bulkheads. Tanks shall be arranged in adequately ventilated spaces equipped with a mechanical air ejector.

Upon completion of construction and fitting of all the pipe connections, tanks shall be subjected to a hydraulic pressure

test with a head equal to that corresponding to 2 m above the tank top or that of the overflow pipe, whichever is the greater.

At the discretion of the *Register*, leak testing may be accepted as an alternative, provided that it is possible, using liquid solutions of proven effectiveness in the detection of air leaks, to carry out a visual inspection of all parts of the tanks with particular reference to pipe connections.

18.6.2 Metallic tanks

18.6.2.1 General

Tanks intended to contain diesel oil shall be made of stainless steel, nickel copper, steel or aluminium alloys.

Steel tanks shall be suitably protected internally and externally so as to withstand the corrosive action of the salt in the atmosphere and the fuel they are intended to contain.

The upper part of tanks is generally not to have welded edges facing upwards or be shaped so as to accumulate water or humidity.

To this end, zinc plating may be used, except for tanks intended to contain diesel oil, for which internal zinc plating is not permitted.

Tanks shall be effectively earthed.

18.6.2.2 Scantlings

The thickness of metallic tank plating shall be not less than the value t, in mm, given by the following formula:

$$t = 4 \cdot s \cdot (h_s \cdot K)^{0,5}$$

where:

s = stiffener spacing, in m;

h_s = static internal design head, in m, to be assumed as the greater of the following values:

- vertical distance from the pdr (see below) to a point located 2 m above the tank top
- two-thirds of the vertical distance from the pdr to the top of overflow

K = where RS is the minimum yield stress, in N/mm^2, of the tank material. Where light alloys are employed, the value of RS to be assumed is that corresponding to the alloy in the annealed condition;

pdr = point of reference, intended as the lower edge of the plate, or, for stiffeners, the centre of the area supported by the stiffener.

In any case the thickness of the tank shall be not less than 2 mm for steel and not less than 3 mm for light alloy.

The section modulus of stiffeners shall be not less than the value Z, in cm^3, given by the formula:

$$Z = 4 \cdot s \cdot S^2 \cdot h_s \cdot K$$

where:

S = stiffener span, in m.

18.6.3 Non-metallic tanks

18.6.3.1 General

Fuel tanks may be made of non-metallic materials.

The materials adopted are to withstand the corrosive action of the fuel to be carried.

The acceptance of non-metallic tanks will be subject to tests on materials (such as after immersion in the fuel to be carried).

18.6.3.2 Scantlings

18.6.3.2.1 The scantlings of non-metallic tanks will be specially considered by the *Register* on the basis of the characteristics of the material proposed and the results of strength tests performed on a sample.

18.6.4 Tests on tanks

18.6.4.1 General

Prior to their installation on board, tanks shall be subjected to a hydraulic pressure test with a head equal to that corresponding to 2 m above the tank top or that of the overflow pipe, whichever is the greater.

On the base of additional verifications proposed by the Shipyard (such as NDT) a leak testing with an air pressure as may be accepted by the *Register* as an alternative.

18.6.4.2 Leak testing

Leak testing shall be carried out by applying an air pressure of 0,15 bar.

Prior to inspection of the tightness of welding, in the case of metallic tanks and pipe connections, it is recommended that the air pressure is raised to 0,2 bar and kept at this level for about 1 hour. The level may then be lowered to the test pressure before carrying out the welding tightness check of the tank and connections by means of a liquid solution of proven effectiveness in the detection of air leaks.

The test may be supplemented by arranging a pressure gauge and checking that the reading does not vary over time.

Leak testing shall be performed before any primer and/or coating is applied. In the case of tanks made of composite material, the test shall be carried out before the surface is externally coated with self-extinguishing resin.

EN		Stockless bower anchors		Chain cables for anchors					Mooring lines		
A < EN ≤ B		No. (1)	Mass per anchor (kg)	Total length (m)	Diameter (mm)				No.	Length (m) (2)	Breaking load kN
					Studless chain cable	Chain cables with stud					
A	B					Grade Q1 steel	Grade Q2 steel	Grade Q3 steel			
50	70	1	100	165	11	-	-	-	2	42	26
70	90	1	120	192,5	12,5	11	-	-	2	50	31
90	110	1	140	192,5	12,5	11	-	-	2	62	35
110	130	2	160	220	14,5	14	12,5	-	3	70	35
130	150	2	180	220	14,5	14	12,5	-	3	74	39
150	175	2	200	220	17,5	16	14	11	3	77	43
175	205	2	230	220	17,5	16	14	11	3	80	47
205	240	2	260	220	19	17,5	16	12,5	4	85	51
240	280	2	310	220	19	17,5	16	12,5	4	90	55
280	320	2	360	247,5	20,5	19	17,5	14	4	95	59
320	360	2	410	247,5	22	20,5	17,5	14	4	100	62
360	400	2	460	247,5	24	22	19	16	4	105	70
400	450	2	520	275	-	22	19	16	4	110	78
450	500	2	580	275	-	24	20,5	17	4	110	86
500	550	2	640	275	-	26	22	20,5	4	130	98
550	600	2	700	302,5	-	26	22	20,5	4	130	105
600	660	2	770	302,5	-	28	24	22	4	130	118
660	770	2	840	302,5	-	30	26	24	4	130	126
720	780	2	910	330	-	30	26	24	4	140	138
780	840	2	980	330	-	32	28	24	4	140	150
840	910	2	1060	357,5	-	32	28	24	4	140	160
910	980	2	1150	357,5	-	34	30	26	4	140	173
980	1060	2	1260	357,5	-	36	32	28	4	140	184

(1) See [2.1.2].
(2) Length of each line.

19 WEATHERTIGHT INTEGRITY OF HULL AND SUPERSTRUCTURE

19.1 GENERAL

19.1.1 Definitions

For the purpose of this Section, the following definitions are presented:

Freeboard deck – is normally the uppermost complete deck exposed to weather and sea, which has permanent weathertight means of closing for all openings on and directly above it, and below which all openings in the hull sides are fitted with permanent means of watertight closing.

Superstructure – is a decked structure on the freeboard deck, extending from side to side of the yacht or with the side plating not being inboard of the shell plating more than 4% of the breadth B.

Additionally, an **enclosed superstructure** is a superstructure with:

- enclosing bulkheads of efficient construction;
- access openings, if any, in these bulkheads fitted with doors complying with the requirements of Regulation 12 of the ICLL 1966, as amended by Protocol of 1988, dealing with the door arrangement; and
- all other openings in sides or ends of the superstructure fitted with efficient weathertight means of closing.

Deckhouse – is a decked structure other than a superstructure, located on the freeboard deck or above.

Weathertight – means ability to prevent the ingression of water into the yacht in any sea conditions.

Deadlight – secondary watertight closure fitted to a glazed opening and which is fitted on the inside of the yacht.

Storm shutter – portable protective closure fitted to a glazed opening and which is fitted on the outside (weatherside) of the yacht.

Glazing – transparent or translucent pane (sheet of material fixed within or to a frame).

19.1.2 General arrangement

19.1.2.1 All openings on the hull and decks through which flooding of spaces contributing to buoyancy, or included in stability calculation, may occur, shall be fitted with closing appliances of appropriate level of tightness (depending on their location on board). Examples of such appliances are doors, hatches, ventilation covers, sidescuttless (portlights), skylights and similar.

19.1.2.2 All openings needed for proper functioning of the vessel that cannot be closed during navigation (for example machinery space ventilation), shall be considered as downflooding points in stability calculation.

19.1.2.3 Openings fitted at superstructures and deck houses considered as enclosed, according to definition in 19.1.1, are also required to be fitted with weathertight closing appliances, even if they not lead to spaces underdeck considered buoyant in stability calculation. Their scantlings and design loads are mostly influenced by their exact location on board.

19.1.2.4 In the case of discrepancy between the specific regulations of the Flag State (if available) and this Section of the Rules, the former shall apply. For example, for a commercial yacht the higher standards may be needed to apply for issuing a LL certificate.

19.1.2.5 Regarding to the position of the opening on the yacht, in general two position can be identified.

Position 1 - from the loaded waterline to the freeboard deck (including raised quarterdeck, if fitted) abaft 1/4 L from the F.P. and up to the superstructure deck forward of that point. All openings fitted on those decks should be considered as on position 1.

Position 2 - upon exposed superstructure decks situated abaft 1/4 L from the F.P. and located at least 1.8 m above the freeboard deck.

Table 19.1

SILL HEIGHT (mm) TYPE AND POSITION OF OPENINGS	NAVIGATION AREA	
	Unrestricted	**Restricted/short range**
Hatchways and skylights:		
– at position 1 - inside 1/4 L from F.P.	380	300
– at position 1 - aft of 1/4 L from F.P.	300	230
– at position 2	150	100
External doors on superstructures and deckhouses protecting entrances leading to the spaces below the freeboard deck or spaces contributing to the stability and buoyancy:		
– at position 1 - inside 1/4 L from F.P.	600	300
– at position 1 - aft of 1/4 L from F.P. (side and front * facing)	230 (300*)	150
– at position 1 - aft of 1/4 L from F.P. (aft facing) – at position 2	150	75

SILL HEIGHT (mm) TYPE AND POSITION OF OPENINGS	NAVIGATION AREA	
	Unrestricted	Restricted/short range
External doors leading directly to the machinery space:		
– at position 1	600	450
– at position 2	380	200
Ventilators:		
– at position 1	900	450
– at position 2	760	380
Air vents:		
– at position 1	760	380
– at position 2	450	230

**NOTE: If the opening is located on the forward bulkhead of the superstructure or deckhouse*

19.1.2.6 Weathertight openings leading to the spaces below, and which may be randomly opened during navigation (for example: hatches, doors and ventilation openings), shall be equipped with coamings (sills). The minimum required sill height above the deck at which the opening is located, can be found in Table 19.1. Required values depend on the yacht's area of navigation, type of opening and its position on board.

19.1.2.7 A plan showing the position of all openings leading to the hull and other buoyant structures used in stability calculation, shall be submitted for approval. The data such as type of openings, their means of closure and tightness level, height of sills, scantlings and similar, should be clearly indicated.

The arrangement and clear opening area of freeing ports in bulwarks shall also be presented in the plan.

19.2 EXTERNAL DOORS

19.2.1 Doors of exposed bulkheads of superstructures and deck houses shall be of adequate dimensions and construction, such to guarantee their weathertight and structural integrity against the external loads, appropriate to their locations. In general, their strength should be equivalent to the adjacent structure.

Doors shall be permanently hinged, fitted with locking devices and opening to outward. Hinges should be fitted at the bow side of the opening.

19.2.2 Where the doors may be required to be used as a means of escape, the securing arrangements shall be operable from both sides.

The electrically operated doors used as a mean of escape shall also be able to be manually operated from both sides, in case of failure of the electrical system.

19.2.3 Doors which shall be kept closed while at sea, and permitted to open only at harbour, should be clearly marked thereof. If fitted anywhere on the part of deck included in position 1 (as per 19.1.2.5), indication of their open position shall be provided at the wheelhouse.

19.2.4 For the enclosed spaces at exposed deck, protected with door compliant to provisions of this Head, there shall be provided an alternative access from the higher tier level if those spaces need to be considered as buoyant in stability calculations.

19.2.5 The use of FRP for doors on the weather decks of yachts build of other materials may be accepted, provided:

- the door is of sufficient strength (equivalent to adjacent structure); and
- the door is not fitted to opening leading to machinery space.

19.2.6 As far as the scantling of the glazing material and type of framing, glazed doors should be treated as any glazed pane located in the same position (see 19.4).

The doors in general should be made of laminated glass. For glazed doors fitted in the first tier of superstructure or deck houses, aft of 1/4 L from the F.P., one of the following solutions may be accepted instead of the storm shutters:

- laminated glass with thickness increase of at least 30% with an interlayer of 3 mm of polycarbonate, or equivalent material;
- laminated glass and one of the solutions indicated as alternative to the storm shutters in 19.4.6.2; or
- laminated glass protected by a solid bulwark of at least the required height, fitted at sides of deck structures set inboard of the hull shell by more than 4% of B.

Additionally to the above alternatives, at least one blanking plate per opening of the same dimensions should be provided for commercial yachts in unrestricted area of navigation.

Glazed doors should not be fitted at the freeboard deck and superstructure deck inside forward 1/4 of the length L, measured from the F.P., except in cases when standard storm shutters are provided for each of the opening.

19.2.7 Regardless of the building material, door opening shall be provided with sill (coaming) of the required height above the deck level. The minimum values are presented in the table 19.1.

On a case-by-case basis, and upon agreement with the Flag State, a part of the required sill for openings that may be used while at sea may be made of the removable part, provided:

- that opening is fitted abaft 1/4 of L from the F.P.,

- the height of the complete sill is at least as required for unrestricted service in table 19.1,
- the height of the permanent sill is at least half of the required value for unrestricted service in table 19.1,
- the removable sill is permanently stored close to the opening, and
- the weathertightness of the complete sill is satisfactorily demonstrated by a hose test.

19.3 HATCHWAYS

19.3.1 General requirements

19.3.1.1 All openings leading to spaces bellow the bulkhead deck, or into the spaces considered as buoyant in stability calculations, and not capable of being closed weathertight, shall be enclosed within either an enclosed superstructure or a weathertight deckhouse of adequate strength.

19.3.1.2 All exposed hatchways which give access from position 1 and position 2 (see the definitions in 19.1.2.5) shall be of substantial weathertight construction and provided with gaskets and efficient means of closure. Their strength shall be equivalent to that of the adjacent structure. Weathertight hatch covers shall be permanently attached to the hatch coamings and provided with adequate arrangements for securing the hatch closed. Covers shall be openable to outwards.

19.3.1.3 Hatches which are designated for escape purposes shall be provided with covers which shall be openable from either side, and in the direction of escape they shall be openable without a key. All handles on the inside shall be non-removable. An escape hatch should be readily identified and easy and safe to use, having due regard to its position.

19.3.2 Hatchways which may be accessed at sea

19.3.2.1 In general, hatches should be kept closed while at sea. However, hatchways which may be open for access at sea shall be as small as practicable (a maximum of 1 m^2 in clear area), and fitted with sills of at least the values as required in table 19.1, with regards to the position on board and yacht's navigation area.

19.3.2.2 Hatchways should be as near to the centreline as practicable, especially on sailing yachts. Covers of hatches shall be permanently attached to the hatch sills and, where hinged, the hinges shall be located on the forward side.

19.3.3 Hatches which have not to be used at sea

19.3.3.1 Flush hatches are generally not to be fitted at positions 1 and 2. However, the ones that need not to be used while at sea may be fitted without coamings, if agreed with the Flag State, and if provided to:

- be kept closed at sea;
- fitted in protected location close to the centreline;
- have at least two drains in the aft part leading overboard;
- be fitted with gaskets;
- have at least 4 clips for size 600 x 600 mm;
- have non-oval hinges which can be considered as clips; and
- be fitted with open/close indication in the wheelhouse.

Flush hatches not satisfying all above requirements shall be of certified watertight type.

19.3.3.2 Flush hatches of clear area greater than 0.36 m^2 (600 x 600 mm) may be accepted only after the detail consideration by *Register* and if agreed with the Flag State.

Flush inspection opening covers provided with gaskets and secured by close-spaced bolts are not considered as hatches for the purpose of this item.

19.4 GLAZED OPENINGS

19.4.1 General

19.4.1.1 Glazed opening is a term used for any opening in the yacht's hull, superstructure or deckhouse, which is fitted with a transparent or translucent material. In general, the mechanical behaviour of the glazed pane is considered as independent from adjacent structure, e.g. as of framed appliance. For large panes, bonded directly into a seat in yacht's structure, a special consideration is needed, based on the requirements of ISO 11336-2.

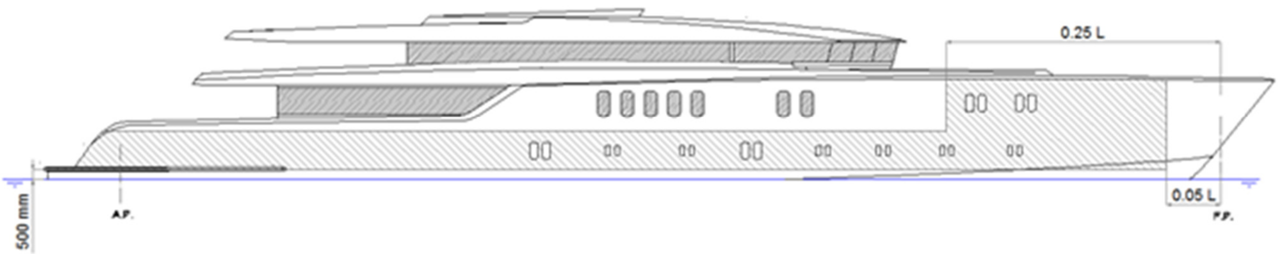
Glazed openings considered in this Head are the sidescuttles (portlights), windows, skylights and glazed doors.

Sidescuttles – As a general rule, a sidescuttle is an opening with an area not exceeding 0.16 m2.

Window – As a general rule, a window is an opening with an area exceeding 0.16 m2.

Skylight – As a general rule, a skylight is a horizontal glazed opening, fitted on a deck exposed to weather.

Figure 19.4.2



19.4.2 Arrangement

19.4.2.1 The lower edge of any glazed opening fitted in the hull shall be at least 500 mm above the full load (summer) waterline. That limit may be lowered to at least 300 mm exclusively for the yachts certified for the restricted areas of navigation 5 – 8 (additional character of class, as in the *Rules for the classification of ships, Part 1 – General requirements, Chapter 1 – General information*, 4.2.).

The glazed openings are not to be fitted in the hull, or first tier superstructure, forward of a line drawn at 0.05 L from the F.P.

Maximum size of glazed openings fitted at hull sides bellow the bulkhead deck or fitted on first tier superstructure forward of a line drawn at 1/4 L from the F.P., are not to exceed 0.85 m^2. The zone at the outer shell where that limit is set, excluding parts where no glazed opening shall be fitted (stated in paragraphs above), is graphically presented as shaded area in figure 19.4.2

19.4.2.2 Any glazed opening fitted in the shaded area in figure 19.4.2 and having a clear area greater than 0.16 m^2, shall be of the non-opening type. No part of the glazing or its framing shall extend out of the outer plane of the shell structure on which is fitted.

19.4.2.3 If openable, sidescuttles fitted in that area shall be of the non-readily openable type and provided with hinged deadlights. Not easy openable means that the sidescuttle need a key or a mechanical mean or tool to be opened and that may keep it closed. For yacht of unrestricted service, an indication of open position shall be provided at a continuously manned position.

Sidescuttle of the non-opening type shall be provided at any position where it become immersed after flooding of any compartment considered in damage stability calculations, for yachts for which those calculations are required.

19.4.2.4 Windows fitted at the outer shell outside of the area shaded in figure 19.4.2 (for example, the openings marked A1 in figure 19.4.3) or on other deck structures which contribute to buoyancy, shall be, if openable, of framed construction and of the non-readily openable type, provided with permanent or portable deadlights (see 19.4.6.3 and 19.4.6.4), ready for use. For a window with clear area of opening larger than 1 m^2, an indication of open position shall be provided at a continuously manned position.

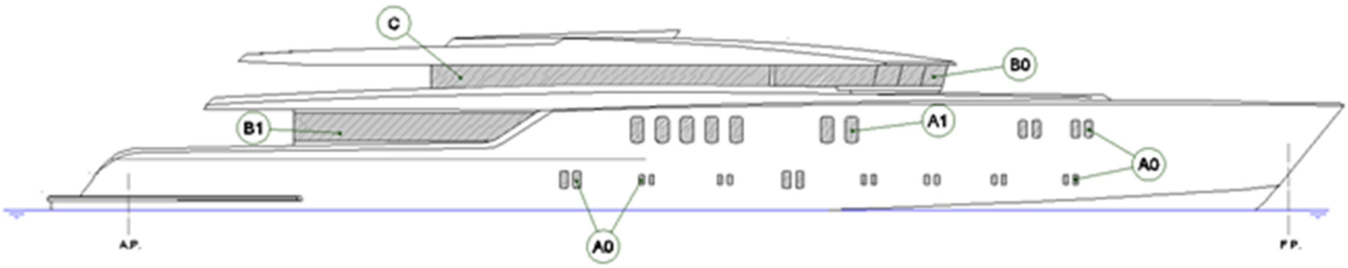
Easy openable windows, with or without frame, are acceptable only in superstructure and deckhouses not contributing to buoyancy. They have to satisfy the following:

- If they open by sliding, and the sliding movement is vertical, it shall be from up to down to open;
- the glass is to have scantlings in accordance with 19.4.3 for such windows;
- if the window is larger than 1 m^2 of clear area, it shall be open only under the supervision of someone of the crew and provided with an indication of open position in the wheelhouse.

19.4.2.5 No glazed opening shall be fitted on the outer shell of machinery compartment.

19.4.2.6 Polarised or tinted glass should not be used in windows provided for navigational visibility.

Figure 19.4.3



A0 - superstructure/side shell glazed openings of less than 0.85 m^2 in clear area
A1 - superstructure/side shell glazed openings of more than 0.85 m^2 in clear area
B0 - windows on exposed positions on first tier superstructure or fronts of second tier deck structures
B1 - windows on protected positions on first tier superstructure and deck houses
C - windows on deck houses of higher tier

19.4.3 Design loads and scantlings

19.4.3.1 Design pressure p_D for glazed openings in end and side bulkheads of superstructures and deckhouses on or above freeboard/bulkhead deck should be calculated according to 5.5.1 of the ISO 11336-1.

In equation (1), found in above stated item of the standard, service factor k_S should be taken as 1.0 for unrestricted service yacht, and 0.75 for a yacht in restricted navigation area.

The minimum design pressure p_D for glazed openings and deadlights in the sides of hull shell and superstructure (pos. A0 and A1 at fig. 19.4.3) which is considered as buoyant in stability calculations, shall be as given in Table 4 of item 5.5.2 of the ISO 11336-1 (70 kN/m^2 and more, depending on the yacht's type and the length L).

The minimum design pressure p_D for glazed openings and deadlights in the sides of superstructure (A1 and windows of pos. A0 when fitted on superstructure, at fig. 19.4.3), which are not considered as buoyant in stability calculations, shall be calculated according to equation given in 5.5.1 of the ISO 11336-1, but using the value of factor *a* as for the fronts of superstructure, when applying table 1 in that item of the standard.

The minimum design pressure p_D for glazed openings and storm shutters in the front sides of deckhouses and superstructures (B0 at fig. 19.4.3) shall be calculated according to equation given in 5.5.1 of the ISO 11336-1, using the value of factor *a* for the fronts of superstructure, as given in table 1 in that item of the standard.

The minimum design pressure p_D for glazed openings and storm shutters in the sides of deckhouses on the bulkhead deck (B1 at fig. 19.4.3) shall be calculated according to equation given in 5.5.1 of the ISO 11336-1, using the value of factor *a* for the sides of deckhouses, as given in table 1 in that item of the standard.

The minimum design pressure p_D for glazed openings in the sides of deckhouses on higher tiers (C at fig. 19.4.3) shall be calculated according to the ISO 11336-1, using the value of factor *a* for the sides or aft end of deckhouses (as appropriate), as given in table 1 in that item of the standard.

For yachts of restricted area of navigation, the minimum required design pressure p_D of 15 kN/m^2 may be reduced after further analysis provided and upon agreement with the *Register*, but in no case shall the minimum p_D be lesser than 10 kN/m^2.

19.4.3.2 Scantling determination of panes exposed to design pressure p_D should be calculated according to Head 5.6 of the ISO 11336-1, also using the guidelines for different shapes of opening, found in Annex A to the standard.

19.4.4 Framing

19.4.4.1 The structure of the yacht shall be verified without the structural contribution of the glass when the strength of the surround is so high that the mechanical behaviour of the glazing is considered as independent from the adjacent structure.

The glaze pane is supposed not carrying loads from the adjacent structures and not having structural function. The installation of the glazing should be done without interruption of the structural elements – if it is not feasible, the local strength of the structure shall be analysed and verified by FEM calculations.

19.4.4.2 The glazing fitted in shaded area in fig. 19.4.2 or at other deck structures contributing to buoyancy should have a frame and shall be mechanically connected or glued to the hull.

The framing shall provide a safe and secure fixing of the glazing. The glazing shall either be clamped with elastomer gaskets or bonded and additionally secured with an elastomer gasket between glazing and retaining frame or bonded at both sides.

The direct contact between frame and glazing shall be avoided. Fitting of glazing panes in such a way that the adhesive is under tension load are not permitted anywhere on the outer shell and deck structures belonging to position 1 (see 19.1.2.5).

Support of the glazing mass and secure positioning within the frame shall be achieved by support pads with comparable elastic properties as the elastomeric gasket or the bonding material.

The strength of metal frames shall ensure that the minimum yield strength of the material is not exceeded when the frames are subjected to the glazing design pressures (pD). Non-metallic frames shall be considered on a case-by-case base. The bolt material shall be compatible with the frame, also. The supplier shall ensure that the mechanical properties are achieved and valid documentation shall be provided.

Types of framing and more detailed guidelines are provided in Section 6 of the ISO 11336-1.

19.4.4.3 For glazed openings fitted in the superstructure and deck houses not contributing to buoyancy and outside the area considered in 19.4.4.2, the fastening solutions may also include bonding without a frame. In such a case, the following shall be assured:

- The adhesive used for the gluing shall be flexible and suitable for the gluing of the glazing material or the frame material to material of the hull;
- glued joints shall be resistant to (or protected against) sunlight (UV, heat, etc.) and all environmental effects or cleaning chemicals normally encountered in the manufacture and use of the yacht;
- the bonding has to work in compression. The gluing detail to be sent for examination.

Bonding shall in general be in a recess designed to accommodate the glazing appliance, contained with an appropriate sealing gap and the required bonding thickness and width. The external edge of the glazing shall not protrude beyond the immediate surrounding surface (e.g. the filler, adjacent structure, or other glazing).

For sloped glazed openings (angle to vertical between 0°and 10°), the bond is considered in tension and where retainers are not provided the bonding have be considered on a case-by-case base. For sloped and overhead glazed openings (angle to vertical >10°), a retainer shall be provided. The retainer shall be designed to take the loads required to hold the glazing in place and prevents the window from falling out in case of bonding failure. Design of the mechanical retention of the glazing shall take into account the installation and location of opening.

An overhead glazed opening that person can stand on, or the one which is located above an area where persons can be underneath, shall be fitted with a mechanical retainer.

Outside of the zone shadowed in fig. 19.4.2 it is acceptable to install one or more not easy openable sidescuttles, of the same or different shapes, glued to larger non openable windows, provided that the following conditions are satisfied:

- The bonding of the fixed windows to the hull/superstructure/deckhouse sides is in accordance with the requirements of the ISO 11336-2;
- the bonding of the frame of the sidescuttle to the fixed window is in accordance with the requirements of the ISO 11336-2;
- the scantlings of the glazing of the windows and sidescuttles are calculated and verified in accordance with requirements of this Head, depending on their position on the yacht;
- the area of the sidescuttle is not more than 50% of the area of the fixed window on which it is glued;
- the distance of the sidescuttle from the window's sides is not less than the half of the diameter of the sidescuttle, if it is circular, or half of the shorter side of the sidescuttle, if it is of rectangular shape. If more than one sidescuttle are glued to one fixed window, the distance between the sidescuttles is also to be not less than the diameter of the larger sidescuttle, if it is circular, or of its shorter side, if rectangular;
- if fitted at positions A1, B0 or B1, as presented in fig.19.4.3, the sidescuttles and window are provided with a storm shutter/deadlight, or equivalent arrangement, covering both. That cover shall be in accordance with 19.4.6;
- the glazed pane of fixed windows are of the laminated glass;
- the sidescuttles shall be of the not ready openable type, if fitted in position A1, as in fig. 19.4.3;
- a mockup of the whole arrangement (surrounding structure + fixed window + sidescuttle bonded to it), but without deadlight and with the sidescuttle closed, shall be hydraulically tested at a pressure not less than 4 p_D applying the procedure detailed in 7.3 of the ISO 11336-1. If the sidescuttle has been already tested separately (in accordance to what required by this Head), the test pressure may be reduced to p_D.

Other arrangements may be considered by the *Register* on a case-by-case basis.

19.4.5 Skylights

19.4.5.1 All skylights shall be of efficient weathertight construction and should be located on or as near to the centreline of the yacht as practicable.

19.4.5.2 If they are of the opening type, they shall be provided with efficient means whereby they can be secured in the closed position.

Generally, the openable skylights should be regarded as a hatchway fitted at the same location. Appropriate requirements of 19.3 should be required, including the minimum height of sill, where required.

Additionally, if used as means of escape, they shall satisfy the same requirements as the hatches used as means of escape (see 19.3.1.3). If they are flush, they shall satisfy the same requirement of flush hatches so be watertight (see also 19.3.3.1).

19.4.5.3 Scantling of glazing pane of skylights fitted on the weather deck at position 1 (see the definition in 19.1.2.5) should be calculated as for the windows located at position A1 in fig. 19.4.3. Accordingly, glazing panes of skylights fitted on the weather deck at position 2 should be dimensioned for the load as required for the windows located at position B1 in fig. 19.4.3.

Skylight fitted on superstructure/deckhouses of higher tiers and not contributing to the buoyancy may be of the scantling as required for windows fitted at aft ends of the superstructure/deckhouses located immediately below the deck on which the skylight is fitted.

Requirements for scantling of skylight found in this item are not considered for the additional load of the person which may step on it - skylights fitted at positions intended to walk on will be considered on a case-by-case basis.

19.4.6 Storm shutters and deadlights

19.4.6.1 The purpose of storm shutters is to protect the glazing against impact by debris or other object and to provide resistance against extreme green sea loads and limit the ingress of water in case of breakage of the glazed openings.

Storm shutters should be fitted externally on the bulkhead at place of opening.

As a minimum, storm shutters shall be provided for openings located in side bulkheads of weathertight deck structures of tier 1 or at front bulkheads of those structures at tier 2 (positions B0 and B1 in fig. 19.4.3). However, for larger yachts with assigned summer freeboard greater for at least a standard superstructure height (h_S; equals 1.80 m) than minimum required according to Ch. III of the ICLL 1966, as amended, storm shutters may be omitted for openings located in side bulkheads at a height above the full load (summer) waterline greater than (0.05 L + 1.80) m, and in front bulkheads at a height above that waterline greater than (0.05 L + 3.60) m.

19.4.6.2 Where windows are requested with storm shutters, to waive them, glass thickness and equivalent thickness (in case of laminated construction) shall calculated using a design pressure increased by a factor 1.5 in respect to design pressure calculated according to 5.5 of the ISO 11336-1.

Alternatively, storm shutters may be also waived by hydrostatic test of the window with its design pressure p_D increased by a factor 1.5 in respect to design pressure calculated according to 5.5 of the ISO 11336-1. The testing procedure shall be in accordance with 7.3 of that standard.

19.4.6.3 The purpose of deadlights is to provide a means to maintain the watertight integrity of the buoyancy volume in case of breakage of the glazing or leakage of the glaze mounting.

Deadlights shall be provided to glazed openings in the side shell (hull and superstructures of full breadth). Positions of those openings are marked as A0 and A1 in fig. 19.4.3. Waiving deadlights to glazed openings in that area is not permitted.

19.4.6.4 Deadlights shall generally be permanently attached if located in shaded area in fig. 19.4.2.

For glazed opening of the non-openable type and for which it would be impractical to arrange the permanent fitted deadlight, a portable deadlight may be allowed instead. They shall be stored in an easily accessible location within or immediately adjacent to compartment on which the opening is fitted, in such a way that it can be readily and safely mounted in any sea condition. Glazed pane of the opening provided with portable deadlight shall be of the laminated glass, with scantlings corresponding to the increased design pressure of 1.3 p_D, with p_D calculated by the equation (1) of 5.5.1 of the ISO 11336-1.

19.4.6.5 Construction, scantlings and testing procedure for storm shutters and deadlights should be in compliance with Section 8 of the ISO 11336-1.

19.4.6.6 Guidance shall be included in the Operating Manual or similar Master instruction, on the sea state at which storm shutters and deadlights shall be fitted and on maintenance and inspection of the storm shutters and deadlights and their means of securing.

19.4.7 Materials and testing

Generally, materials for glazed panes and required testing procedures should be in accordance with Section 7 of the ISO 11336-1.

Additionally, all means of closing for openings which lead to enclosed spaces at positions 1 and 2, as defined in 19.1.2.5, shall be hose tested after installation on board. That includes hatches, doors, glazed openings and their protective covers. The hose test procedure shall be according to 1.2.4.2 of the *Rules for the classification of ships, Part 3 – Hull Equipment*.

19.5 VENTILATION OPENINGS

19.5.1 The ventilation openings serving spaces located below the freeboard/bulkhead deck, or an enclosed superstructure, shall be protected from direct green seas effect and shall be fitted with a sill of minimum height as indicated in table 19.1 of this Section.

The scantlings of ventilation ducts exposed to the weather shall be equivalent to those of the adjacent structure.

19.5.2 Smaller sill heights may be accepted for private yachts on a case-by-case basis, provided:

- ventilation opening is located in a protected area not directly exposed to green seas effect; and
- ventilation opening is fitted with efficiency system limiting direct water ingress (the efficiency of the system shall be hose tested).

19.5.3 Ventilation ducts openings of yachts in unrestricted area of navigation shall be provided with efficient weathertight closing appliances unless:

- The height of the sill is greater than 4.5 m, for opening fitted above the freeboard/bulkhead deck, or above exposed superstructure deck within the forward 1/4 L (at position 1, see 19.1.2.5); or
- the height of the sill is greater than 2.3 m, if opening is fitted elsewhere (at position 2, see 19.1.2.5).

As a general rule, closing appliances shall be permanently attached to the ventilation ducts opening.

19.5.4 The ventilation openings which needs to be open in navigation, such as the ones servicing machinery space (engine room), shall be fitted with water trap system, or other suitable means of preventing ingress of water and spray when open, and shall be provided with a suitable drainage arrangements leading overboard.

19.5.5 Regardless of the above, the ventilation openings which need to be open in navigation shall be considered as downflooding points in stability calculations. Stability curve shall be interrupted at the smallest angle at which any of those openings immerses.

19.6 AIR PIPES

19.6.1 Air pipes serving fuel and other tanks shall be of efficient construction and provided with permanently attached means of weathertight closure. Means of closure may be omitted if it can be shown that the open end of an air pipe is afforded with adequate protection by other structures which will prevent the ingress of water.

19.6.2 Where located on the deck exposed to weather, air pipes shall be kept as far inboard as practicable and be fitted with a sill of sufficient height to prevent inadvertent flooding. Generally, air pipes to tanks are to have a minimum sill height as indicated in table 19.1 of this Section.

19.7 FREEING PORTS

19.7.1 Water freeing arrangements should comply with requirements of ICLL 1966, as amended, as far as it is reasonable and practicable to do so.

19.7.2 In order to enable unobstructed flow of trapped green seas from the exposed deck areas limited by the bulwarks or recess walls, a sufficient number of freeing ports shall be opened in the bulwarks.

Required total area of openings on each side of a yacht in unrestricted area of navigation shall be greater than:

$A = 0.07\ l$

where:

A = total freeing port area for each side, in [m];

l = length of bulwark on one side, but need not exceed 0.7 L.

The value given from the above formula shall be corrected for the height of the bulwarks according to the following criteria:

- If the bulwark height exceeds 1.2 m, the freeing port area shall be increased by 0.004 m^2 per metre of bulwark length for each 0.1 m difference in height.
- Where the bulwark height is less than 0.9 m, the freeing port area shall be decreased by the same ratio as above.

19.7.3 Additionally to general requirement of 19.7.2, where a well is created on each side of the yacht between a superstructure (or deckhouse) and the bulwark in way of that superstructure (or deckhouse), the following formula may be used to determine the required freeing port area (A_{SS}) on each side of the well concerned:

$A_{SS} = 0.28 \cdot A_W / B$

where:

A_W = area of well in way of superstructure or deckhouse (see fig.19.7.3)

B = full breadth at deck.

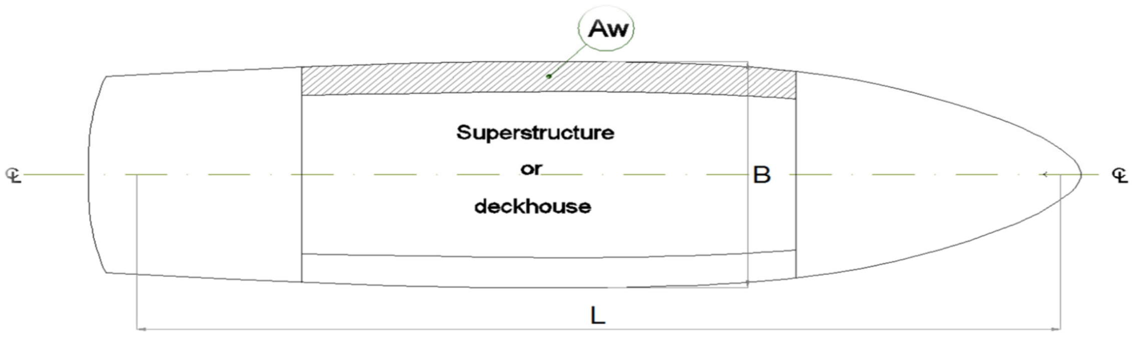
The arrangement of the ports opened along the bulwark up to total area A, as required by 19.7.2, should be such that total area of those ports located in part of the bulwark forming the well with superstructure (or deckhouse) side should not be less than A_{SS}.

19.7.4 Notwithstanding the provisions of 19.7.3, the arrangement of freeing ports along the length L should assure that at least half of the total area A, as required by 19.7.2, is provided at forward half of the length L.

It is recommended that at least 25% of the totally required area should be located in forward quarter (1/4) of the length L. If it is not feasible, that ratio may be reduced up to 20% of the total area.

19.7.5 On sailing yacht where the solid bulwark height does not exceed 150 mm, specific freeing ports, as defined in items above, are not required.

Figure 19.7.3



19.7.6 For superstructure deck above the first tier (position 2, see 19.1.2.5), the freeing ports area at each side should not be less than half of the value calculated by the formula in 19.7.2.

19.7.7 For yachts in restricted areas of navigation, when the above requirements are not feasible, alternative arrangements to achieve adequate safety standard may be considered by the *Register*. However, the minimum required total area of opening ports at one side of yacht shall not be less than:

- 0.75 A, for a yacht in restricted/short range navigation area on international voyages;
- 0.50 A, for a yacht in restricted navigation area not engaged on international voyages;

where A is the total area of openings per a side calculated according to formula provided in 19.7.2.

19.8 RECESSES

19.8.1 Any recess in the weather decks shall be of weathertight construction and shall be self-draining under all normal conditions of heel and trim of the yacht.

A swimming pool or spa bath open to the elements shall be treated as a recess.

19.8.2 The means of drainage provided shall be capable of efficient operation when the yacht is heeled to an angle of 10° - in the case of a motor yacht, and 30° - in the case of a sailing yacht.

The drainage arrangement is to have the capability of draining the recess (when fully charged with water) within 3 minutes when the yacht is upright and at its full (summer) draught. Means shall be provided to prevent the backflow of sea water into the recess.

19.8.3 When it is not practical to provide drainage which meets the above requirements, alternative safety measures may be considered on a case-by-case basis.

19.8.4 Regardless the drainage time, the effect of the recesses with opening area greater than 4 m^2 and which are full of water in normal operations (swimming pool or larger spa bath, for example), shall be taken into consideration with maximum free surfaces correction in intact stability calculations, and damage stability calculations if required.

20 INTACT STABILITY

20.1 GENERAL

20.1.1 The provisions given hereunder apply to yachts of 24 m to 80 m in length L, and which are not certified to carry more than 12 passengers, where:

L - is a length as defined in sub-item 1.4.2.4 of this Part of the Rules.

20.1.2 All yachts shall comply with the relevant set of stability criteria as required by the Flag State.

However, the yachts from item 20.1.1 shall comply as a minimum with stability criteria set in 20.2 of this Part of the Rules. The additional requirements of 20.3 should be satisfied also, as applicable.

For yacht of more than 80 m in length L, the requirements set in Section 2 of the *Rules for the classification of ships, Part 4 – Stability*, shall be complied with.

20.1.3 Generally, provisions and definitions from Section 1 of the *Rules for the classification of ships, Part 4 – Stability* shall be followed, as applicable.

20.1.4 Stability of yacht shall be checked for the following loading conditions:

.1 yacht in the fully loaded departure condition, having a draught to the summer load line, with 100% of stores and fuel, all crew, and with full number of passengers with their luggage and provisions needed;

.2 yacht in the fully loaded arrival condition, with crew, full number of passengers and their luggage and provisions, but with only 10% stores and fuel remaining;

.3 yacht in the minimum operating condition, with the minimum number of crew, and with 10% of stores and fuel;

.4 yacht in the lightship condition.

20.1.5 If there is solid ballast on board, its mass shall be included in the lightship condition. Solid ballast should be located in accordance with a plan approved by the *Register* and in a manner that prevents shifting of position. Particulars of permanent ballast and its position shall be noted in the yacht 's stability booklet. Permanent ballast shall not be removed from the yacht or relocated within the yacht without the approval of the *Register*.

The weight of ballast water may be included in the deadweight of the yacht, in load conditions where necessary. If any of the ballast tanks should be permanently full, it should be sealed, disconnected from the yacht's pipelines and treated as permanent ballast.

20.1.6 Enclosed superstructures, complying with reg. 3(19)(b) of the ICLL and fitted with doors complying with reg. 12 of the ICLL, may be taken as parts of the hull form on which the calculations of GZ curve are based.

20.1.7 For all loading conditions, the initial metacentric height and the righting lever curve shall be corrected for the effect of free surfaces of liquids in tanks, following the provisions set in item 1.4.7 of the *Rules for the classification of ships, Part 4 – Stability*.

20.1.8 Where anti-rolling devices are installed in a yacht, the *Register* shall be satisfied that the criteria can be maintained when the devices are not in operation.

20.1.9 Each yacht should be provided with a stability booklet, approved by the *Register*, which contains sufficient information as is necessary to enable the Master to obtain accurate guidance as to the stability of the yacht, under varying conditions of service, by rapid and simple processes and to operate the yacht in compliance with the applicable stability requirements. Information that should be provided in stability booklet are presented in Head 20.4.

20.1.10 On completion of loading of the yacht and prior to its departure, the Master shall check that the weight items loaded, number of persons on board, and the readings of drafts and trim of the particular loading case, are all inside the range of values corresponding to the loading cases from the approved stability booklet.

20.1.11 Datum draught marks shall be provided at the bow and stern, port and starboard, and be adequate for assessing the condition and trim of the yacht. Such draught marks maybe single datum lines.

The marks shall be permanent and easily read but need not be of contrasting colour to the hull. The marks need not indicate more than one draught at each position and shall be above, but within 1000 mm, of the deepest load waterline. The draught to which marks relate shall be indicated either above the mark on the hull and/or in the yacht's stability information booklet. The position of the marks shall be verified at initial placement by the *Register*.

20.2 STABILITY CRITERIA

20.2.1 Basic stability criteria for single-hull yachts

20.2.1.1 The following criteria shall be applied:

- Area below static stability (righting lever) curve (GZ - curve) up to the angle of 30^0 shall be at least 0.055 m-rad;
- area below static stability curve (GZ-curve) up to the angle of 40^0, or downflooding angle, whichever the least, shall be at least 0.09 m-rad;
- area below static stability curve (GZ-curve) from angle of 30^0 up to the angle of 40^0, or downflooding angle, whichever the least, shall be at least 0.03 m-rad;
- righting lever (GZ) shall be at least 0.2 m at an angle of heel equal to or greater than 30^o;
- minimum initial metacentric height (GM_0) shall be at least 0.15 m, taking into consideration free surface effect of any liquid in yacht's tanks.

20.2.1.2 The maximum righting arm (GZ) shall occur at an angle of heel not less than 25^o. For yachts of wide beam and small depth, indicatively with B/D $\geq$2.5, the following equivalent criteria are required as an alternative:

.1 the maximum righting lever (GZ) shall occur at an angle of heel not less than 15^o; and

.2 the area under the curve of righting levers (GZ curve) shall not be less than 0.070 m-rad up to an angle of 15° when the maximum righting lever (GZ) occurs at 15° and 0.055 m-rad up to an angle of 30° when the maximum righting lever (GZ) occurs at 30° or above. Where the maximum righting lever (GZ) occurs at angles of between 15° and 30°, the corresponding area under the righting lever curve shall be:
$0.055 + 0.001\,(30° - \theta_{max})$* [m-rad].

20.2.2 Basic stability criteria for multihull yachts

20.2.2.1 The following criteria shall be applied:

- Area below static stability curve (GZ) up to the angle θ shall be at least $A \geq 0.055 \cdot 30°/\theta$ [m-rad], where θ [in °] is the least of the following angles:
  - downflooding angle,
  - first peak (maximum) of the static stability curve (GZ), or
  - 30^0;
- area below static stability curve (GZ-curve) from angle of 30^0 up to the angle of 40^0, or downflooding angle, whichever the least, shall be at least 0.03 m-rad;
- the first peak (maximum) of the static stability curve (GZ) shall occur at angle of at least 15^0 ;
- righting lever (GZ) shall be at least 0.2 m at an angle of heel equal to or greater than 30°;
- minimum initial metacentric height shall be at least 0.15 m, taking into consideration free surface effect of any liquid in yacht's tanks.

20.2.3 Weather criterion

20.2.3.1 All yachts, including multihull yachts, shall meet weather criterion (strong waves and wind) for all load conditions from item 20.1.4 (except for lightship condition), with reference to figure 20.2.3 as follows:

.1 the yacht is subjected to a steady wind pressure acting perpendicular to its centreline which results in a steady wind heeling lever l_{w1};

.2 from the resultant angle of equilibrium θ_0, the yacht is assumed to roll owing to wave action to an angle of roll θ_1 to windward. The angle of heel under action of steady wind θ_0 shall not exceed 16° or 80% of the angle of deck edge immersion, whichever is less;

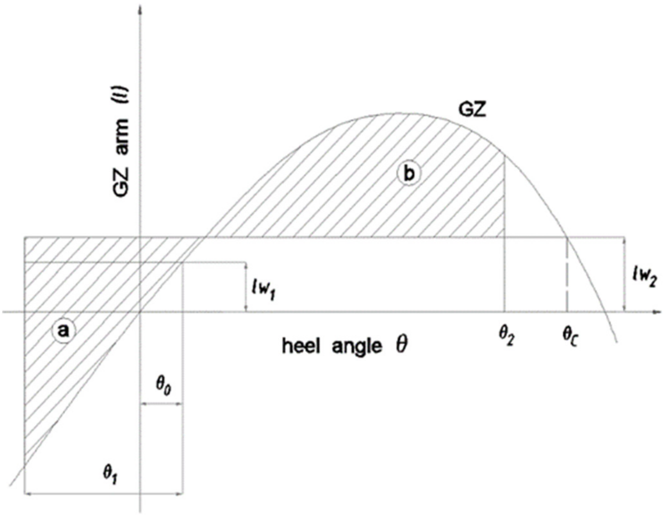
.3 the yacht is then subjected to a gust wind pressure which results in a gust wind heeling lever l_{w2};

.4 under these circumstances, area b shall be equal to or greater than area a, as indicated in figure 20.2.3;

.5 free surface effects shall be accounted for in all conditions of loading.

The angles in figure 20.2.3 are defined as follows:

Figure 20.2.3



θ_0 = angle of heel under action of steady wind

θ_1 = angle of roll** to windward due to wave action (see 20.2.3.1.2 and 20.2.3.3)

θ_2 = angle of down-flooding θ_f or 50° or θ_c , whichever is less,

where:

θ_f = angle of heel at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight immerse. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open.

θ_c = angle of second intercept between wind heeling lever l_{w2} and GZ curves.

20.2.3.2 The wind heeling levers l_{w1} and l_{w2} , referred to in 20.2.3.1.1 and 20.2.3.1.3, shall be taken as constant values at all angles of inclination (as in figure 20.2.3 - horizontal lines on diagram) for commercial yachts, as opposed to **Pleasure yachts**, for which these values may be varied by the square cosine function of the heel angle.

In both cases, the starting values (heel angle 0°) of wind heeling levers l_{w1} and l_{w2} shall be calculated as follows:

$$l_{w1} = \frac{P \cdot A \cdot Z}{1000 \cdot g \cdot \Delta} \quad \text{[m]} \quad \text{and}$$

$$l_{w2} = K \cdot l_{w1} \quad \text{[m]}$$

where:

* θ_{max} is the angle of heel in degrees at which the righting lever curve reaches its maximum.

** The angle of roll of yachts with anti-rolling devices shall be determined without taking into account the operation of these devices.

P = specific wind pressure value, calculated according to the table 20.2.3.2 and depending on the arm of windage area z_w:

z_w - distance between the centre of windage area and the actual waterline plane.

For intermediate values, *P* should be obtained by interpolation;

A = projected lateral area of the portion of the yacht above the waterline [m²];

Z = vertical distance from the centre of A to the centre of the underwater lateral area or approximately to a point at one half the mean draught [m];

Δ = displacement [t];

g = gravitational acceleration of 9.81 [m/s²];

K = 1.5; for **Pleasure yachts** in restricted service, it may be reduced to 1.0.

Table 20.2.3.2

Specific wind pressure, *P* [Pa]

z_w **[m]**	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
P **[Pa]**	113	159	195	226	252	276	298	319	338	356	374	390	406	421

20.2.3.3 The angle of roll θ_1 referred to in 20.2.3.1.2 shall be calculated as follows:

$$\theta_1 = 109\, k\, X_1\, X_2 \sqrt{r \cdot s} \quad \text{[degrees]}$$

where:

X_1 = factor as shown in table 20.2.3.3-1

X_2 = factor as shown in table 20.2.3.3-2

k = 1.0 for a round-bilged hull having no bilge or bar keels, or

= 0.7 for a hull having sharp bilges, or

= as shown in table 20.2.3.3-3 for a hull having bilge keels, a bar keel or both;

r = factor that should be calculated as follows:

$$r = 0.73 + 0.6\, OG / d$$

with:

OG = KG – *d*

KG = height of vertical centre of gravity (VCG) above baseline [m]

d = mean moulded draught of the yacht [m]

s = factor as shown in table 20.2.3.3-4, where *T* is the yacht roll natural period. In absence of sufficient information, the following approximate formula can be used:

Rolling period $T = \dfrac{2 \cdot C \cdot B}{\sqrt{GM}}$ [s]

where:

$C = 0.373 + 0.023\,(B/d) - 0.043\,(L_{WL}/100)$

Table 20.2.3.3-1

Values of factor X_1

B/d	X_1
≤ 2.4	1.0
2.5	0.98
2.6	0.96
2.7	0.95
2.8	0.93
2.9	0.91
3.0	0.90
3.1	0.88
3.2	0.86
3.3	0.84
3.4	0.82
≤ 3.5	0.80

Table 20.2.3.3-2

Values of factor X_2

C_B	X_2
≤ 0.45	0.75
0.50	0.82
0.55	0.89
0.60	0.95
0.65	0.97
≥ 0.70	1.0

Table 20.2.3.3-3

Value of factor *k*

$\dfrac{A_k \cdot 100}{L_{WL} \cdot B}$	*k*
0	1.0
1.0	0.98
1.5	0.95
2.0	0.88
2.5	0.79
3.0	0.74
3.5	0.72
≥ 4.0	0.70

Table 20.2.3.3-4

Value of factor *s*

T	*s*
≤ 6	0.100
7	0.098
8	0.093
12	0.065
14	0.053
16	0.044
18	0.038
≥ 20	0.035

(Intermediate values in these tables should be obtained by linear interpolation)

The symbols in the above tables and formula for the rolling period are defined as follows:

L_{WL} = length of the yacht at waterline [m];

B = moulded breadth of the yacht [m];

d = mean moulded draught of the yacht [m];

C_B = block coefficient;

A_K = total overall area of bilge keels, or area of the lateral projection of the bar keel, or sum of these areas [m^2];

GM = metacentric height corrected for free surface effect [m].

20.2.3.4 Instead of the data from tables and formulae presented in 20.2.3.3, the *Register* may accept the data obtained from model experiments of the particular yacht, following the procedure described in MSC.1/Circ.1200, as the alternative.

20.3 ADDITIONAL CRITERIA FOR SOME YACHTS

20.3.1 Stability of the sailing yachts

20.3.1.1 The requirements set in this item shall be applied to all yachts under sails.

20.3.1.2 For single-hull yacht, the following criteria shall be applied:

.1 Area (B+C) below the curve of static stability (GZ) shall be at least 1.4 times greater than area (A+B) (see figure 20.3.1);

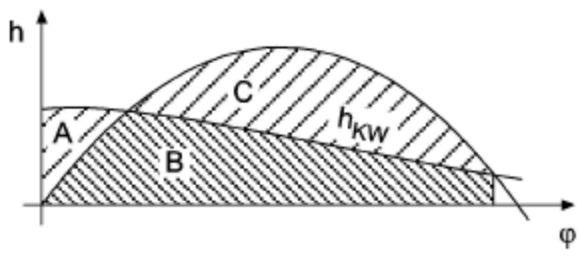
.2 the maximum GZ lever shall be at least 0.3 m;

.3 the positive range of the curve of static stability (GZ) shall be at least: 90° - for yachts with dedicated ballast keel (protruding from the keel line of the main hull); and 60° - for other yachts;

.4 initial transversal metacentric height, GM_0, shall be at least 0.6 m; and

.5 static angle of heel of the yacht, while sailing, shall be up to the least of the following values:
   a) angle of immersion of the deck edge,
   b) angle of immersion of the lower edge of sidescuttles, if openable, or
   c) 20°.

Fig. 20.3.1



$(B+C) \geq 1.4 \cdot (A+B)$

where:

h_{KW} - wind heeling lever, in m, due to wind action on the exposed area (including sails) of the yacht's lateral projection. It should be calculated as follows:

$$h_{KW} = \cos^2\varphi \cdot \frac{P \cdot A \cdot (z - Z)}{1000 \cdot g \cdot \Delta}$$

where:

P - value of wind pressure, in Pa [N/m^2], that shall be taken in accordance with the yacht's navigation area;

A - projected lateral area of the particular sail configuration and the portion of the yacht above the waterline, in m^2;

z - height of the centre of A above the baseline, in m;

Z - height of the centre of the underwater lateral area of the hull above the baseline, or, approximately, one half of the actual draught, in m;

g - 9.81 [m/s^2]; and

Δ - displacement of the yacht in actual load condition, in t.

Load conditions with the most unfavourable stability characteristics shall be included in stability analysis of the yacht under sails. However, at least full load condition (departure with passengers) and minimum operating condition shall be analysed.

Full sails setting should be considered when calculating lateral area A in the formulae above. However, if the yacht fails to satisfy the criterion in 20.3.1.2.1 with all sails set and for the wind taken in accordance with its navigation area, it shall be determined both of the following:

- the permissible wind speed, or force, at which the limit of stability set by the criterion is reached for full set of sails; and
- the permissible set of sails for which the criterion is satisfied, with the wind force taken as required for the yacht's navigation area.

20.3.1.3 For multihull vessels, the criteria set in 20.3.1.2 shall be applied, with required positive range of the curve of static stability (GZ) of at least 60°.

Additionally, requirements for longitudinal stability will be set by the *Register*, on case-by-case basis.

20.3.1.4 Alternatively, the regulations set by the Flag State may be used, if applied in their entirety (for example: *MCA The Large Commercial Yacht Code*; *Red Ensign Group Yacht Code – Part A*; *Transport Malta - Commercial Yacht Code*; *The Republic of Marshall Island - Yacht Code*; and similar).

20.3.2 Planning hull criteria

20.3.2.1 Additional criteria for planning crafts shall be fulfilled if the yacht speed, in m/s, exceeding the value:

$V > 3.7 \cdot V^{0.1667}$

where V is displaced volume, in m^3.

The heeling angle of yacht shall not exceed 12° while running at full speed in any of following cases:

- sudden displacement of all passengers;
- high-speed turning.

This angle shall be verified during sea-trials at calm sea.

20.3.2.2 Additionally, during the trials at calm sea, it should be verified with the *Register's* surveyor that the yacht, when cruising inside its operating speed limits, is not subjected to any of the dynamic instability phenomena, such as:

- chine walking,
- porpoising,
- bow diving,
- bow steering,
- progressive heeling, or
- any combination of the above stated.

20.4 STABILITY BOOKLET

20.4.1 Stability data and associated plans should be drawn up in the working language of the yacht. For the yacht in international services, if that language is not English, the textual parts of the booklet should also be presented in English and enclosed in the booklet. Any translation of the stability booklet of yacht in the process of initial survey should be approved.

20.4.2 The report of the inclining experiment, the trim and stability booklet and, when applicable, the damage stability calculation, shall be submitted to the *Register* for approval. For the purpose of the examination of stability characteristics, body lines plan, general arrangement plan, openings plan and capacity plan shall be submitted for review.

20.4.3 The format of the stability booklet and the information included will vary dependent on the yacht type and operation. The stability booklet shall include the following information:

.1 a general description of the yacht, including:
- the yacht's name and class ID No.
- the yacht's type and service notation
- the full class notation
- the yard, hull No. and the year of delivery
- the moulded dimensions, including the moulded draught to full load waterline
- the full load displacement;

.2 instructions on the use of the booklet;

.3 general arrangement and capacity plans showing watertight compartments and internal communications, also indicating the intended use of compartments and spaces on board;

.4 hydrostatic curves, or tables, for the ranges of displacement and trim that include all normal operating conditions (the results for hull on even keel shall be presented always). The displacement ranges in data shall be presented by draught measures (with clear indication whether the values are taken from the baseline or under the keel);

.5 cross curves (or tables) of stability, calculated on a free-trimming basis, for the ranges of displacement and trim that include all normal operating conditions (the results for hull on even keel shall be presented always). The displacement ranges in data shall be presented by draught measures (with clear indication whether the values are taken from the baseline or under the keel). Clear indication of all the spaces used as closed form for stability calculations shall be presented in this part of the booklet;

6 tank tables showing capacities, centres of gravity and max. free surface moment for each tank on board;

.7 clear information on any operative restrictions;

.8 information about openings exposed to weather and all general precautions for preventing unintentional flooding;

.9 information (or sketch) of the permanent ballast, if fitted;

.10 sketch of positions of the draught marks at hull, with reference on the draught datum used for hydrostatic and stability calculations;

.11 any other necessary data and aids for the safe operation of the yacht under normal and emergency conditions and to maintain the required intact stability and, if applicable, stability after damage;

.12 information concerning the operation of any special cross-flooding arrangements, if installed, with descriptions of damage conditions which may require cross-flooding;

.13 standard operating conditions, at least the ones listed in 20.1.4, and guidance for developing other acceptable loading conditions using the information contained in the booklet. Additionally, for sailing yachts, full load condition and minimum load operating condition shall also be checked for different set of sails, as required by 20.3.1.2;

.14 the results of intact stability calculations (including floating state data, GZ curve and comparation of the results with the criteria values) shall be presented for every operating condition listed in the booklet;

.15 a table of contents and index for each booklet;

.16 lightship data from the inclining test report, or where the stability data are based on a sister yacht, the inclining test report of that sister yacht, along with the lightship measurement report for the yacht in question.

20.4.4 Additionally to the data listed in previous item, sailing yachts are to have some further information included:

- sail plan, with presentation of max. sail area; and
- sketches of sail sets allowed for the particular wind force (speed), if such restrictions are imposed; or
- information of the max. wind force (speed) that yacht can safely withstand with the particular set of sails; or

- steady heel angle limit up to which the yacht is still considered safe to sail.

20.4.5 For yachts which have to fulfil the damage stability requirements of Head 21.3, clear guidance should be noted as to the type and extension of the hull damage and number and positions of flooded spaces for which the yacht is certified to stay in safe state of floating. All instructions concerning the damage control operations needed shall be stated in the booklet.

20.4.6 Provisional stability documentation, based on the estimated lightship particulars, should be submitted for approval to the *Register* during the design phase. It should include check of all stability requirements applicable to the particular yacht (intact, damage, for sailing, for planning).

20.4.7 Final stability documentation, based on the results of the inclining experiment or the lightweight check (see Head 20.5 for clarification), shall be submitted for approval to the *Register*.

When the difference between the estimated lightship characteristics and those obtained from the results of inclining experiment is less than:

- 2% for the difference in lightship weight,
- 1% of the L_{PP}, for the difference in LCG position, and
- 0.2% rise of the measured KG value above the estimated one (with 4 cm of rise set as an absolute limit),

the provisional stability documentation may be accepted as the final stability documentation.

20.4.8 Yacht with previously approved stability information which undergoes a major refit or alteration shall be subjected to a complete reassessment of stability, which includes a new inclining experiment and the approval of related new stability booklet.

For the purpose of this Section, a major refit or major alternation is the one which results in change of at least one of the estimated lightship characteristics above the limits stated in 20.4.7.

20.4.9 Any rigging modification of sailing yacht that increases the overall sail area, or the weight/dimensions of the rig aloft, shall results in updating of the stability booklet, which needs to be re-approved**.**

20.4.7 Stability booklet of yachts provided with stabilizers is to contain instruction to the effect that those devices can have to the stability characteristics of the yacht. The requirements of the stabilizer operation manual should be complied with, also. List of loading conditions for which stabilizers are not to be used shall be presented, if such condition exists, as well as the cases when stabilizers shall be quickly activated.

20.5 DETERMINATION OF LIGHTSHIP CHARACTERISTICS

20.5.1 General

After its completion, the yacht shall be inclined. In some particular cases, as described in 20.5.2.3, the *Register* may accept a lightweight check instead.

The inclining experiment or the lightweight check shall be attended by a surveyor of the *Register*. The *Register* may accept inclining experiment or lightweight check attended by a member of the Flag State.

20.5.2 Lightweight check

20.5.2.1 The lightweight check is a survey which involves auditing all weights on board which shall be added, deducted, or relocated on the yacht at the time of the survey, so that the observed condition of the yacht can be adjusted to the lightship condition. The weight and longitudinal, transverse and vertical location of each weight shall be accurately determined and recorded. The static waterline of the yacht at the time of the survey can be determined by measuring the yacht's freeboard or draught readings, leading to the calculation of the yacht's hydrostatic data for the measured sea density. The lightship displacement and longitudinal centre of gravity (LCG) can be obtained by using all thus obtained information.

20.5.2.2 Lightweight check can be done as a stand-alone test, as in cases noted in 20.5.2.3, or as a survey forming a part of the inclining experiment. During the inclining experiment, the lightweight survey should be done immediately prior the inclining itself.

20.5.2.3 The *Register* may allow a lightweight check to be carried out instead of the inclining experiment in the following cases:

.1 For an individual yacht, provided basic stability data are available from the inclining experiment of a sister yacht and a lightweight check is performed in order to prove that the particular yacht corresponds well to the prototype yacht. In such case the *Register* is satisfied when the results of the lightweight check show a deviation in lightship weight from the prototype yacht not greater than 2%, and a deviation of longitudinal position of the centre of gravity (LCG) of not more than 1% of the length between perpendiculars (L_{PP}). Consequently, the stability data from the prototype ship may be used for the final stability booklet;

.2 On a case by case basis and subject to the agreement of the Flag State, provided that:
- a detailed list of weights and positions of their centre of gravity is submitted,
- a lightweight check is carried out, showing accordance between the estimated values and those determined, and
- adequate stability (with significant margin above the criteria values) is demonstrated in all loading conditions presented in the trim and stability booklet.

20.5.3 Inclining experiment

20.5.3.1 The inclining experiment is a procedure which involves moving a series of known weights, normally in the transverse direction, and measuring the resulting changes in the equilibrium heel angle of the yacht. By using this information and applying basic naval architecture principles, the yacht's vertical centre of gravity (KG, or VCG) is determined.

20.5.3.2 The inclining experiment is required in the following cases:

.1 For any new yacht after its completion, except for the cases specified in 20.5.2.3;

.2 For any yacht if deemed necessary by the *Register*, where any alteration is made that materially affects the stability (see 20.4.8).

20.5.3.3 A detailed procedure for conducting an inclining experiment is presented in Appendix 3 of *The Rules for the classification of ships, Part 4 - Stability*. For the lightweight check, the same procedure applies, but excepting the provisions referring to inclining itself (Sections 6, 9, 10, 11, 12 and 13 of the Appendix).

21 SUBDIVISION AND DAMAGE STABILITY

21.1 APPLICATION

21.1.1 The provisions given in the section apply to commercial and **Pleasure yachts** of 24 m to 80 m in length L, and which are not certified to carry more than 12 passengers, where:

L - is length as defined in item 1.4.2.4 of this Part of the *Rules*.

21.1.2 Damage stability requirements on yachts of more than 80 m in length L and navigating in unrestricted area of operations will be in each case considered separately by the *Register*, but in general, the yacht certified as **Pleasure yacht**, or commercial yacht restricted to operate in areas within 60 NM from a safe haven, should meet the damage stability requirements of the SOLAS 90 for one compartment (Chapter II-1, Part B, Reg. 8 [2.3] to [6]) according to the deterministic method, while the commercial yacht in unrestricted service should meet damage stability requirements of the contemporary SOLAS edition, applicable as to the cargo ship (probabilistic method).

21.1.3 Yachts referred to in 21.1.1 and restricted to operate in areas within 60 NM from a safe haven may be exempted of the requirements of Head 21.3 of this Section.

For those yachts, the following note shall be added to the approved stability booklet: “This vessel has not been assessed for damage stability, and therefore might not remain afloat in the event of damage or flooding.”

21.2 SUBDIVISION AND WATERTIGHT INTEGRITY

21.2.1 General

21.2.1.1 All Yachts shall have at least the following complete transverse watertight bulkheads fitted in the hull:

- A collision bulkhead;
- An after peak bulkhead;
- Two bulkheads forming the boundaries of the machinery space; for yachts with machinery space fitted astern, aft bulkhead of that space may be treated as after peak bulkhead, if it is proved by calculation that the flooding of part of the hull aft oft that bulkhead will result in floating condition which satisfy the requirement of item 21.3.1;
- Regardless of the position of the machinery place, yacht with L greater than 65 m should have at least 4 complete transverse bulkhead to ensure sufficient transverse strength.

Special subdivision arrangements generated by specific functional requirements may be considered by the *Register* on case by case basis.

21.2.1.2 Additional bulkheads may be required for yachts having to comply with damage stability criteria, according to requirements of Head 21.3 of this Section.

21.2.1.3 The transverse watertight bulkheads requested in the items 21.2.1.1 and 21.2.1.2 of this Section shall, generally, be fitted up to the bulkhead deck, as it is defined in item 1.4.2.9 of this Part of the *Rules*. Structural drawings of those bulkheads shall be to be submitted to the *Register* for approval. In general, the provisions for construction and initial tests of watertight bulkheads set in Heads 10.2, 15.3, 15.4 or 16.6 of this Part of the *Rules*, depending of the building material.

21.2.1.4 Each watertight subdivision bulkhead, whether transverse or longitudinal, shall be constructed having scantlings and arrangements capable of preventing the passage of water in any direction under the head of water likely to occur in intact and, if applicable, in damaged conditions. In the damage conditions, the head of water shall be considered in the worst situation, considering both the equilibrium and intermediate stages of flooding.

In all cases, watertight subdivision bulkheads shall be capable of supporting at least the pressure due to a head of water up to the bulkhead deck.

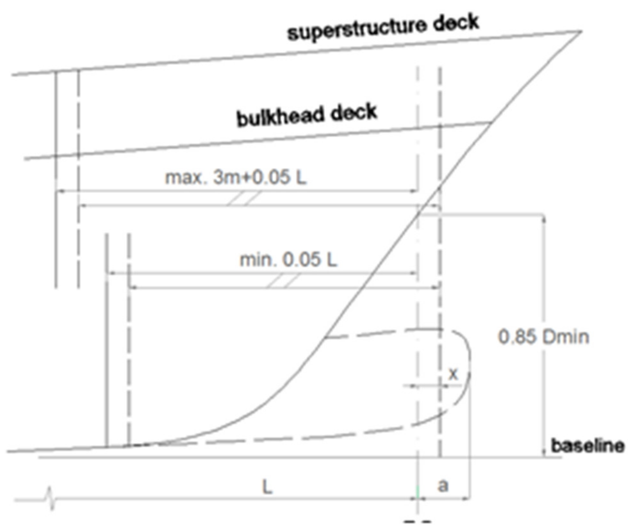
21.2.1.5 Steps and recesses in watertight bulkheads shall be as strong as the bulkhead at the place where each occurs.

21.2.1.6 The provisions of this Section represent the minimum standard required. In the case of discrepancy between the specific regulations of the Flag State (if available) and this Section of the Rules, the former shall apply.

21.2.2 Collision bulkhead

21.2.2.1 A forepeak or collision bulkhead shall be fitted and made watertight up to the bulkhead deck. This bulkhead shall be located at a distance from the forward perpendicular of not less than 5 % of the length L and not more than 3 metres plus 5 % of the length L (see fig. 21.2.2.1).

Fig. 21.2.2.1



Where:

D_{min} = the least moulded depth, according to *Regulation 3* of ICLL 1966, as amended by the Protocol of 1988.

21.2.2.2 Where any part of the hull below the waterline extends forward of the forward perpendicular, e.g. a bulbous bow, the distances required in 21.2.2.1 shall be measured from a point located forward of the fore perpendicular at a distance x (see fig. 21.2.2.1), found:

- at the mid-length (a/2) of such extension; or
- at a distance 1.5 % of the length L; or
- at a distance of 3 metres,

whichever gives the smallest measurement.

21.2.2.3 Collision bulkhead may have steps or recesses, provided they are within the limits stated in 21.2.2.1 (considering also 21.2.2.2, if applicable).

21.2.2.4 For yachts of 500 GT or less in restricted areas of operation, the part of collision bulkhead above the full load waterline may be fitted at a distance less than 5 % L from the forward perpendicular (see fig. 21.2.2.4), if the Flag State doesn't have any objections to it, and provided that:

.1 The position of that part of the bulkhead is both at least (0.2 m + y) aft of the fore perpendicular and at least 4 % L from the foremost point at stem (including forecastle, if fitted), where
y - horizontal distance from the foremost point of the bulkhead deck to the fore perpendicular, in metres;

.2 The lower part of the bulkhead is stepped in aft direction at the level at least 0.5 m above the full load waterline;

.3 The vertical part of the bulkhead under the step, as defined in .2 above, is fitted at a distance from the forward perpendicular of not less than 5 % of the length L;

.4 Neither part of the bulkhead, including the step, is positioned at less than 0.5 m from the stem post outline (measured perpendicularly to that contour line); and

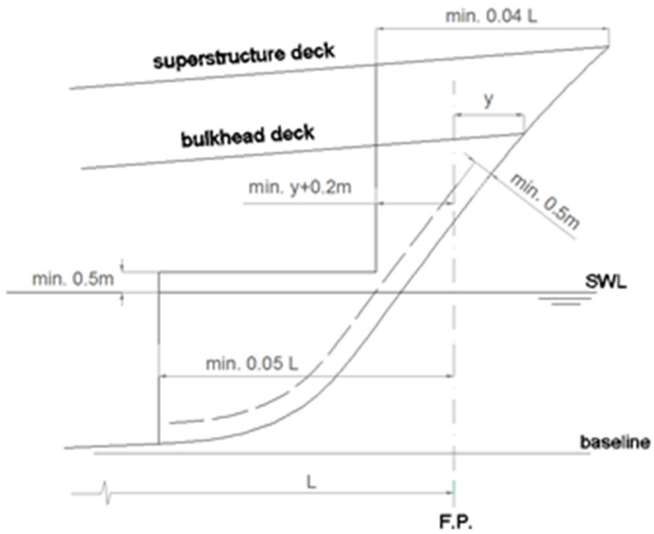
.5 If not accessible, the space of the recess thus created below the horizontal part of the bulkhead is filled with closed cell high density foam for FRP hull, or empty and arranged for easy visual inspection for hull made of other materials.

21.2.2.5 Where a long forward superstructure is fitted, the collision bulkhead shall be extended weathertight to the next full deck above the bulkhead deck.

That extension need not be fitted directly above the bulkhead below, provided all parts of the extension are not located forward of the forward limit specified in 21.2.2.1 (considering also 21.2.2.2, if applicable), or in 21.2.2.4, for yachts on which that sub-item applies.

21.2.2.6 No essential equipment, except anchor windlass, shall be located forward of the collision bulkhead. Exceptionally, and only if the collision bulkhead is located within the limit set out in 21.2.2.1 (considering also 21.2.2.2, if applicable), the emergency bilge and/or fire pump may be located in the space forward of the bulkhead, provided that the easy access from the open deck is arranged and that no other suitable location may be found on board. In that case, the access from the exposed deck shall be treated as an opening that should be used at sea (considering the requirements of the Section 19 of this Part of the Rules).

Fig. 21.2.2.4



21.2.2.7 After further analysis, different arrangements than stated above may be accepted by the *Register*, on a case by case basis.

21.2.3 Afterpeak and machinery space bulkheads

21.2.3.1 An afterpeak bulkhead, and complete transverse bulkheads dividing the machinery space from the accommodation spaces, shall also be fitted and made watertight up to the bulkhead deck. The afterpeak bulkhead may, however, be stepped below the bulkhead deck, provided the same level of watertightness is kept for all parts of such bulkhead, and that the longitudinal extent of the step or recess, measured from the plane of the main transverse bulkhead, is not more than 8 % of L.

21.2.3.2 In all cases where they protrude fore of the after peak bulkhead, stern tubes shall be enclosed in separated watertight space of moderate volume. The stern gland shall be situated in a watertight shaft tunnel or other watertight space of moderate volume, separate from the compartment in which the stern tube is situated. For yachts of 500 GT or less in restricted areas of operation, other measures to minimise the danger of water penetrating into the yacht in case of damage to sterntube arrangements may be taken at the discretion of the *Register*.

21.2.4 Openings in watertight bulkheads

21.2.4.1 The number of openings in watertight subdivisions shall be limited to a minimum compatible with the proper working of the yacht. Pipes and electrical cable may be carried through watertight subdivisions provided that both the watertightness and structural integrity of the bulkhead are ensured by devices suitable in the opinion of the *Register*. Details relevant to these devices and their installation on board shall be submitted to the *Register* for approval.

Lead or other heat sensitive materials may not be used in systems which penetrate watertight subdivision bulkheads and decks, where deterioration of such systems in the event of fire would impair the watertight integrity.

21.2.4.2 As far as the collision bulkhead is concerned, in general a maximum of two pipes may pass through the collision bulkhead below the bulkhead deck. Such pipes shall be fitted with suitable valves operable from above the bulkhead deck and the valve chest shall be secured at the bulkhead inside the fore peak. Such valves may be fitted on the after side of the collision bulkhead provided that they are readily accessible under all service conditions. All valves shall be of steel, bronze, or other approved ductile material.

As a general rule, no access, ventilation duct or any other opening shall be fitted in the collision bulkhead. Special consideration will be given in the particular cases, at the agreement with the Flag State, provided that:

- An access opening is closed with a manhole with close spaced bolts;
- the manhole is positioned as far as practicable above the full load waterline (summer load line);
- a permanent sign is fitted at easy visible position on the bulkhead, indicating that the manhole shall be permanently closed at sea; and
- an alarm, with indicator at the visible place for the crew, is automatically actuated when the manhole is open.

21.2.4.3 Doors in watertight bulkheads shall be watertight doors of the approved type. The strength of the doors shall be equivalent to the surrounding bulkheads. The hand opening and hand closing devices of the door shall be operable from both sides of the door.

For yachts under 500 GT, the *Register* may accept approved hinged doors provided that for such doors indicators are fitted on the bridge showing whether the doors are open or closed. The doors shall be kept closed at sea and marked accordingly.

For yachts equal to or greater than 500 GT, approved hinged doors, with provisions stated above, may be accepted for infrequently used openings in watertight compartments where a crew member will be in immediate attendance when the door is open at sea.

If fitted, sliding watertight doors shall comply to the requirements for such doors, stated in 7.12 of the *Rules for the classification of ships, Part 3 – Hull equipment* The structural requirements and hydraulic test, however, are also applicable to hinged doors.

21.2.5 Openings in outer shell

21.2.5.1 General

The number of openings in the shell plating shall be reduced to the minimum compatible with the design and proper working of the yacht. The arrangement and efficiency of the means for closing any opening in the shell plating shall be consistent with its intended purpose and the position in which it is fitted.

The number of scuppers, sanitary discharges and other similar openings in the shell plating shall be reduced to the minimum either by making each discharge serve for as many as possible of the sanitary and other pipes, or in any other satisfactory manner. All inlets and discharges in the shell plating shall be fitted with efficient and accessible arrangements for preventing the accidental admission of water into the yacht.

In general, the requirements for shell openings set in Reg.15 [8] to [11], Ch. II-1 of the SOLAS Convention, as amended, shall be complied with.

21.2.5.2 Side doors and stern doors

A compartment located below the bulkhead deck, as it is defined in item 1.4.2 of this Part of the Rules, and having a direct access opening on the hull shall be equipped with a watertight door at the shell opening and shall be bounded by watertight bulkheads to separate it from the other adjacent compartments located below the bulkhead deck.

Side doors and stern doors shall be so fitted as to ensure tightness and structural integrity according to their location and the surrounding structure. The lower part of door opening shall be above the maximum load waterline (summer load line). Doors should be of outwards opening type. Scantlings of the doors and supporting structure, their securing and locking arrangement and procedures shall be compliant with the requirements of item 7.4.2 of the *Rules for the classification of ships, Part 3 – Hull Equipment*, regarding the yacht as a ro-ro cargo ship with opening area greater than 6 m^2.

Indicators shall be fitted on the bridge showing whether the doors are open or closed. The doors shall be kept closed at sea and marked accordingly.

Drawings representing the structure of the side/shell doors, their locking devices and their height above the summer waterline, shall be submitted to the *Register* for approval, with a general arrangement enclosed, showing the intended use of the compartment which the doors give access to and the machinery and/or recreational (or sport) vehicles and crafts stored within.

No essential equipment shall be installed in the compartment with shell doors. Access opening to other internal compartments may be permitted exclusively if watertight door of approved type, with indication of opening installed at the bridge, is fitted for closing of such opening.

For yachts of less than 500 GT, the emergency bilge and/or the emergency fire pumps may be fitted in such a compartment if it does not contain petrol and if it has an additional access independent from the machinery space.

21.2.5.3 Engine exhaust outlets

Engine exhaust outlets which penetrate the hull below the bulkhead deck shall be provided with means to prevent back flooding into the hull through a damaged exhaust system. For yachts operating on unrestricted service a positive means of closure shall be provided. The system shall be of equivalent construction to the hull on the outboard side to the closure. Other arrangements may be separately considered by the *Register*, on agreement with the Flag State.

For yachts referred to in 21.1.3 of this Section, it may be accepted that exhaust piping of equivalent construction to the hull is looped up above the waterline on the outboard side of the system to a height as close as possible to the bulkhead deck. In general, the minimum height of that loop above the full load waterline (summer load line) should not be less than 1000 mm. The transverse position of the inboard side of the loop should be also as close to the centreline as possible.

In any case, the material used for exhaust piping shall be suitable to withstand the temperatures reached by the exhaust.

21.2.5.4 Fin shaft stabiliser

If a fin stabiliser is provided, the watertightness of the hull in way of the fin shaft crossing shall be insured. As a general rule, that equipment shall be fitted inside a watertight compartment, or a watertight space of moderate volume. Inspection and maintenance access to such space shall be of the watertight type.

21.2.5.5 Other fittings

Recesses for wells, gangways, winches, platforms, etc shall be watertight and of strength equivalent to that of the adjacent structures. Any penetrations for electrical wiring and piping are to ensure watertight integrity. Discharges shall be provided to prevent the accumulation of water in the normal foreseeable situations of transverse list and trim.

Small openings which are part of on-board systems, as outer shell connections and valves, etc., shall meet requirements laid down in 23.10.

Provision for glazed openings (sidescuttles and windows) are stated in 19.3.

21.3 DAMAGE STABILITY

21.3.1 The watertight bulkheads of the yacht to which the requirements of this Head apply shall be so arranged that minor hull damage that results in the free flooding of any one compartment, will cause the yacht to float at a waterline which, at any point, is not less than 75 mm below the weather deck, freeboard deck, or bulkhead deck if not concurrent.

21.3.2 The minor damage shall be considered to occur anywhere along the yacht's waterline length (from the baseline up to the level of the waterline), except in way of a watertight bulkhead. Only one compartment or one tank is considered as damaged at one time.

However, if a down-flooding or progressive flooding may occur through pipework, ventilation ducts, doors, hatches or any other non-watertight openings, the flooding of the concerned compartments shall be considered.

21.3.3 The damage stability calculations shall be performed using the lost buoyancy method (constant displacement).

21.3.4 The stability required in the final condition after damage, and after equalisation if provided, shall be determined as follows:

.1 The positive residual righting lever curve shall have a minimum range of 15° beyond the angle of equilibrium. This range may be reduced to a minimum of 10° in cases where the area under the righting lever curve is that specified in sub-item .2, multiplied by the ratio 15/range, where range is expressed in degrees.

.2 The area under the righting lever curve shall be at least 0.015 m-rad, measured from the angle of equilibrium to the lesser of:
- the angle at which progressive flooding occurs;
- 22° (measured from upright).

21.3.5 The final conditions of the yacht after damage, and after equalisation if provided, shall be as follows:

.1 in the final equilibrium state there shall be a positive residual metacentric height of at least 50 mm;

.2 in the case of unsymmetrical flooding, the angle of heel shall not exceed 7° for yachts in unrestricted area, and 12° for yachts in unrestricted area of navigation;

.3 in no case shall the margin line, as defined in 21.3.1, be submerged in the final stage of flooding.

21.3.6 For the purpose of making damage stability calculations, the permeability of each watertight compartment or part of a compartment shall be as follows:

Spaces	Permeability
Appropriated to stores	0.60
Occupied by accommodation	0.95
Occupied by machinery	0.85
Void spaces	0.95
Intended for liquids	0 or 0.95*
* Whichever results in the more severe requirement	

21.3.7 When any of the unprotected opening leading to the watertight compartment not directly flooded by considered damage, submerges in the final equilibrium state, it shall be regarded as a major progressive flooding. The righting lever curve shall be considered as terminated at the angle for which progressive flooding occurs and the range and the area referred to in 21.3.4.1 and 21.3.4.2 shall be measured to that angle.

Unsymmetrical flooding shall be kept to a minimum consistent with efficient arrangements. Where it is necessary to correct large angles of heel, the means adopted shall, where practicable, be self-acting, but in any case where controls to cross-flooding fittings are provided, they shall be operable from above the bulkhead deck. The maximum angle of heel after flooding but before equalisation shall not exceed 15°. Where cross-flooding fittings are required, the time for equalisation shall not exceed 15 minutes. Suitable information concerning the use of cross-flooding fittings shall be supplied to the master of the yacht.

21.3.8 The master of the yacht shall be supplied with the data necessary to maintain sufficient intact stability under service conditions to enable the yacht to withstand the critical damage. In the case of yachts requiring cross-flooding, the master shall be informed of the conditions of stability on which the calculations of heel are based and shall be warned that excessive heeling might result if the yacht would sustain damage when in a less favourable condition.

22 FIRE SAFETY

22.1 GENERAL REQUIREMENTS

22.1.1 General

The fire safety objectives of this Section are to:

.1 prevent the occurrence of fire and explosion;
.2 reduce the risk to life caused by fire;
.3 reduce the risk of damage caused by fire to the yacht and the environment;
.4 contain, control and suppress fire and explosion in the compartment of origin; and
.5 provide adequate and readily accessible means of escape for passengers and crew.

In order to achieve the fire safety objectives, the following functional requirements are embodied in this Section, as appropriate:

.1 appropriate separation of spaces by structural boundaries;
.2 restricted use of combustible materials;
.3 minimization of possibility of ignition;
.4 detection of any fire in the space of origin;
.5 containment and extinction of any fire in the space of origin;
.6 protection of means of escape and access for firefighting; and
.7 ready availability of fire-extinguishing appliances.

Due to particular attention that shall be dedicated to yachts with hull and/or superstructure made of non-metallic material, their acceptance for classification is generally limited to 500 GT. The *Register* may, on case by case basis, consider acceptance for classification of yacht of 500 GT and upwards with hull and/or superstructure made of non-metallic material.

Fire safety design and arrangements may deviate from the prescriptive requirements set out in this Section, provided that the design and arrangements meet the fire safety objectives and the functional requirements, this being confirmed by engineering analysis, evaluation and approval of the alternative design and arrangements.

Furthermore, the requirements of the Flag State or other equivalent rules or standards may be considered by the *Register*, on a case by case basis, instead of requirements of this Section.

22.1.2 Definitions

For the purpose of this Section, the following definitions are adopted:

.1 *Accommodation spaces* – those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, game and hobby rooms, barber shops, pantries containing no cooking appliances and similar spaces.

.2 “A” class *divisions* – those divisions formed by bulkheads and decks which comply with the following:

  .1 they shall be constructed of steel or other equivalent material;
  .2 they shall be suitably stiffened;
  .3 they shall be so constructed as to be capable of preventing the passage of smoke and flame to the end of the one-hour standard fire test (see FTP Code);
  .4 they shall be insulated with approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 140 °C above the original temperature, nor will the temperature, at any one point, including any joint, rise more than 180 °C above the original temperature.
  Depending on the time within which the above-indicated temperature rise is ensured in the course of the standard fire test, they may be assigned the following fire integrity standards:
    .1 Class "A-60" for 60 min;
    .2 Class "A-30" for 30 min;
    .3 Class "A-15" for 15 min;
    .4 Class "A-0" for 0 min.

The *Register* requires a test of a prototype bulkhead or deck in accordance with the Fire Test Procedures Code to ensure that it meets the above requirements for integrity and temperature rise. Insulated “A” class bulkheads and decks used on board ships, including the means of affixing the insulation to the "A” class structural members, shall be consistent with the materials, details and arrangements used during, and documented in the test reports issued for the approval test for that insulating material.

.3 *“B” class divisions* – those divisions formed by bulkheads, decks, ceilings or linings which comply with the following:

  .1 they shall be constructed of approved noncombustible materials (combustible veneers are permitted, if in compliance with other applicable requirements of this Rules);
  .2 they shall be constructed as to be capable of preventing the passage of flame to the end of the first half an hour of the standard fire test (see FTP Code).
  .3 they shall have an insulation value such that the average temperature of the unexposed side will not rise more than 140 °C above the original temperature, nor will the temperature at any one point, including any joint, rise more than 225 °C above the original temperature.
  Depending on the time within which the above-indicated temperature rise is ensured in the course of the standard fire test, they may be asigned the following fire integrity standards:
    .1 Class "B-15" for 15 minutes;
    .2 Class "B-0" for 0 minutes.

The *Register* requires a test of a prototype division in accordance with the Fire Test Procedures Code to ensure that it meets the above requirements for integrity and temperature rise.

"B" class divisions used on board ships shall be consistent with the materials, details and arrangements used during, and documented in the test reports issued for, the approval test for that divisions.

.4 *Bulkhead deck* – the uppermost deck up to which the transverse watertight bulkheads are carried.

.5 *"C" class divisions* – fire-resisting divisions constructed of approved non-combustible materials. They need meet neither requirements relative to the passage of smoke and flame nor limitations relative to the temperature rise. Combustible veneers are permitted provided they meet the requirements of this Section.

.6 *Combustible material* – any material other than a non-combustible material.

.7 *Continuous "B" class ceilings or linings* – those "B" class ceilings or linings which terminate at an "A" or "B" class division.

.8 *Continuously manned central control station* – a central control station which is continuously manned by a responsible member of the crew.

.9 *Control stations* – those spaces in which the yacht's radio or main navigating equipment or the emergency source of power is located or where the fire recording or fire control equipment is centralized. Spaces where the fire recording or fire control equipment is centralized are also considered to be a fire control station.

.10 *Fire Test Procedures Code* – the International Code for Application of Fire Test Procedures, 2010 (2010 FTP Code), as adopted by resolution MSC.307(88), as amended.

.11 *Helideck* – a purpose-built helicopter landing area located on a yacht including all structure, fire-fighting appliances and other equipment necessary for the safe operation of helicopters.

.12 *Helicopter facility* – a helideck including any refuelling and hangar facilities.

.13 *Low flame-spread* – means that the surface thus described will adequately restrict the spread of flame, this being determined in accordance with the Fire Test Procedures Code.

.14 *Machinery spaces* – machinery spaces of category A and other 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.

.15 *Machinery spaces of category A* – those spaces and trunks to such spaces which contain either:

.1 internal combustion machinery used for main propulsion;

.2 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

.3 any oil-fired boiler or oil fuel unit, or any oil-fired equipment other than boilers, such as incinerators, etc.

.16 *Non-combustible material* – a material which neither burns nor gives off flammable vapours in sufficient quantity for self-ignition when heated to approximately 750°C, this being determined in accordance with the Fire Test Procedures Code.

.17 *Not readily ignitable* – surface material that will not, upon removal of suitable test flame, continue to burn more than 20 seconds.

.18 *Oil fuel unit* – any equipment used for the preparation and delivery of oil fuel, heated or not, to boilers (including inert gas generators) and engines (including gas turbines) at a pressure of more than 0.18 N/mm^2.

.19 *Public spaces* – those portions of the accommodation which are used for halls, dining rooms, lounges, and similar permanently enclosed spaces.

.20 *Steel or other equivalent material* – any non-combustible material which, by itself or due to insulation provided, has structural and integrity properties equivalent to steel at the end of the applicable exposure to the standard fire test (e.g., aluminium alloy with appropriate insulation).

.21 *Sauna* – a hot room with temperatures normally varying between 80°C and 120°C where the heat is provided by a hot surface (e.g., by an electrically heated oven). The hot room may also include the space where the oven is located and adjacent bathrooms.

.22 *Fire Safety Systems Code* – the International Code for Fire Safety Systems (FSS Code), as adopted by resolution MSC.98(73), as amended.

.23 *Service spaces* – spaces used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, storerooms, work-shops other than those forming part of the machinery spaces, and similar spaces and trunks to such spaces.

.24 *Standard fire test* – a test in which specimens of the relevant bulkheads or decks are exposed in a test furnace to temperatures corresponding approximately to the standard time-temperature curve in accordance with the test method specified in the FTP Code.

.25 *Vehicle spaces* – cargo spaces intended for carriage of motor vehicles with fuel in their tanks for their own propulsion.
.26 *Weather deck* – a deck which is completely exposed to the weather from above and from at least two sides.
.27 *Winching area* - a pick-up area provided for the transfer by helicopter of personnel or stores to or from the yacht, while the helicopter hovers above the deck.

22.1.3 Fire control plan

22.1.3.1 Fire control plan shall be permanently exhibited for the guidance of the crew, showing clearly for each deck the control stations, the various fire sections enclosed by ''A'' class divisions, the sections enclosed by ''B'' class divisions together with particulars of the fire detection and fire alarm systems, the sprinkler installation, the fire-extinguishing appliances, means of access to different compartments, decks, etc., Plan shall be kept up to date; any alterations thereto shall be recorded as soon as practicable. Description in such plan shall be in the language or languages required by the Flag State. If the language is neither English nor French, a translation into one of those languages shall be included.

22.1.3.2 Graphical symbols for fire control plan shall be colour painted and shall comply with IMO Res. A.952(23), as amended (see ISO 17631:2202).

Ships constructed before 1 January 2004 may continue to use the IMO Res. A.654(16), see MSC/Circ.1050.

22.1.3.3 Fire control plan shall be kept up to date, any alterations being recorded thereon as soon as practicable.

22.1.3.4 On yachts of 500 GT and above, in addition to 22.1.3.2, requirements in 22.7.1.2 shall be applied.

22.2 FIRE GROWTH POTENTIAL REDUCTION AND PREVENTION OF IGNITION

22.2.1 Materials

22.2.1.1 All insulation (e.g. fire and comfort) shall be of non-combustible material, except in refrigerated compartments of service spaces.

On yachts of less than 300 GT, acoustic insulation may be of not readily-ignitable materials, subject to the *Register's* special consideration, on case by case basis.

22.2.1.2 In spaces where penetration of oil products is possible, the surface of insulation shall be impervious to oil or oil vapours. Insulation boundaries shall be arranged to avoid immersion in oil spillages.

22.2.1.3 Vapour 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 low flame-spread characteristics.

22.2.1.4 Pipes penetrating 'A' or 'B' Class divisions shall be of approved materials having regard to the temperature such divisions are required to withstand.

Pipes conveying oil or other combustible liquids through accommodation and service spaces shall be of approved materials having regard to the fire risk.

Materials readily rendered ineffective by heat are not to 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. Due regard shall be paid to the Fire Test Procedures Code.

22.2.1.5 On yachts of less than 500 GT, in spaces not fitted with sprinkler or equivalent fire extinguishing system:
.1 upholstery composites (fabric in association with any backing or padding material) used throughout the yacht excluding open decks shall be approved in accordance with the Fire Test Procedures Code, Annex 1, Part 8, or equivalent;
.2 organic foams used in upholstered furniture and mattresses shall be of the combustion modified type;
.3 suspended textile materials such as curtains or drapes shall be approved in accordance with the Fire Test Procedures Code, Annex 1, Part 7, or equivalent.

22.2.1.6 Additional requirements for yachts of 500 gross tonnage and upwards

22.2.1.6.1 Paints, varnishes and other surface finishes to be used in machinery spaces, galleys, exposed interior surfaces and spaces with fire risk are not to be capable of producing excessive quantities of smoke or toxic products when they burn, this being determined in accordance with the Fire Test Procedures Code.

Primary deck coverings, if applied within accommodation and service spaces and control stations, shall be of approved material which will not readily ignite nor give rise to smoke or toxic or explosive hazards at elevated temperatures, this being determined in accordance with the Fire Test Procedures Code.

22.2.1.6.2 All linings, ceilings, draught stops and their associated grounds shall be of non-combustible materials in accommodation and service spaces and control stations.

In spaces protected by an automatic sprinkler system and fully addressable fire detection system, this requirement may be omitted.

22.2.1.6.3 Neither combustible nor oil-absorbing materials shall be used as flooring, bulkhead lining or ceiling in the propulsion machinery control room, machinery spaces, shaft tunnel or rooms where oil tanks are located.

22.2.1.6.4 The following surfaces shall have low flame-spread characteristics in accordance with the Fire Test Procedures Code.
.1 exposed surfaces in corridors and stairway enclosures and of ceilings in accommodation and service spaces (except saunas) and control stations; and
.2 surfaces and grounds in concealed or inaccessible spaces in accommodation and service spaces and control stations.

22.2.1.6.5 The galley floor shall be lined with ceramic tiles or equivalent materials.

22.2.2 Engine room arrangements

22.2.2.1 Use of combustible materials and stowage of flammable materials, except fuel oil in tanks, are not permitted in engine room.

On wooden yachts, particular care shall be taken to prevent oil absorption into the structural elements.

22.2.2.2 The following limitations shall apply to the use of oil:

.1 Storage, distribution and utilisation of fuel and lubricating oil shall be designed in order to minimise the risk of fire.

.2 Except as otherwise permitted by this Section, no oil fuel with a flashpoint of less than 60°C shall be used.

.3 Non-metallic fuel and lubricating oil tanks, on yachts having FRP or wooden hull, shall be located outside engine room. Detachable fuel oil tanks shall be located such that air can circulate around the tank and that they can be readily inspected or movable for inspection.

.4 Fuel oil, lubrication oil and other flammable oils shall not be carried in forepeak tanks.

.5 No flammable oil tank shall be situated where spillage or leakage therefrom can constitute a fire or explosion hazard by falling on heated surfaces, electrical equipment, air intakes or on other sources of ignition.

.6 Flammable oil tanks situated on weather decks and other exposed positions shall be suitably protected against the effect of sun rays.

.7 In order to contain the oil, a drip tray in way of the engine may be accepted.
All residues of persistent oils shall be, by suitable means, collected and retained on board for discharge to collection facilities ashore.

.8 Fuel and lubricating oil pipes which, if damaged, would allow oil to escape from tank, having a capacity of 500 lit. and above, situated above the double bottom shall be fitted with a cock or valve, capable of being closed locally and from a safe position outside the space containing the tank, directly on the tank.
In the case of fuel and lubricating oil tanks having a capacity less than 500 litres or where valves are normally closed (except during transfer operation), remote controls need not to be fitted.

.9 As far as practicable, parts of the oil fuel system containing heated oil under pressure exceeding 0.18 N/mm^2 shall not be placed in a concealed position such that defects and leakage cannot readily be observed. The machinery spaces in way of such parts of the oil fuel system shall be adequately illuminated.

.10 Fuel transfer pumps, fans, oil fired boilers and separators shall be capable of being stopped from outside the machinery space.

.11 Fuel filter bowls shall be of metal construction.

22.2.2.3 The ventilation of machinery spaces shall be sufficient under normal conditions to prevent accumulation of explosive vapours.

22.2.2.4 Engine room boundaries, including closing devices on openings, shall be suitably arranged to prevent escape of fire-extinguishing medium during fire extinguishing.

22.2.3 Heating equipment, saunas and thermal suites

22.2.3.1 Heating equipment

Space heaters (electric radiators or similar), if used, shall be fixed in position and so constructed as to reduce fire risks to a minimum. No such heaters shall be fitted with an element so exposed that clothing, curtains, or other similar materials can be scorched or set on fire by heat from the element.

Electric heating shall comply with the requirements specified in the *Rules for the classification of ships, Part 12 – Electrical Equipment*, 15.1 and 15.2.

Steam and electric radiators shall be fixed in a position at a distance of not less than 50 mm from bulkheads or linings. If the bulkheads and linings are of combustible material, the portions located against the heating elements shall be screened with heat deflectors of non-combustible material, otherwise the heating elements shall be at a distance of not less than 150 mm from the bulkheads and linings made of combustible materials.

22.2.3.2 Construction and arrangement of saunas

22.2.3.2.1 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, on yachts of 500 GT and upwards, against other spaces, except to those inside of the perimeter of the sauna. The fire class may be reduced to “A-30” on yachts under 500 GT, or “B-15” in case of short-range yachts of less than 300 GT.

22.2.3.2.2 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.

22.2.3.2.3 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).

22.2.3.2.4 The traditional wooden benches are permitted to be used in the sauna.

22.2.3.2.5 The sauna door shall open outwards by pushing.

22.2.3.2.6 Electrically heated ovens shall be provided with a timer.

22.2.3.2.7 Electrical equipment, cables and wiring in saunas shall comply with the requirements specified in *Rules for the classification of ships, Part 12 – Electrical Equipment*, 15 and 16.8.

22.2.3.2.8 All spaces within the perimeter of the sauna shall be protected by a fire detection and alarm system and an automatic sprinkler system or equivalent fire extinguishing system. Exemption from requirement for fire extinguishing system may be considered, at the direction of the *Register*, on case by case basis.

22.2.3.3 Construction and arrangement of Thermal Suites (Steam rooms)

22.2.3.3.1 The perimeter of the thermal suite may include changing rooms, showers and toilets.

22.2.3.3.2 Bathrooms with direct access to the suite may be considered as part of it. In such cases, the door between the suite and the bathroom need not comply with fire safety requirements.

22.2.3.3.3 If the steam generator is mounted within the perimeter of the suite, the suite's boundary shall be constructed of:

.1 at least "A-0" fire class divisions on yachts of 500 gross tonnage and upwards and/or having steam generator installed power of 5 kW and over; or

.2 at least "B-0" fire class divisions on yachts of less than 300 gross tonnage and steam generator installed power of less than 5 kW.

Pipes leading to discharge nozzles shall be thermally insulated.

22.2.3.3.3 In case that thermal suite contains a sauna, the requirements in 22.2.3.2 shall be applied, regardless of the location of the steam generator.

22.2.3.3.4 All spaces within the suite's perimeter shall be protected by a fire detection and alarm system.

22.2.4 Deep-fat fryers

22.2.4.1 Deep-fat fryers of cooking oil capacity 15 litres and over shall be fitted with the following:

.1 an automatic or manual fire-extinguishing system tested to an international standard acceptable to the *Register*;

.2 a primary and backup thermostat with an alarm to alert the operator in the event of failure of either thermostat;

.3 arrangements for automatically shutting off the electrical power upon activation of the fire-extinguishing system;

.4 an alarm for indicating operation of the fire-extinguishing system in the galley where the equipment is installed; and

.5 controls for manual operation of the fire-extinguishing system which are clearly labelled for ready use by the crew.

22.2.4.2 For fryers of cooking oil capacity of less than 15 litres, instead of compliance with requirements in 22.2.4.1 the following may be provided, subject to the *Register's* acceptance on case by case basis:

.1 class F or K class fire extinguisher; and

.2 manual isolation of the electrical power supply.

22.2.5 Gaseous fuel (liquified petroleum gas) for domestic purposes

22.2.5.1 Gaseous fuel (Liquified petroleum gas) systems used for domestic purposes shall be approved by the *Register*.

The *Register* may accept the use of gaseous fuel for domestic purposes if gaseous fuel and all components of gaseous fuel arrangement (gas cylinders, gaseous fuel consumers, etc.) comply with recognized standards.

22.2.5.2 Gaseous fuel may be used for galley ranges, rapid water-heaters and provision refrigerators consuming not more than 1 kg of gas per hour. Gaseous fuel of higher capacity may be considered, on case by case basis.

22.2.5.3 Gaseous fuel consumers shall be fitted with automatic shutdown valve for stopping flow of gas in the event of burners flame failure.

For rapid water-heaters pilot flame shall be provided in addition.

22.2.5.4 Enclosed spaces intended for gas-cylinders store-room shall be efficiently ventilated.

Store-room shall be located on the open deck and have direct access from the open deck. Access door shall be opened outwards and shall be fitted with lock and a conspicuous warning signs: "Danger-Explosion"; "No smoking".

22.2.5.5 Location for the storage of gas cylinders on the open deck (not more than two cylinders) shall be so chosen as to preclude mechanical damage of the cylinders and shall be at a distance of not less than 2 m from the accommodation spaces and control stations and shall not be contiguous with store-rooms for flammable liquids. Such a location shall be at a safe distance from the life-saving equipment also.

The cylinders shall be protected from the direct sun-light and from the access of the unauthorized persons thereto by the grating walls and door. In the close vicinity of the cylinders corresponding warning signs shall be exhibited (see 22.2.5.4).

The depth of a recess into a deck structure, used for the exclusive storage of gas cylinders, shall be not greater than 1 m (*see MSC.1/Circ.1276*).

Galleys provided with gas-fired equipment shall not be located adjacent to store-rooms for flammable liquids and combustible materials.

On yachts of less than 500 GT see 22.2.5.22.

22.2.5.6 Electric equipment located in store-room for gas cylinders shall comply with the requirements specified in Rules for the classification of ships, Part 12 – Electrical Equipment, Section 19.

22.2.5.7 Stowage of gas cylinders shall comply with the following requirements:

.1 cylinders shall be stowed in upright position with stop valves on top and secured with straps or similar quick release arrangements;

.2 pressure reducing valve shall be provided between gas cylinder and piping;

.3 where stowage of more than two gas cylinders is provided, a manifold with only one pressure reduction valve may be fitted. Copper pipes shall be used for connection between gas cylinders and the manifold.

.4 shut-off valve or cock shall be fitted between each cylinder and the manifold. Warning sign prohibiting use of more than one cylinder at the same time shall be provided in close vicinity.

22.2.5.8 Enclosed spaces in which gaseous fuel consumers are installed shall comply with following:

.1 the space shall not be located below the lowest open deck;

.2 rapid water-heaters shall be provided with separate flue-gas discharge ducts.

22.2.5.9 Seamless-steel or copper pipes shall be used for gas-distribution piping. Steel pipes shall be protected against corrosion.

22.2.5.10 The wall thickness of pipes shall comply with the requirements prescribed in *Rules for the classification of ships, Part 8 – Piping,* 1.3.

22.2.5.11 Distribution piping between cylinders and gaseous fuel consumers shall be led on weather deck and protected from mechanical damage.

22.2.5.12 Piping joints shall be of the welded type. Threaded joints or flange joints may be used only for control-measuring instruments, fittings and gaseous fuel consumers.

22.2.5.13 A shut-off valve or cock shall be fitted on distribution piping which shall be operated from outside the cylinder store-room. The shut-off valve or cock shall have indication for open and closed position.

22.2.5.14 Where provision is made for more than one gaseous fuel consumer, distribution piping for each consumer shall be fitted with shut-off valve or cock with indication for open and closed position. If such valves or cocks are located in the store-room, arrangements shall be provided to operate them from outside the store-room.

In latter case no shut-off valve or cock on manifold is required (see 22.2.5.13).

22.2.5.15 Pressure reducing valve setting shall not be higher than 5 kPa.

22.2.5.16 A safety valve with a setting pressure of less than 7 kPa shall be provided with gas outlet leading to a safe place on the open deck and fitted close-after to the pressure reducing valve. The safety valve need not be provided if the reducing valve is so designed that gas flow to the low-pressure side is avoided in the case of failure or break of membrane.

22.2.5.17 Piping fittings shall be made of bronze, brass or other non-sparking corrosion-resistant material.

22.2.5.18 Pipeline from gas cylinder to pressure reducing valves shall be tested:

.1 in a workshop, by hydraulic pressure of 2.5 MPa.

.2 after installation on board, by air pressure of 1.7 MPa.

Pipelines from pressure reducing valve to gaseous fuel consumers shall be tested for tightness by air pressure of 0.02 MPa, after installation on board.

22.2.5.19 Galley flue gas ducts from gas-fired equipment, when passing through and/or being contiguous with accommodation spaces, service spaces and control stations, shall comply with the requirements for construction and fire insulation as required for exhaust ducts from galley ranges and shall be provided with automatic fire damper close to the boundaries penetrated (*see MSC/Circ.1276*).

22.2.5.20 Except wooden chopping board, no combustible materials shall be used in galleys provided with gas-fired equipment.

22.2.5.21 The relaxation of application of the requirements of 22.2.5.5 on yachts of restricted service, other than yachts specified in 22.2.5.22, is subject to special consideration by the *Register* in each particular case.

22.2.5.22 On yachts of less than 500 GT, having gas-cylinders store-room located on sun deck above accommodations (e.g. salon, cabins), in case that additional safety measures are provided, the *Register* may waive the requirement for distance of not less than 2 m between gas-cylinders store-room and the accommodation spaces below, and approve location of gas-cylinders store-room above accommodation.

Required additional safety measures are:

.1 passenger access to sun deck shall be prohibited; and

.2 “No smoking” signs shall be provided at sun deck; and

.3 gas-cylinders store-room boundaries, including weakened top boundary, shall be of approved design (drawing showing details shall be submitted for approval); and

.4 gas-cylinders store-room floor deck shall be “A-60” insulated from the accommodation rooms below; and

.5 not more than 2 gas cylinders for domestic use (cylinders for industrial use are not permitted) could be kept aboard (in gas-cylinders store-room); and

.6 gas-cylinders store-room shall be located at least 3 m away from ventilation inlets/outlets and sources of heat; and

.7 gas-cylinders store-room shall be located at least 3 m away from life rafts and lifeboats.

On yachts of less than 300 GT, the *Register* may allow arrangement of store-room on open deck other than sun deck, on case by case basis.

22.2.5.23 Hydrocarbon gas detectors and carbon monoxide detectors shall be provided in any compartment containing a gas-consuming appliance, or in any adjoining space into which the gas (denser than air) may enter.

22.5.24 Materials which are fitted closer than 500 mm to open flame cooking and heating appliances shall be non-combustible.

Curtains or any other suspended textile materials shall not be fitted within 600 mm of any open flame appliance.

22.2.6 Store-rooms for flammable liquids and readily combustible materials

22.2.6.1 Flammable liquids and readily combustible materials shall be stowed in a separate and designated enclosed spaces.

On yachts made of wood, paint, flammable liquids and readily combustible materials shall not be stored on board.

22.2.6.2 Store-room for flammable liquids shall be, in general, located on the open deck and have direct access from the open deck.

Entrance door shall be opened outward and provided with a lock and conspicuous warning signs: "Flammable Liquids"; "No Smoking".

22.2.6.3 Store-room for readily combustible materials shall be, in general, not situated in common with accommodation and service spaces and control stations.

Access shall be provided from the open deck directly or through a corridor or a stairway leading to this room. Entrance door shall be provided with a lock.

22.2.6.4 Location and arrangement of store-room designated for storage of fuel oil with a flash point of less than 43°C shall be subject to special consideration be the *Register* in each particular case.

The fuel oil shall be packaged in metal jerrycans having capacity of not exceeding 60 *l* and fitted with fixed tight closing lids.

For the requirements for helicopter refuelling facilities see 22.10.

22.2.6.5 Store-rooms for flammable liquids shall be mechanically ventilated with separate exhaust fan.

Ventilation shall be so arranged to prevent the build-up of flammable vapours at low and high parts of the store-room. The inlets and outlets of ventilation shall be positioned so that they do not vent into or take air from an area that could cause hazard and shall be fitted with spark arresters.

22.2.6.6 Fire-extinguishing arrangements in store-rooms for flammable liquids shall comply with the requirements as specified in *Rules for the classification of ships, Part 17 – Fire protection*, Section 10.

22.2.6.7 Electric equipment located in store-room for flammable liquids shall comply with requirements specified in *Rules for the classification of ships*, *Part 12 – Electrical Equipment*, 19.4.

22.2.7 Ventilation

22.2.7.1 On yachts of less than 500 GT, requirements in 22.2.7.2 to 22.2.7.9 shall be applied.

On yachts of 500 GT and upwards, *Rules for the classification of ships, Part 17 – Fire protection*, 9.7 shall be applied as for cargo ship.

22.2.7.2 Ventilation systems serving category A machinery spaces shall be independent of ventilation systems serving other spaces.

22.2.7.3 Power ventilation of machinery spaces and galleys 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.

Main inlets and outlets of the ventilation system of machinery spaces and galleys shall be readily closable from outside the spaces being served.

Means of control shall be provided for opening and closure of skylights, closure of openings in funnels which normally allow exhaust ventilation and closure of ventilator dampers.

22.2.7.4 Ventilation ducts serving category A machinery spaces, galleys, spaces containing vehicles or craft with fuel in their tanks or lockers containing fuel tanks shall not pass through accommodation spaces, service spaces or control stations unless the trunking is constructed of steel (minimum thickness 3 mm) and fire insulated to "A-30" class ("B-15" on yachts of less than 300 GT) for at least 5 metres in length from the entrance in the accommodation spaces, service spaces or control stations.

On yachts of 500 GT and upwards, the above insulation shall be "A-60" for the entire length of the duct within the accommodation spaces.

22.2.7.5 For ducts specified in 22.2.7.4, automatic fire dampers shall be provided in the deck or bulkhead within the accommodation spaces, service spaces or control stations.

The automatic fire dampers shall also be manually operable from outside the machinery space or galley.

22.2.7.6 The requirements in 22.2.7.4 and 22.2.7.5 also apply vice versa, i.e. to ventilation ducts for accommodation spaces, service spaces or control stations passing within category A machinery spaces, galleys, spaces containing vehicles or craft with fuel in their tanks or lockers containing fuel tanks.

22.2.7.7 Enclosed spaces in which generating sets and non-structural fuel tanks are installed shall have ventilation separate from systems serving other spaces.

Tank spaces separated from engine room, containing non-structural fuel oil tanks, shall be fitted with exhaust ventilation independent of ventilation systems serving other spaces.

22.2.7.8 For ventilation of store-rooms for flammable liquids see 22.6.5.

22.2.7.9 Suitable means of ventilation to prevent the accumulation of flammable gases which may be emitted from batteries shall be provided.

22.3 CONTAINMENT OF FIRE

22.3.1 General

22.3.1.1 In order to contain a fire in the space of origin, the yacht shall be subdivided by thermal and structural boundaries in accordance with the fire risk. Where openings and penetrations are fitted at these fire divisions, the fire integrity of the divisions shall be maintained at openings and penetrations.

22.3.1.2 Fire resistance requirements of divisions are specified in 22.3.2 and 22.3.3.

See also requirements for materials in 22.2.1 and definitions of "A" and "B" class fire divisions in 22.1.3.

Equivalent fire divisions, acceptable without testing, are specified in 22.3.1.4. and 22.3.1.5.

22.3.1.3 Fire divisions using steel equivalent (aluminium), or fire divisions on yachts having non metallic structure may be accepted if it can be demonstrated that the division, due to non-combustible insulation provided, has required fire resistance properties.

Insulation of the division shall provide that the temperature of the structural core does not rise above the point at which the structure would begin to lose its strength at any time during the applicable exposure to the standard fire test as referenced in FTP Code. For “A” class divisions, the applicable exposure is 60 minutes, and for “B” class divisions, the applicable exposure is 30 minutes.

For aluminium alloy structures, the insulation shall provide that the temperature of the structural core does not rise more than 200ºC above the ambient temperature at any time during the applicable fire exposure.

For composite structures, the insulation shall provide that the temperature of the laminate does not rise more than the minimum temperature of deflection under load of the resin at any time during the applicable fire exposure. The temperature of deflection under load shall be determined in accordance with a recognised international standard.

Insulation need only be applied on the side that is exposed to the greatest fire risk (for example inside the engine room), a division between two such spaces shall however be insulated on both sides unless it is a steel division.

22.3.1.4 The following fire divisions are considered equivalent to “A-30” class division and are acceptable without testing:

.1 steel division:
4,0 mm steel plate insulated with at least 50 mm of type approved mineral wool of at least 100 kg/m3 density;

.2 aluminium alloy division:
5,5 mm aluminium alloy plate insulated with at least 80 mm of type approved mineral wool of at least 100 kg/m3 density; or

.3 composite division:
Two layers of 30 mm of type approved mineral wool of at least 130 kg/m3 density. Layers shall be suitably alternated.

In any case, the outer surface of the mineral wool shall be impervious to oil and oil vapours.

22.3.1.5 The following fire divisions are considered equivalent to “B-15” class division and are acceptable without testing:

.1 steel division:
4,0 mm steel plate with at least 25 mm of type approved mineral wool of at least 100 kg/m3 density.

.2 composite division:
35 mm of type approved mineral wool of at least 150 kg/m3 density, outer surface lined with steel sheet of not less than 1,0 mm thickness; or
two layers of 25 mm of type approved mineral wool of at least 100 kg/m3 density. Layers shall be suitably alternated. The outer surface of the mineral wool shall be impervious to oil and oil vapours; or
reinforced plastic of at least 13 mm thickness having self-extinguishing final laminate layer of not less than 1,5 mm thickness.

.3 wooden division:
35 mm of type approved mineral wool of at least 150 kg/m3 density, outer surface lined with steel sheet of not less than 1,0 mm thickness.

22.3.1.6 Particular attention shall be given to the fixing of fire door frames in bulkheads constructed of materials other than steel. Measures shall be taken to ensure that the temperature of the fixings, when exposed to fire, does not exceed the temperature at which the bulkhead itself loses strength.

22.3.1.7 Openings (doors, windows, portholes, glazing) in fire resisting divisions shall be provided with permanently attached means of closing which shall be at least as effective for resisting fires as the divisions in which they are fitted and shall be to the satisfaction of the *Register*.

22.3.1.8 Penetrations through fire resisting divisions (for passing of pipes, cables, and ducts) shall not decrease fire resistance of that division and shall be to the satisfaction of the *Register*.

22.3.2 Requirements for fire divisions on yachts of less than 500 GT

22.3.2.1 This item is primarily concerned with protection of high-risk spaces such as the engine room and galley.

22.3.2.2 Machinery spaces of category “A”, shall be totally enclosed by “A-30” class boundaries (bulkheads, side shell and deck heads); steel yacht need not have side shell insulated.

On yachts of less than 300 GT, such machinery spaces shall be totally enclosed by “B-15” class boundaries (bulkheads, side shell and deck heads); steel yacht need not have side shell insulated.

Windows within the exterior hull or superstructure within this boundary are not expected to meet “A-30” or “B-15”, as applicable, standards.

22.3.2.3 Yachts of 300 GT and upwards shall have galleys totally enclosed by “B-15” class boundaries (bulkheads, side shell and deck heads).

Windows within the exterior hull or superstructure within this boundary are not expected to meet “B-15” standards.

22.3.2.4 Openings in “A” and “B” Class divisions shall be provided with permanently attached means of closing that shall be at least as effective for resisting fires as the divisions in which they are fitted.

Generally, windows or scuttles shall not be fitted in machinery space boundaries.

22.3.2.5 Where “A” or “B” Class divisions are penetrated for the passage of electric cables, pipes, trunks, ducts, etc., or for girders, beams or other structural members, arrangements shall be made to ensure that the fire resistance is not impaired.

22.3.2.6 Where “A” Class divisions are required to be insulated, it shall be ensured that the heat from a fire is not transmitted through the intersections and terminal points of the divisions or penetrations to uninsulated boundaries. Where the insulation installed does not achieve this, arrangements shall be made to prevent this heat transmission by insulating the horizontal and vertical boundaries or penetrations for a distance of 450 millimetres.

22.3.2.7 The required insulation of shell shall extend to at least 300 mm below the lightest waterline.

22.3.2.8 Shaft seals and other parts of shaft line arrangement that in case of fire could be damaged and therefore cause the ingress of water into the hull, have to be made of metallic material. Only small parts of these items can be non-metallic, provided that they are protected from the effect of a fire or be reasonably fire resistant.

22.3.2.9 Regarding requirements for fire characteristics of ceiling, lining, floor, and other materials used see 22.2.1.

22.3.3 Requirements for fire divisions on yachts of 500 GT and upwards

22.3.3.1 For determining the appropriate fire integrity standards to be applied to divisions between adjacent spaces, such spaces are classified according to their fire risk as shown in categories (1) to (9) below. Where the contents and use of a space are such that there is a doubt as to its classification for the purpose of this item, or where it is possible to assign two or more classifications to a space, it shall be treated as a space within the relevant category having the most stringent boundary requirements. Smaller, enclosed rooms within a space that have less than 30% communicating openings to that space are considered separate spaces. The title of each category is intended to be typical rather than restrictive.

(1) Control stations:
Spaces containing emergency sources of power and lighting.
Wheelhouse and chartroom.
Spaces containing the yachts' radio equipment.
Fire control stations, including fire-extinguishing rooms, Fire control rooms and fire-recording stations.
Control room for propulsion machinery when located outside the machinery space.
Spaces containing centralized fire alarm equipment.

(2) Corridors:
Corridors and lobbies (for guests and for crew).

(3) Accommodation spaces:
Cabins, dining rooms, lounges, offices, pantries containing no cooking appliances (other than equipment such as toasters and microwave ovens) 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 m^2 and drying rooms and laundries.

(6) Machinery spaces of category A:
Spaces as defined in 22.1.3.15.

(7) Other machinery spaces:
Spaces as defined in 22.1.3.14, excluding machinery spaces of category A.
Sprinkler, drencher, or fire pump spaces.

(8) Service spaces (high risk):
Galleys, pantries containing cooking appliances, saunas, paint lockers and store-rooms having areas of 4 m^2 or more, lamp rooms, spaces for the storage of flammable liquids, workshops other than those forming part of the machinery spaces, spaces containing vehicles or craft with fuel in their tanks, lockers storing such fuels and storage lockers for gaseous fuels for domestic purposes.

(9) 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 spaces outside superstructures and deckhouses).

22.3.3.2 Category A machinery spaces shall be separated from accommodation spaces, service spaces, control stations, stairways and corridors by "A-60" class divisions.

In addition, where the hull is built in combustible material, category A machinery spaces and spaces containing internal combustion machinery or oil fired boilers shall be enclosed by "A-30" class divisions.

22.3.3.3 Accommodation spaces, stairways and low risk service spaces shall be divided from corridors by "B-0" class divisions.

Control stations, other machinery spaces and high-risk service spaces shall be divided from corridors by "A-0" class divisions.

22.3.3.4 All bulkheads required to be "B" class shall extend from deck to deck unless a continuous ceiling in "B" class divisions is fitted.

22.3.3.5 The required insulation of shell shall extend to at least 300 mm below the lightest waterline.

22.3.3.6 Regarding requirements for fire characteristics of ceiling, lining, floor, and other materials used see 22.2.1.

22.3.4 Protection of stairways and lifts in accommodation and service spaces

22.3.4.1 Stairways shall be separated from other spaces by enclosures having fire class divisions at least "A-0". Stairways shall be of steel frame construction. The *Register* may consider other materials providing that equivalent fire resistance is ensured.

22.3.4.2 For yacht of 500 GT and upwards:

.1 an isolated stairway which penetrates a single deck only may be protected at one level only by at least "B" class divisions and self-closing door; and

.2 stairways may be fitted in the open in a public space, provided they lie wholly within such public space.

22.3.4.3 For yacht of 500 GT and upwards:

In so far as is practical, stairway enclosures shall not provide direct access to galleys, machinery spaces, service lockers (high fire risk category 8) or other enclosed spaces containing combustibles in which a fire is likely to originate.

22.3.4.4 For yacht of 500 GT and upwards:

A lift trunk shall be so fitted as to prevent the passage of flame from one 'tweendeck to another and means of closing shall be provided to permit the control of draught and smoke.

22.3.5 Ppenings in fire divisions on yachts of 500 GT and upwards

22.3.5.1 In addition to 22.3.1.7, the requirements in 22.3.5.2 to 22.3.5.7 apply on yachts of 500 GT and upwards, except for hatches between store and baggage spaces, and between such spaces and the weather decks.

22.3.5.2 The construction of all doors and door frames in "A" class divisions, with the means of securing them when closed, shall provide resistance to fire as well as the passage of smoke and flame, as follows:

.1 Doors in "A" Class divisions shall comply with the Fire Test Procedures Code, Annex 1, Part 3.

.2 Doors approved without the sill being part of the frame shall be installed such that the gap under the door does not exceed 12 millimetres. A non-combustible sill shall be installed under the door such that floor coverings do not extend beneath the closed door, except where it can be demonstrated that the flooring is not readily ignitable.

Steel watertight doors installed in fire bulkhead need not be insulated.

22.3.5.3 It shall be possible for each door to be opened and closed from each side of the bulkhead by one person only.

22.3.5.4 Fire doors in galley boundaries and stairway enclosures, other than power-operated watertight doors and those which are normally locked, shall satisfy the following requirements:

.1 the doors shall be self-closing and be capable of closing with an angle of inclination of up to 3.5° opposing closure;

.2 the approximate time of closure for hinged fire doors shall be no more than 40 s and no less than 10 s from the beginning of their movement with the yacht in upright position. The approximate uniform rate of closure for sliding doors shall be of no more than 0.2 m/s and no less than 0.1 m/s with the yacht in upright position;

.3 the doors, except those for emergency escape trunks, shall be capable of remote release from the continuously manned central control station, either simultaneously or in groups, and shall be capable of release also individually from a position at both sides of the door. Release switches shall have an on-off function to prevent automatic resetting of the system;

.4 hold-back hooks not subject to central control station release are prohibited;

.5 a door closed remotely from the central control station shall be capable of being re-opened from both sides of the door by local control. After such local opening, the door shall automatically close again;

.6 indication shall be provided at the fire door indicator panel in the continuously manned central control station whether each door is closed;

.7 the release mechanism shall be so designed that the door will automatically close in the event of disruption of the control system or central power supply;

.8 local power accumulators for power-operated doors shall be provided in the immediate vicinity of the doors to enable the doors to be operated at least ten times (fully opened and closed) after disruption of the control system or central power supply using the local controls;

.9 disruption of the control system or central power supply at one door shall not impair the safe functioning of the other doors;

.10 remote-released sliding or power-operated doors shall be equipped with an alarm that sounds at least 5 s but no more than 10 s, after the door is released from the central control station and before the door begins to move and continues sounding until the door is completely closed;

.11 a door designed to re-open upon contacting an object in its path shall re-open not more than 1 m from the point of contact;

.12 double-leaf doors equipped with a latch necessary for their fire integrity shall have a latch that is automatically activated by the operation of the doors when released by the system;

.13 the components of the local control system shall be accessible for maintenance and adjusting;

.14 power-operated doors shall be provided with a control system of an approved type which shall be able to operate in case of fire and be in accordance with the Fire Test Procedures Code. This system shall satisfy the following requirements:

.1 the control system shall be able to operate the door at the temperature of at least 200°C for at least 60 min, served by the power supply;

.2 the power supply for all other doors not subject to fire shall not be impaired; and

.3 at temperatures exceeding 200°C, the control system shall be automatically isolated from the power supply and shall be capable of keeping the door closed up to at least 945°C.

22.3.5.5 Doors and door frames in "B" class divisions and means of securing them shall provide a method of closure which shall have resistance to fire as follows:

.1 Doors in “B” Class divisions shall comply with the Fire Test Procedures Code, Annex 1, Part 3;

.2 Ventilation opening may be permitted in the lower portion of such doors. When such an opening is in or under a door the total net area of the opening(s) shall not exceed 0.05m2. When such an opening is cut in a door it shall be fitted with a grill made of non-combustible material.

.3 Doors approved as “B” Class without the sill being part of the frame, shall be installed such that the gap under the door does not exceed 25 millimetres.

22.3.5.6 All windows and portlights in bulkheads within accommodation spaces, service spaces and control stations shall be so constructed to preserve the integrity requirements of the type of bulkheads in which they are fitted.

Windows shall not be fitted in machinery space boundaries. However, this does not preclude the use of glass in control rooms within the machinery spaces.

22.3.5.7 For penetrations through fire divisions see 22.3.1.8.

22.3.6 Details of construction on yachts of 500 GT and upwards

22.3.6.1 In accommodation and service spaces, control stations, corridors and stairways:

.1 air spaces enclosed behind ceilings, panelling or linings shall be suitably divided by close-fitting draught stops not more than 14 metres apart; and

.2 in the vertical direction, enclosed air spaces, including those behind linings of stairways, trunks, etc. shall be closed at each deck.

The draught stops shall be non-combustible and are to form a continuation above the ceiling of the bulkhead below or the other side of the panelling or lining to the bulkhead, as far as possible.

22.6.3.2 Where the structure or “A” Class divisions are required to be insulated, it shall be ensured that the heat from a fire is not transmitted through the intersections and terminal points of the divisions or penetrations to uninsulated boundaries. Where the insulation installed does not achieve this, arrangements shall be made to prevent this heat transmission by insulating the horizontal and vertical boundaries or penetrations for a distance of 450 millimetres.

22.6.3.3 Without impairing the efficiency of the fire protection, the construction of ceilings and bulkheads shall allow a fire patrol to detect any smoke originating in concealed and inaccessible places, except where there is no risk of fire originating in such places.

22.4 MEANS OF ESCAPE

22.4.1 General

22.4.1.1 The purpose of this Head is to provide means of escape so that persons on board can safely and swiftly escape to the liferaft embarkation deck. For this purpose, the following functional requirements shall be met:

.1 safe escape routes shall be provided;

.2 escape routes shall be maintained in a safe condition, clear of obstacles; and

.3 additional aids for escape shall be provided as necessary to ensure accessibility, clear marking and adequate design for emergency situations.

22.4.1.2 Stairways, ladders and corridors serving all spaces normally accessible shall be arranged so as to provide ready means of escape to a deck from which embarkation into survival craft may be effected.

The arrangement of the yacht shall be such that all compartments are provided with a satisfactory means of escape.

22.4.1.3 On yachts of 500 GT and above, escape route signs shall be fitted as required in 22.7.1.2.

22.4.2 Means of escape from accommodation and service spaces

22.4.2.1 Two means of escape from every restricted space or group of spaces shall be provided. Concealed escapes and escape routes shall be clearly marked to ensure ready exit.

22.4.2.2 The normal means of access to the accommodation and service spaces below the open deck shall be arranged so that it is possible to reach the open deck without passing through a galley, engine room or other space with a high fire risk, wherever practicable.

22.4.2.3 Where accommodation arrangements are such that access to compartments is through another compartment, the second escape route shall be as remote as possible from the main escape route. This may be through hatches of adequate size, leading to the open deck or separate space to the main escape route.

22.4.2.4 On yachts of 500 GT and above, the following additional requirements apply.

Stairways and ladders shall be arranged to provide ready means of escape to the lifeboat and liferaft embarkation deck from all passenger and crew accommodation spaces and service spaces in which the crew are normally employed, other than machinery spaces. In particular, the following provisions shall be complied with:

.1 Below the bulkhead deck two means of escape, at least one of which shall be independent of watertight doors, shall be provided from each watertight compartment or similarly restricted group of spaces.

.2 Above the bulkhead deck, there shall be at least two means of escape from each space or group of spaces, at least one of which is to give access to a readily accessible escape which shall provide continuous fire shelter from the level of its origin to the appropriate survival craft embarkation deck.

.3 There shall be at least one readily accessible enclosed stairway providing continuous fire shelter, where practical, at all levels up to the appropriate lifeboat and liferaft embarkation decks or the highest level served by the stairway, whichever level is the highest. The width, number and continuity of the stairways shall be satisfactory for the number of persons likely to use them.

.4 Access from the stairway enclosures to the lifeboat and liferaft embarkation areas shall avoid high fire risk areas.

.5 Stairways serving only a space and a balcony in that space shall not be considered as forming one of the required means of escape.

.6 If a radio room or wheelhouse has no direct access to the open deck, two means of escape shall be provided, one of which may be a window of sufficient size or another means.

.7 Stairways are not to exceed 3.5 metres vertical rise without the provision of a landing.

.8 In the case where direct access to the appropriate survival craft embarkation deck as required by .1 and .2 is not practical, a ready accessible escape which shall provide continuous fire shelter from the level of its origin to the appropriate open deck with subsequent direct passage to the embarkation deck can be accepted provided that these escape routes including external staircases, have emergency lighting and slip free surfaces under foot.

.9 Protection of access from the stairway enclosures to the lifeboat and liferaft embarkation areas shall be provided either directly or through protected internal routes which have fire integrity and insulation values for stairway enclosures as required in this Section.

.10 Where public spaces span three or more open decks and contain combustibles such as furniture and give access to other enclosed spaces, each level within the space shall have two means of escape, one of which is to give access to a readily accessible escape which shall provide continuous fire shelter from the level of its origin to the appropriate survival craft embarkation deck.

22.4.3 Means of escape from machinery spaces

22.4.3.1 Category “A” machinery spaces on motor yachts shall also be provided with a minimum of two means of escape.

Other machinery spaces shall also have at least two means of escape as widely separated as possible, except where the small size of the machinery space makes it impracticable.

22.4.3.2 Means of escape from engine room giving direct access to accommodation (cabins, living room, etc.) are not allowed.

22.4.3.3 On yachts of 500 GT and above, the following additional requirements apply:

.1 The two means of escape shall consist of either:
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 appropriate survival craft embarkation decks. One of these ladders shall provide continuous fire shelter from the lower part of the space to a safe position outside the space. This shelter shall be of steel or equivalent material, insulated where necessary, and provided with a self-closing door at the lower end. If access is provided at other levels each level shall be provided with a steel or equivalent material self-closing door; or
one steel ladder leading to a door in the upper part of the space from which access is provided to the embarkation 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 embarkation deck.

.2 One of the means of escape from any such space required may be dispensed with on sailing yachts with small machinery spaces, so long as either a door or a steel ladder and walkways provide a safe escape route to the embarkation deck with due regard being paid to the nature and location of the space and whether persons are normally employed in that space.

.3 Two means of escape shall be provided from a machinery control room located within a machinery space, at least one of which shall provide continuous fire shelter to a safe position outside the machinery space.

.4 Two means of escape shall be provided from the main workshop within a machinery space. At least one of these escape routes shall provide a continuous fire shelter to a safe position outside the machinery space.

22.4.4 Dispensation from two means of escape

22.4.4.1 In exceptional circumstances, a single means of escape may be accepted for spaces, other than accommodation spaces, that are entered only occasionally, if the escape route does not pass through a galley, machinery space or watertight door.

22.4.5 Arrangements of escape routes

22.4.5.1 Interior stairways shall be of steel or other equivalent material (e.g. insulated aluminium alloy).

On yachts of less than 500 GT, the *Register* may, on case by case basis, consider use of other material for one of the stairways serving accommodation spaces, while the other required stairway shall be of steel or other equivalent material.

22.4.5.2 No escape route shall be obstructed by furniture or fittings. Additionally, furniture along escape routes shall be secured in place to prevent shifting if the yacht rolls or lists.

All doors in escape routes shall be openable from either side. In the direction of escape they are all to be openable without a key. All handles on the inside of weathertight doors and hatches shall be non-removable. Where doors are lockable, measures to ensure access from outside the space shall be provided for rescue purposes.

22.4.5.3 Lifts are not considered as forming a means of escape.

22.5 FIRE DETECTION AND ALARM

22.5.1 General

22.5.1.1 The purpose of this Head is to detect a fire in the space of origin and to provide for an alarm for safe escape and fire-fighting activities.

22.5.2 Fixed fire detection and fire alarm systems on yachts of less than 500 GT

22.5.2.1 A fixed fire detection and fire alarm system shall be fitted in all enclosed spaces except those containing no significant fire risk (toilets, bathrooms, void spaces, etc).

22.5.2.2 The fixed fire detection and fire alarm system shall be installed in accordance with the requirements of *Rules for the classification of ships, Part 17 – Fire protection*, 7 and 24.9 and shall be audible externally.

22.5.2.3 In addition to 22.5.2.2, the main feeder of the fire detector and alarm system shall run from the main switchboard to the change-over switch without passing through any other distributing switchboard, furthermore emergency feeder of the fire detector and alarm system shall run from the emergency switchboard to the change-over switch without passing through any other distributing switchboard.

This requirement needs not be applied on **Pleasure yachts**.

22.5.2.4 Manually operated call points shall be placed effectively to ensure a readily accessible means of notification.

22.5.3 Fixed fire detection and fire alarm systems on yachts of 500 GT and upwards

22.5.3.1 There shall be installed throughout all accommodation, service spaces and control stations, except spaces which afford no substantial fire risk such as void spaces, sanitary spaces, etc., either:

.1 a fully addressable fixed fire detection and fire alarm system of an approved type complying with the relevant requirements of the *Rules for the classification of ships, Part 17 – Fire protection*, 24.9 so installed and arranged as to detect the presence of fire in such spaces and providing smoke detection in corridors, stairways and escape routes within accommodation spaces. Detectors fitted in cabins, when activated, shall also be capable of emitting, or cause to be emitted, an audible alarm within the space where they are located; or

.2 an automatic sprinkler, fire detection and fire alarm system of an approved type complying with the relevant requirements of the *Rules for the classification of ships, Part 17 – Fire protection*, 24.9 and so installed and arranged as to protect such spaces and, in addition,
a fixed fire detection and fire alarm system and so installed and arranged as to provide smoke detection in corridors, stairways, and escape routes within accommodation spaces.

22.5.3.2 A fixed fire detection and fire alarm system shall be fitted in all enclosed spaces except those containing no significant fire risk (toilets, bathrooms, void spaces, etc).

Ceiling void spaces containing equipment that could present a fire risk shall be fitted with a fixed fire detection and fire alarm system.

22.5.3.3 Manually operated call points complying with the relevant requirements of the *Rules for the classification of ships, Part 17 – Fire protection*, 24.9 shall be placed effectively to ensure a readily accessible means of notification.

22.6 FIXED FIRE EXTINGUISHING SYSTEMS

22.6.1 General

22.6.1.1 Machinery spaces of category A shall be protected by a fixed fire-fighting extinguishing system.

All other machinery spaces containing an oil fired boiler, fuel oil settling tank or fuel oil unit shall also be protected by a fixed fire-fighting extinguishing system.

In accommodation, service spaces and control stations, except spaces which afford no substantial fire risk such as void spaces, sanitary spaces, etc. an automatic sprinkler, fire detection and fire alarm system of an approved type complying with the relevant requirements of the *Rules for the classification of ships, Part 17 – Fire protection*, 24.9 may be required; for yachts of less than 500 GT see 22.2.1.5, for yachts of 500 GT and upwards see 22.5.3.1.

22.6.1.2 The extinguishing medium shall be suitable for the intended use and its amount and time of acting suitable for the intended use.

22.6.1.3 The fixed fire extinguishing system shall be of one of the following types:

- aerosol system,
- CO2 system,

- other gaseous agent system (FM 200, inergen, etc.)
- high expansion foam system,
- pressure water-spraying (water mist) system,
- sprinkler system.

Fire extinguishing system shall be in compliance with the requirements of FSS Code or *Rules for the classification of ships, Part 17 – Fire protectio*n, Section 24 and shall be approved by the *Register*.

Other systems than listed above may be considered, at the discretion of the *Register*, on case by case basis.

22.7 FIRE FIGHTING APPLIANCES

22.7.1 General

22.7.1.1 Fire appliances shall be of an approved type.

The stowage position of fire appliances shall be clearly marked.

22.7.1.2 On yachts of 500 GT and above, escape route signs and equipment location markings shall be in accordance with IMO Res. A.1116(30).

22.7.2 Specification of appliances

22.7.2.1 Required fire appliances are listed in Table 22.7.2-1. and specified in detail in 22.7.3 to 22.7.9.

Table 22.7.2-1

No.	Item/appliance	Quantity	Brief description	See requirement No.
1	Provision of water jets	1 or 2	Sufficient to reach any part of the yacht. One jet is required on **Pleasure yachts** and yachts of less than 500 GT, two jets are required on yachts of 500 GT and upwards	22.7.3
2	Power driven fire pump	1	Independently driven or driven by the propulsion engine	22.7.4
3	Additional independent power-driven fire pump	1	Not to be fitted in the same space as item 2	22.7.4
4	Fire main and hydrants		Sufficient to achieve item 1 with a single length of hose	22.7.5
5	Hoses	at least 3	With jet/spray nozzle with shut-off facility	22.7.6
6	Fire extinguishing in a machinery space of category A	1 1 to 7; or 2+1	A fixed fire extinguishing system approved in accordance with the Fire Safety Systems Code; and 1 portable extinguisher for oil fires for each 74.6 kW power (up to 7 maximum); or 2 portable extinguishers for oil fires together with either one wheeled foam extinguisher of 45 l capacity or dry powder of 16 kg	22.7.8
7	Portable fire extinguishers in machinery spaces other than category A	1	Foam or dry powder portable fire extinguisher. *NOTE: If the machinery space contains an oil-fired boiler, oil fuel settling tank or oil fuel unit, a fixed fire extinguishing system shall be provided*	22.7.8
8	Portable fire extinguishers in accommodation and service spaces (foam or dry powder allowed, carbon dioxide not permitted)	1 1 1 1	Corridor in cabin area Lounge / restaurant The galley Store-rooms One extinguisher may be provided for two or more spaces specified above if these spaces are adjacent. In any case, for each deck, one portable fire extinguisher within 10 m of any position within an accommodation or service space	22.7.7
9	Portable fire extinguishers in wheelhouse	1	Wheelhouse: Dry powder and/or carbon dioxide extinguisher	22.7.7
10	Fire extinguishing in space containing vehicles or craft with fuel in their tanks or lockers storing such fuels	1 1	An approved manual water spray fire extinguishing system; and	22.8.5

No.	Item/appliance	Quantity	Brief description	See requirement No.
			Foam or dry powder portable fire extinguisher in close vicinity outside the space	
11	Portable fire extinguishers in refuelling station arranged within enclosed space containing vehicles or craft with fuel in their tanks	1	Foam or dry powder portable fire extinguisher shall be provided within the space, in close vicinity to the refuelling area	22.9.1.3
12	Helideck fire extinguishing	1 2 2 2	An approved foam application system; and Dry powder extinguishers having a total capacity of not less than 45 kg; and Carbon dioxide extinguishers of a total capacity of not less than 18 kg or equivalent; and Additional fire-fighter's outfits.	22.10.5
13	Fireman's outfit	0 or 1 or 2	Not required for yacht of less than 300 GT; 1 for yacht of 300 GT and more, but less than 500 GT; 2 for yacht of 500 GT and upwards.	22.7.9
14	Fire blanket	1	In the galley	

22.7.3 Provision of water jets

22.7.3.1 At least one jet of water, from a single length of hose, shall be able to reach any part of the yacht normally accessible to passengers or crew while the yacht is being navigated and any store room or any part of a storage compartment when empty.

On yachts of 500 GT and above, two jets of water are required, one of which shall be from a single length of hose.

22.7.4 Fire pumps

22.7.4.1 Two power-driven fire pumps shall be provided, one of which may be driven by the propulsion system, provided that operation of fire pump is ensured even in the case yacht is not sailing.

22.7.4.2 The two pumps shall be installed in two different spaces together with their own source of power and sea connection.

22.7.4.3 On yachts of less than 500 GT the second fire pump may be portable, located outside the space where first (fixed) fire pump is located.

In the case of a portable diesel engine driven fire pump, special attention shall be paid to the requirement of the *Rules for the classification of ships, Part 8 – Piping*, 6.1.1 c).

22.7.4.4 Bilge, sanitary and general service pumps may be accepted as fire pumps, provided that it is not normally used for pumping oil.

22.7.4.5 The power-driven fire pump shall have a capacity [in m3/h] according to following formulae:

2.5 · {1 + 0.066 · [L · (B+D)]0.5 }2

where:

L is the length,

B is the greatest moulded breadth

D is the moulded depth measured to the bulkhead deck at amidships.

When discharging at full capacity through 2 adjacent fire hydrants, the pump shall be capable of maintaining a water pressure of 0.2 N/mm^2 at any hydrant, provided the fire hose can be effectively controlled at this pressure.

For **Pleasure yachts**, maintaining a water pressure of 0.1 N/mm^2 at any hydrant will suffice.

22.7.4.6 The second fire pump, shall have a capacity of at least 80% of that required by 22.7.4.5 and be capable of input to the fire main.

A permanent sea connection, external to the machinery space, shall be provided. "Throw-over" sea suctions are not acceptable.

22.7.4.7 When more fire pumps then minimum of required pumps are installed, such additional pumps are to have a capacity of at least as required in 22.7.4.6 and shall be capable of delivering at least number of water jets as required in 22.7.3.

22.7.4.8 In no case the capacity of each fire pump shall be less than 12 m^3/h.

On yachts of 500 GT and above, the total required capacity of the fire pumps need not to exceed 180 m^3/h.

22.7.4.9 Each centrifugal fire pump shall be provided with a non-return valve in the connection to the fire main.

22.7.5 Fire main and hydrants

22.7.5.1 A fire main, water service pipes and fire hydrants shall be fitted.

The fire main and water service pipe connections to the hydrants shall be sized for the maximum discharge rate of the pump(s) connected to the main.

22.7.5.2 The fire main, water service pipes and fire hydrants shall be constructed such that they shall:

.1 not be rendered ineffective by heat;
.2 not readily corrode; and
.3 be protected against freezing.

Grey cast iron shall not be used for fire mains. Fire mains made of steel shall be galvanized.

22.7.5.3 When a fire main is supplied by 2 pumps, 1 in the machinery space and 1 elsewhere, provision shall be made for isolation of the fire main within the machinery space and for the second pump to supply the fire main and hydrants external to the machinery space. Isolation valve(s) shall be manually operated valves fitted outside the machinery space in a position easily accessible in the event of a fire.

For **Pleasure yachts**, the application of this criterion is not mandatory.

22.7.5.4 The fire main shall have no connections other than those necessary for firefighting or washing down.

22.7.5.5 Fire hydrants shall be located for easy attachment of fire hoses, protected from damage and distributed so that a single length of the fire hoses provided can reach any part of the yacht.

Hydrants shall be properly marked.

22.7.5.6 Fire hydrants shall be fitted with valves that allow a fire hose to be isolated and removed when a fire pump is operating.

22.7.6 Fire hoses and nozzles

22.7.6.1 Fire hoses shall not exceed 20 metres in length, and generally, the diameter for use with a powered pump shall not be less than 38 millimetres.

22.7.6.2 Fire hoses shall be of non-perishable material approved by the *Register* and shall be sufficient in length to project a jet of water to any of the spaces in which they may be required to be used. Each hose shall be provided with a nozzle and the necessary couplings.

Fire hoses and associated tools and fittings shall be kept in properly marked, readily accessible and known locations, close to the hydrants or connections on which they shall be used.

22.7.6.3 Hoses supplied from a powered pump shall have jet/spray nozzles (incorporating a shut-off facility) of diameter 19 millimetres, 16 millimetres or 12 millimetres depending on firefighting purposes.

For accommodation and service spaces, the diameter of nozzles need not exceed 12 millimetres.

For machinery spaces and exterior locations, the nozzle size shall be as to obtain the maximum discharge possible from two jets at the pressure referred to in 22.7.4.5, from the smallest pump.

Fire hose nozzles made of plastic type material, e.g. polycarbonate, are considered acceptable provided capacity and serviceability are documented and the nozzles are found suitable for the marine environment.

22.7.6.4 Hydrants or connections in interior locations on the yacht shall have hoses connected at all times.

For **Pleasure yacht**, at least one hydrant is to have one hose connected at all times.

22.7.6.5 The number of fire hoses and nozzles provided shall correspond to the functional fire safety requirements but be at least 3.

There shall be complete interchangeability of hose couplings and nozzles, unless one hose and nozzle are provided for each hydrant in the yacht.

22.7.6.2 On yachts of 500 GT and upwards, the following additional requirements apply:

.1 the number of fire hoses to be provided shall be one for each 30 m length of the yacht and one spare, but in no case less than three. This number does not include any hoses required in any engine-room or boiler room. The *Register* may increase the number of hoses required so as to ensure that hoses in sufficient number are available and accessible at all times.

.2 larger diameter nozzles may be permitted at the discretion of the *Register*.

22.7.7 Portable fire extinguishers in accommodation and service spaces

22.7.7.1 All portable fire extinguishers shall be of approved types based on the guidelines developed by IMO, see Improved Guidelines for marine portable fire extinguishers, resolution IMO Res. A.951(23) or other equivalent standards, such as Marine Equipment Directive.

The number, location, fire extinguishing medium type and capacity shall be selected according to the perceived fire risk, but for each deck, one portable extinguisher shall be available for use within a distance of 10 metres from any location.

A minimum of at least 3 portable fire extinguishers shall be provided.

As far as practical, the fire extinguishers provided shall have a uniform method of operation and shall be of an approved type and capacity.

22.7.7.2 On yachts of 500 GT and above, each powder and or carbon dioxide extinguisher shall have a capacity of at least 5 kg and each foam extinguisher shall have a capacity of at least 9 l. The mass of portable fire extinguishers shall not exceed 23 kg and they shall have a fire-extinguishing capability at least equivalent to that of a 9 l fluid extinguisher.

22.7.7.3 On yachts of less than 500 GT, the *Register* may consider, on case by case basis, portable fire extinguisher of approved type, but having smaller capacity than required in 22.7.7.2.

22.7.7.4 Portable fire extinguishers of the carbon dioxide type shall not be located or provided for use in accommodation spaces or service spaces.

For control stations and machinery spaces of small size, where there is a risk of asphyxiation, carbon dioxide extinguisher capacity shall be limited to 1 or 2 kg, as appropriate.

22.7.7.5 Except for portable extinguishers provided in connection with a specific hazard within a space when it is manned (such as a galley), portable extinguishers generally shall be located external to, but adjacent to, the entrance of the space(s) in which they shall be used. Extinguishers shall be stowed in readily accessible and marked locations, ready for immediate use.

22.7.7.6 Spare charges shall be provided onboard for at least 50% of each type and capacity of portable fire extinguisher onboard. When an extinguisher is not of a type which is rechargeable when the yacht is at sea, an additional portable fire extinguisher of the same type (or its equivalent) shall be provided.

22.7.8 Fire extinguishing in a machinery spaces

22.7.8.1 In a category A machinery space containing internal combustion type machinery, fire appliances shall be provided at least to the extent listed in item 6 of Table 22.7.2-1.

In a machinery space containing an oil-fired boiler, oil fuel settling tank or oil fuel unit, a fixed fire extinguishing system complying with the Fire Safety Systems Code shall be installed.

22.7.8.2 Portable fire extinguishers shall be installed and the number, location, fire extinguishing medium type and capacity shall be selected according to the perceived fire risk in the space.

In any case, portable fire extinguishers for extinguishing oil fires shall be fitted as required in items 6 and 7 of Table 2.7.2-1. In addition, the following portable fire extinguishers shall be provided:

.1 in a boiler room - at least 2;
.2 in a space containing any part of an oil fuel installation - at least 2; and
.3 in a firing space - at least 1.

22.7.8.3 Spare charges or spare extinguishers shall be provided as required in 22.7.7.6.

22.7.8.4 On yachts of 500 GT and upwards, the *Register* may impose additional requirements, on case by case basis.

22.7.9 Fireman's outfit

22.7.9.1 The fireman's outfits shall be kept ready for use in an easily accessible location that is permanently and clearly marked and, where more than one fireman's outfit is carried, they shall be stored in widely separated positions.

22.7.9.2 One set of fireman's outfit shall be provided on yachts of 300 GT and more, but less than 500 GT.

Two sets of fireman's outfit shall be provided on yachts of 500 GT and upwards.

22.7.9.3 Fireman's outfit shall be of approved type, in compliance with requirements of FSS Code.

Fireman's outfit shall be in compliance with EN 469 standard or equivalent.

22.7.9.4 In addition, one spare set of breathing apparatus cylinders shall be provided for each required fireman's outfit, providing an onboard means of recharging breathing apparatus cylinders is fitted, alternatively two spare sets of breathing apparatus cylinders shall be provided for each required outfit.

22.7.9.5 On yachts of 500 GT and upwards, fireman's outfit shall be Type approved.

22.8 PROTECTION OF SPACES CONTAINING VEHICLES OR CRAFT WITH FUEL IN THEIR TANKS OR LOCKERS STORING SUCH FUELS

22.8.1 General

22.8.1.1 Precaution measures against ignition of flammable vapours shall be taken on yachts made of material other than wood.

On yachts made of wood, carriage of vehicles or craft with fuel in their tanks or storage of such fuels is not allowed.

22.8.1.2 Provisions shall be made to ensure that vehicles, craft and ancillary equipment are securely fastened with due consideration being given to the relative motion of the yacht and possible movement between components.

22.8.1.3 The boundaries and relevant openings of the spaces containing vehicles or craft with fuel in their tanks or lockers storing such fuels to other internal spaces shall be reasonably gastight.

22.8.1.4 Enclosed spaces, and larger lockers on open deck, designated for the safe carriage of petrol or similar fuel, refuelling units or vehicles with fuel in their tanks shall be fitted with:

.1 ducted mechanical exhaust ventilation;
.2 a fixed fire detection and fire alarm system;
.3 gas detection system;
.4 a manual water spray fire extinguishing system; and
.5 drainage or bilge system.

22.8.2 Precaution against ignition of flammable vapours

22.8.2.1 Special consideration shall be given to safe conditions of carriage of petrol and other highly flammable liquids (fuel with a flashpoint equal to or less than 55° C) either in hand portable containers/tanks or in the tanks of vehicles (such as personal water craft, motor cars and helicopters) which may be transported.

22.8.2.2 The quantity of spare petrol and/or other highly flammable liquids carried shall be kept to a minimum, generally up to 150 litres maximum. Greater quantities may be specially considered by the *Register* when the storage location, ventilation, containers, fire suppression and space fire protection and detection are considered adequate for the given increase.

22.8.2.3 Containers used for the carriage of flammable liquids shall be constructed to a recognised standard appropriate to the contents and each container clearly marked to indicate its contents.

22.8.2.4 Small lockers on open deck for the stowage of hand portable containers of petrol shall be located away from high risk areas, have no electrical fittings, and be provided with the following:

.1 natural ventilation openings top and bottom;

.2 drainage leading overboard;
.3 means of securing the fuel containers; and
.4 a facility to boundary cool the locker.

22.8.2.5 In enclosed spaces, and larger lockers on open deck, designated for the safe carriage of petrol or similar fuel, refuelling units or vehicles with fuel in their tanks:

.1 All electrical equipment located up to 450 millimetres above the deck shall be certified safe for petrol vapours.
.2 Electrical equipment located higher than 450 millimetres above the deck shall either:
  .1 comply with IP55 standard of construction (IEC Publication 529 - Classification of Degree of protection Provided by Enclosures); or
  .2 provided with automatic isolation (on all poles) located outside the space on activation of the gas detection system. This option shall not be used for safety systems such as steering motors, rudder indicators, etc.

22.8.2.6 Regardless of the height of installation, it is considered that the following equipment located within the space shall be certified safe for the flammable vapours:

.1 gas detection system;
.2 bilge alarm;
.3 fire detection system;
.4 at least one light fitting (on a dedicated circuit)

It shall be noted that electrical equipment includes starters, distribution boxes, etc.

22.8.3 Ventilation

22.8.3.1 Ducted mechanical exhaust ventilation, which shall be isolated from other ventilated spaces, shall provide the following:

.1 at least 6 air changes per hour (based on the empty space). Ventilation systems may be operated at lower air changes per hour when controlled by a detection system that monitors the flammable and harmful gases in the space. See Revised design guidelines and operational recommendations for ventilation systems in ro-ro cargo spaces (MSC.1/Circ.1515);
.2 reduction of the airflow shall be signalled by an audible and visual alarm on the navigating bridge and at the "in port" control station(s). The alarm system shall be powered from the emergency source of electrical power.;
.3 exhaust ducting shall be arranged to extract from the lower bilge area;
.4 if the fan motors are located in the space or in the ventilation duct, they shall be certified safe to the correct designation for the flammable vapour/liquid;
.5 the ventilation fans shall be of a non-sparking type; and
.6 the ventilation system shall be capable of rapid shut down and effective closure in event of fire. Such controls shall be fitted outside the ventilated space and shall be operable in all the weather and sea conditions.

22.8.4 Fire and gas detection

22.8.4.1 A fixed fire detection and fire alarm system complying with the requirements of 22.5. The system within the space shall also comply with 22.8.2.5.

22.8.4.2 A suitable gas detection system shall be provided, appropriate to the type of vehicle fuel, with audible and visual alarm in the wheelhouse and where it may always be observed by the crew.

At least two gas detectors shall be provided for each monitored space and shall be fitted in the areas where flammable gases are likely to accumulate.

The system shall be designed in compliance with international standard acceptable to the *Register*.

The system shall be continuously supplied from two circuits, one from the ship's main supply and the other from the emergency source of electrical power and shall be provided with an automatic change-over to the standby power supply in case of loss of normal power supply. Power supplies and electrical circuits necessary for the operation of the system shall be monitored for loss of power or fault condition, as appropriate. Occurrence of a fault condition shall initiate a visual and audible fault signal on the bridge.

The system shall also comply with 22.8.2.5.

22.8.5 Fire extinguishing

22.8.5.1 A manual water spray system giving a coverage of 3.5 litres/m^2/minute over the total area of deck, which may be taken from the fire main with the isolating valve located outside the garage.

The system shall be operable from outside the protected space.

An equivalent arrangement may be considered.

Adequate provision shall be made for drainage of water introduced to the space. This shall not lead to machinery or other spaces where a source of ignition may exist.

22.8.5.2 Additional foam or dry powder portable fire extinguisher, in close vicinity outside the space, shall be provided.

22.8.6 Drainage

22.8.6.1 The drainage or bilge pumping arrangements shall be such as to prevent the build-up of free surfaces. The system shall be sized to remove no less than 125% of the combined capacity of both the water spraying system pumps and the required number of fire hose nozzles. The drainage system valves shall be operable from outside the protected space at a position in the vicinity of the extinguishing system controls. If this is not possible, the adverse effect upon stability of the added weight and free surface of water shall be taken into account to the extent deemed necessary by the *Register*. Such information shall be included in the Stability book.

22.9 REFUELLING STATION ARRANGED WITHIN ENCLOSED SPACE CONTAINING VEHICLES OR CRAFT WITH FUEL IN THEIR TANKS

22.9.1 General

22.9.1.1 Refuelling station for fuel with flash point of more than 55°C may be installed in enclosed space (garage) containing vehicles or crafts with fuel in their tanks, providing the following requirements are complied with:

.1 Fuel shall be taken directly from any storage tank with a dedicated refuelling pump located in engine room and a quick closing valve that shall be closable from outside the engine room. Manually operable valve shall be fitted within refuelling station, before the flexible hose of the refuelling system;

.2 The refuelling pump and its power supply, if located in the engine room and necessary for the operation of the refuelling station, shall be capable of being stopped locally and also from the enclosed space in which the refuelling station is fitted. Such valves shall also be manually operable;

.3 The flexible hose shall have the same fire resistance as required for a flexible fuel oil pipe. Gun, pump, flowmeter and any other fittings shall be in accordance with a recognized international standard;

.4 Fuel dripping shall be prevented. Drip tray with a draining pipe shall be located below the refuelling area; and

.5 Label in the refuelling station shall indicate to close the manually operated valve located in the space at the end of the refuelling operations and to empty the part of the system downstream the valve.

22.9.1.2 Ventilation shall to be provided during refuelling operation.

If mechanical ventilation is not provided in the space, the refuelling operation shall be carried out with the garage doors and hatches, if fitted, open.

22.9.1.3 Additional foam or dry powder portable fire extinguisher shall be provided within the space, in close vicinity to the refuelling area.

22.10 HELICOPTER FACILITIES

22.10.1 General requirements

22.10.1.1 The purpose of this Head is to provide additional measures in order to address the fire safety objectives of this Rules for yachts fitted with special facilities for helicopters. For this purpose, the following functional requirements shall be met:

.1 helideck structure shall be adequate to protect the yacht from the fire hazards associated with helicopter operations;

.2 fire-fighting appliances shall be provided to adequately protect the yacht from the fire hazards associated with helicopter operations;

.3 refuelling and hangar facilities and operations shall provide the necessary measures to protect the yacht from the fire hazards associated with helicopter operations; and

.4 operation manuals and training shall be provided.

22.10.2 Application

22.10.2.1 In addition to complying with the requirements of other Sections, as appropriate, yachts equipped with helidecks shall comply with the requirements of this Head.

22.10.2.2 Where helicopters land or conduct winching operations on an occasional or emergency basis on yachts without helidecks, fire-fighting equipment fitted in accordance with the requirements of this Section may be used. This equipment shall be made readily available in close proximity to the landing or winching areas during helicopter operations.

22.10.2.3 Notwithstanding the requirements of 22.10.2.2, yachts constructed on or after 1 January 2020, having a helicopter landing area, shall be provided with foam firefighting appliances which comply with the relevant provisions of Rules for the classification of ships, Part 17 – Fire protection, 24.17.

22.10.2.4 Helicopter facility foam fire-fighting appliances shall be in compliance with *Guidelines for approval of helicopter foam fire-fighting appliances (MSC.1/Circ.1431).*

22.10.3 Structure

22.10.3.1 Construction of steel or other equivalent material

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 superstructure, it shall be insulated to ''A-60'' class standard.

On yachts of less than 500 GT, insulation class may be reduced to "A-30", at the discretion of the *Register*.

22.10.3.2 Construction of aluminium or other low melting point metals

If the *Register* permits aluminium or other low melting point metal construction that is not made equivalent to steel, the following provisions shall be satisfied:

.1 if the platform is cantilevered over the side of the yacht, after each fire on the yacht or on the platform, the platform shall undergo a structural analysis to determine its suitability for further use; and

.2 if the platform is located above the yacht's deckhouse or similar structure, the following conditions shall be satisfied:

  .1 the deckhouse top and bulkheads under the platform shall have no openings;

  .2 windows under the platform shall be provided with steel shutters; and

  .3 after each fire on the platform or in close proximity, the platform shall undergo a structural analysis to determine its suitability for further use.

22.10.4 Means of escape

22.10.4.1 A helideck shall be provided with both a main and an emergency means of escape and access for fire-fighting and rescue personnel. These shall be located as far apart from each other as is practicable and preferably on opposite sides of the helideck.

22.10.5 Fire-fighting appliances

22.10.5.1 In close proximity to the helideck, the following fire-fighting appliances shall be provided and stored near the means of access to that helideck:

.1 at least two dry powder extinguishers having a total capacity of not less than 45 kg;

.2 carbon dioxide extinguishers of a total capacity of not less than 18 kg or equivalent;

.3 a suitable foam application system consisting of 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 22.10.1 for at least five minutes;

.4 the principal agent shall be suitable for use with salt water and conform to performance standards not inferior to those acceptable to the *Register*; *refer to the International Civil Aviation Organization Airport Services Manual, part 1, Rescue and Fire Fighting, chapter 8, Extinguishing Agent Characteristics, paragraph 8.1.5, Foam Specifications table 8-1, level 'B'.*

.5 at least two nozzles of an approved dual-purpose type (jet/spray) and hoses sufficient to reach any part of the helideck;

.6 in lieu of the requirements of 22.10.5.1.3 through 22.10.5.1.5, on yachts constructed on or after 1 January 2020 having a helideck, foam firefighting appliances which comply with the provisions of the Fire Safety Systems Code.

.7 in addition to the requirements of 22.7.9, two sets of fire-fighter's outfits; and

.8 at least the following equipment shall be stored in a manner that provides for immediate use and protection from the elements: adjustable wrench; blanket, fire-resistant; cutters, bolt 60 cm; hook, grab or salving; hacksaw, heavy duty complete with 6 spare blades; ladder; lift line 5 mm diameter and 15 m in length; pliers, side-cutting; set of assorted screwdrivers; and harness knife complete with sheath.

Table 22.10.1 Foam discharge rates

Category	Helicopter overall length	Discharge rate foam solution (litres/minute)
H1	Less than 15 m	250
H2	15 m and over, but less than 24 m	500
H3	24 m and over, but less than 35 m	800

22.10.6 Drainage facilities

22.10.6.1 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 yacht.

22.10.7 Helicopter refuelling and hangar facilities

22.10.7.1 Where the yacht has helicopter refuelling and hangar facilities, the following requirements shall be complied with:

.1 a designated area shall be provided for the storage of fuel tanks which shall be:
  - .1 as remote as is practicable from accommodation spaces, escape routes and embarkation stations; and
  - .2 isolated from areas containing a source of vapour ignition;

.2 the fuel storage area shall be provided with arrangements whereby fuel spillage may be collected and drained to a safe location;

.3 tanks and associated equipment shall be protected against physical damage and from a fire in an adjacent space or area;

.4 where portable fuel storage tanks are used, special attention shall be given to:
  - .1 design of the tank for its intended purpose;
  - .2 mounting and securing arrangements;
  - .3 electric bonding; and
  - .4 inspection procedures;

.5 storage tank fuel pumps shall be provided with means which permit shutdown from a safe remote location in the event of a fire. Where a gravity fuelling system is installed, equivalent closing arrangements shall be provided to isolate the fuel source;

.6 the fuel pumping unit shall be connected to one tank at a time. The piping between the tank and the pumping unit shall be of steel or equivalent material, as short as possible, and protected against damage;

.7 electrical fuel pumping units and associated control equipment shall be of a type suitable for the location and potential hazards;

.8 fuel pumping units shall incorporate a device which will prevent over-pressurization of the delivery or filling hose;

.9 equipment used in refuelling operations shall be electrically bonded;

.10 ‘‘NO SMOKING’’ signs shall be displayed at appropriate locations;

.11 hangar, refuelling and maintenance facilities shall be treated as category A machinery spaces with regard to structural fire protection, fixed fire-extinguishing and detection system requirements;

.12 enclosed hangar facilities or enclosed spaces containing refuelling installations shall be provided with mechanical ventilation, as required for spaces containing vehicles or craft with fuel in their tanks, or lockers storing such fuel. Ventilation fans shall be of non-sparking type; and

.13 electric equipment and wiring in enclosed hangars or enclosed spaces containing refuelling installations shall comply with requirements for spaces containing vehicles or craft with fuel in their tanks, or lockers storing such fuel.

22.10.8 Operations manual and fire-fighting arrangements

22.10.8.1 Each helicopter facility shall have an operations manual, including a description and a checklist of safety precautions, procedures, and equipment requirements. This manual may be part of the yacht’s emergency response procedures.

22.10.8.2 The procedures and precautions to be followed during refuelling operations shall be in accordance with recognized safe practices and contained in the operations manual.

22.10.8.3 Fire-fighting personnel, consisting of at least two persons trained for rescue and fire-fighting duties, and fire-fighting equipment shall be immediately available at all times when helicopter operations are expected.

22.10.8.4 Fire-fighting personnel shall be present during refuelling operations. However, the fire-fighting personnel shall not be involved with refuelling activities.

22.10.8.5 On-board refresher training shall be carried out and additional supplies of fire-fighting media shall be provided for training and testing of the equipment.

23 MACHINERY

23.1 GENERAL REQUIREMENTS

23.1.1 Yachts equal to or over 500 GT, unless otherwise specified elsewhere in this Part, shall comply with applicable requirements of the *Rules for classification of ships, Part 7 – Machinery Installation*, *Part 8 – Piping*, *Part 9 – Machines* and *Part 10 – Boilers, Heat Exchangers and Pressure Vessels.*

23.1.2 Yachts equal to or over 24 m in length and less than 500 GT, unless otherwise specified elsewhere in this Part, shall comply with applicable requirements of the *Rules for classification of ships, Part 7 – Machinery Installation*, *Part 8 – Piping*, *Part 9 – Machines* and *Part 10 – Boilers, Heat Exchangers and Pressure Vessels*, as far as practicable and reasonable, taking into account relaxations and/or alternatives reported in this Section.

23.1.3 Where a specific Part of the Rules for classification of ships do not explicitly refer to yachts, the relevant Rules for cargo ships apply.

For yachts equal to or over 500 GT, relaxations of the Rules for classification of ships given for ships of equal to or over 500 GT navigating in restricted areas may be considered.

For yachts equal to or over 24 m in length and less than 500 GT, relaxations of the Rules for classification of ships given for ships of less than 500 GT navigating in restricted areas may be considered.

23.1.4 The *Register* reserve the right to permit deviations from the requirements of this Section on a case-by-case basis, or to make special demands in the case of novel installations or equipment.

23.1.5 Alternative arrangements for **Pleasure yachts**, sailing yachts or yachts having restricted area of navigation may be agreed on a case-by-case basis.

23.1.6 The *Register* may permit deviations from the requirements of applicable Rules if the criterion of related Flag State Rules is complied with.

23.2 PIPING MATERIALS

23.2.1 In general, materials used for manufacture of pipelines shall comply with applicable requirements in the *Rules for the classification of ships, Part 8 – Piping*, 1.3.1.

23.2.2 Aluminium and aluminium alloys pipes may be accepted in machinery spaces, vehicle spaces and galleys provided that for the following services the wall thickness of such pipes is not to be less 4 mm and that they are insulated to obtain a fire resistance equivalent to steel:

- flammable oil including air, sounding and overflow
- fire extinguishing
- bilge
- scuppers and overboard discharges below freeboard deck (unless fitted with approved closing means at the shell, operated from a position above the freeboard deck)

Outside the machinery spaces, vehicle spaces and galleys, the use of aluminium and aluminium alloy pipes may be accepted considering the fire risk of compartment where such pipes are fitted. The use of aluminium and aluminium alloy pipes in dry exhaust gas systems is prohibited.

In general, pipes, valves and fittings made of aluminium and aluminium alloy shall be used for temperatures not exceeding 200°C.

Wall thickness of aluminium and aluminium alloys pipes exposed to internal pressure shall be determined in accordance with the requirements in the *Rules for the classification of ships, Part 8 – Piping*, 1.3.4 considering the corrosion allowance of at least 0,5 mm. In no case the wall thickness shall be less than that specified in Table 23.2.2.

Table 23.2.2
Minimum wall thickness for aluminium and aluminium alloy pipes

Outside diameter (mm)	Minimum wall thickness (mm)
0 – 10	1,5
12 – 38	2,0
43 – 57	2,5
76 – 89	3,0
108 – 133	4,0
159 – 195	4,5
219 – 273	5,0
above 273	5,5

NOTES:
1. For pipes passing through tanks containing a fluid distinct from that conveyed by the pipe, thickness of the respectively one line below shall be considered.
2. For sea water pipes, the minimum thickness is not to be less than 5 mm.
3. A different thickness may be considered by the *Register* on a case-by-case basis, provided that it complies with recognised standard.

23.2.3 Plastic pipes may be used in piping systems subject to provision of the *Rules for the classification of ships, Part 8 – Piping*, 1.7. For plastic pipes used in flammable oil systems and bilge system, outside the machinery spaces and spaces with fire risk, L1 fire endurance requirement may be replaced by L2.

For non-essential piping systems, plastic pipes need not be of approved type, and the design may be based on a recognized standard. Where such pipes penetrate watertight bulkheads or decks, a remotely controlled metallic shut-off valve shall be fitted at the bulkhead or deck.

The use of plastic pipes may be restricted by the statutory requirements of the related Flag State.

23.3 PIPING ARRANGEMENTS FOR FLAMMABLE OILS

23.3.1 The requirements under this Head apply to:

- fuel oil systems, in all spaces
- lubricating oil systems, in machinery spaces
- other flammable oil systems, in locations where means of ignition are present

23.3.2 The piping arrangement in the flammable oil systems is to comply with the following:

a) Flammable oil piping shall not be led through accommodation and service spaces. Where this requirement is impracticable, an exception can be made provided such pipes are led through the sanitary spaces, the pipes used have a thickness of not less than 5 mm and no detachable joints are employed.
b) Parts of the piping system containing flammable oil under pressure exceeding 0,18 MPa shall be, as far as practicable, arranged in clearly visible and accessible positions.
c) Flammable oil pipes shall not be led above the internal combustion engines, exhaust gas pipes, silencers, electrical installations and other sources of ignition.
In exceptional cases, it is allowed to lead the flammable oil pipes above the sources of ignition provided that in these positions the pipes have no detachable joints or that in necessary places provision is made for suitable screening and drainage preventing the spillage of fuel oil on the sources of ignition.
Alternatively, anti-splashing tape or anti-spray cover made of approved materials may be fitted around flanged joints, flanged bonnets and any other flanged or threaded connections which have possibility of being in contact with potential ignition sources by direct spray or by reflection.
d) Flammable oil piping leading into fire hazard space shall be arranged with easily accessible shut-off valves located outside the fire hazard area.
e) The number of joints in flammable oil piping systems shall be kept to a minimum.

23.3.3 Any relief valve of the flammable oil systems is to discharge to a safe position.

23.3.4 Flammable oil tanks not forming part of yacht's hull, as well as pumps, filters, heaters and other equipment or fittings shall be fitted with drip trays where there is a possibility of flammable oil leakage. Drainage of flammable oil into bilges is not permitted.

Where the drain pipes are provided for collecting leakages, they shall be fitted with sight glasses and led to an appropriate tank. Where trays are available, open funnels may be used instead of sight glasses.

23.3.5 Where fitted, drain tank is not to form part of an overflow system and shall be fitted with an alarm device to give warning if the flammable oil reaches the upper predetermined level in the drain tank.

The ends of the drain pipes shall be led to the tank bottom with a minimum gap.

Where the drain tank is situated in the double-bottom space, structural measures shall be taken to prevent penetration of water into machinery spaces through the open ends of the drain pipes in the event of damage to the shell plating.

Where drain pipes from the drip trays in various watertight spaces are led into the common drain tank, structural measures shall be taken to prevent penetration of water from one flooded space to the other through the open ends of the drain pipes.

23.3.6 All valves and cocks forming part of flammable oil systems shall be capable of being operated from readily accessible positions.

23.4 BILGE SYSTEM

23.4.1 An efficient bilge pumping system shall be provided, capable of pumping from and draining any watertight compartment (other than a tank permanently used for the carriage of liquids for which other efficient means of drainage are provided), under all practical conditions.

23.4.2 Small compartments may be drained by individual hand pump suctions.

Provided the safety of a yacht is not impaired, the *Register* may permit dispensation from the means of pumping or drainage of small compartments.

23.4.3 Where the peaks are not used as tanks for the carriage of liquids, independent drainage by hand pumps or water ejectors may be provided.

Alternatively, drainage of afterpeak may be carried out by means of readily accessible self-closing valve into engine room bilges. Internal diameter of this valve shall not be less than 35 mm.

23.4.4 The fitting of drain valves or similar devices on the collision bulkhead is prohibited.

In general, fitting of drain valves or similar devices on other watertight bulkheads shall be avoided. However, where such valves are provided, they shall be readily accessible and operable from above the freeboard deck. Open/close indication shall be fitted at valve's operating positions.

23.4.5 The bilge system shall be permanently installed and shall normally consist of metallic pipes.

Plastic pipes may be accepted outside machinery space and spaces with fire risk, subject to the requirements of 23.2.3.

For **Pleasure yachts**, flexible hose assemblies may be accepted for the whole length of the system. Such flexible hose assemblies shall be of an approved type for the service conditions and intended application. In general, they are to comply with the requirements of the *Rules for the classification of ships, Part 8 – Piping*, 1.3.8.

23.4.6 Bilge pumping system shall be so arranged as to prevent the possibility of sea water passing inside the yacht, or from one watertight compartment into another.

23.4.7 Each watertight compartment shall be drained by a dedicated bilge branch and the branch shall be fitted with a screw-down non-return valve between the bilge main and the individual branch. The valve shall be operable from readily accessible position and provided with open/close indicator.

Arrangements shall be made such as to allow a free and easy flow of water to bilge suctions. Additional suctions may be required if the flow of water towards the suctions is disturbed by irregularities of the bottom.

Where use of screw-down non-return valve is impracticable, other valves arrangement could be accepted, subject to special consideration by the *Register*.

23.4.8 The arrangement of bilge pipes shall be such as to ensure the possibility of draining the machinery space through the suction directly connected to the power bilge pump, the other compartments being simultaneously drained by other pump. This direct bilge suction shall be in addition to the suction from bilge main, required by 23.4.7.

Direct bilge suction shall be controlled by a screw down non-return valve or equivalent, operable from readily accessible position and fitted with open/close indicator.

23.4.9 In general, suctions shall be located at lowest point of the compartment.

23.4.10 Bilge suction piping up to the connection to the pumps shall be independent of other piping, except in the case where the pump is used for both firefighting and bilge pumping and a section of the piping is required to serve both functions.

23.4.11 At least two fixed and independently powered pumps shall be provided. One of the bilge pumps may be main engine driven pump, or ejector provided that suction capacity is not to be less than the required capacity of bilge pump it replaces. Pumps shall be arranged to take suction from the bilge main.

Bilge pumps shall be of the self-priming type.

The capacity of each power bilge pump shall be determined in accordance with the *Rules for the classification of ships, Part 8 – Piping*, 2.1.8. However, the capacity of each power bilge pump shall not be less than 11 m^3/h or not less than that of the main power fire pump, whichever is greater.

For **Pleasure yachts** and yachts having restricted area of navigation, one of the required bilge pumps may be portable power pump provided that it is equipped with suitable suction and discharge hoses capable of reaching the bilges for each watertight compartment.

Different number, capacity and arrangement of bilge pumps may also be accepted if the criterion of related Flag State Rules is complied with.

23.4.12 In case of one compartment flooded, the bilge system shall be able to control any possible leakage to adjacent compartments. This operation shall not need any manual intervention inside the flooded compartment.

23.4.13 Sanitary, ballast, fire and general service pumps may be accepted as independent power bilge pumps if fitted with the necessary connections to the bilge pumping system and provided that, except for **Pleasure yachts**, they are immediately available for bilge duty when required.

Operation of the any bilge pump is not to be affected by the simultaneous operation of other pumps.

23.4.14 The arrangement of bilge pipes shall be such as to enable one of the bilge pumps to be operated in case the rest of the pumps are inoperative due to examination, repair or maintenance. Non-return valves shall be installed in the piping to isolate the systems during simultaneous operation and to prevent possible flooding through the bilge system.

23.4.15 The inside diameters of the bilge main, direct bilge suction and branch bilge suctions shall be determined in accordance with applicable requirements of the *Rules for the classification of ships, Part 8 – Piping*, 2.2.

23.4.16 Each fixed bilge suction shall be fitted with readily accessible strainer or strum box.

23.4.17 Where it is intended to carry flammable or toxic liquids in enclosed spaces, the bilge system shall be designed to prevent pumping of such liquids through piping and pumps in machinery or other spaces where a source of ignition may exist.

23.4.18 Where auto-start bilge pump is arranged, a visual indicator shall be provided at the navigation bridge to indicate when bilge pump is operating.

Compartments containing potential pollutants, including machinery spaces, should not be fitted with auto-start bilge pumps.

23.4.19 The power bilge pumps shall be possible to operate from the navigation bridge.

Hand bilge pumps shall be capable of being operated from readily accessible positions above the freeboard deck.

23.4.20 For multi-hull yachts, the power bilge pumping units required in 23.4.11 are to take suction from the bilge main in each hull. Where the bilge system in each hull is entirely separate, at least two power bilge pumps shall be provided in each hull meeting the requirements of 23.4.11.

23.4.21 As an alternative to the arrangement required in 23.4.11, separate power bilge pumps may be installed for one or more compartments provided that:

.1 Each fixed power bilge pump is of reliable submersible type.

.2 Capacity of each fixed power bilge pump shall be determined by the following formula:

$$Q = Q_t/(N-1)$$

where:

Q - minimum capacity of bilge pump in [m^3/h]

Q_t - total capacity of bilge pumps, determined in accordance with 23.4.11, in [m^3/h]

N - number of individual submersible fixed bilge pumps

In no case the capacity of each fixed power bilge pump shall be less than 6 m^3/h.

.3 In general, one submersible fixed power pump shall be provided for each watertight compartment.

.4 At least one portable power bilge pump shall be provided with capacity not less than that defined in 23.4.21.2.

It shall be capable of pumping water, but not necessarily simultaneously, from all watertight compartments and shall be provided with suitable suction and discharge hoses capable of reaching the bilges for each watertight compartment.

Portable bilge pump, if electric, shall be supplied from the emergency source of power.

.5 The suction of each fixed power pump shall be fitted with a suitable strainer which can be easily removed for cleaning.

.6 Each fixed power bilge pump shall be possible to operate from the navigation bridge.

.7 At least two non-return devices shall be fitted on discharge line of each fixed power bilge pump, one positively controlled non return valve situated at the shell and the other may be an automatic non-return valve fitted at or near the overboard valve.
Instead of the automatic non-return valve, a pipe loop may be accepted taken up to the highest practicable point below the freeboard deck.

23.4.22 Any space for which bilge pumping arrangement is required shall be provided with a bilge level alarm.

At the discretion of the *Register*, bilge level alarm may be omitted in small buoyancy compartments.

For pleasure yachts, bilge level alarm may be provided for machinery spaces only.

23.4.23 Where fixed pressure water-spraying system is fitted, means shall be provided in the compartment to ensure that such water is discharged directly overboard.

23.5 FUEL OIL SYSTEM

23.5.1 In a yacht in which fuel oil is used, the arrangements for the storage, distribution and utilisation of the fuel oil shall be such as to ensure the safety of the yacht and persons on board.

The provisions of 23.3 shall be complied with, where applicable.

23.5.2 Design pressure for the fuel oil systems shall be determined in accordance with the *Rules for the classification of ships, Part 8 – Piping*, Table 1.3.4.1-4.

23.5.3 Fuel oil used shall be in compliance with the requirements of the *Rules for the classification of ships, Part 7 - Machinery Installations*, 1.1.2.

Proposals for the use or carriage of fuel oil with a flash point below 43°C will be specially considered by the *Register*.

23.5.4 The yacht should be provided with sufficient fuel for its intended area of operation.

23.5.5 Construction of the fuel oil tanks, where they are not integral parts of the yacht's hull, shall comply with the requirements set forth in 18.6.

23.5.6 Fuel oil pumps, valves, filters, and other similar components shall be readily accessible for inspection and maintenance.

23.5.7 In general, the fuel oil pipeline shall have no communication with other piping systems.

Fuel oil tanks are not to be used for carriage of water ballast.

23.5.8 Suitable means shall be provided for the fuel oil transferring operation.

Where fuel oil transfer by pump is anticipated, at least two pumps shall be provided. One of these pumps may be manual.

For **Pleasure yachts**, at least one means of transfer shall be provided, which may be a manual pump.

Where provided, purifiers may be accepted as means of transfer.

23.5.9 For draining water from the bottom of the daily service tanks, these tanks shall be fitted with self-closing valves.

23.5.10 Where daily service tanks are filled automatically or by remote control, means shall be provided to prevent overflow spillages.

23.5.11 In general, fuel oil piping shall be made of metallic materials**.** Where aluminium pipes are used in machinery space and spaces with fire risk, they shall be insulated to obtain a fire resistance equivalent to steel.

Plastic pipes may be accepted outside machinery space and spaces with fire risk, subject to the requirements of 23.2.3.

Minimum lengths of flexible hose assemblies, not exceeding 1,5 m, may be used where necessary to allow for relative movements and vibration between machinery and fixed piping systems.

For **Pleasure yachts**, flexible hose assemblies may be accepted for the whole length of the system.

Flexible hose assemblies shall be of an approved type for the service conditions and intended application. In general, they are to comply with the requirements of the *Rules for the classification of ships, Part 8 – Piping*, 1.3.8.

Alternatively, flexible hoses conforming to the requirements of ISO 7840 and fitted with pressed on end fittings could be accepted, subject to special consideration by the *Register* in each particular case.

23.5.12 Each fuel oil pipe which, if damaged, would allow oil to escape from a fuel oil tank having a capacity of 500 liters and above, shall be provided with shut-off valve fitted directly on the tank, capable of being remotely closed from accessible places located outside the space containing the tank. Quick-closing valves are recommended for that purpose.

The controls for remote operation of the valve for the emergency diesel-generator fuel tank shall be in a separate location from the controls for remote operation of other valves for tanks located in machinery space.

Remote operation for the fuel valves shall be clearly marked in order to avoid the risk of the wrong valve being closed.

In the case of fuel oil tanks having a capacity less than 500 liters or where valves are normally closed (except during transfer operation), remote controls need not to be fitted.

23.5.13 The propulsion machinery and auxiliary engines which are able to use the same type of fuel may be supplied from the same fuel source, provided that the fuel oil lines supplying propulsion machinery and those supplying auxiliary engines are so arranged that a failure within one of those lines is not to render the other lines inoperable.

23.5.14 Filling of fuel oil storage tanks shall be carried out through a permanent pipeline. The end of the fuel oil filling pipe shall be led to the tank bottom with a minimum gap.

23.5.15 Filling pipes of fuel oil tanks are to terminate on open deck or in filling stations isolated from other spaces and efficiently ventilated.

Suitable coamings and drains shall be provided to collect any leakage resulting from filling operations.

23.5.16 When the fuel oil tanks are filled from shore under pressure, provision shall be made against overpressure in the filling pipelines.

For that purpose, a warning label may be accepted with clearly declared design pressure of the filling lines and the local pressure gauge fitted in vicinity of the filling connection.

23.5.17 Filling lines shall be led through the fuel oil tank top. Where this is impracticable, the filling lines shall be fitted with non-return valves installed directly on the tanks.

Where filling pipes are used as suction pipes, non-return valves shall be replaced with a remotely controlled shut-off valves operable from accessible position outside the space in which the tank is located.

23.5.18 Provision shall be made for efficient filtration of the fuel oil supply to the engine.

23.5.19 Except for sailing yachts, the filter fitted in the fuel oil supply line to the propulsion engine shall be such that it can be cleaned without interrupting the operation of the engine.

This requirement may be dispensed with provided that the following conditions are met:

a) where one propulsion engine is fitted, one readily accessible and easily replaceable spare filter shall be available on board, or
b) where two or more propulsion engines are fitted each one with its own filter, it shall be demonstrated during sea trials that the yacht is capable of safe navigation and manoeuvring with one propulsion engine out of use.

23.5.20 Except for sailing yachts, where one fuel oil supply pump is fitted to serve the propulsion engine the arrangement shall be such that the engine is supplied with fuel oil in the event of damage to the fuel oil supply pump.

This requirement may be dispensed with provided that the following conditions are met:

a) where one propulsion engine is fitted, one complete spare fuel oil supply pump of appropriate capacity ready to be connected shall be carried on board, or
b) where two or more propulsion engines are fitted each having its own fuel oil supply pump, it shall be demonstrated during sea trials that the yacht is capable of safe navigation and manoeuvring with one propulsion engine out of use.

23.5.21 For auxiliary engines no additional filter and fuel oil supply pump is required.

23.5.22 Emergency diesel-generator, where fitted, shall be provided with a separate fuel oil tank located in the same room. The fuel oil from such tank shall not be used for other purposes.

23.6 LUBRICATING OIL SYSTEM

23.6.1 The arrangement for the storage, distribution and utilisation of the lubricating oil shall be such as to ensure the safety of the yacht and persons on board.

The provisions of 23.3 shall be complied with, where applicable.

23.6.2 Where applicable, lubricating oil piping and remotely controlled shut-off valves shall comply with the same requirements as for fuel oil systems, according 23.5.11, 23.5.12 and 23.5.17.

23.6.3 Sight-glasses in the piping, where fitted, shall have a suitable degree of fire resistance.

23.6.4 Provision shall be made for efficient filtration of the lubrication oil supply to the engine.

23.6.5 Except for sailing yachts, the filter fitted in the lubrication oil supply line to the propulsion engine shall be such that it can be cleaned without interrupting the operation of the engine.

This requirement may be dispensed with provided that the following conditions are met:

a) where one propulsion engine is fitted, one readily accessible and easily replaceable spare filter shall be available on board, or
b) where two or more propulsion engines are fitted each one with its own filter, it shall be demonstrated during sea trials that the yacht is capable of safe navigation and manoeuvring with one propulsion engine out of use.

23.6.6 Except for sailing yachts, where one lubricating oil supply pump is fitted to serve the propulsion engine the arrangement shall be such that the engine is supplied with lubricating oil in the event of damage to the lubricating oil supply pump.

This requirement may be dispensed with provided that the following conditions are met:

a) where one propulsion engine is fitted, one complete spare lubricating pump of appropriate capacity ready to be connected shall be carried on board, or
b) where two or more propulsion engines are fitted each having its own lubricating pump, it shall be demonstrated during sea trials that the yacht is capable of safe navigation and manoeuvring with one propulsion engine out of use.

23.6.7 For auxiliary engines no additional filter and lubricating pump is required.

23.7 COOLING WATER SYSTEM

23.7.1 The cooling water system provided shall be capable of maintaining all lubricant and coolant temperatures in the propulsion engines, auxiliary engines, and other essential equipment within the manufacturer's recommended limits during all operating conditions.

23.7.2 The provision shall be made for alternative cooling of propulsion engine in emergency condition by sea water.

The requirement for alternative cooling may be dispensed with provided that one complete spare pump of appropriate capacity ready to be connected to cooling circuit is carried on board.

Where two or more propulsion engines are fitted each served by a separate cooling sea water pump, the requirement for alternative cooling may be dispensed with provided that it can be demonstrated during sea trials that the yacht is capable of safe navigation and manoeuvring with one propulsion engine out of use.

For sailing yachts, the requirement for alternative cooling is not mandatory.

23.7.3 The oil and air coolers of the electric propulsion motors shall have standby means of cooling, equivalent to the main means.

23.7.4 Where each of the auxiliary engines is provided with an independent cooling water pump, the alternative cooling in emergency condition for these engines are not required. Where, however, a group of auxiliaries is supplied with cooling water from a common system, provision shall be made for alternative cooling of auxiliary engines by sea water directly.

The requirement for alternative cooling may be dispensed with provided that one complete spare pump of appropriate capacity ready to be connected to cooling circuit is carried on board.

23.7.5 Ballast, other general service pumps operated only with clean water and fire pumps, of sufficient capacity, may be used for alternative cooling of engines, provided that arrangements are made against overpressure in the cooling system.

23.7.6 Where arranged, sea water for alternative cooling in emergency condition of propulsion and/or auxiliary engines shall be taken from sea inlets other than those used for their main cooling. Sea inlets may be interconnected.

Sea inlets shall be submerged under all normal navigating conditions.

23.7.7 On the suction lines of sea water cooling system servicing the propulsion and auxiliary engines, the filters shall be fitted behind the sea inlets.

The cooling sea water system shall be so arranged as to enable the filter to be cleaned without having to stop the engine.

23.7.8 In general, cooling water piping shall be made of metallic materials**.** Where necessary, suitable provision shall be made for protection against contact corrosion.

Plastic pipes may be accepted, subject to the requirements of 23.2.3.

Flexible joints may be used where necessary to allow for relative movements and vibration between machinery and fixed piping systems. Such flexible hose assemblies are to comply with the requirements of the *Rules for the classification of ships, Part 8 – Piping,* paragraphs 1.3.1.8.

Alternatively, where failure may result in flooding, flexible hoses conforming to the requirements of ISO 7840 and fitted with pressed on end fittings could be accepted, subject to special consideration by the *Register* in each particular case.

For **Pleasure yachts**, flexible hose assemblies may be accepted for the whole length of the system.

23.7.9 Cooler installations external to the hull shall comply with requirements set forth in the *Rules for the classification of ships, Part 8 – Piping*, 10.6.

23.8 COMPRESSED AIR SYSTEM

23.8.1 In general, compressed air system shall conform to applicable requirements of the *Rules for the classification of ships, Part 8 – Piping,* 11.

23.8.2 In general, compressed air piping shall be made of metallic materials**.**

Plastic pipes may be accepted, subject to the requirements of 23.2.3.

23.8.3 Compressed air systems shall be so designed that, in the event of failure of one air compressor or one air receiver intended for starting, control purposes or other essential services, the air supply to such services can be maintained**.**

The compressed air system for starting propulsion engines and auxiliary engines for essential services shall be so arranged that it is possible to ensure the initial charge of air receiver(s) without the aid of a power source outside the yacht.

23.8.4 Where, for the purpose of 23.8.3, an emergency air compressor is fitted, its driving engine shall be capable of being started by hand-operated devices. Independent electrical starting batteries may also be accepted.

Alternatively, a hand compressor may be used for the purpose of 23.8.3 provided that it is capable of charging within one hour an air receiver of sufficient capacity to provide three consecutive starts of a propulsion engine or of an engine capable of supplying the energy required for operating one of the main compressors.

23.8.5 Where the propulsion and auxiliary engines are arranged for starting by compressed air, at least one air compressor shall be fitted with a capacity sufficient to supply within one hour the quantity of air needed to satisfy the provisions of the *Rules for the classification of ships, Part 8 – Piping,* paragraphs 11.1.3 to 11.1.6.

23.8.6 Where starting air arrangement for the emergency diesel-generator is one of its required independent means of starting, the following shall be complied with:

a) The starting air arrangement is to include a compressed air receiver, storing the energy dedicated only for starting of the emergency diesel-generator. The capacity of the compressed air available for starting purpose shall be sufficient to provide, without replenishment, at least three consecutive starts.
b) The compressed air starting systems may be maintained by the main or auxiliary compressed air receivers through a suitable non-return valve fitted in the emergency generator space, or by an emergency air compressor which, if electrically driven, is energised by the emergency switchboard.
c) All of these starting, charging and compressed air storing devices shall be located

in the emergency generator space and are not to be used for any purpose other than the operation of the emergency generating set.

23.9 EXHAUST GAS SYSTEM

23.9.1 In general, design of exhaust gas systems is to comply with requirements of the *Rules for the classification of ships, Part 8 – Piping*, 6.1.1.

23.9.2 The exhaust gas pipes, as a rule, shall be led to the open decks.

Engine exhaust outlets which penetrate the hull below the freeboard deck should be provided with means to preclude the possibility of sea water getting into the engine, and generally to prevent any back flooding into the hull through a damaged exhaust system.

Where fitting of a non-return positive closure is not practicable, the exhaust gas piping should be looped up above the waterline on the outboard side of the system, to a minimum height of 1000 mm. Exhaust gas piping from the top of the loop to the shell connection shall be of substantial thickness at least equivalent to shell thickness.

Where the requested minimum height is not possible to achieve for technical reasons, the exhaust gas piping shall be looped up to a maximum possible height below the freeboard deck. Final acceptance of such arrangement shall be a subject to special consideration by the *Register* in each particular case.

23.9.3 Where a shut-off valve is fitted at the overboard discharge, means shall be provided to prevent the engine from being started when the valve is not fully open.

23.9.4 As a rule, the machinery exhaust systems shall not pass-through accommodation. Where it is impractical and could not be avoided, the exhaust gas pipes shall be fitted in a gas tight trunk or each space should be fitted with a carbon monoxide detector, having an alarm provided locally and at a continuously manned station.

23.9.5 Each propulsion and auxiliary engine shall have an individual exhaust gas pipe. Where required, exhaust gas pipes may be connected to a common exhaust gas pipeline provided provision is made for a reliable protective device that will preclude:

- the gases of the common line entering the pipes of the engines not actually at work.
- damage of any of the engines when starting.

23.9.6 Exhaust gas pipes of internal combustion engines shall be thermally insulated by means of suitable insulating material complying with requirements of the *Rules for the classification of ships, Part 7 - Machinery Installation*, 1.11.9.

Where insulation covering the exhaust piping system including flanges is oil-absorbing or may permit penetration of oil, the insulation shall be encased in sheet metal or equivalent.

23.9.7 Where exhaust pipes are water cooled, they shall be so arranged as to be self-draining overboard. Means shall be provided to prevent water from flowing back into the engine when the engine is stopped.

23.9.8 Engine silencers shall be so arranged as to provide easy access for cleaning and overhaul.

23.9.9 Materials, manufacture and application of exhaust gas pipes shall be in compliance with the *Rules for the classification of ships, Part 8 – Piping,* 1.3.1.2, 1.3.7.1 and 1.3.7.2, and tables 1.2.2, 1.3.4.3 and 1.3.7.2-3.

The use of aluminium pipes in dry exhaust gas systems is prohibited.

23.9.10 The use of non-metallic materials could be accepted in water cooled exhaust gas systems, subject to special consideration by the *Register* in each particular case.

The consideration shall be carried out including, but not limited to, the following conditions:

.1 Non-metallic materials shall not be fitted before water injection point.

.2 Protection against unacceptable high temperature in exhaust gas piping shall be provided by means of high temperature alarm after water injection followed by automatic engine shut-down. This alarm shall be integrated into the yacht's alarm system.

3. Use of plastic pipes shall comply generally with the provision of 23.2.3. Inside machinery spaces and spaces with fire risk, plastic pipes shall comply with at least L3 fire endurance requirements in accordance with provision of the *Rules for the classification of ships, Part 8 – Piping,* 1.7.4.1.

4. Silencer made of plastic material may be used provided that it is of an approved type for service conditions and the intended application.

5. High level bilge alarm shall be provided in spaces containing the non-metallic parts of the exhaust gas piping.

6. In general, the rigid pipes shall be used for the exhaust gas lines, having the flexible parts as short as practical only to compensate vibration and temperature dilatation where necessary.
For **Pleasure yachts**, flexible hoses may be accepted for the entire length of exhaust gas lines, after water injection point.
Such flexible parts shall meet the requirements of recognized standard (e.g., ISO 15540 / 15541, ISO 13363, SAE J2006) and shall be secured by means of at least two stainless steel hose clamps at each end. The clamps shall be at least 12 mm wide and are not to be dependent on spring tension to remain fastened. The joint location shall be readily accessible and visible at all times.

.7 The overboard outlets shall be fitted with suitable metallic shut-off valve fitted on the shell connection. Valve shall be controlled from outside space, from where an indicator shall be fitted showing valve's open or closed position.
The system shall be of equivalent construction to the hull on the outboard side to the valve.

For **Pleasure yachts**, the shut-off valve may be controlled from above the deepest loaded waterline. Shut-off valve may be omitted provided that the exhaust piping is looped up above the waterline on the outboard side of the system, complying with 23.9.2.

.8 In general, the exhaust gas outlets on the shell side shall be located above the summer water line.
Submerged exhaust gas outlets could be admitted, subject to special consideration by the *Register* in each particular case. In any case submerged pipeline shall be of equivalent construction to the hull up to the deepest loaded waterline, and exhaust piping shall be looped up above the waterline on the outboard side of the system, complying with 23.9.2. A metallic shut-off valve shall be fitted on the shell connection, operable from above the freeboard deck.
For **Pleasure yachts**, the shut-off valve may be controlled from outside space.

23.10 SCUPPERS, INLETS AND DISCHARGES

23.10.1 Sufficient number and appropriate size of scuppers shall be provided to allow drainage of water that is likely to accumulate in spaces not located in the yacht's bottom.

23.10.2 The number of sea inlets and discharges shall be kept to an operational minimum.

23.10.3 In general, the sea inlets shall be so designed and arranged as to limit turbulence and to avoid the admission of air due to motion of the yacht.

Sea inlets shall be fitted with protecting gratings. Gratings are to have a free flow area not less than twice the total section of the pipes connected to the sea inlet.

23.10.4 As a rule, the discharges at the shall plating, connected to a system without open inboard end, shall be arranged with valves of non-return shut-off type.

All sea inlets at the shell plating shall be arranged with shut-off valves fitted with positive means of closing.

Where this is impracticable, use of the other type of valves and valves arrangement on the shell plating will be specially considered by the *Register*.

23.10.5 Except as provided in paragraph 11.10.10, discharges led through the shell plating either from spaces below the freeboard deck or from spaces within superstructures and deckhouses on the freeboard deck, fitted with weathertight doors, shall be provided with one non-return valve fitted with a positive means of closing it from above the freeboard deck.

Where the inboard end of the discharge pipe is located at least 0,01L above the summer load line, the discharge may have two non-return valves without positive means of closing, provided that the inboard valve is situated above the deepest loaded waterline and is always accessible for examination under service conditions. Alternatively, a locally controlled shut-off valve may be interposed between the two non-return valves.

Where that vertical distance exceeds 0,02L, a single non-return valve without positive means of closing may be accepted.

For **Pleasure yachts**, the positive closing valve may be operated from above the deepest loaded waterline.

23.10.6 Discharges from enclosed superstructures and deckhouses, fitted with weathertight doors, may be led into bilge wells of the machinery space.

23.10.7 Scuppers and discharge pipes originating from open decks and penetrating the shell below the freeboard deck shall be provided with non-return valve at the shell. This valve may be omitted if piping below the freeboard deck is of substantial thickness at least equivalent to shell thickness.

23.10.8 Scuppers leading from superstructures or deckhouses not fitted with weathertight doors shall be led overboard. Requirements specified in 23.10.7 shall be satisfied.

23.10.9 Scupper draining spaces below summer load line shall be led into bilge wells of the machinery space.

23.10.10 Main and auxiliary sea inlets and discharges in connection with the operation of machinery shall be fitted with readily accessible shut-off valves between the pipes and the shell plating or between the pipes and fabricated distant pieces of short rigid construction attached to the shell plating. These valves may be controlled locally and shall be provided with open/close indicator.

23.10.11 The requirements for non-return valves are applicable only to those discharges which remain open during the normal operation of the yacht. For discharges which shall be kept closed at sea, a single positive closing valve is acceptable.

23.10.12 In enclosed spaces fitted with a fixed pressure water-spraying fire-extinguishing system, the drainage arrangement shall be such as to prevent the build-up of free surfaces. If this is not possible, the adverse effect upon stability of the added weight and free surface of water shall be taken into account to the extent deemed necessary by the *Register* in its approval of the stability calculations.

Enclosed vehicle spaces or spaces storing highly flammable or poisonous liquids shall be provided with independent drainage system not communicating with the machinery space or other spaces where sources of ignition may be present.

23.10.13 All sea inlet and discharge valves fitted directly to the shell plating shall be secured by studs screwed into heavy pads of metallic material welded to the plating. The stud holes are not to penetrate the plating.

Alternatively, distance pieces of short rigid construction and made of approved metallic material may be fitted between the valve and the shell plating. Distant piece shall be of substantial thickness at least equivalent to shell thickness.

The distance piece shall extend through the shell plating and shall be welded on both sides or with full penetration welding.

Other securing means could be admitted, subject to special consideration by the *Register*, namely in the case of small size valves.

23.10.14 In wood or composite hulls, openings in the shell are to have suitably reinforced areas or pads to which the valves or fittings are attached.

Valves of nominal diameter up to 50 mm may be attached to the hull fittings having an external collar and internal nut. Valves of nominal diameter over 50 mm shall be attached to the hull with flange joints.

Other equivalent arrangements could be accepted, subject to special consideration by the *Register* in each particular case.

23.10.15 Where substantial thickness is not required for sea inlet and discharge pipes made of metallic materials, requirements of the *Rules for the classification of ships, Part 8 – Piping,* 16.3.1 shall apply.

23.10.16 All shell fittings and valves shall be of steel, bronze or other approved ductile material complying with the requirements of the *Rules for the classification of ships, Part 25 – Metallic Materials*. Valves of ordinary cast iron or similar material are not acceptable.

23.10.17 Operating positions of all sea inlet and discharge valves shall be readily accessible at all times and means shall be provided for indicating whether the valves are open or closed.

All sea inlet and discharge valves shall be fitted to the shell in such a way that piping inboard of the valves may be disconnected without any risk of flooding.

23.10.18 In general, scupper, sea inlet and discharge pipes shall be permanently installed and shall normally consist of metallic pipes.

Plastic pipes may be used above the deepest loaded waterline, provided that a remotely controlled metallic shut-off valve is fitted on the shell connection, operable from outside space.

For plastic scuppers and draining coming from the open deck, suitable means shall be provided to blank the intake opening on deck.

For **Pleasure yachts**, a remotely controlled metallic shut-off valve may be replaced with readily accessible shut-off valve. Shut-off valve may be omitted, provided that piping is looped up above the waterline on the outboard side of the system. Anti-siphon loop is to have a height of 1000 mm or the highest technically feasible, whichever is less, and shall be of an equivalent construction to the hull.

On **Pleasure yachts**, plastic pipes may be fitted at or below the deepest loaded waterline, provided that remotely controlled shut-off valves are fitted on the shell connection, operable from outside space.

On **Pleasure yachts**, flexible hose assemblies may be accepted for the scupper and drain pipes, provided that they are of an approved type for the service conditions and intended application, and shut-off valves or anti-siphon loops are fitted on the shell connection, complying with the same requirements as in the case of plastic pipes. In general, flexible hose assemblies are to comply with the requirements of the *Rules for the classification of ships, Part 8 – Piping*, 1.3.8. Alternatively, where failure may result in flooding, flexible hoses conforming to the requirements of ISO 7840 and fitted with pressed on end fittings could be accepted, subject to special consideration by the *Register* in each particular case.

23.11 AIR, OVERFLOW AND SOUNDING SYSTEM

23.11.1 In general, air, overflow and sounding pipes shall conform to applicable requirements of the *Rules for the classification of ships, Part 8 – Piping,* 5.

23.11.2 Air, overflow and sounding systems shall be permanently installed and shall normally consist of metallic pipes.

With the exception of open decks, plastic pipes may be accepted outside the machinery space and spaces with fire risk, subject to the requirements of 23.2.3.

23.11.3 The height of air pipes from the deck to the point where water may have access below shall be not less than that defined in Section 19, Table 19.1.

23.11.4 Satisfactory appliances which are permanently attached shall be provided for closing the openings of air pipes in order to ensure a watertight closure. Means of air pipe closure may be omitted if it can be shown that the open end of an air pipe is afforded adequate protection by other superstructure which will prevent the ingress of water.

23.11.5 Air pipe automatic closing devices shall be of an approved type, in accordance with requirements of the *Rules for the classification of ships, Part 8 – Piping,* 5.1.6.

For **Pleasure yachts**, air pipe automatic closing appliances conforming to recognised standard may be accepted.

23.11.6 For tanks and other spaces which normally may contain liquids, following could be accepted instead of sounding pipes required by the *Rules for the classification of ships, Part 8 – Piping,* 5.5.1:

- type approved level gauge, effectively protected against possible mechanical damage. In addition, level gauges intended for installation in flammable oil systems shall comply with the requirements of the *Rules for the classification of ships, Part 8 – Piping,* 5.5.2.2, or
- type approved remote level indicator, effectively protected against possible mechanical damage.

For **Pleasure yachts**, level gauges and remote level indicators conforming to recognised standard may be accepted.

23.12 STEERING GEAR

23.12.1 General requirements and definitions

23.12.1.1 For the purpose of this Rule the following definitions and explanations have been adopted:

.1 **Main steering gear** is the machinery, rudder actuators, steering gear power units, if any, ancillary equipment and the means of applying torque to the rudder stock (e.g. tiller or quadrant) necessary for effecting movement of the rudder for the purpose of steering the yacht under normal service conditions.

.2 **Auxiliary steering gear** is the equipment other than any part of the main steering gear necessary to steer the yacht in the event of failure of the main steering gear, but not including the tiller, quadrant or components serving to the same purpose.

.3 **Steering gear power unit** is:
- .1 in case of electric steering gear an electric motor and its associated electrical equipment;
- .2 in case of electrohydraulic steering gear an electric motor and its associated equipment and connected pump;
- .3 in case of other hydraulic steering gear a driving engine and connected pump.
- .4 in the case of manual hydraulic steering gear, a hand pump (could be combined with a steering wheel);
- .5 in the case of manual mechanic steering gear, a steering wheel (main steering gear) or manual lever on top of rudder stock (auxiliary steering gear).

.4 **Steering gear control system** is the equipment by which orders are transmitted from the navigating bridge to the steering gear power units. It shall be understood as steering control system covering the equipment required to control the steering gear power actuating system.

.5 **Power actuating system** means the hydraulic equipment provided for supplying power to turn the rudder stock, comprising a steering gear power unit or units, together with the associated pipes and fittings, and a rudder actuator. The power actuating systems may share common mechanical components, i.e. tiller, quadrant and rudder stock, or components serving to the same purpose.

.6 **Rudder actuator** means the component which converts directly hydraulic pressure into mechanical action to move the rudder.

.7 **Maximum ahead service speed** means the greatest speed which the yacht is designed to maintain in service at sea at her deepest sea going draught.

.8 **Redundancy** is the ability of a component or system to maintain or restore its function when one failure has occurred. Redundancy can be achieved for instance by installation of more units or alternative means for performing a function.

.9 **Design pressure** is the greatest of the following pressures:
- 1,25 times the maximum working pressure
- the setting pressure of the relief valves

23.12.1.2 Unless expressly provided otherwise, every yacht shall be provided with a main steering gear and an auxiliary steering gear to the satisfaction of this Rules. The main steering gear and the auxiliary steering gear shall be so arranged that the failure of one of them will not render the other one inoperative.

23.12.1.3 All the steering gear components and the rudder stock shall be of sound and reliable construction to the satisfaction of this Rules. Special consideration shall be given to the suitability of any essential component which is not duplicated. Any such essential component shall, where appropriate, utilise antifriction bearings such as ball-bearings, roller-bearings or sleeve-bearings which shall be permanently lubricated or provided with lubrication fittings.

23.12.1.4 The design pressure for calculations to determine the scantlings of piping and other steering gear components subjected to internal hydraulic pressure shall be at least 1.25 times the maximum working pressure to be expected under the operational conditions specified in 23.12.2.1.2, taking into account any pressure which may exist in the low-pressure side of the system. At the discretion of the *Register*, fatigue criteria shall be applied for the design of piping and components, taking into account pulsating pressures due to dynamic loads.

23.12.1.5 Relief valves shall be fitted to any part of the hydraulic systems which can be isolated and in which pressure can be generated from the power source or from external forces. The setting of the relief valves shall not exceed the design pressure. The valves shall be of adequate size and so arranged as to avoid an undue rise in pressure above the design pressure.

23.12.1.6 The electrical power circuits and the steering gear control systems with their associated components, cables and pipes required by this Rules shall be separated as far as practicable throughout their length.

23.12.2 Characteristics and performance of steering gear

23.12.2.1 The main steering gear and rudder stock shall be:
- .1 of adequate strength and capable of steering the yacht at maximum ahead service speed which shall be demonstrated;
- .2 capable of putting the rudder over from 35° on one side to 35° on the other side with the yacht at its deepest seagoing draught and running ahead at maximum ahead service speed and, under the same conditions, from 35° on either side to 30° on the other side in not more than 28 seconds;
- .3 operated by power where necessary to meet the requirement of 23.12.2.1.2 and in any case when the *Rules* require a rudder stock of over 120 mm diameter in way of the tiller, excluding strengthening for navigation in ice; and
- .4 so designed that they will not be damaged at maximum astern speed; however, this design requirement need not to be proved by trials at maximum astern speed and maximum rudder angle.

23.12.2.2 The auxiliary steering gear shall be:
- .1 of adequate strength and capable of steering the yacht at navigable speed and of being brought speedily into action in an emergency;
- .2 capable of putting the rudder over from 15° on one side to 15° on the other side in not more than 60 seconds with the yacht at its deepest seagoing draught and running ahead at one half of the maximum ahead

service speed or 7 knots, whichever is the greater;

.3 operated by power where necessary to meet the requirements of .2 and in any case when the Rules require a rudder stock of over 230 mm diameter in way of the tiller, excluding strengthening for navigation in ice.

23.12.3 Steering gear power units

23.12.3.1 Main and auxiliary steering gear power units shall be:

.1 arranged to restart automatically when power is restored after a power failure; and

.2 capable of being brought into operation from a position on the navigating bridge. In the event of a power failure to any one of the steering gear power units, an audible and visual alarm shall be given on the navigating bridge.

23.12.3.2 Where the main steering gear comprises two or more identical power units, an auxiliary steering gear need not to be fitted, provided that the main steering gear is so arranged that after a single failure in its piping system or in one of the power units the defect can be isolated so that steering capability can be maintained or speedily regained. The main steering gear shall be capable of operating the ruder as required in 23.12.2.1 while operating with all power units.

23.13 SHAFTING

23.13.1 In general, propulsion shafting shall conform to applicable requirements of the *Rules for the classification of ships, Part 7 – Machinery installation.*

23.13.2 For yachts less than 300 GT and having restricted area of navigation, when the propeller shaft material is corrosion-resistant material, such as austenitic stainless steel, martensitic stainless steel or duplex stainless steel, the following alternative formula may be used to calculate the minimum diameter of the intermediate and propeller shafts:

$$d_P = F_P \cdot k_P \sqrt[3]{\frac{P}{n} \cdot \frac{1}{1-(\frac{d_{uP}}{d_{vP}})^4} \cdot \frac{560}{R_{mP}+160}}$$

where:

F_P – factor for the type of propulsion installation.
= 95 for single screw yacht with internal combustion engine installations and electric propulsion installations;
= 85 for multiple screw yacht with internal combustion engine installations and electric propulsion installations;

k_P – factor dependent on shaft design features:
Factor k_P applied to the portion of propeller shaft between the forward edge of the aft stern tube bearing and propeller boss, equal to minimum length $2{,}5d_P$.
k_P =1,22 for propeller shafts where the propeller is keyless fitted on the propeller shaft taper or where the propeller is attached to an integral propeller shaft flange.
k_P =1,26 for propeller shafts where the propeller is keyed on the propeller shaft taper.

P – rated power of the main engine (losses in gearboxes and bearings shall be disregarded), [kW];

n – rated speed of propeller shaft, [rpm];

d_{uP} – diameter of internal longitudinal shaft bore, [mm];

d_{vP} – outside shaft diameter, [mm].
If $d_{uP} \le 0{,}4d_{vP}$, it may be taken that:

$$1-(\frac{d_{uP}}{d_{vP}})^4 = 1{,}0$$

R_{mP} – tensile strength of the shaft material taken for calculation, [N/mm²].

Shafts for which the scantling is determined according to the previous formula are to comply with the criteria listed as follow:

.1 Shafting torsional vibration analysis shall be submitted for approval;

.2 Propeller shaft complete survey shall be performed at intervals not exceeding three years.

24 ELECTRICAL INSTALLATIONS AND AUTOMATION

24.1 GENERAL REQUIREMENTS

24.1.1 The requirements of the *Rules for the classification of ships, Part 12 - Electrical equipment* and the *Rules for the classification of ships*, and the Rules, *Part 13 - Automation*, generally apply.