DNV·GL

STANDARD

DNVGL-ST-0342 Edition July 2016

Craft

DNV GL AS

FOREWORD

DNV GL standards contain requirements, principles and acceptance criteria for objects, personnel, organisations and/or operations.

Any comments may be sent by e-mail to *rules@dnvgl.com*

CHANGES - CURRENT

This is a new document.

CONTENTS

SECTION 1 INTRODUCTION

1.1 Scope

1.1.1 General

1.1.1.1 The purpose of this standard is to provide a certification service provided by DNV GL for the small craft industry; mainly for commercial craft, but also recreational craft outside scope of EU Directives.

1.1.1.2 The certification aims at providing an appropriate safety level for the boat types, their intended application and design limitations. The technical and safety standards prescribed are considered adequate for commercial craft with overall lengths in the approximate range 6 to 24 m and with speed up to 45 knots. Craft with lengths and /or maximum speed other than indicated may be certified upon special consideration.

1.1.1.3 The certification services described in this standard apply to newbuilding of craft. No services for the operational phase are provided.

1.1.1.4 Certification according to this standard does not ensure compliance with any mandatory national or international regulations.

1.2 Requirements

1.2.1 General

1.2.1.1 The regulations with respect to certification systematic and formalities are given in Sec.2 and Sec.3. The technical requirements are given in Sec.6 through Sec.28.

1.2.1.2 The requirements which are in force at the date of the written agreement are the basis for the certification.

1.3 Recreational Craft

1.3.1 General

1.3.1.1 Recreational craft within the scope of EU Council Directive 2013/53/EU as amended (RCD) will be assessed by DNV GL as Notified Body according to the assessment procedures of RCD.

The assessment will be based on the requirements of the harmonised ISO standards mandated for RCD.

1.3.1.2 Certificates for recreational craft within the scope of RCD will be issued by DNV GL as Notified Body in accordance with RCD. No other certificates will be issued.

1.3.1.3 Recreational craft outside the scope of RCD shall follow the systematic and procedures specified in Sec.2 and Sec.3, and will be assessed based on the technical requirements given in Sec.6 through Sec.28.

Harmonised ISO standard mandated for RCD may also be applied.

SECTION 2 CERTIFICATION SYSTEMATICS

2.1 General

2.1.1 General

2.1.1.1 The relation between the Customer and DNV GL is regulated in an Agreement signed by both parties. The agreement specifies the scope of the service, the fee, terms of payment and legal obligations.

2.1.1.2 The certification service is performed on the basic assumption that all parties involved (designer, builder/yard, manufacturer, design-owner, sub-contractor, owner, etc.) fulfil their individual obligations. The certification service is not performed in substitution of other parties' role or obligations. Nothing contained in DNV GL services, certificate, report or document issued in connection with or pursuant to these requirements, shall relieve any designer, engineer, builder, manufacturer, yard, seller, owner, operator or other parties from any obligations or consequences of default whatsoever. In particular, compliance with the requirements does not imply acceptance or commissioning of a craft. This is the exclusive responsibility of the owner.

2.2 Certification - Procedures

2.2.1 General

2.2.1.1 The certification Procedures are based on Modules. These procedures (modules) cover the design phase, the manufacturing phase or both. The procedures are based on the modules specified for conformity assessment in accordance with the Directives in the European Union and are described in Sec.3.Information about what procedures to choose and detailed requirements for each module is given in Sec.3.

2.2.1.2 Application for certification shall be sent to the local DNV GL office and include:

— name and address of the applicant
— name and address of the owner of the design
— name and address of the builder (yard, manufacturer) craft specification and type designation
— chosen procedure(s)
— technical documentation.

2.2.1.3 The Applicant has to be authorised by the Owner of the design to act on his behalf.

2.2.1.4 If the Applicant subcontract design or production, the applicant remains responsible for the execution of conformity assessment for all technical documentation, sub-supplies and the finished craft.

2.2.1.5 Any subcontracting will be subject to separate agreement, handling and approval.

2.2.1.6 The Society decides the extent of examinations, tests and inspections required to complete the relevant procedure (module) in each case.

2.2.1.7 Requirement for Manufacturing shall be surveyed and accepted according to requirement in Sec.10 *Metallic materials* and Sec.11 *Fibre reinforced plastics-FRP*.

2.3 Technical documentation

2.3.1 General

2.3.1.1 The Applicant shall submit Technical Documentation for approval irrespective of certification procedure.

2.3.1.2 Technical Documentation shall enable understanding of the design and construction of the craft, and shall confirm compliance with the requirements given in this Standard.

2.3.1.3 Requirements for documentation are found in the beginning of each section:

— Stability [8.1.2]
— Materials [9.1] and [9.2], [11.1] and [18.1.7], [18.1.8]
— Safety [7.1]
— Structure [15.1] (for speed exceeding 45 knots, see [15.2])
— Systems Sec.20 to Sec.28: (Principle Schemes shall show compliance with requirements in text).

2.3.1.4 Documentation of Quality Assurance System (module D) shall be according to [7.2.4].

2.4 Certificates

2.4.1 General

2.4.1.1 The type of certificates to be issued by DNV GL will be:

— *Product Certificate* ([3.1.2.3], [3.2.3.6])
— *Type Approval Certificate* ([3.2.2.5])
— *Quality System Production Certificate* ([3.2.4.8])

2.4.1.2 The certificates shall contain the following information as applicable:

— the name and address of the Builder (yard, manufacturer)
— the identification of the product- craft type designation and reference to Owner of the design
— reference to the Standard and regulations applied
— specification of exemptions or equivalent standards
— any restrictions/limitations in the use of the craft
— validity
— date of issue and signatures.

SECTION 3 PROCEDURES

3.1 One-off craft (Module G)

3.1.1 General

3.1.1.1 The procedure (module) is applicable for One-off certification, i.e. a design on which only one craft is built.

3.1.2 Procedure

3.1.2.1 DNV GL will verify that the Technical Documentation complies with the requirements.

3.1.2.2 DNV GL will carry out surveys during production, examine the complete craft and carry out the appropriate tests as set out in the relevant requirements to ensure its conformity.

3.1.2.3 Upon successful completion of the certification procedure, DNV GL will issue a *Product Certificate*.

3.2 Series of craft (Module B and F or D)

3.2.1 General

3.2.1.1 The procedures (modules) described in [3.2.2], [3.2.3] and [3.2.4] are applicable to one design on which a series of craft is manufactured. [3.2.2] covers the design phase and shall always be followed by a procedure covering the production phase ([3.2.3] or [3.2.4])

3.2.2 Type Approval (Module B)

3.2.2.1 The procedure (module) shall normally be used for approval of a design produced in series and must be followed by a procedure (module) covering the production phase.

3.2.2.2 The procedure shall be according to: DNV GL Type Approval Scheme DNVGL CP 0338.

Guidance note:

Overall principles for Type Approval (TA):

- Application for TA
- Quotation
- Approval of the design
- Initial assessment
- Type testing
- Issuance of TA certificate

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.2.2.3 DNV GL verifies that the Technical Documentation complies with the requirements.

3.2.2.4 DNV GL verifies, by performing examinations and tests that a prototype complies with the applicable requirements and is built in accordance with the Technical Documentation.

3.2.2.5 Upon successful completion with the certification procedure, DNV GL will issue a *Type Approval Certificate* with validity of 5 years.

3.2.3 Product verification (Module F)

3.2.3.1 The procedure (module) covers the production phase and follows Procedure for Type Approval (Module B).

3.2.3.2 The builder shall take necessary actions to ensure that the manufacturing process ensures conformity of the products with the type as described in the approved technical documentation.

3.2.3.3 Normally all products will be individually examined and appropriate tests carried out in order to verify their conformity with the type as described in the type approval certificate and the approved technical documentation.

3.2.3.4 If statistical verification is agreed, the method shall be according to ISO 2859-1:

— Each relevant section shall be considered as an inspection item.
— Sample size shall be based on Table 9-1, General Inspection Level "I"
— Sampling plan shall be according to Table 2-A
— Acceptance Quality Limit (AQL) shall be 1.0

If a lot is found not acceptable, all items shall be re-examined until DNV GL is satisfied that all non-conforming items have been rectified/replaced. DNV GL will determine whether the re-examination shall include all inspection items, or only the particular types of non-conformities which caused initial non-acceptance.

3.2.3.5 Upon successful completion of the certification procedure, DNV GL will issue a *Product Certificate* covering either each unit or a defined lot.

3.2.4 Production verification (Module D)

3.2.4.1 The procedure (module) covers the production phase and follows procedure for Type Approval (Module B).

3.2.4.2 The builder shall operate an approved Quality Assurance System (QA-system) for manufacturing, final product inspection and testing. The QA-system shall be subject to monitoring as specified below.

3.2.4.3 The procedure may cover several designs with valid Type Approval Certificate.

3.2.4.4 The builder shall submit the documentation concerning the QA-system. The QA-system shall ensure compliance of the products with the type(s) as described in the Type Approval Certificate(s) and the approved Technical Documentation.

3.2.4.5 All the elements, requirements and provisions adopted by the manufacturer shall be documented in a systematic and orderly manner in the form of written policies, procedures and instructions.

3.2.4.6 The QA-system documentation must permit a consistent interpretation of the quality programmes, plan, manuals and records.

3.2.4.7 The QA-system shall contain in particular an adequate description of:

— the quality objectives and the organizational structure, responsibilities and powers of the management with regard to product quality

- the manufacturing, quality control and quality assurance techniques, processes and systematic actions that will be used
- the examinations and tests that will be carried out before, during and after manufacture, and the frequency with which they will be carried out
- the quality records, such as inspection reports and test data, calibration data, qualification reports of personnel concerned, etc.
- the means to monitor the achievements of required product quality and the effective operation of the quality system.

3.2.4.8 Upon successful approval of the QA-system DNV GL will issues a Quality System Production Certificate valid for 4 years.

3.2.4.9 DNV GL will carry out audits to make sure that the builder maintains and applies the quality system. The audit will include spot checks on craft under building and review of quality records of built craft.

3.2.4.10 Additionally DNV GL may pay unexpected visits.

SECTION 4 TESTING/SEA TRIALS

4.1 General

4.1.1 General

4.1.1.1 All equipment shall be function tested after installation to demonstrate compliance with the requirements in this standard. The testing shall include sea trial(s) with all equipment installed. All testing shall be carried out according to a plan approved by the surveyor. The surveyor may require witnessing of all or part of the testing and/or sea trials.

SECTION 5 DEFINITIONS

5.1 Definitions

Table 5-1 Definitions

Symbol	*Unit*	*Description*
L	m	Length of hull but excluding rubrails, outside rudders, outdrives, outboard motors, diving platforms, bowsprits, fittings.
L_{WL}	m	Length of hull along waterline measured at the foremost intersection of the stem with the flotation plane and the aftermost intersection of the hull and the flotation plane with the craft fully loaded at rest.
F_p		Intersection of the stem with the flotation plane of the craft fully loaded at rest.
B	m	Maximum beam of hull measured on the outside of the hull shell.
B_{WL}	m	Beam of hull in the waterline. For catamarans: sum of waterline beam for both hulls.
T	m	Maximum draught of hull in fully loaded condition.
D	m	Depth, measured as the vertical distance between the sheerline at the half-length of the waterline and the lowest point of the keel.
Δ	kg	Displacement in fully loaded condition.
V	knots	Maximum speed.
β	°	Deadrise angle is the angle of the bottom from the horizontal measured athwartship at a specific position.
LCG	m	Longitudinal position of the centre of gravity from a chosen datum.
VCG	m	Vertical position of the centre of gravity from a chosen datum.
RM	Nm	Righting moment.
GM	m	Transverse metacentric height.
GZ	m	Righting lever = righting moment (Nm)/(mass (kg) × 9.806).
Decked craft		Craft with deck that can be closed weather tight from stem to stern uninterrupted by other than a strong superstructure or a cockpit so designed that shipping sea will not fill spaces below deck.
Open craft		Craft that is not a decked craft.
Flooded craft		A flooded craft is a craft in a condition in which it can not be filled with more water.
Superstructure		Decked structure on the freeboard deck, extending from side to side of the ship or with the side plating not inboard of the shell plating more than 4% of the breadth (B).
Deckhouse		Decked structure above the strength deck with the side plating being inboard of the shell plating more than 4% of the breadth (B).
Long deckhouse		Deckhouse having more than 0.2 L of its length within 0.4 L amidships.
Short deckhouse		Deckhouse not defined as a long deckhouse.
Mean freeboard F	mm	$F = (f_f + f_m + f_a)/3$

Symbol	*Unit*	*Description*
f_f	mm	Freeboard measured at extreme forward end.
f_a	mm	Smallest freeboard measured at extreme aft end or, for craft with engine wells to the point where water first may enter the craft.
f_m	mm	Freeboard measured at $L_H/2$.
Headroom	m	Vertical distance between top of compartment floor and underside of the deck beam or deck head (whichever is the lower).
Readily accessible		Capable of being reached for operation, inspection or maintenance without the use of tools or the removal of any craft structure or any item of portable equipment.
Accessible		Capable of being reached for operation, inspection or maintenance without the removal any permanent craft structure.
M	kNm	Maximum longitudinal bending moment.
Z	mm^3	Section modulus of hull girder.
Recreational craft		Any craft of any type intended for sport and/or leisure of hull length up to 24 m, regardless of means of propulsion.
Manufacturer		An organization that manufactures the material or product, or carries out part production that determines the quality of a material or product, or does the final assembly of a product.

SECTION 6 ARRANGEMENT

6.1 General

6.1.1 Bulkheads

6.1.1.1 Craft with length 6 m < L < 15 m shall normally be arranged with at least 2 watertight bulkheads.

6.1.1.2 Craft with length L exceeding 15 metres shall be arranged with at least 3 watertight bulkheads, of which one shall be a collision bulkhead with minimum distance $0.05L_{wl}$ and maximum distance $0.1L_{wl}$ from F_p.

6.1.1.3 Watertight bulkheads shall be carried up to freeboard (bulkhead) deck, or may end at first deck above waterline based on special consideration of watertight division and integrity of the hull.

6.1.1.4 Engine compartment and cargo hold are to be separated from each other and from rest of the hull by watertight bulkheads. Minor steps or recesses in the bulkhead may be accepted. For craft with length, L, less than 15 m, the engine compartment may be accepted as a watertight box up to a level above waterline based on special consideration.

6.1.1.5 Doors and hatches in watertight bulkhead may be accepted, except for the collision bulkhead.

6.1.1.6 Small openings for penetrating pipes and electrical cables shall normally be sealed and arranged in top of bulkheads. Openings in bulkheads shall be kept to a minimum.

6.2 Accommodation

6.2.1 General

6.2.1.1 Accommodation areas shall be without sharp corners and protruding parts and shall not be made of material which may break into dangerous fragments. It shall not contain unshielded high temperature areas, high pressure or rotating items, and shall not contain operating controls located in a way to be impeded by persons during normal and emergency conditions.

6.2.2 Seats

6.2.2.1 A seat shall be arranged for every person onboard.

6.2.2.2 A seat shall have the following minimum size:

— beam 500 mm
— depth 750 mm, free space for legs measured from persons back
— height 900 mm, from seat to free height for head.

Sharp edges, arm rest etc. which may cause injury are not accepted.

6.2.2.3 The strength of a seat shall be in accordance with the relevant horizontal longitudinal acceleration of the craft. In general a minimum static load of 1125 N may be used as basic for the scantling. The point of application of the horizontal longitudinal load shall be at the top of the backrest. Seats shall be designed for a vertical load equal to 2 250 N. The point of application of the vertical load shall be at the centre of the seat.

6.2.2.4 For craft with speed exceeding 15 knots, the seats on open decks shall be minimum 380 mm lower than top of bulwark/railing. Equivalent arrangements for protecting persons from falling overboard when seated can be accepted.

6.2.2.5 For craft with speed exceeding 45 knots the seats shall be equipped with seat belt.

6.2.3 Ventilation

6.2.3.1 Accommodation spaces shall have separate inlet and exhaust of air, with documented capacity of ventilation for comfort of persons with closed windows and doors.

6.2.3.2 Heating, cooking and similar installations shall have separate ventilation.

6.2.3.3 Inlets and outlets of ventilation shall be well separated from engine exhausts.

6.2.3.4 All compartments, holds and void spaces shall normally have natural ventilation.

6.2.3.5 Any space intended for flammable liquids etc. shall have separate ventilation.

6.2.4 Sanitary

6.2.4.1 All craft shall normally be arranged with basic sanitary facilities (toilet and wash basin). This requirement may be waived for craft for limited operation in harbour etc.

6.2.5 Exit, Passages etc.

6.2.5.1 All accommodation, and machinery-spaces that are possible to enter, shall normally be arranged with two exits, for which one may be an emergency exit. The exits shall be located as far as possible from each other, and be suitable to use in emergency situation.

6.2.5.2 Width of passages shall be minimum 700 mm in general, but may be reduced to 600 mm for spaces not normally used.

6.2.5.3 Accommodation for maximum 4 persons may be accepted with only one exit if this cannot be blocked in case of fire or other emergency situation and if it leads directly to open deck.

6.2.6 Emergency exit

6.2.6.1 The emergency exit can be an approved hatch, door or window complying with the following:

— minimum light opening 500 × 500 mm, or diameter 450 mm
— easy access with fixed step, ladder and handholds as necessary
— clearly marked and with appropriate instructions for use.
— readily opened from both sides without tools in daylight and dark
— direct access to open deck, or via short passages without any lockable door.

6.2.7 Emergency light

6.2.7.1 Emergency light is to be arranged for accommodation and exits. See also [25.4.1.1].

6.3 Steering Position

6.3.1 General

6.3.1.1 The design and layout of the steering position shall allow the crew to perform their duties without difficulty, fatigue or loss of concentration. The headroom in a wheelhouse shall be minimum 1980 mm.

6.3.1.2 The steering position shall normally not be used for purposes other than navigation, communication and functions essential to the operation of the craft.

6.3.1.3 Fixed seats shall be arranged for the crew.

6.3.2 Field of vision

6.3.2.1 The wheelhouse shall be so arranged and positioned to provide view all round the horizon from the steering and navigation workstations. Where this is not possible, the all round view of the horizon may be obtained by using two combined workstations, or by another approved mean.

6.3.2.2 The view of the sea surface from the operating station when seated, shall not be obscured by more than two craft length forward of the bow to 90° on either side irrespective of the craft's draught and trim.

6.3.2.3 Blind sectors shall be as few and as small as possible, and not adversely affect the keeping of a safe look-out from the operating station. The total arc of blind sectors from right ahead to 22.5° abaft the beam on either side shall not exceed 20°. Each individual blind sector shall not exceed 5°. The clear sector between two blind sectors shall not be smaller than 10°.

6.3.2.4 Arrangement shall be provide so that forward view is not adversely affected by solar glare. Neither polarised nor tinted window glass shall be fitted in the front and side of the wheelhouse. Removable sunscreens/curtains may be provided. Windows should preferably be angled top outboard approx. 15° from vertical to reduce unwanted reflection.

6.3.3 Instruments and equipment

6.3.3.1 The equipment and means for navigation, manoeuvring, control, communication and other essential instruments shall be located sufficiently close together to enable personnel to receive information and to use the equipment while seated. If necessary some functions may be duplicated. A table for chart work shall normally be arranged.

6.3.3.2 Instrument, their panels and controls shall be permanently mounted in console(s) convenient for operation and maintenance. The surface of console tops and instruments shall prevent light reflections.

6.3.3.3 All instruments shall be logically grouped according to their functions, plainly visible and easily readable. Means for screening and dimming of internal and external lights in order to minimise glare and reflections, shall be arranged.

6.3.3.4 All craft shall be provided with a magnetic compass which is capable of operating without electrical supply, and which may be used for steering. This compass shall be mounted in a suitable binnacle containing the required corrective devices and shall be suitable for the speed and motion of the actual craft.

6.3.3.5 IP ratings shall be according to [25.1.1.3].

SECTION 7 SAFETY OF PERSONNEL

7.1 Safety Plan

7.1.1 General

7.1.1.1 A safety plan for the craft, shall be submitted for approval. The plan shall be delivered with the craft. The requirement may be waived for craft with length L not exceeding 8 m, or for craft of simple design and arrangement.

7.1.1.2 The safety plan shall describe the arrangements for the following items:

— life saving equipment
— fire alarm and fire fighting
— emergency exits
— emergency systems (alarms, fans, valves etc.).

In addition the following may be included for information:

— emergency instruction
— first aids.

7.2 Railings, Ladders, Handholds, Decks

7.2.1 Rails and handholds

7.2.1.1 All areas above and below deck intended for human occupation shall be equipped with either railings, bulwark, hand-holds of substantial design or other means of safe grip.

7.2.1.2 Decks shall normally be surrounded by railing or bulwark with minimum 750 mm height. Part of the railing may be dismountable.

7.2.1.3 The distance between vertical stanchions of railing shall normally not be more than 1200 mm. The vertical distance between bars in rails shall normally not exceed 230 mm from deck level and 330 mm elsewhere.

7.2.2 Deck non-slip surface

7.2.2.1 Non-skid surface shall be arranged on all decks and floors intended for human occupancy or work.

7.2.2.2 Decks shall have a toe-rail of minimum 25 mm height at the outboard edge or gunwale.

7.2.3 Outboard rescue ladder

7.2.3.1 For craft with length L exceeding 6 m, or craft with freeboard F exceeding 500 mm, an outboard rescue ladder or steps shall be arranged. The arrangement shall be suitable for a person in the water to enter the craft. The lower step, or any suitable safe part of hull structure to step on, shall be arranged minimum 500 mm below waterline in light condition of the craft.

7.2.3.2 A foldable ladder, or other equivalent system, may be accepted when a safe release system is arranged for access from a position in the water.

7.2.4 Outboard hand grips

7.2.4.1 For craft required to be fitted with buoyancy elements, arrangement shall be fitted to enable persons in the water to hold on to the craft in capsized condition.

7.3 Operation of deck gear

7.3.1 General

7.3.1.1 Winches, cranes and other deck-gear shall be arranged to facility safe working with respect to instruction, operation, view and shielding. Winches with open lines, lifting platforms and all types of movable deck gear, shall be shielded or arranged with automatic emergency stop activated by a person or other inadequate object caught by the lines or gear in operation. Winch barrel, and similar gears shall have protection against line end etc. hitting the person operating the winch or gear.

7.3.1.2 Instruction for safe operation of lifting gears, together with type notation and name of manufacturer, shall be given on a signboard on the gear at the place of operation.

7.3.1.3 Testing of safe work load for winches, cranes and other lifting gears shall be documented, and arrangement to avoid overload shall be fitted.

SECTION 8 STABILITY, WATER- AND WEATHERTIGHT INTEGRITY

8.1 General

8.1.1 General requirements

8.1.1.1 No damage stability calculation is required.

8.1.1.2 For craft required to be arranged with buoyancy elements, the capability in flooded condition shall be documented and verified by full scale test. Enclosed superstructure, deckhouses and trunks may be included as buoyancy elements provided they have approved strength and closing appliances.

8.1.1.3 For craft with fenders along the sides of the hull the fenders may be included when calculating the stability of the craft subject to agreement with the Society. This applies to fenders that are secured or bonded to the hull such that they will not be dislodged when submerged. Fenders shall be solid or may be of foam filled construction in which case the foam shall be bonded to the hull such that it will not be dislodged when submerged. It will be noted on the certificate(s) that the craft shall not be operated with damaged fenders.

8.1.1.4 Marks for maximum draught are to be arranged at bow and stern.

8.1.1.5 Permanent heel or trim which may generate danger for accumulation of water on deck is not accepted.

8.1.1.6 Person mass to be used in calculations and tests = 82.5 kg

8.1.2 Documentation

8.1.2.1 The following documentation shall be submitted for approval:

— stability manual
— inclining test
— closing appliances.

The following documentation is assumed for information:

— general arrangement
— body/lines plan
— freeboard/weathertight integrity plan.

8.1.2.2 The stability manual shall cover all load conditions representative for the intended service of the craft, including drafts, trim and freeboard. The manual (or a separate appendix/ issue) shall also include relevant hydrostatic data, calculation of centres of gravities etc. Stability curves shall be made on a free to trim basis. (Cross curves are normally to be prepared on a designed trim basis).

8.1.2.3 The inclining test is generally to be carried out and documented according to ordinary practice for ship. For craft with length L less than 6 m, and crafts arranged with buoyancy, the ordinary inclining test may be replaced by a full scale stability test.

8.2 Freeboard

8.2.1 Decked crafts

8.2.1.1 The freeboard shall nowhere be less than 200 mm.

8.2.1.2 The height of the forecastle or bulwark at stem shall normally nowhere be less than 0.12 L above deepest waterline. The height may be reduced to the level of freeboard deck at 0.25 L from the stem and aftwards.

A reduction of the height at the stem can be accepted based on an evaluation of the forecastle deck and its possibility to shed water overboard.

8.2.2 Open craft

8.2.2.1 The mean freeboard, F, shall not be less than the larger of:

$$F = \frac{4.5\Delta}{1000LB} \quad (mm)$$

or

$$F_{min} = 500 \text{ mm}$$

Craft not complying with requirement above, shall be arranged with buoyancy elements according to [8.1.1.2].

8.2.2.2 Craft with length L < 6 m shall be arranged with buoyancy elements and satisfying [8.2.2.5].

8.2.2.3 For craft arranged with buoyancy elements, the mean freeboard, F, shall not be less than:

$$F = 200\ B \text{ mm}$$

or

$$F_{min} = 200 \text{ mm}.$$

8.2.2.4 Craft shall have a freeboard aft of not less than:

$$F_{aft} = 0.8\ F$$

8.2.2.5 Craft that neither complies with the requirements to freeboard nor has buoyancy elements, shall be arranged as Decked craft.

8.3 Stability – Decked craft

8.3.1 Decked Craft

8.3.1.1 The stability manual shall document the righting arm GZ for the following conditions:

a) *Lightship* with minimum equipment and cargo. Combined loads are not to exceed 10% of maximum load capacity.
b) *Loaded* with maximum equipment and cargo in holds and on deck. Combined loads are not to be less than 90% of maximum load capacity in the mode of departure and arrival.

c) *Deck load* with maximum equipment and cargo on deck and empty holds in the mode of departure and arrival.
d) Other relevant conditions shall be documented.
e) Emergency condition, see [8.3.1.4].

8.3.1.2 The righting arm at 30° heel shall be minimum 0.20 metres. The maximum value of the GZ-curve shall occur at an angle not smaller than 25°. The GZ curve shall normally be positive up to 50° of heel.

8.3.1.3 When calculating the heeling moment due to operation of lifting gear, winch, towing hook etc., a dynamic factor of 1.4 is normally to be used to include effects from wind, waves etc. The angle of heel shall not exceed 10° for maximum moment in the most unfavourable condition.

8.3.1.4 In maximum load condition the craft shall not capsize or be flooded if all persons moves to the same side, the angle of heel shall not exceed 10°, caused by a heeling weight:

$$P = 82.5 \cdot n \text{ (kg)}$$

where n = total number of persons.

The weight is to be located 1 m above deck along the gunwale.

8.4 Stability – Open craft

8.4.1 Open craft

8.4.1.1 An inclining test may be carried out to determine the metacentric height GM in lightship condition. GM shall normally not be smaller than 0.50 m.

8.4.1.2 The inclining test may be omitted if it for the load condition can be demonstrated that the period of roll in seconds (from one side and back to the same side) is less or equal to the craft beam in meters.

8.4.1.3 The requirement to metacentric height, or period of roll, may be disregarded if it is documented that the GZ curves satisfy the requirements for Decked craft up to an angel of heel of 30°.

8.4.1.4 In maximum load condition the craft shall not capsize or be flooded if all persons moves to the same side, the angle of heel shall not exceed 10°, caused by a heeling weight:

$$P = 82.5 \cdot n \text{ (kg)}$$

where n = total number of persons.

The weight is to be located 1 m above deck along the gunwale.

8.5 Stability - Open craft with buoyancy

8.5.1 Stability in intact condition

8.5.1.1 In lightweight condition the craft is not to be flooded, or the angle of heel shall not exceed 10°, for a heeling weight:

$$P = 22 \times n \text{ (kg) (n = number of persons),}$$

or

$$P_{min} = 44 \text{ (kg).}$$

The heeling weight is to be placed at the gunwale at the maximum beam of the craft, and not less than $B_{max}/2$ from the centreline.

8.5.1.2 In maximum load condition the craft shall not capsize or be flooded if all persons moves to the same side, the angle of heel shall not exceed 10°, caused by a heeling weight:

$$P = 82.5 \times n \text{ (kg)} \text{ (n = total number of persons).}$$

The weight is to be located on the floor as near to the gunwale as possible, but minimum $B_{max}/4$ from centreline and with longitudinal position corresponding to the arrangement of the accommodation. Weights representing equipment shall be located at their respective positions.

8.5.2 Buoyancy in flooded condition

8.5.2.1 In maximum load condition (including any outboard engine) the flooded craft is to float approximately horizontal and not sink when loaded with additional weight:

$$P = 27.5 \times n \text{ (kg)} \text{ (n = total number of persons),}$$

but not less than the larger of

$$P = 55 + 55 (L - 2.5) \text{ (kg),}$$

or

$$P_{min} = 82.5 \text{ (kg).}$$

Weights shall be located at their respective positions on board.

8.5.3 Stability in flooded condition

8.5.3.1 In maximum load condition (including any outboard engine) the flooded craft shall have a positive stability up to 50° of heel when loaded with an additional weight located anywhere along the gunwale:

$$PK = 11 + 5.5 \times n \text{ (kg)} \text{ (n = total number of persons),}$$

or

$$PK_{min} = 27.5 \text{ (kg).}$$

8.6 Freeing ports and drainage

8.6.1 Freeing ports on decked craft

8.6.1.1 Freeing ports shall be spaced along the deck, with lower edge normally flush with deck level.

8.6.1.2 On craft with bulwark, forecastle, deckhouse or open structures forming wells, the total freeing port area on each side of the deck is to be minimum $A = 0.02 V m^2$. The volume V is calculated based on total deck area and height to top of bulwark, with deduction of volume of hatches, deck-house etc.

8.6.1.3 Flaps at freeing ports may be approved if opening area is not reduced, jamming is prevented and hinges are made of non-corrosive material. Locking of flaps is not permitted.

8.6.1.4 Freeing port openings shall be fitted with bars not more than 330 mm apart, and with maximum 230 mm opening below the lowest bar.

8.6.2 Drainage of open craft

8.6.2.1 Drainage of deck shall be arranged from each side of the craft to the bilge, from which pumping shall be arranged. The drainage may also be directly overboard with a non-return arrangement, or a closable arrangement.

8.6.2.2 The area of drainage shall be minimum A = 0.01 V m^2, where V is the volume as defined as for decked craft.

8.7 Weathertight integrity

8.7.1 General

8.7.1.1 Small openings for wire chain, scuppers etc., will be considered as closed if submerged at angle of heel larger than 30°.

8.7.1.2 Openings to spaces below freeboard deck, or to other spaces included as buoyancy in stability calculations, shall be fitted with weathertight closing appliances.

8.7.1.3 Closing appliances shall be built with same strength as the surrounding structure and be arranged to provide safety against sea impact.

8.7.1.4 Closing appliances shall as a minimum include gasket and two closing devices in addition to hinges.

8.7.1.5 The appliance shall be tested with a water jet that shall have a vertical angle of 45° relative to the hatch. The water jet shall be a dense thin water jet delivering a flow of at least 10 l/min, aiming everywhere in an area located within 0.05 m each side of the periphery of the appliance. Spraying shall continue for at least 3 min and after this duration no water shall ingress the gasket.

8.7.2 Hatches

8.7.2.1 Hatches which may be opened at sea shall be hinged or attached by chain and shall be capable of being secured in open position.

8.7.2.2 Hatch coamings shall normally have a height of at least 380 mm. For hatches located at least 380 mm above freeboard deck, a reduction of the coaming height to minimum 150 mm may be accepted.

The hatch can be flush with the deck under the condition that the hatch is not operated at sea.

Flush hatches located at roof top can be opened during the operation at sea.

8.7.2.3 For a rectangular or square hatch cleats shall be fitted with a maximum spacing of 600 mm along the edges and maximum 150 mm from the corners. For circular hatches the cleats shall be fitted with maximum 450 mm spacing measured along the periphery.

8.7.3 Doors

8.7.3.1 Doors shall be possible to operate from either side of the bulkhead.

8.7.3.2 The sill height of door openings to spaces below freeboard deck shall be at least 380 mm. For doors located at least 380 mm above freeboard deck, a reduced height of sill may be accepted, but normally not less than minimum 150 mm.

8.7.3.3 Arrangement for removable washboard replacing a sill may be accepted based on special consideration.

8.7.4 Port and ramps

8.7.4.1 Port and ramps in shipside above weathertight deck may be accepted. Watertightness shall be arranged with gasket and hinges/clamps with spacing not exceeding 300 mm.

8.7.4.2 The arrangement for safety of operation, stop arrangement and any indicators etc. shall be submitted for approval.

8.7.4.3 The lower edge of openings shall not be less than 200 mm above deepest waterline.

8.7.5 Ventilation

8.7.5.1 Ventilation openings shall be arranged to avoid flooding of the craft and normally have minimum height 600 mm above freeboard deck.

8.7.5.2 Ventilation openings shall normally not be immersed at heel angle smaller than 50°.

8.7.6 Air pipes

8.7.6.1 Air pipes are defined as openings for ventilation normally not exceeding an area equivalent to a diameter of 50 mm.

8.7.6.2 Air pipes shall be arranged with non-return valve or goose necks to prevent water ingress.

8.7.6.3 The height of air pipes shall normally not be smaller than 600 mm above the freeboard deck.

8.7.6.4 Air pipes shall be protected from damage from work on deck.

8.7.7 Windows

8.7.7.1 Windows in accommodation spaces may be fabricated from thermally or chemically toughened glass or polycarbonate. Windows shall not fracture in fragments that can easily cause human injury.

8.7.7.2 Windows shall be fitted in rigid frames and secured from being pressed in. A rubber profile is acceptable if the window can not be pressed in and the glass thickness is increased by 20%. Windows may be glued according to requirements in DNV GL rules for RU HSLC Pt.3 Ch.6 Sec.3 [7].

8.7.7.3 The minimum thickness of windows shall be calculated according to the following formula:

$$t = \frac{b}{K}\sqrt{\beta P}$$

P = design pressure at the location of the window
β = according to Figure 8-1
a = the larger dimension of the window opening
b = the smaller dimension of the window opening
K = 225 for chemically toughened glass (CTG)
= 225 for thermally toughened glass (TTG)

= 190 for polymethylmethacrylate (PMMA)
= 190 for polycarbonate (PC).

PC and PMMA window panes shall overlap their frames with not less than 0.03b (mm)

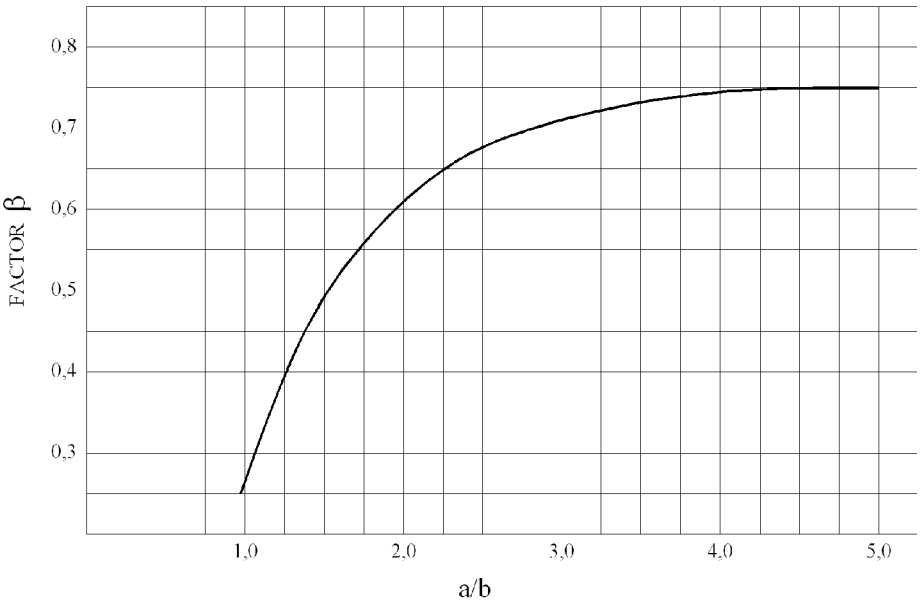


Figure 8-1

8.7.7.4 For windows placed above positions exposed to sea-load the thickness may be reduced by 25%.

8.7.7.5 Horizontal windows in positions exposed to impact from operation are subject to special consideration.

8.8 Buoyancy elements

8.8.1 General

8.8.1.1 Requirements for buoyancy elements are given in [8.1.1.2].

8.8.1.2 Buoyancy elements may consist of foam, prefabricated or formed in position (in-situ), or tanks and double hull filled with air or buoyancy elements. Buoyancy elements must be fixed or permanently fitted and protected against mechanical damage and degradation from the environment.

8.8.1.3 Drainage shall be arranged for enclosed spaces used for buoyancy element. Such spaces shall normally not be used for storage or other facilities.

8.9 Ballast

8.9.1 General

8.9.1.1 Ballast shall be arranged so as to prevent shifting of position. The arrangement should have access for inspection.

8.9.1.2 The ballast material shall be documented to have no corrosive or destructive effect on the hull structure materials.

8.9.1.3 Use of water as ballast may be accepted based on documentation of the arrangement, tanks, filling and operation.

8.9.1.4 Ballast on cement-basis shall be specially documented with respect to arrangement and chemical reaction to hull material, drainage and protection.

SECTION 9 MATERIALS AND MANUFACTURING; GENERAL REQUIREMENTS

9.1 Metallic materials

9.1.1 Aluminium alloys

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

9.1.1.2 Structural aluminium material shall be delivered with a works certificate.

9.1.1.3 Acceptable alloy grades are given in the following table.

Table 9-1 Aluminium alloy grades

5000 Series	*6000 Series*
5052	6060
5154A	6061
5754	6063
5454	6005A
5086	6082
5083	
5383	

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

9.1.1.5 Sec.9 and Sec.10 are not applicable to aluminium alloys for forgings and castings. For these products suitable alloys according to recognized standards may be used.

9.1.2 Steel

9.1.2.1 Structural steel materials shall be weldable.

9.1.2.2 Structural steel materials shall be delivered with a works certificate.

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

9.2 Non-metallic materials

9.2.1 Application

9.2.1.1 This section applies to raw materials for FRP structures and to thermoplastics. Other materials can be considered based on a case by case evaluation

9.2.1.2 Raw materials shall be delivered under a certification scheme recognized by the society or certified by an institution recognized by the society. 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).

9.2.2 Marking of product

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

9.2.2.2 Products lacking the marking specified in [9.2.2.1] shall be subject to a product control testing verified by a recognized institution

SECTION 10 METALLIC MATERIALS, MACHINING, WELDING AND JOINTS

10.1 Aluminium materials

10.1.1 General

10.1.1.1 Aluminium shall be stored in a way such that corrosion is avoided.

10.1.2 Machining and forming

10.1.2.1 Methods for machining and forming shall be in accordance with the material manufacturer's recommendations.

10.1.3 Joints - general

10.1.3.1 Joining of different materials shall not lead to galvanic corrosion.

10.1.3.2 In joints, aluminium to another metal, the materials shall be galvanically insulated.

10.1.4 Joints by welding

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

10.1.4.2 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.

10.1.4.3 Welding procedures shall be approved on site.

10.1.4.4 MIG- or TIG- welding shall be used. MIG-welding is not recommended for thicknesses smaller than 2.0 mm and TIG-welding for thicknesses smaller than 0.7 mm.

10.1.4.5 Spot-welding shall only be used after special consideration.

10.1.4.6 Weld joints shall be prepared and bevelled in accordance with a recognized standard. The edges of the surfaces to be joined shall be free from burrs.

10.1.4.7 The surfaces to be joined shall be cleaned on the top and root sides. The oxide layer shall be removed by brushing, scraping or picking to a minimum distance of 10 mm from the joint. The surfaces shall be dry when welding starts.

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

10.1.5 Joints by riveting

10.1.5.1 The rivet dimension, spacing and distance to the edge shall be in accordance with Table 10-1. In rivet joints with small stresses in the plates, other dimensions and spacing may be tolerated.

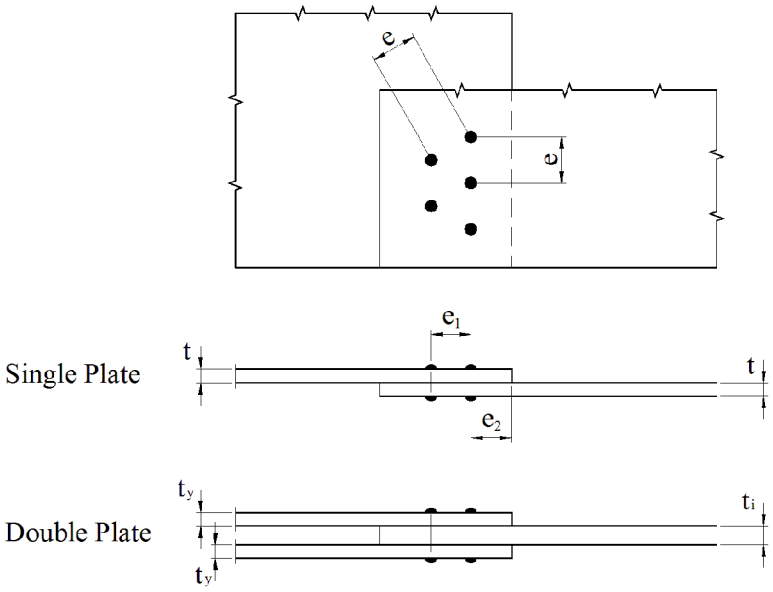


Figure 10-1 Examples of riveted joints

10.1.5.2 Water tight joints shall be at least two-rowed. The rivet spacing in these joints shall not exceed 4 times the rivet diameter

10.1.5.3 The difference in diameter between rivet and hole shall not be larger than shown in the figure below. The holes shall be burred.

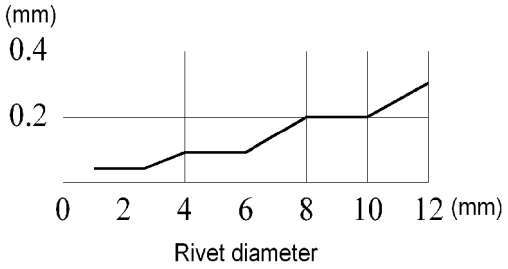


Figure 10-2 Difference in diameter (mm) between hole and rivet versus rivet diameter (mm)

Table 10-1 Rivet joints

Rivet diameter, d	Single plate joint	$d = 2 \cdot t + 1$ $d = 3 \cdot t$	$t < 1$ mm for $t \geq 1$ mm
	Double plate joints	$d = 1.2 \cdot t + 1$ $d = 1.5 \cdot t$	for $t < 3.3$ mm for $t \geq 3.3$ mm
Spacing for load-carrying rivets	One row of rivets in the load direction	$2.5 \cdot d \leq e \leq 6 \cdot d$	
	Two rows of rivets in the load direction	$4 \cdot d \leq e \leq 7 \cdot d$ $3 \cdot d \leq e_1 \leq 5 \cdot d$	
Edge distance	Perpendicular and parallel to the direction of the load	The larger of: $e_2 \geq 2 \cdot d$ $e_2 \geq 4 \cdot t$	

10.1.5.4 Riveting shall be carried out in such a way that the surfaces make good contact.
Example of tacking and riveting sequence is shown in the figure below.

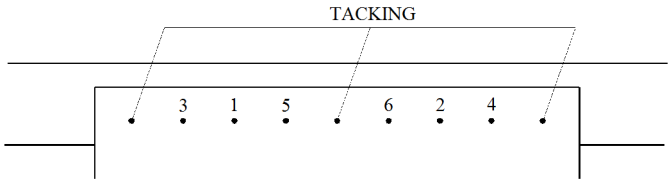


Figure 10-3 Tacking and riveting sequence

10.1.5.5 Blind rivets shall not be used in shell plating or stressed joints.

10.1.6 Joints by adhesive bonding

10.1.6.1 For adhesive bonds, static and dynamic strength including peel strength and impact resistance shall be documented.

10.1.6.2 The adhesive shall have such properties that the strength of the joint does not substantially deteriorate by temperature variations, water or other substances to which the joint will be exposed.

10.1.6.3 The bonding process shall be in accordance with the adhesive manufacturer's recommendations. Special consideration shall be given the pre-treatment of the surfaces to be bonded.

10.1.7 Other joints

10.1.7.1 Joints with through-bolts shall be designed as riveted joints. Self tapping screws are only allowed above waterline in joints carrying insignificant loads.

10.1.7.2 Bolts and nuts in joints below waterline shall be of aluminium or stainless steel. Galvanised steel may be allowed elsewhere.

10.1.7.3 Below waterline connections to stainless steel shall be galvanically insulated from the shell plating.

10.2 Steel materials

10.2.1 General

10.2.1.1 Steel material shall be stored in a way that corrosion is avoided

10.2.2 Welding

10.2.2.1 Welding of construction parts shall be done by or supervised by a welder with approved certificate for the actual or similar material and method of welding.

10.2.2.2 Welding procedures shall be approved on site.

10.2.2.3 Welding electrodes shall be stored in a dry and clean place.

10.2.2.4 Gas-shielded welding shall be performed indoors.

10.2.2.5 Horizontal welding shall be used as far as possible

10.2.2.6 The seams shall be cleaned and free from damaging paint, rust and dirt before welding.

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

10.2.2.8 Welds shall have a minimum throat thickness according to the following table:

Table 10-2 Minimum throat thickness

Plate thickness (mm)	*Throat thickness, a (mm)*
< 4	2.0
4 – 6.5	2.5
6.4 – 8	3.0
> 8	0.45 × thickness of thinnest plate

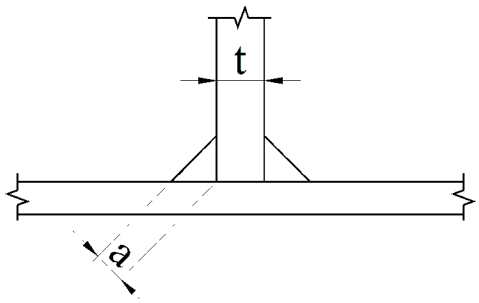


Figure 10-4 Throat thickness, a

10.2.2.9 The following items shall be welded with double side continuous fillet welding:

Table 10-3 Continuous welding

Continuous welding	Brackets for beams and other means of support
	Transverse frames below waterline and floors
	Foundations for engine(s), propulsion and equipment
	Keel and stem

10.2.2.10 For intermittent welding, the weld length and spacing shall be according to the following table:

Table 10-4 Intermittent welding

Thickness of plate: t (mm)	Weld length: l (mm)	Spacing: e (mm)
3 – 4.5	50	100
5 – 6.5	65	130
7 – 8.5	75	150
9 – 10.5	100	200

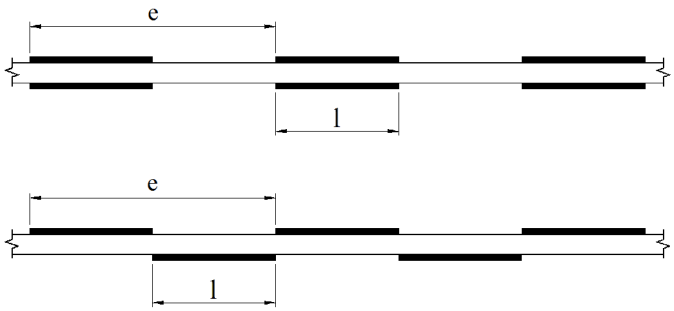


Figure 10-5 Intermittent welding

SECTION 11 FIBRE REINFORCED PLASTICS

11.1 Material properties

11.1.1 General

11.1.1.1 This section applies to fibre reinforced thermosets.

11.1.1.2 The manufacturer shall keep necessary information regarding the raw material.

11.1.2 Properties of reinforcement fibres, resins, sandwich core materials and sandwich adhesives

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

— Relevant DNV GL class programme
— ISO 12215-1
— ISO 12215-2
— other recognized standards.

11.1.3 Sandwich adhesives

11.1.3.1 If a standard for sandwich adhesives is not available, sandwich adhesives shall comply with the requirements given in Sec.14.

11.1.3.2 Requirements for un-cured material are given in [14.2.1].

11.1.3.3 Requirements for cured material are given in [14.2.2].

11.1.3.4 The approval of sandwich adhesives is separated into two different quality grades:

Grade 1 = Required quality of sandwich adhesives for hull constructions
Grade 2 = Required quality of sandwich adhesives for less critical applications.

The approval shall be related to a set of physical properties which shall be specified in the Type Approval Certificate. The minimum properties shall be specified by the manufacturer and verified by the approval testing.

11.2 Manufacturing

11.2.1 Introduction

11.2.1.1 In this section requirements related to the manufacturing, quality assurance and quality control of FRP structures are given. It is to be recognised by the yard that there are limited or no means for non-destructive examination of FRP structures available. The yard shall therefore recognise the importance of exercising a rigorous control of all steps of the fabrication to ascertain that the finished product complies with its specification(s).

11.2.1.2 The use of fabricating procedures differing from those specified in this section will be subject to special consideration.

11.2.2 Storage of raw materials

11.2.2.1 Storage premises shall be so equipped and arranged that the material supplier's directions for storage and handling of the raw materials can be followed.

11.2.2.2 Storage premises for reinforcement materials shall be kept dry and clean so that the raw material is not contaminated. The materials shall be stored in unbroken original packaging before being used. Materials on which the original packaging has been broken shall be adequately protected against contamination when stored again after use.

11.2.2.3 Reinforcement materials shall normally be stored at the same temperature and humidity as the workshop in which they are going to be used. If the storage temperature is not the same the material shall be acclimatised at the workshop temperature and humidity prior to being deployed. The time of acclimatisation shall be adequate for the amount of reinforcement: for unbroken packages the acclimatisation shall have duration of at least two days.

11.2.2.4 Resins, gelcoat, hardeners, additives etc. shall be stored according to the manufacturers recommendations as regards temperature, shelf life etc. Raw materials which are stored at temperatures lower than + 18°C shall be acclimatised to the temperature of the workshop prior to being used. Tanks for resins etc. are to be handled during storage according to the manufacturer's recommendations and equipped and arranged accordingly.

11.2.2.5 Sandwich core materials shall be stored dry and protected against contamination and mechanical damage. Sandwich core materials shall normally be stored at the same temperature as the workshop in which they are going to be used. If the storage temperature is not the same the material shall be acclimatised for at the workshop temperature and humidity prior to being deployed.

11.2.2.6 Sandwich core materials shall be stored in such a way that out-gassing of the material is ensured prior to being used. Outgassing shall be carried out according to the manufacturer's recommendations. When new free surfaces are created in the material, e.g. by sanding, cutting or machining, proper outgassing shall be ensured again.

11.2.2.7 Pre-pregs shall be stored according to the manufacturer's recommendation. For pre-pregs stored in refrigerated conditions a log shall be carried for each package showing the time and at which temperature the package has been stored/used outside its normal storage conditions.

11.2.3 Manufacturing premises and conditions

11.2.3.1 Manufacturing premises shall be so equipped and arranged that the material supplier's directions for handling the materials, the laminating process and curing conditions can be followed.

11.2.3.2 The manufacturing premises shall be free from dust and other contamination that may in any way impair the quality of the end product.

11.2.3.3 The air temperature in the moulding shops shall not be less than +18°C. The stipulated minimum temperature shall be attained at least 24 hours before commencement of lamination, and shall be maintainable regardless of the outdoor air temperature.

The temperature in the moulding shop shall not vary more than ±5°C. This limit can be exceeded provided it has no detrimental effect on the product and provided there is no risk for condensation of humidity.

11.2.3.4 The relative humidity of the air shall be kept so constant that condensation is avoided and shall not exceed 80%. A higher relative humidity can be accepted on a case by case basis provided an adequate margin against the risk for condensation of humidity is provided. In areas where spray moulding is taking place, the air humidity shall not be less than 40%. The stipulated air humidity shall be maintainable regardless of outdoor air temperature and humidity. More stringent requirements to humidity shall be adhered to if recommended by the manufacturer.

11.2.3.5 Other manufacturing conditions may be accepted based on special agreement with the Society provided that condensation of humidity can be safely avoided.

11.2.3.6 Air temperature and relative humidity shall be recorded regularly and the records filed for a period of at least two years. In larger shops there shall be at least one thermohydrograph for each 1500 m^2 where lamination is carried out. The location of the instruments shall be such as to give representative measurement results.

11.2.3.7 Draught through doors, windows etc. and direct sunlight is not acceptable in places where lamination and curing are in progress.

11.2.3.8 The ventilation plant shall be so arranged that the curing process is not negatively affected.

11.2.3.9 Sufficient scaffoldings shall be arranged so that all lamination work can be carried out without operators standing on the sandwich core or on surfaces on which lamination work is taking place.

11.2.3.10 During lamination of larger constructions the temperature shall be recorded at least at two levels vertically in the workshop and the curing system shall be adjusted to compensate for possible temperature differences.

11.2.3.11 Prefabrication of panels and other components shall be carried out on tables, fixtures etc. above the shop floor level. No fabrication shall be carried out on the shop floor.

11.2.4 General requirements to production procedures and workmanship

11.2.4.1 Raw materials for all structural members covered by the rules shall be of approved type in accordance with [9.2]. The supplier's directions for application of the materials shall be followed.

11.2.4.2 Specified procedures shall be implemented for all tasks with significance to the quality of the end product. Where necessary to exercise a satisfactory control of the quality, these procedures shall be documented in writing in controlled documents.

11.2.4.3 The reference direction of reinforcement shall after being laid not deviate from that specified by more than ±5°.

11.2.4.4 Adjacent sheets of reinforcement shall in the normal case overlap to give structural continuity. The overlap length shall be such that the shear capacity of the overlap is not smaller than the tensile strength (perpendicular to the overlap) of the overlapping plies. The shear strength of the matrix shall not be assumed larger than 8 MPa. A higher shear strength can be assumed subject to the approval of the Society. (E.g. for a 0/90° 1000 g/m^2 type glass reinforcement the overlap shall not be smaller than 30 mm.) In areas of low utilisation, overlaps may be dispensed with subject to the approval of the Society. Overlaps shall be staggered through the thickness of the laminate. The distance between two overlaps in adjacent plies shall not be smaller than 100 mm.

11.2.4.5 Thickness changes in a laminate shall be tapered over a minimum distance equal to 20 times the thickness difference.

11.2.4.6 Thickness changes in sandwich core materials shall be tapered over a minimum distance equal to 3 times the thickness difference. A larger distance may be required to maintain structural continuity of the skins.

11.2.5 Sandwich lay-up

11.2.5.1 Sandwich constructions can be fabricated either by:

— lamination on the core
— application of the core against a wet laminate
— by bonding the core against a cured skin laminate using a sandwich adhesive
— by resin transfer, i.e. resin transfer moulding of the core together with one or both of the skin laminates.

11.2.5.2 An efficient bond is to be obtained between the skin laminates and the core and between the individual core elements. The bond strength shall not be smaller than the tensile- and shear strength of the core. The application of a light CSM between the core and skin laminate may be advantageous in this respect.

11.2.5.3 Adequate tools for cutting, grinding etc. of various types of core material shall be specified in the production procedure.

11.2.5.4 All joints between skin laminates and core and between the individual core elements shall be completely filled with resin, sandwich adhesive or filler material. The joint gap between core blocks shall in general not be larger than 3 mm. Larger gaps may be accepted if necessary, based on the characteristics of the sandwich adhesive or filler (e.g. its viscosity) and the thickness of the core. For slamming exposed areas a larger gap width should also be reflected in the qualification testing of the core material and the sandwich adhesive, i.e. during slamming testing.

11.2.5.5 Core materials with open cells in the surface, shall normally be impregnated with resin before it is applied to a wet laminate or before lamination on the core is commenced.

11.2.5.6 When the core is applied manually to a wet laminate the surface shall be reinforced with a chopped strand mat of 450 g/m^2 in plane surface and 600 g/m^2 in curved surfaces. If vacuum is applied for core bonding the surface mats may be dispensed with provided it is demonstrated in the qualification tests that an efficient bond between core and skin laminate is obtained.

11.2.5.7 If the core is built up by two or more layers of core and any form of resin transfer is used, arrangements shall be made to ensure proper resin transfer and filling between the core blocks. This should be achieved by scoring or holing the core blocks and by placing a reinforcement fabric between the core blocks to facilitate resin distribution.

11.2.5.8 Frameworks for core build up shall give the core sufficient support to ensure stable geometrical shape of the construction and a rigid basis for the lamination work.

11.2.5.9 When a prefabricated skin laminate is bonded to a core, measures shall be taken to evacuate air from the surface between skin and core.

11.2.5.10 The core material shall be free from dust and other contamination before the skin laminates are applied or core elements are glued together. The moisture content shall be sufficiently low not to have any adverse effect on curing. The acceptable moisture content shall be specified by the manufacturer of the core material.

11.2.5.11 When vacuum-bagging or similar processes are used it shall be ensured that curing in the sandwich adhesive has not been initiated before vacuum is applied.

11.2.6 Manual lamination

11.2.6.1 The reinforcement material shall be applied in the sequence stated on the approved plan(s).

11.2.6.2 When the laminate is applied in a mould a CSM of max. 450 g/m^2 shall be applied next to the gelcoat. The mat can be dispensed with provided a satisfactory resistance against water can be ensured.

11.2.6.3 The resin shall be applied on each layer of reinforcement. Gas and air pockets shall be worked out of the laminate before the next layer is applied. Rolling of the layers shall be made carefully, paying special attention to sharp corners and transitions. The viscosity and gel-time of the resin shall be adequate to prevent drain-out of resin on vertical and inclined surfaces. The tools and methods used when working the laminate shall not damage the fibres.

11.2.6.4 The time interval between applications of each layer of reinforcement shall be within the limits specified by the resin supplier. For thicker laminates care shall be taken to ensure a time interval sufficiently large to avoid excessive heat generation.

11.2.6.5 Curing systems shall be selected with due regard to the reactivity of the resin and in accordance with the supplier's recommendations. Heat release during curing shall be kept at a safe level in accordance with the material manufacturer's recommendations. The quantity of curing agents shall be kept within the limits specified by the supplier.

11.2.6.6 After completion of lamination, polyester laminates shall cure for at least 48 hours at an air temperature of minimum +18°C. Curing at a higher temperature and a shorter curing time may be accepted on the basis of control of the curing rate. For other types of resins curing shall be carried out according to the specified cure cycle and according to the resin manufacturer's recommendations.

11.2.7 Vacuum assisted resin transfer moulding (VARTM) and vacuum-bagging

11.2.7.1 Points of resin injection shall be located and opened and closed in a sequence such that complete filling of the mould without any air being trapped is ensured.

11.2.7.2 The resin shall be formulated, based on the resin manufacturer's recommendations, such that an adequate viscosity and gel-time is obtained to enable filling of the complete mould and such that the maximum temperature during cure is kept within acceptable limits, e.g. with respect to the temperature sensitivity of sandwich core materials.

11.2.7.3 The pressure level (vacuum) in the mould shall be specified prior to infusion. The pressure shall be adequate to ensure adequate consolidation of the laminate and that the specified mechanical properties are reached and that the mould is properly filled. The pressure shall be maintained throughout the mould during the cure cycle of the laminate, at least past the point of maximum temperature in the laminate, and the specified hold time. The vacuum shall be monitored by the use of pressure gauges distributed throughout the mould such that a reliable indication of the pressure distribution is obtained. This means that pressure gauges shall be placed far away from vacuum suction points. Adequate means to locate and repair leakage shall be deployed.

11.2.8 Spray moulding

11.2.8.1 The term spray moulding is understood to mean the simultaneous deposit of resin and fibreglass reinforcement. Manufacturers using this method are subject to special approval.

11.2.8.2 When approval of the spray moulding process is considered, special attention will be paid to production arrangement, ventilation equipment, the manufacturer's own quality control and other factors of significance to the quality of the finished product.

11.2.8.3 Spray moulding of structural members shall be carried out only by specially approved operators.

11.2.8.4 The equipment used for spray moulding shall give an even and homogenous build up of the laminate. Any dosage devices shall ensure an even application of additives to the polyester resin. No fibres shall be shorter than 19 mm.

11.2.8.5 When spray moulding there shall be an even application over the entire surface. Regular rolling out of the sprayed-on layers shall be carried out. Next to the gelcoat rolling out shall be done for max. 1.5 mm thickness of finished laminate thickness, subsequently for at least each 2.5 mm of finished laminate thickness. The rolling out shall be done thoroughly to ensure adequate compression and removal of gas and air pockets. Special care shall be taken at sharp transitions and corners.

11.2.9 Curing

11.2.9.1 Cure cycles shall be documented by temperature records.

11.2.9.2 For cure taking place at room temperature in the workshop the registrations made in the workshop are sufficient to document the cure cycle.

11.2.9.3 For cure at elevated temperature, fans with ample capacity shall be operated in the compartment in which the cure is carried out to ensure an even distribution of temperature. Continuous records of temperature throughout the complete cure cycle shall be provided. Recording points shall be distributed throughout out the length, width and height of the cure compartment to the extent necessary to verify that the temperature distribution is even.

11.2.10 Secondary bonding

11.2.10.1 A secondary bonding is defined as any bond between two FRP structures which is made after one or both of the individual structures has effectively cured.

11.2.10.2 The surface ply of a laminate subject to secondary bonding and the first ply of the bonding laminate shall normally be of CSM. This mat can be dispensed with provided the necessary bond strength is reached.

11.2.10.3 Surfaces in way of secondary bonding shall be clean and free from dust and other forms of contamination.

11.2.10.4 Laminates on which secondary bonds are to be carried out shall have an adequate surface preparation, normally including grinding.

11.2.10.5 If "peel strips" are used in the bonding surface the required surface treatment may be dispensed for.

11.2.11 Adhesive bonding

11.2.11.1 Adhesive bonds shall be carried out according to the same procedure(s) as on which the design and qualification testing has been based and according to the recommendations from the manufacturer of the adhesive. Procedure(s) shall be submitted to the Society prior to commencement of the bonding work. The

procedure(s) shall give clear requirements to all factors that can affect the quality of the bond. As a minimum the following shall be covered:

— working conditions
— surface preparation
— application
— clamp-up
— curing cycle etc.

SECTION 12 THERMOPLASTICS

12.1 Polyethylene (PE) and acrylonitrile butadiene styrene (ABS)

12.1.1 General requirements

12.1.1.1 The approval is given to the manufacturer who produces the raw material at the final stage before boat 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.

12.1.1.2 Ageing properties shall be verified on sheet material with pigments etc. which shall be used in the production.

12.1.1.3 The content of pigments shall not exceed 4% and are to be evenly distributed in the material. Any detrimental effect on the strength of the material shall be recorded.

12.1.1.4 The impact strength of the material at low temperatures is approved in relation to the fracture character at pendulum notch impact testing. Brittle fracture at temperatures above 0°C shall not be accepted. If the transition between tough and brittle fracture occurs between 0°C and -20°C, the following statement shall be entered on the boat's certificate:

The impact strength of the plastic material is reduced at low temperatures. The craft is not recommended to be used in cold temperatures.

12.1.1.5 The ability of the material to withstand heating by sunlight is subject to approval on the basis of the reduction in the material stiffness between 20°C and 65°C. A reduction in the shear modulus of the material greater than 80% shall not be accepted. If the reduction is between 30% and 80%, the following statement shall be entered on the boat's certificate:

The material softens at high temperatures and may be permanently deformed by long term loading at high temperatures.

12.1.2 Documentation

12.1.2.1 [14.3] specifies requirements for properties and documentation.

12.1.2.2 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.

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

12.1.3 Properties of polyethylene

12.1.3.1 Polyethylene shall comply with the requirements given in [14.3.2]. The test specimens shall be taken from material manufactured in accordance with a method representative for the boat production.

12.1.4 Properties of ABS

12.1.4.1 ABS shall comply with the requirements given in [14.3.3]. The test specimens shall be taken from material manufactured in accordance with a method representative for the boat production.

12.1.4.2 The tolerance on the sheet thickness shall not exceed the following:

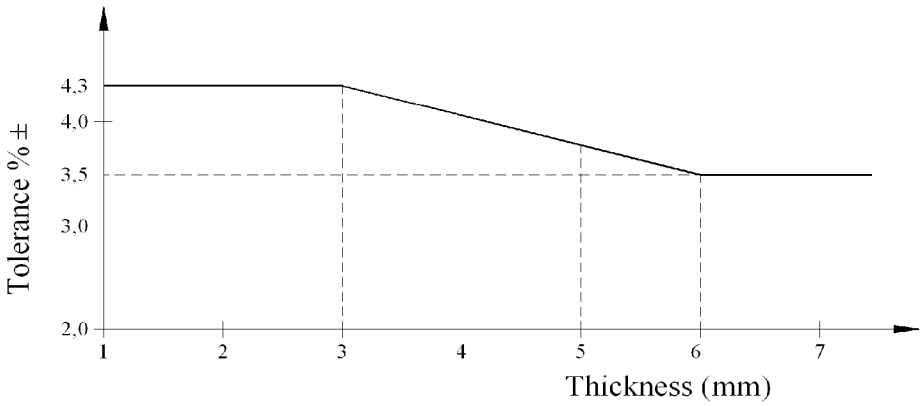


Figure 12-1 Tolerance on sheet thickness

12.1.4.3 Tolerance shall be based on measurements at 20 points evenly distributed over the width of the sheet. The average thickness shall not be less than the nominal sheet thickness.

12.1.4.4 Individual values for shrinkage during heating shall not exceed the following:

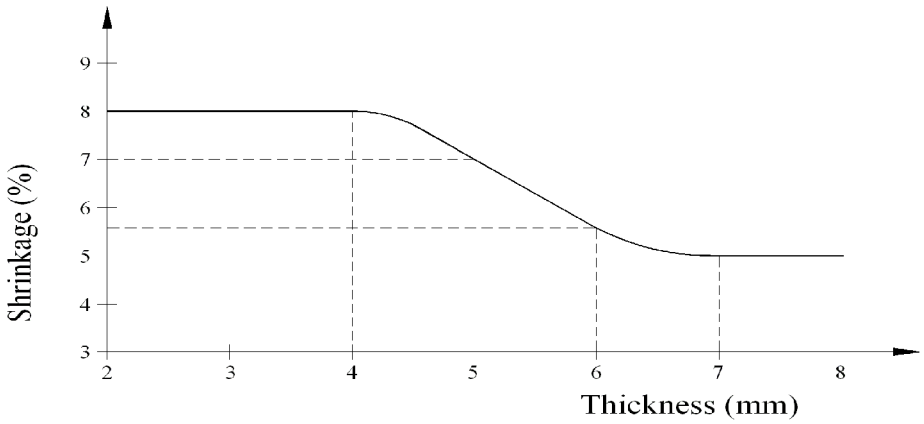


Figure 12-2 Shrinkage during heating

12.1.4.5 The shrinkage of the sheet shall be checked by taking at least 6 specimens measuring approximately 300 × 300 mm from places evenly distributed over the width of the sheet. On each specimen the plate direction is to be indicated, and a circle of diameter 100 mm is marked. The specimens are then placed in talcum powder between metal plates for 30 minutes at a specified temperature. The metal plates shall have a thickness of 0.6 to 0.8 mm.

SECTION 13 OTHER MATERIALS

13.1 Buoyancy materials

13.1.1 Requirements

13.1.1.1 By buoyancy material is meant a low density material e.g. foam with a specific gravity of less than 1.0, which provides buoyancy to the craft when flooded.

13.1.1.2 The water absorption of buoyancy materials shall not exceed 8% by volume after being submerged for 8 days according to ISO 2896. Material complying with IMO Resolution MSC.81(70) shall be deemed to satisfy this requirement.

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

13.1.1.4 Results from tests or compliance to Resolution shall be documented.

13.2 Fabrics for RIB collars

13.2.1 General

13.2.1.1 Fabrics for RIB collars shall be selected by the manufacturer according to the stresses to which the craft is to be subjected (shape, dimensions, maximum load, installed power etc.), and also to the intended service conditions. Use under normal seagoing conditions shall not materially impair their performance.

13.2.1.2 Fabrics for RIB collars shall be tested according to ISO 6185-3 section 4.2.2. The test results shall be documented.

13.2.1.3 RIB collars shall retain their full serviceability within the operating temperature range of -20°C to +60°C.

13.3 Wood

13.3.1 General

13.3.1.1 Timber and plywood shall be suitable for the application and a marine environment.

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

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

13.3.2 Constructional timbers

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

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

13.3.2.3 Constructional timber shall be stored in dry and well ventilated premises free from direct sunlight. Each piece shall be stored flat and held apart from other pieces in order to give satisfactory air circulation.

13.3.3 Plywood

13.3.3.1 Plywood to be used in hull and deck structure shall comply with BS 1088, BS 4079 or other equivalent standard.

13.3.3.2 The facing veneers shall have a good, solid surface free from visible defects.

13.3.3.3 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.

13.3.3.4 Plywood shall be stored flat on a level bed in dry and well ventilated premises free from direct sunlight.

13.3.4 Adhesives for timber and plywood

13.3.4.1 Adhesives shall comply with BS 1204 or other equivalent standard.

13.3.4.2 Adhesives shall be stored according to the manufacturer's recommendation.

SECTION 14 TABLES OF MATERIAL PROPERTIES

14.1 Reinforcement fibres, resin and sandwich core materials

14.1.1 Mechanical properties

14.1.1.1 Minimum mechanical properties are given in the standards that are accepted for certification of the material in question.

14.2 Sandwich adhesives

14.2.1 Un-cured condition

Table 14-1 Sandwich adhesives, uncured

Property	*Unit*	*Test method*	*Requirement*
Density		ISO 3521	Manufacturer's nominal value ±10% To be given for information.
Viscosity		ASTM D 1084 method B (for free-flowing adhesives)	Manufacturer's nominal value ±20% To be given for information. To be given on works certificate.

14.2.2 Cured condition

Table 14-2 Sandwich adhesives, cured material

Property	*Unit*	*Test method*	*Required values for approval testing* *) *May be required tested at production of the craft*		
			Grade 1	*Grade 2*	
Tensile strength, flatwise	MPa	ASTM C 297(specimen: 5×5 cm, speed: 1 mm/min.) — at 23°C: — at heat resistance temperature:	≥ 1.0 > 80% of Msmv	≥ 1.0 > 80% of Msmv	

Property	*Unit*	*Test method*	*Required values for approval testing* *) *May be required tested at production of the craft*		
			Grade 1	*Grade 2*	
Heat resistance	Temp., °C min.	Percentage retention of tensile strength (ASTM C 297 specimen: 5×5 cm, speed: 1 mm/min., min. 45°C) after conditioned to heat resistance temperature	45	45	
Tensile strength and Fracture elongation	MPa %	ISO 527 (Specimen thickness 4 mm) — at -10°C — at 23°C — at heat resistance temperature	Msmv to be given for information ≥ 2.0 ≥ 3.5 ≥ 3.5	Msmv to be given for information ≥ 1.0 ≥ 2.0 ≥ 2.0	* *
Shear strength	MPa	ISO 1922 [1] (23°C)	≥ 0.4	≥ 0.4	
Overall volume shrinkage	%	ISO 3521 [2]	Msmv to be given for information	Msmv to be given for information	
Water resistance	%	Percentage retention of tensile strength (ASTM C 297 specimen: 5×5 cm, speed: 1 mm min., 23°C) after 4 weeks in water at 40°C.	≥ 80	≥ 80	

Msmv: Manufacturer's specified minimum value

1) The test samples are to be made of two pieces of high density core material, preferably PVC foam, with the sandwich adhesive located in the mid plane parallel to the steel supports. The sandwich adhesive layer shall be > 1 mm thick.

2) Curing shrinkage is relevant for gap filling adhesives only.

14.3 Polyethylene (PE) and acrylonitrile butadiene styrene (ABS)

14.3.1 Properties in general for PE and ABS

Table 14-3 Properties and documentation of PE and ABS

Properties	*Test method*	*Results to be given for information except where noted. * Also required by delivery*	
Tensile properties	ISO 527-2 (Test specimen type 2, 5-50 mm/min.)	Curve at 20°C and 65°C	
Shear modulus	ISO 761-2 (torsion pendulum)	Curve for temperature range -20°C -65°C	
Creep	ISO 899-1 (carried out on at least 3 stress levels and 2 test pieces per level)	Isochronous stress-deformation diagram for 1000, 100, 10, 1 and 0.1 hours at 20°C and 65°C	
Fatigue	Fatigue test carried out with constant stress or deformation amplitude	Curves up to at least 100.000 loading cycles at 20°C	* ABS
Hardness	ISO 868 (Shore D)	Given at 20°C, read after 15 seconds	
Falling weight impact	ASTM D 3029 (method A). The radius of the drop hammer's striking surface is to be 12.5 mm	Fracture energy by visible crack as fracture criterion, given at 0°C and at 20°C and with relevant material thickness	
Pendulum impact	With V-notch 45° in accordance with ISO 180. For particularly flexible materials an alternative test method (tensile impact strength) may be used	Fracture energy at 0°C as well as a description of fracture type The notch impact strength is only stated for non-aged materials	
Ageing	ISO 179-1 (Charpy) without notch: Natural ageing DIN 53386, item 6.1. Accelerated ageing: DIN 53387	Plotted fracture energy for aged materials as a function of logarithmic time. The time is normally to cover 48 months natural ageing or 5 000 hours accelerated ageing. A shorter time can be approved if the ageing process is clarified at an earlier stage	
Fuel resistance	Stressed material submerged in normal engine fuel	Description of surface cracking	

Properties	*Test method*	*Results to be given for information except where noted.* ** Also required by delivery*	
Melt index	ISO 1133-1	To be given for polyethylene	
Chemical resistance	ISO 175	List of chemicals which may damage the material	
Density	ISO 1183-2	To be given for polyethylene	PE *
Oxygen index	ASTM D 2863	Value	PE *

14.3.2 Properties for polyethylene

LDPE = Low density polyethylene
MDPE = Medium density polyethylene

Table 14-4 Properties of polyethylene

Property	*Requirement LDPE*	*Requirement MDPE*	*Unit*	*Comments*
Density	- 0.930	0.930 - 0.945	g/cm^3	
Melt index	Stated value ±1.0 Though max. 3.5	As LDPE	g/10 min.	
Tensile yield stress	min. 7.5 min. 4.5	min. 13.0 min. 8.0	N/mm^2 N/mm^2	At 20°C At 65°C
Elasticity modulus in tensile yield	min. 180	min. 350	N/mm^2	At 20°C
Tensile creep strength	max. 2.5 at stress 2.0	2.0 at stress 3.0	% N/mm^2	Deformation after 100 hours at 20°C
Hardness	Stated value ±3	As LDPE	Shore D	Tested at 20°C and read after 15 sec.
Impact strength (drop test without notch)	min. 15	min. 15	J/mm thickness	Freely supported test piece 0°C
Notch impact strength (pendulum test with notch)	Not brittle fracture	Not brittle fracture	Visual	Required only for boats with single skins 0°C
Pore contents	max. 15 max. 20	As LDPE As LDPE	% of thickness % of thickness	In structural parts In the boat elsewhere

Property	*Requirement LDPE*	*Requirement MDPE*	*Unit*	*Comments*
Impact tensile strength of aged material	Not brittle fracture min. fracture energy 1.0 J/cm^3	As LDPE J/cm^2	Visual	Aged material corresponding to 4 years of natural ageing, tested at 0°C and with a test speed 2×10^5 %/mm

14.3.3 Properties for acrylonitrile butadiene styrene (ABS)

Table 14-5 Properties of ABS

Properties	*Requirements*
Tensile yield stress	Min. 30 N/mm^2 at 20°C Min. 18 N/mm^2 at 65°C
Modulus of elasticity	Min. 1600 N/mm^2 at 20°C
Creep	Max. 1.0% deformation after 100 hours at a stress of 7.0 N/mm^2 at 20°C
Bending fatigue strength	At deformation amplitude of 1% and frequency 0.5 Hz the material is to withstand 50 000 load cycles before fracture
Notch impact strength	Min. 2 kJ/m^2 at 20°C in accordance with ISO 179 without notch
Impact strength (pendulum) of aged material	After ageing corresponding to 4 years' natural ageing, the material is to have a fracture energy of at least 2.5 kJ/m^2

SECTION 15 DESIGN PRINCIPLES

15.1 Documentation

15.1.1 Plans and particulars

15.1.1.1 The following plans shall be submitted for approval:

— midship section including main particulars (L_{wl}, B_{wl}, Δ, L) and maximum speed V
— profile and decks
— longitudinal and transversal stiffening members
— shell expansion and framing including openings
— watertight bulkheads and transom including openings and their closing appliances
— tank structure
— engine room structures including foundation for heavy machinery components
— aft peak structures
— forepeak structures
— superstructures and deckhouses including openings with sill heights and their closing appliances
— hatchways, hatch covers and ports including securing and tightening appliances
— Propeller shaft material and dimensions
— propeller shaft brackets with their attachments to the hull
— appendages with their attachments to the hull
— rudder and rudder stock with details of bearings and seals
— arrangement and particulars of anchoring and mooring equipment.

Additional documentation may be required.

Guidance note:

Identical or similar structures in various positions are recommended covered by the same plan.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

15.1.1.2 The following plans shall be submitted for information:

— general arrangement
— tank arrangements
— capacity plan
— body plan
— arrangement of cathodic protection.

15.1.1.3 Additional documentation required are listed in the appropriate sections.

15.1.2 Strength calculations

15.1.2.1 Strength calculations shall normally be submitted for reference to demonstrating that stresses are within required limits.

15.2 Alternative design standards

15.2.1 DNV GL rules for HSLC

15.2.1.1

Application of standards for structural strength design			
V	L_{WL}	*Loads taken in accordance with*	*Scantling requirements taken in accordance with*
> 45 knots	> 18 m	DNV GL RU HSLC Pt.3 Ch.1	DNV GL RU HSLC Pt.3 Ch.2, RU HSLC Pt.3 Ch.3 or RU HSLC Pt.3 Ch.4 (as applicable for hull structure material)
> 45 knots	≤ 18 m	Subject to special consideration by DNV GL and agreement with client.	
≤ 45 knots	----	Sec.16	Sec.17, Sec.18 or Sec.19 or DNV GL RU HSLC Pt.3 Ch.2, RU HSLC Pt.3 Ch.3 or RU HSLC Pt.3 Ch.4 (as applicable for hull structure material)

SECTION 16 DESIGN LOADS

16.1 General

16.1.1 Application

16.1.1.1 The design loads in this section shall only be applied in association with the strength formulas given in this section.

16.1.2 Local reinforcements

16.1.2.1 Structure with local loads from cargo, fenders, deck-gears, foundations etc., shall be reinforced for the actual loads. Forces from cranes shall be multiplied by a factor 1.4. Glass reinforced plastics and wooden crafts shall be reinforced in areas of local wear.

Guidance note:

Crafts intended for beaching shall have rubbing strips and reinforced stem.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

16.2 Design loads

16.2.1 Longitudinal strength

16.2.1.1 The maximum longitudinal bending moment for craft operating entirely in displacement mode shall not be taken less than:

$$M = 0.016 \cdot L_{WL}^{3} \cdot B_{WL} \text{ (kNm)}$$

For other craft the maximum longitudinal bending moment shall not be taken less than the larger of:

1) $M = 0.016 \cdot L_{WL}^{3} \cdot B_{WL}$ (kNm)

2) $M = 0.0025 \cdot \Delta \cdot L_{WL}$ (kNm)

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 central 25% of L with a linear reduction to zero at the fore and aft end of the craft.

16.2.2 Sea pressure on hull bottom

16.2.2.1 The design sea pressure, P_b, acting on the hull 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

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 crafts 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

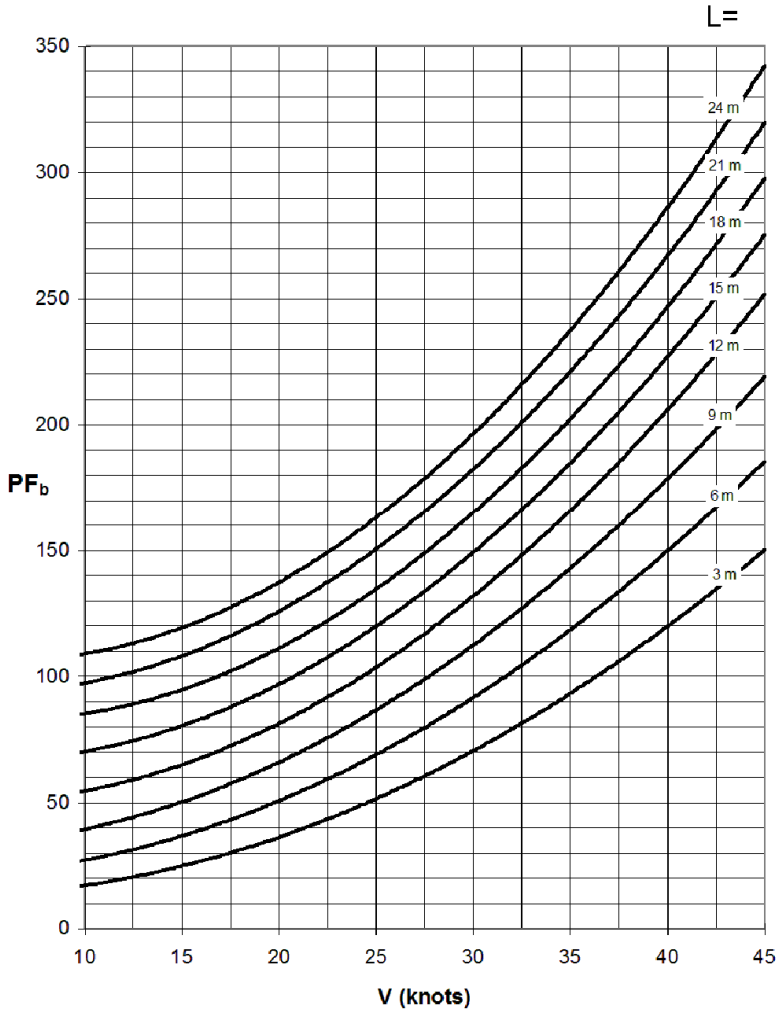
A_d = s^2 (m^2) for plates and panels

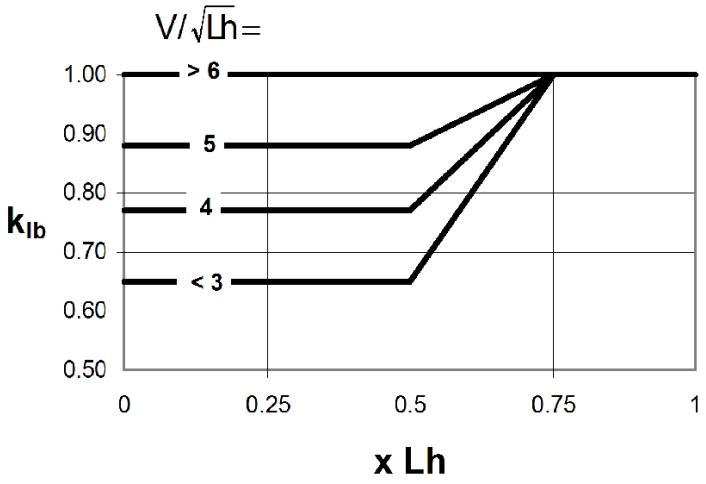
A_d = $s \cdot l$ (m^2) for frames/stiffeners

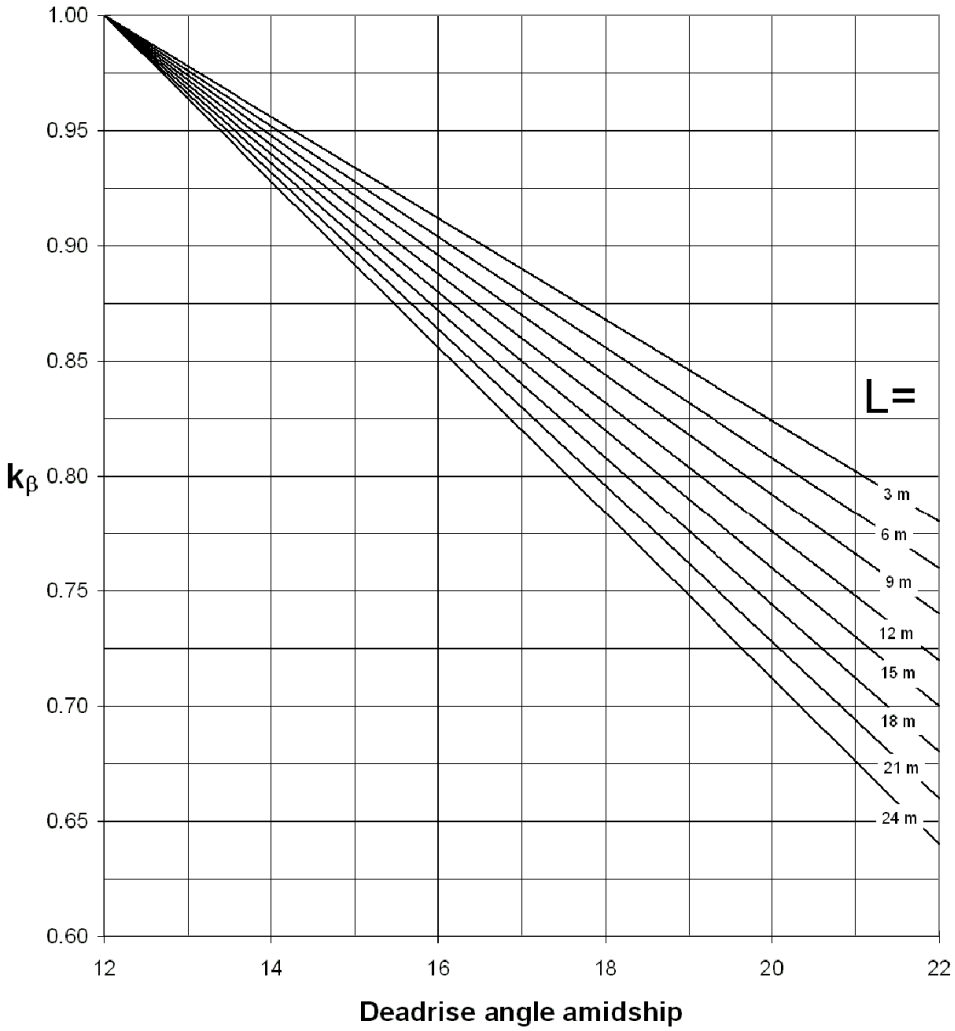
A_r = $0.2 \cdot L \cdot B$ (m^2)

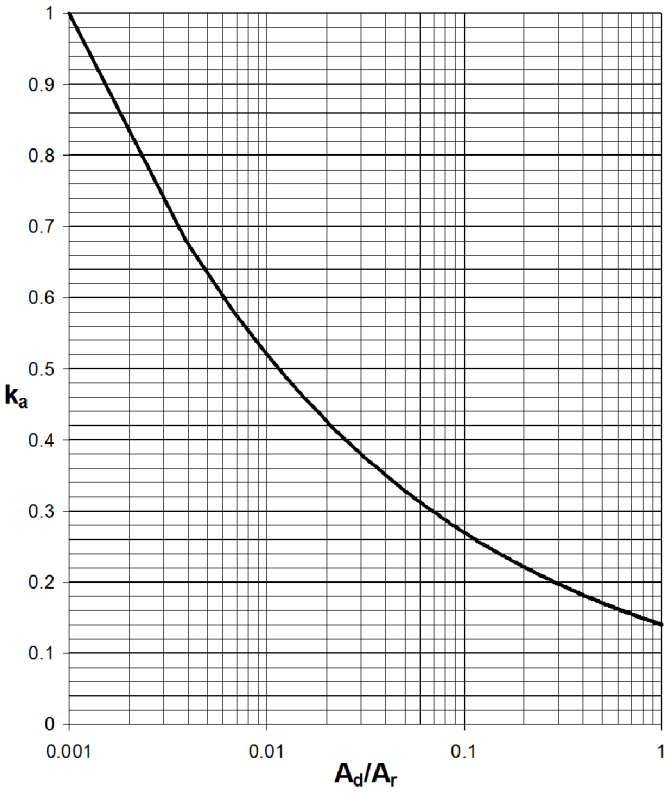
s = shortest panel edge or load breadth for stiffening members in metres

l = span length of stiffening members in metres.



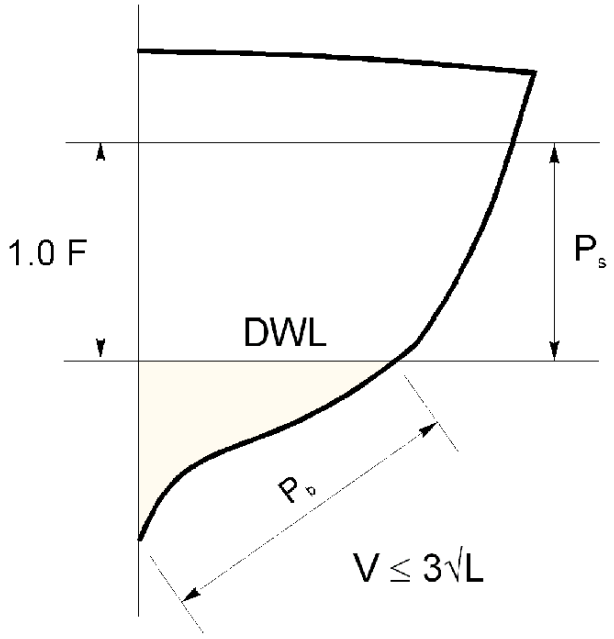

V/√Lh=
> 6
5
4
< 3
1.00
0.90
0.80
0.70
0.60
0.50
klb
0
0.25
0.5
0.75
1
x Lh

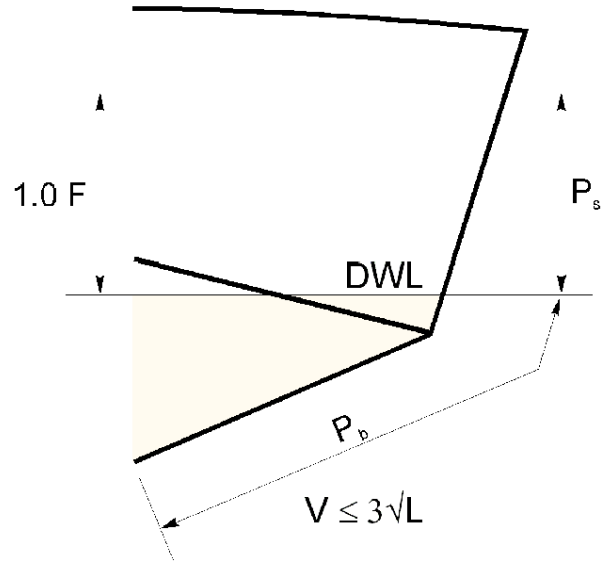

1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
kβ
L=
3 m
6 m
9 m
12 m
15 m
18 m
21 m
24 m
12
14
16
18
20
22
Deadrise angle amidship

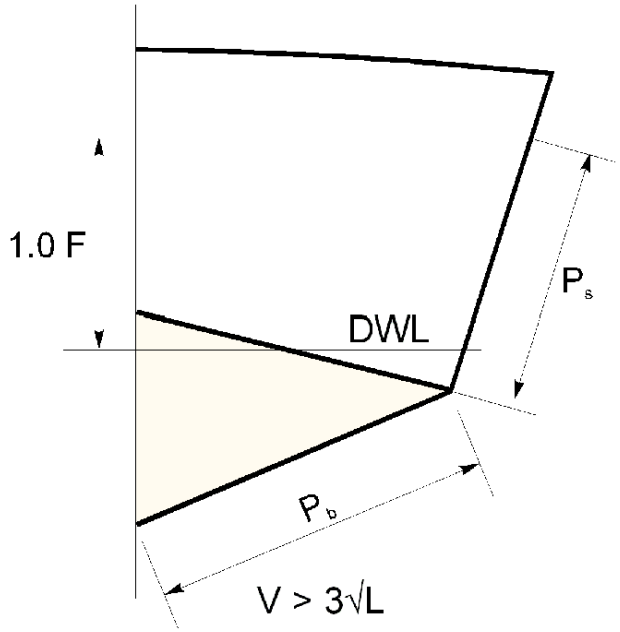


16.2.2.2 The vertical extension of the design sea pressure, P_b, shall be as follows:

- up to the deepest w.l. for crafts with $V \leq 3\sqrt{L}$
- up to the chine for crafts with $V > 3\sqrt{L}$


1.0 F
P_s
DWL
P_p
$V \leq 3\sqrt{L}$


1.0 F
P_s
DWL
P_p
$V \leq 3\sqrt{L}$



16.2.3 Sea pressure on hull side

16.2.3.1 The design sea pressure acting on the hull side shall not be taken less than:

$$P_s = PF_s \cdot k_{ls} \cdot k_v \cdot k_a \ (kN/m^2)$$

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 = $\frac{F_v - h}{F_v}$ for vertical distribution factor

= minimum 0.5 for design category A and B.

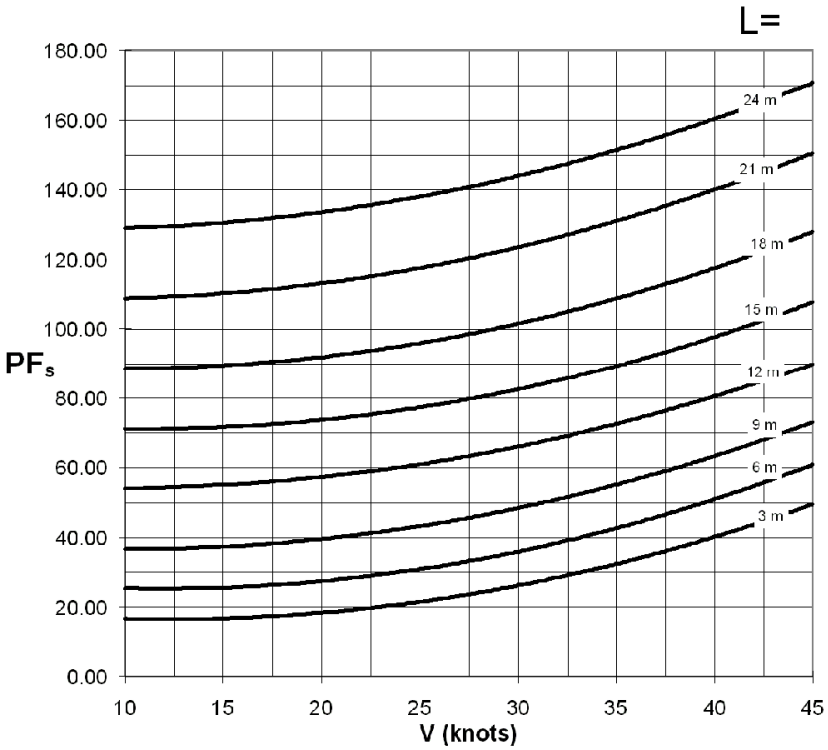
F_v = $\frac{4.5\Delta}{100LB}$

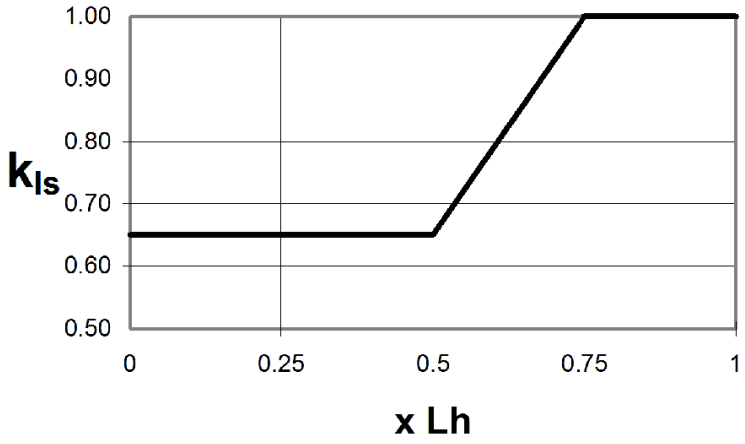
h = distance from side/bottom transition to the load point (m).

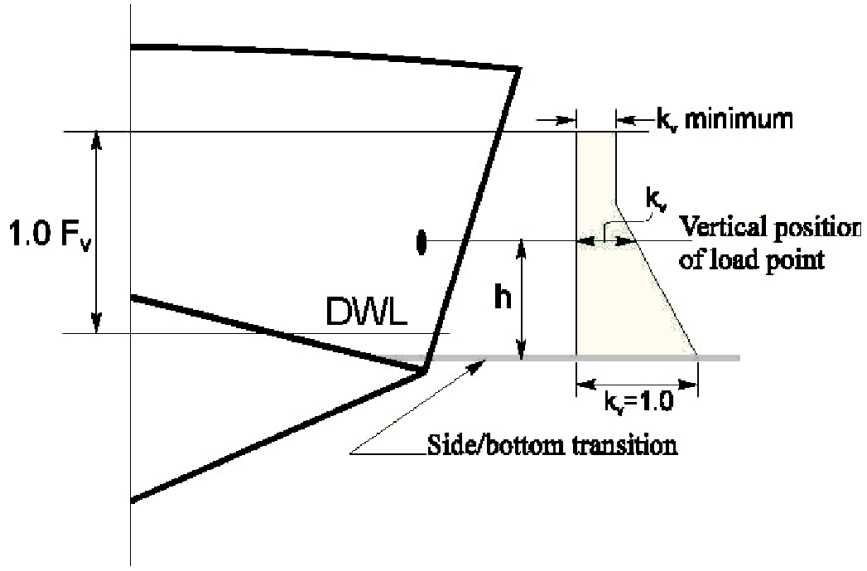
$$F_v = \frac{4.5\Delta}{1000LB}$$

= distance from side/bottom transition to the load point (m).

PF_s, F, h and k_v are shown on the figures below.


L=
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
PFs
24 m
21 m
18 m
15 m
12 m
9 m
6 m
3 m
10
15
20
25
30
35
40
45
V (knots)


1.00
0.90
0.80
0.70
0.60
0.50
kls
0
0.25
0.5
0.75
1
x Lh



16.2.4 Design loads on decks and superstructures

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

P_d = $k_d \cdot L + 4.5$ (kN/m^2)

k_d = 0.2 for exposed main weather deck and superstructure deck forward of 0.25 L from FP

= 0.1 for exposed superstructure decks elsewhere.

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

$$P_{dc} = 10H\left(1 + 0.2\frac{V}{\sqrt{L}}\right)$$

H = deck cargo in t/m^2

= 0.35 t/m^2 for accommodation decks.

16.2.4.3 The design sea pressure on superstructures and deck houses shall not be taken less than given in Table 16-1:

Table 16-1

Position	*p (kN/m^2)*
Front bulkhead	0.3 L + 6
Sides and aft bulkhead	0.15 L + 3
Deck house roof, 1st tier	0.1 L + 3
Deck house roof, elsewhere	0.1 L + 1.5

16.2.5 Design loads for bulkheads and tanks

16.2.5.1 The design load for watertight bulkheads shall not be taken less than:

P_{bh} = $10 \cdot h_b$ (kN/m^2)
h_b = vertical distance in m from load point to top of bulkhead.

16.2.5.2 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/m^2)
= $7 \cdot h_t$ (kN/m^2)
= min. 15 (kN/m^2)
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.

16.2.6 Miscellaneous equipment

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

SECTION 17 ALUMINIUM AND STEEL STRUCTURAL DESIGN

17.1 General

17.1.1 Structural aluminium material

17.1.1.1 The scantling requirements are based on a correction factor f_1 for material strength. f_1 shall be taken according to the following tables:

Table 17-1 Factor f_1 for wrought aluminium alloy sheets, strips and plates, t: 2 mm ≤ t ≤ 40 mm

DNV GL Designation	*Temper*	f_1
VL-5052	H32 H34	0.61 0.69
VL-5154A	0, H111	0.35
VL-5754	H24	0.69
VL-5454	H32 H34	0.73 0.79
VL-5086	H116, H32 H34	0.80 0.88
VL-5083	H116, H321	0.89
VL-5383	H116, H34	0.89
Note: For tempers 0 and H111, the factor f_1 is to be taken from Table 17-4.		

Table 17-2 Factor f_1 for extruded aluminium alloy profiles, rods and tubes, t: 2 mm ≤ t ≤ 25 mm

DNV GL Designation	*Temper*	f_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 17-2 only applies when the main loading direction is longitudinal to the extrusion, see also Table 17-3.		

Table 17-3 Factor f_1 for extruded aluminium alloy profiles, rods and tubes, t: 2 mm ≤ t ≤ 25 mm, transverse to extruding direction

DNV GL Designation	*Temper*	f_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 17-4 Factor f_1 in the welded condition

DNV GL Designation	*Temper*	*Filler*	f_1
VL-5052	0, H111, H32, H34	5356	0.27
VL-5154A	0, H111	5356-5183	0.35
VL 5754	0, H111, H24	5356-5183	0.33
VL 5454	0, H111, H32, H34	5356-5183	0.35
VL-5086	0, H111, H116, H32, H34	5356-5183	0.42
VL-5083	H116, H321 H116, H321	5356 5183	0.53 0.60
VL-5383	H116, H34	5183	0.64
VL-6060	T5	5356-5183	0.27
VL-6061	T4 T5/T6	5356-5183	0.48 0.48
VL-6063	T5 T6	5356-5183	0.27
VL-6005A	T5/T6	5356-5183	0.48
VL-6082	T4 T5/T6	5356-5183	0.46 0.48

17.1.1.2 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 17-5 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 17-6 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 17-7 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

17.1.2 Structural steel

17.1.2.1 The scantling requirements are based on the correction factor f_1 for material strength. f_1 shall be taken according to the following table:

Table 17-8 Factor f_1

Minimum yield strength *(N/mm ^{2})*	*f_1*
235	1.00
265	1.13
315	1.34
355	1.51
390	1.66

17.2 Structural arrangement

17.2.1 Structural design in general

17.2.1.1 The ship arrangement shall take into account:

— continuity of longitudinal strength, including horizontal shear area to carry a strength deck along
— 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.

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

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

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

17.2.1.5 Connections to top flange of girders and stiffeners shall be avoided if not well rounded. Preferably, supporting of outfitting shall be welded to the stiffener web.

17.2.1.6 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.

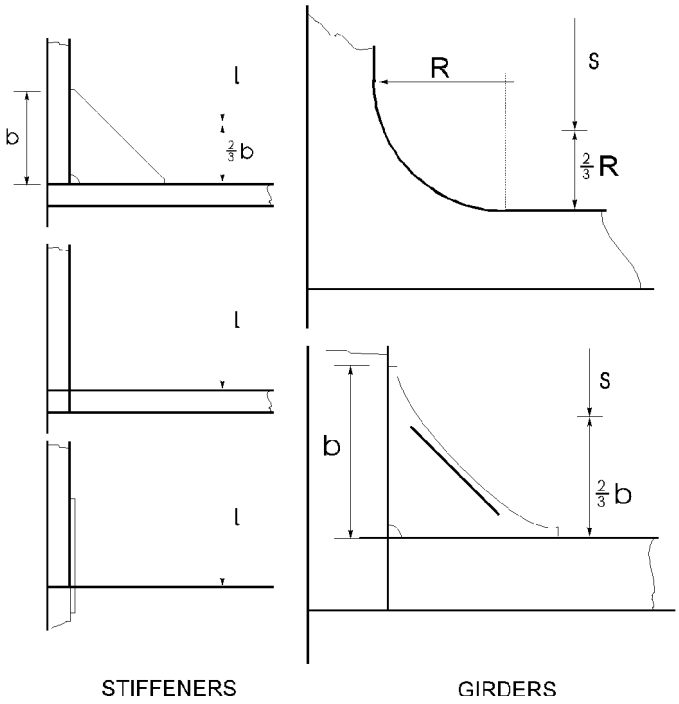


Figure 17-1

17.2.2 Global strength

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

$$Z = 6250\frac{M}{f_1} \quad (mm^3)$$

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 craft.

17.2.2.2 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:

$$B_{III} = b' + b'' + b'''$$

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

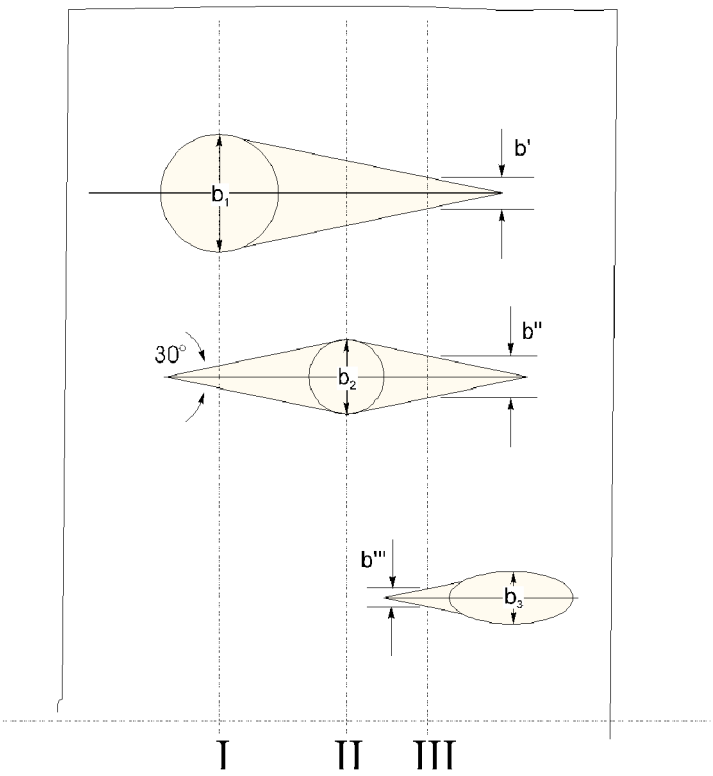


Figure 17-2

17.2.3 Bottom structures

17.2.3.1 The bottom structure shall comply with the requirements given in [17.3] and [17.4]. The local strength of the keel shall be sufficient to withstand loads in connection with docking attachment of external ballast keel, etc.

17.2.3.2 Bottom structures may be longitudinally or transversely stiffened.

17.2.3.3 In planing craft single bottom as well as double bottoms are normally to be longitudinally stiffened.

17.2.3.4 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.

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

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

17.2.3.7 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.

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

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

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

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

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

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

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

17.2.3.15 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.

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

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

17.2.3.18 The longitudinal girders shall be satisfactorily stiffened against buckling.

17.2.4 Side structures

17.2.4.1 The scantlings of side structures shall comply with the requirements given in [17.3] and [17.4].

17.2.4.2 The craft's sides may be longitudinally or vertically stiffened.

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

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

17.2.5 Transom

17.2.5.1 The scantlings of transom not subject to loads from engine or rudder installations shall comply with the requirements of [17.3] and [17.4].

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

17.2.6 Deck structure

17.2.6.1 The scantlings of deck structures shall comply with the requirements given in [17.3] and [17.4].

17.2.6.2 Decks may be longitudinally or transversely stiffened.

17.2.6.3 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.

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

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

17.2.6.6 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

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

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

17.2.7 Bulkhead structure

17.2.7.1 The scantlings of bulkhead structures shall comply with the requirements given in [17.3] and [17.4].

17.2.7.2 Number and location of transverse watertight bulkheads shall be in accordance with the requirements given for the various craft types.

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

17.2.7.4 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.

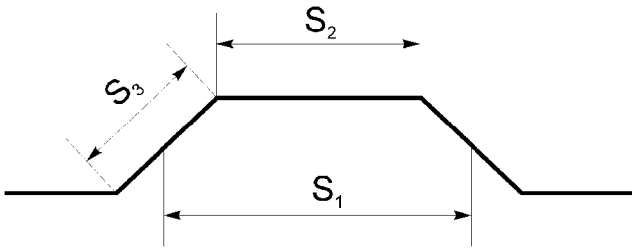


Figure 17-3

17.2.7.5 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 [17.5].

17.2.8 Superstructures and deckhouses

17.2.8.1 The scantlings of superstructures and deckhouses shall comply with the requirements of [17.3] and [17.4].

17.2.8.2 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.

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

17.2.8.4 At the break of superstructures, which have no set-in from the ship'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.

17.2.8.5 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.

17.2.8.6 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.

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

17.2.8.8 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.

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

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

17.3 Steel and aluminium plating

17.3.1 General

17.3.1.1 In this section the general requirements for the local strength of laterally loaded plates are given.

17.3.2 Plate thickness

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

$$t_{min} = t_0 + kL\frac{1}{\sqrt{f_1}} + t_c \quad (mm)$$

$$t_p = 1.7\, f_p\, s\, \sqrt{P} + t_c \,(mm)$$

t_0 and k are given in the tables in [17.3.2.2].

f_p is given in [17.3.2.3].

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

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

Table 17-9 Aluminium

Item	*L ≤ 15 m*		*L > 15 m*	
	t_0	*k*	t_0	*k*
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
Exposed deck, cargo deck	0.8	$0.21 + 0.21 \cdot H$	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 freestanding)	0.4	0.23	3.1	0.05

Table 17-10 STEEL

Item	*L ≤ 15 m*		*L > 15 m*	
	t_0	*k*	t_0	*k*
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	$0.21 + 0.1 \cdot H$	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 freestanding)	0	0.23	2.7	0.05

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

, for open craft

$$k_v = 0.86 + 0.014\ V$$

H = deck cargo (ton/m^2).

17.3.2.3 The combined correction factor f_p is given by:

$$f_p = \sqrt{\frac{f_2 f_3}{f_1}}$$

f_1 as defined in Sec.1 [2.1.3] and [3.1.3]. (Check ref.!)

The aspect ratio correction factor, f_2, is to be taken as:

f_2 = $(1.1 - 0.25\ s/l)^2$
= max. 1.0
= min. 0.72.

The correction factor, f_3, for plate curvature is to be taken as:

f_3 = 1 - h/s
= minimum 0.8.

h and s are defined in the figure below.

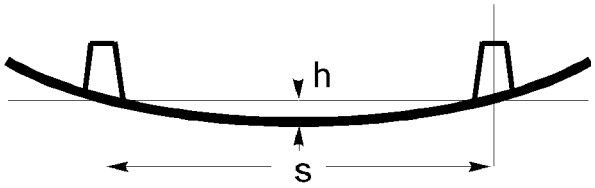


Figure 17-4

17.4 Frames, girders and stiffeners

17.4.1 General

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

17.4.2 Section modulus

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

$$W = 6.25\frac{mPbl^2}{f_1}10^{-3} \quad (cm^3)$$

m = values for the most common structural members are found in the table in [17.4.2.3]

b = load breadth in metres

l = stiffener span in metres.

For curved frames see [17.4.2.2].

f_1 as defined in [17.1].

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

$$l = l_0 - 3\ f + 0.3\ R \text{ metres}$$

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 17-5. When the radius varies, is measured as shown in Figure 17-6 below.

R = bilge radius in metres.

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

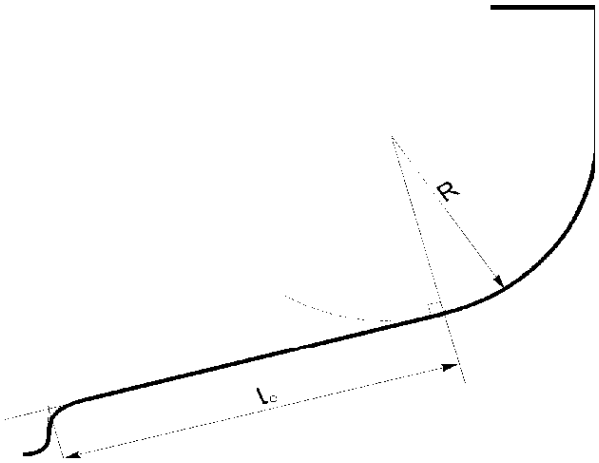


Figure 17-5

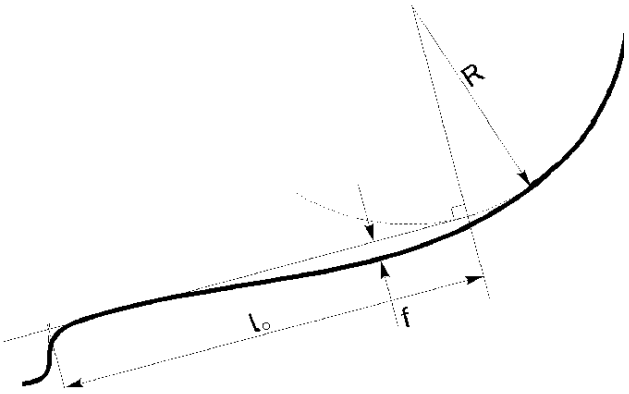


Figure 17-6

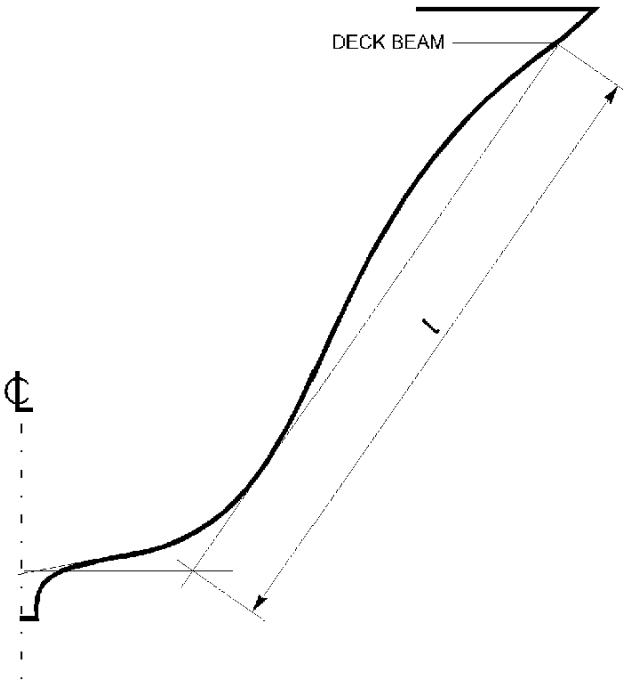


Figure 17-7

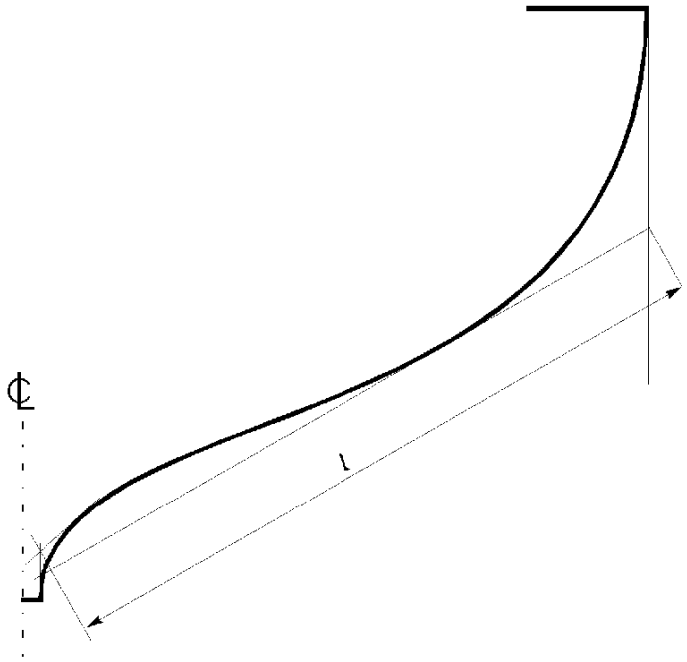


Figure 17-8

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

Table 17-11 m-values

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

Item	*m*
Tank and cargo bulkheads, fixed ends	100
Tanks and cargo bulkheads, simply supported ends	135
Deckhouse stiffener	100
Casings	100

17.4.2.4 The formula given in [17.4.2.1] 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 [17.4.1.1] is multiplied by the factor:

$$\frac{1}{\cos\alpha}$$

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

For angles α < 15° corrections are normally not necessary.

17.4.2.5 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.

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

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

for flats:

$$t_{web} = 1/15 \times \text{flat depth.}$$

for other sections:

$$t_{web} = 1/50 \times \text{web depth, provided net shear area} > 0.075\ l_{sp}$$

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

17.5 Pillars

17.5.1 General

17.5.1.1 In this section the general requirements to steel pillars supporting structure or equipment are given.

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

17.5.2 Scantlings

17.5.2.1 Solid steel or aluminium pillars shall have dimensions according to the table below:

Table 17-12 Solid steel / aluminium pillars

Load (kN) *Steel / Aluminium*	*Pillar length (m)*			
	2.0	*2.5*	*3.0*	*3.5*
	Diameter (mm)			
30 / 12	50	53	56	59
40 / 16	53	56	60	64
60 / 24	56	60	65	69
80 / 32	59	64	69	73
100 / 40	62	68	73	78
130 / 52	65	71	77	82
160 / 64	68	75	81	86
200 / 80	71	78	84	90
240 / 96	74	81	88	94
290 / 116	77	84	91	98
340 / 136	80	88	95	102
400 / 160	83	91	99	106

17.5.2.2 Tubular pillars shall have dimensions according to the table below, based on the scantlings of solid pillars:

Table 17-13 Tubular pillars

Diameter of equiv. solid pillar (mm)	*Pillar length (m)*			
	2.0	*2.5*	*3.0*	*3.5*
50	70 × 6.0	70 × 6.0	70 × 6.0	
55	70 × 6.0	70 × 6.0	70 × 6.0	
60	80 × 6.5	75 × 6.0	75 × 6.0	75 × 6.0
65	90 × 6.5	80 × 6.5	80 × 6.5	80 × 6.0
70	100 × 7.0	90 × 6.5	90 × 6.5	89 × 6.5
75	115 × 7.0	110 × 6.5	110 × 6.5	100 × 6.5
80	130 × 7.5	120 × 7.0	115 × 7.0	105 × 6.5
85	145 × 8.0	130 × 7.5	125 × 7.0	115 × 7.0
90	160 × 8.5	145 × 8.0	135 × 7.5	125 × 7.0

SECTION 18 FRP STRUCTURAL DESIGN

18.1 General

18.1.1 Application

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

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

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

18.1.2 Assumptions

18.1.2.1 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.

18.1.2.2 A sandwich construction is considered to be structural element consisting of three components: 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 [18.4]. It is further assumed that an efficient bond between skins and sandwich core is obtained.

18.1.3 Definitions

18.1.3.1 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 = $\frac{80}{\sigma_{nu}}$ correction factors for strength

f_b = $\frac{130}{\sigma_{bu}}$ correction factors 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.

18.1.4 Calculation methods

18.1.4.1 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 [18.3], [18.4] and [18.5] will be accepted.

18.1.4.2 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.

18.1.4.3 Direct calculations based on the full strength and stiffness properties in all directions shall be carried out in accordance with the procedures given in the Rules for Classification of High Speed and Light Craft.

18.1.5 Structural design in general

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

18.1.5.2 The structural arrangement shall take into account:

— continuity of longitudinal strength, including horizontal shear area to carry a strength deck
— along
— transverse bulkheads or strong webs
— web/pillar rings in engine room
— twin hull connections
— superstructures and deckhouses:
— direct support
— transitions
— deck equipment support
— multi-deck pillars in line, as practicable
— external attachments, inboard connections.

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

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

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

18.1.5.6 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.

18.1.5.7 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.

18.1.5.8 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.

18.1.6 Materials

18.1.6.1 Structural materials shall be approved by the Society.

18.1.7 Mechanical properties of laminate

18.1.7.1 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.

18.1.7.2 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.

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

18.1.7.4 The mean value of the results from the tests shall comply with the requirements given in [18.1.7.1]. No single value shall be less than 80% of the value used as basis for determination of scantlings.

18.1.7.5 The mechanical properties used in the calculations shall be:

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

18.1.7.6 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.

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

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

18.1.8 Mechanical properties of sandwich core materials

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

18.1.8.2 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.

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

18.1.8.4 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.

18.1.8.5 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.

18.1.9 Global strength

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

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

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 end and aft end of the craft.

18.1.9.2 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.

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

18.1.9.4 The effect of openings is assumed to have longitudinal extensions as shown by the shaded areas in Figure 18-1 i.e. inside tangents at an angle of 30° to each other. Example for transverse section III:

$$b_{III} = b' + b'' + b'''$$

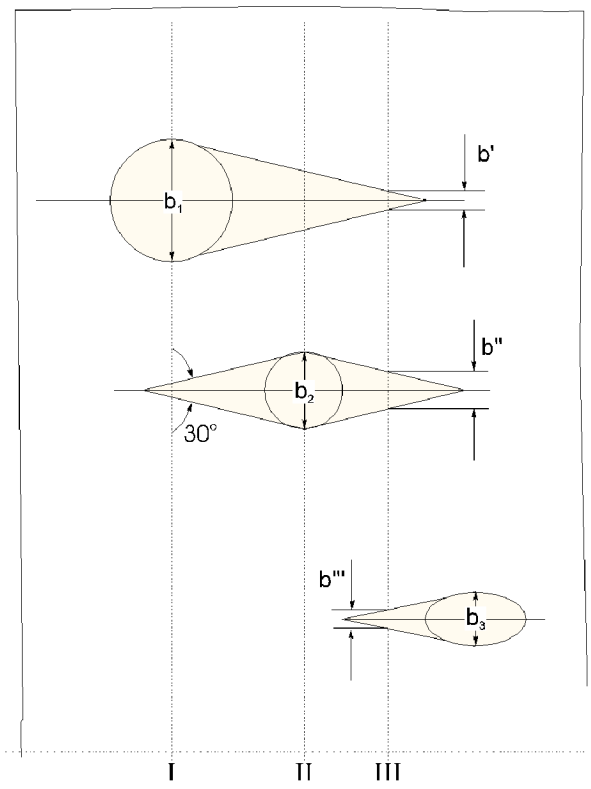


Figure 18-1 Effect of openings

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

18.2 Structural arrangement

18.2.1 Bottom structures

18.2.1.1 The bottom single skin or sandwich panels shall comply with the requirements given in [18.3] and [18.4]. The local strength of the keel shall be sufficient to withstand loads in connection with docking attachment of external ballast keel, etc.

18.2.1.2 Bottom structures may be longitudinally or transversely stiffened.

18.2.1.3 In planning craft single bottom as well as double bottoms shall normally be longitudinally stiffened in single skin constructions. In craft with sandwich construction transverse stiffening may be accepted.

18.2.1.4 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.

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

18.2.1.6 Displacement crafts 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 18-1, 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 craft. If the girder span is greater than the breadth of the craft, 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 subsection [18.5].

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

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

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

18.2.1.10 The scantlings of longitudinal girders may be taken in accordance with Table 18-2 or alternatively according to [18.5].

18.2.1.11 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.

18.2.1.12 Web frames are to be continuous around the cross section of the craft, 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.

18.2.1.13 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.

18.2.1.14 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.

18.2.1.15 Crafts built in sandwich construction and with:

$$\frac{V}{\sqrt{L}} > 4.5$$

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.

18.2.2 Side structures

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

18.2.2.2 The single skin or sandwich panels of the hull sides shall comply with the requirements of subsections [18.3] and [18.4].

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

18.2.3 Transom structure

18.2.3.1 The scantlings of transom not subjected to loads from engine or rudder installations shall comply with the requirements of [18.3] and [18.4].

18.2.3.2 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 following table:

Table 18-1 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.	

18.2.3.3 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 boat, and shall be gradually tapered in thickness.

18.2.4 Deck structure

18.2.4.1 Decks may be longitudinally or transversely stiffened.

18.2.4.2 Deck panels of single skin or sandwich construction shall comply with the requirements of [18.3] and [18.4].

18.2.4.3 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.

18.2.4.4 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.

18.2.5 Bulkhead structures

18.2.5.1 The scantlings of bulkhead structures shall comply with the requirements of [18.3] and [18.4].

18.2.5.2 Number and location of transverse watertight bulkheads are to be in accordance with the requirements given for the various craft types specified in Sec.6.

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

18.2.6 Superstructures and deckhouses

18.2.6.1 The scantlings of superstructures and deckhouses shall comply with the requirements of subsections [18.3] and [18.4].

18.2.6.2 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).

18.2.6.3 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).

18.2.6.4 Long deckhouse - deckhouse having more than 0.2 L, of its length within 0.4 L amidships.

18.2.6.5 Short deckhouse - deckhouse not defined as a long deckhouse.

18.2.6.6 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.

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

18.2.6.8 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.

18.2.6.9 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.

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

Table 18-2 Floors in single bottom

	Height of floor at vessel's centreline × webthickness (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).

Guidance note:

Notes to Table 18-1:

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_1 taken from the following table.

l_s/B	1.10	1.25	1.50	2.00

f_1	1.13	1.25	1.37	1.50

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

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Centre girder

Table 18-3 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.					

Guidance note:

For girder spans greater than vessel's breadth, the table values for flange area and web thickness of the girder are multiplied by the factor f_1 given in note 3 to Table 18-2.

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.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

18.3 Single skin constructions

18.3.1 General

18.3.1.1 In this section the general requirements for the local strength of stiffened single skin constructions are given.

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

18.3.2 Laminate thicknesses

18.3.2.1 The thickness of structural laminates, excluding topcoat and gelcoat, shall not be less than the largest value found from the following formulas:

$$t_{min} = (t_0 + kL)\sqrt{f_b} \quad (mm)$$

$$t_p = k_p f_p s\sqrt{P} \quad (mm)$$

t_0 and k are taken from the table below.

f_p is taken from the formulae in [18.3.2.2].

k_p = 3.82 for bottom panels
= 4.73 for side panels
= 4.11 for panels elsewhere and for all stiffening members.

Table 18-4 Laminate thickness

Item	*L ≤ 15 m*		*L > 15 m*	
	t_0	*k*	t_0	*k*
Hull bottom	2.5	0.58 · k_v	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 + H	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 freestanding)	1.1	0.45	6.2	0.11

k_v = 0.86 + 0.014 · V
H = deck cargo in ton/m^2.

18.3.2.2 The combined correction factor, f_p, is given by:

$$f_p = f_{p1} \cdot f_{p2} \cdot \sqrt{f_b}$$

The aspect ratio correction, f_{p1}, is to be taken from the diagram below:

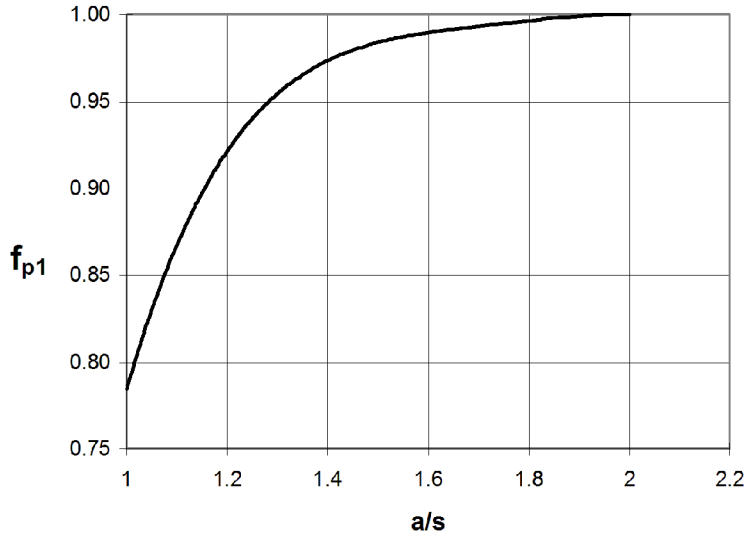


Figure 18-2

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

The panel curvature correction, f_{p2}, is to be taken as:

f_{p2} = 1 - h/s
$f_{p2\ min}$ = 0.8.

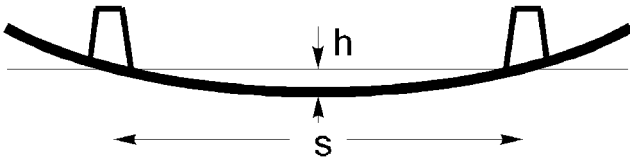


Figure 18-3

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

18.3.3 Local laminate reinforcement

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

$$t_{l\ min} = (t_0 + k \cdot L) \cdot \sqrt{f_b} \ (mm)$$

t_0 and k are given in the following table:

Table 18-5 Laminate reinforcement

Item	*L ≤ 5 m*		*L > 15 m*	
	t_0	*k*	t_0	*k*
Keel type 1 and 2	2.9	$0.9 \cdot k_v$	14.5	0.14
Keel type 3	3.5	$1.1 \cdot k_v$	17.5	0.17
Fore and aft stem	2.9	0.9	14.5	0.14
Chine and transom corners *)	2.4	$0.7 \cdot k_v$	12.0	0.11
Bottom laminate in way of rudder stock, shaft brackets, etc.	3.5	$1.1 \cdot k_v$	17.5	0.17
*) Breadth to each side shall be min. 25 B (mm), but not less than 100 mm				

Extension of keel laminate is shown below.

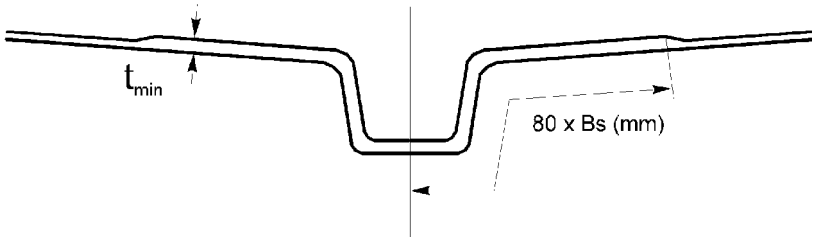


Figure 18-4 Keel type 1

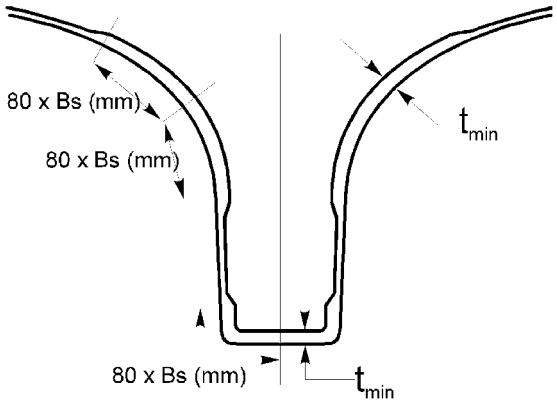


Figure 18-5 Keel type 2

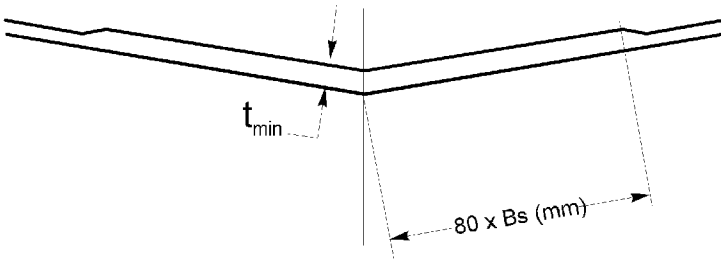


Figure 18-6 Keel type 3

18.4 Sandwich constructions

18.4.1 General

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

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

18.4.2 Panel requirements

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

$$t_{s\,min} = \frac{k t_{1min}}{f_c} \text{ (mm)}$$

$t_{l\,min}$ = minimum thickness found from [18.3.2.1]
f_c = $0.94 + 0.12 \cdot \sigma_c$
σ_c = compressive strength of the core material in N/mm^2.

k is found from the table below:

Table 18-6 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

Structural member	*k*	
	Exposed [1)]	*Protected* [2)]

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 pane which is not subject to loads as described above.

*) Transom not thrust bearing

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

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

f_w = $f_{w1} \cdot f_n$

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

f_i = $f_{i1} \cdot f_{i2} \cdot f_{i3}$

The correction factors for panel aspect ratio, f_{w1} and f_{i1}, are found from the diagram below:

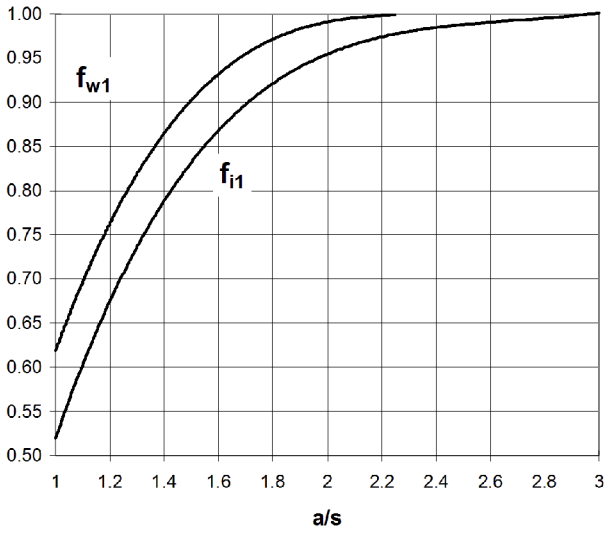


Figure 18-7 Correction factor

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

The correction factor for laminate strength, f_n, is given in [18.1.3.1].

The correction factor for laminate stiffness, f_{i2}, shall be taken as:

$$f_{i2} = \frac{7000}{E_n}$$

The stiffness factor, f_{i3}, shall be taken as:

f_{i3} = 1.0 for decks and floor panels

f_{i3} = 0.5 elsewhere.

If the stiffness of the panel is increased due to curvature, a lower moment of inertia may be accepted.

W and I properties for panels with skin laminates of equal thicknesses are given in [18.4.2.5].

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

$$\tau_u = \frac{1.5 f_{T1} Ps}{d} \text{ (MPa)}$$

For core materials in bottom panels of planning craft 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 [18.4.2.5].

The correction factor for panel aspect ratio, f_{T1}, is found from the diagram below.

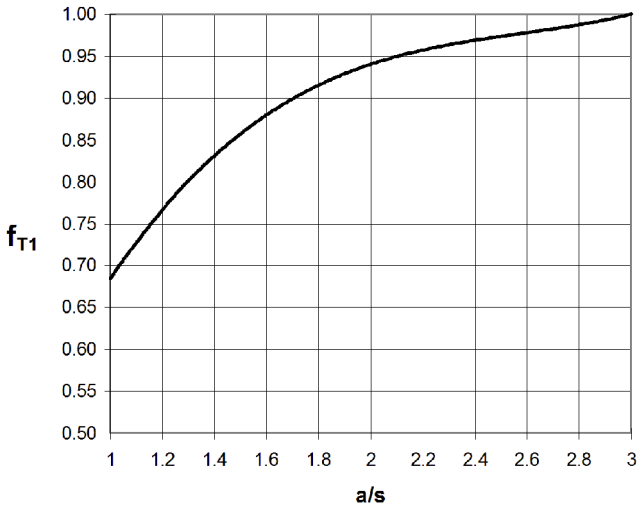
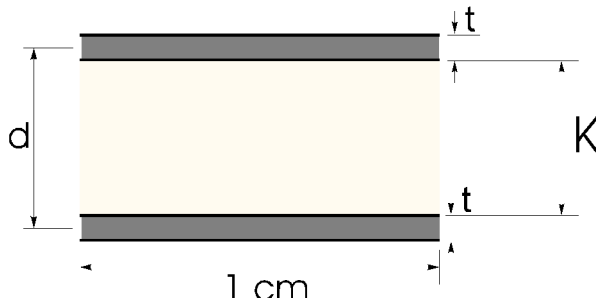


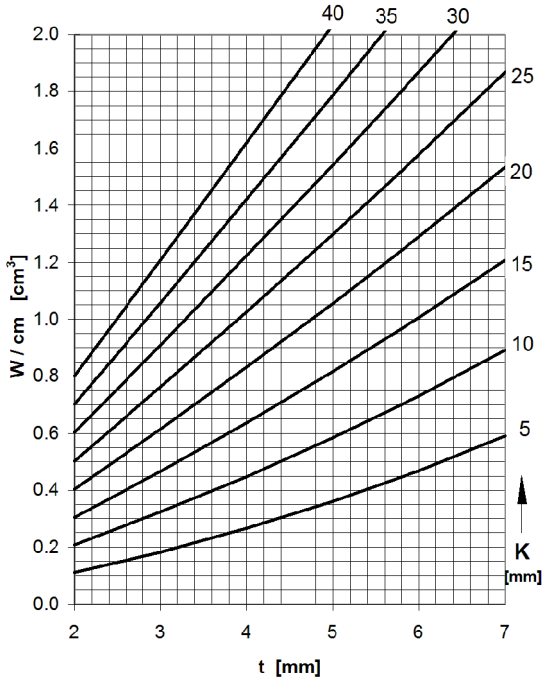
Figure 18-8

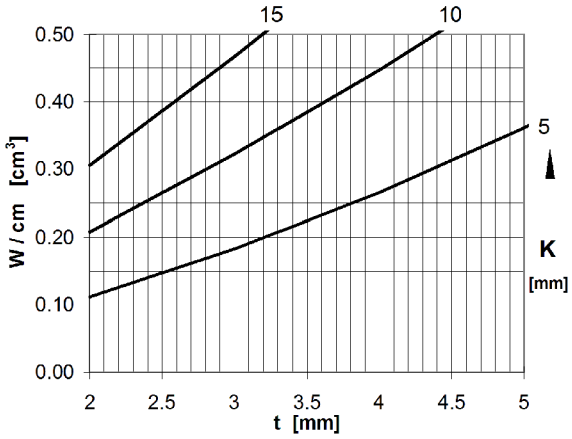
a and s: longest and shortest panel side, respectively.

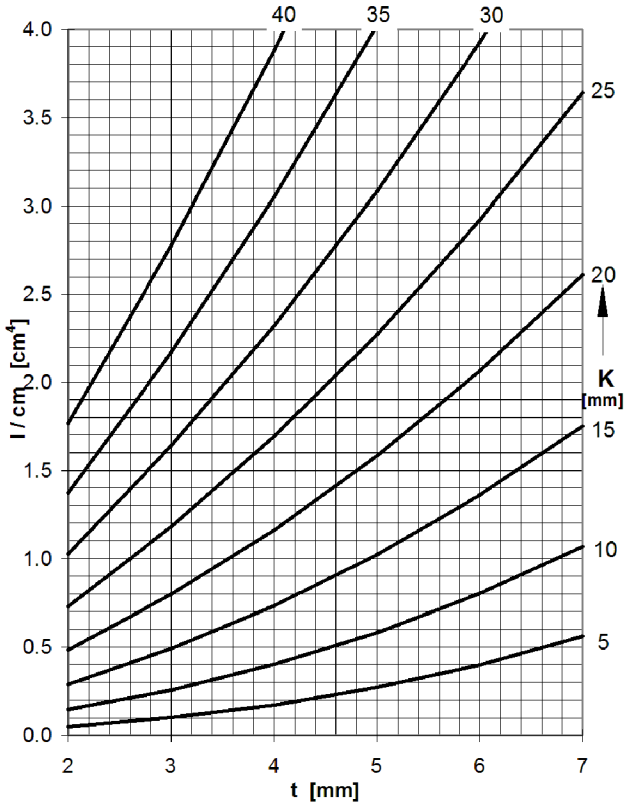
18.4.2.4 Reduced thicknesses may be accepted provided equivalent impact resistance can be documented.

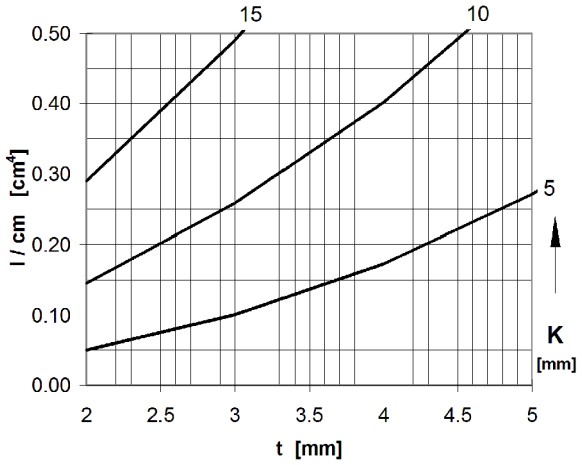
18.4.2.5 Section modulus (W) and moment of inertia (I) of a 1 cm wide sandwich panel with skin laminate of equal thickness, are given in the figures below as a function of core thickness K and skin laminate thickness t.


t
d
K
t
1 cm


40
35
30
25
20
15
10
5
K
[mm]
W / cm [cm³]
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
2
3
4
5
6
7
t [mm]


15
10
5
K
[mm]
W / cm [cm³]
0.50
0.40
0.30
0.20
0.10
0.00
2
2.5
3
3.5
4
4.5
5
t [mm]


40
35
30
25
20
15
10
5
K
[mm]
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
I / cm [cm⁴]
2
3
4
5
6
7
t [mm]


15
10
5
K
[mm]
0.50
0.40
0.30
0.20
0.10
0.00
I / cm [cm⁴]
2
2.5
3
3.5
4
4.5
5
t [mm]

18.4.3 Local panel reinforcements

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

$$t_{s\,min} = \frac{k t_{1min}}{f_c} \text{ (mm)}$$

$t_{l\,min}$ = minimum thickness according to 330

f_c = $0.94 + 0.12 \cdot \sigma_c$

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

k is found from the table below:

Table 18-7 Local panel reinforcement

Item	*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

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.

18.5 Frames, girder and stiffeners

18.5.1 General

18.5.1.1 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.

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

18.5.1.3 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.

18.5.2

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

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

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

b = load breadth in metres

l = stiffener span in metres, for curved frames see [18.5.2.2].

m- and d- values for the most common structural members are found from the table in [18.5.2.3].

f_n and f_i are given in [18.5.2.4].

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

$$l = l_0 - 3 \cdot f + 0.3 \cdot R \text{ metres}$$

l_0 = length in metres of the straight part of the frame in bottom.

When the bilge radius is constant, l_0 is measured as shown in Figure 18-3 below. When the radius varies, l_0 is measured as shown in Figure 18-4 below.

R = bilge radius in metres.

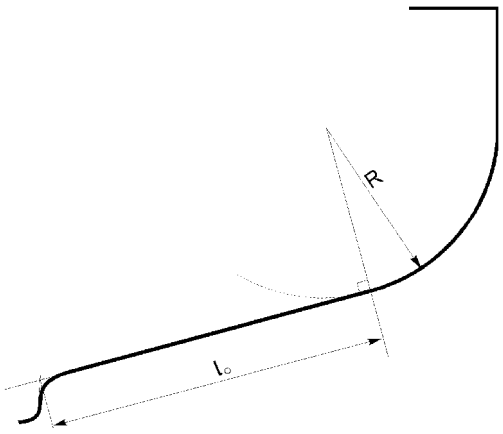


Figure 18-9

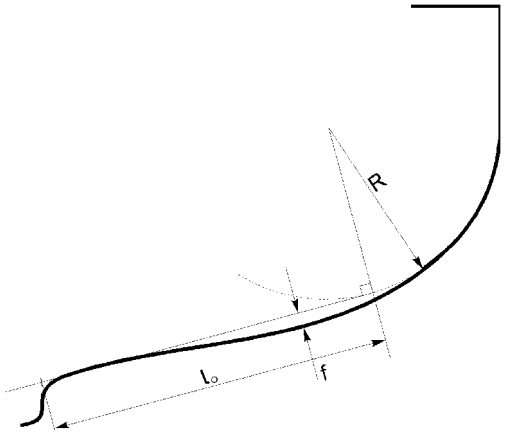


Figure 18-10

For S-shaped frames the length which determines scantlings is measured as shown in Figure 18-5 and Figure 18-6.

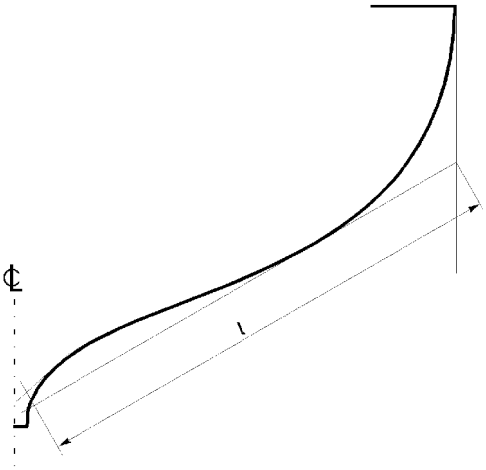


Figure 18-11

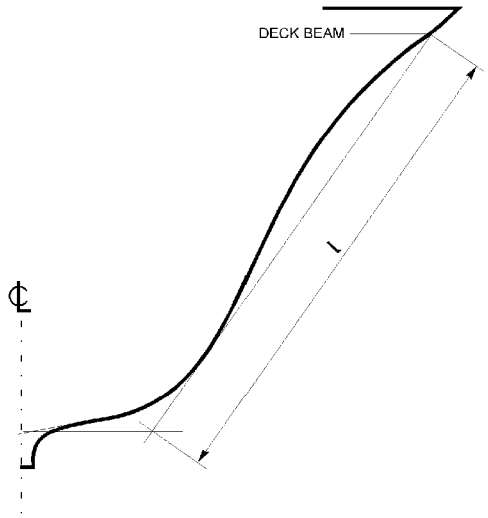


Figure 18-12

18.5.2.3 The m- and d-values shall normally be taken as follows for the various structural members:

Table 18-8 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

Item	*m*	*d*
Casings	1.00	1.0

18.5.2.4 The correction factors for laminate properties shall be taken as follows:

$$f_n = \frac{80}{\sigma_{nu}}$$

$$f_i = \frac{7000}{E_a}$$

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 E_a/E_r. A condition for employing this method is that the strength ratio σ_a/σ_r is not less than the stiffness ratio above.

E_a, σ_a = tensile modulus and strength respectively of the laminate considered

E_r, σ_r = tensile modulus and strength respectively of the reference laminate for which the section modulus requirement is calculated.

18.5.2.5 Section modulus W for profiles with panel as function of flange area A_{fl} sandwich core height H and web thickness t_s is given in the graphs.

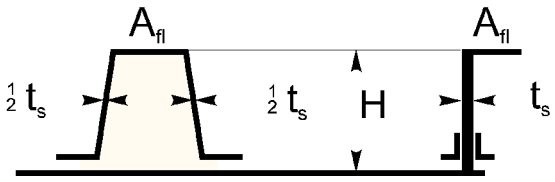


Figure 18-13 Definition of A_{fl}, H and t_s

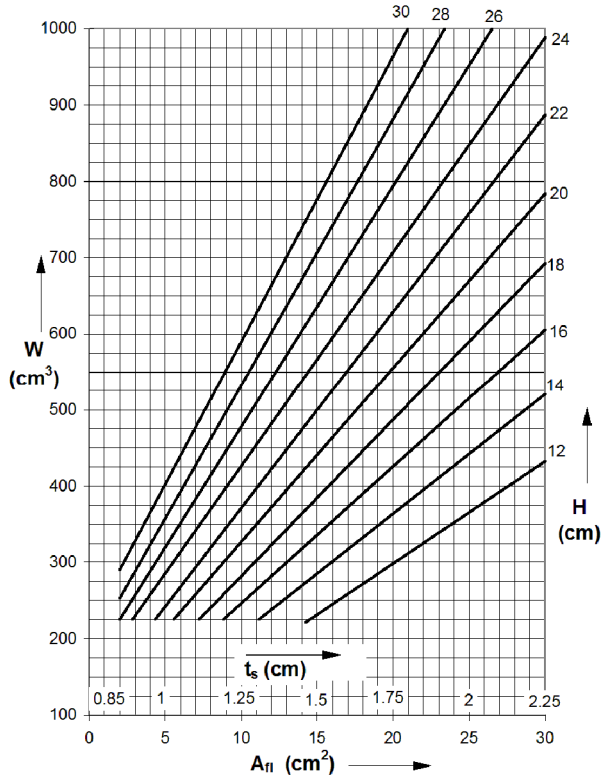


Figure 18-14 Section modulus W of profiles

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

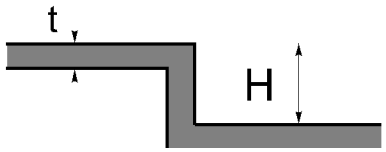


Figure 18-15

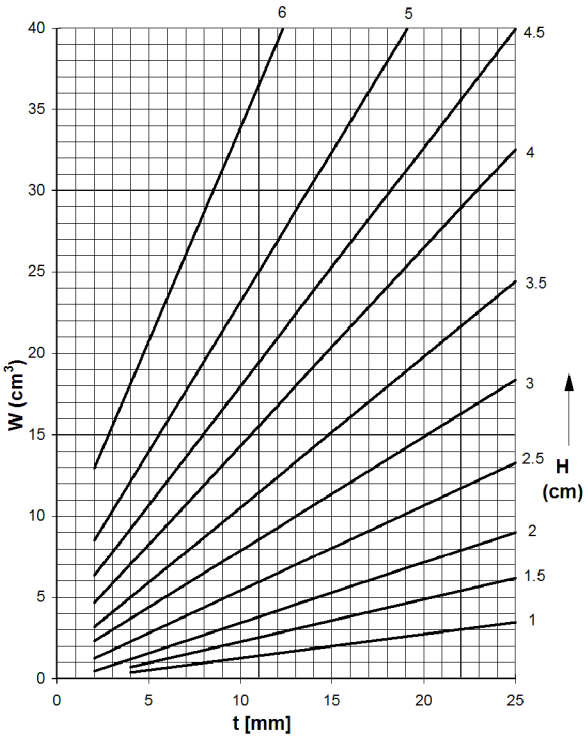


Figure 18-16

SECTION 19 THERMOPLASTIC STRUCTURAL DESIGN

19.1 General

19.1.1 Premises

19.1.1.1 Premises for manufacturing of boats of thermoplastics shall be suitable for the production process applied.

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

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

19.1.2 Marking of produced boats

19.1.2.1 If the applied structural material has properties of significance for the use of the boat which differ from the standard given for boats of glassfibre-reinforced polyester, appropriate information will be given on the certificate.

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

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

19.2 Rotation moulding of polyethylene boats

19.2.1 Moulding condition

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

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

19.2.1.3 The rotation procedure shall be the same for moulding of all boats of the same type.

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

19.2.1.5 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.

19.2.1.6 The sintering time and the after-sintering time is stipulated on the basis of thickness measurements on the boat 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.

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

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

19.2.2 Moulded boats

19.2.2.1 The material in the finished moulded boats is to be without any visible surface flaws of significance to the boat'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.

19.2.2.2 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.

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

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

19.2.3 Internal control

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

19.2.3.2 The boat manufacturer is to record the following process data for each individual boat:

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

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

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

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

19.3 Thermoforming of ABS-sheets

19.3.1 Forming of sheets

19.3.1.1 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 boats, the thickness of the sheets to be used in production of the boat type shall be decided.

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

19.3.1.3 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.

19.3.1.4 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.

19.3.2 Internal control of the boat manufacturing

19.3.2.1 The boat manufacturer shall keep a journal of the sheet supplier's certificate data.

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

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

19.4 Boat construction

19.4.1 Design

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

19.4.1.2 When forming boats 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.

19.4.1.3 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.

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

19.4.2 Assembly

19.4.2.1 No materials built into the boat must have detrimental effects on the other materials applied.

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

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

19.4.3 Rule thickness

19.4.3.1 Rule thickness is the value stated in subsections [19.5] and [19.6].

19.4.3.2 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.

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

19.5 Polyethylene

19.5.1 Manufacturing

19.5.1.1 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 boats.

19.5.1.2 Raw materials should be approved in accordance with Sec.12.

19.5.1.3 If the boat manufacturer is to grind granulate to powder, the grinding and sieving equipment are first to be approved by the Society.

19.5.1.4 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.

19.5.1.5 Material moulded in accordance with the boat manufacturer's actual procedure shall at least have properties as given in the tables in [14.3.1] – [14.3.3].

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

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

$$t_y = ks\sqrt{\frac{PF}{L\ 6.7}}(14 + 3.6\,L)\ \ mm$$

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 PF_s), taken from the figures in [16.2.2] to [16.2.3].

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

t_i = 0.8 t_y mm.

19.5.2.3 Rotation moulded boats should have a hull weight of at least k × 45 kg. The boat 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 boat.

19.5.2.4 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.

19.5.3 Surveillance of the production

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

19.5.3.2 The inner surfaces and weldings are to be visually inspected and the hull thicknesses measured by cutting various sections of the boat.

19.6 Acrylonitrile butadiene styrene (ABS) and equivalent materials

19.6.1 Manufacturing conditions

19.6.1.1 Requirements to forming temperature and sheet thickness are determined for each boat type on the basis of inspection of completed boats.

19.6.2 Material requirements

19.6.2.1 Raw materials shall be approved according to Sec.12.

19.6.2.2 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.

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

Table 19-1 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

19.6.3 Scantlings

19.6.3.1 The following scantling requirements are based on a boat speed not exceeding 10 knots.

19.6.3.2 Thickness of outer hull:

The bottom thickness is not to be less than:

t_b = 1.5 + 0.4 L + 0.06 V mm
$t_{b\,min}$ = 2.6 mm.

19.6.3.3 The side thickness is not to be less than:

ts = 1.5 + 0.4 L mm
$t_{s\,min}$ = 2.4 mm.

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

ti = 0.9 t_s mm

$t_{i\,min}$ = 2.2 mm.

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

19.6.3.6 Boats 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.

19.6.3.7 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.

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

19.6.4 Surveillance of the production

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

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

SECTION 20 MACHINERY

20.1 Certification

20.1.1 Engines

20.1.1.1 Engines shall be of recognised type adapted for maritime use. Engines with a power exceeding 2 500 kW shall be Type Approved by DNV GL or another recognised organisation. Individual product certificates are not required.

20.2 Propulsion and auxiliary engines

20.2.1 Engines

20.2.1.1 Inboard diesel engine(s) shall normally be used for main propulsion. Outboard petrol engines may be accepted when L × B is smaller than 40. Requirements to outboard petrol engine installations are given in Sec.22. Inboard petrol engines are not allowed.

20.2.2 Engine room

20.2.2.1 The engine room shall not be used for other purposes. The normal service points of the engine shall be readily accessible. Rotating parts shall be shielded to prevent personal injury.

20.2.2.2 Windows, scuttles or similar in engine room shall have the same fire rating as surrounding structure.

20.2.2.3 The engine room shall be equipped with artificial lighting.

20.2.2.4 Ventilation of the engine room for the engine's air consumption and cooling shall be arranged according to the engine manufacture's recommendations. The engine room/space shall have ventilation to the outside. The total cross sectional area of intake ventilation openings and ducts shall not be smaller than 7 cm^2/kW or the engine manufacturer's recommendations.

20.2.2.5 Ventilation openings shall be equipped with fire closing appliances that can be operated from outside the engine room and secured in open and closed position.

20.2.3 Engine controls

20.2.3.1 Engines shall be possible to monitor from the helm position. The following indicators or alarms shall be visible/audible:

— speed of revolutions (may be omitted for auxiliary engines)
— lubrication oil pressure
— cooling water temperature
— alarm for loss of exhaust cooling

The instrumentation shall be equipped with adjustable lighting.

20.2.3.2 Boats with an open steering positions and a maximum speed exceeding 25 knots shall have a safety contact at the steering position which will stop the propulsion engine if the helmsman should fall overboard.

20.2.4 Exhaust

20.2.4.1 Each engine shall have a separate exhaust system or according to the engine manufacturer's recommendations.

20.2.4.2 Exhaust lines shall be accessible for inspection.

20.2.4.3 Exhaust line with a surface temperature exceeding 80°C shall be equipped with protection against touching. Exhaust piping shall not be arranged in such a way that other materials or structures reach temperatures above 65°C.

20.2.4.4 Materials in seawater cooled exhaust systems shall be corrosion resistant. Special attention shall be given to avoid galvanic corrosion.

20.2.4.5 Seawater cooled exhaust systems shall be equipped with alarm at the steering position for loss of seawater cooling or for high temperature in the exhaust pipe.

20.2.4.6 Exhaust outlets shall be at least 100 mm above loaded water line or the exhaust line shall consist of a metallic pipe brought at least 100 mm above loaded water line.

20.2.4.7 At one location the lower inside surface of the exhaust pipe shall be at least 350 mm above loaded water line. From this location the pipe shall fall continuously to the exhaust outlet.

20.2.4.8 Flexible rubber and plastic hoses for wet-exhaust system shall be a class B hose according to ISO 13363.

SECTION 21 DRIVEN UNITS

21.1 Shafting

21.1.1

21.1.1.1 The diameter of steel shafting shall be in accordance with the engine manufacturer's recommendation, but not smaller than:

$$d = 90 \cdot \left(\frac{P}{RPM}\right)^{1/3} \cdot \left(\frac{600}{R_m + 160}\right)^{1/3} \quad (mm)$$

P = maximum continuous power of driving engine (kW)
RPM = shaft revolutions pr. minute
R_m = tensile strength (MPa).

21.1.1.2 The dimensions of shafting fabricated from other materials are subject to special consideration.

21.2 Shaft brackets and stern tubes

21.2.1

21.2.1.1 Shaft bearings shall be sufficiently lubricated.

21.2.1.2 One-armed shaft brackets shall have a section modulus W at the craft's bottom not smaller than:

$$W = \frac{l \cdot d^2}{112 \cdot R_m} \quad (cm^3)$$

d = shaft diameter (mm)
l = length of bearing (mm)
R_m = tensile strength (MPa).

At the bearing the section modulus shall not be smaller than 0.6 W.

21.3 Gears, propellers and waterjets

Gears, propellers and water-jets shall be supplied by recognised manufacturers. The equipment shall be approved by DNV GL, either by a type approval or on a case by case basis.

SECTION 22 OUTBOARD INSTALLATIONS

22.1 General

22.1.1 General

22.1.1.1 Outboard installations shall comply with the requirements in this section.

22.1.1.2 Vessels equipped with outboard engines with a power exceeding 15 kW shall be equipped with permanent wheel steering. Permanent wheel steering may be required for other vessels if found necessary for safety reasons. Rudder stops shall be fitted when wheel steering is fitted.

22.1.1.3 Craft with outboard engine shall meet the requirements in ISO 11547 'Small craft – Start–in-gear protection'.

22.2 Arrangement

22.2.1 Installation

22.2.1.1 For outboard engines with power less or equal to 15 kW where the engine is fastened without through-bolts, the transom shall be fitted with a well fastened plate as a protection for the fastening screws for the engine. The upper part of the plate shall have a ridge of at least 5 mm to prevent the engines fastening screws from slipping over the edge.

22.2.1.2 Outboard engines with power greater than 15 kW shall be fastened to the stern using through bolts.

22.2.1.3 Outboard engines with power greater than 15 kW shall be provided with remote steering and controls.

22.2.1.4 Craft fitted with outboard engines where the power exceeds 100 kW shall be fitted in an engine well. The engine well shall be drained to the sea.

22.2.2 Steering

22.2.2.1 The steering gear shall be designed for a force K not less than:

$$K = 10 \cdot P \text{ (N)}$$

where P is the engine power in kW.

22.2.2.2 Consoles and all components at the steering position shall be built, stiffened and secured in such a way that they can absorb the forces to which they are exposed, including dynamic loads from the helmsman considering the vessels movement in seas.

22.2.3 Fuel tanks

22.2.3.1 Petrol tanks shall be secured to hull structure and installed in a separate enclosure with natural ventilation to the outside of the vessel. Filling pipes shall be fitted and carried to open deck. Cross sectional area of supply ducts shall be according:

$$A = 3000 \ln (V/0.14), \text{ min } 3000 \text{ mm}^2 \text{ per opening or duct}$$

where A is the combined area of openings or ducts in mm^2 and V is the net compartment volume in m^3.

22.2.3.2 Petrol tanks shall be fabricated from steel or aluminium. Diesel tanks shall be fabricated from steel, aluminium or FRP. All couplings shall be fitted to the top of the tank. Petrol tanks shall not have any arrangement for drainage.

22.2.3.3 In fuels systems for petrol all metallic components, from filling spigots on deck to, and including the engine, shall be connected by means of electric conductor(s).

22.2.4 Safety

22.2.4.1 Flame dampers, carburettors or other components in the engine system shall be installed to not represent a safety hazard.

22.2.4.2 Penetrations to the engine well for outboard engines shall be effectively sealed by means of rubber sleeves or similar equipment.

SECTION 23 STEERING

23.1 Definitions

23.1.1

23.1.1.1 The following definitions apply in this section:

K = steering force on tiller at point of actuation (N)

F = steering force on rudder (N)

A = rudder area (m^2)

V = maximum craft speed (knots)

S_a = length of tiller from rudder stock centre to point of actuation (mm)

S_b = distance from pressure centre of rudder to lower rudder bearing for spade rudders, to upper bearing for balance rudder (mm)

S_v = 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 = 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 other item, as applicable (MPa).

23.2 Arrangements

23.2.1 General

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

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

23.2.1.3 Rudder stops shall be fitted.

23.3 Forces on steering system

23.3.1 Rudder steering

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

$$K = F \cdot \frac{S_v}{S_a} \quad \text{(N)}$$

with F not taken smaller than:

$$F = 110 \cdot A \cdot V^2 \quad (N)$$

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

23.3.2 Waterjet installations

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

23.4 Rudder stock

23.4.1 General

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

for balance rudders

$$M = \left(\frac{FS_b}{4} + \frac{F}{2}\left(S_b + 2S_v^2\right)^{\frac{1}{2}} \right) \text{[Nmm]}$$

for spade rudders

$$M = \left(\frac{FS_b}{2} + \frac{F}{2}\left(S_b^2 + 2S_v^2\right)^{\frac{1}{2}} \right) \text{[Nmm]}$$

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

$$d = 2.2\left(\frac{M}{\sigma_{0.2}}\right)^{\frac{1}{3}}$$

for solid stocks.

Hollow stocks shall satisfy the following criteria:

$$d = \left(\frac{d_o^4 - d_i^4}{d_o}\right)^{\frac{1}{3}}$$

d_o = outer diameter of stock

d_i = inner diameter of stock.

23.4.1.3 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.

23.4.1.4 The diameter of pintles shall not be smaller than

$$0.6 \cdot d + 5 \text{ mm}.$$

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

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

$$d_b = 0.65 \cdot \frac{PCD}{2 \cdot \sqrt{n}} \quad (mm)$$

n = number of bolts, shall not be smaller than 4

PCD = pitch circle diameter, shall not be smaller than 2 · d.

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

23.4.1.7 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.

23.5 Rudder

23.5.1

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

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

$$t = 3 + 0.125 \, d \text{ (mm)}$$

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

$$t = 4 \text{ (mm)}$$

23.5.1.4 In addition to the requirements to minimum thickness the following requirements shall be

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

$$W = \frac{M_{bend}}{\sigma_{all}}$$

M_{bend} = bending moment at the cross section due to maximum rudder lift force

σ_{all} = allowable bending stress.

σ_{all} 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.

23.5.1.6 The total effective shear area A_{web} of vertical webs in any horizontal cross section shall not be smaller than given by:

$$A_{web} = \frac{S}{\tau_{all}}$$

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

τ_{all} = allowable shear stress.

τ_{all} 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.

23.6 Steering system

23.6.1 Hydraulic steering system with or without external source of power

23.6.1.1 The capacity of the steering system shall be documented.

23.6.1.2 The complete installation shall be tested for leaks.

23.6.1.3 The satisfactory function of the steering system shall be verified by practical operational test at sea trial.

23.6.1.4 Hand operated hydraulic steering systems shall be CE-marked according to Council Directive 94/25/EC and installed according to the manufacturers recommendations.

23.6.2 Cable steering system

23.6.2.1 The capacity of the steering system shall be documented.

23.6.2.2 Cable steering systems shall be CE-marked according to Council Directive 94/25/EC and installed according to the manufacturers recommendations.

23.6.2.3 The satisfactory function of the steering system shall be verified by practical operational test at sea trial.

23.6.3 Steering wheel

23.6.3.1 Steering wheels shall be CE-marked according to Council Directive 94/25/EC. For not CE-marked steering wheels the requirements below apply.

23.6.3.2 For small high speed craft the steering wheel shall be tested with force equal to 700 N in the forward and aft ward direction applied at the weakest point of the steering wheel periphery. The test shall be carried out at room temperature. The steering wheel shall exhibit no breakage or permanent deformation after the test.

23.6.3.3 For open steering positions a steering wheel fabricated from plastic materials without structural metal frame shall not show any major decrease in strength after ageing in xenon light corresponding to 4 years of natural ageing. This requirement may be deleted for black wheels.

SECTION 24 PIPING SYSTEMS AND TANKS

24.1 General

24.1.1 General

24.1.1.1 Materials used in piping systems shall be suitable for the carried liquid and external environment to which it is exposed. Corrosion and variation in temperature shall be considered. Different materials shall not be combined such that there is a possibility for galvanic corrosion.

24.1.1.2 All components in the installation shall have sufficient strength and be so mounted that the system including its foundations will withstand the accelerations and vibrations to which it may be exposed as well as the design pressure. They shall be protected against mechanical damage. Expansion loops or equivalent arrangement shall be provided to allow expansion/contraction of pipes.

24.1.1.3 Flexible hoses used in fuel system, seawater cooling system, bilge system and other systems where a failure of the connection will lead to flooding shall be fitted with two stainless steel hose clips or pressed on end couplings.

24.1.1.4 Pipes or hoses shall not be installed over switchboard or electrical distribution panels.

24.2 Bilge System

24.2.1 Arrangement

24.2.1.1 The bilge system shall normally consist of rigid pipes fabricated from steel, FRP or thermoplastics. Metallic materials shall be used in the engine room. The bilge system shall be permanently installed. If flexible hoses are used attention shall be given collapse due to suction.

24.2.1.2 The bilge system shall be able to empty all compartments except tanks.

24.2.1.3 Separate suction lines shall be fitted to each watertight compartment and be equipped with a valve between the main bilge line and the individual suction line. The valve shall be possible to operate from above floors. Emptying by use of the bilge system of small compartments may not be required based on special consideration.

24.2.1.4 One bilge pump driven directly by the engine or by electric motor shall be installed. The bilge pump shall have a capacity Q not smaller than:

Table 24-1 Bilge pump capacity

Loa (m)	*Capacity (l/minute)*
< 8	60
8 – 10	80
10 – 12	120
12 – 15	180
15 – 24	250

The bilge pump shall be possible to operate from the steering position. For craft with L larger than 6 m minimum two pumps shall be fitted, each with at least 50% of the capacity given above.

24.2.1.5 Alternative to the arrangement using one bilge pump, separate bilge pumps may be installed for one or more compartments. Pumps shall be possible to operate from the steering position.

24.2.2 Alarm

24.2.2.1 Engine and cargo spaces shall be fitted with bilge alarm. This does not apply to open craft.

24.3 Fuel system

24.3.1 Arrangement

24.3.1.1 Fuel strainers, filters and water separators shall be easily accessible and possible to replace, drain and clean with engine in operation.

24.3.1.2 Fuel tanks shall not be located above the engine.

24.3.1.3 Fuel tanks may be integral or separate.

Separate tanks shall be mounted such that air can circulate freely around the tank and such that they can be readily inspected or movable for inspection.

24.3.2 Fuel tanks

Fuel tanks shall be fabricated from steel, aluminium, polyethylene or FRP. Tanks in engine room shall be fabricated from steel or aluminium.

24.3.2.1 The plate thicknesses (mm) shall not be smaller than:

Carbon steel:	3.0 (mm)
Stainless steel:	3.0 (mm)
Aluminium:	4.0 (mm)
FRP:	4.0 (mm)
PE:	5.0 (mm).

24.3.2.2 Fuel tanks shall have an inspection hatch. For removable tanks an inspection hatch is not required.

24.3.2.3 Wash bulkheads shall allow adequate circulation of the fuel along the top and bottom of the tank.

24.3.2.4 Each tank shall have separate filling pipe and air vent. The air vent shall be mounted in a way to prevent water from entering the tank. The filling pipe shall have an internal diameter of at least 38 mm. The vent pipe shall have an internal diameter of at least 16 mm. If the filling pipe has a screw coupling or similar device for the filling line, the internal cross sectional area of the vent pipe shall not be smaller than 125% of the internal cross sectional area of the filling pipe.

24.3.2.5 The amount of fuel in the tank arrangement shall be possible to verify at any given time, e.g by fitting a level gauge to each tank. External sight glass shall have a self-closing valves.

24.3.3 Fuel piping

24.3.3.1 Fuel lines may consist of metal pipes or flexible hoses, or a combination thereof. Fuel lines shall not pass over engine(s) or be arranged such that a leakage can occur on to sources of ignition (e.g. hot surfaces).

24.3.3.2 The engine shall be connected to the fuel line by a short flexible hose.

24.3.3.3 Flexible hoses shall satisfy the requirements of ISO 7840 Small craft fire resistant fuel hoses type A1 or A2, and be marked in accordance with this standard.

24.3.3.4 Fuel lines shall be equipped with a metallic shut-off valve mounted on the tank. The valve shall be possible to close from above deck.

24.3.3.5 At least two hose clips fabricated from stainless steel shall be used at each connection on flexible hoses. Spigots shall be sufficiently long to accept the hose clips and have grooves or a bead.

24.3.3.6 Flexible hoses for pressurised system(s) shall be fitted with pressed on end fittings.

24.3.4 Testing

24.3.4.1 After installation a leakage test shall be carried out of the whole installation with a pressure equal to 20 kPa.

24.4 Seawater cooling systems

24.4.1 General

24.4.1.1 Flexible hoses may be fitted. Flexible hoses shall be mounted in such a way that they are protected against mechanical damage. Flexible hoses shall comply with the same requirements given for flexible hoses used in fuel systems. Flexible hoses shall be secured with at least two stainless steel hose clips or pressed-on couplings.

24.4.1.2 Seawater intakes shall have strainers or filters. All filters shall be fitted such that they can be cleaned while the engine is running.

24.5 Freshwater systems and grey water systems

24.5.1 General

24.5.1.1 Fresh water tanks shall be accessible for cleaning.

24.5.1.2 Integral freshwater tanks shall not be located contiguous to fuel or grey water tanks.

24.5.1.3 Toilet water shall be collected in dedicated tanks possible to empty from above deck.

24.6 Shell penetrations

24.6.1 General

24.6.1.1 Penetration located lower than 200 mm above deepest waterline shall be arranged with closing valve or other equivalent means for preventing water from passing inboard. The valve shall be readily accessible for operation from a position above floor, or immediately below via easy operable and marked hatch in floor plate.

24.6.1.2 Penetration located less than 200 mm above deepest waterline and connected to a system with open inboard end located below lowest part of bulkhead-deck, and penetration located in a position immersed at an angle of heel of 10º, shall in addition to closing valve be arranged with non-return valve.

24.6.1.3 Valve shall have system name and indicator showing closed and open position.

24.6.1.4 Material of valve and hull flange shall be of steel, bronze or other equivalent accepted ductile material resistant to corrosion.

SECTION 25 ELECTRICAL SYSTEMS

25.1 General

25.1.1 General requirements

25.1.1.1 The present section does not apply to electrical components on the propulsion or auxiliary engine(s). Equipment considered to represent a safety hazard may be required replaced or modified regardless of where it is mounted.

25.1.1.2 The present section does not cover personnel protection with respect to exposure to electromagnetic fields, e.g. from radar and CRT screens.

25.1.1.3 Electrical connections and components shall be protected from the expected conditions in conformity with IEC 60529:

— minimum IP X7 if exposed to short-term immersion
— minimum IP X5 if exposed to splashing water
— minimum IP X2 if located in protected locations inside the craft.

25.1.1.4 Electrical equipment located in an environment with explosion hazard shall be Ex approved. Battery installations and gas installations are considered explosion hazard areas.

25.1.2 Protection

25.1.2.1 Circuit breakers shall not be placed in tank compartment or compartments for equipment that may generate explosive gases (e.g. battery installation, gas installations).

25.1.2.2 Safety equipment as e.g. radio, sound horn, search light etc. and consumers with drawing a current larger than 5 A shall be equipped with separate circuit breakers.

25.1.2.3 Navigation lights shall have separate circuit breakers. If the functioning of the navigation light can not be monitored from the steering position each light shall be equipped with an optical or audible alarm to the steering position indicating if the light is functioning. Malfunctioning of the system for indication shall not influence the function of the navigation light.

25.1.3 Switchgear and controlgear assemblies

25.1.3.1 Switchboards shall be protected against leaks and spray from sea and piping and shall be accessible for maintenance and replacement and visual inspection during operation.

25.1.3.2 Each group on the switchboard shall be independently available for measurement of insulation.

25.2 DC systems – voltage ≤ 50 V

25.2.1 General

25.2.1.1 Direct current systems which operate at nominal potential not exceeding 50 V shall comply with ISO 10 133 and the requirements given in this section.

25.2.1.2 A circuit plan shall be supplied with the craft when delivered and be available onboard. All markings shall be permanent.

25.2.2 Battery installations

25.2.2.1 Battery installations with a capacity exceeding 5 kWh shall be placed in compartments with ventilation to the outside of the craft. Battery installations placed in accommodation areas shall be ventilated separately to the outside of the craft.

25.2.2.2 Each battery shall be marked indicating the connected consumers and how connections between batteries shall be carried out.

25.2.2.3 Batteries installed inside the same watertight compartment as the propulsion engine(s) shall be mounted such that they are not short circuited when the compartment is filled with water up to the loaded water line. Alternatively, emergency batteries for supply to emergency lighting, navigation equipment and radio, may be placed above main deck.

25.2.2.4 For main engines with electric starter, the starter shall be possible to connect to two separate groups of batteries. One of the groups shall be assigned to starting and shall not be used to supply other consumers. The other group may be one used for consumers and which have a capacity that is sufficient to start the main engine.

25.2.3 Distribution systems

25.2.3.1 For propulsion engines with a power output less than 100 kW, the engine may be used as conductor when starting the engine.

25.2.3.2 Gas alarms, theft alarms, heating equipment and automatic bilge pumps may be connected between the battery/generator and the main switchboard, but must have separate protection with circuit breakers.

25.2.3.3 Cable penetrations in watertight bulkheads and decks shall be watertight.

25.2.3.4 The following cables shall be carried as separate, insulated single conductors:

— conductor to connect generator to batteries
— conductor to connect battery to electrical starter
— conductor to connect battery or generator to switchboard.

The conductor between battery and electrical starter shall not be protected by circuit breaker. The conductor shall comply with the engine manufacturer's recommendations.

25.2.3.5 Interior lighting shall be distributed on at least two separate circuits.

25.3 AC systems – voltage ≤ 240 V

25.3.1 General

25.3.1.1 Alternating current systems which operate at nominal voltage not exceeding 250 V shall comply with ISO 13297 and the requirements given in this section. Such systems shall be installed as single phase systems.

25.3.1.2 A circuit plan shall be supplied with the craft when delivered and be available onboard. All markings shall be permanent.

25.3.1.3 Electrical equipment located in an environment with explosion hazard shall be Ex approved. Battery installations and gas installations are considered explosion hazard areas.

25.3.2 Distribution systems

25.3.2.1 Cable penetrations in watertight bulkheads and decks shall be watertight.

25.3.2.2 Interior lighting shall be distributed on at least two separate circuits.

25.3.3 Shore connections

25.3.3.1 The cable(s) for shore connection shall have a solid sheath resistant to oil and weathering. The socket inlet shall be protected from spray water and rain.

25.3.3.2 Equipment connected to the shore connection shall become earthed to the shore connection.

25.4 Emergency power supply

25.4.1 Emergency power supply

25.4.1.1 An alternative power supply shall be available capable of supplying the following consumers for a period of at least 3 hours:

— emergency lights in wheelhouse, accommodation and engine room (for small craft portable flashlights may be accepted as emergency lights)
— navigation lights or Not Under Command lights
— fire detection and alarm systems
— remote control devices for fire extinguishing systems, if electrical
— radio facilities.

The alternative power supply shall be fitted outside the engine room and above the flooded waterline with the engine room flooded.

SECTION 26 FIRE SAFETY

26.1 General

26.1.1 Definitions

26.1.1.1 Definitions and nomenclature in the present section follows the definitions and nomenclature in the FTP Code for the craft structure.

26.1.1.2 The following designations are used to classify and identify fires of different nature:

— Class A: fires involving solid material, usually of organic nature
— Class B: fires involving liquids or liquefiable solids
— Class C: fires involving electrical equipment
— Class D: fires involving combustible metals (i.e. magnesium).

26.1.2 Fire safety in general

26.1.2.1 Fire safety shall be achieved by the use of passive and active means.

26.1.2.2 Passive means is structural fire protection and control of installations and combustible materials.

26.1.2.3 Active means is fire-fighting equipment.

26.1.2.4 Other requirements for fire safety than listed in this section may be specified under specific service notations.

26.2 Structural fire protection

26.2.1 Engine and tank spaces

26.2.1.1 Engine spaces in crafts fabricated from FRP shall be enclosed with fire protection of minimum 15 minutes rating. Arrangement and materials for structural fire protection shall be approved. The fire protection shall cover the entire boundary of the engine space above lowest waterline.

26.2.1.2 For small crafts (normally L < 15 m) other arrangements than specified in [26.2.1.1] may be accepted based on special consideration (e.g. intumescing paint, fire retarding resin on interior surface of FRP laminates).

26.2.1.3 Fuel and lubrication oil tanks located entirely or partly above the floor in the engine space shall have fire resisting division of at least B-15 rating.

26.2.1.4 Openings for ventilation of the engine space shall be equipped with closing appliances readily operable from the outside of the engine space.

26.2.1.5 Tank spaces separated from engine spaces need not follow the same requirements as given for engine spaces in [26.2.1.1] and [26.2.1.2], but shall be ventilated to the outside of the craft.

26.2.2 Control of combustible materials

26.2.2.1 Acoustic insulation material used in engine spaces shall 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.

26.3 Portable fire extinguishers

26.3.1 General

26.3.1.1 The craft shall be equipped with portable fire-fighting extinguishers.

26.3.1.2 Any portable fire extinguisher shall be type approved under European Standard EN3, under the Marine Equipment Directive or other national recognized standard.

26.3.1.3 The extinguisher(s) fitted shall individually or as combined be suitable for fighting ABC-fires.

26.3.1.4 No individual extinguisher shall be rated less than 30A/180B.

26.3.1.5 Any individual portable carbon dioxide (CO_2) extinguisher shall have a maximum capacity of 2 kg.

26.3.2 Location of portable fire extinguishers

26.3.2.1 The total number of portable fire extinguishers shall be adequate to meet the following requirements. A single extinguisher may meet more than one of the requirements.

26.3.2.2 Readily accessible portable fire extinguisher(s) shall be located:

— within 2 m unobstructed distance from the main helm position
— within each 20 m^2 of the accommodation area
— within (L/3) m from the centre of any berth, measured horizontal
— within 2 m unobstructed distance from any permanent installed cocker/stove or open flame device.

26.3.2.3 Portable CO_2 extinguishers shall only be fitted in accommodation spaces when flammable liquids are present (e.g. galley) or where energized electrical equipment is located (e.g. electric motor space, battery space, switchboard).

26.3.2.4 Where CO_2 extinguishers are used, there shall be only one CO_2 extinguisher in each hazard area. A warning notice shall be affixed near the extinguisher.

26.3.2.5 If the portable fire extinguisher is located where it is exposed to splashed or sprayed water, the nozzle and triggering device shall be shielded.

26.3.2.6 The extinguisher may be stowed in a locker or other enclosed space. The locker or opening part of the space shall be labelled.

26.3.3 Fire blanket

26.3.3.1 If an open-flame cooker is fitted, a fire blanket, in accordance with EN 1869, shall be within reach and readily accessible for immediate use.

26.4 Fire detection

26.4.1 Engine spaces

26.4.1.1 The engine spaces shall be equipped with a fire detection system with both audible and visible alarm at the helm position. The detection system may be part of a fixed fire extinguishing system.

26.5 Fixed fire extinguishing systems

26.5.1 General

26.5.1.1 Engine spaces shall be protected by a fixed fire-fighting extinguishing system.

26.5.1.2 The system shall be a manual system or a manual/automatic combined system if applicable. A manual release system shall be activated from the helm position. The release mechanism shall be protected against sea-spray and unintended release. The operation instruction shall be posted close to the release mechanism.

Automatic release of the system shall be indicated by both audible and visual alarms at the helm position.

Both engine and powered ventilation shall have automatic shutdown upon discharge of automatic systems.

26.5.1.3 The extinguishing medium shall be suitable for fighting AB-fires.

26.5.1.4 The amount of extinguishing medium and emptying time shall be adequate for the space considered such that the fire is efficiently extinguished.

26.5.1.5 The fixed fire extinguishing system shall be of one of the following types:

— aerosol system
— CO_2 system
— gaseous agent
— high expansion foam system
— water mist systems.

26.5.1.6 Cylinders for the extinguishing medium shall be protected against sea-spray, mechanical damage and temperatures exceeding 50ºC. Cylinders shall not be located in accommodation areas.

26.5.1.7 Nozzles shall be located in a way that an even distribution of the extinguishing medium is achieved.

26.5.2 Aerosol system

26.5.2.1 Aerosol system shall be type approved according to IMO MSC/Circ. 1007.

26.5.2.2 The system may be either a manual or a manual/automatic combined system.

26.5.3 CO_2 system

26.5.3.1 The system shall be manually operated only. Discharge shall be indicated by both audible and visible alarm.

26.5.3.2 The amount of extinguishing medium shall be minimum 0.6 kg/m^3 net volume, but in any case not less than 2 kg in total.

26.5.3.3 CO_2 cylinders shall not be located in the engine room.

26.5.3.4 CO_2 cylinders or fittings on distribution lines shall not be located in a way that any extinguishing medium can enter into the accommodation area in the event of leakage in the system.

26.5.3.5 CO_2 systems shall have a separate fire detection system.

26.5.4 Gaseous agent system

26.5.4.1 Gaseous agent system shall be type approved according to IMO MSC/Circ. 848,as amended by Circ. 1267

26.5.4.2 The system may either be a manual or a manual/automatic combined system.

26.5.5 Foam system

26.5.5.1 The system may either be a manual or a manual/automatic combined system.

26.5.6 Water mist system

26.5.6.1 Water mist system shall be type approved according to IMO Circ. 1165

Guidance note:

Water mist systems tested according to other standards (e.g. Factory Mutual) may be accepted.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

26.5.6.2 The system may either be a manual or a manual/automatic combined system.

26.5.6.3 A water mist system shall be designed for a protection time of at least 20 minutes.

26.5.6.4 Water based systems requiring fresh water shall 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 fresh water tank is increased to 15 minutes.

SECTION 27 NAVIGATION

27.1 General

27.1.1 General

27.1.1.1 Navigation lights according to national or international regulations shall be fitted.

SECTION 28 OTHER SYSTEMS

28.1 Cooking and heating appliances

28.1.1 General

28.1.1.1 Stoves and heating units shall be securely fastened.

28.1.1.2 Where flues are installed, they shall be insulated or shielded to avoid overheating or damage to adjacent material or to the structure of the craft.

28.1.2 Units using liquid fuel

28.1.2.1 Open-flame burners shall be fitted with a drip-pan.

28.1.2.2 Drip-pan shall have at least 20 mm high coaming able to collect the fuel in case of leakages.

28.1.2.3 Where open-flame-type water heaters are installed, adequate ventilation and flue protection shall be provided.

28.1.2.4 Where a pilot light is installed, the combustion chamber room shall be sealed, except for cookers.

28.1.2.5 Appliances using petrol for priming, or as a fuel, shall not be installed.

28.1.3 Liquid fuel tanks

28.1.3.1 For tanks and supply lines, the applicable requirements of Sec.23 apply.

28.1.3.2 Non-integral tanks shall be securely fastened and shall be installed outside Zone II, figure below.

28.1.3.3 A readily accessible shut-off valve shall be installed on the tank. If this is outside the galley, a second valve shall be fitted in the fuel line in the galley space, outside zone II, figure below, and not behind the cooker. This requirement does not apply where the tank is located lower than the cooker/heater and there is no possibility of back siphoning.

28.1.3.4 Filler openings for tanks shall be visibly identified to indicate the type of fuel to be used with the system.

28.1.4 Materials near open flame appliances

28.1.4.1 Materials and finishes used in the vicinity of open-flame cooking and heating devices within the ranges defined in figure below, shall comply with the following requirements, taking into account the movement of the burner up to an angle of 20° where gimballed stoves are fitted. The requirements do not apply to the cooker itself:

— Free-hanging curtains or other fabrics shall not be fitted in Zone I or II.
— Exposed materials installed in Zone I shall be glass, ceramics, aluminium, ferrous metals, or other materials with similar fireproof characteristics, or be thermally insulated.
— Exposed materials installed in Zone II shall be glass, ceramics, metals, or other materials with similar fireproof characteristics, or be thermally insulated from the supporting substrate to prevent combustion of the substrate, if the surface temperature exceeds 80°C.

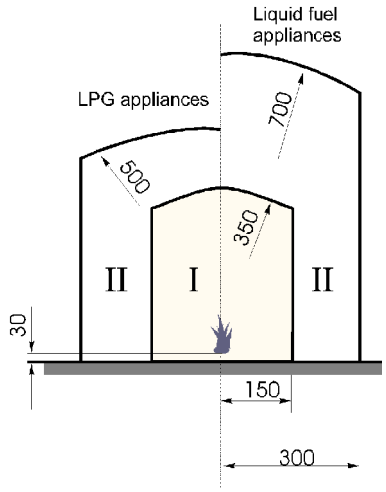


Figure 28-1

28.2 LPG installations

28.2.1 General

28.2.1.1 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.

CHANGES – HISTORIC

There are currently no historical changes for this document.

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