RULES
FOR THE CLASSIFICATION OF SHIPS

Part 34 – RULES FOR THE CLASSIFICATION OF VESSELS OF LESS THAN 24 METERS IN LENGTH

July 2021

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 34 – RULES FOR THE CLASSIFICATION OF VESSELS OF LESS THAN 24 METERS IN LENGTH

have been adopted on 28th June 2021 and shall enter into force on 1st July 2021

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

International Maritime Organization (IMO)

Resolutions:	A.951(23), MSC.81(70)
Circulars:	MSC/Circ.848, MSC/Circ.1007, MSC/Circ.1165 and MSC/Circ.1267

International Association of Classification Societies (IACS)

Recommendations (Rec.):	Rec. 99 (rev.1, April 2013)

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 vessels of less than 24 meters in length 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, are to be complied with, as far as applicable.

The classification of a vessel 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 Administration of the state whose flag the vessel is entitled to fly, and/or of the State of the base port from which the vessel operates.

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

1.1.3 The vessel complying with the classification requirements of this Part of the Rules will be assigned with the class notation **L24**, and is always to be complemented by one of the types of the vessel defined in 1.3.2 (e.g. "***Crew transfer vessel L24***"), in addition to class notation assigned according to the *Rules for the classification of ships, Part 1 – General requirements, Chapter 1 General information, Section 4*.

In a case that vessel complies with requirements of this Part of the Rules but will not be subject to maintaining the class through periodical class surveys (refer to 1.12), appropriate Attestation of class may be issued instead of Certificate of class.

1.2 APPLICATION

1.2.1 The requirements in this Part of the Rules apply for the classification of vessels, including multi-hull vessels and rigid inflatable boats (RIBs), in commercial use, having a load line length between 6 and 24 meters, with a maximum speed of 45 knots.

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

Vessel falling under the scope of Recreational Craft Directive (Directive 94/25/EC, as amended, or Directive 2013/53/EU, as applicable) shall be reviewed under requirements of the applicable Directive.

1.2.3 The application of this Part of the Rules to vessels with reinforced plastic hull or aluminium alloy hull and having different load line length or speed may be considered by the *Register* on a case-by-case basis, depending on their specific operation and construction characteristics.

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 The requirements for assignment of any specific class notations, including descriptive notes, will be established by the *Register* on a case-by-case basis, subject to provisions of the *Rules for the classification of ships, Part 1 – General requirements, Chapter 1 – General information*.

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* are to 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 Passenger ships for overnight accommodation may be subject to additional requirements, specially considered by the *Register* in each particular case.

1.2.9 The *Register* may consider the classification of vessels 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.

1.2.10 Rules and standards specified in 1.9 are considered equivalent to the requirements of this Part of the Rules.

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

When evaluating eligibility for classification of the existing ship, a proven service record of satisfactory performance, for a period of at least five (5) years, may be used as a criterion of equivalence.

1.3 CLASS NOTATIONS

1.3.1 General requirements for the assignment of class notations are stated in the *Rules for the classification of ships, Part 1 – General requirements, Chapter 1 – General information, Section 4*.

1.3.2 In addition to the requirements for the assignment of the additional character of class denoting the **type of the vessel** stated in the *Rules for the classification of ships, Part 1 – General requirements, Chapter 1 – General information*, 4.2.5, the following types of the vessels, complemented with class notation **L24**, should be used.

Crew transfer vessel - vessel intended for transport of the crew, special or offshore personnel from harbours to offshore installations or vessels.

Diving support vessel - vessel intended to supporting diving operations, and either having permanent diving systems installed, or having a non-permanent diving system.

Fishing vessel - vessel intended and specially equipped for fishing and exploiting other living resources of the sea.

Fish farm support vessel - vessel intended and specially equipped for fish farm support activities.

General cargo vessel - vessel intended for the carriage of general cargo.

Offshore support vessel - vessel intended and specially equipped for the carriage of special or offshore personnel, materials, and equipment to offshore installations or vessels, as well as to provide assistance in performing special activities (inspection, maintenance and repair) to offshore installations or vessels.

Passenger vessel - self-propelled vessel intended to carry passengers, specially designed and equipped for that purpose. For passenger vessels with overnight accommodation see 1.2.8.

Patrol vessel - naval, coast guard, or police vessel, intended for coastal defence, border protection, patrolling and immigration law-enforcement.

Pilot vessel - vessel intended for pilotage services and other occasional services to or from vessels in the pilotage area.

Research vessel - vessel intended and specially equipped for scientific research, expeditions and surveys, carrying special personnel (persons carried on board in connection with the special purpose of that vessel or because of special work being carried out aboard that vessel).

Search and Rescue (SAR) vessel - vessel intended for search and rescue operations.

Tug - vessel intended and specially equipped for towing and/or rescuing and salvage and/or manoeuvring assistance to other ships or other floating units.

Yacht - recreational craft for sport or pleasure, either for personal or for commercial use.

Notwithstanding the above, class notation **L24** may be complemented to some of the vessel types other than above upon special consideration of the *Register*.

1.3.3 The additional character of class denoting the **navigation area** shall be assigned in accordance with the *Rules for the classification of ships, Part 1 – General requirements, Chapter 1 – General information*, 4.2.

Vessels designed in accordance with the requirements of the Rules are categorized under different **design categories**, each having its corresponding limit operating conditions, directly related to maximum allowable wind force and significant wave height ($H_{1/3}$) given in Table 1-3.

Table 1-3

Design category	Wind force (Bf)	Significant wave height ($H_{1/3}$, metres)
A - Ocean	Exceeding 8	Exceeding 4
B - Offshore	Up to (and including) 8	Up to (and including) 4
C - Inshore	Up to (and including) 6	Up to (and including) 2
D - Sheltered waters	Up to (and including) 4	Up to (and including) 0.3

When assigning the additional character of class denoting the navigation area, the following correlation between the navigation areas as defined in the *Rules for the classification of ships, Part 1 – General requirements, Chapter 1 – General information,* 4.2.3 and design categories as defined in Table 1-3 shall apply:

.1 Navigation area 1 (unrestricted service) or 2 (great coastal service) corresponds with design category A.

.2 Navigation area 3 (short coastal service), 4 (coastal service) or 5 (national service) corresponds with design category B.

.3 Navigation area 6 * and 7 (national coastal service in sheltered sea areas) corresponds with design category C.

.4 Navigation area 8 (service in enclosed sea areas) corresponds with design category D.

* **NOTE:** Navigation area 6 (national coastal service) is exclusively applicable to Croatian flagged vessels.

1.4 DEFINITIONS

1.4.1 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.

1.4.2 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 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 **Administration** - the Administration of the Government of the State whose flag the vessel is entitled to fly.

.2 **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.

.3 **Hull -** the hull is the outer boundary of the enclosed spaces of the vessel, except for the deckhouses.
.4 **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.
.5 **Main deck -** the main deck is the uppermost complete deck of the hull. It may be stepped.
.6 **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.
.7 **Recognized standards** - applicable international or national standards acceptable to the *Register.*

1.5 REQUIREMENTS FOR CERTIFICATION OF SHIPYARDS, MATERIALS AND EQUIPMENT

1.5.1 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.

1.5.2 Materials and equipment are to 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).
- 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,
- fire doors,
- fire detection system,
- fire pump,
- fire hydrants,
- fire hoses and nozzles,
- portable fire extinguishers,
- fender tube (if included in stability calculations),
- 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:
- anchors,
- anchor chains,
- 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.

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

1.6 TECHNICAL DOCUMENTATION

1.6.1 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.
- Technology of building.
- Welding plan.
- Testing plan.
- Tanks structure.
- 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 and rudder stock.
- Hatchways, hatch covers and manholes including securing and tightening appliances.
- Anchoring and mooring equipment.
- Doors plan.
- Windows and portholes plan.
- Cathodic protection plan.

Stability and freeboard
- Stability calculation and/or Manual.
- Inclining test report.
- Weathertight integrity plan.
- Freeboard 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.
- 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.

1.7 ARRANGEMENT PRINCIPLES

1.7.1 Arrangement of bulkheads

Vessels are to be fitted with watertight bulkheads extended up to the deck:

- 1 watertight bulkhead if $L < 6$ [m].
- 2 watertight bulkheads if $6 < L \leq 15$ [m].
- 3 watertight bulkheads (one should be the collision bulkhead) if $L > 15$ [m]; in this case vessels are to be provided with a collision bulkhead located between 0.05 L_{WL} and 0.1 L_{WL} aft from *Fp*.

The engine room on vessels of more than 15 [m] in length is to be enclosed within watertight divisions and the top of the space to be above the design waterline.

The number of doors and hatches in watertight bulkheads are to be reduced to the minimum and to be watertight.

Small openings for penetrating pipes and electrical cables are to be watertight and located in the central higher part of the bulkhead.

1.7.2 Accommodation and protection of persons on board

1.7.2.1 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 and especially for vessels intended to be at sea for more than 24 hours, 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 Administration should be observed.

1.7.2.2 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 to eight changes of air per hour when access openings to spaces are closed.

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

All spaces accessible by the persons on board are to be provided at least with natural ventilation.

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

In some cases, and if available specific requirements of the Administration should be taken into account.

1.7.2.3 Adequate toilet facilities, separated from the rest of the accommodation, should be provided for persons on board.

In general, there should be at least one flushing marine toilet and one wash hand basin with suitable ventilation. However, this requirement may be waived for vessels designated for restricted navigation areas, as deemed appropriate and justified by the *Register* in each specific case.

Notwithstanding the above, specific requirements of the Administration should apply for the number and disposition of toilet facilities for passengers and crew, depending on the duration of the voyages (e.g. for vessels intended to be at sea for more than 24 hours) and designated navigation area.

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).

1.7.2.4 An ergonomic seat with the following minimum size is to be provided for every person on board:

- width 500 [mm],
- depth 750 [mm], free space for legs measured from person's back,
- headroom height 900 [mm].

The installation of seats 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.

Seats and their attachments, and the structure in the proximity of the seats, 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.

The strength of a seat is to be in accordance with an international standard accepted by the *Register* and the accelerations of the vessel. A minimum static load of 1 [kN] at the top of the backrest and a vertical load at the centre of the seat equal to 2 [kN] are to be considered for the scantling.

For a vessel with a speed exceeding 15 knots, the seats on the open decks are to be a minimum 380 [mm] lower than the top of the bulwark/railing unless they are provided with means for protecting persons from falling overboard when seated (such as seat belts).

On a vessel, with a speed exceeding 45 knots all the seats are to be equipped with seat belts.

In some cases, and if available specific requirements of the Administration regarding size, scantling, and the disposition of the seats should be taken into account.

1.7.3 Steering position

1.7.3.1 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.

The headroom at the steering position is to be a minimum of 2 [m].

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

The steering position is to be equipped with the instrument and the equipment required by the Administration.

1.7.3.2 The field of vision at the steering position should comply with the applicable requirements given in EN ISO 11591. The requirements of the Administration, if available, may be also used as an alternative.

1.8 SAFETY OF PERSONNEL

1.8.1 All areas above and below deck intended accessible to persons is to 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 with the following characteristics:

- minimum 900 [mm] height for all vessels, while for the vessels carrying passengers it should not be less than 1000 [mm],
- distance between vertical stanchions not more than 1.5 [m],
- vertical distance between the lowest course and the deck normally should not exceed 230 [mm] and 330 [mm] elsewhere on decks other than external decks,
- the top rail is to have an ergonomic shape.

Part of the railing may be allowed to be removable.

1.8.2 All accessible areas on open working decks are to be provided with a non-slip surface (e.g. chequered plate, unpainted wood, a non-skid pattern moulded in FRP, non-slip deck paint, or an efficient non-slip covering), with decks having a toe-rail of a minimum 25 [mm] height at the outboard edge or gunwale. On rigid inflatable vessels, the upper surface of the inflatable buoyancy tube should be provided with a non-slip finish.

1.8.3 For vessels with length L exceeding 6 [m], or vessels with freeboard Fb exceeding 500 [mm], the overside boarding ladder or another equivalent arrangement for board persons from the water is to be fitted. The arrangement is to be suitable for a person in the water to board the vessel and is to extend at least 500 [mm] below the operational waterline of the vessel. A foldable ladder, or another equivalent arrangement, may be accepted when a safe release system is accessible for persons boarding from the water.

1.8.4 For vessels fitted with inflatable buoyancy tubes, the arrangement is to be provided to enable persons in the water to hold on to the vessel floating in capsized condition (e.g. handgrips).

1.8.5 The *Register* should be satisfied that the safety and stability of the vessel are not endangered with the disposition of winches, deck cranes, and other lifting appliances and with lifting operations in general.

In general, winches, deck cranes, and other 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.

Winch barrel and similar gears are to have protection against line end, etc., hitting the person operating the winch or gear.

Safety rules and operating instructions for lifting equipment are to be provided.

1.9 EQUIVALENT RULES AND STANDARDS

1.9.1 Rules and standards specified in Table 1-9 are considered equivalent to applicable requirements of this Part of the Rules.

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

1.10 FIELD SURVEY AT THE PREMISES OF THE SHIPBUILDER

10.1 General provisions related to field survey at the premises of the shipbuilder (manufacturer), as stated in the *Rules for the classification of ships, Part 1 – General requirements, Chapter 2 – Survey during construction and initial survey, Section 1*, are to be followed also, as far as applicable, but by taking into account any specific requirement contained in this Part of the Rules.

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

1.11 ADMISSION TO CLASS OF VESSELS NOT BEING BUILT UNDER THE SUPERVISION OF THE *REGISTER*

11.1 Requirements stated in the *Rules for the classification of ships, Part 1 – General requirements, Chapter 2 – Survey during construction and initial survey, Section 2*, are to be complied with.

1.12 PERIODICAL CLASS SURVEYS OF VESSELS IN SERVICE

12.1 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, are to be complied with.

Table 1-9

Design category / Applicability	A	B	C	D
Hull	Rules for the classification of ships, Part 2, Hull	Rules for the classification of ships, Part 2, Hull HRN EN ISO 12215-5; HRN EN ISO 12215-6; HRN EN ISO 12215-7	Rules for the classification of ships, Part 2, Hull HRN EN ISO 12215-5; HRN EN ISO 12215-6; HRN EN ISO 12215-7	Rules for the classification of ships, Part 2, Hull HRN EN ISO 12215-5; HRN EN ISO 12215-6; HRN EN ISO 12215-7
Openings in hull and freeboard data	Rules for the Classification of ships, Part 3, Hull equipment	Rules for the Classification of ships, Part 3, Hull equipment HRN EN ISO 12216; HRN EN ISO 12217-1; HRN EN ISO 12217-2	Rules for the Classification of ships, Part 3, Hull equipment HRN EN ISO 12216; HRN EN ISO 12217-1; HRN EN ISO 12217-2	Rules for the Classification of ships, Part 3, Hull equipment HRN EN ISO 12216; HRN EN ISO 12217-1; HRN EN ISO 12217-2
Anchoring, mooring and towing arrangement	Rules for the Classification of ships, Part 3, Hull equipment	Rules for the Classification of ships, Part 3, Hull equipment HRN EN ISO 15084	Rules for the Classification of ships, Part 3, Hull equipment HRN EN ISO 15084	Rules for the Classification of ships, Part 3, Hull equipment HRN EN ISO 15084
Non-structural tanks	Rules for the classification of ships, Part 2, Hull	Rules for the Classification of ships, Part 2, Hull HRN EN ISO 21487	Rules for the classification of ships, Part 2, Hull HRN EN ISO 21487	Rules for the Classification of ships, Part 2, Hull HRN EN ISO 21487
Rudder	Rules for the Classification of ships, Part 3, Hull equipment	Rules for the Classification of ships, Part 3, Hull equipment HRN EN ISO 12215-8	Rules for the Classification of ships, Part 3, Hull equipment HRN EN ISO 12215-8	Rules for the Classification of ships, Part 3, Hull equipment HRN EN ISO 12215-8
Stability	Rules for the Classification of ships, Part 4, Stability	Rules for the Classification of ships, Part 4, Stability HRN EN ISO 12217-1; HRN EN ISO 12217-2	Rules for the Classification of ships, Part 4, Stability HRN EN ISO 12217-1; HRN EN ISO 12217-2	Rules for the Classification of ships, Part 4, Stability HRN EN ISO 12217-1; HRN EN ISO 12217-2
Propeller shaft brackets	Rules for the Classification of ships, Part 2, Hull	Rules for the Classification of ships, Part 2, Hull	Rules for the Classification of ships, Part 2, Hull	Rules for the Classification of ships, Part 2, Hull
Tailshaft	Rules for the Classification of ships, Part 7, Machinery installation	Rules for the Classification of ships, Part 7, Machinery installation	Rules for the Classification of ships, Part 7, Machinery installation	Rules for the Classification of ships, Part 7, Machinery installation
Bilge system	Rules for the Classification of ships, Part 8, Piping	Rules for the Classification of ships, Part 8, Piping HRN EN ISO 15083 applicable to vessels of not more than 15 m in length and yachts	Rules for the Classification of ships, Part 8, Piping HRN EN ISO 15083 applicable to vessels of not more than 15 m in length and yachts	Rules for the Classification of ships, Part 8, Piping HRN EN ISO 15083 applicable to vessels of not more than 15 m in length and yachts
Fuel oil system	Rules for the Classification of ships, Part 8, Piping	Rules for the Classification of ships, Part 8, Piping HRN EN ISO 10088 applicable to vessels of not more than 15 m in length and yachts	Rules for the Classification of ships, Part 8, Piping HRN EN ISO 10088; applicable to vessels of not more than 15 m in length and yachts	Rules for the Classification of ships, Part 8, Piping HRN EN ISO 10088; applicable to vessels of not more than 15 m in length and yachts

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).

For vessel of not more than 15 m in length, The Register may accept works certificate for structural materials.

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).

For vessel of not more than 15 m in length, The Register may accept works certificate for structural materials.

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 and thermoplastics

2.1.2.1.1 Raw materials for FRP structures and for thermoplastics 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,
- thermoplastic granulate/powder and sheets,
- 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 ships, Part 26 – Welding* 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* generally applies, to the extent deemed necessary by the *Register*.

2.3 FIBRE REINFORCED PLASTICS

2.3.1 The materials shall comply with the requirements given in one of the following standards:

- ISO 12215-1
- ISO 12215-2
- other recognized standards.

In case of sandwich adhesives, if standard is not available, the *Register* may accept material, subject to special consideration.

2.4 THERMOPLASTICS

2.4.1 The approval of Polyethylene (PE) and acrylonitrile butadiene styrene (ABS) material to be given to the manufacturer who produces the raw material at the final stage before vessel production.

For rotational moulding the approval is granted to the granulate/powder manufacturer.

For thermoforming of sheets, the approval is granted to the sheet manufacturer.

The test specimens shall be taken from the material which is used in production, but the material shall not be weakened due to the manufacturing process.

The approval shall state the manufacturing process for which the material is approved.

2.5 WOOD

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

2.5.2 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.

2.5.3 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.

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

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 RIB collars

2.6.2.1 Fabrics for RIB collars shall be suitable for the stresses to which the vessel is to be subjected (shape, dimensions, maximum load, installed power, etc.), and also to the intended service conditions. Use under normal seagoing conditions and expected ambient temperatures shall not materially impair their performance.

2.6.2.2 Fabrics for RIB collars shall be tested according to ISO 6185-3 section 4.2.2.

2.6.3 Other materials

2.6.3.1 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 are to be carried out based on structural modelling, loading and checking criteria accepted by the *Register*.

3.1.2 Equivalency

In lieu of complying with requirements of Section, the *Register* may accept compliance with EN ISO 12215 or 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, cargo, 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.

3.2 DESIGN LOADS

3.2.1 Longitudinal strength

3.2.1.1 The maximum longitudinal bending moment for vessel operating entirely in displacement mode shall be taken as:

$$M = 16 \cdot L^3 \cdot B \cdot 10^{-3} \text{ (kNm)}$$

For other vessel the maximum longitudinal bending moment shall be taken as the larger value of:

1) $M = 16 \cdot L^3 \cdot B \cdot 10^{-3}$ (kNm)
2) $M = 2.5 \cdot \Delta \cdot L \cdot 10^{-3}$ (kNm)

***L* =** distance, in [m], measured on the waterline at the scantling draught

***B* =** breadth of ship, in [m], measured amidships at the scantling draught, d_{sc}.

In no case shall the maximum longitudinal bending moment be taken less than 100 kNm.

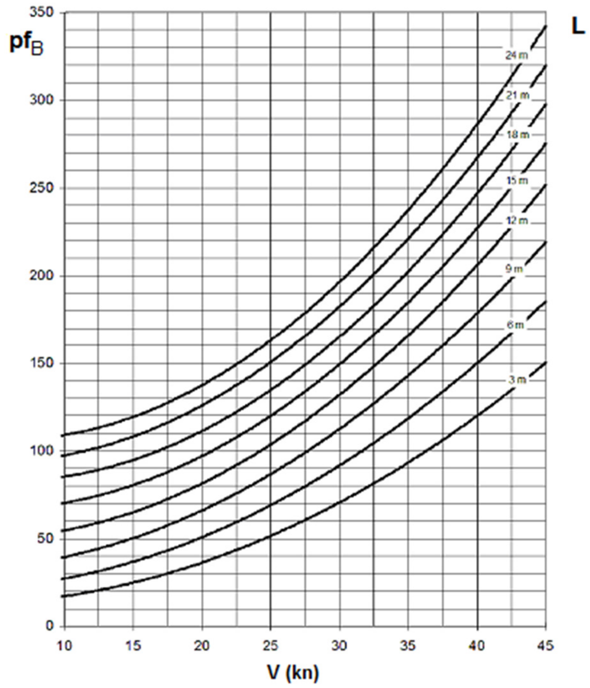
The maximum longitudinal bending moment shall be applied to the 25% of L amidship, with a linear reduction to zero at the fore and aft end of the vessel.

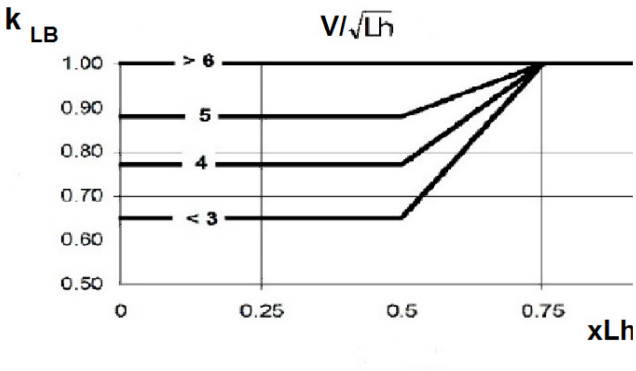
3.2.2 Load on the vessel's bottom

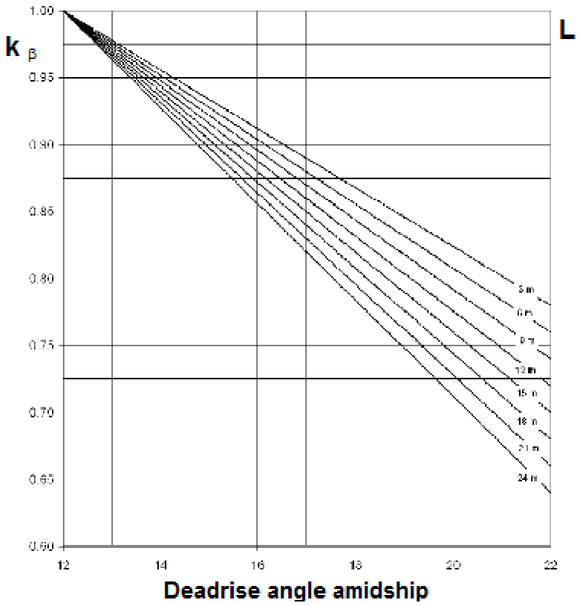
3.2.2.1 The design sea pressure, p_B, acting on the vessel's bottom shall not be taken less than:

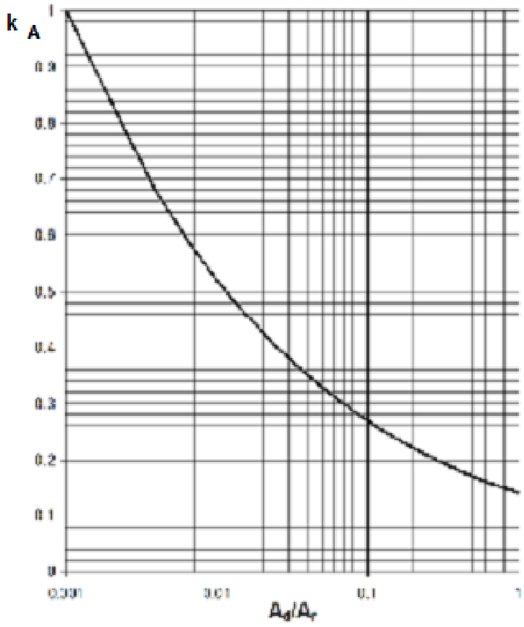
$$p_B = pf_B \cdot k_{LB} \cdot k_\beta \cdot k_A \text{ (kN/m}^2\text{)}$$

pf_B= pressure factor taken from fig. below
V = max. speed (knots)
k_{LB} = longitudinal distribution of sea pressure, to be taken from figures below. Intermediate values to be found by interpolation.
k_β = correction for deadrise angle applicable to vessels with speed $V > 3*\sqrt{L}$ and length L > 9 m, taken from the figure below. The deadrise angle shall not be taken greater than 22 degrees.
k_A = area reduction factor considering the size of the design area, A_d, relative to the reference area A_r to be taken from the figure below.
$A_d = s^2$ (m^2) for plates and panels
$A_d = s \cdot l$ (m^2) for frames/stiffeners
$A_r = 0.2 \cdot L \cdot B$ (m^2)
s = shortest panel edge or load breadth for stiffening members in metres.
l = span length of stiffening members in metres.



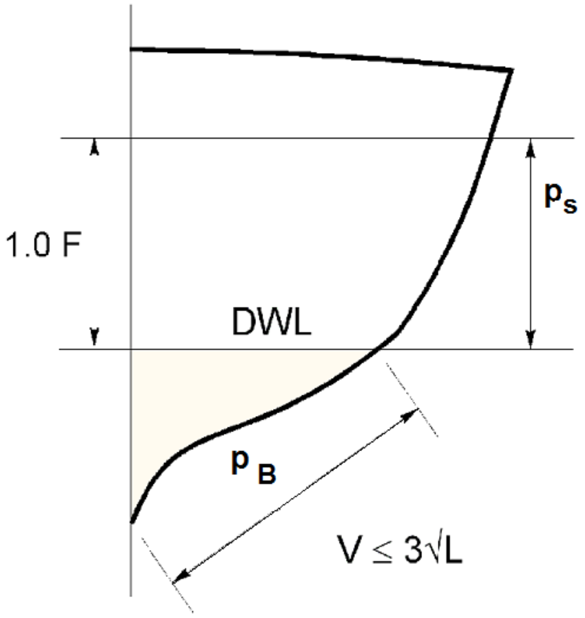


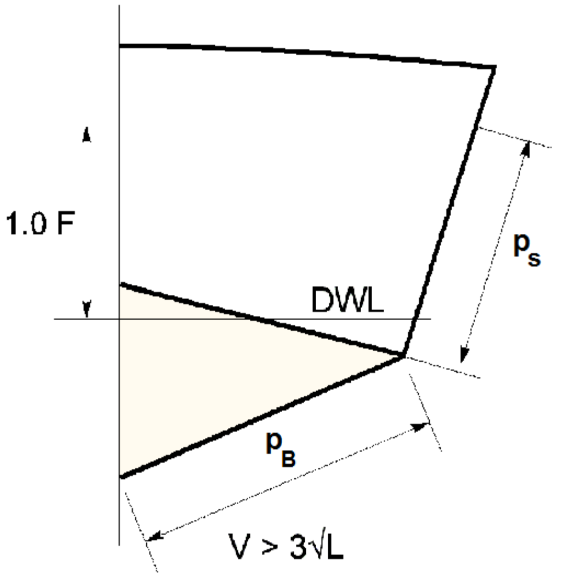




3.2.2.2 The vertical extension of the design sea pressure, pB, shall be as follows:

- up to the deepest wl for vessels with $V \leq 3^{\sqrt{L}}$
- up to the chine for vessels with $V > 3^{\sqrt{L}}$



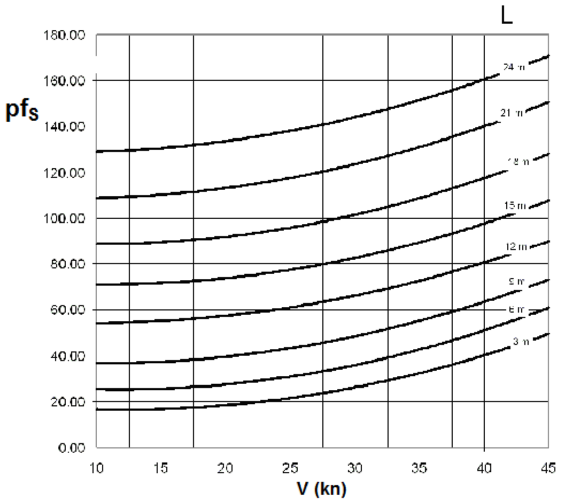


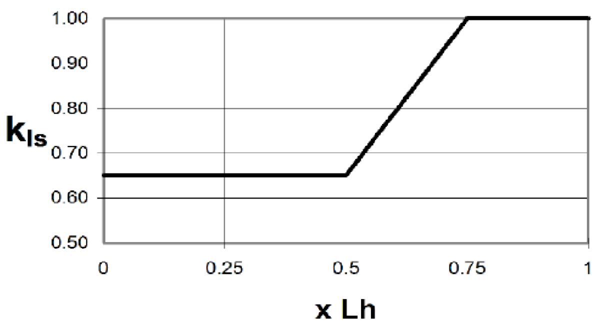
3.2.3 Load on vessel's side

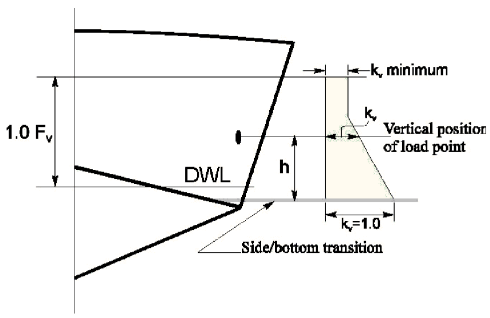
3.2.3.1 The design pressure on the hull side shall, at least, be taken as:

$p_s = pf_s \cdot k_{ls} \cdot k_v \cdot k_a$ (kN/m²)

pf_s = pressure factor taken from figure below
V = max. speed
k_{ls} = longitudinal distribution factor to be taken from the figure below
$k_v = (F_v\text{-}h)/F_v$ = minimum 0.5 for design category A and B
$F_v = (4.5 \cdot \Delta)/(10^3 \cdot L \cdot B)$
H = distance from side/bottom transition to the load point (m)
pf_s, F, h and k_v are shown on the figures below.







3.2.4 Loads on decks and superstructures

3.2.4.1 The design sea pressure acting on decks shall not be taken less than:

$p_D = kd \cdot L + 4.5$ (kN/m²)

kd = 0.2 for exposed main weather deck and superstructure deck forward of 0.25 L from FP
= 0.1 for exposed superstructure decks elsewhere.

3.2.4.2 The design load for accommodation decks and decks intended for cargo shall be taken as:

$p_{dc} = 10 \cdot q \cdot (1 + 0.2 \cdot V/\sqrt{L})$

q = deck cargo in t/m²
= 0.35 t/m² for accommodation decks.

3.2.4.3 The design sea pressure on superstructures and deck houses shall not be taken less than given in Table 3-1:

Table 3-1

Position	p (kN/m²)
Front bulkhead	0.30 L + 6
Sides and aft bulkhead	0.15 L + 3
Deck house roof, 1st tier	0.10 L + 3
Deck house roof, elsewhere	0.10 L + 1.50

3.2.5 Design pressure for bulkheads and tanks

3.2.5.1 The design load for watertight bulkheads shall not be taken less than:
$p_b = 10 \cdot h_b$ (kN/m²)
h_b = vertical distance in m from load point to top of bulkhead.

3.2.5.2 The design load for tanks for oil, freshwater, water ballast, etc. shall not be taken less than:
$p_t = 10 \cdot h_s + 10$ (kN/m²)
$= 7 \cdot h_p$ (kN/m²)
= min. 15 (kN/m²)
h_s = vertical distance in m from the load point to the top of tank
h_p = vertical distance in m from load point to top of air pipe or filling pipe whichever is the greater.

3.2.6 Interface between the waterjet and the hull

3.2.6.1 The interface between the waterjet and the vessel shall be designed for the reaction forces in the jet and the design pressure at the location.

4 STEEL AND ALUMINIUM ALLOY STRUCTURES

4.1 GENERAL

4.1.1 Structural steel

4.1.1.1 The scantling requirements are based on the correction factor k_1 for material strength.

Factor k_1 shall be taken according to the table 4.1 or calculated or determined as follows:

$k_1 = R_{eH} / 235$

Table 4-1
Factor k_1

Minimum yield strength (N/mm^2)	k_1
235	1.00
265	1.13
315	1.34
355	1.51
390	1.66

4.1.2 Structural aluminium alloy

4.1.2.1 The scantling requirements are based on a correction factor k_1 for material strength.

Factor k_1 shall be taken according to the tables 4-2 to 4-8.

Table 4-2
Factor k_1 for wrought aluminium alloy sheets, strips and plates, t: 2 mm ≤ t ≤ 40 mm

Designation of the *Register*	Temper	k_1
5052	H32 H34	0.61 0.69
5154A	0, H111	0.35
5754	H24	0.69
5454	H32 H34	0.73 0.79
5086	H116, H32 H34	0.80 0.88
5083	H116, H321	0.89
5383	H116, H34	0.89
Note: For tempers 0 and H111, the factor k_1 is to be taken from Table 4-5.		

Table 4-3
Factor k_1 for extruded aluminium alloy profiles, rods and tubes, t: 2 mm ≤ t ≤ 25 mm

Designation of the *Register*	Temper	k_1
VL-6060	T5	0.55
VL-6061	T4 T5/T6	0.46 0.76
VL-6063	T5 T6	0.44 0.60
VL-6005A	T5/T6	0.76
VL-6082	T4 T5/T6	0.46 0.90
Note: Table 4-3 only applies when the main loading direction is longitudinal to the extrusion, see also Table 4-4.		

Table 4-4
Factor k_1 for extruded aluminium alloy profiles, rods and tubes, t: 2 mm ≤ t ≤ 25 mm, transverse to extruding direction

Designation of the *Register*	Temper	k_1
VL-6060	T5	0.51
VL-6061	T4 T5/T6	0.46 0.71
VL-6005A	T5/T6 6 < t < 10 10 < t < 25	0.76 0.67
VL-6082	T5 / T6	0.85

Table 4-5
Factor k_1 in the welded condition

Designation of the *Register*	Temper	Filler	k_1
5052	0, H111, H32, H34	5356	0.27
5154A	0, H111	5356-5183	0.35
5754	0, H111, H24	5356-5183	0.33
5454 5086	0, H111, H32, H34 0, H111, H116, H32, H34	5356-5183 5356-5183	0.35 0.42
5083	H116, H321 H116, H321	5356 5183	0.53 0.60
5383	H116, H34	5183	0.64
6060	T5	5356-5183	0.27
6061	T4 T5/T6	5356-5183	0.48 0.48

Designation of the *Register*	Temper	Filler	k_1
6063	T5 T6	5356-5183	0.27
6005A	T5/T6	5356-5183	0.48
6082	T4 T5/T6	5356-5183	0.46 0.48

4.1.2.2 The scantling requirements in this section are based on the properties of aluminium material as fabricated (no deformation hardening) with minimum properties in accordance with the tables below.

Table 4-6
Mechanical properties of wrought aluminium alloy sheets, strips and plates 2 mm ≤ t ≤ 40 mm

Alloy	Tensile strength (N/mm^2)	Yield strength *) (N/mm^2)
5052	170	65
5154A	215	85
5754	190	80
5454	215	85
5086	240	95
5083	275	125
5383	290	145

*) Applies to welded condition.

Table 4-7
Mechanical properties for extruded aluminium alloy profiles, rods and tubes 2 mm ≤ t ≤ 25 mm

Alloy	Temper	Tensile strength (N/mm^2)	Yield strength (N/mm^2)
6060	T5 or T6	190	150
6061	T4	180	110
	T5 or T6	260	240
6063	T5	150	110
	T6	205	170
6005A	T5 or T6	260	215
6082	T4	205	110
	T5 or T6	310	260

Table 4-8
Mechanical properties for closed extruded aluminium alloy profiles, rods and tubes, 2 mm ≤ t ≤ 25 mm, Transverse to extrusion direction

Alloy	Temper	Tensile strength (N/mm^2)	Yield strength (N/mm^2)
6060	T5	175	135
6061	T4	165	110
	T5 or T6	245	205
6005A	T5 or T6		
	6 mm < t < 10 mm	260	215
	10 mm < t < 25 mm	230	195
6082	T5 or T6	290	240

4.2 STRUCTURAL ARRANGEMENT

4.2.1 Structural design in general

4.2.1.1 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.

4.2.1.2 Brackets are to extend to the nearest stiffener, or local plating reinforcement shall be provided at the toe of the bracket.

4.2.1.3 Connections of outfitting details to the hull shall, generally, be such that stress-concentrations are minimized and welding to high stressed parts is avoided as far as possible.

4.2.1.4 Connections shall be designed with smooth transitions and proper alignment with the hull structure elements. Terminations shall be supported.

4.2.1.5 Connections to top flange of girders and stiffeners shall be avoided if not well rounded. Supporting of outfitting should be welded to the stiffener web.

4.2.1.6 The effective span of a stiffener (l) or girder (s) depends on the design of the end connections in relation to adjacent structures. Unless otherwise stated the span points at each end of the member, between which the span is measured, shall be determined as shown on the following figure. It is assumed that brackets are effectively supported by the adjacent structure.

Figure 4-1

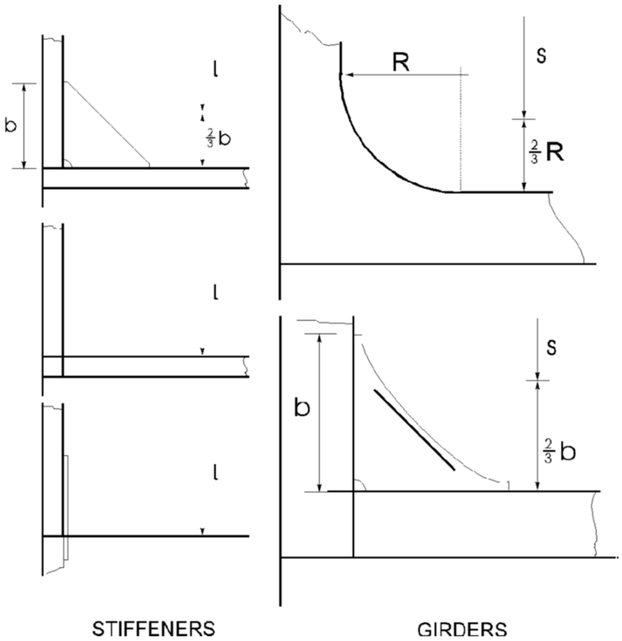
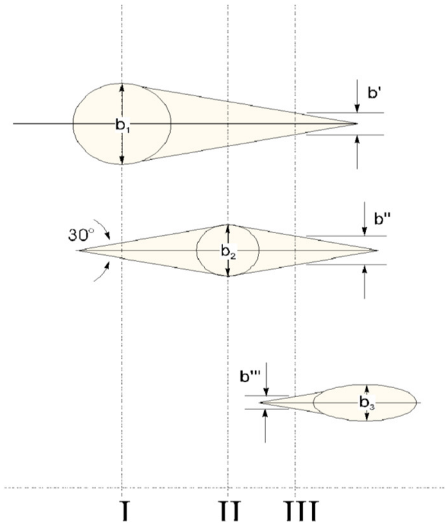


Figure 4-2



4.2.2 Global strength

4.2.2.1 The section modulus of hull girder shall not be less than:

$Z = 6250 \cdot M / k_1$ (mm^3)

along the central 25% of the length of the hull girder. Outside the central part, the section modulus may be reduced linearly to zero at the fore and aft end of the vessel.

4.2.2.2 The effective sectional area of continuous longitudinal strength members is in general the net area after deduction of openings. Superstructures which do not form a strength deck are not to be included in the net section. This applies also to deckhouses and bulwarks. The effect of openings is assumed to have longitudinal extensions as shown by the shaded areas in the figure below i.e. inside tangents at an angle of 30 ° to each other. Example for transverse section III:

$BIII$ = b' + b'' + b'''

For twin hull vessels the effective breadth of wide decks without longitudinal bulkhead support will be considered.

4.2.3 Bottom structures

4.2.3.1 The bottom structure shall comply with the requirements given in 4.3 and 4.4. The local strength of the keel shall be sufficient to withstand loads in connection with docking attachment of external ballast keel, etc.

4.2.3.2 Bottom structures may be longitudinally or transversely stiffened.

4.2.3.3 In planning vessel single bottom as well as double bottoms are normally to be longitudinally stiffened.

4.2.3.4 The longitudinal shall preferably be continuous through transverse members. If they are to be cut at transverse members, i.e. watertight bulkheads, continuous brackets connecting the ends of the longitudinal shall be fitted or welds shall be dimensioned accordingly.

4.2.3.5 Longitudinal stiffeners shall be supported by bulkheads and web frames.

4.2.3.6 Displacement vessels with single bottom and transverse frames shall have floors at each frame. The floors shall be continuous from side to side.

4.2.3.7 Web frames are to be continuous around the cross section i.e. floors side webs and deck beams are to be connected. Intermediate floors may be used.

4.2.3.8 In the engine room plate floors shall be fitted at every frame. In way of thrust bearings additional strengthening shall be provided.

4.2.3.9 Longitudinal girders shall be carried continuously through bulkheads. In vessel built in sandwich construction longitudinal girders may be fitted to support the bottom panels.

4.2.3.10 A centre girder shall be fitted for docking purpose if the external keel or bottom shape does not give sufficient strength and stiffness.

4.2.3.11 Openings shall not be located at ends of girders without due consideration being taken to shear loadings.

4.2.3.12 Under the main engine, girders extending from the bottom to the top plate of the engine seating shall be fitted.

4.2.3.13 Engine holding down bolts shall be arranged as near as practicable to floors and longitudinal girders.

4.2.3.14 In way of thrust bearing and below pillars additional strengthening shall be provided.

4.2.3.15 Manholes shall be cut in the inner bottom, floors and longitudinal girders to provide access to all parts of the double bottom. The vertical extension of lightening holes shall not exceed one half of the girder height. The edges of the manholes shall be smooth. Manholes in the inner bottom plating shall have reinforcement rings. Manholes shall not be cut in the floors or girders in way of pillars.

4.2.3.16 In double bottoms with longitudinal stiffening, the floors shall be stiffened at every bottom longitudinal.

4.2.3.17 In double bottoms with transverse stiffening, longitudinal girders shall be stiffened at every transverse frame.

4.2.3.18 The longitudinal girders shall be satisfactorily stiffened against buckling.

4.2.4 Side structures

4.2.4.1 The scantlings of side structures shall comply with the requirements given in 4.3 and 4.4.

4.2.4.2 The vessel's sides may be longitudinally or vertically stiffened.

4.2.4.3 The continuity of longitudinal shall be as required for bottom and deck longitudinal respectively.

4.2.4.4 Vertical side frames shall normally be connected to floors and deck beams with well-rounded transitions and a continuous flange laminate.

4.2.5 Transom

4.2.5.1 The scantlings of transom not subject to loads from engine or rudder installations shall comply with the requirements of 4.3 and 4.4.

4.2.5.2 The scantlings of trust bearing transom for outboard engine or stern drive mounts will be subject to case by case approval.

4.2.6 Deck structure

4.2.6.1 The scantlings of deck structures shall comply with the requirements given in 4.3 and 4.4.

4.2.6.2 Decks may be longitudinally or transversely stiffened.

4.2.6.3 Longitudinals shall preferably be continuous through transverse members. If they are to be cut at transverse members, i.e. watertight bulkheads, continuous brackets connecting the ends of the longitudinal shall be fitted.

4.2.6.4 The plate thickness shall be such that the necessary transverse buckling strength is achieved, or transverse buckling stiffeners may have to be fitted intercostals.

4.2.6.5 The thickness of bulwark plates shall not be less than required for side plating in a superstructure in the same position.

4.2.6.6 A strong section shall be continuously welded to the upper edge of the bulwark. Bulwark stays shall be in line with transverse beams or local transverse stiffening. The stays shall have sufficient width at deck level. The deck beam shall be continuously welded to the deck in way of the stay. Bulwarks on forecastle decks shall have stays fitted at every frame.

4.2.6.7 Stays of increased strength shall be fitted at ends of bulwark openings. Openings in bulwarks shall not be situated near the ends of superstructures.

4.2.6.8 Where bulwarks on exposed decks form wells, ample provision shall be made to freeing the decks for water.

4.2.7 Bulkhead structure

4.2.7.1 The scantlings of bulkhead structures shall comply with the requirements given in 4.3 and 4.4.

4.2.7.2 Number and location of transverse watertight bulkheads shall be in accordance with the requirements applicable for the vessel type.

4.2.7.3 The stiffening of the upper part of a plane transverse bulkhead shall be such that the necessary transverse buckling strength is achieved.

4.2.7.4 Longitudinal and transverse bulkheads may be corrugated.

For corrugated bulkheads the following definition of spacing applies (see figure below):

s = s_1 for section modulus calculations

= 1.05 s_2 or 1.05 s_3 for plate thickness calculations.

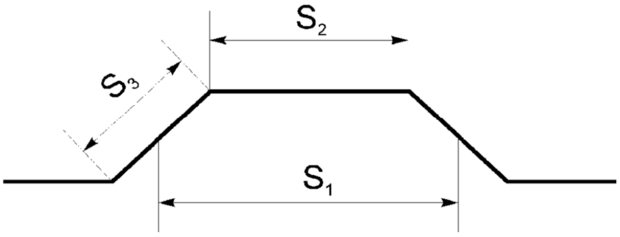


Figure 4-3

4.2.7.5 Bulkheads supporting decks shall be regarded as pillars. The compressive loads and buckling strength shall be calculated as indicated in E assuming:

i = radius of gyration in cm of stiffener with adjoining plate. Width of adjoining plate shall be taken as 40 t, where t = plate thickness.

Local buckling strength of adjoining plate and torsional buckling strength of stiffeners shall be checked in accordance with 4.5.

4.2.8 Superstructures and deckhouses

4.2.8.1 The scantlings of superstructures and deckhouses shall comply with the requirements of 4.3 and 4.4.

4.2.8.2 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 shall 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.

4.2.8.3 Sufficient transverse strength shall be provided by means of transverse bulkheads or girder structures.

4.2.8.4 At the break of superstructures, which have no set-in from the vessel's side, the side plating shall extend beyond the ends of the superstructure and shall be gradually reduced in height down to the deck or bulwark. The transition shall be smooth and without local discontinuities. A substantial stiffener shall be fitted at the upper edge of plating. The plating shall be additionally stiffened.

4.2.8.5 In long deckhouses, openings in the sides shall have well rounded corners. Horizontal stiffeners

shall be fitted at the upper and lower edge of large openings for windows.

4.2.8.6 Openings for doors in the sides shall be substantially stiffened along the edges. The connection area between deckhouse corners and deck plating shall be increased locally.

4.2.8.7 Deck girders shall be fitted below long deckhouses in line with deckhouse sides.

4.2.8.8 Deck beams under front and aft ends of deckhouses shall not be scalloped for a distance of 0.5 m from each side of the deckhouse corners.

4.2.8.9 For deckhouse side stiffeners the scantlings may not be greater than required for twin deck frames with equivalent end connections.

4.2.8.10 Casings supporting one or more decks above shall be adequately strengthened.

4.3 STEEL AND ALUMINIUM PLATING

4.3.1 General

4.3.1.1 In this section the general requirements for the local strength of laterally loaded plates are specified.

4.3.2 Plate thickness

4.3.2.1 Plate thicknesses shall be not less than the largest value found from the following formulae:

$t_{min} = t_0 + k_m L/k_1^{0.5} + t_c$ (mm)

$t_p = 1.7 \cdot k_p \cdot s \cdot p^{0.5} + t_c$ (mm)

t_0 and k_m are given in the tables in Table 4-9 and 4-10, as applicable.

k_p is given in 4.3.2.3.

t_c = corrosion allowance for steel constructions as given for the respective type and service notations. To be taken as zero for aluminium constructions.

4.3.2.2 t_0 and k are to be taken from the tables below:

Table 4-9
Aluminium

Item	L ≤ 15 m		L > 15 m	
	t_0	k_m	t_0	k_m
Hull bottom	1.5	$0.23 \cdot k_v$	4.3	0.04
Hull side	1.0	0.23	3.8	0.04
Transom, not supporting engine	1.0	0.23	3.8	0.04

Item	L ≤ 15 m		L > 15 m	
Exposed deck, cargo deck	0.8	0.21+0.21·H	3.7	0.03
Accommodation deck	0.8	0.21	3.5	0.03
Superstructures and deckhouses	0.4	0.21	3.1	0.03
Structural/watertight bulkheads	0.4	0.21	3.1	0.03
Tanks (except free-standing)	0.4	0.23	3.1	0.05

Table 4-10
Steel

Item	L ≤ 15 m		L > 15 m	
	t_0	k_m	t_0	k_m
Hull bottom	1.0	$0.23 \cdot k_v \cdot k_d$	3.8	0.04
Hull side	0.5	$0.2 \cdot k_d$	3.3	0.04
Transom, not supporting engine	0.5	0.23	3.3	0.04
Exposed deck, cargo deck	0.3	$0.21+0.1 \cdot q$	3.2	0.03
Accommodation deck	0.3	0.21	2.0	0.03
Superstructures and deckhouses	0	0.21	2.7	0.03
Structural/watertight bulkheads	0	0.21	2.7	0.03
Tanks (except free-standing)	0	0.23	2.7	0.05

$k_d = \sqrt{\Delta/(12 \cdot L \cdot B)^{\wedge}1.5}$),

for open vessel

$k_v = 0.86 + 0.014\ V$

q = deck cargo (t/m^2).

4.3.2.3 The combined correction factor k_p is given by:

$k_p = (k2 \cdot k3/k_1)^{0.5}$

k_1 as defined in 4.1

The aspect ratio correction factor, k2, is to be taken as:

$k2 = (1.1 - 0.25\ s/l)^2$

= max. 1.0

= min. 0.72.

The correction factor, k3, for plate curvature is to be taken as:

$k3 = 1 - h/s$

= minimum 0.8.

h and s are defined in the figure below.

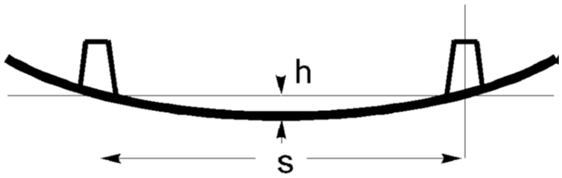


Figure 4-4

4.4 FRAMES, GIRDERS AND STIFFENERS

4.4.1 General

4.4.1.1 In this section the general requirements for the strength of laterally loaded frames, beams and other stiffeners in steel and aluminium constructions are given.

4.4.2 Section modulus

4.4.2.1 The section modulus of stiffening members is not to be less than:

$W = 6.25 \cdot m \cdot p \cdot b \cdot l^2/(10^3 \cdot k_1)$ (cm^3)

m = values for the most common structural members are found in the table in 4.4.2.3

b = load breadth in metres

l = stiffener span in metres.

For curved frames see 4.4.2.2.

k_1 as defined in 4.1.

17.4.2.2 For concave frames the length which determines the scantlings is given by:

$l = l_0 - 3 \cdot f + 0.3 \cdot R$ (m)

l_0 = length in metres of the straight part of the frame in bottom. When the bilge radius is constant, is measured as shown in Figure 4-5. When the radius varies, is measured as shown in Figure 4-6.

R = bilge radius in metres.

For S-shaped frames the length which determines scantlings is measured as shown in the figures below.

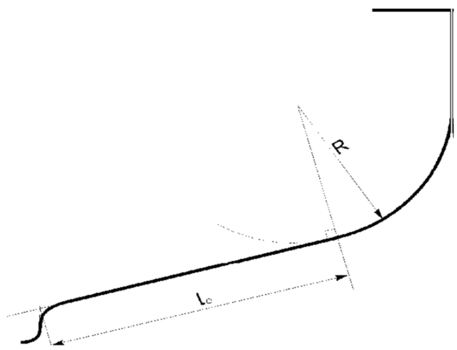


Figure 4-5

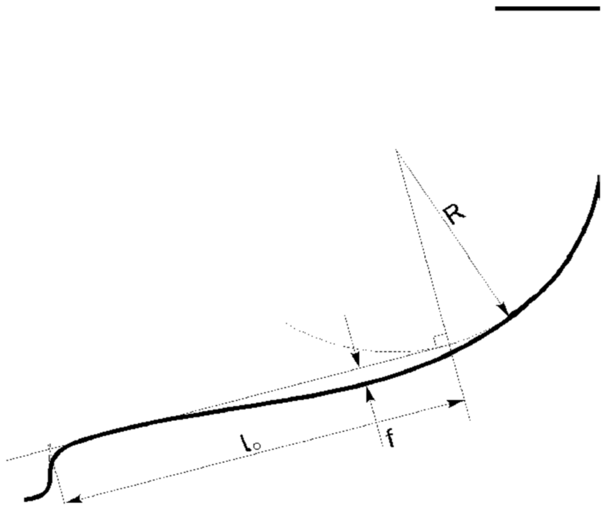


Figure 4-6

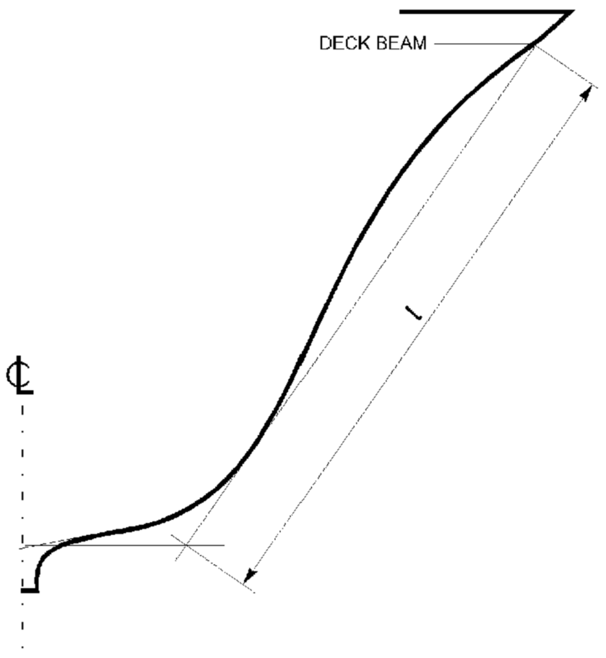


Figure 4-7

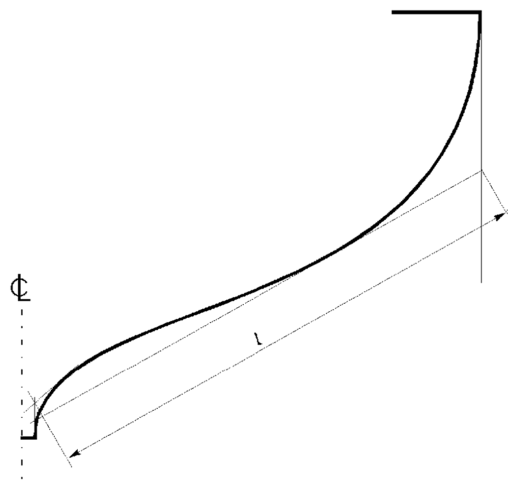


Figure 4-8

4.4.2.3 The m-values are normally to be taken as follows for the various structural members:

Table 4-11

Item	m
Continuous longitudinals	85
Non-continuous longitudinals	100
Transverse	100
Vertical members, ends fixed	100
Vertical members, simply supported	135
Bottom longitudinal	85
Bottom transverse	100
Side longitudinal	85
Side vertical	100
Deck longitudinal	85
Deck transverse	100
W.T. bulkhead, fixed ends	65
W.T. bulkhead, fixed one end	85
W.T. bulkhead, simply supported ends	125
Tank and cargo bulkheads, fixed ends	100
Tanks and cargo bulkheads, simply supported ends	135
Deckhouse stiffener	100
Casings	100

4.4.2.4 The formula given in 4.4.2.1 is to be regarded as the requirement about an axis parallel to the plating. As an approximation the requirement to standard section modulus for stiffeners at an oblique angle with the plating may be obtained if the formula in 4.4.1.1 is multiplied by the factor:

$1/\cos\alpha$

α = angle between the stiffener web plane and plane perpendicular to the plating.

For angles $\alpha < 15°$ corrections are normally not necessary.

4.4.2.5 When several members are equal, the section modulus requirement may be taken as the average requirement for each individual member in the group. However, the requirement for the group is not to be taken less than 90% of the largest individual requirement.

4.4.2.6 Effective plate flange may normally be taken equal to the stiffener spacing.

4.4.2.7 The thickness of web and flange is not to be less than:

for flats:

t_{web} = 1/15 × flat depth;

for other sections:

t_{web} = 1/50 × web depth, provided net shear area > 0.075 l_{sp}

t_{flange} = 1/15 × flange width from web.

4.5 PILLARS

4.5.1 General

4.5.1.1 **S**teel pillars may be used for supporting structure or equipment. Pillars made of aluminium alloy are subject to special consideration.

4.5.1.2 Where practicable, deck pillars are to be located in line with pillars above or below. Otherwise, beams or girders in deck in way shall be reinforced.

5 FRP STRUCTURES

5.1 GENERAL

5.1.1 Application

5.1.1.1 The requirements in this section apply to fibre reinforced plastic (FRP) single skin and sandwich constructions.

5.1.1.2 Additional or modified requirements may be given in association with the various type and service notations.

5.1.1.3 Alternative scantling determination methods may be accepted upon consideration in each individual case.

5.1.2 Types of FRP structures

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

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

It is assumed that the properties and the proportions of the component materials are such that when a sandwich panel is exposed to a lateral load the bending moments are carried by the skins and the shear forces by the sandwich core. The condition for compliance with this assumption is given in 5.4. It is further assumed that an efficient bond between skins and sandwich core is obtained.

5.1.3 Definitions

5.1.3.1 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/ σ_{nu} correction factor for strength

f_b = 80/ σ_{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.

5.1.4 Calculation methods

5.1.4.1 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.

5.1.4.2 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.

5.1.4.3 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.

5.1.5 Structural design in general

5.1.5.1 Attention is drawn to the importance of structural continuity in general.

5.1.5.2 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.

5.1.5.3 Corners and dimensional transitions shall be well rounded to avoid stress concentrations.

5.1.5.4 Tensile loads perpendicular to the plan of the laminate should be avoided.

5.1.5.5 Thickness differences in laminates should be tapered over a length of at least 20 × thickness difference.

5.1.5.6 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.

5.1.5.7 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.

5.1.5.8 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.

5.1.6 Materials

5.1.6.1 Structural materials shall be approved by the *Register*.

5.1.7 Mechanical properties of laminate

5.1.7.1 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.

5.1.7.2 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.

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

5.1.7.4 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.

5.1.7.5 The mechanical properties used in the calculations shall be:

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

5.1.7.6 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.

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

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

5.1.8 Mechanical properties of sandwich core materials

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

5.1.8.2 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.

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

5.1.8.4 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.

5.1.8.5 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.

5.1.9 Global strength

5.1.9.1 The section modulus of the hull girder shall not be less than:

$Z = 38\,000 \cdot f_n \cdot \mathrm{M}$ (mm^3)

reduced linearly to zero at the fore end and aft end of the vessel.

5.1.9.2 When calculating the moment of inertia and section modulus of the mid ship section, the effective sectional area of continuous longitudinal strength members is in general the net area after deduction of openings.

5.1.9.3 Superstructures which do not form a strength deck are not to be included in the net section. This applies also to deckhouses and bulwarks.

5.1.9.4 The effect of openings is assumed to have longitudinal extensions as shown by the shaded areas in Figure 5-1 i.e. inside tangents at an angle of 30° to each other. Example for transverse section C:

b_C = b' + b'' + b'''

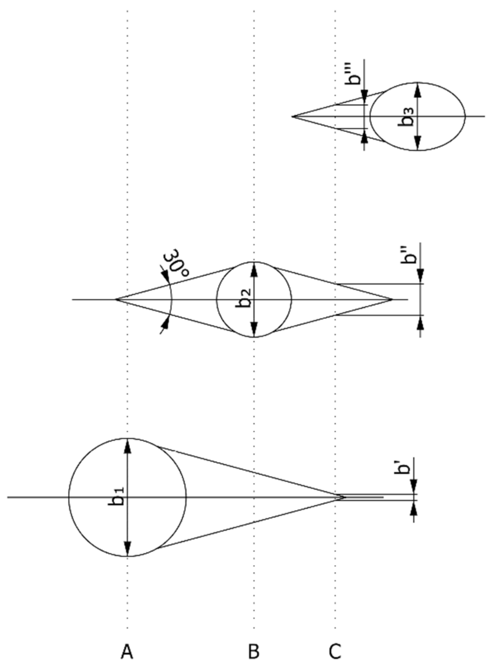


Figure 5-1
Effect of openings

5.1.9.5 For twin hull vessels the effective breadth of wide decks without longitudinal bulkhead support will be considered.

5.2 STRUCTURAL ARRANGEMENT

5.2.1 Bottom structures

5.2.1.1 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.

5.2.1.2 Bottom structures may be longitudinally or transversely stiffened.

5.2.1.3 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.

5.2.1.4 The longitudinal should preferably be continuous through transverse members. At their ends longitudinal are to be fitted with brackets or to be tapered out beyond the point of support.

5.2.1.5 Longitudinal stiffeners are to be supported by bulkheads and/or web frames.

5.2.1.6 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.

5.2.1.7 Longitudinal girders are to be carried continuously through bulkheads. In vessel built in sandwich construction longitudinal girders may be fitted to support the bottom panels.

5.2.1.8 A centre girder is to be fitted for docking purpose if the external keel or bottom shape does not give sufficient strength and stiffness.

5.2.1.9 Openings should not be located at ends of girders without due consideration being taken to shear loadings.

5.2.1.10 The scantlings of longitudinal girders may be taken in accordance with Table 5-2 or alternatively according to 5.5.

5.2.1.11 Main engines are to 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.

5.2.1.12 Web frames are to be continuous around the cross section of the vessel, i.e. web- and flange laminates of floors, side webs and deck beams are to be efficiently connected together. If intermediate floors are fitted, their ends should be well tapered or connected to local panel stiffening.

5.2.1.13 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.

5.2.1.14 In double bottoms manholes are to 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.

5.2.1.15 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.

5.2.2 Side structures

5.2.2.1 The hull sides may be longitudinally or vertically stiffened. The continuity of longitudinal is to be as required for bottom and deck longitudinal respectively.

5.2.2.2 The single skin or sandwich panels of the hull sides shall comply with the requirements of 5.3 and 5.4.

5.2.2.3 Vertical side frames shall normally be connected to floors and deck beams with well-rounded transitions and a continuous flange laminate.

5.2.3 Transom structure

5.2.3.1 The scantlings of transom not subjected to loads from engine or rudder installations shall comply with the requirements of 5.3 and 5.4.

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 5-1.

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.	

5.2.3.3 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.

5.2.4 Deck structure

5.2.4.1 Decks may be longitudinally or transversely stiffened.

5.2.4.2 Deck panels of single skin or sandwich construction shall comply with the requirements of 5.3 and 5.4.

5.2.4.3 Longitudinal should preferably be continuous through transverse members. At their ends longitudinal are to be fitted with brackets or be tapered out beyond the point of support.

5.2.4.4 Bulwark sides are considered to be a part of the hull side and shall have scantlings accordingly. A strong flange is to be made along the upper edge of the bulwark. Bulwark stays are to 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 are to be fitted at the foot of the bulwark stays. Stays of increased strength are to be fitted at ends of bulwark openings. Openings in bulwarks should not be situated near the ends of superstructures.

5.2.5 Bulkhead structures

5.2.5.1 The scantlings of bulkhead structures shall comply with the requirements of 5.3 and 5.4.

5.2.5.2 Number and location of transverse watertight bulkheads are to be in accordance with the requirements given for the vessel types.

5.2.5.3 Bulkheads supporting decks are to be regarded as pillars. The buckling strength will be considered in each individual case.

5.2.6 Superstructures and deckhouses

5.2.6.1 The scantlings of superstructures and deckhouses shall comply with the requirements of subsections 5.3 and 5.4.

5.2.6.2 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).

5.2.6.3 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).

5.2.6.4 Long deckhouse - deckhouse having more than 0.2 *L* of its length within 0.4 *L* amidships.

5.2.6.5 Short deckhouse is a deckhouse not defined as a long deckhouse.

5.2.6.6 In superstructures and deckhouses, the front bulkhead is to 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 are to be located above girders and frames in the hull structure and are to be in line in the various tiers of accommodation. Where such structural arrangement in line is not possible, there is to be other effective support.

5.2.6.7 Sufficient transverse strength shall be provided by means of transverse bulkheads or girder structures.

5.2.6.8 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.

5.2.6.9 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.

5.2.6.10 Casings supporting one or more decks above shall be adequately strengthened.

Table 5-2
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 to Table 5-2

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.

l_s / B	1.10	1.25	1.50	2.00
f_l	1.13	1.25	1.37	1.50

4) Web thickness ts is measured as shown in the sketch.

Centre girder

Table 5-3
Longitudinal bottom girders

Flange area in cm^2 / 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 to Table 5.3:

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 f_l given in note 3 to Table 5-2.

Side Girders

	Vessel's breadth *B* in metres		
	4	***5***	***6***
f_2	0.40	0.47	0.50

For side girders:

Flange area = f_2 × flange area of centre girder

Web thickness = 0.9 × web thickness of centre girder.

5.3 SINGLE SKIN CONSTRUCTIONS

5.3.1 General

5.3.1.1 In this item the general requirements for the local strength of stiffened single skin constructions are specified.

5.3.1.2 Buckling strength of single skin panels subjected to longitudinal hull girder or local compression loads will be individually considered.

5.3.2 Laminate thicknesses

5.3.2.1 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 5.4

f_p is taken from the formulae in 5.3.2.2.

k_p= 3.82 for bottom panels

= 4.73 for side panels

= 4.11 for panels elsewhere and for all stiffening members.

Table 5-4
Laminate thickness

Item	*L* ≤ 15 m		*L* >15m	
	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 engine	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
Accommodation deck	1.7	0.42	6.8	0.08
Superstructures and deckhouses	1.7	0.42	6.8	0.08
Structural/watertight bulkheads	1.1	0.42	6.2	0.08
Tanks (except free-standing)	1.1	0.45	6.2	0.11

$k_v = 0.86 + 0.014 \cdot V$

q = deck cargo in t/m^2

5.3.2.2 The combined correction factor, *fp*, is given by:

$$fp = fp1 \cdot fp2 \cdot \sqrt{f_b}$$

The aspect ratio correction, *fp1*, is to be taken from the Figure 5-2.

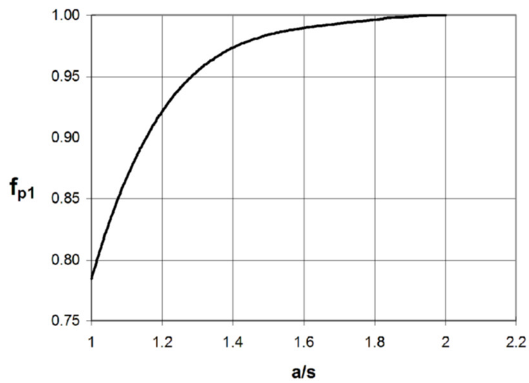


Figure 5-2

a and *s* are the longest and shortest panel edge respectively.

The panel curvature correction, *fp2*, is to be taken as:

$fp2 = 1 - h/s$

$fp2\ min = 0.8$

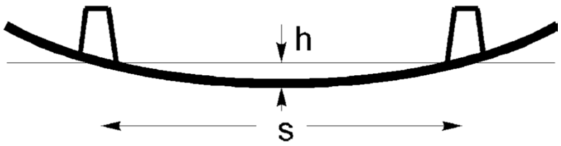


Figure 5-3

5.3.2.3 Reduced thicknesses may be accepted provided equivalent impact resistance can be documented.

5.3.3 Local laminate reinforcement

5.3.3.1 The structural laminates shall locally be reinforced to a thickness not less than:

$tl\ min = (t0 + k \cdot L) \cdot \sqrt{f_b}$ (mm)

t0 and *k* are given in the Table 5-5.

Table 5-5 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 kv	14.5	0.14
Keel type 3	3.5	1.1 x kv	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 kv	12.0	0.11
Bottom laminate in way of rudder stock, shaft brackets, etc.	3.5	1.1 x kv	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.

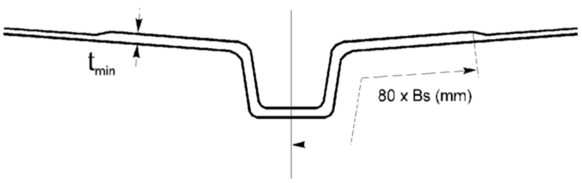


Figure 5-4
Keel type 1

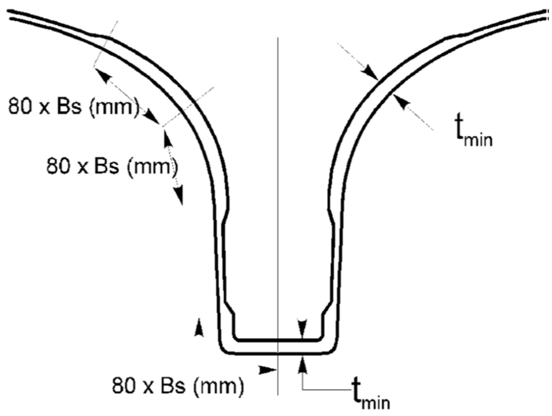


Figure 5-5
Keel type 2

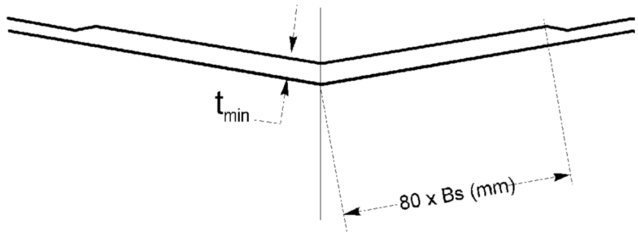


Figure 5-6
Keel type 3

5.4 SANDWICH CONSTRUCTIONS

5.4.1 General

5.4.1.1 In this section the general requirements for the local strength of sandwich constructions are given.

5.4.1.2 Buckling strength of sandwich constructions subjected to longitudinal hull girder or local compression loads will be individually considered.

5.4.2 Panel requirements

5.4.2.1 The thickness of skin laminates of sandwich panels shall not be less than:

$ts\ min = k \cdot t1_{min}/f_c$ (mm)

$tl\ min$ = minimum thickness found from 5.3.2.1

$fc = 0.94 + 0.12 \cdot \sigma c$

σc = compressive strength of the core material in N/mm^2

k is defined in Table 5-6.

Table 5-6 Panel requirements

Structural member	k	
	Exposed [1)]	Protected [2)]
Hull bottom	0,4	0,3
Hull side and transom[*)]	0,42	0,31
Cargo deck	0,63	0,48
Exposed deck	0,63	0,48
Accommodation deck	0,4	0,3
Superstructures and deckhouses	0,4	0,3
Structural/watertight bulkheads	0,4	0,3

Notes to Table 5-6:

[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

5.4.2.2 The section modulus and moment of inertia of a 1 cm wide panel strip shall be not less than:

$W = 0.04 \cdot fw \cdot P \cdot s^2$ (cm^3)

$fw = fw1 \cdot f_n$

$I = 0.0364 \cdot fi \cdot p \cdot s^3$ (cm^4)

$fi = fi1 \cdot fi2 \cdot fi3$

The correction factors for panel aspect ratio, fw1 and fi1, are defined in the Figure 5-7.

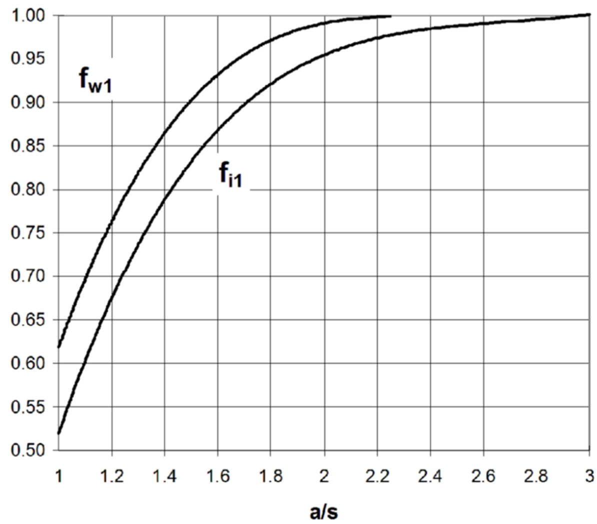


Figure 5-7
Correction factor

a and s: longest and shortest panel side, respectively.

The correction factor for laminate strength, f_n, is given in 5.1.3.1.

The correction factor for laminate stiffness, fi2, shall be taken as:

$fi2 = 7000/E_n$

The stiffness factor, *fi*3, shall be taken as:

fi3 = 1.0 for decks and floor panels

fi3 = 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 5.4.2.5.

5.4.2.3 The shear strength of the core material shall be not less than:

$\tau_u = 1{,}5 \cdot fT_1 \cdot P_s/d$ (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 5.4.2.5.

The correction factor for panel aspect ratio, fT1, is defined in the Figure 5-8.

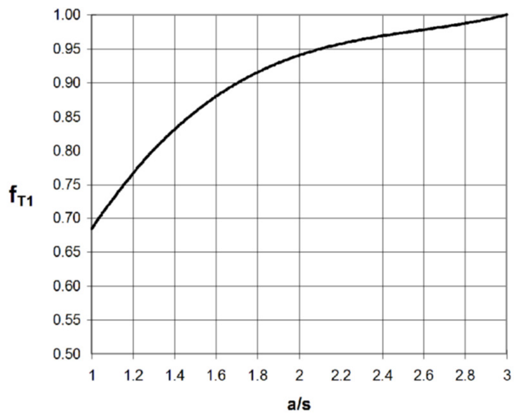
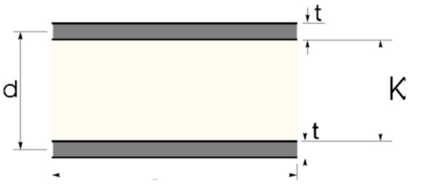


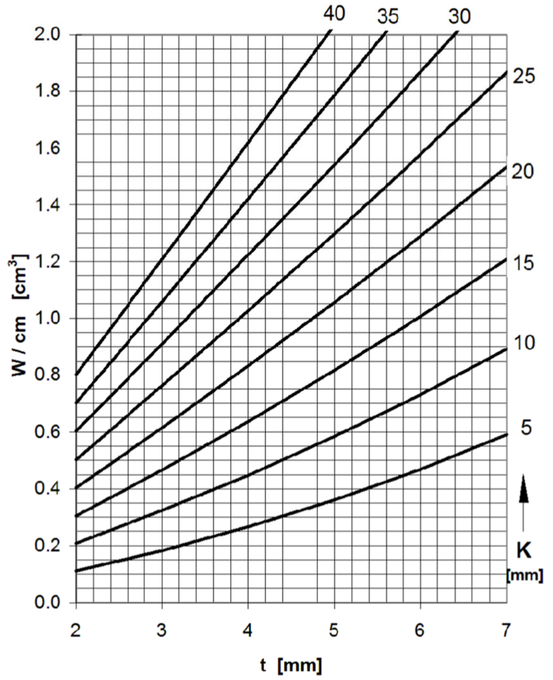
Figure 5-8

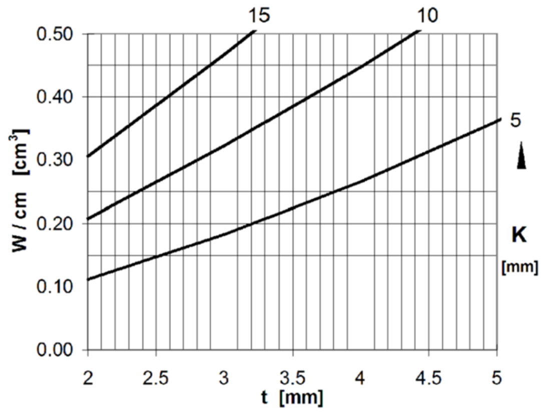
a and s: longest and shortest panel side, respectively.

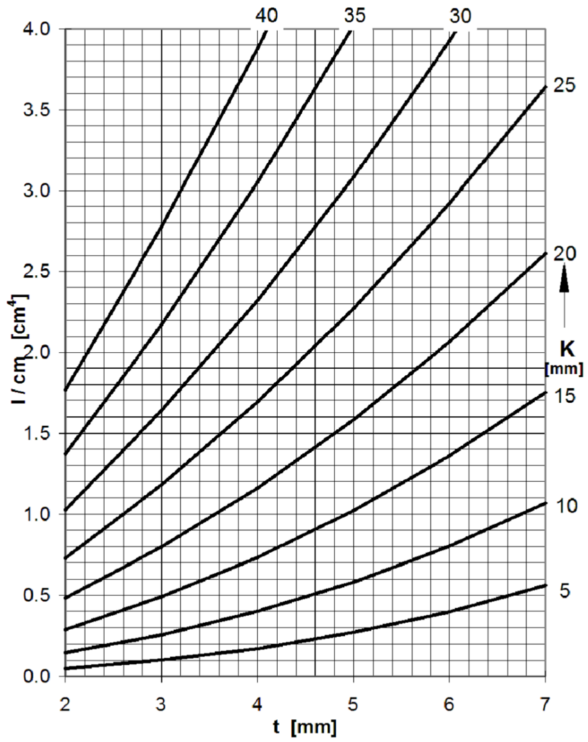
5.4.2.4 Reduced thicknesses may be accepted provided equivalent impact resistance can be documented.

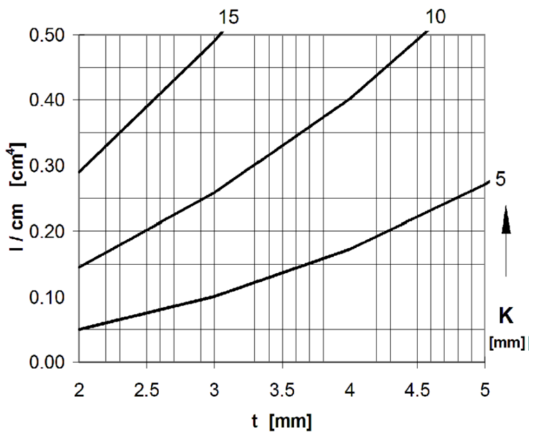
5.4.2.5 Section modulus (W) and moment of inertia (I) of a 1 cm wide sandwich panel with skin laminate of equal thickness, are given in the figures below as a function of core thickness K and skin laminate thickness t.


t
d
K
t


W / cm [cm³]
t [mm]
40
35
30
25
20
15
10
5
K
[mm]


W / cm [cm³]
t [mm]
15
10
5
K
[mm]


I / cm [cm⁴]
t [mm]
40
35
30
25
20
15
10
5
K
[mm]


I / cm [cm⁴]
t [mm]
15
10
5
K
[mm]

5.4.3 Local panel reinforcements

5.4.3.1 The sandwich panel skin laminates shall locally be reinforced to a thickness not less than:

$ts\ min = k \cdot T_{1min}/f_c$ (mm)

$tl\ min$ = minimum thickness according to 5.3.2.1

$fc = 0.94 + 0.12 \cdot \sigma c$

where σc is compressive strength of the core material in MPa.

k is found from the table below:

Table 5-7 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 to Table 5-7:

[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.

5.5 FRAMES, GIRDER AND STIFFENERS

5.5.1 General

5.5.1.1 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.

5.5.1.2 Stiffening profiles are normally to be attached to the base panel by secondary bonding.

5.5.1.3 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.

5.5.2 Stiffening member requirements

5.5.2.1 The section modulus of stiffening members is not to be less than:

$W = 4.0 \cdot m \cdot f_n \cdot P \cdot b \cdot l^2$ (cm^3)

$I = 36.4 \cdot d \cdot fi \cdot P \cdot b \cdot l^3$ (cm^4)

b = load breadth in metres

l = stiffener span in metres, for curved frames see 5.5.2.2.

m- and d- values for the most common structural members are found from the table in 5.5.2.3.

f_n and fi are given in 5.5.2.4.

5.5.2.2 For curved frames the length l which determines the scantlings is given by:

$l = l0 - 3 \cdot f + 0.3 \cdot R$ metres

$l0$ = length in metres of the straight part of the frame in bottom.

When the bilge radius is constant, l0 is measured as shown in Figure 5-9. When the radius varies, l0 is measured as shown in Figure 5-10.

R = bilge radius in metres.

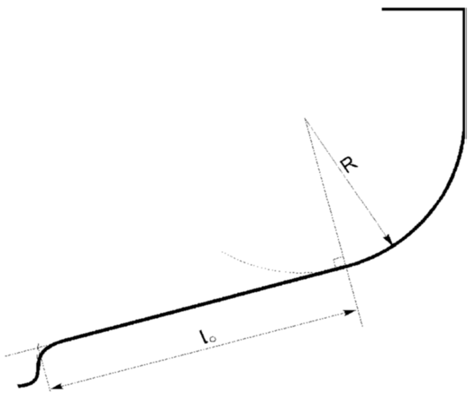


Figure 5-9

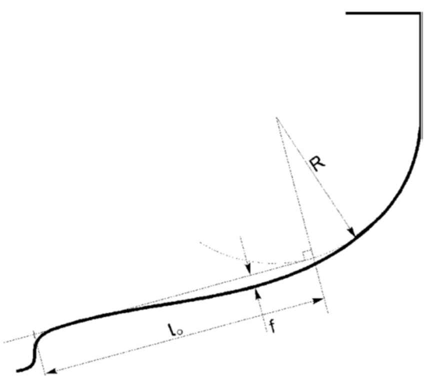


Figure 5-10

For S-shaped frames the length which determines scantlings is measured as shown in Figure 5-11 and Figure 5-12.

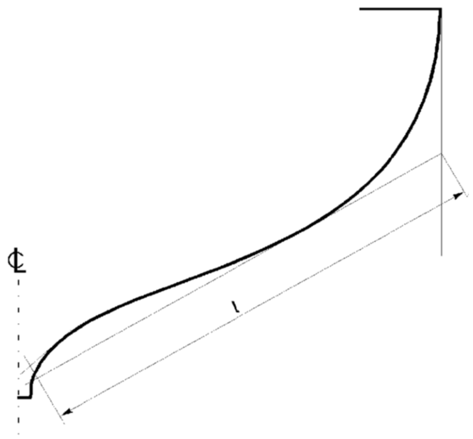


Figure 5-11

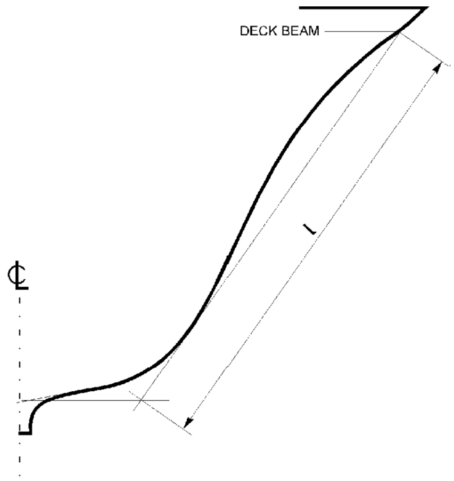


Figure 5-12

5.5.2.3 The m- and d-values for the various structural members are specified in Table 5-8.

Table 5-8 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
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

5.5.2.4 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.

5.5.2.5 Section modulus W for profiles with panel as function of flange area Afl sandwich core height H and web thickness ts is given in the following Figures.

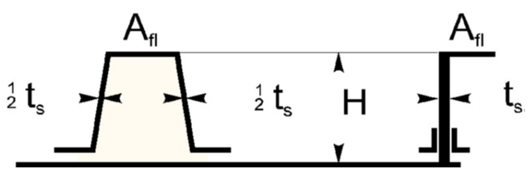


Figure 5-13 Definition of Afl, H and ts

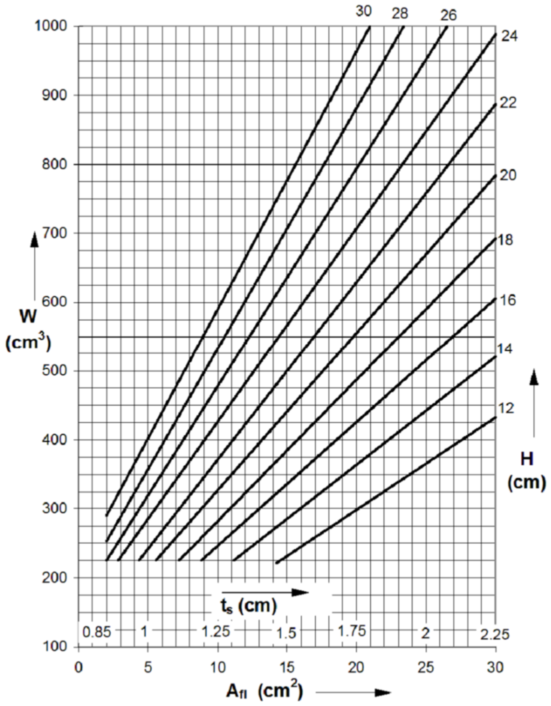


Figure 5-14 Section modulus W of profiles

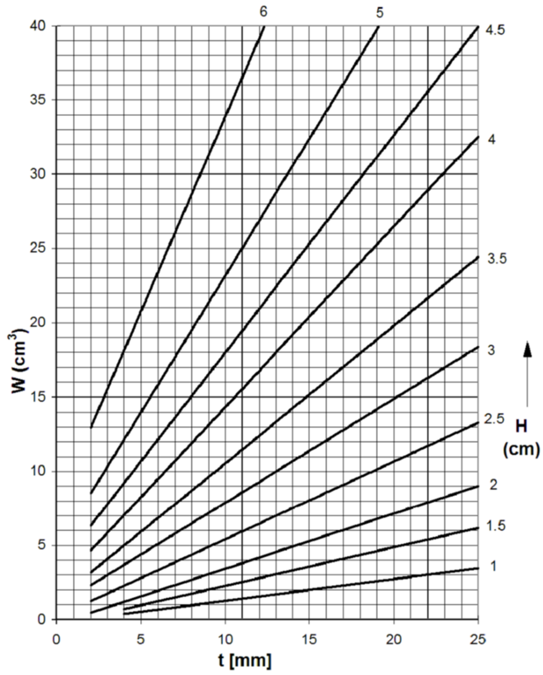


Figure 5-16

5.5.2.6 Section modulus W of skin laminate steps as function of step height and laminate thickness t.

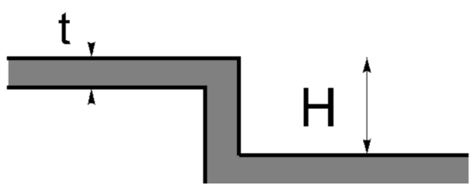


Figure 5-15

6 THERMOPLASTIC STRUCTURES

6.1 GENERAL

6.1.1 Premises

6.1.1.1 Premises for manufacturing of vessels of thermoplastics shall be suitable for the production process applied.

6.1.1.2 Uncontrollable draughts must be avoided in the vicinity of the production machinery and in cooling rooms.

6.1.1.3 Premises and production machinery shall be arranged to avoid risk of pollution by oil spill, dust etc.

6.1.2 Marking of produced vessels

6.1.2.1 If the applied structural material has properties of significance for the use of the vessel which differ from the standard given for vessels of glass fibre-reinforced polyester, appropriate information will be given on the certificate.

6.1.2.2 The vessel is to have a durably fitted plate or similar which clearly states the structural material of the vessel.

6.1.2.3 The vessel manufacturer shall supply the following with each vessel: information on the vessel's presupposed use, directions for maintenance and repair as well as information on substances which may have detrimental effects on the vessel's structural material.

6.2 ROTATION MOULDING OF POLYETHYLENE VESSELS

6.2.1 Moulding condition

6.2.1.1 Release compositions applied to the mould are not to have any detrimental effects on the vessel material, e.g. stress cracking.

6.2.1.2 Regenerated raw material will not be accepted for use in hulls manufactured by rotation moulding.

6.2.1.3 The rotation procedure shall be the same for moulding of all vessels of the same type.

6.2.1.4 The weight quantity of powder in the mould is not to be less than 1% below the specified value.

6.2.1.5 The temperature shall be automatically controlled. The temperature and its specified permissible variations will be subject to approval in each case, on the basis of the limitations of the raw material properties. The temperature at each measuring point is not to vary by more than +5°C for each moulding process.

6.2.1.6 The sintering time and the after-sintering time is stipulated on the basis of thickness measurements on the vessel type in question to ensure that an even distribution of material in the mould is obtained. The process time is not to vary by more than + I minute from the approved time. Any welding together of inner and outer mould is to be approved in each separate case.

6.2.1.7 The cooling-down process is to be the same for each vessel of the same type and will be stipulated on the basis of the sintering temperature, vessel type and raw material, so that deformations in the material are avoided.

6.2.1.8 If alterations are made in the manufacturing method, the *Register* is to be informed for considering whether special tests will be required to check the material quality.

6.2.2 Moulded vessels

6.2.2.1 The material in the finished moulded vessels is to be without any visible surface flaws of significance to the vessel's service. Surfaces and cross sections are not to show any sign of either insufficient fusion of the powder particles or thermal degradation of the material.

6.2.2.2 Pores or air bubbles must not be so numerous or of such size that the material properties are significantly reduced. The amount and size allowed shall be stipulated for each type of material.

6.2.2.3 The material in the moulded vessels is to comply with the requirements to minimum mechanical properties specified for the raw material in question.

6.2.2.4 Completed vessels must not have significant deformations, and all welded joints are to be tight.

6.2.3 Internal control

6.2.3.1 The vessel manufacturer shall keep a journal of the raw material supplier's certificate data, and store samples from each material delivery.

6.2.3.2 The vessel manufacturer is to record the following process data for each individual vessel:

- weighed quantity of powder,
- temperature,
- sintering and after-sintering time,
- cooling-down time.

6.2.3.3 Each vessel shall also to be visually checked for surface flaws and tightness of welded joints.

6.2.3.4 Each vessel shall be marked with its production number, which also shall identify the mould in which the vessel has been manufactured. The marking is to be made in a durable way.

6.2.3.5 Thickness measurements shall normally be carried out on vessels that are cut into several sections. Such measurements shall be carried out on one out of 200 vessels manufactured in each mould.

6.3 THERMOFORMING OF ABS-SHEETS

6.3.1 Forming of sheets

6.3.1.1 The forming process shall be such that the material properties are not significantly reduced during the production process. After checking the thickness of some completely formed vessels, the thickness of the sheets to be used in production of the vessel type shall be decided.

6.3.1.2 The temperature distribution on the sheet shall be the same for all vessels formed. The temperature of the sheet and the mould must be within the limits specified for the relevant material.

6.3.1.3 After forming of the hull the yield point of the material under tensile testing is not to deviate by more than 20% from the yield stress in the production direction. The mean value from 5 test specimens shall be used as a basis.

6.3.1.4 Stressed structural parts shall be formed without sharp edges. The radius of any curvature on the mould side shall not be less than twice the rule thickness, and on the opposite side not less than 5 times the rules thickness. Sharper edges may, however, be accepted if special reinforcements reduce the stress concentration.

6.3.2 Internal control of the vessel manufacturing

6.3.2.1 The vessel manufacturer shall keep a journal of the sheet supplier's certificate data.

6.3.2.2 Each thermoformed sheet shall be visually checked for surface flaws.

6.3.2.3 At positions agreed with the Surveyor, the skin thickness on the vessels in production should be checked by measurement at least once a day, and at least once for every 50 vessels. The results shall be recorded.

6.4 VESSEL CONSTRUCTION

6.4.1 Design

6.4.1.1 The design of the vessel shall be suitable for the manufacturing process and the raw material being used.

6.4.1.2 When forming vessels of thermoplastics, it is to be taken into consideration that the mechanical properties of the material vary with the temperature and the duration of the loading.

6.4.1.3 Hard points in the structure are as far as practicable to be avoided. Stiffening is to be evenly distributed over the hull, to the extent this is practicable.

6.4.1.4 The design is to be such that sufficient hull stiffness is obtained. Large flat surfaces are to be avoided as far as practicable.

6.4.2 Assembly

6.4.2.1 No materials built into the vessel must have detrimental effects on the other materials applied.

6.4.2.2 The skins in double hulled constructions and in sandwich constructions shall be watertight. Screws or bushings in the skins must also be watertight.

6.4.2.3 Where exposed, the connection between inner and outer skin shall be watertight.

6.4.3 Rule thickness

6.4.3.1 Rule thickness is the value stated in 6.5 and 6.6.

6.4.3.2 A measured thickness is regarded as satisfactory when the average of the values measured at 20 points is not less than the rule thickness and if none of the values measured at the individual points is more than 15% below rule thickness.

6.4.3.3 Local reinforcements that are welded or glued to the hull, may upon special consideration be regarded as part of the skin thickness.

6.5 POLYETHYLENE

6.5.1 Manufacturing

6.5.1.1 Requirements to moulding time, temperatures and cooling time are determined based on quantity of powder used and the rotation speed, on the background of inspection of complete moulded vessels.

6.5.1.2 Raw materials should be approved in accordance with Section 2.

6.5.1.3 If the vessel manufacturer is to grind granulate to powder, the grinding and sieving equipment are first to be approved by the *Register*.

6.5.1.4 A pigment of approved type and in the approved quantity is to be added to the powder. During or after the grinding the powder is to be sifted through a mesh of not more than 800 m.

6.5.1.5 Material moulded in accordance with the vessel manufacturer's actual procedure shall at least have properties as given in 2.4.

6.5.2 Scantlings, low density polyethylene (LDPE) and medium density polyethylene (MDPE)

6.5.2.1 The thickness of the outer hull bottom and side shall not be less than:

$$Ty = k \cdot s \cdot \sqrt{\left(\frac{PF}{6.7\ L}\right)} \cdot (14+3{,}6 \cdot L) \quad \text{(mm)}$$

where:

k = 1.0 for LDPE

k = 0.85 for MDPE

s = stiffener spacing in meter

PF = pressure factor for bottom, respectively side (PF and PFs), taken from the figures in 3.2.2 to 3.2.3.

6.5.2.2 The thickness of the inner hull is not to be less than:

ti = 0.8 ty (mm)

6.5.2.3 Rotation moulded vessels should have a hull weight of at least k × 45 kg. The vessel should be stiffened in such a way that keel, bottom or side sheets are not to be deformed or deplaced by normal load without reducing the usage of the vessel.

6.5.2.4 Transom for engine mounting is normally to be stiffened over its full breadth. Scantlings based on practical testing with simulated loads from the engine may be accepted.

6.5.3 Surveillance of the production

6.5.3.1 Moulding time, temperature, density and meltindex of the materials shall be recorded.

6.5.3.2 The inner surfaces and welding are to be visually inspected and the hull thicknesses measured by cutting various sections of the vessel.

6.6 ACRYLONITRILE BUTADIENE STYRENE (ABS) AND EQUIVALENT MATERIALS

6.6.1 Manufacturing conditions

6.6.1.1 Requirements to forming temperature and sheet thickness are determined for each vessel type on the basis of inspection of completed vessels.

6.6.2 Material requirements

6.6.2.1 Raw materials shall be approved according to Sec.2.

6.6.2.2 Material tests are carried out on sheets produced with low internal stresses and low orientation. When testing the shrinkage of the sheet, the test specimens are to be heated to 150°C.

6.6.2.3 When using foam in structural members, the following requirements are to be complied with:

Table 6-1 Foam properties

Properties	Requirements Foam
Compressive strength	0.4 N/mm^2
Shear strength	0.4 N/mm^2
Connection skin/core	Fracture in glued joints is not to occur

6.6.3 Scantlings

6.6.3.1 The following scantling requirements are based on a vessel speed not exceeding 10 knots.

6.6.3.2 Thickness of outer hull:

The bottom thickness is not to be less than:

$tb = 1.5 + 0.4\ L + 0.06\ V$ (mm)

$tb\ min = 2.6$ (mm)

6.6.3.3 The side thickness is not to be less than:

$ts = 1.5 + 0.4\ L$ (mm)

$ts\ min = 2.4$ (mm)

6.6.3.4 The thickness of the inner hull is not to be less than:

$ti = 0.9$ ts (mm)

$ti\ min = 2.2$ (mm)

6.6.3.5 If the vessel is intended for a speed exceeding 10 knots, the material thickness will be considered in relation to the stiffening system and the vessel speed in each case.

6.6.3.6 Vessels built in accordance with the above requirements shall have at least one longitudinal stiffening or the equivalent. The need for any additional stiffening will be considered in each case.

6.6.3.7 The transom is normally to be stiffened over its full breadth if use of outboard engine is intended. Scantlings based on practical tests with simulated loads from the engine, may be accepted.

6.6.3.8 All stiffening shall be of such shape that stress concentrations are avoided as far as practicable.

6.6.4 Surveillance of the production

6.6.4.1 The yield stress of the material before and after forming is checked by random sample testing.

6.6.4.2 By random sample testing at the raw material manufacturer the sheet thickness, shrinkage, and impact strength tested with drop weight shall be checked.

7 WOODEN STRUCTURES

7.1 GENERAL

7.1.1 Scope

This section applies to the scantling determination of the structure of sailing vessel, motorsailers and motor vessels of normal monohull form, traditionally carvel or clinker built on transverse frames.

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*.

7.1.2 Basic principles for scantling determination

7.1.2.1 Determination of the component scantlings of structural members shall be carried out in accordance with the Tables 7-22 to 7-36 respecting the scantling numerals **B**/3 + **H**1or **L** (**B**/3 + **H**1). Structural members of hulls with larger dimensions or unusual proportions shall have the scantlings determined by individual calculations.

The scantlings given in Tables 7-22 to 7-36 for the structural members listed below apply to timber with a bulk density of:

Structural member	Standard bulk density [g/cm^3] [1)]
Keel Stem Floors Frames Transom beams	0.70
Shell Sheer plank Reinforced deck beams Beam knees Carlines Engine seatings Deadwood	0.56
Decks Deck beams Planks, shelves	0.45
[1)] In standard atmosphere condition with a moisture content of 12%.	

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

7.1.2.3 Keel, stem/sternpost and other hull structural members may be lamellated. Scantlings are to be suitably calculated.

7.1.3 Types of wood and materials

7.1.3.1 Wood

Timbers for load bearing components shall be best quality, adequately dried, sound, free from sap, knots and detrimental flaws. Twisted timber shall not to be used. For non-load-bearing components, e.g. interior parts, no particular types of wood are specified.

7.1.3.2 Plywood

Structural members from plywood exposed to the weather, such as decks, superstructures, deckhouses, etc. shall comply with the *Rules for the classification of ships, Part 24 – Non-metallic materials*.

7.2 SHELL

7.2.1 Shell planks shall be quartersawn (riftsawn). Thickness and width are listed in Tables 7-22 and 7-23. Planks around the bilge should be narrower than those for other areas. Plank thicknesses are the ones after shaping. If the frame spacing is increased compared with Table values, plank thickness is to be increased in proportion, a reduction of plank thickness is permissible if frame spacing is reduced.

7.2.2 For double-planked vessels whose scantling numeral **L** (**B**/3 + **H**1) is greater than 28, the total thickness of the shell may be reduced by 10% in accordance with Table 7-22.

Spacing of butts in shell planking			
	Plank thickness		
	under 20 mm	*20 – 33 mm*	*over 33 mm*
if strakes adjoin	1.00 m	1.20 m	1.50 m
if there is one intermediate strake	0.70 m	0.90 m	1.20 m
if there are two intermediate	0.40 m	0.60 m	0.90 m

7.2.3 Shell planking is to be fitted in as long lengths as possible. Planks in one strake may however be joined by glued joints or butt straps. Where there are joints in two neighbouring strakes of planking, these must be at least three frame spaces apart. If there is one strake in between, they must be two frame spaces apart; if two, one frame space.

7.2.4 If the shell planking does not have glued joints, the planks are to be connected by butt straps. The distances between butts are to be taken from the Table below: Plank butts in the plane of the same frame are only permitted if there are three intermediate strakes.

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

7.2.6 Butt straps of wood or sea-water-compatible metal are to be arranged in between frames with drainage at both ends. They should be wide enough to overlap adjoining strakes by at least 10 mm. Wooden straps should be of the same thickness as the shell; metal ones are to have an equivalent strength. For arrangement details of butt straps see Fig. 7-1.

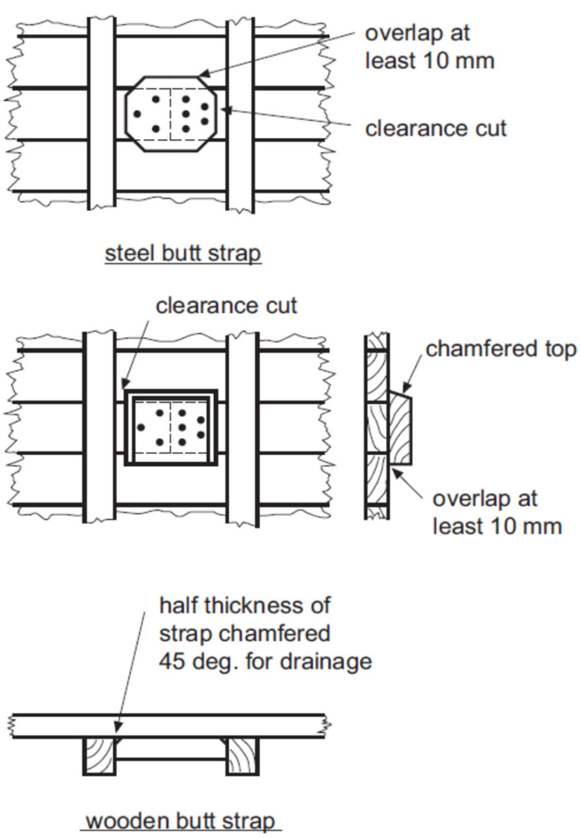


Fig.7-1

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

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

7.3 BULKHEADS

7.3.1 Bulkhead plating

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

$P_{dc} = 10 \cdot H \cdot (1 + 0.2 \cdot V / \sqrt{L})$

$s = a \cdot C \cdot \sqrt{h1 \cdot k}$ [mm]

a = stiffener spacing in [m]

$h1$ = pressure head in [m] measured from bulkhead bottom edge to bulkhead deck

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

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

C = 4.0 in case of collision bulkhead

= 2.9 for other bulkheads

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

7.3.2 Bulkhead stiffeners

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

$W = k \cdot C \cdot a \cdot (h_2 + 0.5) \cdot l^2$ (cm^3)

a = stiffener spacing in [m]

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

l = length of stiffener in [m]

k = 12 for stiffeners of teak, kambala, oak, sipomahogany and laminated stiffeners

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

7.3.3 Non-watertight bulkheads

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

7.4 FLOORS

7.4.1 Floors shall be fitted over 0.75 $\mathbf{L}_{WL}$ of the midbody of the vessel at each frame; see Fig. 7-2. In the case of vessels with curved or lamellated frames, whose scantling numeral **L** (**B**/3 + **H**1) is less than 20, floors may be spaced 1½ frames apart within 0.75 $\mathbf{L}_{WL}$ in accordance with Table 7-22; under the mast tabernacle however floors are required at each frame.

7.4.2 In the afterbody, a spacing of two frames suffices beyond 0.75 $\mathbf{L}_{WL}$, a spacing of three frames beyond $\mathbf{L}_{WL}$; in the forebody beyond $\mathbf{L}_{WL}$ a spacing of two frames. Where sterns hang over, as with conventional vessel sterns and retracted transoms, no floors are needed in the overhang beyond $\mathbf{L}_{WL}$ provided the frames are carried continuously from one side to the other.

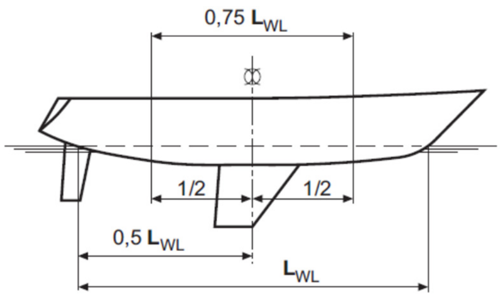


Fig.7-2

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

7.4.4 For vessels where the scantling numeral **L** (**B**/3 + **H**1) is more than 25, wooden floors, steel plate floors or wooden plank floors shall be fitted in the area of the fin keel.

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

7.4.6 Floor scantlings are given in Tables 7-24 and 7-25 based on the scantling numeral **B**/3 + **H**1 and floor spacing, for the mid-body area of 0.75 $\mathbf{L}_{WL}$. If the spacing is greater than that in the Table, the floor scantlings are to be increased in the same proportion. For the floors beyond 0.75 $\mathbf{L}_{WL}$ whose spacing is increased in accordance with 4.2, increase in scantlings is not required.

7.4.7 Beyond $\mathbf{L}_{WL}$, arm lengths may be reduced to 1/3 of the associated frame lengths.

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

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

7.4.10 The arms of flat bar steel floors may be tapered off to the scantlings given in Table 1.25 for arm ends, from the first third onwards. Similarly, the projecting leg of angle bar floors may be tapered off to leg thickness from the first third of the arm length onwards.

7.4.11 The scantlings for wooden floors given in Tables 7-24 and 7-25 apply to the centre of the floor. Towards the ends of the arms, the height may gradually be reduced to that of the frame. If ballast keel bolts are taken through wooden floors, the floor width is to be increased by half a bolt diameter.

7.4.12 The heights given in Table 7-24 for steel plate or wooden plank floors are the heights above the top edge of the wood keel. Beyond $\mathbf{L}_{WL}$, the height may gradually be reduced to twice that stated for naturally grown frames. The floors are to be extended high enough for the associated frames to be rigidly joined to them.

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

7.4.14 Steel plate floors are to be joined to the wood-keel and the shell by angle bars of the shape of the stipulated steel frames. However, the profile flanges in contact with the keel must be wide enough to be at least 1/3 of the flange width between bolt hole and profile edge. The upper edges of plate floors are to be flanged. Plate floors may in the region of 0.6 **B** amidships have lightening holes no greater in height than half the local web height and not exceeding the local web height in length.

7.5 FRAMES

7.5.1 Frames may either be pre-bent, bent-in, lamellated grown, of metal or made by a combination of these. Frame spacing is given in Table 7-22. Frame spacing may be altered if the thickness of shell planking is increased (see 7.2.1). Frame scantlings are to be determined from Tables 7-26 and 7-27 based on the scantling numeral **B**/3 + **H**1 and the frame spacing chosen.

7.5.2 Forward and aft of the length $\mathbf{L}_{WL}$, the section modulus of bent, lamellated or steel frames may be reduced by 15 %; that of grown frames by 20 %.

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

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

7.5.5 Grown frames shall have the same width from keel to deck, the height on the other hand may be gradually reduced from the top edge of the floor to the deck, down to the frame height shown in Table 7-27.

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

7.5.7 Metal frames shall be welded to floor plates and beam knees. Sailing vessels with an **L** (**B**/3 + **H**1) up to 14 shall have two reinforced frames in way of the mast; larger ones at least three. In place of the reinforced frames, intermediate ones may be fitted which have the same cross section as the neighbouring ones.

7.5.8 For vessels with an **L** (**B**/3 + **H**1) greater than 26, reinforced or intermediate frames are additionally to be provided at the ends and in the middle of longer deck openings. The minimum number of reinforced or intermediate frames is to be taken from the following Table.

L (B/3 + H_1)	Number of reinforced or intermediate frames
>26	4
>35	5
>47	6
>62	7
>80	8
>115	9

Bulkheads or partial bulkheads of adequate strength may replace the reinforced frames. The section modulus of the reinforced frames is to be at least 30% greater than that of normal frames. In the area of the beam shelves, the height of the reinforced frames may be reduced to that of the other grown frames.

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

7.5.10 In the case of vessels with an **L** (**B**/3 + **H**1) greater than 62, one of the reinforced frames in way of the mast shall be a web frame; where **L** (**B**/3 + **H**1) exceeds 78, at least two must be in the form of web frames. Metal web frames comprise of a metal floor, a web plate and a reverse frame or a flange located at the inner edge of the web frame.

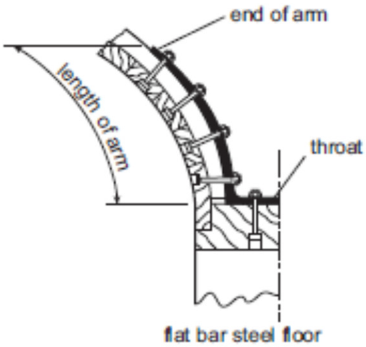


Fig. 7-3

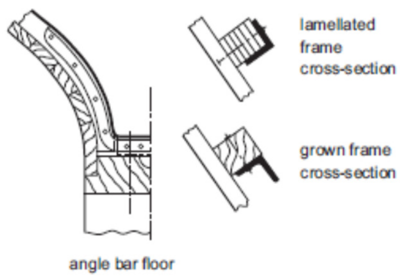


Fig. 7-4

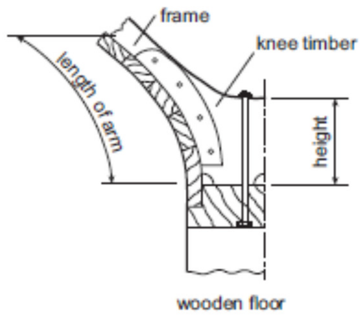


Fig. 7-5

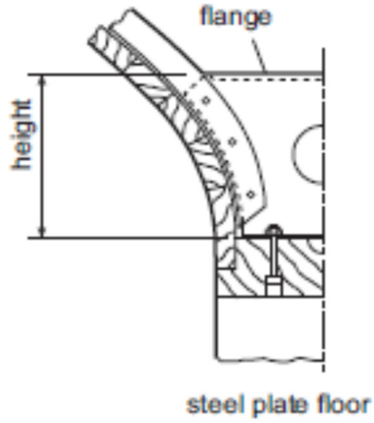


Fig. 7-6

7.5.11 Steel web frames shall comply with the following Table:

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

The web plates may have round lightening holes with a diameter of 1/3 of the web height. Hole edges shall be at least 1/4 of the web height apart.

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

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

7.6 BEAM SHELVES AND BILGE PLANKS

7.6.1 The cross sections required for the beam shelves and bilge planks on each side of the hull are given in Table 7-

22. The shelves/planks shall extend from the stem to the transom. Beyond 0.75 $\mathbf{L}_{WL}$ towards the ends, their cross section may gradually be reduced to 75%. They shall be fitted in the maximum possible lengths. If they are butt joined or scarified, the butt length shall be at least six times the height of the shelf/plank. Butts shall not be located in way of the mast, the chain plates or other areas where forces are introduced into the structure. The port and starboard beam shelves shall be linked by bow pointers or stem knees at the stem and shall be connected to the transom by knees.

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

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

7.6.4 In way of the mast and the chain plates, secondary shelves shall be additionally fitted whose cross section is 75% of that of the shelf in accordance with Table 1.22. The length of these secondary shelves shall be at least 0.3 $\mathbf{L}_{WL}$. If the shelves have been subdivided into primary and secondary ones, half the beam shelf cross section is sufficient for the additional secondary shelves near the mast. Vessels with plywood decks do not require the additional secondary shelves near the mast, nor are they needed where there are plywood decks on which strip planking has been laid if the thickness of the plywood is at least 50 % of the deck plank thickness in accordance with Table 1.22.

7.7 DECK STRUCTURE

7.7.1 Decks

7.7.1.1 Deck planks must be quartersawn (riftsawn) planks. Plank thickness is given in Table 7-22.

7.7.1.2 The widths of strip planking planks shall approximately match with the requirements of Table 7-23.

7.7.1.3 Plywood decks are permitted. The thickness of the plywood panels must be at least 65% of the thickness given in Table 1.22 for deck planks. Joints in the plywood deck are to be scarified. Scarfs in plywood must be at least ten panel thicknesses long.

7.7.1.4 Decks are to have a hardwood (mahogany, oak, teak or similar) plank sheer/gunwale capping plank around the outboard edge, at least as thick as the shell according to the Table and at least 3 to 5 times as wide as it is thick. In the case of plywood decks this plank of solid wood is only required for vessels with a scantling numeral **L** (**B**/3 + **H**1) greater than 25. The outer cut edges of plywood decks must be protected by means of fillets.

7.7.2 Deck beams and beam knees

7.7.2.1 Deck beam scantlings are to be determined in accordance with Table 7-28, based on their respective length and the beam spacing. The relevant beam length is that between the outer edges of the beam shelves. In the case of half beams or supported beams the relevant length is that between the shelf outer edge and the cabin or hatch longitudinal coaming or the support. The minimum length to be inserted is 0.5 **B**.

7.7.2.2 Beam spacing may be increased to about 1.25 times the frame spacing in accordance with Table 7-22; in very large vessels even up to 1.4 times. The beam section modulus is to be determined based on the actual spacing.

7.7.2.3 The heights of the deck beam cross sections determined in accordance with 7.7.2.2 may be reduced to 75% towards the beam ends.

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

7.7.2.5 The continuous deck beams in way of the mast and the beams at the ends of large deck openings, e.g those at the forward edge of the cabin and the after edge of the cockpit, are to be reinforced. If the beams are supported by bulkheads, their section modulus shall be increased by 50%; if they are unsupported, by 150%. For calculating the section modulus of the deck beams at the ends of the cabin, the beam spacing inserted is to be equal to the frame spacing in accordance with Table 7-22.

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

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

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

7.7.2.9 The minimum number of hanging knees is given in Table 7-29, their arm lengths and scantlings in Table 7-30. In lieu of hanging knees, adequately strong bulkheads of partial bulkheads are also permitted.

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

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

7.7.2.12 Floor beam scantlings may be determined in accordance with Table 7-28. Based on their length and spacing their section modulus may be reduced up to 75%.

7.7.3 Diagonal braces

7.7.3.1 Sailing vessel and motorsailers with an **L** (**B**/3+ **H**1) greater than 35, diagonal braces shall be arranged on the frames in way of the mast which are to end at the futtock chain plates. The futtock chain plates are to be extended to the frames forward and aft of the shroud chain plates. Their width is to be about 1.4 times the frame spacing.

7.7.3.2 In the case of sailing vessel and motorsailers with an **L** (**B**/3 + **H**1) greater than 70, the deck beam in way of the mast is to be provided with a cross of diagonal braces. Such braces are not needed in the case of plywood decks.

7.7.3.3 The scantlings of diagonal braces are given in Table 7-29.

7.8 KEEL

7.8.1 Height and width of the wood keel halfway along $\mathbf{L}_{WL}$ are given based on the scantling numeral **L** (**B**/3 + **H**1). The height applies to the full length of the wooden keel; the width may be tapered off towards the ends, down to stem/sternpost width. In the case of centreboard vessels, the cross section of the wooden keel in way of the centreboard case is to be increased by 10%. The height of lamellated wooden keels may be 5% less than that of solid ones.

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

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

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

7.8.5 For vessels whose **L** (**B**/3 + **H**1) is less than 35, the wooden keel shall be one piece. Vessels with an **L** (**B**/3 + **H**1) of 35 to 100 may have a two-piece wooden keel with a scarf joint; even larger vessels, a three-piece keel with scarf joints. The scarfs shall be in the area of the metal fin, if ever possible.

7.8.6 The scarfs are to take the form of hook scarfs or in the case of larger vessels double-hook scarfs. The scarf length shall be at least six times the keel height. The keel scarfs shall have softwood stopwaters in the rabbet, see 7.11 and Fig. 7-7.

7.8.7 The wooden keel may be built up by gluing together separate laminated planks running horizontally.

7.8.8 If the mast stands on the stem-keel scarf or in the vicinity of this, a mast stool shall be provided on the floors. In smaller vessels this stool should at least extend over 3 floors; in larger ones, over 5 or 6. Mast steps must not be cut directly into the keel or keel scarfs.

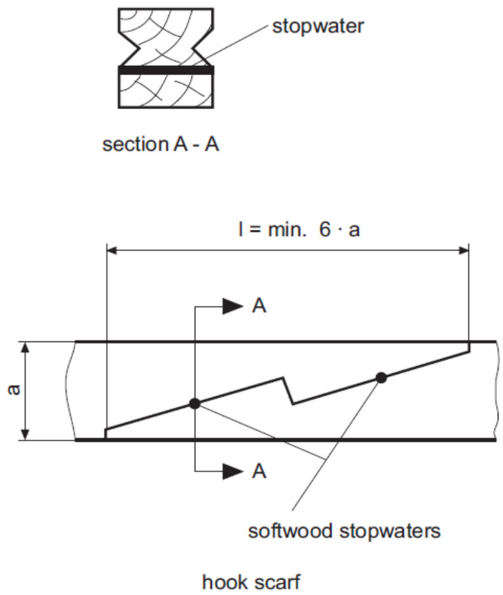


Fig. 7-7

7.9 STEM/STERNPOST AND TRANSOM BEAM

7.9.1 The height of the stem on the design waterline must be at least 1,2 times the height of the wooden keel in accordance with Table 7-31. Between the rabbets the thickness of the stem shall be at least twice that of the shell planking. The width of the rabbet shall be at least 1.5 times the shell planking thickness. The leading edge of the stem and the trailing edge of the sternpost may be tapered.

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

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

7.9.4 If shafting is led through the sternpost, this shall be widened so as to leave at least 0.4 of the tabular sternpost width either side of the stern tube where this is taken through.

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

7.9.6 The transom beam shall be rigidly connected to the sternpost. The cross section of the transom beam at the forward end and in the area where the rudder stock/tube is taken through must at least equal the square of the height of the stem in accordance with 7.9.1. Towards the after end the cross section may be reduced to 75%. The height of the transom beam shall be at least 2.5 times the height of the bent-in frames. The seat of the transom beam must be of adequate length. Care is to be taken to make sure that the bolting is adequate (recessed bolts if appropriate).

7.10 COACHROOFS, DECKHOUSES

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

7.10.2 The scantlings of deck beams at the ends of superstructure, hatches and cockpits shall be determined in accordance with 7.6.2.

7.10.3 The cross sections of the deck carlines shall approximately match the data in Table 7-32; the height of the deck carlines shall be about half the height of the beams and their width shall be 4,5 times the thickness.

7.10.4 The thickness of side walls and deck planking of the superstructure is given in Table 7-32.

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

7.10.6 The spacing of the superstructure deck beams (cabin beams) shall be about 25% less than the frame spacing in accordance with Table 7-22; in the case of plywood decks however the beam spacing may be increased depending on the thickness of the deck and the camber of the cabin beam. The cabin beam scantlings are to be determined in accordance with Table 7-28, based on their spacing and their length, but their section modulus may be 20% less.

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

7.10.8 Hatch coamings shall be of adequate strength.

7.11 BOLTING CONNECTION OF STRUCTURAL MEMBERS

7.11.1 General

7.11.1.1 The necessary data about interconnection of the individual members are given in Tables 7-33 to 7-36.

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

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

7.11.2 Floors

7.11.2.1 Number and diameter of the bolts connecting the floors to shell and keel are given in Table 7-34.

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

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

7.11.2.4 Frames in the afterbody extending from one side of the vessel to the other without any floors shall be fastened to the transom beam by bolts in accordance with Table 7-34.

7.11.3 Shell and frames

7.11.3.1 Each shell plank shall be fastened to each frame by at least 2 screws. The screws are to be staggered (zigzag) to prevent the frames from splitting. Screw diameters are given in Table 7-35.

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

7.11.3.3 The butt straps are to be fastened to each of the planks by screws of the same diameter as those for shell-to-frame connection in accordance with Table 7-35.

7.11.3.4 If grown frames have butt-strapped joints, the straps shall be fastened to each frame part by 3 bolts in the case of scantling numerals **B**/3 + **H**1 up to 2; by at least 4 bolts in the case of larger scantling numerals.

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

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

7.11.4 Deck beams, hanging knees and beam shelves

7.11.4.1 Each deck beam is to be joined to the beam shelf; the half deck beams also to the carlines. In vessels up to an **L** (**B**/3 + **H**1) = 60, wood screws shall be used; in those with higher scantling numerals, bolts and nuts shall be used.

7.11.4.2 The hanging knees shall be fastened to the frames and deck beams by rivets or wood screws in accordance with Table 7-36.

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

7.11.4.4 The beam shelves shall be screwed to every frame.

7.11.5 Deck beams

7.11.5.1 The gunwale/covering board is to be screwed to the shell. The diameters of the wood screws are given in Table 7-35. The length of the screws shall be at least twice the thickness of the planks and the distance between screws equal to twelve screw diameters. The gunwale/covering board shall be fastened to every deck beam.

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

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

7.11.5.4 The screw diameters are given in Table 7-35.

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

7.11.6 Diagonal braces

Diagonal braces shall be fastened to the frames/deck beams and each shell or deck plank by at least one screw in accordance with Table 7-35.

7.12 WORKMANSHIP

7.12.1 The workshops for building wooden vessels shall be fully enclosed spaces with heating as well as supply and exhaust ventilation.

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

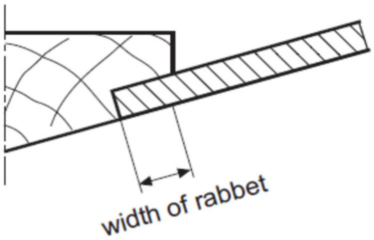


Fig. 7-8

7.12.3 Load bearing structural members of a vessel shall be made with an adequate accuracy of fit. They are to be preserved to prevent water penetration.

7.12.4 Holes for wood screws shall be drilled with a conical drill. Maximum attention shall be paid to the watertightness of hull and superstructure. It is therefore necessary to take into consideration the properties of the wood, in particular its swelling and shrinkage properties which vary in the three dimensions, even when cutting the component to size. As wood, in particular hardwood, swells and shrinks tangentially much more than radially, deck and shell planking, and that of watertight bulkheads, shall consist of quartersawn (riftsawn) planks. It is advised to cut deadwood tangentially.

7.12.5 To guarantee watertightness between the scarfs of keel and stem/sternpost, stopwaters shall be provided where the rabbet crosses the scarf or a stop of the keel or stem/sternpost. Stopwaters should be of softwood, which does not rot much nor becomes brittle when air is excluded from it. Spruce or pine are suitable. Stopwaters shall have a diameter of at least 10 mm in small vessels; up to a maximum of 22 mm in large ones. They shall have a press fit, hammered in at totally dry state into clean holes cut with a sharp drill.

7.12.6 To allow for proper drainage of water to the bilges, and to prevent dirt accumulating in corners, care shall be taken to assure that any condensation or leakage water can run down to the lowest point of the bilges, to the strum box. This means that limber holes shall be provided in the floors, large enough to be easily cleaned.

7.12.7 Inside the vessel, good circulation of air through any areas and corners with a plank lining is to be ensured by means of ventilation openings, fingerholes and by making clearance cuts. It is recommended that all joinery such as lockers, cupboards, etc. be installed removable to permit subsequent conservation of the parts they conceal.

7.12.8 The connection between superstructure sidewalls and deck shall be made with special care and using proven methods, to avoid any leaks.

Table 7-22
Beam shelves, bilge planks, shell, and deck

L (B/3 + H_1)	Frame spacing	Beam shelves	Bilge planks	Shell	Deck
*m*²	*mm*	*cm*²	*cm*²	*mm*	*mm*
7	120	17	—	11	18
8.5	130	19	—	12	18
10	140	21	—	13	18
11.5	150	24	—	14	18
13	160	28	—	15	18
14.5	170	31	—	16	18
16	180	34	—	17	18
17.5	190	37	—	18	18
19	200	40	—	19	18
20.5	210	43	—	20	19
22	220	46	—	21	20
23.5	230	49	—	22	21
25	240	52	—	23	22
27	250	56	—	24	23
29	260	60	—	25	24
31	270	64	—	26	25
33	280	69	—	27	26
35	285	73	—	28	27
37	295	77	59	29	28
39	305	80	62	30	29
41	310	84	64	31	30
43	320	88	67	32	30
46	330	94	70	33	31
49	340	100	73	34	32
52	345	106	76	35	33
55	355	112	80	36	34
58	360	117	84	37	35
61	370	123	87	38	36
64	380	129	90	39	37
67	385	135	93	40	38
75	405	149	102	42	40
85	420	167	112	44	42
96	440	185	123	46	44
108	455	204	134	48	46
122	475	225	147	50	48
140	495	250	162	52	50

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

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

Table 7-23
Widths of shell- and strip deck planks

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

Table 7-24
Floors

B/3 + H_1	Frame spacing	Steel plate floors		Wooden plank-floors	
		height	thickness	height	thickness
m	*mm*	*mm*	*mm*	*mm*	*mm*
1.4	115	140	2.5	140	24
1.4	170	145	2.5	145	30
1.5	130	145	2.5	145	24
1.5	195	150	3.0	150	30
1.6	140	150	3.0	150	24
1.6	210	155	3.0	155	32
1.7	145	155	3.0	155	26
1.7	220	160	3.5	160	34
1.8	155	160	3.5	160	27
1.8	230	165	3.5	165	35
1.9	165	170	3.5	170	28
1.9	250	175	3.5	175	37
2.0	180	175	3.5	175	30
2.0	270	180	4.0	180	40
2.2	200	190	4.0	190	32
2.4	220	200	4,0	200	35
2.6	240	210	4.0	210	38
2.8	260	220	4.0	220	41
3.0	275	235	4.0	235	44
3.2	290	245	4.0	245	47
3.4	305	255	4.0	255	49
3.6	320	270	4.5	270	52
3.8	340	280	4.5	280	55
4.0	360	290	4.5	290	57
4.4	385	320	5.0	320	63
4.8	415	345	5.0	345	69
5.2	425	375	5.0	375	75
5.6	435	400	5.5	400	80
If the frame spacing is changed, the thickness of the floors is to be altered in the same ratio.					

Table 7-25
Floors

B/3 + H_1	Frame spacing	Arm length	Flat bar steel floors		Angle bar floors W	Wooden floors	
			Throat	Arm end		height	thickness
m	*mm*	*mm*	*mm*	*mm*	cm^3	*mm*	*mm*
1.4	115	175	22 x 5	17 x 4	0.60	37	15
1.4	170	175	23 x 7	20 x 5	0.85	48	18
1.5	130	180	20 x 7	17 x 5	0.92	46	17
1.5	195	180	25 x 8	24 x 5	1.37	53	23
1.6	140	190	21 x 8	20 x 5	1.27	50	20
1.6	210	190	26 x 10	22 x 7	1.90	58	28
1.7	145	200	26 x 7	22 x 5	1.54	53	23
1.7	220	200	28 x 10	24 x 7	2.30	68	27
1.8	155	210	26 x 8	21 x 6	1.95	58	25
1.8	230	210	31 x 10	28 x 7	2.90	77	28
1.9	165	225	30 x 8	24 x 6	2.38	63	27
1.9	250	225	36 x 10	31 x 7	3.60	82	31
2.0	180	235	26 x 10	22 x 7	2.88	69	29
2.0	270	235	36 x 12	32 x 8	4.35	89	33
2.2	200	260	33 x 10	28 x 7	3.92	82	32
2.4	220	280	37 x 12	33 x 8	4.65	91	37
2.6	240	300	38 x 14	31 x 10	6.02	98	44
2.8	260	320	44 x 14	37 x 10	7.40	100	50
3.0	275	340	47 x 15	35 x 12	8.66	109	54
3.2	290	360			9.91	118	58
3.4	305	380			11.40	125	62
3.6	320	400			13.20	131	67
3.8	340	420			14.60	141	71
4.0	360	440			17.70	150	75
4.4	385	480			21.00	167	84
4.8	415	520			24.40	180	93
5.2	425	560			27.50	195	99
5.6	435	600			29.80	209	101
If the frame spacing is changed, the thickness of the floors or the section moduli for steel angle bar floors given in column 6 are to be altered in the same ratio.							

Table 7-26
Frames: Section moduli without effective width of plate

B/3 + H_1	Section moduli referred to a basic frame spacing of 100 mm			
	Curved	Laminated	Naturally grown	Steel profiles
	W_{100}	W_{100}	W_{100}	W_{100}
m	cm^3	cm^3	cm^3	cm^3
1.4	0.70	0.68	2.0	0.105
1.5	0.85	0.83	2.5	0.127
1.6	1.02	0.99	3.1	0.150
1.7	1.20	1.17	3.7	0.177
1.8	1.39	1.36	4.3	0.206
1.9	1.59	1.55	4.9	0.236
2.0	1.81	1.75	5.6	0.266
2.1	2.04	1.97	6.2	0.300
2.2	2.29	2.19	7.0	0.334
2.3	2.56	2.42	7.8	0.370
2.4	2.85	2.66	8.6	0.409
2.5	3.17	2.94	9.5	0.453
2.6	3.51	3.25	10.4	0.502
2.7	3.88	3.58	11.4	0.555
2.8	4.27	3.94	12.5	0.606
2.9	4.70	4.32	13.7	0.671
3.0	5.16	4.74	14.9	0.739
3.1	5.65	5.17	16.2	0.807
3.2	6.18	5.65	17.6	0.884
3.3	6.75	6.15	19.2	0.965
3.4	7.37	6.71	20.8	1.055
3.6	8.75	7.93	24.5	1.250
3.8	10.32	9.30	28.8	1.480
4.0	12.09	10.82	33.6	1.730
4.2	14.06	12.57	39.0	2.010
4.4	16.32	14.43	45.0	2.320
4,6	18.60	16.49	51.6	2.660
4.8	21.17	18.61	58.8	3.020
5.0	23.95	21.00	66.8	3.430
5.2	26.97	23.55	75.5	3.840
5.4	30.23	26.30	84.9	4.320
5.6	33.71	28.20	94.9	4.820
5.8	37.43	32.30	105.5	5.350
The frame section moduli are given for a basic spacing of 100 mm. If the spacing selected differs from that, the section moduli are to be increased in the same ratio.				

Table 7-27
Grown frames: section moduli and cross sections

W	**breadth x height**
cm^3	*mm*
3.00	23 x 28 / 23
3.60	24 x 30 / 24
4.44	26 x 32 / 26
5.23	27 x 34 / 27
6.05	28 x 36 / 28
7.21	30 x 38 / 30
8.54	32 x 40 / 32
9.97	33 x 42 / 33
11.20	35 x 44 / 35
12.86	36 x 46 / 36
14.60	38 x 48 / 38
16.69	40 x 50 / 40
18.50	41 x 52 / 41
20.90	43 x 54 / 43
23.00	44 x 56 / 44
25.20	45 x 58 / 45
28.20	47 x 60 / 47
32.40	49 x 63 / 49
37.00	51 x 66 / 51
42.90	54 x 69 / 54
48.50	56 x 72 / 56
54.30	58 x 75 / 58
61.00	60 x 78 / 60
68.00	62 x 81 / 62
75.40	64 x 84 / 64
84.50	67 x 87 / 67
93.00	69 x 90 / 69
106	72 x 94 / 72
120	75 x 98 / 75
135	78 x 102 / 78
149	80 x 106 / 80
167	83 x 110 / 83
186	86 x 114 / 86
209	90 x 118 / 90
232	93 x 122 / 93
254	95 x 126 / 95
276	98 x 130 / 98
303	101 x 134 / 101
328	103 x 138 / 103
358	106 x 142 / 106
The first height given for naturally grown frames is that in way of the floors, which may be gradually reduced to the second height towards the deck.	

Table 7-28
Deck beams, section moduli without effective width of plate

Beam length	Section moduli referred to a basic beam spacing of 100 mm			
	Wooden beams	Laminated beams	Steel sections	Deck load
	W_{100}	W_{100}	W_{100}	p
m	*cm³*	*cm³*	*cm³*	*kN/m²*
0.8	0.52	0.47	0.081	1.84
1.0	0.86	0.78	0.132	1.93
1.2	1.28	1.15	0.180	2.02
1.4	1.84	1.66	0.248	2.11
1.6	2.84	2.23	0.335	2.20
1.8	3.30	2.97	0.446	2.29
2.0	4.20	3.78	0.568	2.38
2.2	5.27	4.75	0.712	2.48
2.4	6.52	5.87	0.882	2.57
2.6	7.90	7.10	1.068	2.67
2.8	9.51	8.56	1.290	2.75
3.0	11.25	10.25	1.520	2.84
3.2	13.25	11.92	1.790	2.94
3.4	15.44	13.90	2.090	3.04
3.6	17.80	16.00	2.410	3.12
3.8	20.40	18.35	2.760	3.22
4.0	23.30	20.95	3.150	3.30
4.2	26.40	23.75	3.570	3.40
4.4	29.75	26.80	4.020	3.49
4.6	33.30	30.00	4.500	3.59
4.8	37.20	33.50	5.030	3,67
5,0	41.40	37.30	5.600	3,76
5,2	45.70	41.10	6.180	3,85
5,4	50.50	45.40	6.820	3,95
5,6	55.60	50.00	7.510	4.05
5,8	61.20	55.00	8.270	4.13
6.0	67.30	60,50	9.100	4.23
6.2	73.50	66,00	9.940	4.33
6.4	79.70	71.60	10.790	4.42
6.6	86.50	77.80	11.630	4.52

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

The section moduli are given for a basic beam spacing of 100 mm; they shall be increased in the ratio of the selected spacing to the basic spacing. Additionally, for beams shorter than the vessel's breadth **B** the section moduli shall be multiplied by the deck loading p_1 corresponding to the breadth **B** and be divided by the deck load p_2 corresponding to the beam length in question.

Example:

Beam length = 2.40 m
Breadth **B** = 4.00 m
Beam spacing = 370 mm
W_{100} = 6.52 cm³
p_1 = 3.30 kN/m²
p_2 = 2.57 kN/m²

W = 6.52 x 3.7 (3.30 : 2.57) = 31 cm³

Table 7-29
Diagonal braces and number of hanging knees

L (B/3 + H_1)	**Diagonal braces**	**Hanging knees**
m^2	*mm*	*number*
to 13	-	3
to 20	-	4
to 27	-	5
to 30	-	6
to 35	50 x 4	6
to 40	50 x 4	6
to 45	60 x 4	6
to 50	50 x 4.5	7
60	80 x 4.5	7
70	90 x 5	8
80	100 x 5	8
90	100 x 6	9
100	110 x 6	9
110	120 x 6	10
120	130 x 6	10
130	145 x 6	11

Table 7-30
Scantlings of hanging knees

$B/3 + H_1$	Flat bar steel knee [1)] width x thickness	Angle bar W	Arm length	Bracket Thickness	Wooden Leg Thickness	Knee length
m	*mm*	*cm^3*	*mm*	*mm*	*mm*	*mm*
1.60	19 x 7	0.8	290	2.5	16	85
1.75	19 x 8	0.9	300	2.5	18	95
1.90	22 x 8	1.0	310	2.5	20	105
2.10	25 x 9	1.3	325	3	22	115
2.30	26 x 11	1.6	340	3	26	130
2.50	28 x 12	1.8	360	3.5	28	145
2.70	30 x 13	2.1	380	3.5	30	160
2.90	30 x 15	2.4	400	3.5	32	175
3.15	33 x 16	2.8	420	4	35	190
3.40	37 x 17	3.3	440	4	38	205
3.65	40 x 18	3.7	460	4	41	220
3.90	44 x 19	4.1	480	4	44	235
4.15	47 x 21	4.7	500	5	47	250
4,40	49 x 23	5.3	520	5	50	265
4.65	53 x 24	5.8	540	5	53	280
4.90	55 x 26	6.5	560	5	56	300
5.20	60 x 27	7.3	580	6	59	320
5.50	65 x 28	8.2	600	6	62	340
5.80	66 x 30	9.0	620	6	65	360

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

Table 7-31
Wooden keel and stem/sternpost

L (B/3 + H_1)	Sailing vessels	Wooden keel amidships	Motor vessels
	width	height [1)]	width
m^2	*mm*	*mm*	*mm*
7	123	57	123
8	131	59	131
9	139	61	139
10	145	64	145
11	152	66	152
12	159	68	159
13	165	70	165
14.5	175	74	172
16	185	77	178
17.5	195	81	182
19	205	84	185
20.5	214	87	187
22	223	90	189
23.5	232	93	191
25	241	96	193
26.5	248	99	195
28	255	102	196
29.5	262	105	197
31	269	108	198
32.5	275	111	199
34	282	114	200
35.5	288	117	201
37	294	119	202
39	301	122	203
41	309	125	204
43	315	128	205
45	323	131	206
47	330	134	207
49	337	137	208
51	342	140	209
54	350	144	210
57	358	147	212
60	366	151	213
63	374	155	214
66	381	158	215
69	387	161	216
72	394	164	217
76	401	168	218
80	409	171	219
84	416	175	220
88	424	179	222

Table 7-31
Wooden keel and stem/sternpost *(continued)*

L (B/3 + H_1)	Sailing vessels	Wooden keel amidships	Motor vessels
	width	height [1)]	width
m^2	*mm*	*mm*	*mm*
92	431	182	224
96	439	185	226
100	446	188	228
105	454	192	230
110	461	195	233
115	469	198	236
120	476	201	239
125	483	204	242
130	490	207	245
135	497	210	248
140	505	213	251

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

Table 7.32
Superstructure, carlines

L (B/3 + H_1)	Superstructure side walls		Superstructure deck		Carlines
	Solid wood	Plywood	Solid wood	Plywood	
m^2	*mm*	*mm*	*mm*	*mm*	*cm^2*
7	18	9	8	6	7
8.5	18	10	8	6	7
10	19	11	9	6	9
11.5	19	12	9	6	11
13	20	13	10	6	12
14.5	20	13	10	7	13
16	21	14	11	7	14
17.5	21	14	12	8	15
19	22	15	12	8	16
20.5	22	15	13	8	17
22	23	15	14	9	18
23.5	23	15	14	9	19
25	23	15	15	10	20
27	24	16	15	10	21
29	24	16	16	10	22
31	24	16	16	11	23
33	24	16	17	11	24
35	24	18	17	11	25
37	25	18	18	11	26
39	25		18	12	26
41	25		19	12	27
43	25		19	12	28
46	25		20	13	29
49	26		20	13	30
52	26		21	13	31
55	26		21	13	32
58	27		21	14	33
61	27		22	14	34
64	27		22	14	35
67	27		23	15	36
71	28		23	15	37
75	28		24	15	38
80	29		24	15	39
85	29		24	16	40
90	30		25	16	41
96	30		25	16	42
102	31		25	16	43
108	31		26	16	44
115	32		26	17	45
122	33		27	17	45
130	34		27	17	46
140	35		27	17	47

Table 7-33
Bolting-up keel, stem/sternpost, deadwood, transom beam, etc.

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

Table 7-34
Connecting floors with keel and shell and frames

B/3 + H_1	Bolts		Bolts			
	In the arms		In the throat			
			for 0.8 L_{WL}		at the ends of the vessel	
	number	*mm Ø*	*number*	*mm Ø*	*number*	*mm Ø*
to 1.50	3	5.5	1	8	1	8
1.50 to 1.75	3	5.5	2	8	1	8
1.75 to 1.90	3	6	2	8	1	9
1.90 to 2.10	3	6	2	9	1	9
2.10 to 2.30	4	6	2	9	1	10
2.30 to 2.50	4	6.5	2 3	10 9	1 2	10 7
2.50 to 2.70	4	7	2 3	11 10	1 2	11 8
2.70 to 2.90	4	8	2 3	11 10	1 2	11 8
2.90 to 3.15	4	9	2 3	12 11	1 2	12 9
3.15 to 3.40	4	9	2 3	12 11	1 2	12 9
3.40 to 3.65	5	10	2 3	13 12	1 2	13 9
3.65 to 3.90	5	10	2 3	14 13	1 2	14 10
3.90 to 4.15	5	11	2 3	15 14	1 2	15 11
4.15 to 4.40	5	11	3	15	2	12
4.40 to 4.65	5	12	3	16	2	13
4.65 to 4.90	5	12	3	17	2	14
4.90 to 5.20	5	13	3	18	2	15
5.20 to 5.50	5	14	3	19	2	16
5.50 to 5.80	5	15	3	20	2	17

Table 7-35
Screws in shell and deck

Plank thickness	**Shell with frames screws**	**Deck planks to deck and shell beams screws**
mm	*mm Ø*	*mm Ø*
to 15	4	4
15 to 17	4	4
17 to 19	4.5	4
19 to 23	5	4.5
23 to 26	5.5	5
26 to 29	6	5.5
29 to 32	6.5	6
32 to 35	7.5	7
35 to 38	8	7.5
38 to 41	8.5	8
41 to 44	9	8.5
44 to 47	10	9
47 to 50	10.5	9.5
50 to 53	11	10

Table 7-36
Screwing hanging knees and shelves to frames and deck beams

B/3 + H_1	**Number**	**Screws**
m		*mm Ø*
to 1.50	3	4.5
1.50 to 1.75	3	5
1.75 to 1.90	3	5.5
1.90 to 2.10	3	6
2.10 to 2.30	3	7
2.30 to 2.50	4	8
2.50 to 2.70	4	8
2.70 to 2.90	4	9
2.90 to 3.15	4	10
3.15 to 3.40	4	10
3.40 to 3.65	5	11
3.65 to 3.90	5	11
3.90 to 4.15	5	12
4.15 to 4.40	5	12
4.40 to 4.65	6	13
4.65 to 4.90	6	13
4.90 to 5.20	6	14
5.20 to 5.50	6	15
5.50 to 5.80	6	16

8 HULL EQUIPMENT

8.1 RUDDER

8.1.1 General requirements

8.1.1.1 Rudder and rudder stock shall have product certificate 3.2 according to EN 10204.

8.1.1.2 In lieu of compliance with requirements of this Head, the *Register* may accept compliance with other recognized standard, subject to special consideration on case by case basis.

8.1.13 The following definitions apply in this header:

C_T = steering force on tiller at point of actuation (N)
C_R = steering force on rudder (N)
A = rudder area (m^2)
V = maximum vessel speed (knots)
Sa = length of tiller from rudder stock centre to point of actuation (mm)
Sb = distance from pressure centre of rudder to lower rudder bearing for spade rudders, to upper bearing for balance rudder (mm)
Sv = distance from rudder pressure centre to axis of rotation, not to be taken smaller than 40% of the chord length aft of the leading edge for plate rudders, not to be taken smaller than 30% of the chord length aft of the leading edge for profile rudders (mm)
P = maximum engine power output (kW)
M_T = combined bending moment and torque on rudder stock (Nmm)
D = diameter of rudder stock (for solid stock) (mm)
$\sigma 0.2$ = yield stress of rudder stock or the other item, as applicable (MPa).

8.1.2 Arrangements

8.1.2.1 The steering arrangement shall ensure reliable manoeuvring of the vessel at the maximum engine power for which the vessel is certified. The steering system shall be protected.

8.1.2.2 It shall be possible to steer the vessel by means of an emergency arrangement also when the normal means of actuating the rudder/waterjet has failed.

8.1.2.3 Rudder stops shall be fitted.

8.1.3 Forces on steering system

8.1.3.1 Rudder steering

The steering force C_R with rudder shall not be taken smaller than:

$C_R = C_T\ Sv/Sa$

with F not taken smaller than:

$C_R = 110\ A\ V^2$ (N)

The means of actuating the rudder shall have a capacity corresponding to not less than 2 times the maximum torque on the rudder stock.

8.1.3.2 Waterjet installations

The steering forces from water jets shall be specified by the manufacturer of the water jet.

8.1.4 Rudder stock

8.1.4.1 The combined bending moment and torque, M, on the rudder stock shall not be taken smaller than:

for balance rudders
$M_T = 0.25 \cdot C_R \cdot Sb + 0.5 \cdot C_R \cdot (Sb + 2 \cdot Sv^2)^{0.5}$

for spade rudders
$M_T = 0.25 \cdot C_R \cdot Sb + 0.5 \cdot C_R \cdot (Sb^2 + 2 \cdot Sv^2)^{0.5}$

8.1.4.2 The diameter d of the rudder stock shall not be smaller than:

$d = 2.2 \cdot (M_T/s_{0.2})^{1/3}$

for solid stocks.

Hollow stocks shall satisfy the following criteria:

$d = ((d_0^4 - d_i^4)/d_0)^{1/3}$

$$d = \sqrt[3]{\frac{d_0^4 - d_i^4}{d_0}}$$

do = outer diameter of stock
di = inner diameter of stock.

8.1.4.3 The length of the bearings shall normally not be smaller than d. The nominal contact pressure on the bearing (stock diameter × length of bearing) shall normally not exceed:

- 7.0 (MPa) for steel against steel
- 4.5 (MPa) for steel against white metal
- 5.5 (MPa) for steel against synthetic materials, water lubricated.

8.1.4.4 The diameter of pintles shall not be smaller than 0.6 · d + 5 (mm)

8.1.4.5 Fillets shall be carried out with radii such that undue stress concentrations are avoided.

8.1.4.6 The diameter of bolts, d, in flanged couplings shall not be smaller than:

$$d_b = 0.65 \cdot \frac{D_1}{2 \cdot \sqrt{n}}$$

n = number of bolts, shall not be smaller than 4
D_1 = pitch circle diameter, shall not be smaller than 2 · d.

The thickness of the flanges and where width outside the bolt holes shall not be smaller than d.

8.1.4.7 The packing box of the rudder stock housing shall normally not be placed lower than 100 mm above the deepest waterline. If placed below a grease filled packing box with at least two seals shall be fitted.

8.1.5 Rudder leaf

8.1.5.1 Rudders can be fabricated from steel, aluminium or fibre reinforced thermosets (FRP). FRP can be used in profile rudders only.

Other materials are subject to the *Register* special consideration, on case by case basis.

8.1.5.2 The plate thickness t in steel plate rudders shall not be smaller than:

$t = 3 + 0.125$ d (mm)

8.1.5.3 The plate thickness of steel profile rudders shall not be smaller than:

$t = 4$ (mm)

8.1.5.4 The section modulus W of the rudder at any horizontal section through the rudder shall not be smaller than given by:

$$w = \frac{M_B}{\sigma_d}$$

M_b = bending moment at the cross section due to maximum rudder lift force

σ_d = allowable bending stress.

σ_d shall not be taken larger than:

- 50% of specified minimum yield strength for steel.
- 50% of minimum yield strength in welded condition for aluminium.
- 33% of ultimate tensile/compressive strength as relevant for FRP.

8.1.5.5 The total effective shear area A_w of vertical webs in any horizontal cross section shall not be smaller than given by:

$$A_w = \frac{S}{\tau_d}$$

S = maximum lift force of the part of the rudder below the cross section

τ_d = allowable shear stress.

τ_d shall not be taken larger than:

- 29% of specified minimum yield strength for steel.
- 29% of minimum yield strength in welded condition for aluminium.
- 33% of ultimate shear strength for FRP.

8.2 PROPELLER SHAFT BRACKETS

8.2.1 Propeller shafting could be enclosed in bossing or independent of the main hull and supported by shaft brackets.

8.2.2 The arrangement and scantlings of bracket arms shall be as follows.

Bracket arms are to be attached to deep floors or girders of increased thickness, and the shell plating is to 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, is to be not less than 0.2 · **d**S, where:

dS = Rule diameter, in mm, of the propeller shaft, calculated with the actual mechanical characteristics.

The arm is to 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 are to be perpendicular, as far as practicable.

The bearing length of the shaft bracket boss, in mm, is to be not less than 3 · **d**S.

The thickness, in mm, of the shaft bracket boss after boring operation is to be not less than:

$tb = 0.2 \cdot d_S \cdot (k_1 + 0.25)$

where:

$\mathbf{k_1} = \mathbf{R}ms/\mathbf{R}mb$,

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:

$S = 87.5 \cdot 10^{-3} \cdot d_{SO}^2 \cdot (1600 + Rma) / Rma$

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 appropriate metallurgical temper.

Single-arm shaft brackets are to have a section modulus at vessel plating level, in cm^3, of not less than:

$W = 3 \cdot 10^{-2} \cdot l \cdot d_{SO}^2 \cdot (n \cdot d_{SO})^{0,5} / Rma$

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.

8.2.3 **Plated bossing**. Where the propeller shafting is enclosed within a plated bossing, the aft end of the bossing is to be adequately supported.

The scantlings of end supports are to be individually considered. Supports are to be designed to transmit loads to the main structure.

End supports are to be connected to at least two deep floors of increased thickness or connected to each other within the vessel.

Stiffening of the boss plating is to be individually considered. At the aft end, transverse diaphragms are to 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 are to be fitted.

8.3 SUPPORTING STRUCTURE OF WATERJETS

8.3.1.1 The supporting structures of waterjets are to 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 is to 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, is to be individually considered. In general, such thicknesses are to be not less than 1.5 times the thickness of the adjacent bottom plating.

8.4 ANCHORING EQUIPMENT

8.4.1 Anchoring gear

Vessel shall be equipped with anchoring gear which assures swift and safe laying out and heaving up of the stipulated anchors in all foreseeable situations, and which hold the vessel at anchor.

The anchoring gear comprises of anchors, anchor chains or cables and possibly anchor winches or other equivalent equipment for laying out and heaving up the anchors and for keeping the vessel at anchor.

8.4.2 Equipment numeral

8.4.2.1 The required equipment with anchors, chains and cables shall be determined in accordance with Table 8-1 and 8-2 according to the equipment numeral E_n. The equipment numeral is obtained from the following formula:

$$E_n = 0.6 \cdot \mathbf{L} \cdot \mathbf{B} \cdot \mathbf{H} + A$$

L = Rule length (m)
B = breadth (m)
H = moulded depth
A = 0.5 times the volume of the superstructures [m3] (Superstructures and deckhouses whose width is less than **B**/4 may be disregarded.)

8.4.2.2 In the case of small vessel whose displacement is less than 1.5 t, the equipment is to be based on the displacement.

8.4.3 Anchors

8.4.3.1 The anchor weights listed in Tables 8-1 and 8-2 apply to "High holding power" anchors.

The following types of anchor have so far been accepted as anchors with high holding power:

BRUCE anchor
CQR (plough) anchor
Danforth anchor
D'Hone anchor
Heuss special anchor
Pool anchor
Kaczirek bar anchor

A stock anchor may be used if its weight is 1.33 times that in the Table.

Other types of anchor require special approval. Procedure tests and holding trials shall be carried out in accordance with the *Rules for the classification of ships, Part 25 - Metallic materials*.

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

8.4.3.3 Materials for anchors must comply with the *Rules for the classification of ships, Part 25 - Metallic materials*.

Anchors weighing more than 75 kg must be tested on tensile testing machine in the presence of a surveyor.

For anchors below 75 kg and those intended for vessel with a restricted operating category, proof is sufficient that anchors and chains have been reliably tested.

8.4.4 Towing line

Each vessel shall be equipped with a towing line in accordance with Table 8-1 or 8-2.

8.4.5 Anchor lines/cables and chains

8.4.5.1 On vessel with a displacement ≤ 1.5 t, the towing line may be used as anchor line.

If the displacement is ≥ 1.0 t, at least 3.0 m chain with 6.0 mm nominal thickness is to be shackled between anchor and line.

8.4.5.2 On vessel with a displacement ≥ 1.5 t whose $\mathbf{L}_{WL}$ is ≤ 15 m, both anchors may be on chains or on lines with chain outboard shot.

Anchor chains shall be determined in accordance with columns 5 and 6 of Table 8-1 or 8-2.

Synthetic fibre anchor lines shall be 1.5 times as long as the stipulated anchor chain and fitted with a spliced-in thimble at one end. They shall have the same maximum tensile strength as the towing line. Regarding notes for the selection of other ropes, see Table 8-3.

8.4.5.3 Between line and anchor a chain outboard shot is to be shackled whose nominal thickness is determined in accordance with column 6 of Table 8-1 or 8-2 and whose length is obtained from the following Table:

Nominal thickness of chain outboard shot [1)] [mm]	Length of chain outboard shot [m]
6 – 8	6.0
9 – 15	12.5
[1)] ISO 4565 EN 24565 DIN 766	

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

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

8.4.6 Anchor winches

8.4.6.1 For anchors weighing 30 – 50 kg, anchor winches are recommended and shall have product certificate.

8.4.6.2 For anchors weighing more than 50 kg, winches are obligatory and shall have product certificate.

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

8.4.7 Chain locker

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

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

8.5 TOWING AND MOORING EQUIPMENT

8.5.1 Towing bollard

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

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

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

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

8.5.2 Mooring equipment

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

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

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

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

2 lines of 1.5 · **L** [m] each, and
2 lines of 1.0 · **L** [m] each

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

Displacement [t]	Nominal rope diameter d2 [1)] [mm]
to 0.2	10
0.6	12
1.0	14
2.0	14
6.0	16
12.5	18
25.0	20
50.0	22
75.0	24
100.0	26
[1)] Three-strand hawser-lay polyamide rope in accordance with DIN 83330 For notes concerning the choice of other ropes see 8-3	

8.6 NON-STRUCTURAL FUEL TANKS

8.6.1 General

8.6.1.1 Fuel tanks shall be designed and constructed to withstand, without leakage, the dynamic stresses to which they will be subjected. Internal diaphragms shall be fitted, where necessary, in order to reduce the movement of liquid.

Tanks shall be suitably fastened to withstand the stresses induced by movement of the vessel. Tanks shall be accessible for inspection and check of piping.

Tanks intended to contain fuel with a flashpoint below 55°C determined using the closed cup test (petrol, kerosene and similar), shall have inspection openings on the top of the tank. Such tanks are to be arranged in adequately ventilated spaces equipped with a mechanical air ejector. These tank spaces shall be separated from accommodation spaces by integral gastight bulkheads.

Upon completion of construction and fitting of all the pipe connections, tanks are to 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.

8.6.1.2 For vessels of less than 15 m in length and for yachts, requirements of EN ISO 21487 are considered equivalent to requirements of this head.

8.6.2 Metallic tanks

8.6.2.1 Metallic tanks shall be made of stainless steel, steel or aluminium alloys. Other materials may be considered by the *Register*, on a case by case basis.

8.6.2.2 Tanks shall be earthed.

8.6.2.3 Scantlings of metallic tanks

The required thickness of metallic tank plating is given by the following formula, but in no case the thickness of the tank could be less than 2 mm for steel and less than 3 mm for light alloy.

$\boldsymbol{t} = 4 \cdot s \cdot (h_{ST} \cdot M)^{0,5}$ [mm]

where:

s = stiffener spacing, in meters;

h_{ST} = static internal design head, in m, to be assumed as the greater of the following values:

- vertical distance from the referent point (see below) to a point located 2 m above the tank top
- two-thirds of the vertical distance from the referent point (see below) to the top of overflow

Referent point is the lower edge of the plate, or, for stiffeners, the centre of the area supported by the stiffener.

$M = 235/ R_Y$

where R_Y is the minimum yield stress, in N/mm^2, of the tank material. Where light alloys are employed, the value of R_Y to be used is that corresponding to the alloy in the annealed condition.

The required section modulus of stiffeners is given by the following formula:

$\boldsymbol{W} = 4 \cdot s \cdot l^2 \cdot h_{ST} \cdot M$ [cm^3]

where:

l = stiffener span, in m.

8.6.2.4 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.

8.6.2.5 The upper part of tanks is generally not to have welded edges facing upwards or be shaped so as to accumulate water or humidity.

8.6.3 Non-metallic tanks

8.6.3.1 Tanks may be made of non-metallic materials. In that case, mechanical characteristics obtained by the mechanical tests are to be used for scantling calculations.

Mechanical tests are to be carried out on samples of the laminate and after immersion in the fuel oil at ambient temperature for at least one week. After immersion the mechanical properties of the laminate shall not decrease below 80% of the sample value.

8.6.3.2 Scantlings of non-metallic tanks is subject to special consideration of the *Register*, based on the characteristics of the material and the results of strength tests performed on a sample.

The minimum required thickness t of the plating is given by the following formula, but in no case the thickness shall be less than 8 mm, with reinforcement weighing not less than 30% of plating weight.

$\boldsymbol{t} = 6 \cdot s \cdot h_{ST}^{0,5}$ [mm]

where:

s and h_{ST} = as defined in 8.6.2.3.

The required section modulus of stiffeners is given by the following formula:

$\boldsymbol{W} = 15 \cdot s \cdot l^2 \cdot h_{ST}$ [cm^3]

where:

l = stiffener span, in meters;

s and h_{ST} = as defined in 8.6.2.3.

8.6.3.3 The surface of the tanks shall be externally coated with self-extinguishing resin and internally coated with resin suitable for hydrocarbons.

The self-extinguishing characteristics of the external coating of the tank shall be in accordance with recognized standard, such as ASTM D635 or equivalent.

Table 8-1
Anchors, anchor cables and lines of sailing vessel and motorsailers

Equipment numeral Z [m^3]	Displacement D [t]	Weight of		Anchor cable		Towing line	
		1. anchor [3] [kg]	2. anchor [kg]	Length [4] [m]	Nominal thickness [1] [mm]	Length [m]	Nominal diameter [2] [mm]
–	up to 0.15	2.50	–	–	–	5 L_{WL}	12
–	at 0.20	3.00	–	–	–		12
–	at 0.30	3.50	–	–	–		12
–	at 0.40	4.50	–	–	–		12
–	at 0.50	5.00	–	–	–		12
–	at 0.60	5.50	–	–	–		14
–	at 0.75	6.50	–	–	–		14
–	at 1.00	7.50	–	–	–		14
–	at 1.50	8.70	–	–	–		14
up to 10	at 2.00	10.50	9.00	22.50	6.00		16
at 15	at 3.00	12.00	10.00	24.00	6.00		18
at 20	at 4.00	13.00	10.50	25.00	6.00		18
at 25	at 5.00	13.50	11.00	26.00	7.00		18
at 30	at 6.00	15.00	13.00	27.00	7.00		18
at 40	at 8.00	17.00	15.00	29.00	8.00		20
at 55	at 12.00	21.00	18.00	32.50	8.00		22
at 70	at 17.00	25.00	21.00	36.00	9.00	4.75 L_{WL}	22
at 90	at 23.00	29.00	25.00	40.00	10.00		22
at 110	at 29.00	34.50	29.00	43.00	10.00		24
at 130	at 36.00	40.00	34.00	47.00	11.00	4.50 L_{WL}	24
at 155	at 44.00	46.50	40.00	52.50	13.00		24
at 180	at 52.00	53.00	45.00	57.00	13.00		24
at 210	at 57.00	62.00	53.00	62.00	13.00		26
at 245	at 72.00	73.50	62.00	68.00	14.00	4.25 L_{WL}	26
at 280	at 84.00	84.00	71.00	74.00	16.00		26
at 300	at 100.00	95.00	81.00	78.00	16.00		26

Z Equipment numeral in accordance with 1.2.1

Notes:
[1] Nominal thickness of round bar steel chain in accordance with DIN 766, ISO 4565, EN 24565.
[2] 3-strand hawser-lay polyamide line in accordance with DIN 83330.
[3] May be reduced by 25% if the vessel in question operates exclusively on inland waterways (Design category D) where strong currents and high seas can be excluded. A stock anchor of 1.33 times the weight may be used.
[4] Applies for one anchor in each case.

Table 8-2
Anchors, anchor chains and lines of motor vessel

Equipment numeral Z [m³]	Displacement D [t]	Weight of		Anchor cable		Towing line	
		1. anchor [3] [kg]	2. anchor [kg]	Length [4] [m]	Nominal thickness [1] [mm]	Length [m]	Nominal diameter [2] [mm]
–	up to 0.15	2.50	–	–	–	5 L_{WL}	12
–	at 0.20	3.00	–	–	–		12
–	at 0.30	3.50	–	–	–		12
–	at 0.40	4.50	–	–	–		12
–	at 0.50	5.00	–	–	–		12
–	at 0.60	5.50	–	–	–		14
–	at 0.75	6.50	–	–	–		14
–	at 1.00	7.50	–	–	–		14
–	at 1.50	8.70	–	–	–		14
up to 10	at 2.00	9.00	–	20.00	6.00		16
at 15	at 3.00	10.00	–	22.00	6.00		18
at 20	at 4.00	11.00	–	23.00	6.00		18
at 25	at 5.00	12.00	–	24.00	6.00		18
at 30	at 6.00	13.00	–	25.00	7.00		18
at 40	at 8.00	14.00	12.00	26.00	7.00		20
at 55	at 12.00	18.00	15.00	29.00	8.00		22
at 70	at 17.00	21.00	18.00	32.50	8.00	4.75 L_{WL}	22
at 90	at 23.00	25.00	15.00	36.00	9.00		22
at 110	at 29.00	29.00	25.00	38.50	10.00		24
at 130	at 36.00	34.50	29.00	42.00	10.00	4.5 L_{WL}	24
at 155	at 44.00	40.00	34.00	47.00	11.00		24
at 180	at 52.00	46.00	39.00	51.00	13.00		24
at 210	at 57.00	52.50	44.00	55.50	13.00		26
at 245	at 72.00	61.00	52.00	61.00	13.00	4.25 L_{WL}	26
at 280	at 84.00	70.50	60.00	66.50	14.00		26
at 300	at 100.00	79.50	67.50	70.00	16.00		26

Z Equipment numeral in accordance with 8.4.20

Notes:
[1] Nominal thickness of round bar steel chain in accordance with ISO 4565, EN 24565, DIN 766.
[2] 3-strand hawser-lay polyamide line in accordance with DIN 83330.
[3] May be reduced by 25% if the vessel in question operates exclusively on inland waterways (Design category D) where strong currents and high seas can be excluded. A stock anchor of 1.33 times the weight may be used.
[4] Applies for one anchor in each case.

Table 8-3
Notes regarding the selection of synthetic fibre ropes

1. Characteristic values and trade names

Material letter symbol	**Polyamid PA**	**Polyester PES**	**Polypropylene PP**
Trade name	Perlon Nylon	Trevira Diolen Terylene	Poly Polyprop Hostalen
Density [kg/dm^3]	1.14	1.38	0.19
Elongation at break [%]	35 – 50	20 – 40	20 – 40
Melting point [°C]	225 – 250	260	163 – 174
Light toughness	good	very good	good only if UV stabilised

2. Mechanical properties of 3-strand hawser-lay ropes

Polyamide ropes [1]		**Polyester ropes [2]**		**Polypropylene ropes [3]**	
Nominal diameter [mm]	**Minimum breaking [4] strength [kN]**	**Nominal diameter [mm]**	**Minimum breaking [4] strength [kN]**	**Nominal diameter [mm]**	**Minimum breaking [4] strength [kN]**
6	7.35	6	5.80	6	5.90
8	13.20	8	10.50	8	10.40
10	20.40	10	16.80	10	15.30
12	29.40	12	24.00	12	21.70
14	40.20	14	33.70	14	29.90
16	52.00	16	43.40	16	37.00
18	65.70	18	54.80	18	47.20
20	81.40	20	68.20	20	56.90
22	98.00	22	82.00	22	68.20
24	118.00	24	98.50	24	79.70
26	137.00	26	115.50	26	92.20

Notes:
[1] In accordance with DIN 83330.
[2] In accordance with DIN 83331.
[3] In accordance with DIN 83332.
[4] The minimum breaking strength is reduced by the following operational influences.
Splicing (approx. 10%).
Solar radiation.
Internal heating, as a result of work.
External heating due to friction (hawsepipe, capstan drum, etc.).
If lines are knotted, a 50% loss of strength shall be taken into consideration.
Polyamide rope tractive power reduces by 10 – 15% when wet.
Care for synthetic fibre ropes calls for attention as follows: Stowage below deck, once at sea (solar radiation).
Do not stow near heating appliances.
From time to time inspect ropes carefully for internal and external defects. In heavily stressed lines, the material can be broken down. by internal friction (heat), which may also become evident by pulverisation between the strands. Polyamide ropes may harden.
Replace defective thimbles. Splice-in loose thimbles afresh and seize-in firmly.

9 STABILITY, FREEBOARD AND CLOSING APPLIANCES ON THE VESSEL'S HULL

9.1 STABILITY GENERAL

9.1.1 All vessels shall have sufficient stability in all stages of the voyage or operation.

9.1.2 Stability booklet with stability calculations shall be submitted to the *Register* for approval. Stability booklet of vessels intended for carriage of cargo of mass exceeding 1 t and/or that have lifting appliances installed, shall contain hydrostatics data (in tables or curve form) and tables of maximum allowed heights of centre of gravity (KG max), for all operative range of draughts and trims.

Stability booklet shall include instructions to skipper/master how to obtain height of centre of gravity of a new load condition, and how to compare it with maximum allowed values.

Following load conditions shall be included in stability calculations:

- vessel with maximum number of persons, 100% of stores and maximum amount of cargo on board;
- vessel with maximum number of persons, 50% of stores and maximum amount of cargo on board;
- vessel with maximum number of persons, 10% of stores and maximum amount of cargo on board;
- vessel in minimum operating condition, (minimum number of crew and 10% of stores);
- additional load conditions depending of vessel type and purpose.

The following additional load conditions shall be approved for certain types of vessels:

Fishing vessels:

- load condition with maximum allowed quantity of catch and other cargo (ice, boxes, etc.) carried on the deck;
- the most unfavourable load condition with maximum moment induced by fishing gear.

Passenger vessels:

- load condition with passengers crowded on a vessel side (not more than 4 persons per 1 m^2 of area need to be considered), and 100% of stores;
- load condition with passengers crowded on a vessel side (not more than 4 persons per 1 m^2 of area need to be considered), and 10% of stores.

Vessels carrying cargo:

- load condition with maximum allowed weight of cargo, offsetted for at least ¼ width of cargo deck from CL, and 100% of stores;
- load condition with maximum allowed weight of cargo, offsetted for at least ¼ width of cargo deck from CL, and 10% of stores.

Vessels with cargo gear:

- load condition assuming operation of cargo gear that results with maximum heeling moment, with maximum allowed weight of cargo on deck, and 100% of stores;
- load condition assuming operation of cargo gear that results with maximum heeling moment, with maximum allowed weight of cargo on deck, and 10% of stores;
- load condition assuming operation of cargo gear that results with maximum heeling moment, and 10% of stores.

9.1.3 Design category A may be assigned only to decked vessels (including vessels with side buoyancy spaces, if draining of main deck meets requirements stated in 9.10.1).

Design category B may be assigned to decked vessels and enclosed vessels.

Design categories C and D may be assigned to decked vessels, enclosed vessels, and open vessels.

9.1.4 Stability assessment on the impact of the tanks on the vessel's stability should be carried out and the free surface effect considered for all following stability criteria.

For detailed instructions on calculating free surface effects, provisions of item 1.4.7 of the *Rules for the classification of ships, Part 4 – Stability* may be followed.

9.1.5 Additionally, for the purpose of stability calculation, a mass of 85 kg shall be taken for every person onboard, with centre of gravity on 0.2 m above any surface provided for seat. It is not allowed, for the purpose of stability calculation, to position persons in spaces below the vessel's sheer line, even if there is an accommodation provided.

9.2 STABILITY CRITERIA

9.2.1 Basic stability criteria for single-hull decked vessels and enclosed vessels of design categories A and B

9.2.1.1 The following criteria shall be applied:

- Area below static stability curve (GZ) up to the angle of 30° shall be at least 0.055 m-rad;
- area below static stability curve (GZ) up to the angle of 40°, or downflooding angle, whichever the least, shall be at least 0.09 m-rad;
- area below static stability curve (GZ) from angle of 30° up to the angle of 40°, or downflooding angle, whichever the least, shall be at least 0.03 m-rad (not required for totally enclosed vessels of design category B);
- static stability lever (GZ) shall be at least $6/\theta_{max}$ [m], where θ_{max} is the angle in [°] at which the first maximum of static stability curve (GZ) occurs, but in any case, shall be at least 0.20 m;

- minimum initial metacentric height shall be at least 0.35 m, taking into consideration free surface effect of any liquid in vessel's tanks.

9.2.1.2 In addition to 9.2.1.1, the following criteria shall also be fulfilled:

- the maximum stability moment (GZ_{max} lever multiplied by vessel's displacement) shall be at least:
  - 2.55 [tm] if $\theta_{max} \geq 30^\circ$,
    $76.5/\theta_{max}$ [tm] if $\theta_{max} < 30^\circ$,
    for vessels of design category A;
  - 0.72 [tm] if $\theta_{max} \geq 30^\circ$,
    $21.5/\theta_{max}$ [tm] if $\theta_{max} < 30^\circ$,
    for vessels of design category B, and
- area below curve of static stability (GZ) up to the angle θ_{max} when $\theta_{max} < 30^\circ$ shall be at least:
  $A \geq 0.055 + 0.002 \cdot (30^\circ - \theta_{max})$ [m-rad].

9.2.2 Basic stability criteria for decked multihull vessels

9.2.2.1 The following criteria shall be applied:

- Area below static stability curve (GZ) up to the angle θ shall be at least $A \geq 0.055 \cdot 30^\circ/\theta$ [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°;
- the first peak (maximum) of the static stability curve (GZ) shall occur at angle of at least 10°;
- static stability lever (GZ) shall be at least $6/\theta_{max}$ [m], where θ_{max} is the angle in [°] at which the first peak (maximum) of the static stability curve (GZ) occurs, but in any case, shall not be less than 0.20 m
- minimum initial metacentric height shall be at least 0.35 m, taking into consideration free surface effect of any liquid in vessel's tanks.

9.2.3 Weather criterion

9.2.3.1 All vessels, including multihull vessels, with design categories A and B shall meet weather criterion (strong waves and wind) for all load conditions, according to the Figure 9-1.

Wind heeling lever shall be taken as constant for the full range of heeling angles, and shall be determined according to the following equation:

$$M_w = 0.0306 \cdot A_V \cdot (A_V / L_{WL} + T_M) \cdot v_w^2 \text{ [kgm]}$$

$$l_w = M_w / \Delta$$

where:

l_w = wind heeling lever. For the purpose of Figure 9-1, it should be assumed that $l_{w1} = l_{w2} = l_w$;

Δ = vessel's displacement, in [kg];

A_V = windage area (lateral projection of the vessel above the waterline), in m^2 – it shall not be taken less than $0.55 \cdot L_h \cdot B_h$, where L_h i B_h are length and breadth of the hull, respectively;

T_M = vessel's draught at the middle of L_{WL}, in [m];

v_w = wind speed: 28 m/s for design category A, and 21 m/s for design category B;

θ_o = wind heeling equilibrium angle;

θ_l = roll back angle due to waves:
- 25+20/V, in [°], for design category A, and
- 20+20/V, in [°], for design category B,

where V is displacement volume, in [m^3]. This angle shall be applied to the left from the equilibrium angle, according to Figure 9-1;

θ_2 = downflooding angle θ_f, or 50°, or θ_c (angle of second intersection between wind heeling lever l_w and GZ curve), whichever the least.

The vessel shall meet the following requirement: area "b" at Figure 9-1, shall be equal or greater than area "a". Free surface effect of any liquid contained in vessel's tanks shall be taken into account for all load conditions.

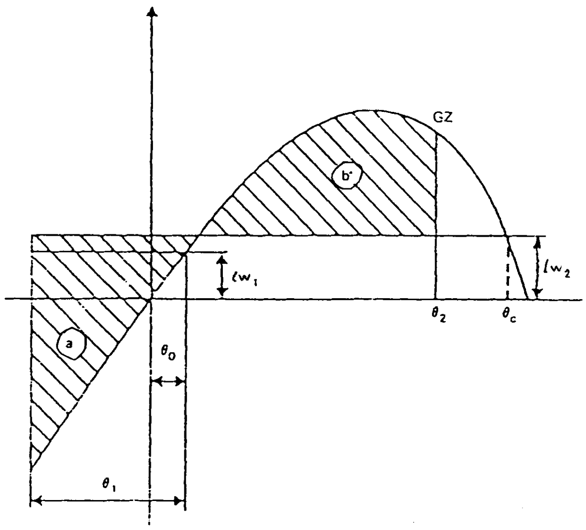


Figure 9-1

9.2.4 Stability criteria for totally enclosed, partially enclosed, and open vessels, of design categories C and D

Totally enclosed, partially enclosed, and open vessels, of design categories C and D shall meet following requirements:

- Static stability lever (GZ) shall be at least $6/\theta_{max}$ [m], where θ_{max} is the angle in [°] at which the first maximum of static stability curve (GZ) occurs, but in any case, shall be at least 0.20 m;
- minimum initial metacentric height shall be at least 0.35 m, taking into consideration free surface effect of any liquid in vessel's tanks;
- resulting transverse angle of heel in case of cargo/passenger displacement shall be less than:

$\theta_{Tmax} \geq 11.5 + (24 - L_h)^3 / 520$ [°];

- residual freeboard [m] after heeling shall be at least:
  - $0.26 \cdot B_h$ for decked vessels of design category A,
  - $0.145 \cdot B_h$ for decked and totally enclosed vessels of design category B,
  - $0.046 \cdot B_h$ for decked, totally enclosed, and open vessels with buoyancy chambers, of design category C,
  - 0.1 m for decked vessels, totally enclosed vessels, and open vessels with buoyancy chambers, of design category D,
  - $0.11 \cdot \sqrt{L_h}$ for partially enclosed vessels, and open vessels without buoyancy chambers, of design category C,
  - $0.07 \cdot \sqrt{L_h}$ for partially enclosed vessels, and open vessels without buoyancy chambers, of design category C.

If the vessel's A_V (according to definition in „Weather criterion“, above) is more than $L_h \cdot B_h$, weather criterion shall be met also, for wind lever calculated according to 9.2.3, but assuming v_w = 17 m/s for design category C, and 13 m/s for design category D. Resulting angle of equilibrium, θ_o, shall be less than half of θ_{Tmax} , calculated according to the formulae above.

9.2.5 Planning criteria

9.2.5.1 Additional criteria for **planning vessels** shall be fulfilled if the vessel 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 vessel shall not exceed 12° while running at full speed in any of following cases:

- displacement of cargo or passengers;
- high-speed turning.

This angle shall be verified during sea-trials at calm sea.

9.3 DETERMINATION OF LIGHTWEIGHT CHARACTERISTICS

9.3.1 The mass of empty vessel can be determined using any of the following methods:

a) direct weighting using crane dynamometer, weighbridge, load cells or similar, corrected for the actual load condition;
b) calculation from the lines plan, using a waterline determined on the vessel afloat by means of freeboards or draughts observed, using the measured specific gravity of surrounding water, and then corrected for the actual load condition.

9.3.2 The **vertical position of the centre of gravity** (VCG, or KG) can be found using any of the following methods:

a) an inclining experiment in water (see Appendix 3 of the *Rules for the classification of ships, Part 4 – Stability*), the results being corrected for the actual load condition;
b) an inclining experiment in air, using a known length of suspension and moving weights transversely (as in water), the results being corrected for the actual load condition;
c) calculation based on the calculated mass and centres of gravity of all individual components, raised by an addition of 5% of (FM + TC).

Method a) shall not be used for vessels with a metacentric height greater than 5.0 m (such as multihulls), since inclining experiments in water for such vessels are liable to significant inaccuracies.

Method c) shall not be used for vessels with a metacentric height of less than 1.5 m, since significant inaccuracies might result. It can, however, be used for preliminary assessment.

9.3.3 The **longitudinal position of the centre of gravity** (LCG) of the empty vessel can be found using any of the following methods:

a) calculation from the lines plan, using a waterline determined on the vessel afloat by means of freeboards or draughts observed, using the measured specific gravity of surrounding water, and then corrected for the actual load condition;
b) calculation based on the calculated mass and centres of gravity of all individual components;
c) suspension of the vessel in air, identifying the LCG using a plumb line from the suspension point.

9.4 DAMAGE SURVIVABILITY

9.4.1 General

9.4.1.1 This header applies to all vessels of design category A and B that, either: carrying more than 12 passengers or members of special personnel; or have *"Patrol"* or *"SAR"* service notation; or apply for additional class notation *"SD"*.

9.4.1.2 Multihull vessels should be fitted with engine rooms that are separated by a watertight bulkhead.

9.4.1.3 In assessing survivability, the following standard space permeabilities (in %) should be used:

- appropriated for stores - 60;
- appropriated for stores, but not by a substantial quantity thereof - 95;
- appropriated for accommodation - 95;
- appropriated for machinery - 85;
- appropriated for liquids - 0 or 95, whichever results in the more onerous requirements.

Other methods of assessing floodable volume may be considered, to the satisfaction of the *Register*.

9.4.1.4 Spaces that are normally occupied at sea are to be provided with at least two independent means of escape preferably at opposite sides / ends of the superstructure that allow positive freeboard independent of its location. Any weathertight doors or openings leading from undamaged spaces, that are normally occupied at sea, to the weatherdeck should be regarded as downflooding points for the purposes of the damage stability calculation.

9.4.1.5 In assessing survivability, the vessel should meet the damage stability criteria for one of two methods. The first (denoted Option 1) considers minor hull damage scenarios with limited equilibrium trim and heel angles after damage. This has historically been used by monohulls and some catamarans. The second method (denoted Option 2) considers minimum length single compartment damage scenarios with more onerous residual stability, combined with increased allowable equilibrium angles after damage. That option has been developed to address particular stability issues raised by low waterplane area vessels with deep hulls which typically have large intact freeboards, such as catamarans.

9.4.2 Damaged stability, Option 1

9.4.2.1 Vessels should be so arranged that after minor hull damage or failure of any one hull fitting in any one watertight compartment, it will satisfy the residual stability criteria below. This may be achieved by fitting watertight subdivision or alternative methods to the satisfaction of the *Register*. Minor damage should be assumed to occur anywhere in the vessel but not on a watertight subdivision.

9.4.2.2 In damaged condition, the residual stability should be such that:

.1 the angle of equilibrium does not exceed 7 degrees from the upright;
.2 the resulting righting lever curve has a range to the downflooding angle of at least 15 degrees beyond the angle of equilibrium;
.3 the maximum righting lever within that range is not less than 100 mm;
.4 the area under the curve is not less than 0.015 metre-radians;
.5 this damage should not cause the vessel to float at a waterline less than 75 mm from the weatherdeck at any point.

9.4.3 Damaged Stability, Option 2

9.4.3.1 Damaged Stability should be calculated with any one compartment flooded. The extent of damage should be:

.1 A damage length of 10% L_h should be considered in the calculations. Where the distance between two transverse watertight bulkheads is less than the damage length, one or more bulkheads should be disregarded in the damage stability calculations, such that the compartment length considered is equal or above the damage length. The damage length given above need not to be applied for the forepeak and afterpeak compartment/s.
.2 The transverse extent of damage should be up to and including the centreline of the vessel. A catamaran need only be considered to have damaged the full extent of one hull, provided the two hulls are totally independent, and that there are not cross connections that, if damaged, would flood the other hull and wet deck compartment. Trimarans should be considered to have damaged wing and centre compartments up to the centre line of the vessel.
.3 The vertical extent of damage should be taken for the full vertical extent of the vessel; and
.4 the shape of the damage should be assumed to be a rectangular block.

Additionally, a damage scenario which considers damage to all the forward compartments of each hull of a multihull that fall within 5% L_h from the forward extremity of the watertight hull, measured on vessel centreline, shall be assessed to ensure that these do not result in a more onerous damaged stability condition.

Watertight compartments aft of the transom that do not form part of the hull length and do not extend below the design waterline need not be considered in the damaged length assessment.

If any damage of lesser extent than that required would result in a more severe condition, such damage shall be assumed.

9.4.3.2 In the damaged condition, the residual stability and damaged waterline should be such that:

1. the angle of equilibrium (combined heel and trim) does not exceed 15 degrees from the upright, while sufficient non-slip deck surfaces and suitable holding points, e.g., rails, grab bars, etc., are provided along escape routes and accessing escape routes;
2. the resulting righting lever curve has a range to the downflooding angle of at least 20 degrees beyond the angle of equilibrium;
3. the maximum righting lever within that range is not less than 200 mm;
4. the area under the curve is not less than 0.045 metre-radians;
5. the final equilibrium waterline is below the lowest point of any opening which is not closed by an approved watertight closure - this includes air pipes, hatch covers, doors and any other weathertight closure; and
6. this damage causes the vessel to float at a waterline of at least 75mm from the weatherdeck.

Margin line criterion, in 6. above, may be relaxed on application to the Register, provided that all of the following are met:

.1 the immersed portion of the weather deck is not a life-saving appliance storage area;
.2 it is not part of an assembly station, evacuation point or part of an evacuation route; and
.3 that no more than 10% length of the deck edge on the damaged side is immersed in the process, and that negative freeboard measured from the deck edge is limited to a maximum of 300 mm.

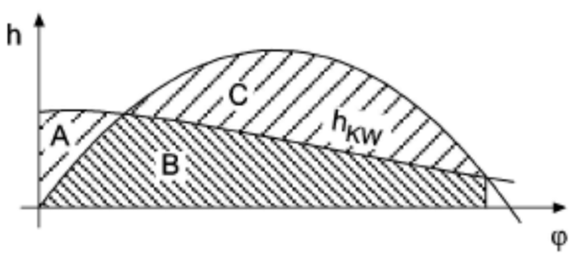
9.5 SAILING VESSEL'S STABILITY

9.5.1 This header applies to all vessels under sails.

9.5.2 For single-hull vessels, 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 9-2);
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 vessels with dedicated ballast keel (protruding from the keel line of the main hull); and 60° - for other vessels;
4. initial transversal metacentric height, GM_0, shall be at least 0.6 m; and
5. static angle of heel of the vessel, 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, or
   c) 20°.

Fig. 9-2



$$(B+C) \geq 1.4 \cdot (A+B)$$

Where:

h_{KW} = wind heeling lever, in m, due to wind action on the exposed area (including sails) of the vessel's lateral projection. It should be calculated as follows:

$$h_{KW} = \cos^2\varphi \cdot \frac{P \cdot A \cdot (h - H)}{1000 \cdot g \cdot \Delta}$$

where:

P = value of wind pressure, in Pa (N/m^2), that shall be taken in accordance with the vessel's design category;

A = projected lateral area of the particular sail configuration and the portion of the vessel above the waterline, in m^2;

h = height of the centre of A above the baseline, in m;

H = 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 vessel in actual load condition.

Load conditions with the most unfavourable stability characteristics shall be included in stability analysis of the vessel under sails.

Full sails setting should be considered when calculating lateral area A in the formulae above. However, if the vessel fails to satisfy the criterion 1. with all sails set and for the wind taken in accordance with its category, 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 vessel's design category.

9.5.3 For multihull vessels, the criteria set in 9.5.2 shall be applied, with required positive range of the curve of static stability (GZ) of at least 60°.

Alternatively, the requirements of HRN EN ISO 12217-2 may be applied.

9.6 STABILITY OF VESSELS ENGAGED IN TOWING

9.6.1 For vessels of design category A and B and all vessels with L > 20 m, engaged in towing and escort operations, applicable requirements of Section 3.7 of the *Rules for the classification of ships, Part 4 – Stability*, shall be applied.

9.6.2 Generally, a vessel engaged in towing should be a decked vessel and comply with the general stability requirements which are appropriate to the vessel.

The danger to safety of deck edge immersion makes an open vessel generally unsuitable for towing other vessels or floating objects.

However, open vessels may tow vessels of less than twice their displacement, exclusively in harbour areas (navigation area 8) and in favourable weather.

For vessels with stability information books, the book should include loading conditions for towing.

9.6.3 Stability criteria

Stability for towing conditions may be deemed satisfactory if the heeling lever (defined below) does not exceed 0.5 times the maximum GZ for the most critical loading condition.

$$\text{Heeling lever} = \frac{0.6 \cdot \text{max. bollard pull} \cdot z}{\text{displacement}}$$

where:

z - vertical distance between hawser and centre of the propeller(s), in m.

The height of the hawser should be measured at:

- the fixed gog, or the side rails if higher, if a fixed gog is always used; or

- the top of the winch drum (with no towline deployed), or the side rails if higher, if a fixed gog is not always used.

If the maximum GZ occurs at an angle greater than 30 degrees of heel, then the GZ value for 30 degrees of heel should be used instead of the angle of maximum GZ.

The stability of vessels without stability information books (as, for example, the open ones considered in 9.6.2) can be deemed satisfactory if:

- in the normal working condition, the freeboard is such that the deck edge is not immersed at an angle of less than 10 degrees; and
- The results of the heel test indicate that:

$$\frac{w \cdot d}{L_h \cdot B_h \cdot T \cdot \rho \cdot \tan(\theta)} \geq \frac{0.076 \cdot K}{f}$$

where:

K = 1.524 + 0.08L - 0.45r

L_h = hull length of vessel (metres);

B_h = hull breadth (metres);

T = hull draught (metres);

R = length of radial arm of towing hook

(metres);

F = freeboard (metres);

P = density of sea water;

Θ = heel angle from heel test;

W = weight moved for heel test;

D = transverse distance moved by weight for heel test.

The heel test should be carried out in small increments in both directions, and the average resultant heel angle noted for the average heeling moment w·d.

9.6.4 Alternative standards for towing and escort operations may be applied at the satisfaction of the *Register*.

9.7 STABILITY OF VESSELS FITTED WITH A DECK CRANE OR OTHER LIFTING DEVICE

9.7.1 For the purposes of this header only, a lifting device does not include a person retrieval system, the vessel's own anchor handling equipment, or davits for tenders, where judged by the *Register* not to have a detrimental effect on the stability of the vessel.

9.7.2 A vessel fitted with a deck crane or other lifting device should be a decked vessel.

In addition, for the vessel in the worst anticipated service condition for lifting operations, compliance with the following criteria should be demonstrated by a practical test or by calculations:

.1 With the crane or other lifting device operating at its maximum load moment, with respect to the vessel, the angle of heel generally should not exceed 7 degrees or that angle of heel which results in a freeboard to deck edge, anywhere on the periphery of the vessel, of 250 mm, whichever is the lesser angle (consideration should be given to the operating performance of cranes or other lifting devices of the variable load-radius type and the load moment with respect to the vessel for lifting devices situated off centreline).

.2 When an angle of heel greater than 7 degrees, but not exceeding 10 degrees, occurs, the *Register* may accept the lifting condition providing that all the following criteria are satisfied when the crane, or other lifting device, is operating at its maximum load moment:

- .1 the range of stability from the angle of static equilibrium to downflooding, or angle of vanishing stability, whichever is the lesser, is equal to or greater than 20 degrees;
- .2 the area under the curve of residual righting lever up to 40 degrees from the angle of static equilibrium or the downflooding angle, if this is less than 40 degrees, is equal to or greater than 0.1 metre-radians;
- .3 the minimum freeboard to deck edge at side, measured at A.P. and F.P., throughout the lifting operations should not be less than half the assigned freeboard to deck edge at side amidships. For vessels with less than 1000 mm of assigned freeboard, the freeboard value to deck edge at A.P. and F.P., should not be less than 500 mm; and
- .4 the freeboard to deck edge, anywhere on the periphery of the vessel, is at least 250 mm.

9.7.3 Information and instructions to the master on vessel safety when using a deck crane or other lifting device should be included in the Stability Information Booklet. The information and instructions should include:

.1 the maximum permitted load and outreach of the device which satisfy the requirements for vessels stability, or the Safe Working Load (SWL), whichever is the lesser (operating performance data for a crane or other lifting device of variable load-radius type should be included as appropriate);

.2 details of all openings leading below the main deck which should be secured weathertight; and

.3 the request for all personnel to be above the deck before any lifting operation commences.

9.7.4 Requirements for a lifting system which incorporates counterbalance weight(s),or needs a counter ballasting, or for a vessel that cannot comply with the requirements of this Section but is otherwise deemed to have adequate residual stability, may be specially considered by the *Register*.

9.7.5 Vessels fitted with stern gantries, or fitted with lifting devices over the vessel's side, may be exempted of the requirement to have a stability book with lifting conditions, provided it can be demonstrated to the satisfaction of the *Register* that:

- the lifting device is not of a variable load radius type (e.g., knuckle boom crane);
- the SWL of the lifting device does not exceed 1 % of the vessel's displacement. Where the displacement of the vessel is not known, it may be estimated from the following formula:

$\Delta = C_B \cdot L_{OA} \cdot$ Moulded Beam · Full Load Draught · 1.025

The *Register* is to approve the value of C_B used; in the case of doubt, C_B of 0.9 can be used for pontoons and similar objects, or 0.67 for other, more boat-like hull forms; and

- a practical test has been conducted with the gantry/lifting device at the maximum rated load/radius, which demonstrates the maximum heel angle of 7 degrees and minimum heeled freeboard of 250 mm, around the periphery of the vessel, are achieved.

9.7.6 For vessels engaged in lifting operations, applicable requirements of Section 3.16 of the *Rules for the classification of ships, Part 4 – Stability*, shall be followed.

9.7.7 Alternative standards for lifting operations may be applied at the satisfaction of the *Register*.

9.8 FREEBOARD

9.8.1 In the case of open or partially decked vessel, the freeboard is the minimum distance from the flotation plane to the upper edge of the gunwale, or to an opening in the hull without a watertight closure.

9.8.2 For decked vessel, the freeboard is to be measured to the upper edge of the deck at its lowest point.

9.8.3 For the non-sailing vessels of length of more than 6 m, freeboard shall be determined as follows:

.1 Minimum freeboard of the decked vessel (with continuous freeboard deck in one level), measured between the flotation plane and the upper edge of the deck at its lowest point shall be at least:

$$f_{min} \geq k_{DC} \cdot 0.7 \cdot V / (L_{WL} \cdot B_{WL}), \text{ [m]}$$

where:

k_{DC} = coefficient for design category:
1.00 for category A,
0.90 for category B,
0.75 for category C,
0.50 for category D.

V = volume of displacement for loading condition with maximum draught, in cubic meters [m^3].

In case of decked vessel with cockpit or recess, the freeboard measured between the flotation plane and the upper edge of the flotation chamber or gunwale at its lowest point shall be greater than both values from the following table, related to the design category and type of vessel (in m):

B	C, D
0.50	0.35
$L_h/17$	$L_h/24$

Additionally to the above, the freeboard of the cockpit deck shall be at least 150 mm for the vessels with $L_h < 8$ m and 250 mm for the vessels with $L_h > 12$ m. For the vessels with L_h between 8 m and 12 m, the value of required minimum freeboard shall be obtain by linear interpolation.

.2 Minimum freeboard of the partially decked vessel or open vessel, measured between the flotation plane and the upper edge of the gunwale at its lowest point, shall be greater than values from the following table, related to the design category and type of vessel (in m):

Open vessel with flotation elements		Partially decked vessel		Open vessel without flotation elements	
C	*D*	*C*	*D*	*C*	*D*
0.40	0.35	0.60	0.50	0.70	0.50
$L_h/20$	$L_h/24$	$L_h/12$	-	$L_h/10$	-

.3 Freeboard mark shall be clearly marked on the vessel sides at half of the L_{WL} corresponding to the level of maximum draught, with mark's lines dimensions of 150 mm x 15 mm.

9.9 CLOSING APPLIANCES ON THE VESSEL'S HULL

9.9.1 Only openings on the hull and decks through which flooding of spaces contributing to buoyancy, or included in stability calculation, may occur, are taken in consideration in this header.

All such openings shall be equipped with closing appliances which can be either fixed or openable. Examples of such appliances are doors, covers, hatches, portlights (sidescuttless), etc.

For the new vessels, technical requirements listed in standards EN ISO 9093, EN ISO 11812 and EN ISO 12216, may be applicable.

9.9.2 All openings needed for proper functioning of the vessel that cannot be closed during navigation (for example engine room ventilation), shall be considered as downflooding points in stability calculation.

Such openings, except vents with coaming height according to table 9-1, shall not be located within forward 1/3 of L_h, and on vessels of design category A or B shall not be located below freeboard deck.

On the vessels of design category C or D, those openings can be located below freeboard deck only if considered as downflooding points in stability calculations and if all stability criteria are fulfilled up to the first angle of their immersion.

9.9.3 Regarding to the position of the opening on the vessel, two position can be identified.

Position 1 - from the loaded waterline to the level of 600 mm above freeboard deck, except at forward 1/3 of vessel's length L_h (measured from the bow), where that level shall be at least 900 mm above the freeboard deck.

Position 2 - above the level situated at 900 mm from freeboard deck on the forward 1/3 of vessel's length L_h (measured from the bow) and 600 mm above the freeboard deck otherwise.

9.9.4 Watertight openings (degree of watertightness 1 and 2, according to EN ISO 12216) that are kept closed during navigation (such as openings for engine access and servicing), need not to be equipped with coamings.

9.9.5 Weathertight openings (degree of watertightness 1, 2 and 3, according to EN ISO 12216), that may be randomly opened during navigation (for example: hatches, doors and windows), shall be equipped with coamings. The minimum required coaming height above the deck at which particular opening is located, can be found in Table 9-1. Required values depend of design category and type of opening.

If the assigned freeboard is higher than the minimum required, the minimum required coaming height can be reduced to the value obtained from the following equation:

$$h_S \geq h_{S1} - (h_{S1} - h_{S2}) \cdot (f - f_{min}) / \delta, \text{ [mm]}$$

where:

- h_S = corrected minimum coaming height in [mm]
- h_{S1} = required minimum coaming height on position 1, in [mm],
- h_{S2} = required minimum coaming height on position 2, in [mm],
- f = assigned freeboard [m],
- f_{min} = the minimum required freeboard, in [m],
- δ = vertical distance between opening and limit level (900 mm from the freeboard deck on the forward 1/3 of the vessel's length Lh, otherwise 600 mm above the freeboard deck).

9.9.6 In any case, coaming height shall not be less than 100 mm at *Position 1* and 50 mm at *Position 2*, except if closing appliances are of watertight type (degree of watertightness 1 and 2 according to EN ISO 12216).

Table 9-1

COAMING HEIGHT (mm)	DESIGN CATEGORY			
TYPE AND POSITION OF COAMINGS	***A***	***B***	***C***	***D***
Cargo hatchways, hatches and skylights:				
– at position 1	450	380	230	100
– at position 2	150	100	50	50
Doors, windows and portlights (sidescuttles) 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	300 (450 *)	300 (380 *)	230	100
– at position 2	230	150	50	50
Ventilators:				
– at position 1	760	600	380	230
– at position 2	380	230	150	150
Air vents:				
– at position 1	300 (450 *)	300 (380 *)	230	230
– at position 2	230	230	150	150

** If the opening is located on the forward bulkhead of the superstructure or deckhouse*

9.9.7 Generally, doors and hatches shall be made of material which is equivalent to the surrounding structure and shall fullfill requirements of the standard EN ISO 12216.

The *Register* shall decide about any exemption from these requirements.

Hinges on superstructure side doors and on hatch covers located on weather deck shall be on the bow side of cover. Doors shall be equipped with minimum two separated clamping devices.

Windows are generally to be of toughened safety glass. Other materials may be found acceptable based on the considerations of their strength, impact resistance and ageing properties. Window glasses are, in general, to be firmly mounted in stiff frames with due respect to possible impacts. In superstructures and deckhouses, other types of mounting, gluing, etc. shall be properly documented.

Thickness and mechanical properties of transparent material for windows and portlights shall be in accordance with the requirements of the *Rules for the classification of ships, Part 24 – Metallic materials*. Alternatively, requirements of the HRN EN ISO 12216 may be applied.

Polarised or tinted glass should not be used in windows provided for navigational visibility (although portable tinted screens may be provided for nominated windows).

Due attention should be paid to the design of the windows provided for navigational visibility, in order to avoid any interior reflection which could affect visibility in unfavourable weather conditions or navigation at night.

9.9.8 A portlight or window should not be fitted in the main hull below the weather deck, unless the glazing material and its method of fixing in the frame are equivalent in strength (based on the design pressure) to that required for the structure on which it would be fitted. Any window that would be used in that area should be regarded as large porthole, and dimensioned and fitted accordingly. If not of circular or oval shape, the opening shall be fitted with appropriate radius in corners. For the purpose of this Head, any such window is regarded as a porthole in the following text.

Any portlight fitted on vessels of design categories A and B and located below the weather deck, shall be fitted with attached deadlight.

A portlight fitted below the weather deck and not provided with attached deadlight, should be provided with a "blank" (the number of blanks should be sufficient for at least half of the number of such portlights of each different size on the vessel), which can be efficiently secured in place in the event of breakage of the portlight. The blank should be of suitable material and *strength* to the satisfaction of the Certifying Authority. Such a "blank" is not required for a vessels of design category C or D.

9.9.9 Maximum clear area of any glazing panel fitted on hull sides below the weather deck, or on the sides of a buoyant structure above the weather deck, shall not be greater than 0.85 m^2.

9.9.10 Portlights fitted on vessel's side, including transom, shall have their lower edge at least 300 mm above the deepest load line for the vessel of design category A, and 200 mm otherwise. Portlights fitted on vessel's hull, shall be of non-openable type, if fitted with its lower edge bellow 500 mm above the deepest load line, and of non-readily openable type, if fitted above that level.

9.9.11 On passenger vessels of category C and D intended for underwater sightseeing, windows can be fitted below the waterline under the following conditions:

.1 In case of water ingress following window failure, SOLAS 90 damage stability criteria for 1 compartment is complied with, with the compartment on which outer sides the windows are fitted, considered as flooded.

.2 Watertight bulkheads limiting the compartment on which outer sides the windows are fitted, shall withstand hydrostatic load of head of water up to the main deck level.

.3 The strength of the underwater windows shall be equivalent to the surrounding structure. Exceptions from this requirement may be considered in a case when windows are located in separate watertight well, with bulkheads extended to the main deck (freeboard deck). In that case, the vessel shall meet intact stability and freeboard requirements with the well-considered as flooded.

9.10 FREEING PORTS AND THROUGH THE HULL'S PENETRATIONS

9.10.1 In order to enable unobstructed flow of water from the exposed deck areas limited by the bulwarks or recess walls, a sufficient number of freeing ports shall be opened in the bulwark. Required area of openings on each side of the vessel shall be greater than:

$$A \geq k \cdot V_C, \ [m^2]$$

where:

k = coefficient related to design category: 0.02 for design category A,

0.01 for design category B,

0.005 for design category C,

0.002 for design category D,

V_C = volume of recess or area closed by bulwarks, in [m^3]. It may be calculated as deck area multiplied with the lowest height of the surrounding bulwarks or recess coamings.

Alternatively, requirements listed in HRN EN ISO 11812 may be applied.

9.10.2 In general, pipeline ends penetrating through the outer shell below the line drawn 200 mm above and parallel to the waterline corresponding to the deepest operational draught, shall be equipped with non-return valves with positive means of control.

9.10.3 All outer shell connections and valves shall meet requirements laid down in 11.1 and 11.6.

9.11 ADDITIONAL BUOYANCY AND SUBDIVISION

9.11.1 All vessels shall have sufficient additional buoyancy in addition to the volume of the displacement corresponding to the deepest loaded waterline.

9.11.2 For a single-hull totally enclosed vessel with minimum freeboard exceeding that required by 9.8.3.1 and with subdivision arrangement according to this section, this requirement is considered as satisfied.

9.11.3 Multihull vessels, except those compliant with requirements of Head 9.4, shall have at least the following additional volume (buoyancy), located between the deepest loaded waterline and the waterline parallel to the baseline and passing through the edge of the lowest down-flooding opening:

- 100% of the volume of the displacement corresponding to the deepest loaded waterline, for design category A,
- 70% of the volume of the displacement corresponding to the deepest loaded waterline, for design category B,
- 30% of the volume of the displacement corresponding to the deepest loaded waterline, for design category C,
- 20% of the volume of the displacement corresponding to the deepest loaded waterline, for design category D.

9.11.4 Open vessels, except inflatable **vessels**, shall have sufficient positive buoyancy in flooded condition.

9.11.5 Inflatable vessels shall have at least 5 chambers. It shall be proofed, by calculation or test, that after failure of any chamber, the vessel in full load condition, has positive residual buoyancy, and has initial metacentric height of at least 0.05 m, and that the resulting equilibrium heeling angle is less than 45° or the down-flooding angle of any of the intact compartments, whichever the least.

Alternatively, requirements of the latest edition of HRN EN ISO 6185, may be applied.

9.11.6 All vessels with L_h>12 m shall have collision bulkhead located between $0.05 \cdot L_{WL}$ and $0.1 \cdot L_{WL}$ aft of the forward perpendicular. Collision bulkhead shall extend to the first watertight deck above the deepest loaded waterline. Alternatively, the *Register* may accept that collision area, from the bow to the $0.05 \cdot L_{WL}$ aft of the forward perpendicular is filled with low density foam or other buoyant material, provided that satisfactory evidence is presented that any such proposed material is the most suitable alternative, and that is:

.1 of closed-cell form (if foam), or otherwise impervious to water absorption;

.2 structurally stable under service conditions;

.3 chemically inert in relation to structural materials with which it is in contact, or to other substances with which it is likely to be in contact.

9.11.7 All totally enclosed vessels with engine room compartment shall have watertight bulkhead on the forward end of that compartment.

9.11.8 All vessels intended for carriage of cargo below the main deck shall have cargo holds separated by watertight bulkheads extending up to the main deck.

9.11.9 All open and partially enclosed vessels shall have freeboard at the forward perpendicular of at least 120% of the assigned freeboard value (at the main frame position).

9.11.10 Additional bulkheads may be required for vessels having to comply with damage stability criteria, according to requirements of Head 9.4. The number of openings in watertight subdivisions is to be limited to a minimum compatible with the proper working of the vessel. If fitted, such openings shall comply to the appropriate requirements set in the other parts of the Rules, implementing at least the standards applicable to the commercial yachts.

10 FIRE SAFETY

10.1 GENERAL REQUIREMENTS

10.1.1 The requirements of the Administration may be considered by the *Register*, on a case by case basis, instead of those of this Section.

Cargo vessel complying with the requirements of IACS Recommendation 99 – Recommendations for the Safety of Cargo Vessels of less than Convention Size, Chapter 4 – Firefighting, is considered compliant with requirements of 10.2 to 10.7.

On passenger ships for overnight stay (having passenger cabins), instead of requirements of this Section, *Register* may, subject to special consideration in each particular case, apply requirements of the *Rules for the classification of ships, Part 17 – Fire protection,* Sections 5, 6, 9 and 11.

10.2 STRUCTURAL FIRE PROTECTION, VENTILATION AND MEANS OF ESCAPE

10.2.1 Thermal and fire insulation shall be of non- combustible material.

Acoustic insulation material used in engine spaces is to as a minimum have a non-fuel-absorbent surface towards the engine and an oxygen index of at least 21 in accordance with ISO 4589-3 at an ambient temperature of 60 °C.

Engine spaces in vessel made of GRP of more than 15 m in length are to be made with laminated construction with fire retarding resin and/or intumescent resin.

10.2.2 Engine room in vessel, made of glass reinforced plastic or aluminium or wood, of more than 15 m in length shall be enclosed with fire protection of minimum 15-minutes fire rating, see 10.2.3. Arrangement and materials for structural fire protection are to be recognized by the *Register*. The fire protection is to cover the entire boundary of the engine room starting from 300 mm below the lowest waterline.

Engine room in vessel made of glass reinforced plastic of not more than 15 m in length is to be made with laminated construction with fire retarding resin and/or intumescent resin.

Engine room in vessel of not more than 15 m in length, made of aluminium or wood, is to be insulated to satisfaction of the *Register*.

Engine room in vessel made of steel shall be insulated to 15-minute fire rating towards accommodation spaces, cargo spaces and store lockers.

When lifeboats or life rafts or floating devices are situated directly above engine room or galley, deck in that area shall be insulated to 15-minute fire rating.

The *Register* may impose more stringent insulation requirements in some special cases, on a case by case basis, depending on vessel's specific operation and construction characteristics.

10.2.3 15-minute fire rating means:

.1 certified fire division of at least "B-15" class; or

.2 division (bulkhead and/or deck) insulated with mineral wool of at least 35 mm thickness having density 150 kg/m3, lined with steel plate of at least 1 mm thickness; or

.3 division (bulkhead and/or deck) of GRP material of at least 13 mm thickness having self-extinguishing final laminate layer of not less than 1,5 mm thickness.

10.2.4 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*.

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*.

10.2.5 Materials and finishes used in the vicinity of open-flame cooking devices, within the range of 0,5 m in every direction, shall comply with the following requirements:

- Free-hanging curtains or other fabrics shall not be fitted.
- Exposed materials shall be glass, ceramics, aluminium, ferrous metals, or other materials with similar fireproof characteristics, or be thermally insulated.

10.2.6 On passenger ships the following additional requirements shall be applied:

- Galley lining, ceiling and floor on passenger ship shall be of non-combustible material.
- "B" class fire divisions shall be installed in corridors, stairways, and escape routes. Lining, ceiling, and floor therein shall be of materials having low flame spread characteristics.

10.2.7 Fuel and lubrication oil tanks in the engine room shall be of metallic material and shall be insulated to 15-minutes fire rating.

Non-metallic fuel and lubricating oil tanks 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.

10.2.8 Openings for ventilation of the engine space shall be equipped with closing appliances readily operable from the outside of the engine room.

Tank spaces separated from engine room is to be fitted with suitable exhaust ventilation.

10.2.9 All accommodation, service spaces and machinery spaces are to be provided with at least 2 means of escape located as far as possible from each other and be suitable to be readily used in an emergency.

Width of passages should be at least 700 mm in general but may be reduced to 600 mm for spaces not normally used.

Accommodation for maximum 4 persons may be accepted with only one escape if this cannot be blocked in case of fire or other emergency situation and if it leads directly to open deck.

The *Register* may dispense with one means of escape from any space so long as either a door or a steel ladder provides a safe escape route to the open deck, due regard being paid to the nature and location of the space and whether persons are normally employed in that space.

A second means of escape shall be provided in the steering gear space when the emergency steering position is located in that space unless there is a direct access to the open deck.

Normally escape hatches are to be:

- minimum light opening 450 × 450 mm, or equivalent;
- provided with fixed step, ladder and handholds where necessary;
- clearly marked and with appropriate instructions;
- readily opened from both sides without tools;
- direct access to open deck or to a safe escape route without any lockable door.

Windows and portholes in compliance with above requirements could be used as escape hatches.

Emergency light has to be provided for accommodation and relevant escape ways. Reference may be done to ISO 9094.

10.3 FIRE DETECTION AND ALARM

10.3.1 The engine spaces are to be equipped with a fire detection system with both audible and visible alarm at the helm position. The detection system may be integrated in the fixed fire extinguishing system.

Vessels of not more than 15 m in length having helm position in close vicinity to engine room may be relaxed of this requirement, on case by case basis.

On passenger ships with overnight stay, the following additional spaces shall be equipped with a fire detection system:

- galleys;
- cabins (crew and passenger);
- corridors, stairways and escape routes.

Fire detection system shall be type approved.

10.4 FIRE PUMPS, FIRE MAIN, FIRE HOSES AND NOZZLES

10.4.1 Main fire pump

Vessel of more than 15 m in length shall be provided with fire pump having capacity of at least 12 m^3/h.

Passenger vessel of more than 15 m in length shall be provided with fire pump having capacity of at least 15 m^3/h.

Fire pump may be driven from main engine provided that operation of fire pump is ensured even in the case vessel is not sailing.

Vessel of not more than 15 m in length generally need not be provided with fire pump, however the *Register* may require fire pump in some special cases, on a case by case basis.

Fire pump together with its source of power shall not be installed forward of the collision bulkhead. For cargo vessels, relaxation of this requirement could be granted, subject to special consideration by the *Register*.

Sanitary, bilge or general service pump may be accepted as fire pump, provided that it is not normally used for pumping oil and that if it is subject to occasional duty for the transfer or pumping of oil fuel, suitable change-over arrangement is fitted.

Fire pump situated outside the machinery space shall have independent sea water suction arranged in the space where fire pump is installed.

10.4.2 Emergency fire pump

Passenger vessel of more than 15 m in length for overnight stay of passengers, and passenger vessels carrying more than 100 passengers, in addition to main fire pump, shall be provided with emergency fire pump having capacity of at least 12 m^3/h.

The emergency fire pump, its sea water inlet, and suction and delivery pipes and isolating valve shall be located outside the space where main fire pump is fitted. If this arrangement cannot be made, the sea suction may be fitted in the machinery space if the sea inlet valve is remotely controlled from a position in the same compartment as the emergency fire pump. Short lengths of suction or discharge piping may penetrate the machinery space, provided they are enclosed in a substantial steel casing and insulated to 15-minute fire rating.

Alternatively, a portable diesel engine driven emergency fire pump, located outside the space where main fire pump is located, may be accepted.

For vessels not required to be fitted with emergency fire pump, at least three fire buckets shall be provided, see 10.6.8.

10.4.3 Diameter and pressure of the fire mains

The diameters of the fire main and water service pipes are to be sufficient for the effective distribution of the maximum required discharge. With the discharging capacity specified in 10.4.1, 10.4.2 and 10.4.4, the pressure at any hydrant, wherever located, is to be maintained such that a jet of water is emanated from the nozzle for a distance of at least 8 m.

10.4.4 Number and position of hydrants

The number and position of hydrants are to be such that at least one jet of water may reach any part of the vessel normally accessible to the passengers or crew while the ship is being navigated and any part of any cargo space when empty.

At least one hydrant is to be provided in machinery spaces. If the machinery spaces are unattended, it is sufficient that the hydrant is positioned near the access to such spaces.

10.4.5 Fire mains and hydrants

Materials readily rendered ineffective by heat are not to be used for fire mains and hydrants unless adequately protected. Grey cast iron shall not be used for fire mains. Fire mains made of steel shall be galvanized.

The pipes and hydrants are to be so placed that the fire hoses may be easily coupled to them. The arrangement of pipes and hydrants is to be such as to avoid the possibility of freezing. Hydrants shall be painted in red.

A valve is to be fitted to serve each fire hydrant so that any fire hose may be removed while the fire pumps are in operation.

The fire main shall have no connections other than those necessary for firefighting and washing down.

Every centrifugal fire pump which is connected to the fire main shall be fitted with a screw down non-return discharge valve or other equivalent valves arrangement.

10.4.6 Fire hoses

Fire hoses are to be of non-perishable material approved by the *Register* and are to be sufficient in length to project a jet of water to any of the spaces in which they may be required to be used.

The length of a firehose is to be from 6 m up to 15 m.

Each hose is to be provided with a nozzle and the necessary couplings. Fire hoses are to be kept together with any necessary fittings and tools ready for use in conspicuous positions near the water service hydrants or connections.

Additionally, in interior locations of passenger ships carrying more than 36 passengers, fire hoses are to be connected to the hydrants at all times.

Ships are to be provided with fire hoses the number and diameter of which are to be to the satisfaction of the *Register*, but, in any case, at least one hose for each hydrant is to be fitted.

Fire hoses on open decks shall be kept in suitable cabinets, protected from weather conditions. Cabinets shall be properly marked.

10.4.7 Nozzles

Standard nozzle sizes are to be 12 mm, 16 mm and 19 mm. For accommodation and service spaces, a nozzle size greater than 12 mm need not be used.

Nozzles of fire hoses are to be of an approved dual purpose type (i.e. spray/jet type) incorporating a shut-off.

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.

10.5 FIXED FIRE EXTINGUISHING SYSTEMS

10.5.1 General

10.5.1.1 The engine spaces are to be protected by a fixed fire-fighting extinguishing system.

The system is to be a manual system or a manual/automatic combined system if applicable. A manual release system is to be activated from the helm position. The system activation controls are to be protected from environment and unintended operation and provided with operation instructions posted close to the release mechanism.

Simple one-piece systems with automatic release only, such as glass ampoule with extinguishing media, could be accepted on a case by case basis.

Automatic release of the manual/automatic combined system, acceptable only in unmanned rooms, is to be indicated by both audible and visual alarms at the helm position.

The mechanical ventilation and the engines have to be automatically shut down in case of activation of the fixed fire extinguishing system.

10.5.1.2 The extinguishing medium is to be suitable for the intended use and its amount and time of acting suitable for the intended use.

10.5.1.3 The fixed fire extinguishing system is to be of one of the following types:

- aerosol system,
- CO2 system,
- gaseous agent system,
- high expansion foam system,
- pressure water-spraying (water mist) system.

10.5.1.4 Cylinders for the extinguishing medium are to be protected from environment and unintended operation, mechanical damage and temperatures exceeding 50 ºC. Cylinders are not to be located in accommodation spaces.

10.5.1.5 Nozzles are to be located to grant uniform distribution of the extinguishing agent.

10.5.2 Aerosol system

Aerosol system is to be type approved according to IMO MSC/Circ. 1007. The system may be either a manual or a manual/automatic combined system.

For wooden vessel, medium quantity shall be increased 50% above requirements for steel vessel.

10.5.3 CO_2 system

The system is to be manually operated only. The system is to be approved by the *Register*.

Discharge is to be indicated by both audible and visible alarm.

The amount of extinguishing medium is to be minimum 0.6 kg/m3 net volume, but in no case less than 2 kg in total.

CO_2 cylinders are not to be located in the engine room.

CO_2 cylinders or fittings on distribution lines are not to be located in a way that any extinguishing medium can enter into the accommodation area in the event of leakage in the system.

CO_2 systems shall have a separate fire detection system.

For wooden vessel, medium quantity shall be increased 50% above requirements for steel vessel.

10.5.4 Gaseous agent system

Gaseous agent system is to be type approved according to IMO MSC/Circ. 848, as amended by MSC./Circ. 1267.

The system may either be a manual or a manual/automatic combined system.

For wooden vessel, medium quantity shall be increased 50% above requirements for steel vessel.

10.5.5 Foam system

The system may either be a manual or a manual/automatic combined system.

The system shall be approved by the *Register*.

10.5.6 Pressure water-spraying system

Pressure water-spraying system is to be type approved according to IMO Circ.1165, as amended.

The system may either be a manual or a manual/automatic combined system.

Pressure water-spraying system is to be designed for a protection time of at least 20 minutes.

Water based systems requiring fresh water are to be connected to dedicated water tanks with capacity for minimum 5 minutes operation for the largest space, and automatic switch-over to sea-water supply. Alternatively, manual switchover may be used if the capacity of the freshwater tank is increased to 15 minutes.

10.6 PORTABLE FIRE APPLIANCES

10.6.1 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.

10.6.2 For vessels of more than 15 m in length, each powder 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.

For vessels of not more than 15 m in length, each powder extinguisher shall have a capacity of at least 2 kg, each carbon dioxide extinguisher shall have a capacity of not more than 2 kg, each foam extinguisher shall have a capacity of at least 6 l.

10.6.3 One of the portable fire extinguishers intended for use in any space shall be stowed near the entrance to that space.

10.6.4 Carbon dioxide fire extinguishers shall not be placed in accommodation spaces. In helm position and other spaces containing electrical or electronic equipment or appliances necessary for the safety of the ship, fire extinguishers shall be provided whose extinguishing media are neither electrically conductive nor harmful to the equipment and appliances.

10.6.5 Fire extinguishers shall be situated ready for use at easily visible places, which can be reached quickly and easily at any time in the event of a fire, and in such a way that their serviceability is not impaired by the weather, vibration or other external factors. Portable fire extinguishers shall be provided with devices which indicate whether they have been used.

The extinguisher may be stowed in a locker or other enclosed space. The locker or opening part of the space is to be labelled.

10.6.6 A fire extinguisher is to be fitted in the following locations:

- one extinguisher for main helm position,
- one extinguisher for each 10 m in the accommodation area,
- one extinguisher for any permanent installed cocker/stove or open flame device or cooking appliance,
- one extinguisher for engine room. Could be stored outside, within 3 m distance from entrance to engine room.

10.6.7 If an open-flame cooker is fitted, a fire blanket, in accordance with EN 1869, is to be within reach and readily accessible for immediate use.

10.6.8 Three fire buckets shall be provided if the vessel is not fitted with emergency fire pump.

Each fire bucket shall be of about 9 litres capacity and provided with an attached lanyard.

Fire buckets shall be stowed in a readily accessible space, which can be reached quickly and easily at any time in the event of a fire, outside a space where main fire pump is located. They shall be light and easy to handle and shall be painted in red.

10.7 LPG GAS FOR DOMESTIC PURPOSES

10.7.1 LPG systems shall be in accordance with ISO 10239, which covers:

- working pressure of the system,
- stowage of gas containers,
- material and routing of LPG supply line,
- installation, ventilation,
- appliance and their connection,
- leakage tests.

10.7.2 LPG systems may be used only for cooking, while use for heating is not permitted.

10.7.3 Enclosed spaces in which gaseous fuel consumers are installed shall not be located below the lowest open deck.

Store-room for gas bottle shall be located on the weather deck and have direct access from the weather deck. Access door shall be opened outwards and shall be fitted with lock and a conspicuous warning signs: “Danger-Explosion”; “No smoking”.

10.8 CARRIAGE OF DANGEROUS GOODS

10.8.1 Requirements of the *Rules for the classification of ships, Part 17 – Fire protection, Section 19* shall generally be applied.

10.8.2 The following relaxations may be applied, subject to reduction of allowable cargoes, see 10.8.3.

- one jet of water is required to be trained on any part of the cargo space when empty (instead of four jets required in Rules, Part 17, 19.3.1.2);
- requirements of the *Rules for the classification of ships, Part 17 – Fire protection*, 19.3.6 regarding personnel protection are not required;
- 15 minutes fire rating is required (instead of A-60” required by the *Rules for the classification of ships, Part 17 – Fire protection*, 19.3.8).

10.8.3 Relaxations specified in 10.8.2 may be applied to carriage of dangerous goods, of classes 1, 2, 3, 6.1, 8 and 9 only, and only on open deck of the steel vessel.

10.8.4 Carriage of dangerous goods on FRP, aluminium and wooden vessels is subject to the *Register*’s special consideration, on case by case basis.

11 MACHINERY

11.1 GENERAL REQUIREMENTS

11.1.1 Vessels of more than 15 m in length, 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.*

Requirements of the *Rules for classification of ships*, *Part 8 – Piping,* 1.5 and 16 shall be complied with as far as it is reasonable and practicable to do so.

For yachts, relaxations and/or alternatives reported in this Section, other than those set out in 11.6, may be considered.

11.1.2 Vessels of not more than 15 m in length, 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.

11.1.3 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.

11.2 BILGE SYSTEM

11.2.1 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.

As an alternative to the requirements of this Head, for vessels of design categories B, C, D, a bilge system complying to the applicable requirements of ISO 15083 could be accepted, subject to special consideration by the *Register* in each particular case.

11.2.2 Small compartments may be drained by individual hand pump suctions.

Provided the safety of a vessel is not impaired, the *Register* may permit dispensation from the means of pumping or drainage of small compartments.

11.2.3 Where the peaks are not used as tanks for the carriage of liquids, independent drainage by hand pumps may be provided.

11.2.4 For non-fully enclosed vessels of design categories B, C, D, with no bilge compartments, instead of permanently installed bilge system, a suitable means of manual operation (e.g., hand bailer or bucket) to drain the bilge water could be provided, subject to special consideration by the *Register* in each particular case.

11.2.5 The bilge system shall be permanently installed and shall normally consist of rigid pipes.

If flexible hose assemblies are used, they are to be of type recognized by the *Register*, suitable for intended use and special attention is to be given to collapse due to suction. They are to be located so as to minimize the risk of accidental damage.

11.2.6 The bilge system fitted in machinery space shall be made of metallic materials. Where bilge system fitted outside machinery space is manufactured from material sensitive to heat then the arrangements are to be such that pipe failure in one compartment will not render the bilge suction piping in another compartment inoperable.

11.2.7 Bilge pumping system shall be so arranged as to prevent the possibility of sea water passing inside the vessel, or from one watertight compartment into another.

11.2.8 Each watertight compartment is to be drained by a dedicated bilge branch and the branch is to be fitted with a screw-down non-return valve between the bilge main and the individual branch. The valve is to be operable from above the floors and provided with open/close indicator.

Where use of screw-down non-return valve is impracticable, other valves arrangement could be accepted, subject to special consideration by the *Register*.

11.2.9 At least one fixed power pump and one fixed hand bilge pump shall be provided. Pumps are to be arranged to take suction from the bilge main.

The capacity of the power bilge pump shall not be less than 5.5 m^3/h or not less than that of the fire pump, where fire pump is required to be fitted in accordance with 10.4.1.

The capacity of the hand pump shall not be less than 40 l/ min.

Power bilge pump may be driven by the propulsion engine. Where two power bilge pumps are installed, they shall be driven by different sources of power.

In passenger vessels, wherever practicable, bilge pumps shall not be installed within the same watertight compartment.

Different number and capacity of bilge pumps may also be accepted if the criterion of related Administration Rules is complied with.

11.2.10 Sanitary and general service pumps may be accepted as independent power bilge pumps if fitted with the necessary connections to the bilge pumping system.

A power bilge pump may also serve as fire pump, where fire pump is required to be fitted in accordance with 10.4.1.

11.2.11 Where the bilge and fire pump systems are interconnected, the dedicated bilge pump is to be capable of pumping the bilges overboard at the same time as the fire/bilge pump charges the fire main. Non-return valves shall be installed in the piping to isolate the systems during simultaneous operation and prevent possible flooding through the bilge system.

11.2.12 The inside diameter of the bilge main and direct bilge suction shall be determined on the assumption that the rated speed of water in the bilge main is not less than 2 m/s under normal service conditions, considering capacity of power bilge pump determined in accordance with 11.2.9.

Inside diameter of the bilge main and direct bilge suction shall not be in any case less than inside diameter of power bilge pump suction connection.

In no case the inside diameter of main and branch bilge pipes is to be less than 25 mm.

11.2.13 Each fixed bilge suction shall be fitted with readily accessible strainer or strum box.

11.2.14 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.

11.2.15 The arrangement of bilge pipes is to be such as to ensure the possibility of draining the engine space through the suction directly connected to the power bilge pump, the other compartments being simultaneously drained by other pump. This direct bilge suction is to be in addition to the suction from bilge main.

Direct bilge suction is to be controlled by a screw down non-return valve or equivalent, operable from above the floors and fitted with open/close indicator.

11.2.16 A bilge pipe penetrating the collision bulkhead shall be fitted with a screw-down valve located on the forward side of the collision bulkhead and operated from the weather deck. Where valve is readily accessible under service conditions, a screw-down valve without remote operation may be fitted on the after side of the collision bulkhead.

11.2.17 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.

11.2.18 Where auto-start bilge pump is arranged, a visual indicator shall be provided at the steering position to indicate when bilge pump is operating.

Compartments containing potential pollutants, including machinery spaces, should not be fitted with auto-start bilge pumps.

11.2.19 The power bilge pumps shall be possible to operate from the steering position.

Hand bilge pumps are to be capable of being operated from readily accessible positions above the deepest operational draught.

11.2.20 As an alternative to the arrangement required in 11.2.9, separate power bilge pumps may be installed for one or more compartments provided that:

.1 Each power bilge pump is of fixed reliable submersible type.

.2 Capacity of each power bilge pump shall be determined by the following formula:

$$Q = \frac{l}{L} Q_t$$

where:

Q - minimum capacity of bilge pump in [m^3/h]

Q_t - total capacity of bilge pumps, determined in accordance with 11.2.9, in [m^3/h]

L - length of the vessel, as defined in 1.4.2, in [m]

l - length of the compartment to be drained, measured at its bottom, in [m]

In no case the capacity of each power bilge pump is to be less than 2,5 m^3/h.

.3 In general, one submersible power pump is to be provided for each watertight compartment.

.4 At least one portable bilge pump is to be provided with capacity not less than that defined in 11.2.9 for a hand pump.
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.

.5 The suction of each power pump is to be fitted with a suitable strainer which can be easily removed for cleaning.

.6 Each power bilge pump shall be possible to operate from the steering position.

.7 At least two non-return devices shall be fitted on discharge line of each 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.

11.2.21 Any space for which bilge pumping arrangement is required shall be provided with a bilge level alarm. This requirement does not apply to open vessel.

At the discretion of the *Register*, bilge level alarm may be omitted in small buoyancy compartments.

11.3 FUEL OIL SYSTEM

11.3.1 As an alternative to the requirements of this Head, for vessels of design categories B, C, D a fuel oil system complying to the applicable requirements of ISO 10088 could be accepted, subject to special consideration by the *Register* in each particular case.

11.3.2 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.

11.3.3 Fuel oil used shall be in compliance with the requirements of the *Rules for the classification of ships, Part 7 - Machinery installation*, 1.1.2.

Proposals for the use or carriage of fuel oil with a lower flash point will be specially considered by the *Register*.

11.3.4 A vessel should be provided with sufficient fuel for its intended area of operation.

11.3.5 Construction of the fuel oil tanks, where they are not integral parts of vessel's hull, shall comply with the requirements set forth in 8.6.

Alternatively, diesel fuel oil tanks complying to the applicable requirements of ISO 21487 could be accepted for the vessels of design categories B, C, D, subject to special consideration by the *Register* in each particular case.

11.3.6 Fuel oil tanks situated on weather decks and other exposed positions shall be suitably protected against the effect of sun rays.

No fuel oil tank is to be situated where spillage or leakage therefrom can constitute a hazard by falling on heated surfaces.

11.3.7 In glass-reinforced plastic vessels the fuel oil tanks shall not directly adjoin the accommodation spaces. The air space between the fuel oil tank and the accommodation space shall be effectively ventilated.

11.3.8 Fuel oil tanks shall be separated from the drinking water, feed water and vegetable oil tanks, as well as from lubricating oil tanks, by cofferdams meeting requirements of the *Rules for the classification of ships, Part 2 - Hull*, 11.1.4.

11.3.9 Fuel oil, lubrication oil and other flammable oils shall not be carried in fore peak tanks.

11.3.10 For draining water from the bottom of the daily service tanks, these tanks shall be fitted with self-closing valves.

11.3.11 Fuel oil tanks not forming part of vessel's hull, as well as pumps, filters and other equipment or fittings shall be fitted with oil-tight drip trays where there is a possibility of fuel oil leakage. Drainage of fuel oil into bilges is not permitted.

11.3.12 Where daily service tanks are filled automatically or by remote control, means are to be provided to prevent overflow spillages.

11.3.13 In general, the fuel oil pipeline shall have no communication with other piping systems and shall not pass-through cargo tanks.

Fuel oil tanks are not to be used for carriage of water ballast.

11.3.14 Pressure pipes for conveying pressurized fuel oil with pressure greater than 0.18 MPa shall be arranged in clearly visible and accessible positions.

11.3.15 Fuel oil piping shall be made of metallic materials. Where aluminium pipes are used in engine space, they shall be insulated to obtain a fire resistance equivalent to steel.

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. 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.

Alternatively, flexible hoses satisfying the requirements of ISO 7840 and fitted with pressed on end fittings could be accepted for pressurised systems, subject to special consideration by the *Register* in each particular case.

Flexible hoses satisfying the requirements of ISO 7840 and fitted with hose clips could be accepted for non-pressurised systems, subject to special consideration by the *Register* in each particular case. At least two hose clips fabricated from stainless steel and suitably fixed at each end connection shall be used.

11.3.16 Fuel oil pipes, as a rule, shall not be led above the internal combustion engines, exhaust gas pipes, silencers, electrical installation and other sources of ignition.

In exceptional cases, it is allowed to lead the fuel 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.

The number of joints in such piping systems shall be kept to a minimum.

11.3.17 In general, fuel oil piping shall not be led through accommodation and service spaces. Where this is impracticable, the *Register* may permit exception if pipes used have a thickness of not less than 5 mm and no detachable joints are employed.

11.3.18 Each fuel oil pipe, which, if damaged, would allow oil to escape from a fuel oil tank having a capacity of 500 lit. 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.

Remote operation for the fuel valves is to be clearly marked.

In the case of fuel oil tanks having a capacity less than 500 litres, remote controls need not to be fitted.

11.3.19 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 to be so arranged that a failure within one of those lines is not to render the other lines inoperable.

11.3.20 Filling of fuel oil storage tanks shall be carried out through a permanent pipeline. When the fuel oil tanks are filled from shore under pressure, provision is to 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.

11.3.21 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.

11.3.22 Provision is to be made for efficient filtration of the fuel oil supply to the engine.

11.3.23 Where filter fitted in the fuel oil supply line to the propulsion engine is such that it cannot be cleaned without interrupting the operation of the engine, following conditions needs to be satisfied:

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 vessel is capable of safe navigation and manoeuvring with one propulsion engine out of use.

11.3.24 Where one fuel oil supply pump is fitted to serve the propulsion engines following conditions needs to be satisfied:

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 vessel is capable of safe navigation and manoeuvring with one propulsion engine out of use.

11.3.25 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.

11.4 COOLING SEA WATER SYSTEM

11.4.1 The cooling sea water system provided shall be capable of maintaining all lubricant and coolant temperatures in the engine within the manufacturer's recommended limits.

11.4.2 The provision is to be made for alternative cooling of propulsion engine in emergency condition by sea water. Precautions shall be taken as to prevent overpressure in the cooling system.

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 vessel is capable of safe navigation and manoeuvring with one propulsion engine out of use.

11.4.3 The oil and air coolers of the electric propulsion motors shall have standby means of cooling, equivalent to the main means.

11.4.4 Where each of the auxiliary engines is provided with an independent cooling sea water pump, the alternative cooling in emergency condition for these engines are not required. Where, however, a group of auxiliaries is supplied with cooling sea water from a common system, provision is to be made for alternative cooling of auxiliary engines.

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.

11.4.5 General service pumps operated only with clean water and fire pumps may be used for alternative cooling of engines, provided arrangements are made against overpressure in the cooling system.

11.4.6 In passenger vessels, sea water for cooling system shall be taken from at least two sea inlets, located one on each side of the vessel. Each sea water cooling pump is to be connected to both sea inlets. Sea inlets may be interconnected.

11.4.7 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.

11.4.8 Cooling sea water piping shall be made of metallic materials**.** Where necessary, suitable provision shall be made for protection against contact corrosion.

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. Such flexible hose assemblies are to comply with the same requirements given for flexible hose assemblies used in fuel oil systems, as stated in 11.3.15.

11.4.9 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.

11.5 EXHAUST GAS SYSTEM

11.5.1 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.

11.5.2 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 to a maximum possible height below freeboard deck provided the exhaust gas piping from the top of the loop to the shell connection is of substantial thickness at least equivalent to shell thickness. Final acceptance of such arrangement shall be a subject to special consideration by the *Register* in each particular case.

11.5.3 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 steering position.

11.5.4 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.

11.5.5 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 is to be encased in sheet metal or equivalent.

11.5.6 Where exhaust pipes are water cooled, they are to 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.

11.5.7 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.

11.5.8 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 is to be carried out including, but not limited to, the following conditions:

.1 Non-metallic materials shall not be fitted before water injection point.

.2 Suitable protection against unacceptable high temperature in exhaust gas piping shall be provided by means of high temperature alarm after water injection. This alarm shall be integrated into the vessel's alarm system.

.3 Other equivalent arrangements could be accepted, subject to special consideration by the *Register* in each particular case.

.4 Use of plastic pipes shall comply generally with the provisions of the *Rules for the classification of ships, Part 8 – Piping*, 1.7.

.5 Silencer made of plastic material may be used provided that it is of approved type for service conditions and the intended application.

.6 High level bilge alarm shall be provided in spaces containing the non-metallic parts of the exhaust gas piping.

.7 In general, the rigid pipes are to be used for the exhaust gas lines, having the flexible parts as short as practical only to compensate vibration and temperature dilatation where necessary.

Such flexible parts shall meet the requirements of recognized standard (e.g., ISO 13363, SAE J2006).

.8 The overboard outlets are to be fitted with suitable metallic shut-off valve fitted on the shell connection. Valve is to be controlled from above the deepest operational draught.

11.6 SEA INLETS AND DISCHARGES

11.6.1 The number of sea inlets and discharges are to be kept to an operational minimum.

11.6.2 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*.

11.6.3 Shell penetration located below a line drawn 200 mm above the deepest operational draught and connected to a system with open inboard end located below freeboard deck shall be provided with non-return valve fitted with a positive means of closing.

11.6.4 Scuppers and discharge pipes originating from freeboard deck or at any level above the freeboard deck and penetrating the shell below a line drawn 200 mm above the deepest operational draught shall be provided with non-return valve at the shell.

This valve may be omitted if the piping is of substantial thickness at least equivalent to shell thickness.

11.6.5 Scuppers leading from superstructures or deckhouses not fitted with weathertight doors shall be led overboard.

11.6.6 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.

11.6.7 The requirements for non-return valves are applicable only to those discharges which remain open during the normal operation of the vessel. For discharges which are to be kept closed at sea, a single positive closing valve is acceptable.

11.6.8 All sea inlet and discharge valves fitted directly to the shell plating are to 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 (e.g., ISO 9093-1) could be admitted, subject to special consideration by the *Register*, namely in the case of small size valves.

11.6.9 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 (e.g., ISO 9093-2), subject to special consideration by the *Register* in each particular case.

11.6.10 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.

11.6.11 All shell fittings and valves required by this Head 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.

Valves made of polymer materials, conforming to recognized standards (e.g., ISO 9093-2), could be accepted outside engine space and in non-fire risk space, above the deepest operational draught, subject to special consideration by the *Register* in each particular case.

11.6.12 All sea inlet and discharge valves required by this Head shall be located in positions where they are readily accessible at all times and fitted with open/close indicator.

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.

11.6.13 Sea inlet and discharge pipes made of plastics are to comply with the applicable requirements of the *Rules for the classification of ships, Part 8 – Piping,* 1.7.

Where fitted within an engine space or fire risk space, a means shall be provided (e.g., suitable metallic shut-off valve) to stop the ingress of water in the event of the pipe being damaged, operable from above the deepest operational draught.

11.7 STEERING GEAR

11.7.1 The steering arrangement is to be suitable to manoeuvres the vessel at the maximum power and it is to be suitable protected from damages.

Every vessel shall be provided with an efficient main steering gear and auxiliary means of steering.

11.7.2 Main Steering Gear: a vessel shall be provided with main steering gear that is:

.1 of adequate strength and capable of steering the vessel at all service speeds;
.2 designed to operate at maximum astern speed without being damaged; and
.3 capable of moving the rudder from 35° on one side to 30° on the other side in not more than 28 seconds with the vessel moving ahead at maximum service speed.

11.7.3 Auxiliary steering gear: a vessel shall be provided with an auxiliary steering gear that is:

.1 of adequate strength;
.2 capable of moving the rudder from 15° on one side to 15° on the other side in not more than 60 seconds with the vessel at one-half its maximum service speed ahead, or 7 knots, whichever is greater; and
.3 controlled from a location that permits safe manoeuvring of the vessel and does not expose the person operating the auxiliary means of steering to personnel hazards during normal or heavy weather operation.

A suitable hand tiller may be used as the auxiliary steering gear.

11.7.4 An auxiliary steering gear need not be provided where one of the following auxiliary means of steering are provided:

.1 the main steering gear and its controls are provided in duplicate;
.2 multiple propeller propulsion, with independent control from the operating position for each propeller unit, is provided, and the vessel is capable of being steered from the control station;
.3 no regular rudder is fitted and steering action is obtained by a change of setting of the propelling unit; or
.4 where a rudder and hand tiller are the main steering gear.

11.7.5 The main steering gear and the auxiliary means of steering shall be arranged so that the failure of one of them will not render the other one inoperative.

The auxiliary means of steering shall be capable of being rapidly brought into action and shall be of adequate strength and of sufficient power to enable the vessel to be steered at navigable speed.

The main steering gear shall be designed so that transfer of control from the main steering gear to the auxiliary means may be achieved rapidly. Any tools or equipment necessary to make the transfer shall be readily available.

11.7.6 Mechanical rudder stops are to be provided. These stops may be structural or internal to the main steering gear.

11.7.7 The main steering system shall be operable from the operating station. Control of the main steering gear, including control of any necessary associated devices, motor, pump, valve, etc., shall be provided from the operating station.

The indication of the angular position of the rudder(s) or direction of thrust shall be provided on the operating station and on the alternative steering position. Operating station means the principal steering station on the vessel from which the crew normally navigates the vessel.

11.7.8 A means of communication shall be provided between the operating station and the steering gear compartment or alternative steering position.

11.8 SHAFTING

11.8.1 The diameter of the propeller shaft d_P shall not be less than that calculated from the following formula:

$$d_p = K \cdot \sqrt[3]{\frac{P}{n} \cdot \frac{560}{R_m + 160}}$$

where:

d_P - diameter of the propeller shaft, in [mm]

P - rated power of the main engine (losses in gearboxes and bearings shall be disregarded), in [kW];

n - rated speed of propeller shaft, in [rpm];

R_m - tensile strength of the shaft material, in [N/mm²].

K - factor for the of propulsion installation:

= 120 for the vessel of design category A with one propulsion line and for passenger vessel

= 100 for the vessel with two propulsion lines of design category A

= 90 for the vessel of design category B, C, D

11.8.2 Propeller shafts with internal longitudinal shaft bore will be specially considered by *Register* in each particular case.

12 ELECTRICAL INSTALLATIONS AND AUTOMATION

12.1 GENERAL REQUIREMENTS

12.1.1 The requirements of the *Rules for the classification of ships, Part 12 - Electrical equipment* and the *Rules for the classification of ships, Part 13 - Automation*, generally apply.

12.1.2 Depending on vessel specific operation and construction characteristics, instead of requirements of this Section, the *Register* may, subject to special consideration by the *Register* in each particular case, apply requirements of recognized national or international standards, provided they are acceptable to the *Register*. Amongst these are (e.g.) the publication of the following standards acceptable to the *Register*:

- HRN EN ISO 10133 - "Small craft - Electrical systems - Extra-low-voltage d.c. installations".
- HRN EN ISO 13297 - "Small craft - Electrical systems - Alternating current installations".
- HRN EN 60092-507 - "Electrical installations in ships - Part 507 - Small vessels".

12.1.3 The *Register* reserve the right to permit deviations from this Part of the Rules on a case-by-case basis, or to make special demands in the case of novel installations or equipment.